

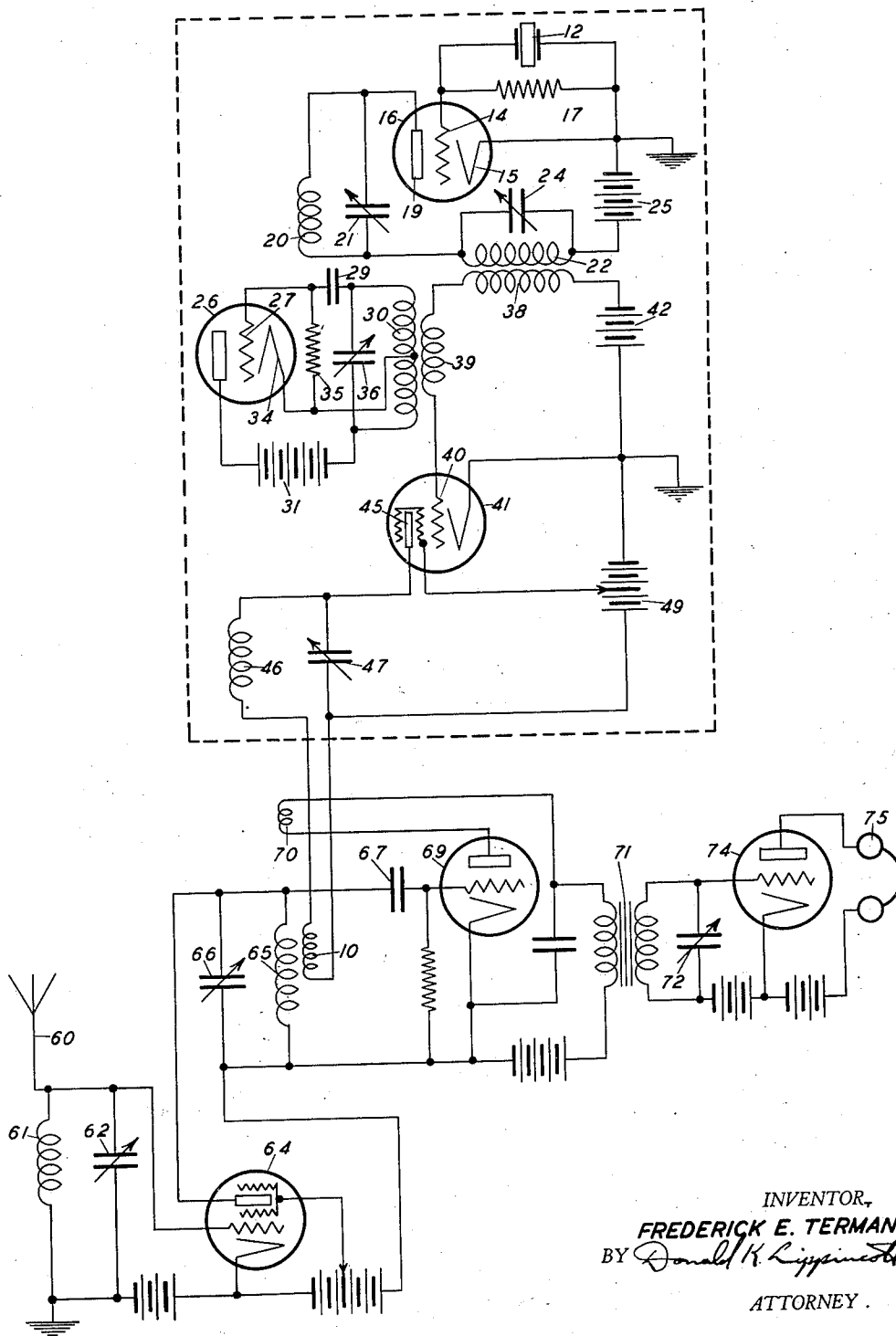
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RADIO RECEIVING SYSTEM

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RADIO RECEIVING SYSTEM

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My invention relates to heterodyne receivers of radio or carrier current signals. Although primarily adapted to the reception of high frequency telegraph signals, the invention is also applicable to superheterodyne reception of voice and to all other methods of reception in which a local oscillator is utilized to produce a heterodyning frequency.

The primary object of my invention is to provide a frequency-stabilized local oscillator for producing a frequency to beat against the received signal, thus making possible the achievement of what may be called the secondary objects of the invention, i. e., to provide a method of receiving high frequency signals which eliminates constant retuning to hold the pitch of the received note constant; to permit sharp tuning of the received signal after heterodyning; to reduce noise in the low frequency circuits; and to provide sharper selectivity and reduce interference between desired and undesired signals.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

The figure is a diagram showing the application of my invention to a high frequency receiver circuit.

The use of frequency-stabilized or crystal oscillators to control radio transmitters has resulted in a high degree of stability in the frequency of the transmitted wave. Where the crystals are properly controlled as to temperature, frequency stability to one part in a million may readily be obtained, while such instability or frequency variations as do occur take place gradually and over swings of relatively long periods.

Because the frequency of a crystal is determined primarily by its dimensions, and may be varied but slightly by changes in pressure or other operating conditions, and because of the necessity for receiving signals from various sources upon a single receiver, the advantages of crystal stabilization have not been applicable to receiving circuits. The received signals have been heterodyned against the oscillations of ordinary vacuum tube oscillators whose frequency cannot, in general, be maintained constant to within less than one part in ten thousand. With a stable received signal and a varying heterodyne oscillator, the received note varies by as many cycles as does the local oscillator.

It is usually desirable that the heterodyne note of the received signal be maintained at approximately 1,000 cycles. Where the received signal is of a frequency of, say, 15,000 kilocycles, a variation of one part in ten thousand in the local oscillator may cause a variation in the beat note of 1,500 cycles. This great a variation may lead to the entire disappearance of the beat note or, if the variation be in the other direction, it may more than double its frequency. In order to maintain the frequency of the note at 1,000 cycles the local oscillator must constantly be retuned.

Furthermore, if the beat note be variable it is not feasible to gain selectivity by tuning after heterodyning, but the low frequency circuits must, instead, be made unselective or substantially aperiodic. The amount of noise accepted by these circuits is directly proportional to the width of the band which they will receive, and therefore with broadly tuned audio frequency circuits it is not only necessary for the operator to pick out a particular note which he desires from among many others of not greatly different pitch, but it is also necessary for him to listen to this note above the relatively large amount of "noise" or random impulses not characterized by musical pitch.

The advantages of my invention are predicated upon the possibility of utilizing a local oscillator or heterodyne which is substantially as stable in its frequency as is the transmitted signals. This permits the selection of a definite tone for the beat note, which remains substantially unchanged as long as desired. The audio frequency circuit may then be tuned as sharply as desired, thus eliminating not only the necessity for constant retuning of the receiver, but also interfering beat notes and a very large proportion of interfering noise. It is not difficult to construct audio frequency tuning systems having a band width of 1 cycle or less. Where the received signals may be held within the range of such a system the advantages to be gained are obvious.

Broadly considered, my invention comprises a local oscillator which may be of any of the well known crystal-controlled or other frequency-stabilized types. This oscillator generates a frequency which is a large proportion of the desired heterodyning frequency, either as a fundamental or as one of its harmonics. A second oscillator is provided of the tunable type. This second oscillator is not frequency-stabilized, but its frequency is but a small proportion of the desired heterodyning frequency. The outputs of

the two oscillators are mixed and passed through a detector or a linear amplifier to produce a modulation product of the desired heterodyning frequency, which is injected into the circuit of an oscillating detector at sufficient intensity to hold the latter in synchronism therewith, thus combining exact frequency control with the sensitivity of the oscillating detector. Since the unstabilized oscillator provides a very small proportion of the total number of cycles of the heterodyning frequency, instabilities of the order of one part in ten thousand in this oscillator produce only a very few cycles change in the total frequency supplied.

I prefer to operate the crystal oscillator upon one of its harmonic frequencies. Under these circumstances, if a single crystal be used, the tuned oscillator need be operated over a range only one-half of the total frequency of the crystal fundamental. By providing a plurality of crystals which may be used alternatively, the proportion of the total frequency supplied by the unstabilized oscillator may be made even less.

The low frequency portion of the system is preferably sharply tuned to the beat frequency, thus excluding interfering signals and a large proportion of interfering noise.

The elements of a preferred form of the invention are shown schematically in the drawing, the figure representing a receiver for high frequency telegraph signals. Any satisfactory antenna system may be used, such as the elevated conductor 60 tuned by means of the inductance coil 61 and variable condenser 62. The received signals are preferably fed into a tetrode 64, functioning as a radio frequency amplifier, of conventional type, but this may be omitted if desired. The output of the tetrode includes a coil 65, tuned by a condenser 66, and is coupled through a condenser 67 with an oscillating detector tube 69. Oscillation of this tube is secured by coupling the plate circuit thereof back to the coil 65 by means of a tickler coil 70.

Although the extreme sensitivity of oscillating detectors has long been known, their frequency stability in general is poor, and for this reason they have frequently been replaced by non-oscillating detectors with separate oscillators to supply the heterodyning frequency. In accordance with this invention, however, a stabilizing oscillation of the beating frequency is injected into the detector circuit by means of the coil 10. The injected oscillation pulls the detector into step without decreasing its sensitivity, and if the injected frequency is itself maintained stable, as by the oscillator system next to be described, the sensitivity of this type of detector is combined with sufficient frequency stability to enable the output circuit to be tuned to the beat note, and thus gain not only further sensitivity but decreased interference or output noise.

The heterodyne frequency generator which is used in the preferred embodiment of my invention comprises the equipment enclosed in the dotted lines 11, which represent the shielding which preferably encloses this apparatus. The generator comprises a crystal-controlled oscillator of standard type, wherein the quartz crystal 12 is connected between grid 14 and filament 15 of a vacuum tube 16, the crystal being shunted by a grid leak 17.

The plate 19 of the tube connects to a parallel resonant circuit comprising a coil 20 and variable condenser 21, which are preferably tuned

slightly above the fundamental frequency of the crystal 12. In series with this circuit is a second parallel resonant circuit comprising a coil 22 tuned by a condenser 24, this circuit being tuned to the desired harmonic of the crystal. The plate current for the oscillator is supplied from a battery or other suitable source 25.

A second oscillator is provided comprising a tube 26 whose grid 27 connects through a blocking condenser 29 to one end of an inductance coil 30. The other end of the coil connects through the plate supply 31 to the plate 32 of the tube. The filament 34 connects with the center of the coil, and the latter is tuned by a variable condenser 36. A grid leak 35 maintains the grid at proper operating potential. This oscillator will be recognized as the well known Hartley circuit. Any other well known form of tuned oscillating circuit may be substituted if desired.

An inductance coil 38 is coupled with the coil 22, and a second inductance coil 39 is coupled to the coil 30. These two coils are connected in series with the grid 40 of a tube 41, this grid being provided with a strong negative bias from the battery 42, so that the tube 41 is alinear in response, functioning as a detector or modulator. The tube is shown as being of the tetrode type, but it is to be understood that a triode may be used if desired.

In series with the plate 45 of the alinear tube 41 is a resonant circuit comprising an inductor 46 which is connected in series with the coupling coil 10, the two coils being tuned by a variable condenser 47. The plate and screen grid potentials are supplied by the battery 49.

It will be understood that a selected harmonic of the frequency generated by the tube 16 in combination with the crystal oscillator 12, mixed with an oscillation from the tube 26, is applied to the tube 41, whose alinear characteristic causes the usual modulation products, i. e., sum and difference frequencies, to appear in its output circuit. The desired modulation product is selected by tuning the condenser 47, to provide the desired heterodyning frequency.

The operation of the heterodyne frequency generator is as follows: Assuming a signal frequency of 14,500 kilocycles, and that the frequency of the crystal 12 is 3,000 kilocycles. The circuit comprising the coil 20 and condenser 21 is tuned slightly above the 3,000 kilocycle frequency, while the circuit comprising the coil 22 and condenser 24 is tuned to the 5th harmonic of this frequency or 15,000 kilocycles. The oscillator circuit comprising the coil 30 and variable condenser 35 is tuned to a frequency of 499 kilocycles.

The frequencies appearing in the output circuit of the tube 41 will be 499 kilocycles, 15,000 kilocycles, and the sum and difference of these two frequencies, i. e., 15,499 kilocycles and 14,501 kilocycles. The latter frequency is selected by tuning the condenser 47, and is heterodyned against the received frequency of 14,500 kilocycles to produce a 1 kilocycle beat note in the output of the detector 50.

The crystal oscillator is stable to within one part in a million, and hence the maximum frequency variation in its output will be 15 cycles. The output of the tube 26 is stable to within one part in ten thousand, and hence the maximum frequency variation to be expected from this source is about 50 cycles. Under the worst conditions therefore the maximum variations to be expected in the heterodyning frequency is 65 cycles, as compared to an expected variation of 75

at least 1,500 cycles were an unstabilized heterodyning frequency generator used. The change to be expected in the beat frequency is therefore only about 6½ per cent, instead of a change of over 100 per cent to be expected with the unstabilized type of heterodyning frequency generator or local oscillator.

Assuming still that the crystal oscillator operates on a fundamental frequency of 3,000 kilocycles, and that only a single crystal is used, the maximum frequency to which the unstabilized oscillator need be tuned, to cover as broad a band as may be desired, is 1,500 kilocycles, or one-half the fundamental frequency of the crystal. By selecting the proper crystal harmonic and sum or difference frequency, any desired heterodyning frequency may be obtained from this combination. More accurate control of the heterodyning frequency may be obtained from the use of a lower fundamental crystal frequency and a higher harmonic of that frequency, or by using the selected one of a plurality of crystals in order to obtain the proper heterodyning frequency. What is necessary in order to fulfill the fundamental principle of this invention is that the greater proportion of the heterodyning frequency be supplied from the crystal oscillator, while a relatively small proportion of that frequency is provided by the unstabilized oscillator.

Since the output of the detector 69 is at a substantially constant frequency, the output transformer 71 may be tuned by a condenser 72, thus increasing its response in the range of the detected signals and decreasing its response to noise and interferent signals. The tube 74 and telephones 75 represent any suitable amplifying and translating device.

Although I have referred directly only to oscillating crystals as frequency-control elements, it is to be understood that magnetostriction controls or devices for producing a high degree of frequency stability may be used within the scope of this invention, which relates to the use of the highly frequency-stabilized oscillations rather than their production.

It is to be understood that by the terms "heterodyning", "beating", etc., as used in this specification, I include not only conventional methods of

frequency changing by the interaction of two frequencies, but also other methods of producing analogous results, e. g., the methods described in my copending applications, Serial Numbers 489,917, filed October 20, 1930, and 539,655 filed May 25, 1931 and my Patent No. 1,950,759, granted March 13, 1934.

I claim:

1. A receiving system for high frequency signals comprising a frequency-controlled oscillator, a tunable oscillator, means for mixing and combining the output energy of said oscillators to produce modulation products thereof, means for selecting a desired modulation product, receiving means responsive to a desired signal, an oscillating detector connected to respond to said received signal, and means for injecting said modulation product into said detector to stabilize its frequency of oscillation.

2. The method of receiving radio signals with a circuit including an oscillating detector which comprises the steps of generating separately a stabilized oscillation, generating a separate oscillation of lower frequency, modulating said stabilized oscillation with said lower frequency to produce a partly stabilized modulation product, and injecting said modulation product into said detector circuit to maintain the oscillation of said detector at a desired frequency.

3. In combination with a vacuum tube detector of the self-oscillating type, a source of oscillations of the frequency desired of said detector and of greater frequency stability than said detector, and means for injecting oscillations from said source into said detector to lock said detector into step at the desired frequency.

4. A radio receiving circuit including a vacuum tube detector having means for coupling the input and output circuits thereof to cause self-oscillation, a separate source of oscillations of the frequency desired of said detector and having a greater degree of frequency stability than said detector, and means for coupling said source to said detector circuit to inject therein oscillations from said source to lock the oscillations of said detector into step at the desired frequency.

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