Sept. 15, 1942. W. VAN B. ROBERTS 2,296,056

FREQUENCY MODULATION RECEIVER

Filed Aug. 16, 1939

Fig. 2

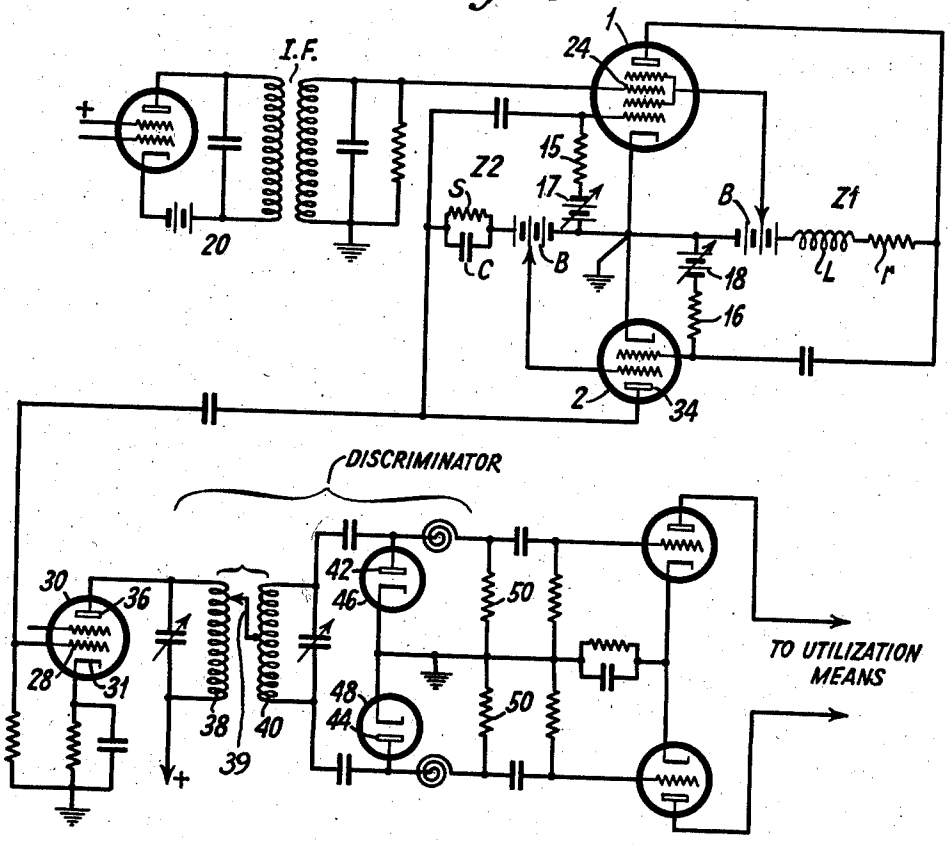
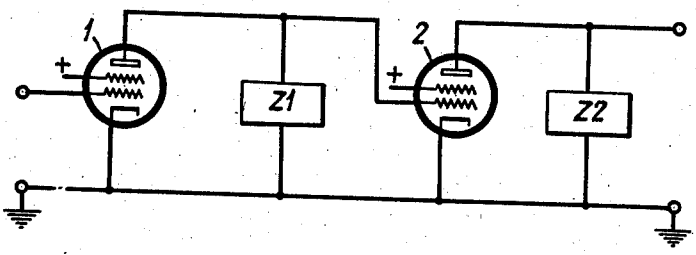


Fig. 1



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FREQUENCY MODULATION RECEIVER

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6 Claims. (Cl. 250—20)

This invention relates to the reception of frequency modulated signals, and, in particular, to local oscillator arrangements adapted to be locked in step with a signal of variable frequency.

An object of the invention is to provide an oscillator circuit having so little inherent frequency stability as to permit its frequency of oscillation to be readily controlled by a signal voltage.

A further object is to provide an oscillator whose frequency is so thoroughly under control of an applied signal voltage that the oscillator frequency is held synchronous with the signal frequency in spite of rapid and large variations of said signal frequency.

A further object of the invention is to provide a means for receiving the modulation characteristics of an incoming signal independent of the amplitude of the incoming signal so that as the amplitude thereof is above a minimum value.

Figure 1 shows schematically the nature of an oscillation generator arranged in accordance with my invention, and

Figure 2 shows a particular embodiment of my invention included in a system for receiving phase or frequency modulated signals.

Referring to Figure 1, if unit voltage is impressed on the grid of tube 1, coupled at its anode by impedance Z1 to the grid of tube 2 having an impedance Z2 in its output, the output voltage at the upper terminal of Z2 is $g1\ g2\ Z1\ Z2$ (where $g1$ and $g2$ are the transconductances of tubes 1 and 2 respectively). Hence, if the product of the impedances Z1 and Z2 is real, the output voltage is exactly in phase with the assumed input voltage, and if the product is, furthermore, greater than the reciprocal of the product of the two tube transconductances $g1$ and $g2$, the ouput voltage is greater than the assumed input voltage. Then if the output voltage is fed back to the input of the first tube, oscillations will build up in the tubes and circuits. The frequency of these oscillations will depend in general upon the nature of the circuit impedances, such as Z1 and Z2, the frequency generally being that frequency at which the voltage fed back is in phase with the assumed input voltage. The more rapidly the phase of the voltage fed back departs from being in phase with an assumed input voltage as the frequency is assumed to change, the greater the frequency stability of the system as an oscillator, and the less readily can the system be forced to oscillate at a frequency other than its natural frequency by the application of a control voltage of a different frequency. Conversely, the frequency of oscillation in such a system is all the more easily locked in step with a control frequency, the less the phase of the voltage fed back departs from the assumed input control voltage for a given change in frequency of operation. In the ideal case, illustrated in Figure 1, it is possible to choose impedances Z1 and Z2 such that the voltage fed back is in phase with the assumed input voltage regardless of the frequency of the assumed input voltage. In such a case the system has no natural frequency of oscillation of its own and will follow the frequency of any applied control voltage. In practice such an ideal condition may not be strictly realizable due to departures from the ideal in the tubes and also due to unavoidable wiring and tube capacities, but the frequency stability may be very greatly reduced as compared to conventional oscillators so as to give a high degree of controllability to the oscillations.

In Figure 2 there is shown an oscillation circuit of the type described, where the impedance of Z1 consists of an inductance L in series with a resistance r while Z2 consists of the parallel combination of a capacity C and a conductance s. In this case it is readily shown that if we choose the constants auch that $L/r=C/s$, then the product of the impedances of Z1 and Z2 is equal to r/s regardless of frequency. In order to produce oscillations, it is then only necessary to arrange that r/s is greater than

$$\frac{1}{g1g2}$$

These adjustments may be made independently by adjusting the capacity to meet the first requirement and then adjusting the tube transconductances to meet the second requirement, for example, by varying the bias on one or both tubes by any means such as, for example, variable sources 17 and 18.

To insure that the oscillator follows the control frequency during rapid variations of the latter, even when the theoretical requirements are not rigorously complied with, it is advisable to make the time constants of the impedances, namely L/r and C/s, each small.

Control voltage from the intermediate frequency amplifier 20 of a superheterodyne receiving system, for example, may be applied to an independent control grid 24 of one of the tubes as shown or may be injected at any other convenient point in the oscillator circuit. Output voltage from the oscillating circuit is preferably

taken across C as this connection does not add any unnecessary capacity across L which theoretically should not have any capacity in shunt thereto. For example, the grid 28 of a coupling tube 30, the cathode 31 of which is grounded, may be connected to the anode 34 of tube 2. The oscillator voltage may be applied to any type of frequency detector circuit such as the well-known discriminator network widely used for A. F. C. purposes and which is shown here arranged for push-pull output. That is, the anode 36 of coupling tube 30 is connected to an inductance 38 forming the primary winding of a transformer the secondary winding 40 of which is connected between the anodes 42 and 44 of diode detectors 46 and 48. The anode 36 of tube 30 is also coupled directly to the anodes 42 and 44 by way of a connection 39 between taps or windings 38 and 40. The discriminator circuits 38 and 40 serve in a well-known manner to convert any changes of the frequency of the oscillating voltages impressed thereon into corresponding amplitude variations in the voltages which are detected by rectifiers 46 and 48 and appear in the output resistances 50 which are differentially connected. The adjustment of these circuits and rectifiers is such that in the presence of normal control frequency on the grid 24 of tube 1, the discriminator circuits are electrically balanced and equal (small) currents flow in resistances 50 in opposite directions. When the control frequency shifts, the discriminator circuits are electrically unbalanced and a difference potential is set up in resistances 50 the amplitude of which corresponds to the amount of frequency shift and the polarity of which corresponds to the direction in which the frequency of the control voltage on grid 24 deviated. The potentials on 50 may be applied directly to indicating means or amplified and then used.

It will be seen that the signals detected by the frequency detection portion of Figure 2 are almost exclusively produced by the local oscillator system of Figure 2 so that their amplitude is substantially independent of the intermediate frequency amplitude, this intermediate frequency voltage serving only to maintain synchronism between a local oscillator and the intermediate frequency. Therefore, it will be appreciated that so long as the desired signal controls the local oscillator, it will be impossible to observe any effect from any other signal or noise voltage which is sufficiently weaker than the desired signal, so that it does not at any time interrupt the continuity of control of the oscillator by the desired signal. For example, if the desired signal amplitude is 20 volts and if only 5 volts is necessary to control the oscillator frequency, then an interfering station producing an intermediate frequency of 10 volts amplitude cannot by combining in any phase relation with the desired signal prevent the resultant voltage from at least equaling a peak value of 10 volts once every cycle of the desired signal, which is by hypothesis sufficient to maintain control. In other words, reception of a weaker signal is, practically speaking, suppressed in the presence of a stronger signal. This effect is of particular importance in minimizing noise produced by static pulses whose magnitude is small compared to the desired signal and which cannot, therefore, be suppressed by the usual noise suppressors whose action depends upon a relatively large peak of interfering voltage of short duration.

It is, also, of importance in connection with television transmission by phase or frequency modulation because with such transmission signals reflected from buildings, for example, and which are substantially weaker than the directly received signal cannot produce the secondary images characteristic of reflected signals in the case of amplitude modulated television signals.

In general, it may be said that the present invention permits the elimination from the transmission circuit between the transmitting station and the signal utilization device (loudspeaker, kinescope, or the like) of substantially all variations, distortions, or interference effects traceable to variation of the transmission loss through the medium or to the addition of interfering signals which, in combination with the desired signal, may be considered as producing amplitude variation superposed on the desired signal.

What I claim is:

1. An oscillation generation system adapted to be controlled as to frequency over a range of frequencies by a control voltage of varying frequency comprising, a plurality of amplifier tube stages, coupling impedances connecting said tube stages in cascade and coupling the output of the last stage to the input of a preceding stage, and means for injecting said control voltage into said stages, the product of the coupling impedances in said stages being greater than the product of the reciprocals of the transconductances of the tubes as to its real part, while its imaginary part is small compared to its real part over a wide range of frequencies whereby said oscillation system has relatively poor frequency stability and will oscillate under control of said control voltage over a wide frequency deviation range thereof.

2. A system as recited in claim 1 wherein said system comprises two amplifier tube stages coupled by impedances as recited in claim 1 and wherein said impedances comprise inverse reactive networks.

3. A system as recited in claim 1 wherein said system comprises two amplifier tube stages coupled by impedances as recited in claim 1 and wherein one of said impedances is a series combination of an inductance and resistance and the other of said impedances is a parallel combination of a capacity and a conductance.

4. A system as recited in claim 1 wherein said system comprises two amplifier tube stages coupled by impedances, one of which comprises the series combination of an inductance and resistance, the other of which comprises the parallel combination of a capacity and a conductance and wherein the ratio of said inductance to said resistance is substantially equal to the ratio of said capacity to said conductance.

5. In a system for amplifying frequency modulations on wave energy and rejecting all other wave energy of substantially less amplitude, an oscillator comprising two electron discharge devices each having input and output electrodes, one of said devices having a control electrode, an impedance having an inductive component and a resistive component coupling the output electrodes of one of said devices to the input electrodes of the other of said devices, an impedance having a capacitive component and a conductive component connecting the output electrodes of the other of said devices to the input electrodes of said one of said devices, said oscillator having an inherently poor frequency stability means for impressing frequency modulated wave energy on said control electrode of said one of said devices and an output circuit coupled to one of said de-

vices to be excited by voltages produced by said devices.

6. An oscillator comprising a pair of electron discharge tubes each having input and output electrodes, a resistance (*r*) and inductance (L) in series between the output electrodes of one tube and the input electrodes of the other tube, and a second resistance (*s*) and condenser (C) in parallel between the input electrodes of said one tube and the output electrodes of said other tube, the values of said resistances and condensers being such that

$$\frac{L}{r}=\frac{C}{s} \text{ and } \frac{R}{s}$$

is greater than

$$\frac{1}{g1g2}$$

where *g*1 and *g*2 are the transconductances of said one and said other tube respectively and said oscillator being characterized by a relatively small frequency stability whereby oscillations will be produced over a relatively wide frequency range under control of applied frequency-variable currents.

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