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STABILIZED FREQUENCY MODULATOR

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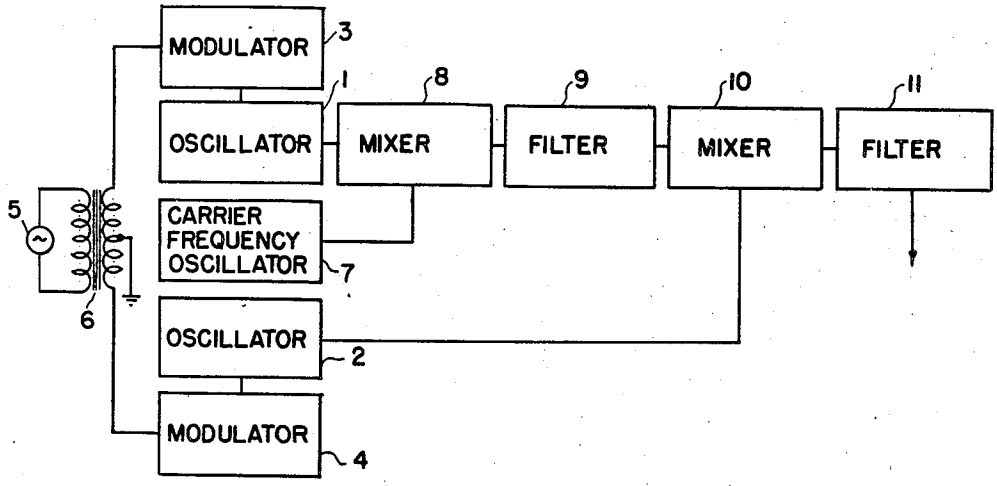


FIG. 1

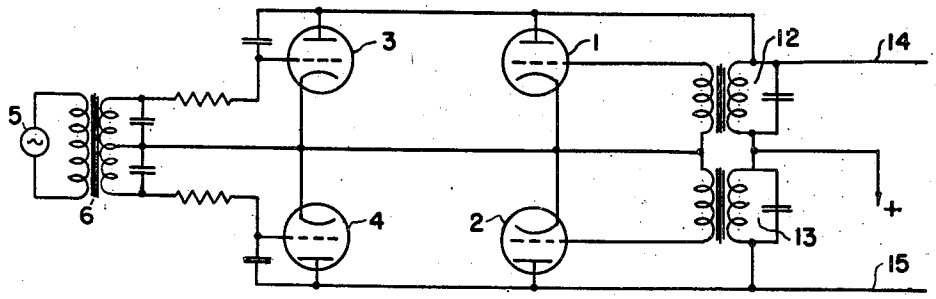


FIG. 2

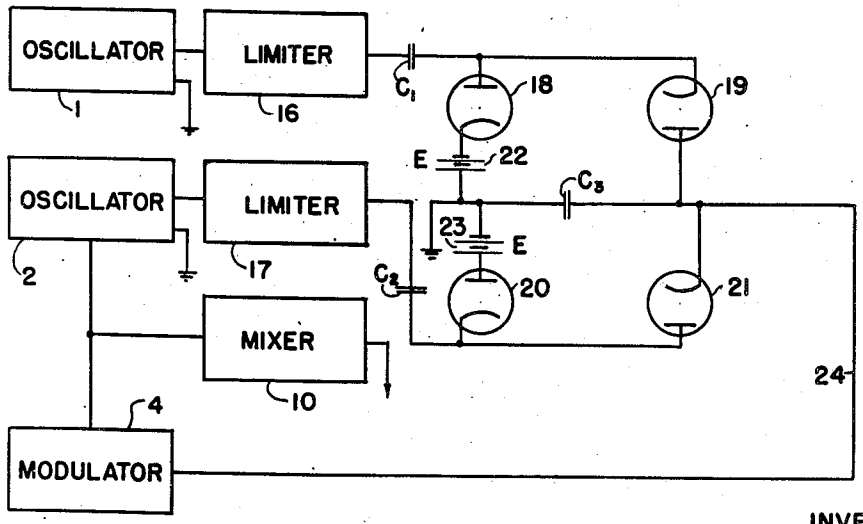


FIG. 3

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STABILIZED FREQUENCY MODULATOR

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In circuit arrangements for frequency modulating a carrier oscillation, an undesired frequency modulation can occur due to external influences. These external influences cause additional frequency modulation to the desired frequency modulated oscillations. For example, variations in temperature affect the frequency-determining oscillatory circuit of the carrier wave oscillator with the result that the frequency of the generated carrier wave varies. Variations of the supply voltages and variations of vacuum tube characteristics, as a change in mutual conductance due to ageing of the oscillator tube, bring about an undesired frequency modulation. The invention has as its object, the reduction of this phenomenon.

According to the invention, the object is achieved by a circuit arrangement in which at least one of two auxiliary carrier oscillations generated by separate oscillators is modulated by the modulating oscillations. The separate oscillators employ identical construction so that the generated frequencies are equal and are influenced to an equal extent by external influences. One of these auxiliary carrier oscillations is mixed with an oscillation of the frequency of the desired carrier oscillation and the difference and sum frequencies thus obtained are mixed respectively with the other auxiliary carrier oscillation; the frequency-modulated sum or difference frequency may then be further utilized.

The circuit arrangement according to the invention may also be such that both auxiliary carrier waves are modulated. In this case, the modulating oscillations are applied to the auxiliary carrier waves in push pull. An undesired frequency-modulation may also be developed by variations in the frequency modulator itself. For example, if the modulator employs a reactance tube, variations of the supply voltages, contact potentials, and ageing of the discharge tube are responsible for variations of the reactance presented by the tube, leading to an undesired frequency-modulation.

According to the invention, if a circuit is employed in which both auxiliary carrier oscillations are modulated by the modulating oscillations, the two frequency modulators which bring about the frequency modulation of the auxiliary carrier oscillations employ identical construction so that the external influences acting on the modulators bring about an identical undesired frequency modulation of the associated oscillator. It is found that in the frequency-modulated carrier oscillation obtained, the undesired frequency modulation will be suppressed.

In order that the invention may be readily

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understood and carried into effect it will now be described more fully with reference to the accompanying drawing, forming a part of the specification and in which:

Fig. 1 is a block diagram of a circuit arrangement according to the invention,

Fig. 2 is a schematic diagram of a circuit arrangement employed in connection with the circuit arrangement shown in Fig. 1, and

Fig. 3 is a schematic diagram of a further embodiment of the invention.

Referring to Fig. 1 of this drawing two oscillators 1 and 2 are shown, each of these generates an auxiliary carrier oscillation having the frequency f_m. These oscillations are frequency-modulated by modulators 3 and 4. The modulating oscillations received from a source 5 are supplied in push pull to the modulators through transformer 6. The instantaneous frequency changes brought about by this modulation are Δf_1 and Δf_2 respectively. The oscillations occurring in the output circuit of the oscillator 1 and 2 respectively will then have the frequency

$$f_m - \Delta f_1$$

and $f_m + \Delta f_2$. Due to the previously mentioned external effects, the frequency of the auxiliary carrier oscillations generated by the oscillators varies in frequency by amount n_1; the oscillator 2 by an amount n_2. The frequency f_1 of the oscillations in the output circuit of the oscillator 1 will then be:

$$f_1 = f_m - \Delta f_1 + n_1 \quad (1)$$

and the frequency f_2 of the oscillations in the output circuits of the oscillator 2 will be:

$$f_2 = f_m + \Delta f_2 + n_2 \quad (2)$$

According to the invention, the oscillations in the output circuit of the oscillator 1 are supplied to a mixing stage 8 together with an oscillation of the frequency f_0. f_0 is the ultimately desired carrier oscillation, and is generated by oscillator 7. This oscillator may be crystal controlled so that frequency f_0 will remain essentially constant. In the output circuit of the mixing stage 8, oscillations are developed having the sum- and difference-frequency

$$f_0 + f_1$$

and

$$f_0 - f_1$$

Of these frequencies, the difference frequency is filtered at 9, and supplied to a second mixing stage 10, together with the modulated auxiliary carrier oscillation received from the oscillator 2.

The sum frequency $f_s=f_2+f_0-f_1$, is finally supplied to a filter **11**, and further utilized. By substitution of Equations 1 and 2 above, f_s may be written in the form:

$$f_s=f_2+f_0-f_1=f_m+\Delta f_2+n_2+f_0-f_m+\Delta f_1-n_1$$
$$f_s=f_0+\Delta f_1+\Delta f_2+n_2-n_1$$

showing that the oscillation obtained is a frequency-modulated carrier wave having the desired mean frequency f_0, the instantaneous desired frequency deviation $\Delta f_1+\Delta f_2$, and an undesired frequency deviation component n_2-n_1. When both oscillators **1** and **2** employ identical construction and are influenced in a substantially identical manner by external conditions, as variations in temperature, etc.; $n_2=n_1$, and the undesired frequency deviation component is suppressed. A frequency-modulated carrier oscillation of the frequency f_0 results which has only the desired frequency modulation $\Delta f_1+\Delta f_2$. It is evident that a similar result would be obtained if only one of the two auxiliary carrier oscillations were modulated, the difference residing only in that the expression for f_s, Δf_1 or Δf_2 disappears depending on which of the two auxiliary carrier oscillations is modulated.

Fig. 2 shows the oscillator-modulator part of the circuit arrangement worked out in detail in accordance with the diagram of Fig. 1.

The oscillators are formed by feedback discharge tubes **1** and **2** whose frequency-determining oscillatory circuits **12** and **13**, tuned to the same frequency, and connected to reactance valves **3** and **4**. The modulating oscillations received from the source **5** are fed in push-pull to the reactance tubes. The frequency-modulated auxiliary carrier oscillations generated by the oscillator-modulator **1**, **3** and **2**, **4** are fed through a conductor **14**, **15** to the mixing stages **8** and **10** respectively of Fig. 1. The two mixing stages **8** and **10**, the filters **9** and **11** and the oscillator **7** are not shown in further detail in Fig. 2; the circuit arrangement of these component members is known. A circuit arrangement according to the invention in which the two auxiliary carrier oscillations are modulated in push-pull by the modulating oscillations has the property that an undesired frequency-modulation due to circuit unbalance is suppressed in the modulators themselves.

If for example the supply voltages of the reactance valves **3** and **4** in the circuit arrangement shown in Fig. 2 vary, an undesired frequency modulation m_1 or m_2 respectively of the auxiliary carrier oscillations f_m is developed. These undesired frequency modulations compensate each other in a manner similar to that described with regard to the undesired frequency modulation n_1 and n_2 in the oscillators **1** and **2** if the modulators are similarly constructed so that m_1 and m_2 are similar.

An important advantage of the circuit described by the invention resides in that the operation of the circuit is dependent of the amplitude of the two auxiliary carrier oscillations; it is only essential that the two frequencies remain identical. Even if the two oscillators generating the auxiliary carrier oscillations are constructed in an identical manner, there will always be a slight difference between the two frequencies. To reduce this difference as much as possible, use may be made of a circuit arrangement for automatic frequency control, for example a circuit as shown in Fig. 3. In this circuit arrangement, the oscillations generated by

the oscillators **1** and **2** of Fig. 1 or 2 are supplied to limiters **16** and **17**. These limiters are so adjusted that their outputs have equal amplitude. The output of limiter **16** is connected through condenser C_1 to two diodes **18**, **19** connected in opposition. The output of limiter **17** is connected through a condenser C_2 to two diodes **20** and **21** also in opposition. Each of the diodes **18** and **20** has a negative bias E, supplied by the sources of voltage **22** and **23**. The connecting point of these sources of voltage is through condenser C_3 to the junction of the diodes **19** and **21**. It may be assumed that condenser C_3 has a considerably larger magnitude than condensers C_1 and C_2.

The circuit arrangement of Fig. 3 operates as follows:

During the first half of the positive half-cycle of the output voltage of limiter **16**, condenser C_1 is charged through diode **18**. During the second half of the positive half-cycle and the first half of the following negative half-cycle, C_1 becomes discharged through diode **19** and condenser C_3, imparting a charge to C_3. This is repeated during each subsequent cycle, increasing the charge upon condenser C_3. The charge on condenser C_3 per unit of time is proportional to the frequency of the output voltage of the limiter **16**; thus it is proportional to the frequency of the oscillator **1**. In exactly the same manner, an opposite charge is developed across condenser C_3 by the output voltage of the limiter **17**; since the output voltage of the limiter **17** charges condenser C_2 through the diode **20** and C_2 discharges through the diode **21** and the condenser C_3. The charge transferred thusly to condenser C_3 per time unit, is proportional to the frequency of the oscillator **2**. The charging current of C_3 through diode **19** is opposed to the charging current of C_3 through diode **21**; the condenser C_3 remains without voltage when the charge received per time unit through the diode **19** is equal to the charge dissipated per time unit via the diode **21**, when the frequencies of the oscillators **1** and **2** are equal. If the oscillator frequencies differ, a positive or negative voltage is developed across C_3 as the frequency of the oscillator **1** differs from the frequency of the oscillator **2**. This voltage is supplied through conductor **24** to the modulator **4**, for example which controls the frequency of the oscillator **2** to conform to the frequency of oscillator **1**.

What I claim is:

1. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier wave frequency, means to generate a first auxiliary oscillation of predetermined frequency, means to generate a second auxiliary oscillation of said predetermined frequency, said first auxiliary oscillation and said second auxiliary oscillation generating means being subject to the same extraneous influences tending undesirably to vary the frequency of said first and said second auxiliary oscillations, means to combine a modulating oscillation with one of said auxiliary oscillations to produce a frequency-modulated auxiliary oscillation, means to mix said pilot oscillation and said frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation having difference sideband fre-

quencies only, means to mix said derived resultant frequency-modulated carrier oscillation with the other of said auxiliary oscillations to produce a frequency-modulated carrier oscillation of sum and difference sideband frequencies, and means to filter said frequency-modulated carrier oscillation to derive a frequency-modulated oscillation of one sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

2. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier frequency, means to generate a first auxiliary oscillation of predetermined frequency, means to generate a second auxiliary oscillation of said predetermined frequency, said first auxiliary oscillation and said second auxiliary oscillation generating means being subject to the same extraneous influences tending undesirably to vary the frequency of said first and said second auxiliary oscillations, means to combine a modulating oscillation with said first and said second auxiliary oscillations to produce a first frequency-modulated auxiliary oscillation of different frequency and a second frequency-modulated auxiliary oscillation of sum frequency, means to mix said pilot oscillation and said first frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter said resultant frequency-modulated carrier oscillation to derive a resultant frequency-modulated carrier oscillation having difference sideband frequencies only, means to mix said derived resultant frequency-modulated carrier oscillation with said second frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, and means to filter said resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation of sum sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

3. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier frequency, means to generate a first auxiliary oscillation of predetermined frequency, means to generate a second auxiliary oscillation of said predetermined frequency, said first auxiliary oscillation and said second auxiliary oscillation generating means being identical in construction and subject to the same extraneous influences tending undesirably to vary the frequency of said first and said second auxiliary oscillations, means to combine a modulating oscillation with said first and said second auxiliary oscillations to produce a first frequency-modulated auxiliary oscillation of difference frequency and a second frequency-modulated auxiliary oscillation of sum frequency, means to mix said pilot oscillation and said first frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter said resultant frequency-modulated carrier oscillation to derive a resultant frequency-modulated carrier oscillation having difference sideband frequencies only, means to mix said derived resultant frequency-modulated carrier oscillation with said second frequency-modulated auxiliary oscillation to produce a resultant

frequency-modulated carrier oscillation having sum and difference sideband frequencies, and means to filter said resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation of sum sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

4. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier frequency, means to generate a first auxiliary oscillation of predetermined frequency, means to generate a second auxiliary oscillation of said predetermined frequency, said first auxiliary oscillation and said second auxiliary oscillation generating means being subject to the same extraneous influences tending undesirably to vary the frequency of said first and said second auxiliary oscillations, an automatic frequency control circuit to maintain the frequencies of said first and said second auxiliary oscillations substantially equal, means to combine a modulating oscillation with said first and said second auxiliary oscillations to produce a first frequency-modulated auxiliary oscillation of difference frequency and a second frequency-modulated auxiliary oscillation of sum frequency, means to mix said pilot oscillation and said first frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter said resultant frequency-modulated carrier oscillation to derive a resultant frequency-modulated carrier oscillation having difference sideband frequencies only, means to mix said derived resultant frequency-modulated carrier oscillation with said second frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, and means to filter said resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation of sum sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

5. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier wave frequency, a first oscillator to generate a first auxiliary oscillation of predetermined frequency, a second oscillator to generate a second auxiliary oscillation of said predetermined frequency, said first and said second oscillators being identical in construction and being subject to the same extraneous influences tending to vary the frequencies produced therein undesirably, a first reactance tube circuit coupled to said first oscillator, a second reactance tube circuit coupled to said second oscillator, means to apply modulating oscillations to said reactance tubes in push-pull relationship to produce a first frequency-modulated auxiliary oscillation of difference frequency and a second frequency-modulated auxiliary oscillation of sum frequency, means to mix said pilot oscillation and said first frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter said resultant frequency-modulated carrier oscillation to derive a resultant frequency-modulated carrier oscillation having difference sideband frequencies only, means to mix said derived resultant fre-

quency-modulated carrier oscillation with said second frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, and means to filter said resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation of sum sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

6. A circuit arrangement for frequency-modulating a given stable oscillation of carrier frequency, comprising means to generate a stable pilot oscillation of carrier wave frequency, a first oscillator to generate a first auxiliary oscillation of predetermined frequency, a second oscillator to generate a second auxiliary oscillation of said predetermined frequency, said first and said second oscillators being identical in construction and being subject to the same extraneous influences tending to vary the frequencies produced therein undesirably, a first reactance tube circuit coupled to said first oscillator, a second reactance tube circuit coupled to said second oscillator, a frequency control circuit comprising a first amplitude limiter coupled to said first oscillator, a second amplitude limiter coupled to said second oscillator and being adjusted to limit the amplitude value of said second auxiliary oscillation to the amplitude value of said first auxiliary oscillation, a first diode having the anode thereof capacitively coupled to said first limiter, a second diode having the cathode thereof connected to the anode of said first diode, a third diode having the cathode thereof capacitively coupled to said second limiter, a fourth diode having the anode thereof connected to the cathode of said third diode and the cathode thereof connected to the

anode of said second diode and to said second reactance tube circuit, means to apply negative bias to said first diode, means to apply negative bias to said third diode and a capacitor coupling the cathode of said first diode and the anode of said third diode to the anode of said second diode and the cathode of said fourth diode whereby the frequency of said first oscillator is maintained substantially equal to that of said second oscillator, means to mix said pilot oscillation and said first frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, means to filter said resultant frequency-modulated carrier oscillation to derive a resultant frequency-modulated carrier oscillation having difference sideband frequencies only, means to mix said derived resultant frequency-modulated carrier oscillation with said second frequency-modulated auxiliary oscillation to produce a resultant frequency-modulated carrier oscillation having sum and difference sideband frequencies, and means to filter said resultant frequency-modulated carrier oscillation to derive a frequency-modulated carrier oscillation of sum sideband frequency only whereby said first and said second auxiliary oscillations having undesirable frequency variations are suppressed.

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