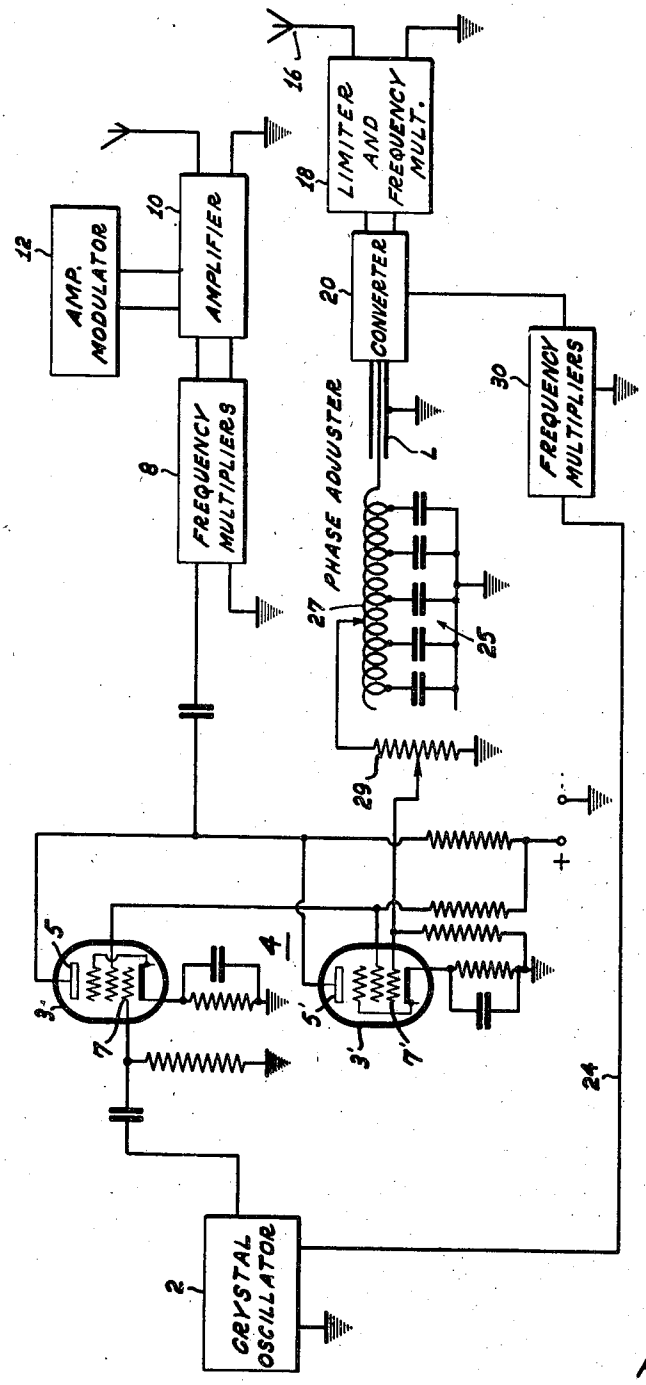
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STABILIZED OSCILLATORY SYSTEM

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INVENTOR.
H. E. GOLDSTINE
BY H. E. Goldstine
ATTORNEY.

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STABILIZED OSCILLATORY SYSTEM

Hallan E. Goldstine, Rocky Point, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

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This application concerns radio signalling systems and similar systems wherein there is need of oscillatory energy of a phase and frequency which does not materially vary in an undesired manner.

For example, in present day transmitters a substantially constant source of oscillations, such as a crystal oscillator, supplies a fundamental frequency which is used directly or multiplied in frequency as the carrier of the signals which may be code, or telephony, or pictures, etc. In passing from the crystal source to the point at which modulation or transmission takes place the phase may be modulated in an undesired manner by non-linearity in the system. For example, such undesired phase modulation might very well result from non-linear operation of electron discharge devices in conjunction with circuit reactances in frequency multiplier or amplifier stages.

A primary object of my invention is reduction of undesired phase or frequency modulation of currents used in signalling and similar systems wherein it is desired that the currents be of substantially constant phase.

Briefly, this object is attained in accordance with my invention by taking energy, of say the crystal frequency F_0, from the system at a point following the point at which the undesired phase or frequency modulations $K\phi$ are produced, say after the current of frequency F_0 and undesired deviation $K\phi$ has been multiplied N times and supplying the same to a mixer or converter, also supplied with oscillatory energy F_0 (taken more directly over a separate path) from the crystal which energy is multiplied by a factor N+1. The difference frequency equal to $F_0-NK\phi$ (where ϕ represents the undesired phase modulation) is taken from the converter and added (algebraically) to the crystal output of frequency F_0 fed to the multipliers in a stage preceding the multipliers and in proper phase relation to reduce the undesired phase or frequency deviation.

Other objects and the manner in which the same are attained will appear from the detailed description which follows. In this description reference will be made to the attached drawing, wherein the single figure is a circuit diagram showing the essential features of a signalling system arranged in accordance with my invention and including my improved means for reducing undesired phase deviation in alternating current. The invention is of wide application and the embodiment is illustrative, although it discloses a practical signalling system.

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In the figure, 2 is a source of oscillations of substantially constant frequency, for example, a crystal oscillator. 4 designates in general an amplifier or repeater arrangement feeding oscillatory energy from the crystal to the frequency multiplier stages at 8. The amplifier or repeater 4 will be described in greater detail hereinafter. The frequency multiplied oscillations from 8 are supplied to an amplifier 10 and then used. In the amplifier 10, the oscillatory energy of multiplied frequency may be modulated by signals as desired. For purposes of illustration, I have shown an amplitude modulator 12 coupled to the amplifier 10.

Some of the carrier current, say for example, the carrier current of multiplied frequency, is taken from a stage following the frequency multipliers, as for example, by lines from 10 or picked up by an aerial system 16 and supplied to a converter 20. If we say the crystal oscillator frequency is F_0 and the undesired phase deviation takes place at this frequency, then we may consider that the aerial 16 picks up and supplies to the limiter and if desired frequency multiplier 18 and to converter 20, current of a frequency $N(F_0+K\phi)$, where N is the factor of frequency multiplication and $K\phi$ represents the undesired phase deviation of the current of frequency F_0.

The crystal oscillator also supplies by line 24 oscillations of the fundamental frequency F_0 to a frequency multiplier 30 and from the frequency multiplier 30 to the converter 20. In the example given, the frequency multipliers in 30 should preferably have a multiplication factor of N+1, so that this multiplier 30 supplies to the converter 20 current of a frequency $(N+1)F_0$.

In order to compress or reduce the undesired phase or frequency deviations the difference frequency is taken at the output of 20 and in the example given, this difference frequency is equal to $F_0-KN\phi$. This difference frequency is then supplied by way of lines or other means described in detail hereinafter to the amplifier 4, wherein it is combined with the original crystal oscillator energy and fed to the frequency multipliers in 8.

The amplifier in 4, as stated above, may take many forms, the essential feature being that the R. F. output is a function of the R. F. grid excitation. In other words, the R. F. output is to be proportional to the R. F. input. In the embodiment illustrated, the amplifier 4 comprises a pair of pentodes 3 and 3'. Pentode tubes are used as an example because the screen grids therein insures that there is little reaction of the plate circuit on the control grids. The anodes

5 and 5' of these two tubes are tied together and coupled to the frequency multiplier 8.

The control grid 7 of tube 3 is coupled to the crystal oscillator 2. The control grid 7' of tube 3' is coupled by way of a phase adjuster to the converter 20. The electrodes of these tubes are supplied with operating potentials by the means shown schematically and a description of the same is believed unnecessary. The essential requirement of these amplifiers has been given above, and it is noted that amplifiers operating Class C are satisfactory.

The combining of the output of 2 and the output of the converter 20 in the amplifier 4 is not a mixing or converting action. The two currents are combined in the proper phase so that they produce a resultant substantially of the frequency F_0 and of a phase and frequency which tend to compensate or wipe out the undesired phase or frequency modulation produced in the circuits following the amplifier 4.

In a practical arrangement the proper phase of the current fed to tube 3' as a consequence of the resultant supplied to the multiplier 8 may be obtained by lines of adjustable length coupling the converter 20 to the control grid 7' of tube 3'. Reactance networks or an R and C network may be used here. For purposes of illustration, I have shown the converter 20 as feeding a phase adjuster 25 of a conventional type. The lines L may also serve as phase shifters and are considered in adjusting the tap on the inductance 27. The phase or frequency reduction or correction depends in part on the phase relation of the currents combined in the outputs of tubes 3 and 3'.

The amount of phase correction also depends in part on the relative amplitude of the currents supplied to tubes 3 and 3' of the amplifier 4. A means for adjusting the amplitude of the current from 20 is a potentiometer 29, a point of which is connected to the grid 7'.

Relatively changing the phases or the amplitudes of the voltages or currents from converter 20 and source 2 in the amplifier 3 changes the phase of the voltage or current in the multipliers 8 and following stages. Increasing the amplitude of the current out of converter 20 causes the phase of the resultant current to swing toward the phase of the current supplied from the converter 20 through the phase shifter to tube 3'.

Thus by adjustment of the phase and the amplitude or one thereof of the voltage or current supplied by the feedback connection, compensation, as described in detail above, is made in such a manner that undesired phase swings of the current supplied to multipliers 8 and following stages are reduced as much as necessary.

Adjustment of the relative amplitudes of the currents selected out of the source 2 and the converter 20 provides a means for adjusting the amount of undesired phase or frequency compensation which takes place. The amplitude of the current out of 20 is adjusted by the potentiometer 29. Similar means may be used in unit 2 to adjust the amplitude of the current supplied from this source. Adjustment of the current amplitudes may be made also by adjusting the gains of the tubes 3 and 3'. As the feedback R. F. is reduced the phase correction is reduced.

In practice the output of the system is put on a phase modulation or frequency modulation receiver and the adjustments described above or one thereof at the transmitter is used to derive

zero or minimum deviation as indicated by the receiver output.

The source of oscillations of constant frequency at 2 may be a crystal oscillator or an oscillator of any type which provides oscillations of substantially fixed frequency. The unit 2 may also include frequency multipliers.

The frequency multipliers at 8, 18 and 30 may be of any conventional approved type and since frequency multipliers are so well known in the art no description of the operation of the same will be given here. The same may be said of the limiter in 18.

The converter at 20 likewise may be of any conventional approved type. Since the arrangement and operation of converters is very well known in the art, a detailed description thereof will not be given herein.

The amplifier and amplitude modulator likewise may be conventional circuit arrangements. Moreover, as stated above, other types of modulation and various types of signals may be used here.

I claim:

1. The method of producing oscillatory energy of substantially fixed phase and frequency and of carrier wave frequency which includes these steps, generating oscillatory energy of substantially fixed frequency, multiplying the frequency of said generated oscillatory energy to obtain oscillator energy of carrier wave frequency the phase of which may vary in an undesired manner, selecting a portion of the frequency multiplied oscillatory energy, multiplying the frequency of another portion of the generated oscillatory energy of substantially fixed frequency by a multiplication factor differing from the multiplication factor of said first multiplying step by one, mixing the last mentioned frequency multiplied oscillatory energy with said selected portion of the frequency multiplied oscillatory energy to derive oscillatory energy of the difference frequency wherein any phase variations are also multiplied, adding the derived oscillatory energy and the generated oscillatory energy algebraically, and adjusting the phase of the derived oscillatory energy to a value such that it neutralizes and cancels phase variations in said first mentioned frequency multiplied oscillatory energy.

2. In a carrier frequency wave energy generating and wave energy frequency stabilizing system, a source of wave energy of substantially fixed frequency, an output circuit, an amplifier stage having input electrodes excited by said wave energy and having output electrodes, a frequency multiplier coupling the output electrodes of said amplifier to said output circuit to supply wave energy of multiplied frequency to said output circuit which wave energy may vary in phase in an undesired manner, a converter stage excited by the output of said frequency multiplier, a second frequency multiplier having a multiplication factor differing from the multiplication factor of said first frequency multiplier by one, coupling said source of wave energy to said converter, and an amplitude adjuster and phase shifter coupling said converter to said first mentioned frequency multiplier.

3. In a carrier frequency wave energy generating and wave energy frequency stabilizing system, a source of wave energy of substantially fixed frequency, an output circuit, a first tube amplifier having input electrodes excited by said wave energy and having output electrodes, a frequency

multiplier coupling the output electrodes of said amplifier to said output circuit to supply wave energy of multiplied frequency to said output circuit which wave energy may be varied in phase in an undesired manner, a converter stage excited by the output of said frequency multiplier, a second frequency multiplier having a multiplication factor differing from the multiplication factor of said first frequency multiplier by one, coupling said source of wave energy to said converter, a second amplifier tube having input electrodes and having output electrodes coupled in parallel with the output electrodes of said first tube amplifier, and a phase shifter coupling said converter to the input electrodes of said second amplifier tube.

4. A system as recited in claim 3, wherein a potentiometer is included in the coupling between the phase shifter and the input electrodes of the second amplifier tube.

HALLAN E. GOLDSTINE.

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