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FREQUENCY CONTROL SYSTEM

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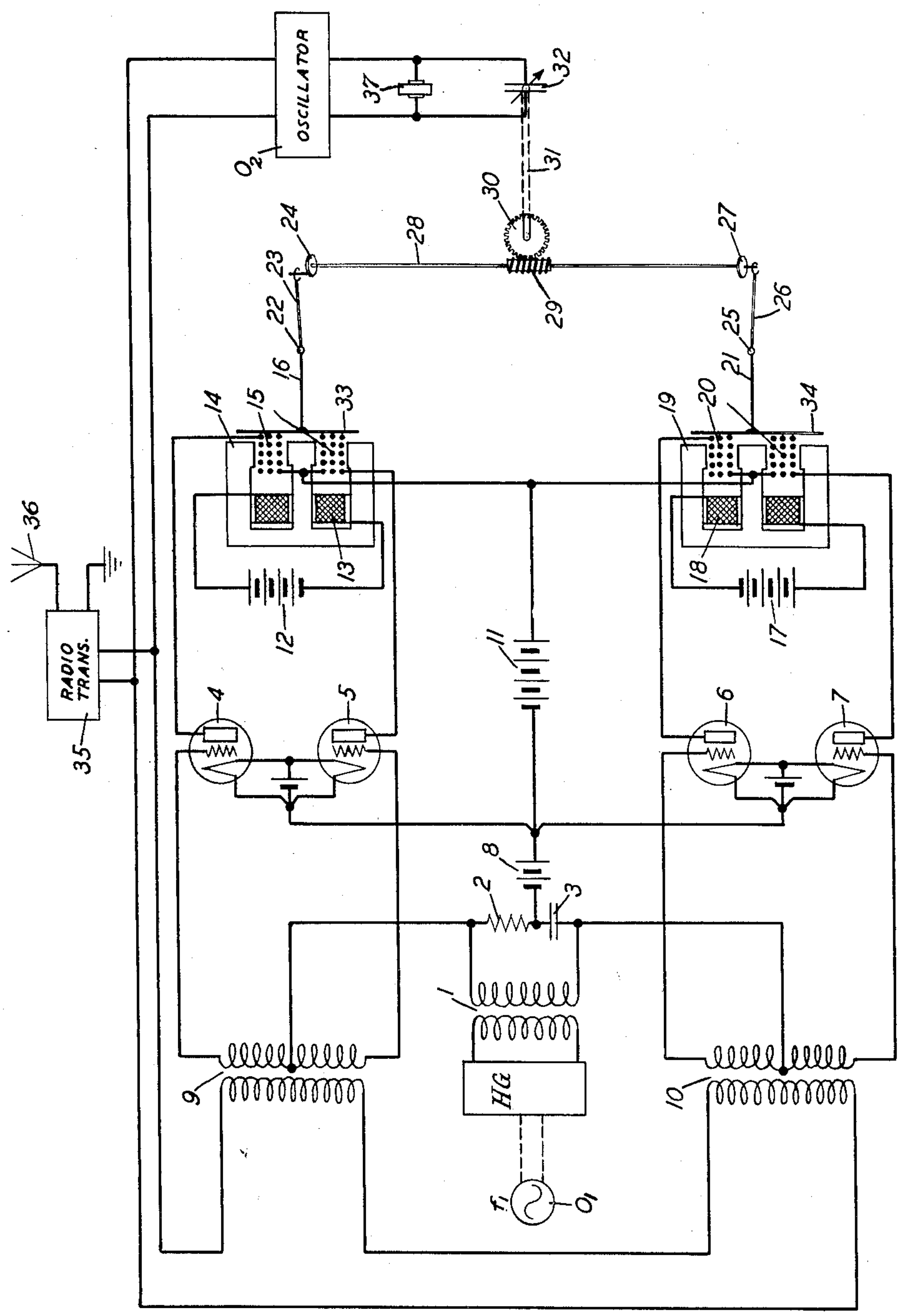

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FREQUENCY CONTROL SYSTEM

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2 Claims. (Cl. 250—36)

This invention relates to an arrangement for determining the frequency of a local source of current by means of a master source, the waves from which may be transmitted over a transmission circuit or other transmission medium. Such an arrangement has application in connection with the synchronization of different radio stations and the like.

In connection with radio and telephone work many cases arise where it is desirable to maintain a secondary standard oscillator at exactly the same frequency as a standard primary or control source. This is desirable for example in the case of synchronizing broadcasting transmitters and in the case of single sideband receiving of short wave signals where the local carrier wave must be equal in frequency to the incoming carrier wave.

In accordance with the present invention an automatic device for accomplishing this result is provided which involves the use of a split-phase double balanced modulator operating a synchronous motor which in turn operates the adjusting means of the control source. The apparatus is of such a nature that it is adapted to be used for holding in synchronism two oscillators operating at any closely adjacent frequencies.

The single figure of the drawing is a schematic circuit diagram showing the device of the invention.

A source of oscillations O_1 having a frequency f_1 may be taken to represent an incoming controlling wave which may be a low frequency wave received over wire lines or a wave of the same frequency as that to be controlled. In the latter event, of course, no harmonic generator is used. In case f_1 is a low frequency, a harmonic generator HG of any well known type is used to step up the frequency to that of the wave to be controlled. The incoming wave from source O_1 is supplied to the split-phase double balanced modulator through a transformer 1. Resistance 2 and condenser 3 constitute a phase splitting device so that the controlling wave is applied to the balanced modulator comprising vacuum tubes 4, 5 and associated circuits in ninety degrees phase difference from the phase in which it is applied to the balanced modulator comprising vacuum tubes 6, 7 and associated circuits. A source 8 of unidirectional current serves to negatively bias the grids of all four of the modulator tubes.

A wave is generated locally in the crystal controlled oscillator circuit O_2. This oscillator is used to supply carrier frequency waves to the radio transmitter 35 which is associated with antenna 36. A component of this locally generated wave is applied to the split-phase double balanced modulator through transformers 9 and 10. A source 11 of unidirectional current is in the common plate circuit of all four modulator tubes and supplies plate current for the modulator. The split-phase double balanced modulator is disclosed in my Patent 1,762,725, issued June 10, 1930.

In the output of the balanced modulator 4, 5 is a driving unit which may be an ordinary moving coil loud speaker unit or any similar device. A source 12 supplies polarizing current for this unit through coils 13 which are wound around the core 14 of magnetic material. Moving coils 15 are in the plate circuit of the two tubes 4, 5 and the junction point of these coils is connected to the common space current source 11. When the controlling and controlled waves are of different frequencies, a difference frequency wave will be produced in the moving coil. There will accordingly take place reciprocating rectilinear motion of a shaft or piston rod 16 which is attached to the diaphragm 33 secured to the moving coils 15.

A similar unit is associated with the output circuit of the modulator 6, 7. A source 17 supplies polarizing current to coil 18 around a core 19 of magnetic material. Moving coils 20 are connected in the plate circuits of the tubes and the junction point of these coils is connected to the source 11. A driving shaft or piston rod 21, attached to moving coil 20 through diaphragm 34, is likewise driven in reciprocating rectilinear motion by this unit.

Due to the fact that the controlling wave is applied to the two modulator circuits in quadrature, the two piston rods 16 and 21 will be ninety degrees out of phase in their motion and one will lead the other depending on which of the two input frequencies is higher. That is, if the frequency of the locally generated or controlled wave is higher than the controlling wave, the piston rod 16 will lead the piston rod 21 by ninety degrees, while if the controlled wave is two cycles lower in frequency than the controlling wave, the piston rod 21 will lead the piston rod 16 by ninety degrees. It will be seen that the two moving coil units operate as a two cylinder engine and may be utilized to produce curvilinear motion in the usual manner. It will also be seen that the curvilinear motion may be directed in either direction by making one of the waves higher or lower than the other in frequency.

Piston rod 16 is connected through a wrist pin 22 to connecting rod 23 which drives a crank wheel 24. Piston rod 21 is connected through a wrist pin 25 to a connecting rod 26 which drives a crank wheel 27. Connecting rods 23 and 26 are connected to crank wheels 24 and 27 ninety degrees apart so that the curvilinear motion may be obtained. A shaft 28 connects the driven crank wheels 24 and 27 and has thereon a worm 29 adapted to mesh with worm gear 30 and thus rotate shaft 31 which varies the capacity of condenser 32 connected in parallel with the crystal 37 which controls the frequency of the crystal oscillator O_2.

Now assume that the crystal oscillator is to be maintained at a frequency of 500 kilocycles and that the incoming controlling wave of frequency f_1 is a wave of 4,000 cycles. The incoming wave is stepped up in frequency to 500 kilocycles by harmonic generator HG and since the wave frequency f_1 is maintained precisely at 4,000 cycles at the station where it is generated, the wave of 500 kilocycles derived from HG will also be precisely maintained at a frequency of 500 kilocycles. If the crystal oscillator O_2 shifts its frequency so that it is two cycles higher than 500 kilocycles, a wave of two cycles will be produced in the output circuits of each of the two tube modulators and the shaft 28, worm 29, worm gear 30, and shaft 31 will be rotated in such a direction as to increase the capacity of the condenser 32 connected across the crystal, and thus decrease the frequency of the crystal oscillator O_2 and bring it back to precisely 500 kilocycles. When this point is reached the difference frequency will be zero and no further torque will be applied to the condenser, and no further adjustment made, so that the crystal oscillator will remain at this frequency. If the crystal oscillator shifts its frequency so that it is two cycles lower than 500 kilocycles, an output wave of two cycles frequency will be produced in the outputs of the two modulators, but this will tend to rotate the shaft 28 in the opposite direction and hence adjust the condenser so as to reduce its capacity and increase the frequency of the crystal oscillator. It will thus be seen that the crystal oscillator is maintained precisely on its correct carrier frequency.

What is claimed is:

1. In a frequency control system, means for supplying a controlling wave, means for generating a controlled wave comprising a frequency determining reactance device, means for translating, without frequency change, one of said waves into a plurality of components differing in phase, independent means for combining each of said components with a portion of the untranslated wave to thereby produce beat frequency waves corresponding in number to the number of said components and correspondingly differing in phase, mechanical means for actuating said frequency determining reactance device, and means responsive independently to each of said beat frequency waves coactuating said mechanical means whereby to adjust the frequency of the controlled wave to equality with the frequency of said controlling wave and to stabilize it at such frequency.

2. The system of the preceding claim in which said mechanical means is a rotatable element and said responsive actuating means therefor comprises, a reciprocating motor adapted to be actuated by each said beat frequency wave, connecting rods actuated by said motors and a crank means integral with said rotatable element and connected to said connecting rods so that said rods have angular displacements corresponding to the corresponding phase relations of movement of said rods which in turn are functions of the relative phases of said beat frequency waves.

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