

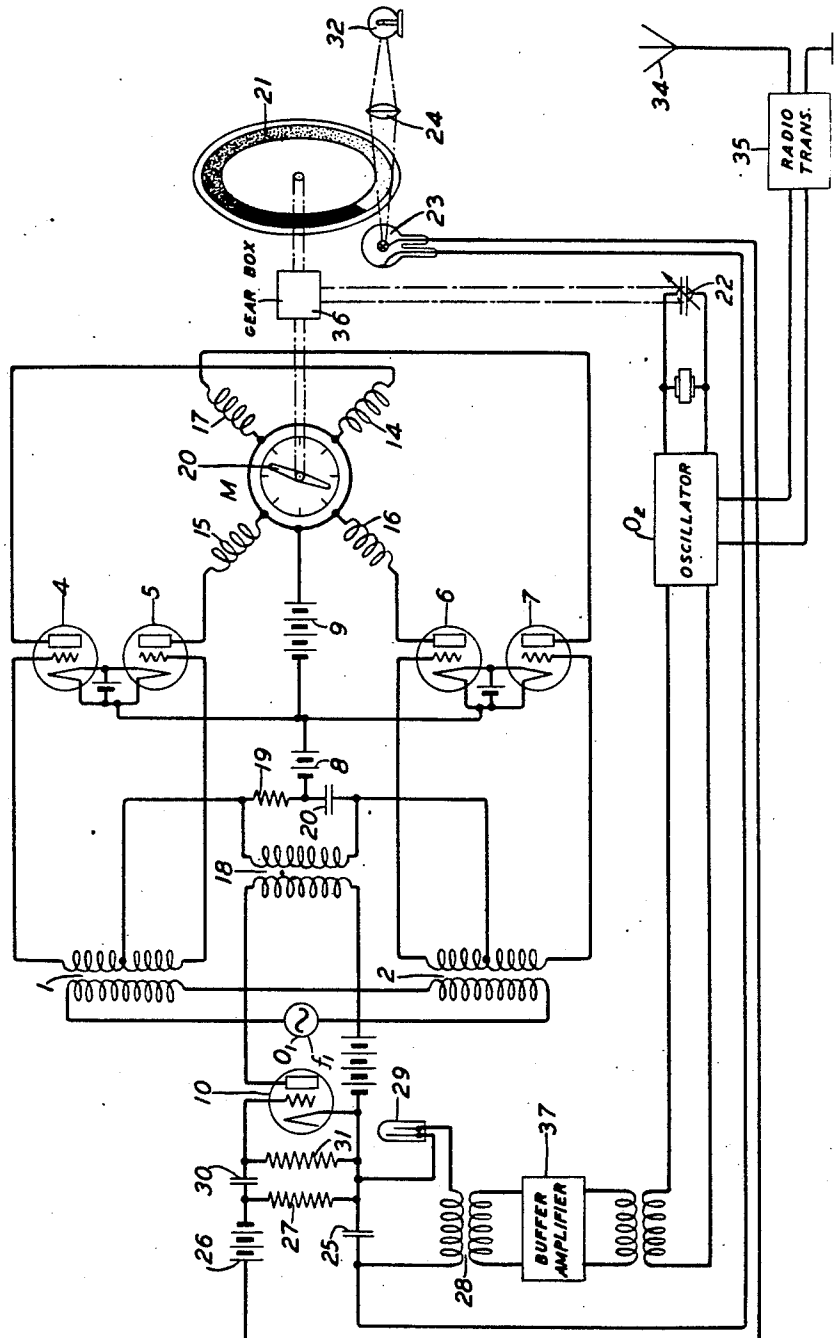
Nov. 7, 1933.

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1,934,400

FREQUENCY CONTROL SYSTEM

Filed Sept. 30, 1931



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1,934,400

FREQUENCY CONTROL SYSTEM

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Application September 30, 1931
Serial No. 565,984

2 Claims. (Cl. 250-36)

This invention relates to frequency control systems, and more particularly to frequency control in common frequency broadcasting systems.

The object of the invention is to provide means for controlling the frequency of the locally generated oscillations at a plurality of radio broadcasting stations so that they will be in synchronism.

A feature of the invention is the provision of means for controlling the frequency of the locally generated oscillations by an incoming standard frequency wave, and of continuing the generation of local oscillations of carrier frequency during an interval when the incoming standard frequency wave is not effective.

Another feature of the invention is the provision of means for increasing or decreasing the frequency of the locally generated oscillations to correct for deviations below or above the proper carrier frequency of the system of the standard frequency wave.

In the system described herein an incoming wave, which may be transmitted over wire lines if desired, and may therefore be of low frequency, is applied to the input terminals of a split-phase double balanced modulator. A component of locally generated oscillations is fed to a frequency divider which divides the frequency to reduce it to that of the incoming standard frequency wave and applies the divided frequency differentially to the split-phase double balanced modulator. A synchroscope or motor in the output of the modulator turns a disc of varying opacity, which is interposed between a light source and a photoelectric cell to vary the amount of light falling on the cell with angular movement of the disc. The photoelectric cell thus controlled is in the circuit of a relaxation oscillator to which a component of the locally generated oscillations is applied, and which acts as a frequency divider. The low frequency wave obtained from the frequency divider is applied differentially to the input of the split-phase double balanced modulator, so that a variation of this frequency will cause rotation of the motor and rotate the disc. This varies the constants of the relaxation oscillator and corrects for phase differences. The motor also varies the capacity of a condenser in parallel to the crystal in the local crystal oscillator and corrects the frequency.

In the drawing the single figure is a circuit diagram of the device of the invention.

A source of incoming waves of frequency f_1 is represented at O_1 and as before mentioned this frequency may be a low frequency of waves which

arrive over wire lines. In a preferred embodiment it is a 4,000 cycle wave. This wave is applied through transformers 1, 2 to the vacuum tubes 4, 5, 6, 7 which with their associated circuits constitute the split-phase double balanced modulator. The grids of these tubes are negatively biased with respect to their cathodes by a battery 8. Plate current for these tubes is obtained from a unidirectional current source 9. The plate circuits of the tubes 4, 5, 6 and 7 respectively traverse windings 14, 15, 16 and 17 of a motor or synchroscope M and pass by way of source 9 to the respective cathode filaments. Another wave which is derived from a local crystal controlled oscillator O_2 is applied to the modulator from amplifier 10. The wave from amplifier 10 is impressed by transformer 18 on the grid circuits of the modulator tubes. Resistance 19 and condenser 20 which are associated in series and are connected to form a shunt path across the secondary winding of transformer 18 constitute a phase splitting device so that the wave from amplifier 10 is applied to modulator tubes 4, 5 in 90° phase displacement from the phase which is applied to tubes 6, 7. The waves from the two sources O_1 and O_2 are practically identical in frequency, that is, they will not vary in frequency more than approximately 30 cycles per second. A wave of this difference frequency is produced in the output circuit of the modulator. Coils 14 and 15 are coaxial and are arranged at right angles to coils 16 and 17 which are also coaxial. If frequency f_1 is slightly higher than the frequency of the oscillations which oscillator O_2 supplies to the transformer 18, a rotating field will be set up which will rotate in one direction, while if the frequency f_1 is slightly lower than the frequency of the oscillations supplied to transformer 18, a rotating field will be set up which will rotate in the opposite direction. The rotor 20 of the motor M will be caused to rotate correspondingly and will, through the gears in the gear box 36, rotate the disc 21 and operate a variable member of the variable condenser 22 to change the effective capacity of the condenser. The operation of a split-phase double balanced modulator is disclosed in U. S. Patent 1,762,725, issued June 10, 1930, to W. A. Harrison.

Disc 21 which is of varying opacity, is interposed between a source of light 32 and a photoelectric cell 23 on which light from the source is focused by means of lens 24 so that rotation of the disc will vary the amount of light falling on the photoelectric cell. This will vary the resist-

ance of the cell and change the rate of charging of a condenser 25 by means of a battery 26. A resistance 27 is connected between battery 26 and condenser 25, and across condenser 25 is connected a shunt path comprising the secondary winding of a transformer 28 and a neon tube 29 in series. Resistance 27, battery 26, photoelectric cell 23, secondary of transformer 28, neon tube 29 and condenser 25 constitute a relaxation oscillator. If operated alone, condenser 25 would be gradually charged through the resistance of photoelectric cell 23 until the breakdown point of tube 29 is reached, at which time the condenser 25 would be discharged through it until the energy accumulated therein had been dissipated. The tube 29 would then again become non-conducting and condenser 25 would again begin to charge. In the system shown the crystal controlled oscillator O_2 is applying oscillations to the circuit of the relaxation oscillator through the buffer amplifier 37 of the usual three-element thermionic type and the primary of transformer 28. The relaxation oscillator is connected through condenser 30 and resistance 31 through the input circuit of amplifier 10. The circuit constants are adjusted so that the oscillations in the crystal oscillator are not of sufficient magnitude to break down the neon tube 29, but with an increase of the potential on the condenser 25, a point is eventually reached where the neon tube will break down with one of the waves from the crystal oscillator. The break-down will recur cyclically at some submultiple of the crystal frequency and at a phase dependent upon the constants of the circuit. This phase is in turn dependent upon the transparency of the disc 21 which is controlled by the output of the modulator circuit. The frequency of the oscillations produced by crystal controlled oscillator O_2 is controlled by the condenser 22 which is connected in parallel with the crystal, and the crystal oscillator O_2 supplies carrier frequency oscillations to the radio broadcast transmitter 35 which is connected to the circuit of antenna 34 for broadcasting.

Let it be assumed that the frequency f_1 represents an incoming standard frequency wave of 4,000 cycles, and that it is desired to control the carrier broadcast frequency of the station at 800 kilocycles. The crystal oscillator O_2 will then be generating a wave of 800 kilocycles, plus or minus small deviations, and will be operating as a master oscillator to control the carrier frequency of the radio transmitter 35 in the usual manner. The relaxation oscillator will be adjusted to operate on the 200th submultiple (two or more relaxation oscillators may be used and the frequency division accomplished in several steps, if desired) and so long as the crystal oscillator frequency is exactly 800 kilocycles, it will deliver a wave to the modulator circuit of 4,000 cycles.

If the crystal oscillator frequency increases by 20 cycles, the frequency of the output waves of the relaxation oscillator will increase by two tenths of a cycle, and the modulator output will contain a wave of two tenths of a cycle frequency. This will set up a rotating field in the stator of the motor at this frequency, and cause the rotor to turn and increase the capacity of the condenser connected across the crystal. This

will reduce the crystal oscillator frequency to 800 kilocycles. The rotor will also rotate the disc 21 and decrease the light which reaches the photoelectric cell, thus increasing the resistance of the cell in the circuit of the relaxation oscillator so that the neon tube will break down in the proper phase with each 200th cycle of the wave from the crystal oscillator.

If the crystal oscillator frequency decreases by 20 cycles, the operation will be the same except that the stator field will rotate in the opposite direction, and turn the rotor to make the proper correction.

The disc, light source, lens and photoelectric cell may be omitted from the system described by substituting for the photoelectric cell a variable resistance arranged to be controlled by the gears of gear box 36.

What is claimed is:

1. In a frequency control system, means for supplying a controlling wave, means for generating a controlled wave, means for combining said waves to produce a magnetic field which rotates at a rate proportional to the difference between the frequencies of said waves, rotor means responsive to the rate of rotation of said magnetic field and therefore to said different frequency, and means responsive to said rotor means for adjusting both the frequency and the phase of the controlled wave.

2. In a radio frequency control system, means for supplying a controlling wave of relatively low frequency, means for generating a controlled wave of relatively high frequency, means for deriving the relatively low frequency wave from said relatively high frequency wave, means for translating one of said low frequency waves, without change of frequency, into two components separated in phase by 90° , a push-pull modulator having a pair of input circuits and a pair of output circuits, means to apply one of said component waves and the untranslated low frequency wave to said input circuits so that one of the waves will be applied in opposite phase with respect to the two input circuits and the other wave will be applied to both input circuits in the same phase relation, a differential coil having windings in the output circuits of said push-pull modulator, a second push-pull modulator similar to the first mentioned and similarly adapted to combine the said untranslated low frequency wave with the other of the two component waves, a differential coil having windings in the output circuits of said second push-pull modulator, the differential coils of said push-pull modulator circuits comprising the field windings of a two-phase synchronous motor the magnetic field of which rotates once for each beat between the two low frequency waves, a rotor in said field, a variable condenser in the frequency determining circuit of the means for generating the controlled wave mechanically coupled with said rotor, a photoelectric cell in the circuit of said means for deriving the relatively low frequency wave from said relatively high frequency wave, a light source, and a shaded disc adapted to be rotated by said rotor between said light source and said photo-electric cell.

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