

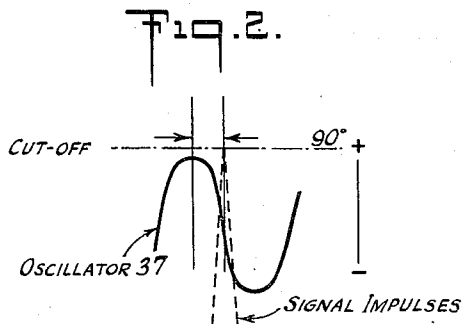
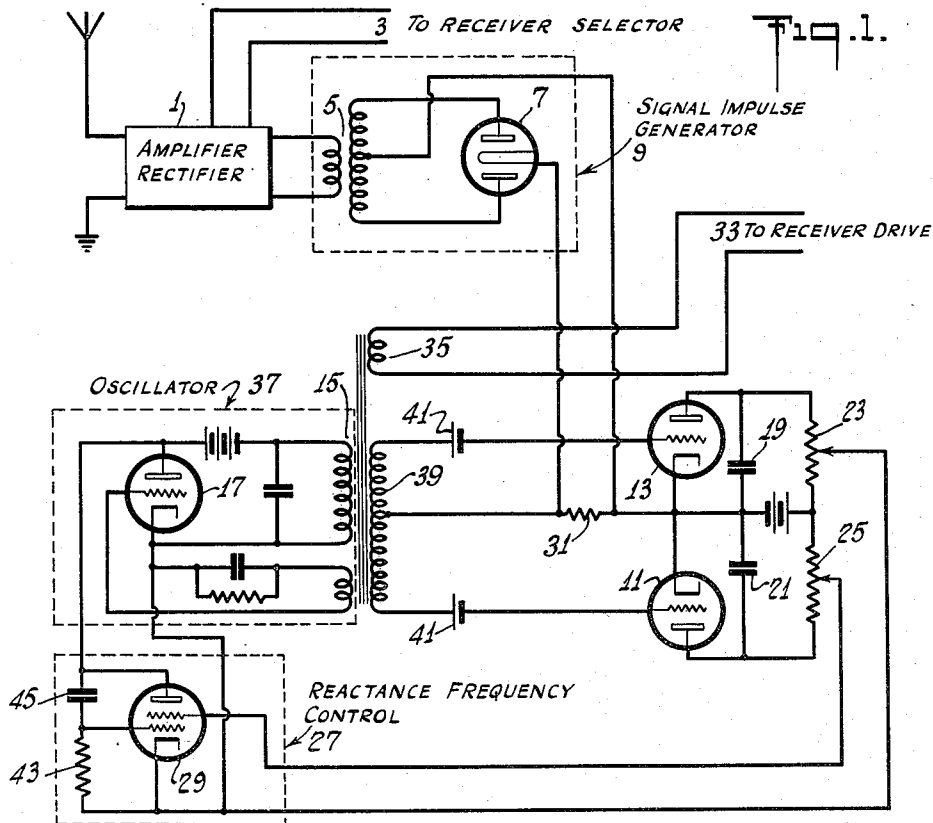
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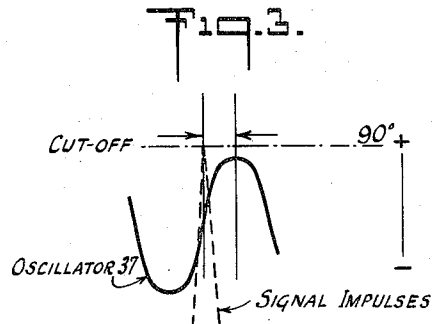
2,352,541

ELECTRONIC SYNCHRONIZATION SYSTEM

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PHASE RELATIONS OF WAVEFORM COMPONENTS ON GRID OF TUBE 13



PHASE RELATIONS OF WAVEFORM COMPONENTS ON GRID OF TUBE 11

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2,352,541

ELECTRONIC SYNCHRONIZATION SYSTEM

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6 Claims. (Cl. 178—69.5)

My invention relates to electronic derivation of correction energy for phasing and synchronizing oscillators in communication systems, particularly in time division multiplex telegraphy.

Present methods of creating correction energy to be used in multiplex systems such as those described in Mathes' Patents 2,038,375, 2,062,009, and 2,212,447, involve certain mechanical functions which do not provide great flexibility and are not adaptable to extreme variations in waveform of the transmitted signal.

In time division multiplex, the receiving channel selection system must be held in close synchronization and phase relation with the transmitted signal. The keying frequency of the multiplex signal varies integrally in sub-multiples of the highest keying frequency due to random similarity of signal sense value in successive channels.

The objects of my invention are, first, to provide highly accurate frequency and phase correction; second to eliminate mechanical moving parts; third, to allow operation under wide variations of waveform of the transmitted signal; and fourth, to allow increased keying speeds and a greater number of channels.

I accomplish these objects by means of an electrical circuit in which correction energy is derived as a function of the phase differential between the steep slope portions of the transmitted signal and the waveform of the oscillator controlling the receiving system.

In the accompanying drawing,

Figure 1 shows one arrangement for obtaining correction energy in accordance with this invention, and

Figures 2 and 3 illustrate phase relations of component waveforms in the grid circuits of tubes 13 and 11.

Referring to Fig. 1, I show a communications receiver circuit including conventional antenna and ground connections. I show also an amplifier rectifier 1 which supplies energy through conductors 3 to a conventional receiving selector and to a signal impulse generator 9, which is used in a correction circuit. The signal impulse generator creates impulses from elements of the received signal. Tube 17 and associated circuit elements comprise an oscillator 37 which is used to control the synchronous drive unit for the receiving system. The output from this oscillator may otherwise be used, if desired, in performing certain well-known synchronizing functions. Tubes 11 and 13 measure the phase relation between the output of the impulse generator 9 and

the waveform of the oscillator 37. The result is integrated by the resistance-capacity circuits comprising condensers 19 and 21 and resistors 23 and 25. This voltage differential is the correction energy used to bias the reactive frequency control unit 27 for correction of the oscillator to the desired phase and frequency relationship with the received signal.

The reactive frequency control unit 27 is an arrangement for correction of frequency well known to the art. For a detailed description of the theory of operation, I refer to British Patent No. 504,766, by M. G. Crosby, or to an article entitled, "Automatic tuning, simplified circuits and design practice," in Proceedings I. R. E., vol. 25, March 1937.

Certain basic functions of this electronic system of deriving correction energy have their mechanical analogy in the aforementioned Mathes' Patents 2,038,375 and 2,062,009. The output from oscillator 37 has a wave form which provides the rotational effect of the commutator or cam arrangement and the differentially connected tubes 11 and 13 replace the brushes or wiper springs of the mechanical method.

Referring to Fig. 1 in greater detail, the steeply rising and falling portions of the signal occurring at the beginning and the end of each dot element are separated from the D. C., or steady state portion, by transformer 5; then they are made unidirectional by the action of full wave rectifier 7 and its load resistor 31. These impulses are applied in positive polarity to the grid control circuits of tubes 11 and 13 by resistor 31, which is common to both tubes. The fixed grid bias of these tubes is negative beyond cutoff; a D. C. voltage from the biasing sources 41 being slightly greater than the peak values of the applied signal impulses.

The output from oscillator 37 is differentially connected to the grid circuits of tubes 11 and 13 through the winding 39 on transformer 15. The amplitude of this voltage in the grid circuits of these tubes is equal to that of the signal impulses introduced by resistor 31.

The operation of this arrangement will now be described. Three frequency relations between the oscillator 37 and the baud frequency of the received signal will be considered: (a) when the oscillator is in synchronism, (b) when it is faster, and (c) when it is slower. The first condition, synchronism, is necessary for proper control of the receiving system.

When the frequency of the oscillator 37 is identical to the baud frequency of the signal impulses

across resistor 31 with a phase relation of 90 degrees, neither tube 11 nor 13 draws anode current, because there are no combined values of waveform sufficient to overcome their fixed bias. With proper polarity of the differentially applied oscillator energy, signal impulse peak values will lag corresponding oscillator waveform values by 90 degrees in the grid circuit of tube 13, and lead them by 90 degrees in the grid circuit of tube 11. The phase relations of these component waveforms are shown by Figures 2 and 3.

Summarizing the above condition, neither tube 11 nor 13 draws current, there is no voltage differential in resistors 23 and 25. No correction energy is applied to the control grid of the reactance frequency control tube 29. Hence, the desired phase relation between the receiving equipment and the transmitted signal will continue.

When the frequency of the oscillator 37 decreases slightly with respect to the baud frequency of the signal impulses across resistor 31, the phase differential between the peak waveform values in the grid circuit of tube 13 will be lowered. These combined values will project above the cutoff value of grid bias, and current impulses will flow in the anode circuit. The current impulses will cause an increasing discharge of condenser 19 and a voltage drop across resistor 23. By applying this voltage drop in the proper polarity and magnitude through the variable taps on resistors 23 and 25 to the control grid of the reactance frequency control tube 29, the frequency of the oscillator 37 can be increased slightly to restore the desired phase relationship of the receiving equipment.

During the above action, tube 11 will continue in cutoff condition because the phase differential between signal impulse peak values and corresponding oscillator 37 waveform is increasing.

When the frequency of the oscillator 37 increases a similar action, differential to that just described, occurs in tubes 11 and 13 and associated circuit elements. The voltage drop in resistor 25, with respect to the grid circuit of the reactance control tube 29, will be of opposite polarity to that which occurred in resistor 23 during the previous action and the effect will be to decrease the frequency of the oscillator 37 slightly. In this manner the desired phase relationship of the receiving system is maintained.

The control action of the reactance frequency control tube 29 is biased to begin at some predetermined voltage differential across resistors 23 and 25. With the proper selection of circuit parameters, this control action can be of any desired speed and magnitude. Integration circuits, composed of condensers 19 and 21 and resistors 23 and 25, can be adjusted to produce correction within a limited time equal to a predetermined number of signal bauds. In practice, if the frequency of the oscillator is slightly fast or slow, an equilibrium of correction voltage will be established to keep it at the proper frequency.

By referring to Figures 2 and 3, showing waveform components in the grid circuits of tubes 13 and 11 respectively, the possible effects of variations in both waveforms can be visualized. Changes in bias of the received signal will not effect the correction energy because signal impulses would be symmetrically disposed in leading and lagging phase relations with respect to the instant of balance. If, however, the distortion is sufficient to cause current impulses in both tubes 13 and 11, the result will be balanced in their differentially connected outputs. Other distortion

of the signal waveform caused by attenuation in the transmission medium or superfluous transients is balanced out in the same manner.

This arrangement of the invention, utilizing a reactance frequency control unit for correction of the speed of the receiving system, should not be construed as limiting its application. The correction energy can be used to effect phase and frequency control by any mechanical or electrical means.

It can be seen that this method of correction is flexible and lends itself to many different circuit arrangements without departing from the spirit of the invention. With judicious selection of constants the full limits of transmission capability can be secured.

I claim:

1. A synchronizing system for telegraph apparatus comprising an oscillator for controlling the speed at which said apparatus is driven, a reactance frequency control device in circuit with said oscillator, a pair of discharge tubes having input circuits which are differentially coupled to the output side of said oscillator, a bias resistor common to said input circuits, means operative in the presence of unbalanced outputs from said tubes for causing said reactance device to vary the frequency of said oscillator, and means responsive to mark-space transitions, also space-mark transitions, by which the incoming signals are characterized, for producing transient pulses through said resistor, departures of said pulses from a normal phase relation to the output wave from said oscillator being effective to unbalance the outputs from said tubes.

2. In a communication system wherein transfer of intelligence is effected by regularly timed signal elements, and including correction means for maintaining synchronism of the receiving equipment with respect to said signal elements, the method of controlling said correction means which comprises generating impulses in response to changes in the sense of said signal elements, combining said impulses with a locally derived waveform to produce reactance frequency control pulses that are normally symmetrically phase-displaced with respect to the peaks of said waveform, causing said control pulses when unsymmetrically phase-displaced to accelerate or decelerate the output of said locally derived waveform, and controlling said correction means by said accelerated or decelerated locally derived waveform.

3. A synchronizing system for telegraph apparatus comprising a rectifier in circuit with a source of signal potentials, said rectifier being arranged to deliver uni-directional impulses in response to changes in the sense of said signal potentials, an oscillator the output from which is useful in maintaining synchronism between receiving equipment of said telegraph apparatus and the arrival moments of said signal potentials, a pair of discharge tubes having input circuits which are differentially coupled to the output side of said oscillator, a bias resistor common to said two input circuits, means for directing said uni-directional impulses through said bias resistor, output circuits for said discharge tubes having symmetrically arranged parameters, an electronic reactance frequency control device in circuit with said oscillator, and means operable in response to output potentials delivered by one or the other of said tubes in the presence of unbalanced control potentials

applied thereto, for causing the reactance of said frequency control device to accelerate or decelerate said oscillator.

4. A system for synchronizing a periodic device with a series of incoming impulses, comprising a rectifier arranged to produce uni-directional potentials in response to shifts in the sense of said incoming impulses, a pair of discharge tubes each having an input circuit and an output circuit, an impedance across which said uni-directional potentials are impressed, said impedance being common to said input circuits, an electronic oscillator having at least one resonant circuit and an electronic reactance frequency control device in shunt with said resonant circuit, and means for causing said control device to be variably influenced by output potentials derived from one or the other of said pair of discharge tubes, thereby to accelerate or retard the output wave delivered by said oscillator.

5. A system according to claim 4 and including components having a time constant value in the output circuits of said pair of discharge tubes, which value is suitably determined for integrating the effects of a desired succession of said uni-directional potentials.

6. A synchronizing system for a receiving telegraph apparatus comprising a resistor, means for impressing across said resistor rectified components of received signal elements, said components being of the same polarity at the occurrence of each shift in the sense of said signal elements, an oscillator having resonant circuit parameters arranged to produce an output wave normally equivalent in frequency to a baud frequency standard by which said signal elements are timed, a normally balanced electronic circuit arrangement having two electron discharge tubes, means coupling the input circuits of said tubes differentially to the output side of said oscillator, said input circuits having a common portion which includes said resistor, a frequency control tube having an input circuit arranged to receive control potentials from said normally balanced electronic circuit upon the occurrence of an unbalancing phase shift of its output, and a reactive element coupled to the output of said frequency control tube and in circuit with the resonant circuit of said oscillator for varying the frequency of said oscillator in dependence upon the degree and sense of said phase shift.

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