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J. A. RANKIN

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PHASE-RESPONSIVE SYSTEM

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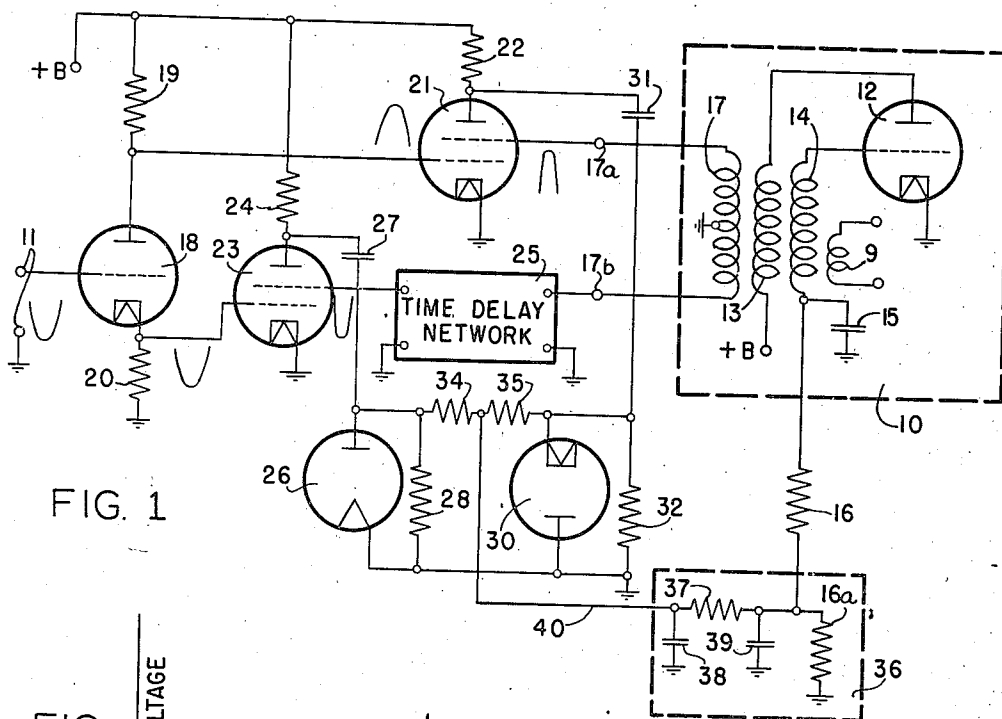
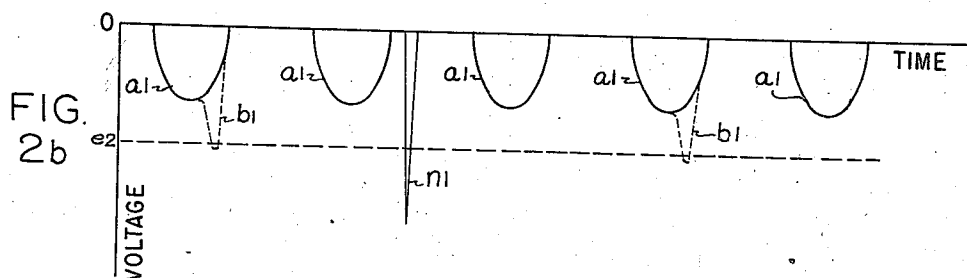
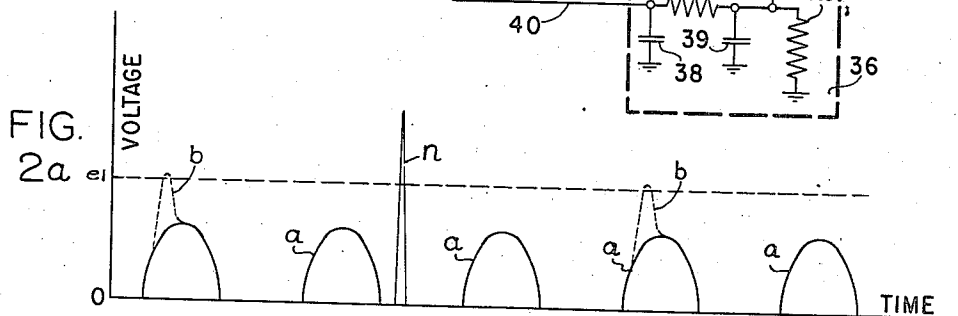


FIG. 1



INVENTOR.

JOHN A. RANKIN

BY *Mueller, Dodds & Mason*

ATTORNEYS

UNITED STATES PATENT OFFICE

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PHASE-RESPONSIVE SYSTEM

John A. Rankin, Park Ridge, Ill., assignor to Belmont Radio Corporation, Chicago, Ill., a corporation of Illinois

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This invention relates to phase-responsive systems and, while it is of general application, it is particularly adapted for the synchronization of scanning oscillators of television receivers from received synchronizing pulses.

It has been the general practice to synchronize a scanning oscillator of a television receiver by triggering it directly with the received synchronizing pulses after separation from the composite television signal and after separation of the line-synchronizing pulses from the field-synchronizing pulses. While ideally this arrangement is effective to initiate each scanning line and each scanning field at precisely the correct point in the scanning cycles, it has been found that, in practice, it is difficult to prevent incorrect triggering of the scanning oscillators by random noise pulses in the received signal, particularly if such pulses occur approximately at the time a synchronizing pulse is due. The result of such spurious triggering of the scanning oscillators is line tearing and jumping in the case of the line-scanning oscillator and, in case of the field-scanning oscillator, failure to interlace properly or complete loss of the picture. The present invention is directed to a phase-responsive system which, while of general application, is particularly suitable for maintaining a constant average phase relation between the received synchronizing pulses of a television signal and the scanning waves developed by the scanning oscillators of a television receiver.

It is an object of the invention, therefore, to provide a new and improved phase-responsive system by means of which the average phase between two periodic electric waves may be maintained constant.

In accordance with the invention, a phase-responsive system for developing an electrical effect varying with the relative phase of two periodic electrical waves comprises means for combining the two waves with a given polarity, means for individually deriving from the waves two waves of opposite polarity, and means for combining the opposite polarity waves. The system also includes means for relatively time-displacing at least one of the waves before combining, means for individually rectifying the two combined waves, and an output circuit connected to derive the difference in the outputs of the two rectifying means.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying draw-

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ing while its scope will be pointed out in the appended claims.

Referring now to the drawing, Fig. 1 is a circuit diagram of a phase-responsive system embodying the invention as applied to the synchronization of a periodic wave generator from an input periodic wave; while Figs. 2a and 2b are graphs of certain operating characteristics of the system of Fig. 1 to aid in an explanation of the invention.

Referring now to the drawing, there is represented a phase-responsive system embodying the invention for developing an electrical effect varying with relative phase of two periodic electrical waves, specifically for synchronizing a periodic wave generator 10 with an input periodic wave of an integrally related frequency applied to input terminals 11. By the term "integrally related frequency" is meant that the ratio of the frequency of the input wave to that of the generated wave or the ratio of the frequency of the generated wave to that of the input wave is an integer; that is, the generated wave is a harmonic or a subharmonic of the input wave while the input wave and the generated wave may be of any desired wave shapes, preferably one of the waves, for example the input wave, is a relatively broad pulse wave such as a half-sine wave, as represented adjacent the terminals 11, while the other wave developed by the generator 10 is a relatively narrow pulse wave, as indicated at the output connections of the generator 10 described hereinafter. For example, the generator 10 may be of the conventional blocking-oscillator type comprising a vacuum tube 12 supplied with a space current from a suitable source +B through a transformer primary winding 13. The grid circuit of the tube 12 includes a transformer secondary winding 14 coupled to the winding 13 and a time-constant circuit including a condenser 15 effectively in parallel with a resistor 16 and a resistor 16a in series. The transformer also includes a tertiary winding 17 having its midpoint grounded and coupled to the primary winding 13 and an output winding 9 from which may be derived the narrow-pulse wave of opposite polarity.

The system also includes means for combining the input wave at the terminals 11 with a wave derived from the generator 10 with the same given polarity, for example with a positive polarity, and with the pulses thereof at least partially coinciding in time. This means includes a vacuum tube repeater or amplifier 18 having a signal-input grid to which the input signal at the ter-

minals 11 is applied and an anode load resistor 19 and a cathode load resistor 20. This means also includes a combining or modulating tube 21 having two signal-input grid electrodes individually connected to the load resistor 19 and to the terminal 17a of winding 17 and provided with an anode load resistor 22.

The system also includes means for individually deriving from the two waves two other waves of opposite polarity. This means comprises the cathode load resistor 20 of the tube 18 across which is developed an input-signal pulse wave of polarity opposite to that developed across the anode load resistor 19, as indicated by the adjacent pulse in Fig. 1, and the other half of the transformer tertiary winding 17 which supplies a generated wave of opposite polarity from the terminal 17b.

There is also provided a second vacuum tube combining amplifier or modulator 23 having two signal-input grid electrodes one of which is connected to the cathode load resistor 20 to receive the input wave of opposite polarity and the other of which is connected to the terminal 17b to receive the generated wave of opposite polarity. The tube 23 is provided with an anode load resistor 24 while the tubes 18, 21 and 23 are supplied with space current from a suitable source +B.

The system also includes means for relatively time-displacing at least one of the waves before combining and, by way of example, there is illustrated a time-delay network 25 interposed between the terminal 17b and the signal grid of the combining tube 23 and effective to delay the narrow pulse wave of opposite polarity developed by the generator 10.

Included in the system are means for individually peak-rectifying the two combined waves. This means comprising a diode rectifier 26 coupled across the load resistor 24 of the combining tube 23 through a coupling condenser 27 and provided with a shunt load resistor 28. Similarly, the combined wave developed across the load resistor 22 of the combining tube 21 is applied through a coupling condenser 31 to a diode rectifier 30 connected with reverse polarity and provided with shunt load resistor 32.

Connected to the two peak rectifiers described is an output circuit 40 for deriving the difference in the outputs of the two peak rectifiers and comprising means responsive to such difference for controlling the frequency of the generator 10. The circuit 40 includes isolating resistors 34 and 35 connected to the load resistors 28 and 32, respectively, of the two rectifiers and a filter circuit 36 comprising a series resistor 37 and shunt condensers 38 and 39 and is connected to the junction between constant resistors 16 and 16a in the grid circuit of the blocking-oscillator generator 10.

The operation of the phase-responsive system of the invention may be best understood by reference to Figs. 2a and 2b, which illustrate the invention as applied to the synchronization of the generator 10 at the fourth subharmonic of the input wave, that is, with the system operating as a frequency divider. In Fig. 2a the pulses *a* represent the input wave of positive polarity developed across the load resistor 19 and applied to an input grid of the combining tube 21. The pulses *b* represent the pulses derived from the blocking oscillator 10 supplied from the terminal 17a to the other signal input grid of the combining tube 21. The blocking oscillator operates

in a conventional manner to develop in its output circuit a pulse voltage wave comprising a series of brief pulses of approximately half-sine-wave shape separated by intervals determined by the time constant circuit 15, 16, 16a. This may be utilized in any one of a number of ways well known to the art; for example in a television receiver this pulse wave may be used to synchronize a scanning-wave generator. This wave comprising short duration pulses, such as the pulses *b*, may be derived from the output winding 9.

The circuit constants are so proportioned that, during normal operation, the pulses *a* and *b* at least partially coincide in time. As illustrated the pulse *b* falls on the leading sloping side of the input pulse *a*. In this figure the voltage *e*₁ represents the peak-rectified voltage developed by the rectifier 30 and appearing across its load resistor 32.

Similarly in Fig. 2b are represented the input pulses *a*₁ of opposite polarity as combined with the generated pulses *b*₁ of opposite polarity. The pulses *b*₁ are delayed by the network 25 by an amount such that they are still at least partially coincident with the input pulses *a*₁ but preferably by an amount less than the duration of one of such pulses so that the pulses *b*₁ fall on the opposite or lagging sloping side of the input pulses *a*₁. In this figure the voltage *e*₂ represents the peak-rectified output of the rectifier 26 appearing across its load resistor 28. The difference between the two rectified voltages *e*₂ and *e*₁ developed by the rectifiers 26 and 30 is derived by means of the control circuit 40 and the isolating resistors 34, 35 which develop a unidirectional bias voltage varying with the difference in the outputs of the two rectifiers 26 and 30 and, by way of the filter circuit 36, apply such difference voltage to the control electrode of the blocking oscillator tube 12 to control the frequency thereof in a well-known manner.

From the foregoing it will be clear that, should the frequency of the blocking oscillator 10 tend to fall below that of the input synchronizing wave at the terminals 11, the pulses *b* and *b*₁ generated thereby will tend to lag the input pulses *a* and *a*₁, respectively. This is effective to increase the positive peak rectified voltage *e*₂ and to decrease the negative peak rectified voltage *e*₁, thereby decreasing the normal negative bias on the grid of the tube 12 to decrease the period of the generator 10, that is to increase its frequency, until a condition of equilibrium is restored. Obviously, in case the frequency of the generator 10 tends to rise above that of the input wave at the terminals 11, the reversed process takes place.

While the invention has been described as applied to a frequency divider, that is an arrangement for generating a pulse wave which is a subharmonic of the input wave, it will be apparent that it is equally applicable to a system having any other integral frequency relation between the input wave and that developed by the generator 10. It is only necessary that the pulses *a* and *b*, and *a*₁ and *b*₁ coincide in time, which necessarily follows from the integral frequency relationship. In the case of frequency multiplication, a plurality of pulses *b* and *b*₁ will fall between each adjacent pair of pulses *a* and *a*₁, respectively, while in the case in which the frequency of the input wave is the same as that generated by the blocking oscillator 10, one of the pulses *b* or *b*₁ will fall on each of the pulses *a* or *a*₁, respectively. In the case of frequency multiplication

or frequency division the average voltages built up on condensers 27 and 31 by the peak rectifiers 26 and 30, respectively, act as biases on the rectifiers and prevent their response to either the input wave or the generated wave alone and limit their response to the combined input and generated wave. It will further be apparent that any of the four waves utilized to develop the control voltage may be advanced or retarded with respect to the others to produce the desired ultimate relative time displacement and that either the input waves or the generated waves of opposite polarities may both be shifted with respect to the other in order to provide a different average phase relation between the input waves and the generated waves.

An important advantage of the phase-responsive system described resides in the fact that it is substantially completely unresponsive to spurious noise pulses which may be present in the pulse wave *a* appearing at the input circuit 11. This characteristic can be seen by reference to Figs. 2a and 2b in which there are represented noise pulses *n* and *n*₁ appearing on the pulse waves *a* and *a*₁ of opposite polarity and impressed upon the peaked rectifiers 26 and 30, respectively. Due to the fact that these two noise pulses *n* and *n*₁ are of the same phase and of opposite polarity, their effects on the rectified outputs of the rectifiers 26 and 30 are equal and opposite so that no net noise component is impressed upon the control circuit 40. This is true for all conditions, except in the case of a noise pulse which coincides in time with a portion of one of the derived pulses *b* or *b*₁. By making the pulses *b* as narrow as possible, the chance of a noise pulse *n* coinciding with a pulse *b* is minimized. However, even in this case the only effect of the noise pulses is that due to their average energy content, which ordinarily is inappreciable. Thus, it is seen that in the arrangement described the blocking oscillator 10 is not excited directly by the input synchronizing pulses at the terminals 11 and thus is completely shielded from any random or spurious noise pulses appearing at the input terminals. The only effect of such spurious pulses on the operation of the system is that due to their average energy content which, as explained above, is inappreciable.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed as new is:

1. A phase-responsive system for developing an electrical effect varying with the relative phase of two periodic electrical waves comprising, means for combining the two waves with a given polarity, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually rectifying said two combined waves, and an output circuit connected to derive the difference in the outputs of said rectifying means.

2. A phase-responsive system for developing an electrical effect varying with the relative phase of two periodic electrical pulse waves of integrally related frequencies comprising, means for combining the two waves with a given polarity and with the pulses thereof at least partially

coinciding in time, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining by an amount such that the pulses thereof are still at least partially coincident with those of the wave with which it is combined, means for individually rectifying said two combined waves, and an output circuit connected to derive the difference in the outputs of said rectifying means.

3. A phase-responsive system for developing an electrical effect varying with the relative phase of two periodic electrical pulse waves of integrally related frequencies, one wave consisting of relatively broad pulses and the other of relatively narrow pulses, comprising, means for combining the two waves with a given polarity and with the pulses thereof at least partially coinciding in time, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing said narrow-pulse waves of opposite polarities before combining by an amount less than the duration of one of said broad pulses, means for individually rectifying said two combined waves, and an output circuit connected to derive the difference in the outputs of said rectifying means.

4. A phase-responsive system for developing an electrical effect varying with the relative phase of two periodic electrical pulse waves of integrally related frequencies comprising, means for combining the two waves with a given polarity and with the pulses thereof at least partially coinciding in time, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually peak rectifying said two combined waves, and an output circuit connected to derive the difference in the outputs of said rectifying means.

5. A phase-responsive system for synchronizing a periodic-wave generator with an input periodic wave of an integrally related frequency comprising, means for combining the input wave with a wave derived from the generator with a given polarity, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually rectifying said two combined waves, and means responsive to the difference in the outputs of said rectifying means for controlling the frequency of said generator.

6. A phase-responsive system for synchronizing a periodic-wave generator with an input periodic wave of an integrally related frequency comprising, means for combining the input wave with a wave derived from the generator with a given polarity, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually rectifying said two combined waves, and a circuit for developing a unidirectional bias voltage varying with the difference in the outputs of said rectifying means for application to said generator to control the frequency thereof.

7. A phase-responsive system for synchronizing a periodic-wave generator with an input periodic

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wave of an integrally related frequency comprising, means for combining the input wave with a wave derived from the generator with a given polarity, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing one of said generated waves before combining with the input wave of corresponding polarity, means for individually rectifying said two combined waves, and means responsive to the difference in the outputs of said rectifying means for controlling the frequency of said generator, whereby the synchronization of said generator is substantially unaffected by spurious noise pulses superimposed on said input wave.

8. A phase-responsive system for synchronizing a periodic-wave generator generating a relatively narrow pulse wave with an input periodic wave comprising relatively broad pulses and of an integrally related frequency comprising, means for combining the input wave with a wave derived from the generator with a given polarity, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing one of said generated waves before combining with the input wave of corresponding polarity, means for individually rectifying said two combined waves, and means responsive to the difference in the outputs of said rectifying means for controlling the frequency of said generator, whereby the synchronization of said generator is substantially unaffected by spurious noise pulses superimposed on said input wave.

9. In a television system including a generator

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for producing a scanning wave and means for deriving a synchronization wave for controlling said scanning generator; a phase-responsive system for synchronizing said generator with said synchronization wave comprising, means for combining said synchronization wave with said scanning wave, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually rectifying said two combined waves, and means responsive to the difference in the outputs of said rectifying means for controlling the frequency of said generator.

10. In a television system including a generator for producing a scanning pulse wave and means for deriving an input synchronization pulse wave for controlling said generator; a phase-responsive system for synchronizing said generated pulse wave with said synchronization pulse wave comprising, means for combining the two waves with a given polarity and with the pulses thereof at least partially coinciding in time, means for individually deriving from said waves two waves of opposite polarity, means for combining said opposite-polarity waves, means for relatively time-displacing at least one of said waves before combining, means for individually peak rectifying said two combined waves, and means responsive to the difference in the outputs of said rectifying means for controlling the frequency of said generator, whereby the synchronization of said generator is substantially unaffected by spurious noise pulses superimposed on said input synchronization wave.

JOHN A. RANKIN.