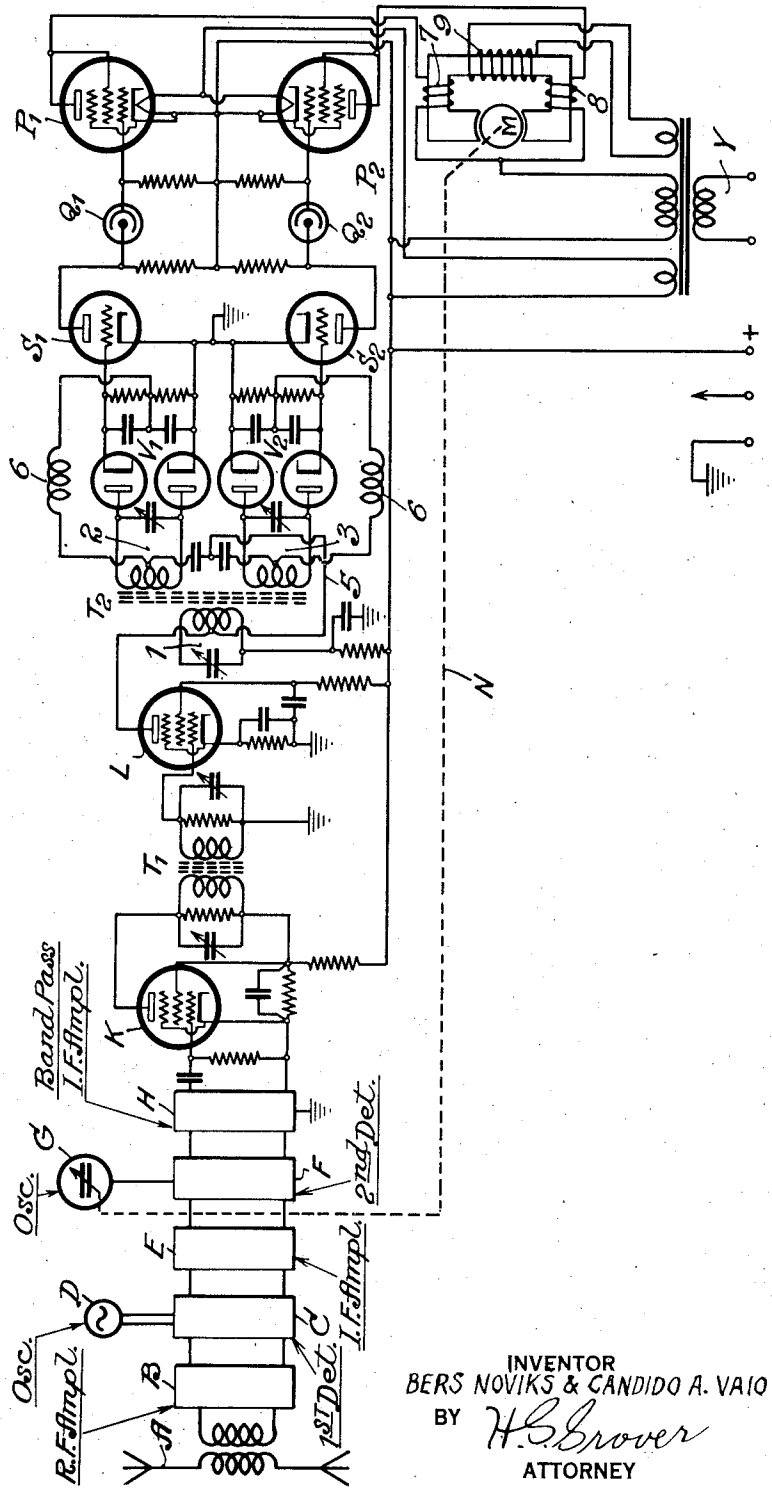
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FREQUENCY VARIATION RESPONSE CIRCUIT

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FREQUENCY VARIATION RESPONSE CIRCUIT

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This invention relates to high frequency variation response circuits, and more particularly to frequency response networks of a type utilizing changes in phase relations of primary and secondary circuit voltages which occur in coupled tuned circuits when the applied high frequency energy departs from the resonance frequency of the tuned circuits. Circuits of this general type are commonly referred to as frequency discriminator circuits, attention being invited to Seeley Patent No. 2,121,103, granted June 21, 1938, and Usselman Patent No. 1,794,932, granted March 3, 1931, for descriptions of known types of discriminator circuits.

The present invention is an alternative type of high frequency variation response circuit employing the following features: (1) A pair of discriminator and detector systems, each involving two rectifiers and a direct current amplifier. (2) A glow discharge tube associated with each discriminator system which is conductive only when the frequency is off the assigned value. (3) A motor arrangement having a two-phase winding which is adapted to rotate in either of two directions under control of the pair of discriminator systems. Although the preferred form of the invention employs all of these features, obviously the invention is not limited to the precise arrangements shown and described hereinafter.

The present invention finds particular application wherever there is need for a frequency response network which supplies a rapidly increasing output of one polarity or another according to whether the frequency of the applied energy departs in one direction or the other from a mean frequency by more than a predetermined amount. The high frequency variation response circuit of the invention can be used in an automatic frequency control system, or in a receiving system employed to receive frequency modulated carrier waves. If used to receive frequency modulated carrier waves, the frequency variation response network is utilized in connection with the detection of frequency modulated waves, as known in the art.

A more detailed description of the invention follows in conjunction with a drawing, whose single figure illustrates a preferred embodiment of an automatic frequency control circuit in a superheterodyne receiver.

Referring to the drawing, there is shown a double detection receiver employing an energy collector in the form of an antenna A, a radio frequency amplifier B for amplifying the energy collected on the antenna, a first detector C, which beats with energy produced from a first local oscillator D to produce an intermediate frequency which is fed to an intermediate frequency amplifier E. Energy from the intermediate frequency amplifier E is then fed to a second detector F where it beats with energy from a second local oscillator G to produce a second and lower intermediate frequency wave which is passed on to band-pass intermediate frequency amplifier H. The energy passing through band-pass intermediate frequency amplifier H is then amplified in the second intermediate frequency amplifiers K and L. A transformer T_1 is employed to couple the output from amplifier K to the input of amplifier L. Local oscillator G is controlled as to frequency by means of a link N which is geared to a two-phase modified Telechron motor M, the latter being controlled through coupling tubes P_1, P_2, glow discharge device limiters Q_1, Q_2, direct current amplifiers S_1, S_2, and pairs of detectors V_1, V_2, in the manner described hereinafter. In practice, the automatic frequency control from motor M is applied to the second beat frequency oscillator G by means of a small condenser (indicated diagrammatically) located across the main tuning condenser (not shown). The motor is linked to the vernier condenser of the oscillator G through a suitable reduction gear. This vernier condenser, by way of example, can be rotated through a ten to thirty-six reduction gear with a rotation speed of about 3.6 revolutions per minute. In the output of the second intermediate frequency amplifier detector there is provided a transformer T_2 comprising a primary winding 1 coupled to two secondary windings 2 and 3. Each of these windings cooperates with a condenser, individual thereto, to form a tuned circuit. These tuned circuits (as well as the tuned circuits including the coils of transformer T_1) are tuned to the mid-band frequency to be passed through the system. The mid point of primary winding 1, it should be noted, is connected through a lead 5 to the mid points of the secondary windings 2 and 3 to supply in-phase potentials to the pairs of detectors V_1, V_2. The primary winding 1 is also inductively coupled to the secondary windings 2 and 3 to supply antiphase potentials to the two detectors of each pair V_1 or V_2. The outputs of the detectors V_1 and V_2 are respectively coupled to the grids of direct current vacuum tube amplifiers S_1, S_2. A suitable radio frequency choke coil 6 connects the mid point of each output circuit of each pair of detectors to the mid point of the associated sec-

ondary coil of the transformer T_2. The anodes of the direct current amplifiers S_1, S_2 are connected together through suitable resistors and each anode is coupled to a limiter Q_1 or Q_2 comprising a glow discharge voltage regulator type tube. These limiter tubes Q_1, Q_2 are arranged to be conductive when the frequency of the local oscillator is on the assigned value and one of the tubes will be conductive and the other non-conductive when the frequency is off the assigned value, depending upon whether the frequency is either above or below the assigned value. The coupling tubes P_1, P_2 couple the limiter tubes to coil windings 7 and 8 on the two-phase induction motor. It will thus be noted that the coils 7 and 8 are energized by alternating current via the two coupling tubes P_1, P_2, in turn excited through the limiters Q_1, Q_2 from the direct current amplifiers S_1, S_2, the latter being coupled to the discriminator circuits constituted by 2, V_1 and 3, V_2. When the frequency is on the assigned value, the alternating currents through coils 7 and 8 will be equal and opposite. When, however, the frequency is off the assigned value a predetermined amount, the current through one coil will be cut off, because the space current through its associated coupling tube will be cut off, while leaving unaltered the current through the other coil. In effect, the space path of each coupling tube provides a series resistance for its directly connected coil winding on the modified Telechron motor. A third coil 9 on the motor M obtains its driving force from the alternating current supply line Y. This supply line also provides heating current for the filaments of the coupling tubes and a suitable polarizing voltage for the anodes of the coupling tubes through the coils 7 and 8. The modified motor M is, in effect, a two-phase motor which operates by virtue of the difference in current through the windings 7 and 8. The value of this current difference is dependent upon the amount of change of impressed frequency from the assigned frequency corresponding to the resonance frequencies of the tuned circuits 1, 2, 3.

In one embodiment of the invention successfully tried out in practice, the first oscillator D was arranged to beat the incoming signal down to the first intermediate frequency of 465 kilocycles per second, and the second oscillator G was arranged to beat the first intermediate frequency energy down to a second intermediate frequency of 65 kilocycles per second. The second intermediate frequency amplifier tubes K and L were 6SJ7 and 6SK7 tubes, respectively. The pair of detectors of circuits V_1 and V_2 employed 6H6 tubes. The direct current amplifier tubes S_1, S_2 were 6SF5 tubes. The limiters Q_1, Q_2 were RCA 991 voltage regulator tubes which had a 30 db. limiter characteristic. The coupling tubes P_1, P_2 were 6V6 tubes. The motor M was a General Electric clock motor.

What is claimed is:

1. In a frequency variation response network, a first resonant circuit, second and third resonant circuits inductively coupled to the first resonant circuit, connections from the electrical centers of said second and third resonant circuits to a point on said first resonant circuit, said resonant circuits being tuned to the same frequency, an alternating current input circuit coupled to said first resonant circuit, a pair of rectifiers having corresponding electrodes connected across said second resonant circuit, another pair of rectifiers having similar corresponding electrodes connected across said third resonant circuit, a first direct current amplifier coupled to the outputs of one pair of rectifiers and a second direct current amplifier coupled to the outputs of the other pair of rectifiers, and a two-phase induction motor having different windings the currents in which are under the control of said different direct current amplifiers, and a third winding coupled to a driving source of alternating current energy, whereby a difference in the outputs of said direct current amplifiers causes said motor to rotate in either of two directions depending upon the sense of departure in frequency of the applied alternating current waves from the resonance frequency of said tuned circuits.

2. In a frequency variation response network, a first resonant circuit, second and third resonant circuits inductively coupled to the first resonant circuit, connections from the electrical centers of said second and third resonant circuits to a point on said first resonant circuit, said resonant circuits being tuned to the same frequency, an alternating current input circuit coupled to said first resonant circuit, a pair of rectifiers having corresponding electrodes connected across said second resonant circuit, another pair of rectifiers having similar corresponding electrodes connected across said third resonant circuit, a first direct current amplifier coupled to the outputs of one pair of rectifiers and a second direct current amplifier coupled to the outputs of the other pair of rectifiers, a glow discharge device limiter in circuit with the output of each direct current amplifier, a coupling tube having its input circuit connected to each limiter, and a motor having different windings the currents in which are under the control of the different direct current amplifiers and a third winding coupled to a driving source of alternating current energy, whereby a difference in the outputs of said direct current amplifiers exceeding a predetermined value determined by the characteristics of said limiters causes said motor to rotate in either of two directions depending upon the sense of departure in frequency of the input alternating current waves from the resonance frequency of said tuned circuits.

3. The combination with a superheterodyne receiver including a first detector, a first local oscillator, a second detector and a second variable local oscillator, and a second intermediate frequency amplifier, of an automatic frequency control system comprising a first resonant circuit and a pair of discriminators comprising second and third resonant circuits tuned to the same mid band frequency, said second and third tuned circuits being inductively coupled to said first tuned circuit, connections from the electrical center of said second and third resonant circuits to a point on said first resonant circuit, connections from the output of said second intermediate frequency amplifier to said first resonant circuit, a detector for each discriminator comprising a pair of rectifiers connected across each of said second and third resonant circuits a direct current amplifier for each pair of rectifiers, a glow tube limiter in the output of each direct current amplifier, and means coupled to said glow tube limiters responsive to the difference in the resulting direct current voltages caused by a variation in the frequency of the waves applied to said first resonant circuit for varying the frequency of said second local oscillator in such sense and magnitude as to restore the second intermediate frequency to the resonance frequency of said tuned circuits.

4. The combination with a superheterodyne receiver including a first detector, a first local oscillator, a second detector, a second variable local oscillator, and a second intermediate frequency amplifier, of an automatic frequency control system comprising first, second and third resonant circuits tuned to the same mid band frequency, said second and third tuned circuits being inductively coupled to said first tuned circuit, connections from the electrical centers of said second and third resonant circuits to a point on said first resonant circuit, connections from the output of said second intermediate frequency amplifier to said first resonant circuit, a pair of rectifiers having corresponding electrodes connected across said second resonant circuit, another pair of rectifiers having similar corresponding electrodes connected across said third resonant circuit, a first direct current amplifier coupled to the outputs of one pair of rectifiers, and a second direct current amplifier coupled to the outputs of the other pair of rectifiers, and a two-phase motor having different windings energized by the different direct current amplifiers, and a third winding coupled to a driving source of alternating current energy, a link between the shaft of said motor and said second local oscillator, whereby a difference in the outputs of said direct current amplifiers caused by a variation in the frequency of the waves applied to said first resonant circuit causes said motor to rotate in either of two directions depending upon the sense of departure in frequency of the applied alternating current waves from the resonance frequency of said tuned circuits.

5. In combination, a pair of vacuum tubes each having a grid and an anode, a source of control potential, connections for applying a potential from said source to one of said grids and a potential of reverse polarity from said same source to the other grid, a glow tube for each vacuum tube having one electrode connected to the anode of the associated vacuum tube, and another electrode connected to a coupling vacuum tube whereby one polarity of the control potential in excess of a predetermined potential will cut off the space current through one coupling vacuum tube while leaving unaltered the flow of space current through the other coupling tube, and vice versa, a reversible motor having a plurality of windings, there being a winding in series with the space path of each coupling tube and another winding in circuit with an alternating current source whereby the field currents supplied to the motor are independent of the control potentials beyond said predetermined value.

6. In a frequency variation response network, an alternating current input circuit, means including a pair of direct current amplifier tubes for producing direct current voltages of different relative polarity in response to changes in the frequency of the current in said input circuit on opposite sides of a mean frequency, a coupling tube for each direct current amplifier tube, a Telechron motor having a pair of windings, connections from one terminal of said windings to different output electrodes of said coupling tubes, a direct connection between the other terminals of said windings, said direct connection extending to a source of low frequency power, and a third winding for said motor having opposite terminals coupled to said source.

7. In a frequency variation response network, a first resonant circuit, a pair of discriminators each having a resonant circuit inductively coupled to the first resonant circuit, connections from the electrical centers of the resonant circuits of said discriminators to a point on said first resonant circuit, all of said resonant circuits being tuned to the same frequency, an alternating current input circuit coupled to said first resonant circuit, two detectors, one for each of said discriminators and each detector comprising a pair of rectifiers connected across its associated resonant circuit, two direct current amplifiers each followed by an individual limiter, each amplifier being coupled to a different one of said detectors, and means coupled to the outputs of said limiters and responsive to the difference in the resulting direct current voltages.

8. In a frequency variation response network, a first resonant circuit, second and third resonant circuits inductively coupled to the first resonant circuit, connections from the electrical centers of said second and third resonant circuits to a point on said first resonant circuit, said resonant circuits being tuned to the same frequency, an alternating current input circuit inductively coupled to said first resonant circuit, a pair of rectifiers having corresponding electrodes connected across said second resonant circuit, another pair of rectifiers having similar corresponding electrodes connected across said third resonant circuit, a first direct current amplifier coupled to the outputs of one pair of rectifiers and a second direct current amplifier coupled to the outputs of the other pair of rectifiers, a limiter in circuit with the output of each direct current amplifier, a coupling tube having its input circuit connected to each limiter, and a motor having different windings the currents in which are under the control of the different direct current amplifiers and a third winding coupled to a driving source of alternating current energy, whereby a difference in the outputs of said direct current amplifiers exceeding a predetermined value determined by the characteristics of said limiters causes said motor to rotate in either of two directions depending upon the sense of departure in frequency of the input alternating current waves from the resonance frequency of said tuned circuits.

9. An automatic frequency control system comprising a frequency variation response network having a first resonant circuit, a pair of discriminators each having a resonant circuit inductively coupled to the first resonant circuit, connections from the electrical centers of the resonant circuits of said discriminators to a point on said first resonant circuit, all of said resonant circuits being tuned to the same frequency, an alternating current input circuit coupled to said first resonant circuit, a detector for each of said discriminators comprising a pair of rectifiers connected across its associated resonant circuit, a direct current amplifier followed by a limiter coupled to each of said detectors, a reversible motor having different windings energized by the outputs from the different limiters, and a third winding coupled to a driving source of alternating current, whereby a difference in the outputs of said limiters caused by a variation in the frequency of the alternating current input circuit causes said motor to rotate in either of two directions depending upon the sense of departure in frequency of said input circuit from the resonance frequency of said tuned circuits.

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