

June 13, 1944.

M. G. CROSBY

2,351,193

FREQUENCY MODULATION DETECTOR CIRCUIT

Filed June 13, 1942

2 Sheets-Sheet 1

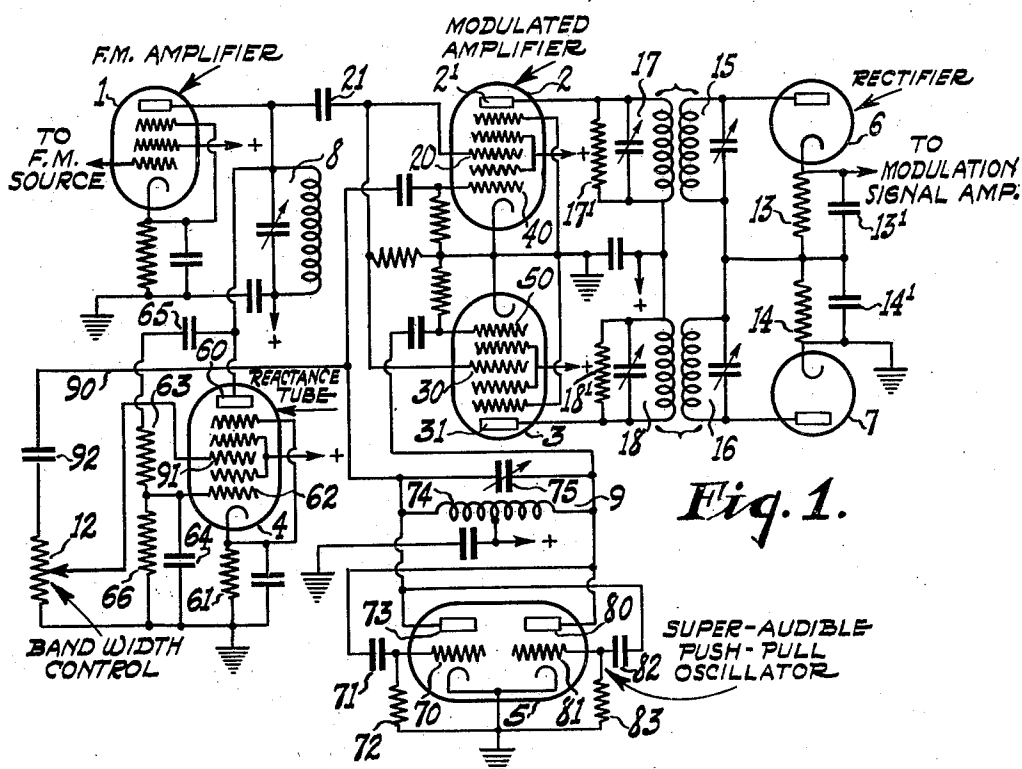


Fig. 1.

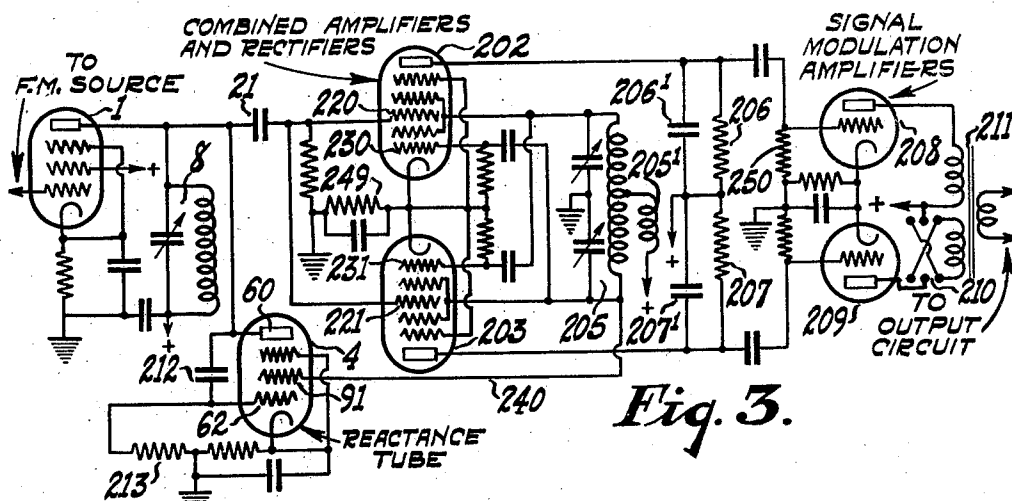


Fig. 3.

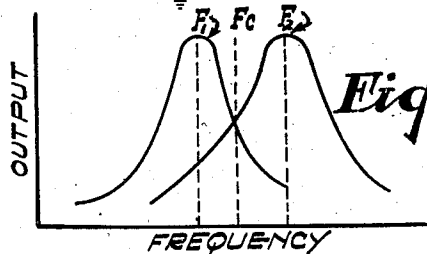


Fig. 2.

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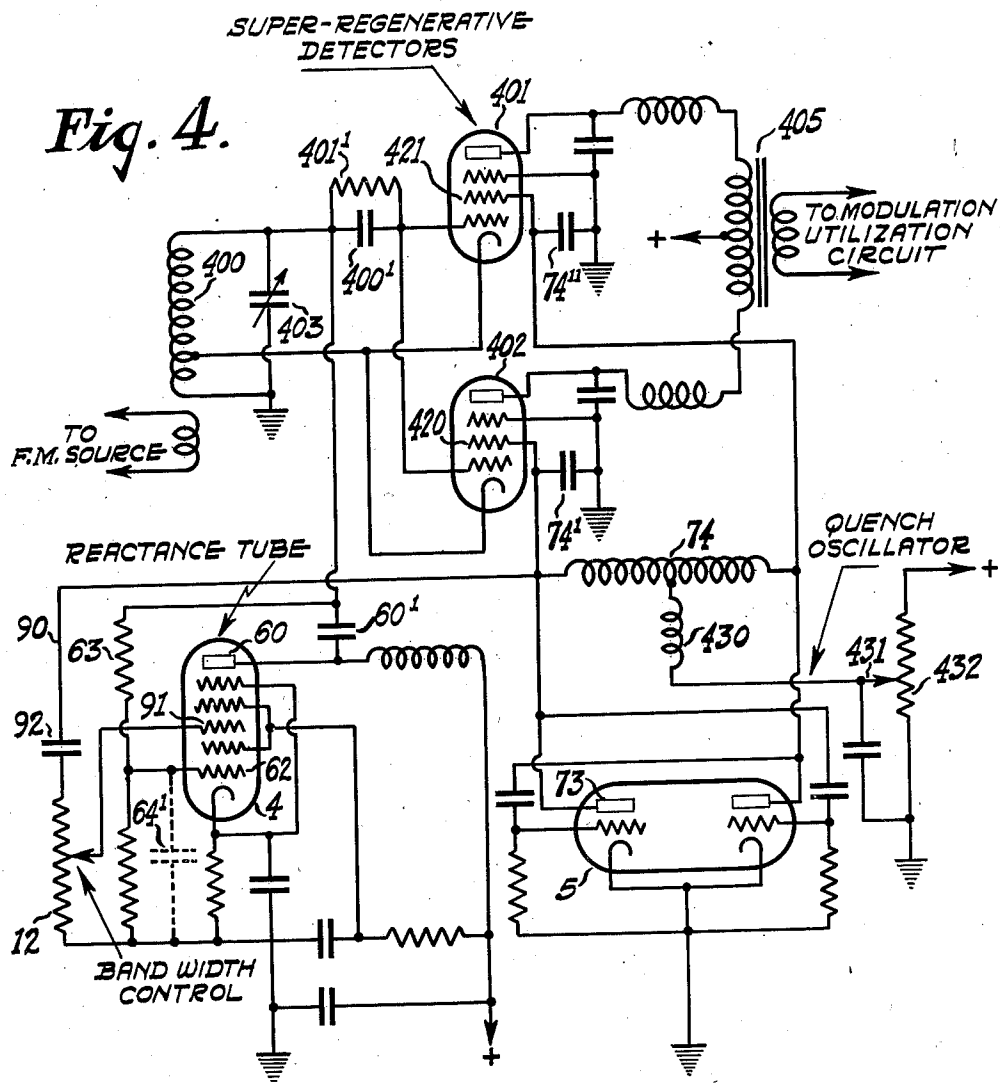
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FREQUENCY MODULATION DETECTOR CIRCUIT

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2 Sheets-Sheet 2



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2,351,193

FREQUENCY MODULATION DETECTOR
CIRCUITMurray G. Crosby, Riverhead, N. Y., assignor to
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Application June 13, 1942, Serial No. 446,876

19 Claims. (Cl. 250—27)

My present invention relates generally to detectors of angular velocity-modulated carrier waves, and more particularly to improvements in frequency modulated carrier wave detectors.

As is well known to those skilled in the art of frequency modulation transmission and reception, the usual method of frequency modulation detection involves the feeding of the frequency modulated carrier wave (FM) energy to a discriminator-rectifier network capable of converting the FM wave energy into amplitude modulated carrier wave energy. The latter is then rectified to provide the modulation signal voltage corresponding to the modulation signals originally applied to the carrier wave at the transmitter. The discriminator section of the demodulator network usually comprises sloping filters having overlapping characteristics somewhat in the fashion shown by Fig. 2 of this application. The output voltages of the rectifiers are connected differentially to combine the rectified signal voltages which are 180 degrees apart in phase by virtue of the opposite slopes of the discriminator filters.

It is one of the main objects of my present invention to provide a single tuned circuit as the discriminator network of an FM demodulator of the balanced type.

Another important object of this invention is to provide a discriminator-rectifier for angular velocity-modulated carrier waves wherein a single tuned circuit is used to provide the sloping filters for opposed detectors whereby there is provided a frequency discriminator which may be easily tuned from one frequency to another since there is only one tuning control.

Another important object of this invention is to provide a system for converting FM wave energy into amplitude modulated wave energy for detection, and in which a balanced detection is obtained with a single tuned circuit.

Still another object of the invention is to provide a discriminator for a frequency modulation detector wherein the discriminator consists of a single tuned circuit; the side of the resonance curve of the tuned circuit providing one of the sloping filters of the discriminator, and the other sloping filter being provided by switching the reactance of a reactance tube across the aforesaid tuned circuit; the two detectors fed by the single tuned circuit being alternately switched on in synchronism with the switching of the reactance tube so that one detector is operated with tuning proper for one sloping filter while the other de-

tor is in operation with the tuning proper for the opposite sloping filter.

Still other objects of this invention are to provide a simplified discriminator network for a frequency modulation receiver, wherein means is provided for easily and effectively varying the operating band width.

Still another object of my invention is to embody the mode of operation disclosed herein in a simplified super-regenerative frequency modulation receiver.

Still other objects of my invention are to improve generally the efficiency and simplicity of frequency modulation radio receivers, and more especially to provide discriminator-rectifier circuits which are reliable in operation and economically manufactured and assembled.

The novel features which I believe to be characteristic of my invention are set forth in particularity in the appended claims; the invention itself, however, as to both its organization and method of operation will best be understood by reference to the following description taken in connection with the drawings in which I have indicated diagrammatically several circuit organizations whereby my invention may be carried into effect.

In the drawings:

Fig. 1 shows one embodiment of the invention applied to frequency modulation reception, Fig. 2 illustrates the characteristics of the discriminator network,

Fig. 3 shows a modification of the FM demodulator wherein circuit simplification is secured,

Fig. 4 shows a further embodiment of the invention applied to secure super-regenerative action.

Referring now to the accompanying drawings, there is shown in Fig. 1 that portion of an FM superheterodyne receiver essential to a proper understanding of the invention. The network shown in Fig. 1 is that section of an FM receiver which acts as the discriminator-rectifier network. Assuming that the receiver is employed in the presently assigned FM broadcast band of 42-50 megacycles (mc.), those skilled in the art of such reception will know that each channel has a maximum width of 200 kilocycles (kc.). Actually, at the FM transmitter the carrier is deviated to a maximum of 75 kc. on either side of the carrier, or center, frequency of the transmitter.

The carrier frequency is deviated in accordance with the amplitude of the modulation signals, whereas the rate of frequency deviation is dependent upon the modulation frequencies per

se. The present invention is not limited to the 42 to 50 mc. band, since it is equally applicable to lower frequency bands or even higher frequency bands. Furthermore, the invention is not restricted to high frequency deviation systems, but may be utilized in connection with small frequency deviation systems. Furthermore, the generic term "angular velocity-modulated carrier wave" is utilized herein to designate that the system is applicable to frequency, or phase, modulated carrier wave reception.

Where the receiver is of the superheterodyne type, the collected FM wave energy is reduced in center frequency to an intermediate frequency (I. F.) value which may be chosen from a range of 2 to 20 mc. as, for example, 4 mc. The usual type of first detector circuit is employed for that purpose. The I. F. energy is passed through one or more I. F. amplifiers. Usually the I. F. energy is subjected to a limiter action in order to minimize amplitude modulation effects which exist in the energy prior to the demodulator. As is well known to those skilled in the art, such amplitude modulation effects commonly arise due to a variety of reasons which need not be set forth in this application. The limiter functions to feed the FM wave energy to the discriminator network so that the detected signal voltage will correspond exactly to the modulation signals at the transmitter.

Assume, then, that tube 1 in Fig. 1 may represent the last I. F. amplifier in such cases where no limiter is employed, or that the tube 1 embodies an amplitude modulation limiter. The plate circuit of tube 1 includes a resonant circuit 8 which is tuned normally to the frequency F_1 on one side of F_c , as shown in Fig. 2. The significance of this normal resonating of circuit 8 will be explained at a later point. The circuit 8 functions as the discriminator section of the FM demodulator circuit. The rectifier section of the demodulator comprises the diode rectifiers 6 and 7 whose cathodes are connected together by series load resistors 13 and 14. The cathode end of resistor 14 is grounded, while the cathode end of resistor 13 is connected to the input electrode of the modulation signal voltage amplifier. The latter, where the modulation signals are of audio frequency, may comprise one or more audio amplifiers followed by a proper reproducer. Each of the load resistors 13 and 14 is bypassed by its respective I. F. bypass condenser 13' and 14'.

The junction of resistors 13 and 14 is connected to the junction of the series-arranged resonant input circuits 15 and 16. The anode of diode 6 is connected to one side of input circuit 15, while the anode of diode 7 is connected to the opposite side of circuit 16. The resonant circuits 15 and 16 are fed with amplitude modulated carrier wave energy derived from the FM wave energy by a pair of tubes 2 and 3 which function as modulated, or controlled, amplifier tubes. Each of tubes 2 and 3 may be of the well known pentagrid type. The cathodes of tubes 2 and 3 are connected in common to ground.

The plate 2' of tube 2 is connected to the high potential side of resonant output circuit 17, while the plate 3' of tube 3 is connected to the high potential side of resonant output circuit 18. The junction of circuits 17 and 18 is connected to a common positive potential terminal of a direct current source, the current supply lead being bypassed to ground for I. F. currents. Each of resonant circuits 17 and 18 may be shunted by respective damping resistors 17' and 18' to pro-

vide the proper pass band characteristics. Circuits 17 and 18 are reactively coupled, while circuits 18 and 16 are similarly reactively coupled. Each of 17-18 and 18-16 is a band-pass transformer tuned to the mean, or center, frequency of the FM energy (I. F.) fed to the input grid of tube 1.

The tube 2 has a third grid thereof designated by the numeral 20, and the latter is connected by direct current blocking condenser 21 to the plate side of the discriminator circuit 8. The lead to grid 20 is also connected to the third grid 30 of tube 3. Each of grids 20 and 30 is shown located within a positive electrostatic shielding field. The first grids 40 and 50 respectively of tubes 2 and 3 are connected through respective direct current blocking condensers to opposite sides of an oscillatory tank circuit 9. The oscillatory circuit 9 is part of a super-audible push-pull oscillator network which includes the twin-triode tube 5. The function of the oscillator is to control the degree of amplification of the amplifier tubes 2 and 3, as well as to control the effectiveness of a reactance tube 4.

Considering first the construction and function of the reactance tube, the tube 4 is shown as a pentagrid type tube whose plate 60 is connected to the plate side of the discriminator circuit 8. The cathode of the reactance tube is connected to ground through the usual carrier by-passed biasing resistor 61. The plate to cathode impedance of tube 4 is, therefore, effectively in shunt across the resonant circuit 8. This impedance is made to simulate a shunt inductance across tuned circuit 8 when the tube 4 is biased to its operating point. This is accomplished in well known manner by applying to the first grid 62 of the tube an alternating voltage which is in phase quadrature with the alternating voltage at the plate 60.

The quadrature voltage is secured by shunting the plate to cathode impedance of tube 4 with a phase shifter which comprises resistor 63 in series with the condenser 64. The condenser 65 is a direct current blocking condenser, and the resistor 66 acts as a grid return resistor for grid 62. As is well known, the resistive magnitude of resistor 63 is high compared to the reactance value of condenser 64. In that case the alternating voltage applied to grid 62 is substantially in phase quadrature with the alternating voltage at plate 60. Under this condition the plate to cathode impedance of tube 4 simulates a shunt inductance across circuit 8.

The effectiveness of reactance tube 4, as well as the degree of amplification of each of tubes 2 and 3, is controlled by the push-pull oscillator now to be described. The cathodes of the triodes of tube 5 are connected in common to ground. Grid 70 of one of the oscillator triodes is connected through the direct current blocking condenser 71 to the plate 80 of the other oscillator triode. The grid return resistor 72 connects the grid 70 to ground. The plate 73 is connected to one end of the oscillator tank circuit coil 74, while the plate 80 is connected to the opposite end of coil 74. The grid 81, associated with plate 80, is connected through a direct current blocking condenser 82 to the plate 73. The grid 81' is connected by grid return resistor 83 to ground. The coil 74 is shunted by the variable condenser 75 so that the oscillator tank circuit 9 may be adjusted to a desirable operating frequency. The oscillator is tuned to a super-audible value. Its frequency is

preferably several times the frequency of the maximum modulation frequency which is being received. The plates 73 and 80 of tube 5 can be supplied with proper positive potential from a positive potential lead, which is properly bypassed for oscillation frequencies, connected to the midpoint of oscillator coil 74.

The oscillatory energy developed across tank circuit 9 is applied to each of grids 40 and 50 of tubes 2 and 3. Grid 40 is connected by a direct current blocking condenser to one end of coil 74, while grid 50 is connected through a direct current blocking condenser to the opposite end of coil 74. The oscillatory voltage is applied to tube 4 by connecting one end of coil 74, for example the end connected to oscillator plate 73, through lead 90 to the third grid 91 of reactance tube 4. The grid 91 is connected to the adjustable contact element of potentiometer 12. The low potential end of the potentiometer resistor is connected to ground, while the opposite end is connected through the direct current blocking condenser 92 to the lead 90. Adjustment of the potentiometer 12 furnishes a band width control.

Considering, now, the operation of the circuit shown in Fig. 1, tubes 2 and 3 are generally amplifier tubes which are controlled by the push-pull oscillator. Tube 4 is a reactance tube which affects the resonant frequency of tuned circuit 8. The circuits of tubes 2 and 3 are transformer-coupled to diodes 6 and 7. The FM wave energy is applied to the input grid of tube 1, and the detected modulation signal voltage is taken off from the differentially connected resistors 13 and 14. In operation, tuned circuit 8 would normally be tuned to the frequency F_1 shown in Fig. 2. F_1 is the peak frequency of the normal resonance curve of tuned circuit 8. This places the carrier frequency F_c on the high frequency side of the normal resonance curve of tuned circuit 8.

One of the amplifier tubes, for example tube 3, amplifies the output energy of tuned circuit 8 when its grid 50 is supplied with a positive half cycle from the oscillator tank circuit 9. At this same time the other tube 2 is biased to space current cut-off by the negative half cycle received from oscillatory tuned circuit 9. The reactance tube 4 is, also, biased to space current cut-off by this same negative half cycle. Thus, for the duration of a half cycle the tube 3 amplifies the output energy of tuned circuit 8, and passes the amplified energy to the diode rectifier 7. For the duration of the next half cycle tube 2 will be operative, and reactance tube 4 will be biased to its operating point.

During this succeeding half cycle the tube 3 will, of course, be biased to cut-off, and will, therefore, be inoperative. Hence, during that half cycle the tube 2 amplifies the output energy of tuned circuit 8. However, during this half cycle the reactance tube 4, by virtue of the inductive effect of its plate to cathode impedance, tunes circuit 8 to frequency F_2 . The latter is on the opposite side of F_c . In other words, the effect of tube 4, during its operation, is to change the resonance curve of tuned circuit 8 to the right hand one of the two curves shown in Fig. 2.

The peak frequency of the new resonance curve is spaced from center frequency as much as F_1 was previously spaced on the opposite side. Accordingly, it will be seen that one of the modulated amplifier tubes amplifies the output energy of the tuned circuit 8 when it is tuned below the carrier, or center, frequency during one half cycle

of the control, or switching, wave produced by oscillator tube 5. On the other hand, the other amplifier tube amplifies the output energy during the succeeding half cycle of the control, or switching, oscillations, at which time reactance tube 4 tunes the tuned circuit 8 to the higher frequency F_2 .

It will, therefore, be appreciated that although embodying but a single tuned circuit, nevertheless the effect of a pair of sloping filters is simulated by virtue of the tuned circuit 8 having operatively associated therewith a reactance tube. The latter functions alternately to shift the peak frequency value of the resonance curve of tuned circuit 8 in accordance with the alternations of a source of control oscillations. The potentiometer 12 controls the amount of switching voltage fed to the reactance tube control grid 91. Hence, the frequency separation between the peak frequencies F_1 and F_2 may be controlled. Accordingly, the potentiometer 12 acts as a control over the band width of the discriminator circuit 8. For example, when receiving FM wave energy in the 42 to 50 mc. band, the potentiometer 12 would be adjusted so that the frequency spacing between F_1 and F_2 will be in excess of 150 kc.

This invention is not limited to a reactance tube which simulates an inductive effect across the discriminator circuit 8, nor is it limited to the utilization of a separate switching oscillator. Thus, in Fig. 3 I have shown the reactance tube 4 having its plate to cathode impedance simulate a capacity effect. The phase shifter in this case comprises condenser 212 and resistor 213 arranged in series between the plate and ground. The control grid 62 of the reactance tube is connected to the junction of the condenser and resistor. Since the quadrature voltage is now taken off across resistor 213, it is well known a capacity effect will be produced across circuit 8 when tube 4 is operative.

The controlled amplifier tubes are now designated by numerals 202 and 203. The inner control grids 220 and 221 respectively of tubes 202 and 203 are connected through the direct current blocking condenser 21 to the plate side of discriminator circuit 8. The plates of each of tubes 202 and 203 are connected to opposite ends of the series-arranged resistors 206 and 207. Each of resistors 206 and 207 is bypassed for I. F. currents by respective shunt condensers 206' and 207'. The junction of the resistors is connected to a source of positive potential. The switching oscillations are provided from a resonant tank circuit 205. One of the sides of the latter is connected to the screen grid electrodes of tube 202 while the opposite side of the tank circuit is connected to the screen grid electrodes of tube 203. The midpoint of the tank coil is connected to a source of positive potential through a radio frequency choke coil 205'.

The inner control grids 230 and 231 of tubes 202 and 203 respectively are each connected by direct current blocking condensers in the cross-connection form of circuit shown in Fig. 3. Thus, grid 231 is connected to the side of tank circuit 205 which is connected to the screen grids of tube 203. The grid 230 is connected to that side of tank circuit 205 to which the screen grids of tube 202 are connected. The junction of the grid return resistors of each of grids 230 and 231 is connected to the common cathode connection. The carrier by-passed biasing resistor 249, connected to ground, biases grids 220 and 221 so that they act as detector grids. The inner control grid 91 of

reactance tube 4 is connected by lead 240 to one side of the tank circuit 205, and in this way the switching oscillatory energy is applied to the control grid 91. The tank circuit 205 is tuned to a super-audible frequency. During positive half cycles of the switching oscillations the reactance tube 4 is operative. Due to the high reactance of condenser 212 and the low resistance of resistor 213, the plate to cathode impedance of tube 4 simulates a capacity across tuned circuit 8.

In this form of the invention tubes 202 and 203 are operated as detectors, and the detected output appears across resistors 206 and 207. Amplifiers 208 and 209 amplify the detected signal voltages for combination in transformer 211. This is done by having the control grids of each of tubes 208 and 209 connected to opposite ends of the resistor 250 whose midpoint is grounded. The ends of resistor 250 are connected by respective direct current blocking condensers to the opposite ends of load resistors 206 and 207.

In other words, tubes 202 and 203 act as the alternate controlled amplifiers, as in the case of tubes 2 and 3 of Fig. 1; they also function to provide the switching oscillations in the manner of oscillator tube 5 of Fig. 1; and additionally function in the manner of the opposed rectifiers 6 and 7. It will, therefore, be seen that tubes 202 and 203 of Fig. 3 provide a triple function in this circuit. The switch 210 in Fig. 3 adjusts the receiver for FM reception when it is adjusted so as to have the primary sections of transformer 211 arranged in push-pull connection. On the other hand the switch 210 can be arranged so as to have the primary winding sections in parallel arrangement, should it be desired to receive amplitude modulated carrier wave energy. Due to the use of a capacitive reactance tube in the circuit of Fig. 3 the tuned circuit 8 would be tuned above F_c , in other words to the peak frequency F_2 when the reactance tube 4 is biased to cut-off. When the switching oscillations adjust the bias of reactance tube 4 to its operating point, the tank circuit 8 will then be tuned below F_c to the frequency F_1 . The series connected condensers across circuit 205 act as screen bypass condensers, as well as tuning condensers. The junction of the series condensers is grounded.

The circuit arrangement shown in Fig. 4 shows how the present principle of operation may be applied to a super-regenerative circuit to produce back-to-back, or balanced, frequency modulation detection employing but a single tuning control. In this circuit arrangement tubes 401 and 402 are super-regenerative detector tubes. The cathodes thereof are connected in common to an intermediate point of the coil 400 which is part of the resonant input circuit of the detector tubes. The adjustable condenser 403 shunts the coil 400, and adjusts the tuning thereof for best output. The tuning of circuit 400—403 is so chosen that, when the reactance tube is biased to cut off, the resonant frequency is off to one side of the center frequency. The source of the FM wave energy can be an antenna, the ultra-high frequency amplifier of a receiver, or it can be the usual I. F. amplifier network of a superheterodyne receiver. The input control grids of the detector tubes are connected in common to the right hand terminal of the grid condenser 400', the latter being shunted by the grid leak resistor 401'. The plates of the detector tubes are connected through radio frequency choke coils to opposite ends of the primary winding of the modulation voltage output transformer 405. The midpoint of the primary 75

winding is connected to a source of positive potential.

Tubes 401 and 402 will, therefore, be seen to function as oscillating detector tubes, the circuit 400—403 acting as an oscillator tank circuit. The super-regenerative action is produced by quenching the oscillations of the detector tubes by a quench oscillator of the push-pull type. The quench oscillator is connected in very much the same fashion as is the push-pull oscillator shown in Fig. 1. That is, the twin triode tube 5 has its control grids cross-connected to the plates of the opposite triodes. The quench oscillator coil 74 has one end thereof connected by a lead to the screen grid 420 of tube 402, while the opposite end of coil 74 is connected by a separate lead to the screen grid 421 of the second detector tube 401. Each of grids 420 and 421 is bypassed to ground for radio frequency currents. The midpoint of the quench oscillator coil 74 is connected through coil 430 to an adjustable potentiometer contact element 431. The contact element 431 is adjusted along the potentiometer resistor 432 whose upper end is connected to a point of positive potential and whose lower end is at ground potential.

The reactance tube is constructed in very much the same manner as is shown in connection with Fig. 1. Hence, the same reference numerals are employed where the circuit elements are similar. The reactance tube 4 has its control grid 91 connected to the adjustable contact element of potentiometer 12 which functions as a band width control device. The lead 90 connects the upper end of potentiometer 12 to that end of coil 74 which is connected to the quench oscillator plate 73. The phase shifter comprises resistor 63 in series with condenser 64'. In this case the quadrature condenser, connected between the control grid 62 and cathode, is the inherent control grid to cathode capacity of the tube. The plate 60 of reactance tube 4 is connected through the direct current blocking condenser 60' to the high potential side of input coil 400.

In considering the operation of the system shown in Fig. 4, it will be understood that the oscillating detector tubes 401 and 402 are alternately quenched by means of quench oscillator 5. The quench oscillator may generally operate at a frequency in the vicinity of 100 kc. The quench tank circuit comprises coil 74 and condensers 74' and 74''. Potentiometer 432 is the conventional plate voltage control for adjusting the super-regenerative detectors to their optimum condition. The quench oscillator has its oscillations applied to the screen grids 421 and 420 of the oscillating detectors in push-pull relation so that one tube is quenched while the other is oscillating. The oscillations take place in the super-regenerative manner in which the oscillation builds up on the positive half cycle of the quench frequency. Hence, tube 401 will be operated during one half cycle, and tube 402 will function during the next half cycle of the quench frequency. It will be recognized that this operation is analogous to the operation described in connection with Fig. 1.

The reactance tube 4 has its plate to cathode impedance connected across the tuned oscillation circuit 400—403. The inductive reactance effect due to the tube 4 will be effective during one half cycle of the quench frequency, and ineffective during the other half cycle. Thus, while one of the oscillating detector tubes, for example 401, is operating, the quench oscillator will be

feeding a negative half cycle to the reactance tube 4 so as to bias it to cut-off. The circuit 400-403 then assumes the normal frequency without the effect of the reactance tube. During the next half cycle, however, tube 402 is operative, and the reactance tube 4 is biased to its operating point by the positive half cycle from the quench oscillator. This places a reactance across circuit 400-402 which detunes it from its normal frequency. The switching of the reactance tube and the oscillating detector tubes produces detected outputs which appear in the plate circuits of tubes 401 and 402 as though they were fed by separately tuned circuits having characteristics such as shown in Fig. 2.

Accordingly, it will be seen that the resultant effect of the circuit shown in Fig. 4 is to provide back-to-back detection which may be combined in push-pull by means of transformer 405 to receive FM wave energy. If it were desired to receive amplitude modulated carrier wave energy the plate circuits of the detector tubes could be connected in parallel instead of in push-pull. Potentiometer 12 controls the amount of quench voltage which controls the reactance tube 4, and thereby controls the frequency separation which would exist between F_1 and F_2 of the response curves of circuit 400-403.

While I have indicated and described several systems for carrying my invention into effect, it will be apparent to one skilled in the art that my invention is by no means limited to the particular organizations shown and described, but that many modifications may be made without departing from the scope of my invention, as set forth in the appended claims.

What I claim is:

1. In combination with a source of angular velocity-modulated carrier wave energy, a pair of opposed detectors, a resonant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, means for feeding energy developed across said resonant circuit to each of said detectors, means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value on the opposite side of said mean frequency, and additional means for rendering said reactive effect means ineffective concurrently with rendering of one of said detectors inoperative, said last additional means being adapted to render said one detector and reactive effect means concurrently effective when the other detector is rendered ineffective.

2. In a frequency modulated carrier wave receiving system, a single resonant input circuit, a pair of opposed rectifiers having a common modulation signal voltage output circuit, a pair of amplifiers, said amplifiers each having an input electrode coupled to said resonant input circuit, said amplifiers having respective output electrodes coupled to respective ones of said rectifiers, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing a reactive effect across said resonant circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a source of oscillatory energy connected to said reactance tube and to each of said amplifier input electrodes, said source of oscillatory energy rendering the reactance tube and one amplifier ineffective during one half cycle of the source of oscillatory energy and rendering the reactance

tube and said one amplifier effective during a succeeding half cycle.

3. A frequency discriminator in which a single sloping filter performs the functions of a pair of opposite sloping filters comprising means for alternately altering the frequency response of the single sloping filter, a pair of detectors having said single filter as a common input circuit, and said means at the same time switching the operation of the pair of detectors so that they alternately contribute to the output for utilization.

4. A frequency discriminator in which a single sloping filter performs the functions of a pair of opposite-sloping filters comprising means for alternately altering the frequency response of the single sloping filter, a pair of detectors fed in common by said single filter, and means so as to alternately excite said pair of detectors.

5. In combination with a source of angular velocity-modulated carrier wave energy, a pair of opposed detectors, a resonant circuit normally tuned to a frequency spaced from the mean frequency of said energy by a predetermined value, means for feeding said energy to said resonant circuit, means for feeding energy developed across said resonant circuit to each of said detectors, means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value on the opposite side of said mean frequency equal to said frequency spacing, control means for rendering said reactive effect means concurrently ineffective with one of said detectors, said control means being adapted to render said one detector and reactive effect means concurrently effective when the other detector is rendered ineffective.

6. In combination with a source of angular velocity modulated carrier wave energy, a pair of opposed rectifiers, a resonant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, means for feeding energy developed across said resonant circuit to each of said rectifiers, means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value on the opposite side of said mean frequency, a control oscillator for rendering said reactive effect means ineffective concurrently with rendering of one of said rectifiers inoperative, said oscillator being adapted to render said one rectifier and reactive effect means concurrently effective when the other rectifier is rendered ineffective.

7. In combination with a source of angular velocity modulated carrier wave energy, and a pair of opposed rectifiers, a frequency discriminator comprising a single resonant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, means for feeding energy developed across said resonant circuit to each of said rectifiers, an electronic means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value on the opposite side of said mean frequency, a super-audible oscillator, connected to said rectifiers and electronic means, for alternately rendering said electronic means ineffective concurrently with rendering of one of said rectifiers inoperative.

8. In combination with a source of angular velocity-modulated carrier wave energy, a frequency discriminator comprising a single reso-

nant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, means for demodulating energy developed across said resonant circuit, electronic means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value located on the opposite side of said mean frequency, and additional means for cyclically rendering said reactive effect means ineffective.

9. In a frequency discriminator for frequency modulated carrier wave energy, a single tuned circuit normally resonated to a frequency spaced by a predetermined frequency value from a predetermined center frequency which is the mean frequency of said wave energy, electronic means for providing a reactive effect across the tuned circuit sufficient to tune it to the opposite side of center frequency by said frequency spacing, and means for cyclically rendering said electronic means ineffective.

10. In a frequency modulated carrier wave receiving system of the super-regenerative type, a resonant input circuit, a pair of opposed detectors having a common modulation signal voltage output circuit, said detectors each having an input electrode coupled to said resonant input circuit, means for regenerating said input circuit, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing a reactive effect across said resonant circuit sufficient to resonate the latter to the opposite side of the center frequency, a source of quench oscillatory energy connected to said reactance tube and to each of said detector input electrodes, said source of oscillatory energy rendering the reactance tube and one detector ineffective during one half cycle and rendering the reactance tube and said one detector effective during a succeeding half cycle.

11. In combination with a pair of opposed detectors, a frequency discriminator consisting of a single tuned circuit, means for varying the frequency of the tuned circuit thereby to enable it to simulate the action of a pair of opposite-sloping filters, and means for alternately rendering said varying means ineffective while concurrently alternately switching the output of the tuned circuit from one detector to the other thereby alternately to excite said detectors.

12. In a frequency modulated carrier wave receiving system, a single resonant input circuit, a pair of opposed detector tubes having a common modulation signal voltage output circuit, said detectors each having an input electrode coupled to said resonant input circuit, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing a reactive effect across said resonant circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a resonant tank circuit, tuned to a super-audible oscillation frequency, connected to certain of the electrodes of the detector tubes thereby to provide a source of oscillatory energy, means connected to said reactance tube to apply oscillations thereto, said source of oscillatory energy rendering the reactance tube and one detector ineffective during one half cycle of the source and rendering the reactance tube and the other detector effective during a succeeding half cycle.

13. In a frequency modulated carrier wave receiving system, a pair of opposed rectifiers having a common modulation signal voltage output circuit, a pair of amplifiers, said amplifiers each having an input electrode, said amplifiers having respective output electrodes coupled to respective ones of said rectifiers, a discriminator circuit tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, means coupling said discriminator to the input electrodes, a reactance tube circuit providing a reactive effect across said circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a source of oscillatory energy connected to said reactance tube and to each of said amplifier input electrodes, said source of oscillatory energy rendering the reactance tube and one amplifier ineffective during one half cycle and rendering the reactance tube and said one amplifier effective during a succeeding half cycle.

14. In a frequency modulated carrier wave receiving system, a single resonant input circuit, a pair of opposed rectifiers having a common modulation signal voltage output circuit, a pair of amplifiers, said amplifiers each having an input electrode coupled to said resonant input circuit, said amplifiers having respective output electrodes coupled to respective ones of said rectifiers, by band-pass transformers, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing an inductive effect across said resonant circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a source of super-audible oscillatory energy connected to said reactance tube and to each of said amplifier input electrodes, said source of oscillatory energy rendering the reactance tube and one amplifier ineffective during one half cycle and rendering the reactance tube and said one amplifier effective during a succeeding half cycle.

15. In a frequency modulation receiving system of the type using a pair of opposed rectifiers and a single tuned circuit as the discriminator; the method which includes producing control oscillations, applying frequency modulated carrier wave energy to the single circuit, normally tuning the tuned circuit to one side of the mean frequency of said wave energy, and cyclically varying the frequency of the single circuit in response to the control oscillations.

16. In a frequency modulated carrier wave receiving system, a discriminator comprising a single resonant input circuit, a pair of opposed rectifier tubes having a common modulation signal voltage output circuit, said tubes each having an input electrode coupled to said resonant input circuit, said tubes having respective output electrodes coupled to said output circuit, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing a reactive effect across said resonant circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a source of oscillatory energy connected to said reactance tube and to each of said input electrodes, said source comprising a tank circuit tuned to a superaudible frequency, each of said tubes including at least two electrodes cooperating with the tank circuit to provide oscillatory energy, said source of oscillatory energy rendering the reactance tube and one tube ineffective during

one half cycle of the source and rendering the reactance tube and said one tube effective during a succeeding half cycle.

17. In combination with a source of angular velocity-modulated carrier wave energy, a pair of opposed detector tubes, a resonant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, means for feeding energy developed across said resonant circuit to each of said detector tubes, means for providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value located on the opposite side of said mean frequency, a superaudible control oscillator for rendering said reactive effect means ineffective concurrently with rendering of one of said detector tube inoperative, said oscillator comprising an oscillatory tank circuit common to oscillation electrodes provided in each detector tube, said oscillator being adapted to render said one detector and reactive effect means concurrently effective when the other detector is rendered ineffective.

18. In combination with a source of angular velocity-modulated carrier wave energy, a frequency discriminator comprising a single resonant circuit normally tuned to a frequency located on one side of the mean frequency of said energy, means for feeding said energy to said resonant circuit, opposed detector tubes for demodulating energy developed across said resonant circuit, means for

providing a reactive effect across said resonant circuit such as to change the resonant frequency of said circuit to a value located on the opposite side of said mean frequency, and additional means consisting of an oscillatory tank circuit common to oscillation electrodes in each detector tube, for cyclically rendering said reactive effect means ineffective.

19. In a frequency modulated carrier wave receiving system, a discriminator consisting of a single resonant input circuit, a pair of opposed detector tubes having a common modulation signal voltage output circuit, said detectors each having an input electrode coupled in parallel to said resonant input circuit, said resonant circuit being tuned normally to one side of the center frequency of applied frequency modulated carrier wave energy, a reactance tube circuit providing a reactive effect across said resonant circuit sufficient to tune the latter to a frequency located on the opposite side of the center frequency, a resonant tank circuit connected to certain of the electrodes of each of the detector tubes thereby to provide a source of oscillatory energy, means connected from the tank circuit to said reactance tube to apply oscillations thereto, said source of oscillatory energy rendering the reactance tube and one detector tube ineffective during one half cycle of the source and rendering the reactance tube and the other detector effective during a succeeding half cycle.

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