

April 26, 1938.

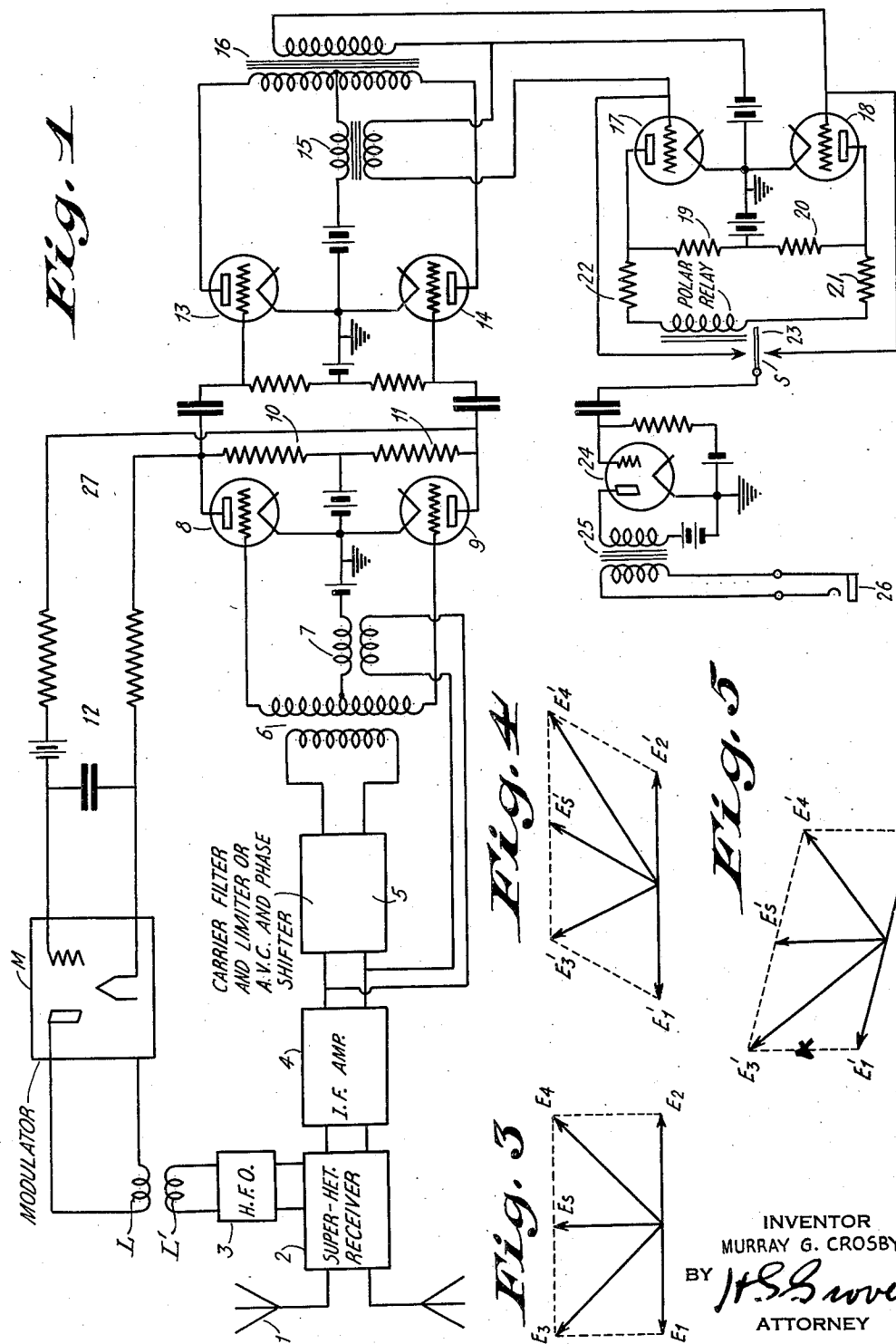
M. G. CROSBY

2,115,360

RECEIVER

Filed Jan. 21, 1935

2 Sheets-Sheet 1



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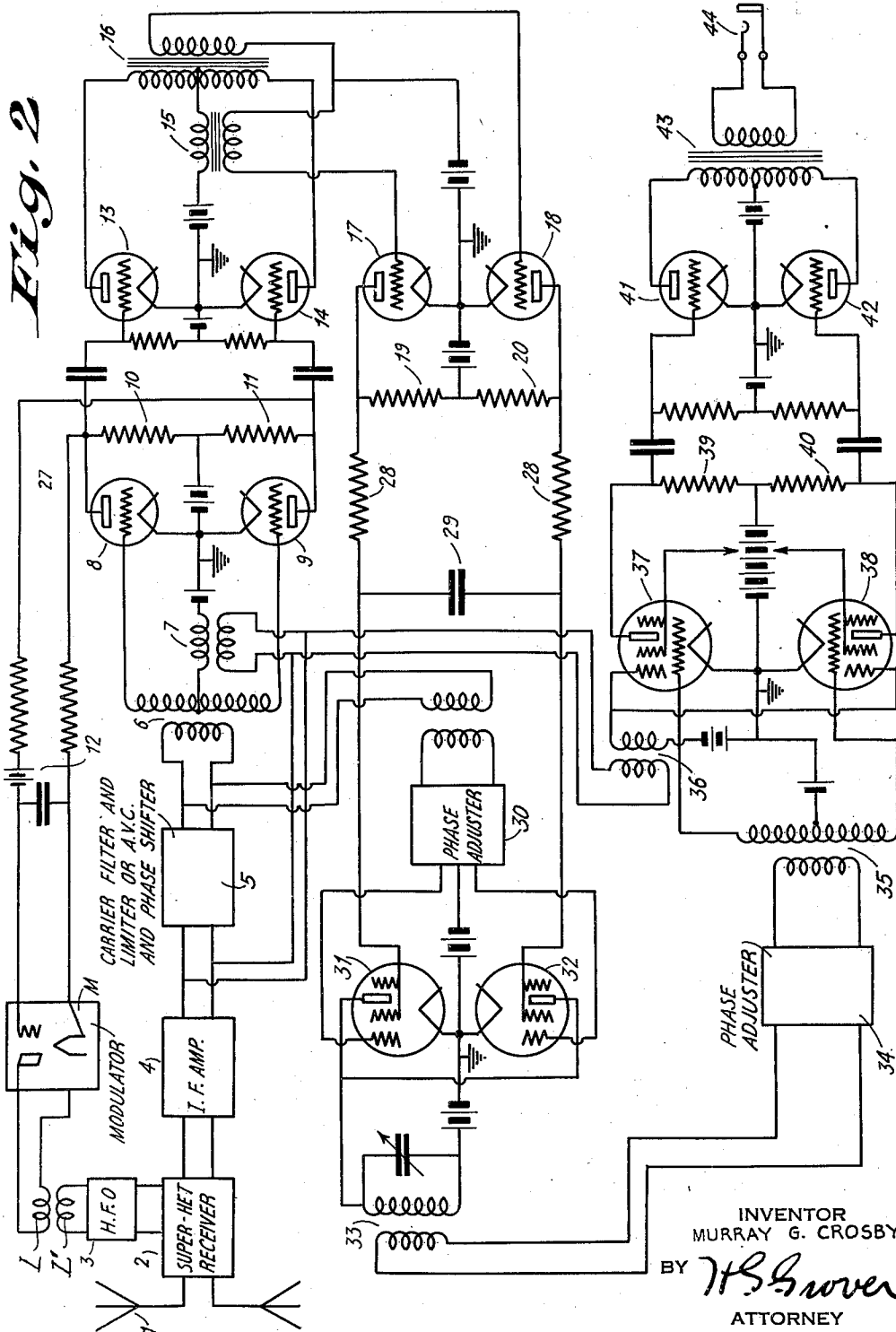
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2 Sheets-Sheet 2



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2,115,360

RECEIVER

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Application January 21, 1935, Serial No. 2,639

24 Claims. (Cl. 250—20)

This invention relates to means for receiving waves modulated in phase or in amplitude and includes means for causing said receiver to be sensitive to the reception of said waves irrespective of the nature of the modulation thereon and irrespective of the fact that the nature of the modulation on said waves may change in character from time to time due to causes encountered during the transmission of said signals.

More in particular this invention relates to a type of receiver wherein an automatic correction is produced to compensate for the type of multipath transmission fading distortion in which the signal modulation is distorted from an amplitude modulated wave to a phase modulated wave, or vice versa.

In my novel receiver a modulated wave is detected by two demodulators, one of which is primarily responsive to phase modulated waves and the other to waves modulated in amplitude. A differential voltage is produced by means described more in detail hereinafter in the outputs of the two demodulators and is utilized to actuate a phase shifting device which adjusts the phase of the filtered carrier utilized for demodulating purposes so that the audio detectors which render the signal for recording purposes are receptive to the type of modulation coming in at the particular time.

In an alternative arrangement, the differential voltage operates a switching device which switches the receiver output used for signal purposes from a phase modulation detector to an amplitude modulation detector.

In Crosby U. S. appln. Ser. No. 719,643, filed April 9, 1934, Patent #2,019,446 dated October 29, 1935, I have disclosed a receiver which resembles the present receiver to the extent that in said receiver of said prior application the demodulator is caused to respond to the particular type of modulation predominant on the received wave. For example, if a phase modulated wave has been distorted so that it has the semblance of an amplitude modulated wave, the receiver of the prior disclosure will amplify and demodulate the wave and render the signals. Conversely, if an amplitude modulated wave has been transmitted and has been distorted during transmission so that it takes the character of a phase modulated wave, said receiver will receive, amplify, demodulate and record the same. This is accomplished by switching or reversing the nature of the demodulator at a rapid rate.

The receiver of the present invention has the advantage that it is capable of automatically

choosing the condition of reception which is best at all times and automatically adapts itself to such reception. In the receiver of Crosby, appln. Ser. No. 719,643, Patent #2,019,446, there might be a case where the modulation would remain undistorted for long intervals during which the switching device of said prior receiver would be operated unnecessarily. Consequently, the said switching device might impair the signal to noise ratio. To illustrate this point, let the following example be taken. If the signal were being received as pure amplitude modulation and the switching device were in operation, the amplitude modulation signal and noise would be present one half of the time, so that their output would be halved. The other half of the time, the phase modulation noise would also be present. Thus, the receiver output might consist of one unit of signal as compared to two units of noise. In the receiver of the present invention, when pure amplitude modulation is received, the automatic adjustment makes the receiver receptive only to amplitude modulation, so that one unit of signal and one unit of amplitude modulation noise only is present. Consequently, an improvement of two to one in the signal noise ratio is effected in the present receiver, as compared to receivers known heretofore. The same is true where the wave received is modulated in phase only.

The novel features of my invention have been pointed out with particularity in the claims appended hereto.

The nature of my invention and the manner in which the same is carried out will be understood from the following detailed description thereof and therefrom, when read in connection with the attached drawings throughout which like reference numerals indicate like parts in so far as possible, and in which:

Figure 1 illustrates a receiver including signal amplifying means, a detector from which the amplified signal may be obtained, and a pair of differential detectors which control the connection between the detector from which the signal is obtained and the receiver in a manner that is primarily responsive to that type of modulation on the signal wave when it reaches the receiver;

Figure 2 is a modification of the arrangement of Fig. 1; however, in Fig. 2, automatic means is provided for rendering the detector sensitive or responsive to that type of modulation being received at the particular instant only; while

Figures 3 to 5 inclusive, are vector diagrams

utilized in illustrating the operation of the receivers in the prior figures.

The general operation of my device will be pointed out briefly first in connection with the drawings. Reference will be made to the receiver of Fig. 1 which shows a specific embodiment in which a switch S at the input of the audio amplifier 24 from which the signal for recording purposes is obtained is automatically connected to the output of transformer 16 the input of which is connected in push-pull relation to the anodes of a pair of differentially connected detectors when the received wave is modulated in phase either intentionally or in a manner to simulate phase modulation, due to distortion during transmission. When the wave received is amplitude modulation, or simulates amplitude modulation due to distortion, the said detector from which the signal for recording purposes is obtained is connected in a manner described later, by the switch to the secondary winding of transformer 15, the primary winding of which is connected in parallel with the anodes and cathodes of said differentially connected detectors. In this manner, the amplifier from which the recorded energy is obtained is caused to respond to that type of modulation which is strongest.

More in detail, the signal coming in on the antenna 1 is fed to a superheterodyne receiver consisting of a radio frequency amplifier and demodulator 2, a high frequency oscillator 3 and an intermediate frequency amplifier 4. The high frequency oscillator 3 is of the automatic frequency controlled type, whose frequency is partially dependent upon tuning of the circuits thereof and partially dependent upon the nature of the energy supplied thereto by way of the automatic frequency controlled energy supply line 27. Energy from the output of the intermediate frequency amplifier 4 is supplied to a unit 5, including a carrier filter circuit preferably of the crystal type, an amplitude limiter or automatic volume control, and where desired, a phase shifter.

The filtered and limited energy is fed from the output of 5 to the primary winding of a transformer 6, the secondary winding of which connects the control grids of the differential detector tubes 8 and 9 in push-pull relation, so that stripped or filtered carrier energy is applied from 5 in phase opposition to the control grids of 8 and 9, as has been illustrated in Fig. 3 by vectors E_1 and E_2 . At the same time, unfiltered carrier energy is supplied from the output of the intermediate frequency amplifier 4 to the primary winding of a transformer 7, the secondary winding of which is connected in parallel between the control grids and cathodes of tubes 8 and 9, so that unfiltered carrier energy is supplied in phase to the control grids of the differential detectors 8 and 9 as indicated by the vector E_3 of Fig. 3. The resultant voltages are represented by the vectors E_3 and E_4 when the intermediate frequency obtained by beating oscillations from 3 with the received wave, is at the peak of the filter in 5. If the frequency of the oscillator 3 or received signal should change, the vectors of Fig. 3 may shift to the position E_1' and E_2' shown in Fig. 4 due to the phase change of E_1 and E_2' as effected by the crystal filter. Now, the resultant voltages E_3' and E_4' are no longer equal. Differential currents are developed through resistances 10 and 11 and these currents produce voltages which act through the time constant unit 12 and modulator M to shift the frequency developed by 3 in the direction necessary to put the beat frequency back to

the resonance frequency of the filter circuit in 5 and the frequency of the intermediate frequency amplifier 4. The time constant of the line 27 condenser and resistance 12 and modulator M input is such that it responds to frequency changes but not to signal modulations. A change of frequency in the opposite direction acts in a sense oppositely to that indicated in Fig. 4. The modulator M may include a thermionic modulator tube having its input connected by resistance and capacity to the control circuit 27, and its anode coupled to a reactance L in turn coupled to the reactance L' in a circuit of the thermionic generator of the unit 3. The reactance L' determines in part the frequency of the oscillations generated by the oscillator in 3. The condenser in the time unit 12 also serves the purpose of keeping the audio voltages from reaching the high frequency oscillator circuits in 3. In setting forth the operation of the frequency control circuits the modulating potentials may be and have been disregarded. The device operates as indicated on a change of frequency irrespective of the type of modulation on the wave and irrespective of whether the change resulted from a change in the oscillations from 3 or of a change in the received wave.

The frequency control device, and in particular the differential detectors 8 and 9 and the time constant device 12 and modulator M have been described in detail and claimed in Crosby U. S. application, Ser. No. 616,803, filed June 13, 1932 Patent #2,065,565 dated December 29, 1936.

As described in Crosby U. S. application #616,803, Patent #2,065,565 dated December 29, 1936, when the unfiltered energy from 5 is applied cophasally to the control grids of the tubes in the differential detectors, and the unfiltered energy is applied in phase quadrature (90° or 270°) the energy so combined may be detected to produce an output characteristic of phase modulations on the unfiltered carrier when the detector outputs are added differentially by the push-pull connection. The same arrangement will give output energy which varies in amplitude in accordance with amplitude modulations on the unfiltered carrier etc., when the detector outputs are added in parallel by connecting the outputs in parallel. This is because the output of both tubes adds cumulatively in the output circuit, so that the output energy waxes and wanes at signal frequency.

The manner in which my receiver responds either to phase or amplitude modulation will now be described. In describing this operation reference will be made to Figs. 3, 4 and 5.

Referring to Fig. 3, E_1 and E_2 represent the filtered carrier voltage fed to detectors 8 and 9 via differential transformer 6. E_3 represents the signal voltage fed via transformer 7. These voltages combine to form resultant E_3 to one detector tube and resultant E_4 to the other detector tube. The 90 degree phase relationship between E_3 and the voltages E_1 and E_2 is produced by means of the phase shifter in unit 5. This 90 degree relation is maintained, except for the sudden phase deviations due to phase modulation, in this position by means of the automatic tuning control which, in turn, holds the intermediate frequency in tune with the carrier filter.

When phase modulation is applied, E_3 shifts in phase to the position E_3' in Fig. 4. The filtered carrier voltages E_1 and E_2 do not shift in phase since the carrier filter removes the side-bands due to modulation and consequently the phase

shift due to modulation. The resultant voltages fed to the detector grids are E_3' and E_4' which are decreased and increased in amplitude, respectively. E_5 also shifts with modulation in the opposite direction to that shown in Fig. 4. Hence, the resultants E_3' and E_4' are increased and decreased, respectively. In this manner the phase deviations with modulation (which are fast enough so that time constant circuit 12 does not allow the automatic tuning control to correct for them) produce amplitude modulations on the resultants. The envelopes of these amplitude modulations are 180 degrees apart in phase so that after detection the push-pull transformer 16 adds them in-phase in the coupling tube outputs.

When amplitude modulation is applied to the signal voltage, E_5 , the amplitudes of the resultants E_3 and E_4 are modulated also. The envelopes of the amplitude modulations will be in-phase so that the parallel connection transformer 15 will give the output.

The automatic tuning circuit functions in a manner similar to the detection of phase modulation but due to the time constant circuit 12, only slow changes of phase furnish controlling energy. The normal phase relation (or mean phase relation when phase modulation is applied) of the detector grid voltages is as shown in Fig. 3. When the frequency of the energy fed to the carrier filter, unit 5, varies, due to the extreme selectivity of the carrier filter, the phase of the output changes. The detector grid voltages are then as shown in Fig. 5. The filtered carrier has shifted in phase and the resultants E_3' and E_4' are no longer balanced with respect to amplitude. With the detector grid voltages unbalanced, their plate currents will be unbalanced and there will be a differential voltage across resistors 10 and 11. This differential voltage is fed via line 27 and the time constant circuit 12 to the grid of modulator tube M. A variation in the grid voltage of modulator M causes a variation in its plate impedance. The modulator's plate impedance is coupled to the high frequency oscillator tuning by means of a capacitive, inductive, resistive, or network coupling such as a transmission line or wave filter. Hence, a variation of the modulator plate impedance causes a variation in the tuning of the high frequency oscillator. By virtue of the controlling action of the voltage on the grid of the modulator, the variation of the high frequency oscillator tuning is held to a value just sufficient to restore the detectors to the balanced condition as portrayed in Fig. 3. When this balanced condition is obtained, the intermediate frequency energy is properly tuned through the carrier filter.

In order to combine the detector outputs in the two manners described above, the differential potentials produced by the differential currents in 10 and 11 are impressed as shown on the control grids of a pair of differential coupling tubes 13 and 14. The anode electrodes of tubes 13 and 14 are connected as shown in push-pull or differential relation, by way of the primary winding of transformer 16. The anode electrodes of tubes 13 and 14 are also connected in parallel as shown by way of the primary winding of transformer 15.

If the signal is coming in as a true amplitude modulation, or as a simulated amplitude modulation, energy varying at signal frequency will appear in the primary winding of 15 and be induced in the secondary winding of 15. If the

signal is coming in as true phase modulation, or simulated phase modulation, energy characteristic of the phase modulations on the signal will appear in the primary winding of the transformer 16 and will be induced in the secondary winding of transformer 16. Thus, if the outputs of these two transformers are detected as they are by demodulators 17 and 18, the differential currents across 19 and 20 may be utilized to operate a polarized relay 23, including a switch S to connect the receiver output including the tube 24, transformer 25 and telephone or other indicator jack 26 to the output of 13 and 14, either by way of the transformer 15 or by way of the transformer 16, dependent upon whether the amplitude modulations or the phase modulations on the unfiltered carrier predominate.

Resistors 21 and 22 match the impedance of the relay to the impedance of the detector outputs. Polarized relay 23 has its armature connected to the input of the receiver output coupling tube 24. The two contacts of the relay are connected to the high sides of the secondary windings of the transformers 15 and 16 so that when the armature is in one position the receiver output is connected to the amplitude modulation output transformer 15 and when the armature is in the other position, the receiver output is derived from the phase modulation transformer 16. Consequently, if an amplitude modulated signal is distorted during transmission so that it resembles a phase modulated wave predominantly, the relay will connect the tube 24 to the transformer 16, whereas if an amplitude modulated wave resulting from amplitude modulation or distorted phase modulation is received, the tube 24 will be connected to the output of transformer 15.

The receiver of Fig. 2 is identical with the receiver of Fig. 1 up to and including the detectors 17 and 18 and the resistors 19 and 20. Moreover, the numbered parts up to and including the parts referred to of the two circuits correspond. In Fig. 2, however, the differential voltage from detectors 17 and 18 is utilized to operate a phase adjuster which automatically keeps the phase of the filtered carrier at the proper adjustment to receive that type of modulation which appears to predominate. The differential voltage from detectors 17 and 18 is fed by way of time constant circuit 28, 29, in phase opposite to the screen grids of the modulator tubes 31 and 32 which, as shown, are connected in a differential phase modulation circuit including the elements 30, 31, 32 and 33. The control grids of tubes 31 and 32 are connected as shown by way of a phase adjuster 30 to the output of the carrier filter and amplitude limiter 5. The phase adjuster 30 is so set that the filter synchronized carrier wave reaches the control grids of the tubes 31 and 32 to excite the same in phase quadrature, or in 90° phase shifted relation. As indicated above, when the voltage on the screen grid of tube 31 goes down, the voltage on the screen grid of tube 32 goes up, and vice versa, since these tubes are connected as shown in push-pull relation to the tubes 17 and 18. When the voltage on the screen grid of one tube goes down, that tube, for example 31, becomes inoperative and allows the other modulator tube, for example 32, to furnish the carrier energy to the circuit 33. The phase of the carrier energy in 33 will accordingly be determined, in part at least, by the phase of the carrier supplied to the control grid of 32. When 32 becomes inoperative, 31 supplies energy to the

tank circuit 33, thus we have the two tubes alternately supplying energy to the tank circuit 33, and this energy shifts in phase between 90° as the limiting phase relation, as determined by the energy supplied from 30 to the control grids of tubes 31 and 32. A modulator of the type just described has been described in detail and claimed in Crosby application No. 690,330, filed Sept. 21st, 1933, and Crosby application No. 588,309, filed Jan. 23, 1932, Patent No. 2,018,577, dated May 25, 1937.

The carrier energy from the modulator 31, 32 is passed through a phase adjuster 34 to the primary winding of a transformer 35 and from the secondary winding of transformer 35 to the control grids of tubes 37 and 38. Since the secondary winding of transformer 35 connects the control grids of tubes 37 and 38 in push-pull relation, the carrier energy from 34 is supplied to said control grids in phase opposition. The suppressor grids of tubes 37 and 38 are connected in parallel with the secondary winding of a transformer 36, which is in turn connected with the output of the intermediate frequency amplifier 4. The transformer 36 accordingly impresses unfiltered and unlimited carrier energy in phase on the suppressor grids of tubes 37 and 38. The demodulated signal appearing across the resistors 39 and 40 is passed from said resistors to the coupling tubes 41 and 42 and thence to an indicator inserted at 44.

Phase adjuster 34 may be adjusted to give optimum output of the audio detectors 37 and 38. This adjustment is such that when the modulation is purely one kind, the audio output will be maximum. Thus if the modulation is pure amplitude modulation the transformer 15 having its primary winding connected in parallel with the anodes of tubes 13 and 14, will furnish the output energy. The differential transformer 16 will furnish no energy. The secondary winding of transformer 15 supplies energy to the input electrodes of tube 17 to thereby render tube 17 more conductive and cause more current to flow through resistor 19. This in turn lowers the voltage applied to the screen grid electrode of phase modulator tube 31, so that it becomes inoperative or less operative than the phase modulator tube 32. Tube 32 accordingly supplies the energy to circuit 33. Assumed that the phase of the carrier voltage fed to the grid of the tube 32 is 0°, since tube 32 is operative, the phase of the voltage in circuit 33 will be 0° also. The phase adjuster 34 is then adjusted for normal carrier exalted amplitude modulation reception in which the filtered carrier is combined by way of 32, 33, 34, 35 on the inputs of tubes 37 and 38, either in phase or 180° out of phase with the unfiltered energy supplied by way of 36 to the suppressor grids of tubes 37 and 38. Signals characteristic of the amplitude modulations on the received carrier are produced in the transformer 43.

With the above adjustments and circuit constants left the same, if the modulation on the carrier changes to phase modulation, the following circuit operation takes place. The differential transformer 16 will now be energized, while the transformer 15 will not be energized. Consequently, tube 18 has its control grid biased less negative and increased current flows in the anode circuit of tube 18 and through the resistance 20. This increase of current through resistance 20 lowers the potential applied to the screen grid of tube 32, and causes the same to become inoperative, or at least less operative than tube 31.

Hence, since the phase of the carrier voltage on the grid of tube 31 is 90° from that on the tube 32, the phase of the voltage in the circuit 33 will be 90°, instead of 0. Thus, the carrier has been shifted in phase 90° with respect to the unfiltered signal in 36 in the presence of phase modulations on the carrier wave, so that audio detectors 37 and 38 are now receptive to the said phase modulations on the received carrier.

In the circuit of Fig. 1, the mechanical relay 23 may be replaced by any system of electron tubes or gaseous discharge devices, such as thyratron and neon tubes, to effect the less mechanical switching action between the output of the receiver and the tube 24.

The circuit of Fig. 1 may also be arranged so that the relay 23 switches the phase of the carrier or signal between the two proper adjustments, e. g. 0 and 90°, to receive the two types of modulation.

All of the different circuits of my copending U. S. application #719,643 Patent #2,019,446 dated October 29, 1935, may be utilized for the automatic switching or phase adjusting, as disclosed in this application. For instance, the receiver of Fig. 4 of copending application, S. N. 719,643 Patent #2,019,446 dated October 29, 1935, may be arranged so that the coupled tubes 42 and 43 of said figure may be switched automatically according to the signal phase from one type of modulation to the other.

The circuits of Figs. 1 and 2 have been given for purposes of illustration only, and obviously many elements therein may be altered or substituted without departing from the spirit of the present invention. For example, any tube shown therein may be replaced by tubes of other types, so long as said tubes used for replacement have the necessary elements to serve the purposes in hand. Moreover, although I have shown several sources of potential, it will be realized that the said sources may be replaced by a single source.

I claim:

1. In combination, a system for demodulating signal modulated carrier waves, the type of modulation of which may vary during transmission due to natural causes, and automatic means connected with said system and energized by energy therefrom to vary the demodulation characteristic of said system as the type of said modulation on said wave varies.

2. In combination a thermionic device for demodulating signal modulated carrier waves, the type of modulation of which may vary during transmission due to natural causes, signal receiving and amplifying means, and automatic means connected with said device and with said receiving and amplifying means and energized by energy from the latter to vary the demodulation characteristic of said device as the type of modulation of said wave varies.

3. In combination a system for receiving and amplifying signal modulated carrier waves, the type of modulation of which may vary during transmission due to natural causes, thermionic signal demodulating means connected at its input to said system, automatic means connected with said system and with said demodulating means energized by energy from said system to vary the characteristic of said demodulating means as the type of said waves varies, and automatic means connected with said system and energized by carrier waves therein to maintain, said device tuned to said carrier wave.

4. In combination, a system for receiving car-

rier waves modulated in amplitude which modulation may be distorted during transmission to simulate phase modulation and automatic means connected with said system and energized by energy therefrom to alter the character of said system from an amplitude modulated wave receiving system to a phase modulated wave receiving system.

5. In combination, a system for receiving and amplifying carrier waves modulated in amplitude which modulation may be distorted during transmission to simulate phase modulation, wave demodulating means connected at its input to the output of said system, and automatic means connected with said system and with said wave demodulating means and energized by wave energy from said system to alter the character of said demodulating means from an amplitude modulated wave demodulating means to a phase modulated wave demodulating means.

6. In combination a system for receiving carrier waves modulated in amplitude which modulation may be distorted during transmission to simulate phase modulation, automatic means connected with said system and energized by wave energy therein to alter the character of said system from an amplitude modulated wave receiving system to a phase modulated wave receiving system, and automatic means coupled to said system and energized by wave energy therein to maintain said system tuned to the wave being received.

7. Means adapted to receive a signal carrying carrier wave, the type of modulations on which may vary from time to time during transmission comprising in combination, a carrier wave receiver including demodulating means, and means connected with said receiver for varying the demodulation characteristic of said demodulating means as the type of modulation of said wave varies.

8. Means adapted to receive a signal carrying carrier wave, the type of modulation on which may vary from time to time during transmission comprising in combination, a tunable carrier wave receiver including demodulating means, means connected with said receiver and said demodulating means for varying the demodulation characteristic of said demodulating means as the type of modulation of said wave varies, and means connected with said receiver for varying the tune thereof as the frequency of the received carrier wave varies.

9. An all purpose receiver comprising in combination signal receiving and amplifying means of the heterodyne type including a high frequency oscillator, a demodulator and an intermediate frequency amplifier, a filter having its input electrodes coupled with said intermediate frequency amplifier, a pair of thermionic tubes, a circuit connecting the output of said filter in push-pull relation with like electrodes in said tubes, a circuit connecting the output of said intermediate frequency amplifier in parallel relation with like electrodes in said tubes, a transformer having a primary winding connected in parallel with the output electrodes of said pair of tubes, a second transformer having a primary winding connecting the output electrodes of said pair of tubes in phase opposition, a second pair of thermionic tubes one of which has its control electrode and cathode connected to the secondary winding of said first named transformer and the other of which has its control grid and cathode connected to the secondary winding of said second named

transformer, a pair of demodulator tubes, a circuit connecting the output of said filter in phase opposition to like electrodes in said pair of demodulator tubes, differential modulating means and phase adjusting means in said last named circuit, a circuit coupling the output of said second pair of tubes to said differential demodulating means, and a circuit connecting the output of said intermediate frequency amplifier in phase to like electrodes in said pair of demodulator tubes.

10. The method of demodulating signal modulated wave energy the character of the modulation of which may vary during transmission which includes the steps of, beating said waves with local oscillations to produce a signal carrying beat note, stripping all signal modulations from energy of said beat note energy, combining said last named energy with original signal carrying beat note energy in phase quadrature to obtain a component, controlling the frequency of the local oscillations in accordance with said component, combining energy from which all signal modulations have been removed in phase displaced relation with original signal carrying beat note energy to render the signal and relatively varying the phase of said last energies as combined in accordance with variations in the character of the modulations on said signal carrying beat note.

11. An all purpose receiver comprising in combination signal receiving and amplifying means of the heterodyne type including a high frequency oscillator, a demodulator and an intermediate frequency amplifier, a filter having its input electrodes coupled with said intermediate frequency amplifier, said filter circuit having an output, a pair of thermionic tubes, a circuit coupling the output of said filter with like electrodes in said tubes, a circuit coupling the output of said intermediate frequency amplifier in parallel relation with like electrodes in said tubes, a first transformer having a primary winding connected in parallel with the output electrodes of said pair of tubes, a second transformer having a primary winding connecting the output electrodes of said pair of tubes in push-pull relation, a relay comprising a second pair of thermionic tubes one of which has its control electrode and cathode connected to the secondary winding of said first named transformer and the other of which has its control electrode and cathode connected to the secondary winding of said second named transformer, a signal coupling tube having a control grid, and a relay including two contacts one of which is connected to the secondary winding of said first transformer and the other of which is connected to the secondary winding of said second transformer, said relay also having an armature differentially connected to the control grid of said last named tube.

12. The method of receiving signal modulated wave energy the character of modulation on which may vary during transmission which includes the steps of filtering said signal wave energy to derive therefrom a component from which signal modulations have been substantially removed, combining said filtered component in displaced mean phase relation with signal carrying wave energy and varying the said mean phase relation of said energies as combined, as the character of the modulation on the wave varies.

13. The method of demodulating signal modulated wave energy the character of the modulation of which may vary during transmission

which includes the steps of, stripping all signal modulation from a portion of the wave energy, combining said energy from which all signal modulations have been stripped in mean phase displaced relation with original signal energy, and relatively varying the mean phase displacement of said energies as combined in accordance with variations in the character of the modulations on said signal carrying wave energy.

14. In a system for receiving waves modulated in amplitude or phase and for automatically adjusting said system to respond predominantly to the particular type of modulation on said wave, a wave absorbing and amplifying means, said amplifying means having an output circuit, a signal demodulator comprising a pair of thermionic tubes each having an anode, a cathode and a control grid, a circuit coupling said output circuit in push-pull relation to the control grids and cathodes of said tubes, a circuit coupling said output circuit in parallel with the control grids and cathodes of said tubes, a filter in one of said circuits, a phase modulator in one of said circuits, and an additional means coupling said output circuit to said phase modulator for modulating the phase of the energy reaching said detector control grids over said one of said paths in accordance with the character of the signal energy in said output circuit.

15. In a system for receiving waves modulated in amplitude or phase and for automatically adjusting said system to respond predominantly to the particular type of modulation on said wave, a wave absorbing and amplifying means, said amplifying means having an output circuit, a pair of thermionic demodulator tubes each having an anode, a cathode and a control grid, a circuit coupling said output circuit in push-pull relation to the control grids and cathodes of said tubes, a circuit coupling said output circuit in parallel with the control grids and cathodes of said tubes, a filter in one of said circuits, a circuit connected with the output electrodes of said demodulator tubes, and means connected with the control grids of said tubes and controlled by the character of the modulation on the received waves for producing currents in said output circuit of said demodulator tubes predominantly characteristic of the predominant modulations on said received wave.

16. In a system for receiving waves modulated in amplitude or phase and for automatically tuning said system to respond to said waves irrespective of frequency variations therein and for automatically adjusting said system to respond predominantly to the particular type of modulation of said wave, wave absorbing and amplifying means including a tunable circuit, said means having an output circuit, a signal demodulator device comprising a pair of thermionic detector tubes each having an anode, a cathode and a control grid, a circuit coupling said output circuit in push-pull to the control grids and cathodes of said tubes, a circuit coupling said output circuit in parallel with the control grids and cathodes of said tubes, a filter in one of said last named circuits, a circuit connecting the anodes of said tubes in push-pull relation, a frequency control circuit coupling the anodes of said tubes to said tunable circuit, a pair of coupling tubes each having an anode and a control grid and each having their control grid coupled to the anode of a different one of said first named tubes, a circuit connecting the anodes of said coupling tubes in parallel, a circuit coupling the anodes of

said coupling tubes in push-pull relation, a second pair of thermionic detector tubes each having an anode, a cathode and a control grid, an output circuit connected with the anodes of said second pair of detector tubes, a circuit coupling like electrodes in said second pair of detector tubes in phase to said first named output circuit, a circuit connecting like electrodes in said second pair of detectors in phase opposition to said first named output circuit, filtering means in one of said last two circuits, phase modulating means in the other of said last named circuits, said phase modulating means comprising a pair of thermionic modulator tubes having their control grids connected in phase opposition by a circuit coupled to said first named output circuit and their anodes connected in parallel by a circuit coupled to the control grids of said second pair of detectors, a second pair of coupling tubes, each having an anode and a control grid, a circuit coupling the control grid of one of said last named coupling tubes to the circuit connecting the anodes of said first named pair of coupling tubes in parallel, and a circuit coupling the control grid of the other of said last named pair of coupling tubes to the circuit connecting the anodes of said first named pair of coupling tubes in push-pull relation.

17. In a system for receiving waves modulated in amplitude or phase and for automatically adjusting said system to respond predominantly to the particular type of modulation on said wave, a wave absorbing and amplifying means, said amplifying means having an output circuit, a signal demodulator comprising a pair of thermionic tubes each having an anode, a cathode and a control grid, a circuit coupling said output circuit in push-pull to the control grids and cathodes of said pair of tubes, a circuit coupling said output circuit in parallel with the control grids and cathodes of said pair of tubes, a filter in one of said circuits, an output circuit connecting the anodes of said tubes in parallel, an output circuit connecting the anodes of said tubes in push-pull relation, a relay coupled to said output circuits, a coupling tube having input electrodes, and means cooperating with said relay and with said coupling tube input electrodes for coupling the input electrodes of said coupling tube to one or the other of said output circuits.

18. In combination, a system for receiving and demodulating signal modulated carrier waves, the type of modulation of which may vary in transmission due to natural causes, and automatic means connected with said system for changing the demodulation characteristic of said system in accordance with variations in the type of modulation of said wave.

19. In combination, a system for demodulating carrier waves modulated in phase or amplitude, the type of the modulation of which may vary in transmission due to natural causes to resemble amplitude and phase modulation respectively, automatic means connected with said system for varying the demodulation characteristic of said system as the type of said modulation of said wave varies, and automatic means connected with said system for tuning said system to the wave to be received irrespective of variations in the mean frequency of said wave.

20. In combination, an electron discharge demodulator device having input and output electrodes and having its input electrodes energized by signal modulated carrier waves, the type of modulation of which may vary in transmission due to natural causes, and electron discharge

5 tube means having input electrodes and output electrodes connected with said device and controlled by the character of the modulations of the carrier wave energy in said device for varying the demodulation characteristic of said device as the type of modulation of said carrier wave varies.

10 21. In combination, an electron discharge demodulator system having input and output electrodes and having its input electrodes energized by carrier waves modulated in phase which modulation due to natural causes may be changed during transmission to simulate amplitude modulation, and means connected with the output electrodes of said demodulator and energized by said modulated wave for automatically varying the demodulation characteristic of said electron discharge demodulator system as the modulation on said waves changes to simulate amplitude modulation.

15 22. In combination, a system for demodulating carrier waves modulated in amplitude which modulation due to natural causes may be changed to simulate phase modulation, and means connected with said system for automatically varying the demodulation characteristic of said system as the modulation on said carrier waves changes to simulate phase modulation.

23. In combination, a tunable circuit for receiving carrier waves modulated in phase which modulation due to natural causes may be changed to simulate amplitude modulation, a demodulator connected with said circuit, means connected with said circuit and demodulator for automatically varying the demodulation characteristic of said demodulator as the character of modulation on said wave changes, and means connected with said circuit and said demodulator and energized by wave energy therein to tune said circuit to the carrier wave being received irrespective of variations in the frequency thereof.

15 24. The method of receiving signal modulated wave energy the character of modulation on which may vary during transmission which includes the steps of, filtering said signalling wave energy to derive therefrom a component from which signal modulations have been substantially removed, combining said filtered component with signal carrying wave energy to demodulate the latter, and varying the mean phase relation of said component and wave energy as combined relative to a substantially phase quadrature relation as the character of the modulation on the wave varies.

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