

April 11, 1939.

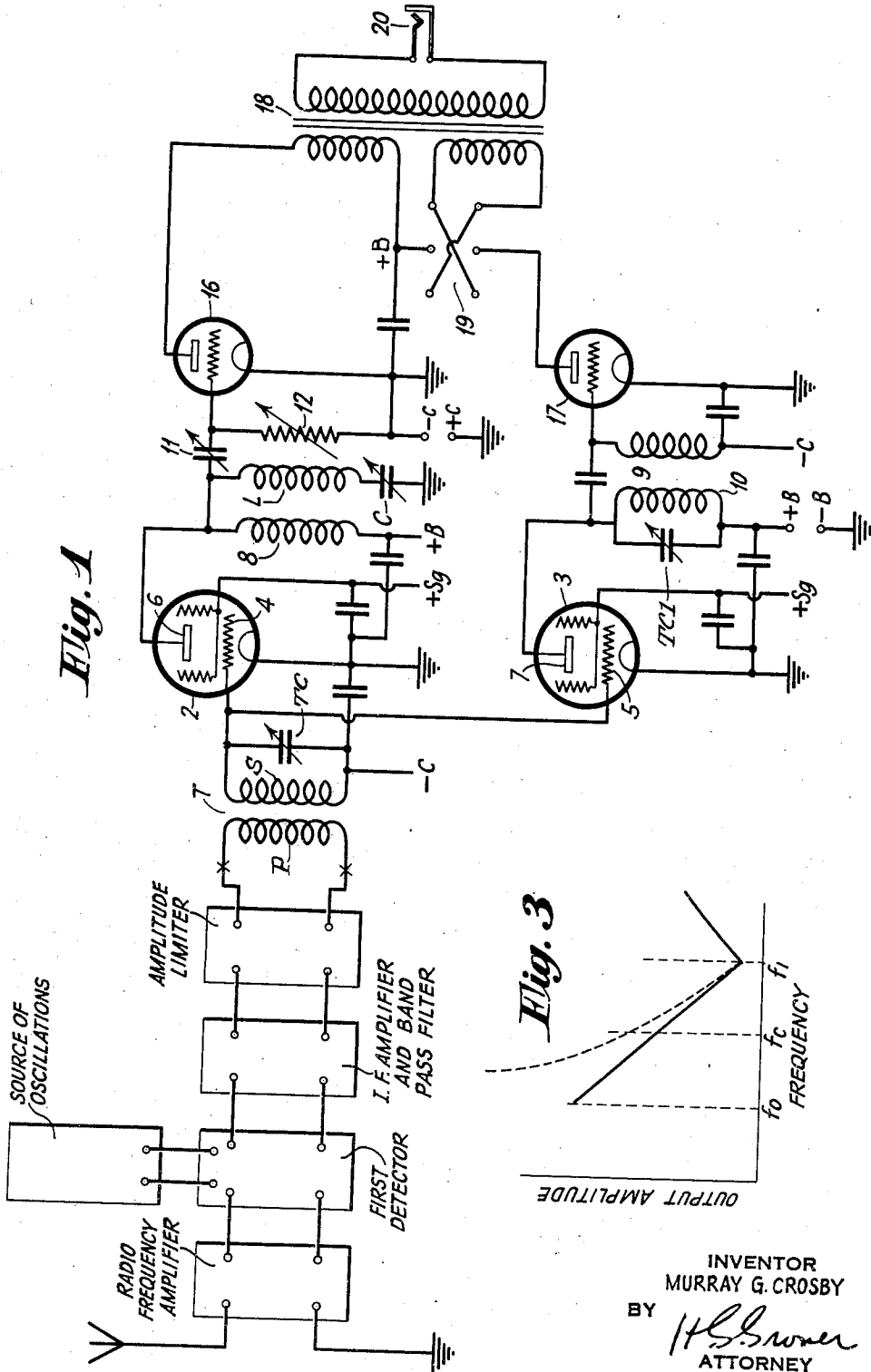
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FREQUENCY MODULATION RECEIVER

Filed Dec. 9, 1936

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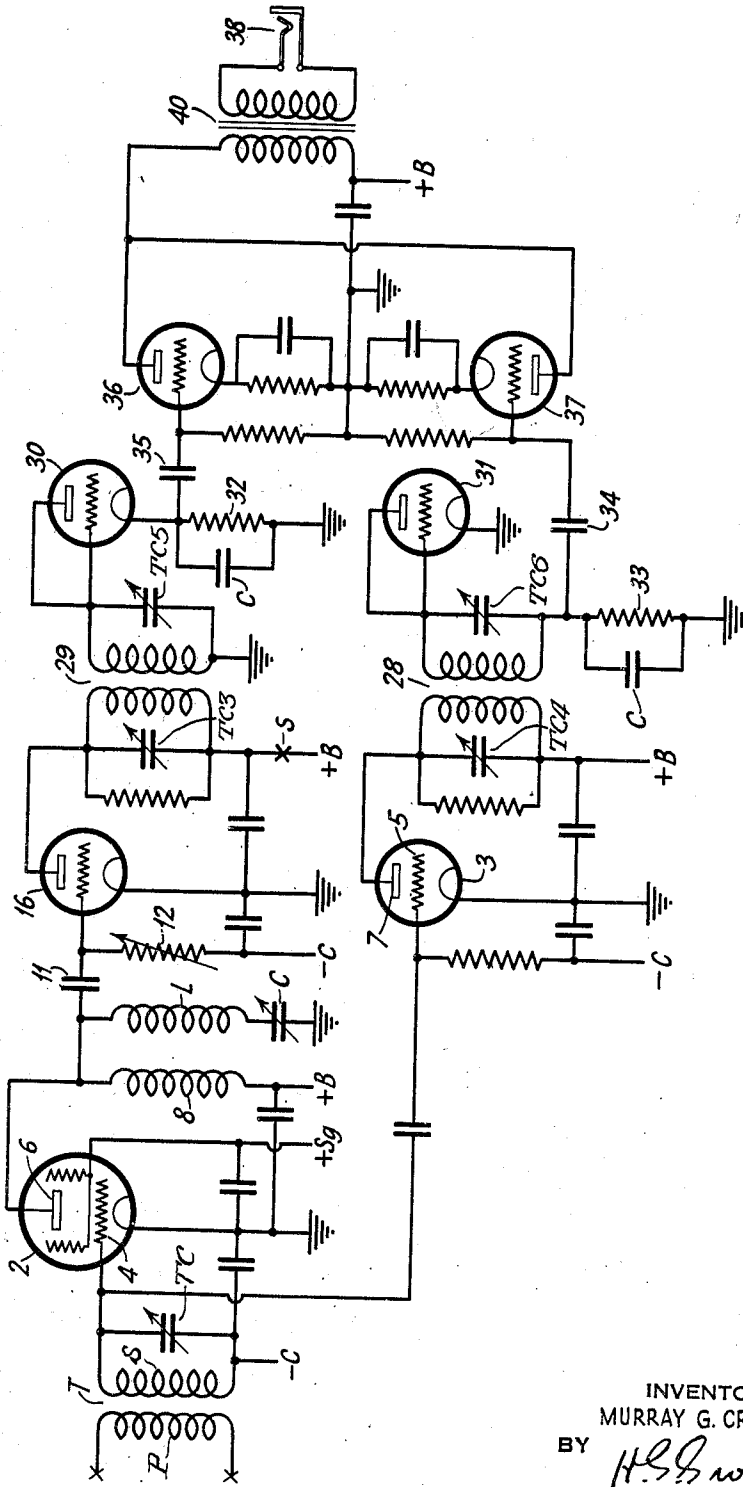
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Fig. 2



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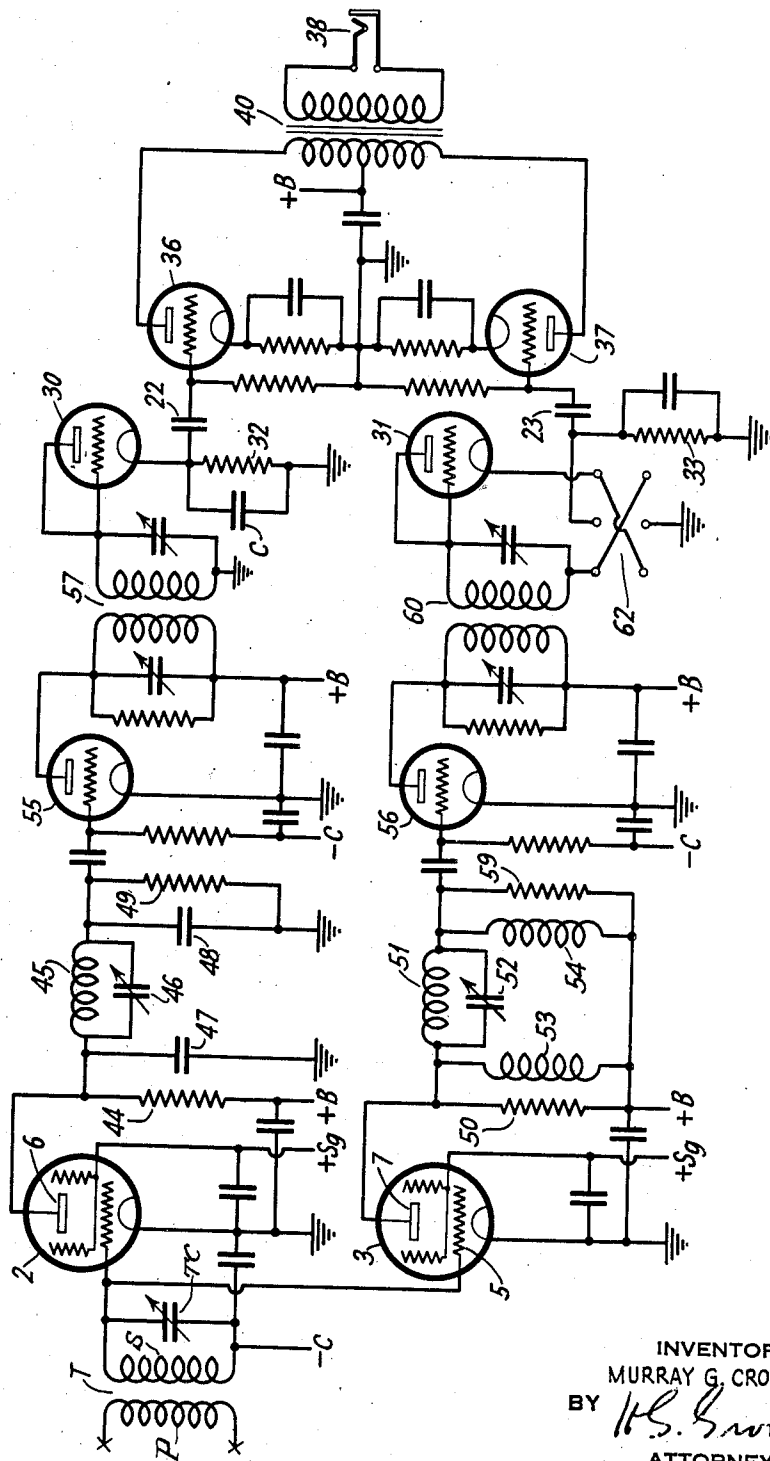
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FREQUENCY MODULATION RECEIVER

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Fig. 4



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FREQUENCY MODULATION RECEIVER

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Application December 9, 1936, Serial No. 114,894

16 Claims. (Cl. 250—20)

This invention concerns an improved method of and means for receiving frequency or phase modulated wave energy wherein the frequency or phase modulated wave energy is received, passed through a sloping filter which converts the frequency or phase modulations on the wave to amplitude variations, and the resultant amplitude modulated wave is detected in the usual manner. The undesired amplitude modulation is removed by also passing the modulated wave energy through another circuit which is aperiodic rather than of the sloping filter type, and combining the detected output of this circuit with the output of the detector following the sloping filter in such phase relation that the amplitude modulation components oppose and compensate and the components characteristic of the frequency modulation wave energy is reproduced free of the undesired amplitude modulation.

In the receivers of this general type known in the prior art the undesired amplitude modulation is removed by passing the frequency modulated wave through two filters of opposite slope and combining their detected outputs differentially. George L. Usselman Patent #1,794,932 of March 3, 1931, describes such a receiver. This type of receiver is commonly called a back-to-back receiver. Another example of such a receiver is contained in my United States application #703,770, filed December 23, 1933, Patent #2,060,611, dated November 10, 1936. In this disclosure the effect of two filters of opposite slopes is obtained by utilizing only one filter of sloping characteristic. To obtain the effect of an opposite sloping filter I combine the output of the sloping filter with a filter having a flat-topped characteristic. I then combine the energy resulting from said latter combination with energy from the output of the filter of sloping characteristic in proper phase relation. In this way a back-to-back receiver effect is provided without requiring two filters of the sloping characteristic type. This reduces the costs of the necessary apparatus since filters of the sloping type are more expensive than circuits of flat-topped characteristic.

In the receiver of this disclosure, the same back-to-back action is obtained with a single sloping filter by a different method than that disclosed in my application referred to in the preceding paragraph. In my analysis of the back-to-back receiver I discovered that it would be possible merely to substitute a circuit of flat-topped characteristics capable of responding uniformly to all frequencies and linearly to ampli-

tude modulations only, for one of the sloping filters of the back-to-back type of receiver. The advantage of the back-to-back type of receiver resides in its ability to remove undesired amplitude modulations and thus eliminate distortion produced by the use of detectors of the square law type. If the square law detector distortion is eliminated by employing linear detectors as I do in the present disclosure, the remaining advantage is the removal or elimination of undesired amplitude modulation of the frequency modulated wave as to its effect on the reproduced signal. To gain this second advantage in accordance with the present invention a second sloping filter is not required. All that is necessary is an additional detector for the amplitude modulation present on the frequency modulated wave so that the amplitude modulation may be bucked out of the receiver output as obtained from the sloping filter and its detector. Thus, my invention involves two novel features which briefly are, linear detection in frequency modulation receivers of the back-to-back type and the advantage flowing therefrom which is elimination of one sloping filter.

My receiver also utilizes a novel diode detector system wherein linear detection is produced and wherein the detector output circuits include resistances so connected that a differential or accumulative energy combination may be had so that when frequency or phase modulation is received, unwanted amplitude modulations oppose and cancel. The outputs may, however, be added accumulatively in which case the receiver will respond to amplitude modulations of the wave. Other objects and advantages will appear in the detailed description which follows. In describing the invention in detail, reference will be made to the drawings wherein;

Figure 1 illustrates diagrammatically a circuit arrangement which includes the essential features of a frequency modulation receiver arranged in accordance with my present disclosure;

Figure 2 illustrates a modification of the arrangement of Figure 1. Figure 2 differs from Figure 1 in that linear detection is obtained by the use of diode detectors whereas in Figure 1 triode detectors are used although detector tubes having more electrodes may be used;

Figure 3 is a graph showing the characteristic of the filter circuit of sloping characteristic used in Figure 1 of the drawings; while

Figure 4 is a modification of the arrangement of Figure 2. In Figure 4 both filters are of the sloping type and an additional scheme for com-

binning the energies in phase or in phase opposition is disclosed.

The circuit of Figure 1 shows the essential features of the frequency modulation receiver of this disclosure wherein plate detectors, linear in character, are provided. Such detectors may be made substantially linear by operating them at a relative high level of signal voltage input. Details of this operation will be considered hereinafter. The receiver may comprise a tuned radio frequency amplifier followed by an amplitude limiter or may comprise as shown the usual units of a heterodyne receiver including a radio frequency amplifier, a first detector, a local oscillator, and an intermediate frequency amplifier and band pass filter. Here, as in the case of a radio frequency amplifier, the output is impressed on an amplitude limiter of any known type such as, for example, an over-loaded tube or a fast automatic volume control system. The amplitude limited frequency modulated wave energy is impressed on the primary winding P of a transformer T and from the secondary winding S of the transformer T on the control grid 4 of a coupling tube 2 and also on the control grid 5 of a coupling tube 3. The secondary winding S is tuned by a condenser TC. The energy is impressed in phase on the control grids 4 and 5 as shown. The anode of coupling tube 6 is connected to a reactance 8 and to a series tuned circuit comprising inductance L and condenser C and from the high voltage terminal of circuit LC by way of a coupling condenser 11 to the control grid of a linear detector tube 16. The control grid of tube 16 is maintained at the desired negative potential for linear plate detection by potentials supplied from any source through resistor 12. The anode of tube 16 is connected to a primary of the transformer 18 the secondary of which may be connected by jack 20 to a utilization circuit. The anode 7 of tube 3 is connected by way of an impedance coupling 9 to the control grid of a linear rectifier tube 17 which has its anode electrode connected by way of a reversing switch 19 to a primary winding on the transformer 18. Potential for the control grid of tube 17 is insured substantially linear operation is supplied by a direct current conductive element of the impedance coupling circuit 9 and the anode of tube 3 is likewise supplied with potential by way of a direct current conductive element of the impedance coupling 9. The impedance coupling shown may be replaced by any known type of impedance coupling as long as the same is aperiodic or flat-topped in character. The inductance 10 in the plate circuit of 3 may be shunted by a tuning condenser TC1 as shown so that the impedance coupling 9 may be tuned to the desired frequency. As stated above, coupling 9 of Figure 1 is intended as an impedance coupling with a substantially flat top characteristic. In the prior art impedance couplings took the form of two inductances coupled by a capacity, but in the present state of the art, a broad tuned circuit is used since it has been found that an impedance coupling cannot always be depended upon to produce a flat-top characteristic. Consequently, in this circuit I took the precaution to tune the inductance 10 by condenser TC1 so that an inductance of low enough Q could be chosen which would make the circuit practically flat over the desired range of frequencies. Another alternative to the use of a low Q coil is to use a shunt resistance across the tuned circuit to make the effective Q of the

circuit low enough so that inappreciable side band cutting will be effected. A still further alternative is the use of a band pass transformer in place of the impedance coupling.

The intermediate frequency energy limited to remove amplitude variations thereon insofar as feasible, is fed by transformer T to the control grids of coupling tubes 2 and 3. The output of coupling tube 2 is fed through the intermediate frequency choke 8. The circuit comprising inductance L and condenser C in series is such that the output amplitudes plotted against frequency characteristic of coupling tube 2 is as shown by the full lines in Figure 3, where f_c is the carrier frequency and f_0 to f_1 is the band width of the received modulated wave. The tuned circuit LC is tuned to resonate at f_1 . Condenser 11 and grid resistor 12 are adjusted to improve the linearity of the characteristic of Figure 3. That is, if the tuned circuit forms a curved line as shown by the dotted line of Figure 3, condenser 11 may be adjusted to have a reactance comparable to resistor 12 so as to further attenuate lower frequencies and improve the over-all characteristic of the sloping filter circuit to obtain the characteristic as shown by the full line of Figure 3.

Coupling tube 3 is aperiodically impedance or resistance coupled via coupling 9 to detector 17. The outputs of detectors 16 and 17 are combined in transformer 18 in phase or phase opposition depending on the position of switch 19. Jack 20 makes the output available for use.

In the receiver of Figure 1, the branch via coupling tube 2 feeds the frequency modulated energy via a sloping filter to detector 16. Thus, as the frequency is modulated, an amplitude modulation envelope is superimposed upon the wave which varies in accordance with the applied frequency modulation. Detector 16 linearly detects this amplitude modulation and passes it through transformer 18. There will also be present in the detected output of 16 potential variations characteristic of any amplitude modulation which was present on the original unfiltered frequency modulated wave. This latter amplitude modulation will be unaffected by the sloping filter for, while one side band is reduced in amplitude, the other is raised a compensating amount. The phase of the sidebands is also unaffected by the sloping filter. Consequently, the output of detector 16 will contain the detected frequency and amplitude modulation components.

Detector 17 is fed by an aperiodic circuit so that it will detect only the amplitude modulation present on the frequency modulated wave. Hence, when transformer 18 is connected in the push-pull connection, the components, characteristic of amplitude modulation of the wave, in the output of 17 will buck or oppose those from 16. The resulting output available for use will be characteristic of the desired frequency modulation only.

The receiver of Figure 2 is similar to that of Figure 1 except that linear diode detectors are used. Tubes 16 and 3 are coupling tubes which feed transformers 29 and 28 with the filtered and unfiltered signals, respectively. The primary windings of these transformers may be tuned as shown by condensers TC3 and TC4 respectively and the circuits including the primaries are damped by resistances connected as shown in shunt to the windings. The secondary windings of transformers 29 and 28 which also may be tuned by condensers TC5 and TC6 respectively

feed diode detectors 30 and 31, respectively. In order that the amplitude modulation output from diode 31 may buck out the amplitude modulation component of diode 30, the output resistors of the two diodes are reversed with respect to each other as shown in the diagram. Thus, resistor 32 is placed between the cathode of diode 30 and ground, and resistor 33 is placed between the low side of the secondary of transformer 28 and ground. The rectified energy from the high potential ends of resistances 32 and 33 is fed by coupling condensers 35 and 34 to the control electrodes of coupling amplifier tubes 36 and 37. The anodes of 36 and 37 are connected in parallel by the primary winding of output transformer 40. The jack 38 permits utilization of the output energy in any manner. The polarities of the detected potentials are reversed by the connections of 32 and 33 so that they are out of phase or opposed on the grids of 36 and 37, and potential variations caused by amplitude modulation of the wave oppose and cancel while potential changes in the output of 30 characteristic of frequency modulation of the wave appears across the terminals of the primary of 40. In this manner, the undesired amplitude modulation is cancelled and the detected frequency modulation remains. Coupling and blocking condensers 34 and 35 keep the diode direct current components from being applied to the grids of 36 and 37. Condensers C by-pass the radio frequency energy fed to the diodes and form low impedance paths around 32 and 33 for the radio frequency wave energy.

If it is desired to receive wave energy modulated in amplitude the tube 16 may be cut out of the circuit in any manner such as, for example, by opening switch S in the anode direct current circuit thereof.

The potential reversing features of the receiver of Figure 2 may be applied to the ordinary type of back-to-back receiver wherein two sloping filters are utilized as is shown in Figure 4. The coupling tubes 2 and 3 may be connected as in Figures 1 and 2. In this receiver, a low pass filter consisting of elements 44, 45, 46, 47, 48, and 49 forms a sloping filter of one polarity of slope. This filter is adjusted so that the carrier frequency is midway between the cut-off frequency and the frequency of maximum attenuation. Elements 50, 51, 52, 53, 54, and 49 form a high-pass filter in a similar manner so that a slope of opposite polarity, or direction, is obtained. It is noted that the two sloping filters are somewhat similar in character. However, the terminating shunting reactances 47 and 48 are inductive whereas 53 and 54 are capacitive. The character of these reactances control the direction of slope of the filter, i. e., whether it is positive or negative. Tubes 2, 3, 55, and 56 are coupling tubes. Tubes 30 and 31 are the diode detectors. In order to provide means for reversing the polarity of the potentials applied from one diode to the coupling tubes 36 or 37, the resistor 33 of diode 31 may be switched from the cathode to the low side of transformer 60 by means of switch 62. Thus, with 62 adjusted so that resistors 32 and 33 are both in the cathode to ground circuits, frequency modulation may be received. This is true because now the polarities of the potentials fed to the control grids of tubes 36 and 37 are in phase while the anodes of tubes 36 and 37 are in push-pull and the potentials characteristic of the frequency modulations are accumulative, due to the opposite slopes of the filters, while the potential changes characteristic of the amplitude

modulations oppose or cancel in the output of 36 and 37. With the switch in the other position, amplitude modulation may be received and frequency modulation cancelled. This is because the potentials characteristic of the amplitude modulations have been reversed by switch 62 and added in the output circuit while the potential changes characteristic of the frequency modulations are in phase and now cancel in the output.

These receivers are of course equally adaptable to the use of a non-heterodyne receiver. The superheterodyne arrangement is not a necessity. In this case, amplified modulated wave energy may be impressed directly on the primaries of T in Figures 1, 2, and 4. In the illustration, the receiver elements preceding the primary of transformer T of Figure 1 may be added to Figures 2 and 4.

As is well known in the art of frequency modulation, limiting or fast automatic volume control may be employed to maintain a constant volume at the receiver and minimize the effects of fading.

The sloping filters of these receivers may consist of any arrangement of circuit elements to produce the desired characteristics. Thus, band-pass or band-elimination filters might replace the filters or tuned circuits shown.

Any of the receivers shown herein may be adapted for the reception of phase modulation by the use of correction circuits in the audio frequency output channels in the manner described in my United States application #618,154, filed June 20, 1932.

In the receivers where only a single sloping filter is used, it is not necessary to conform to the slope as shown in Figure 3. A filter of opposite slope with its resonant or minimum point at the lower frequency edge of the wave band, could be used just as well.

I claim:

1. In a system for receiving and demodulating wave energy modulated in frequency or phase in accordance with signals and for compensating noise modulation and unwanted amplitude modulation of said wave energy, circuit means on which said wave energy may be impressed, a pair of electron discharge detector tubes each having a control grid, a cathode and an anode, a filter circuit of sloping characteristic coupling said circuit means to the control grid and cathode of one of said tubes for exciting the same by potentials characteristic of the desired frequency or phase modulations on said wave energy, and the undesired amplitude modulations on said wave energy, said filter circuit being tuned to have a maximum output at one side of the wave channel, a minimum output at the other side of the wave channel and a mean output at the medial frequency of the wave channel, a circuit having an aperiodic or flat-topped characteristic coupling said first named circuit to the control grid and cathode of the other of said detector tubes for exciting the same by potentials characteristic of the unwanted amplitude modulations only on said wave energy, and a utilization circuit connected to the anodes of said tubes whereby the energies characteristic of the noise and unwanted amplitude modulations supplied by said tubes to the utilization circuit oppose in said utilization circuit and cancel.

2. In a system for receiving and demodulating wave energy modulated in frequency or phase in accordance with signals and for compensating noise modulation and unwanted amplitude modulation

lation of said wave energy, circuit means on which said wave energy may be impressed, a pair of substantially linear electron discharge detector tubes each having a control grid, a cathode and

- 5 an anode, a filter circuit of sloping characteristic coupling said circuit means to the control grid and cathode of one of said tubes for exciting the same by potentials characteristic of the desired frequency or phase modulations on said wave en-
10 ergy, and the undesired amplitude modulations on said wave energy, a circuit having an aperiodic or flat-topped characteristic coupling said first named circuit to the control grid and cathode of the other of said detectors for exciting the same
15 by potentials characteristic of the unwanted modulations only on said wave energy, a utilization circuit connecting the anodes of said tubes in push-pull relation whereby the energies character-
20 istic of the unwanted amplitude modulations supplied by said tubes to the utilization circuit oppose in said utilization circuit and cancel.

3. In means for demodulating wave energy modulated in phase or in frequency in accordance with signals, a pair of electron discharge
25 rectifier tubes each having an anode and a cathode, an alternating current circuit tuned substantially to the frequency of said wave energy connected between the anode and cathode of each of said tubes, an impedance connected be-
30 tween the anode and cathode of each tube, filter circuits of different character for impressing said modulated wave energy on said alternating current circuits to produce a flow of current in said
35 tubes and impedances whereby potentials are produced in said impedances characteristic of the modulations on said wave energy, and means for combining the potentials produced in said im-
pedances.

4. In means for demodulating wave energy
40 modulated in phase or in frequency in accordance with signals and undesirably modulated in amplitude, a pair of electron discharge rectifier tubes each having an anode and a cathode, an alternating current circuit tuned substantially to
45 the frequency of said wave energy connected between the anode and cathode of each of said tubes, an impedance connected between the anode and cathode of each tube, a sloping filter for impressing said modulated wave energy on one
50 of said alternating current circuits, an aperiodic circuit for impressing said modulated wave energy on the other of said alternating current circuits, whereby rectified currents flow in said tubes and impedances and potentials are produced in
55 one of said impedances characteristic of all modulations on said wave energy, and potentials characteristic of amplitude modulations only of said wave are produced in the other impedance, and means for combining the potentials produced
60 across said impedances in phase opposition.

5. In means for demodulating wave energy modulated in phase or in frequency or in amplitude in accordance with signals, a pair of elec-
65 tron discharge rectifier tubes each having an anode and a cathode, an alternating current circuit tuned to substantially the frequency of said wave energy connected between the anode and cathode of each of said tubes, an impedance connected between the anode and cathode of each
70 tube, a circuit for impressing said modulated wave energy on one of said alternating current circuits, an additional circuit for impressing said modulated wave energy on the other of said alternating current circuits, whereby rectified cur-
75 rents are caused to flow in said impedances and

potentials are produced in each of said impedances characteristic of modulations on said wave energy, and means for combining the potentials produced in said impedances in phase opposition or in phase.

6. In means for demodulating wave energy modulated in phase or in frequency in accordance with signals, a pair of electron discharge rectifier tubes each having an anode and a cathode, alternating current circuits tuned to substantially the mean frequency of said wave energy each connected at one of their terminals to the anode of a different one of said tubes, a direct current impedance connecting the free terminal of each of said alternating current circuits to the cathode of a different one of said tubes, a capacity shunting each of said impedances, circuit means for impressing wave energy modulated in phase or frequency, on said alternating current circuits whereby potentials characteristic of the modulations on said wave energy are produced in said impedances, a pair of coupling tubes each having an input electrode, and an output electrode, circuits coupling the input electrodes of said tubes to opposed rectified
25 current potential points on said impedances, and a utilization circuit connected with the anodes of said coupling tubes.

7. In a means for demodulating wave energy modulated in phase or in frequency or in amplitude in accordance with signals, a pair of electron discharge rectifier tubes each having an anode and a cathode, an alternating current circuit tuned substantially to the mean frequency of said wave energy connected at one terminal to the anode of one of said tubes, an impedance connecting the cathode of said one of said tubes to the other terminal of said alternating current circuit, a second alternating current circuit tuned to substantially the mean frequency of said wave energy connected at one terminal to the anode of the other of said tubes, an impedance connecting the other terminal of said second alternating current circuit to the cathode of the other of said tubes, bypassing condensers shunting each of said impedances, means for impressing wave energy modulated in phase or in frequency or amplitude on said alternating current circuits so that rectified energy flows in said impedances and produces potential drops in said impedances, a sloping filter in one of said means, a pair of electron discharge coupling tubes each having a control grid, a cathode and an anode, means for impressing the potential drop across one of said impedances between the control grid and cathode of one of said coupling tubes, means for impressing the potential drop through the other of said impedances between the control grid and cathode of the other of said coupling tubes, potential reversing means in one of said last named means
60 and an output circuit connected with the anodes of said coupling tubes.

8. In a means for demodulating wave energy modulated in phase or in frequency in accordance with signals, a pair of electron discharge
65 rectifier tubes of the diode type each having an anode and a cathode, an alternating current circuit tuned substantially to the frequency of said wave energy connected at one terminal to the anode of one of said tubes, a resistance connecting the cathode of said one of said tubes to the other terminal of said alternating current circuit and to ground, a second alternating current circuit tuned substantially to the frequency of said wave energy connected at one terminal to
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the anode of the other of said tubes, a second resistance connected to the other terminal of said second alternating current circuit to the cathode of the other of said tubes and to ground, a capacity shunting each of said resistances, means for impressing wave energy modulated in phase or in frequency on said alternating current circuits, a sloping filter in at least one of said means, a pair of electron discharge coupling tubes each having a control grid, a grounded cathode and an anode, means for impressing potentials from the cathode end of one of said impedances to the control grid of one of said coupling tubes, means for impressing potentials from the anode end of the other of said impedances to the control grid of the other of said coupling tubes, and an output circuit connected with the anodes of said coupling tubes.

9. In means for converting frequency or phase modulations on wave energy comprising a carrier and sideband energy into corresponding amplitude variations of said wave energy, a filter circuit comprising input terminals and output terminals, a tuned circuit in series between an input terminal and an output terminal, a reactance in shunt to said input terminals, a reactance in shunt to said output terminals, the tune of said tuned circuit and value of said reactances being adjusted so that said filter has a sloping characteristic and the carrier frequency falls between the cut-off frequency and frequency of maximum attenuation, and means for impressing said phase modulated wave energy on said input terminals and deriving characteristic amplitude modulations from said output terminals.

10. Converting means as recited in claim 9 wherein said reactances are inductive.

11. Converting means as recited in claim 9 wherein said reactances are capacitive.

12. In a system for demodulating frequency modulated wave energy, a filter circuit tuned to resonance at a frequency different from the carrier frequency of said wave energy, an aperiodic circuit, said filter circuit and said aperiodic circuit having input and output terminals, means for impressing frequency modulated wave energy on said input terminals of both of said circuits, a rectifier having two electrodes, a pair of resistances, means connecting one of said electrodes to ground through one of said resistances, an alternating current circuit tuned to substantially the frequency of said wave energy coupling the other electrode of said tube to ground and to the output of one of said first two circuits, a second diode rectifier having two electrodes, a second alternating current circuit tuned to substantially the frequency of said wave energy and having one of its terminals connected to an electrode of said second rectifier and its other terminal connected through the other of said pair of resistances to ground, means connecting the other electrode of said second rectifier to ground, means coupling said second alternating current circuit to the output of the other of said first two circuits, and a utilization circuit connected to both of said resistances.

13. A means for demodulating wave energy modulated in accordance with signals, a pair of electron discharge rectifier tubes each having input and output electrodes, an alternating current circuit tuned substantially to the frequency of said wave energy connected at one terminal to the anode of one of said tubes, a resistance connected between the other terminals of said alternating current circuit and the cathode of

said one of said tubes, a second alternating current circuit tuned substantially to the frequency of said wave energy connected at one terminal to the anode of the other of said tubes, a second resistance connecting the other terminal of said last alternating current circuit to the cathode of the other of said tubes, a capacity shunting each of said resistances, a signal responsive circuit coupled with both of said resistances, and means for impressing wave energy to be demodulated on said alternating current circuits.

14. In a system for receiving and demodulating wave energy modulated in frequency or phase in accordance with signals and for reducing unwanted amplitude modulations of said wave energy, circuit means on which said wave energy may be impressed, a pair of electron discharge detector tubes each having input and output electrodes, a filter circuit of sloping characteristic coupling said circuit means to the input electrodes of one of said tubes for exciting the same by potentials characteristic of the desired frequency or phase modulations on said wave energy and undesired amplitude modulations on said wave energy, a circuit having an aperiodic or flat-topped characteristic coupling said first named circuit means to the input electrodes of the other of said detector tubes for exciting the same by potentials characteristic of the amplitude modulations on said wave energy, impedances connected with the electrodes of said tubes so that rectified current flowing in said tubes produce potential drops in said impedances, a utilization circuit, and means for impressing potentials from said impedances in push-pull relation on said utilization circuit whereby the energies characteristic of the unwanted amplitude modulations supplied by said tubes to a utilization circuit oppose in said utilization circuit and cancel and the energies characteristic of the phase or frequency modulations add.

15. In a system for receiving and demodulating wave energy modulated in frequency or phase in accordance with signals and for compensating unwanted amplitude modulation of said wave energy, circuit means on which said wave energy may be impressed, a pair of electron discharge detector tubes each having a control grid, a cathode and an anode, a filter circuit of sloping characteristic coupling said circuit means to the control grid and cathode of one of said tubes for exciting the same by potentials characteristic of the desired frequency or phase modulations on said wave energy, and the undesired amplitude modulations on said wave energy, a circuit having an aperiodic or flat-topped characteristic coupling said first named circuit to the control grid and cathode of the other of said detectors for exciting the same by potentials characteristic of the unwanted amplitude modulations only on said wave energy, and a utilization circuit connecting the anodes of said tubes in push-pull relation whereby the energies characteristic of the unwanted amplitude modulations supplied by said tubes to the utilization circuit oppose in said utilization circuit and cancel.

16. In a system for receiving and demodulating wave energy modulated in frequency or phase in accordance with signals and for compensating unwanted amplitude modulation of said wave energy, circuit means on which said wave energy may be impressed, a pair of electron discharge detector tubes each having input electrodes including a cathode and output electrodes including said cathode, a filter circuit of sloping char-

acteristic coupling said circuit means to the input electrodes of one of said tubes for exciting the same by potentials characteristic of the desired frequency or phase modulations on said wave energy, and the undesired amplitude modulations on said wave energy, a circuit having an aperiodic or flat-topped characteristic coupling said first named circuit to the input electrodes of the other of said detectors for exciting the

same by potentials characteristic of the unwanted amplitude modulations only on said wave energy, and a utilization circuit connecting the output electrodes of said tubes in differential relation whereby the energies characteristic of the unwanted amplitude modulations supplied by said tubes to the utilization circuit oppose in said utilization circuit and cancel.

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