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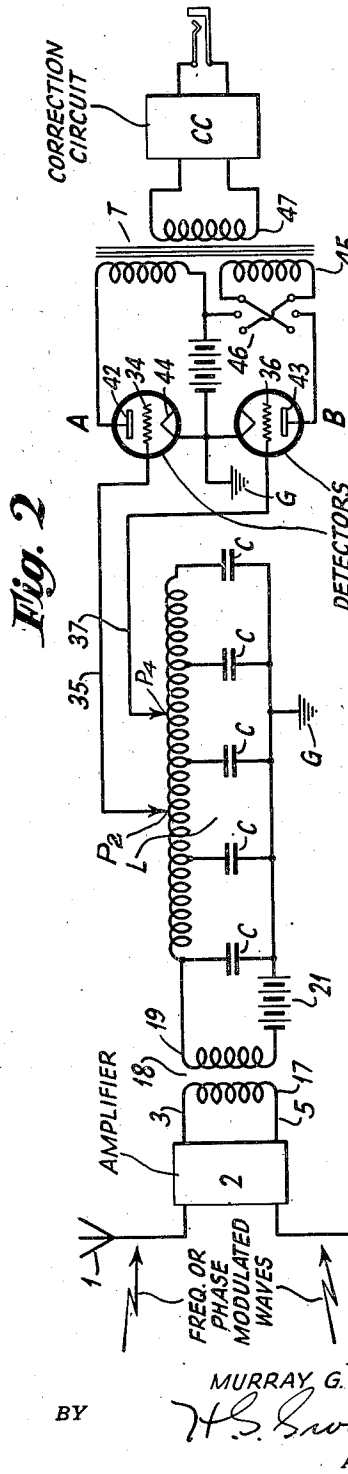
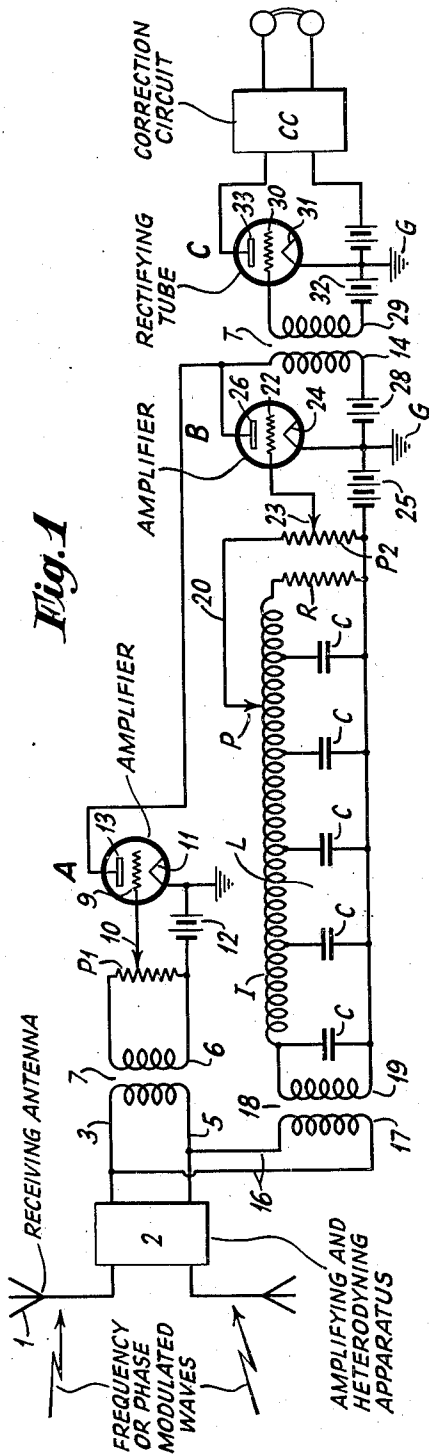
M. G. CROSBY

2,230,212

SIGNAL RECEIVER

Original Filed June 20, 1932

6 Sheets-Sheet 1



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2,230,212

SIGNAL RECEIVER

Original Filed June 20, 1932

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Fig. 3

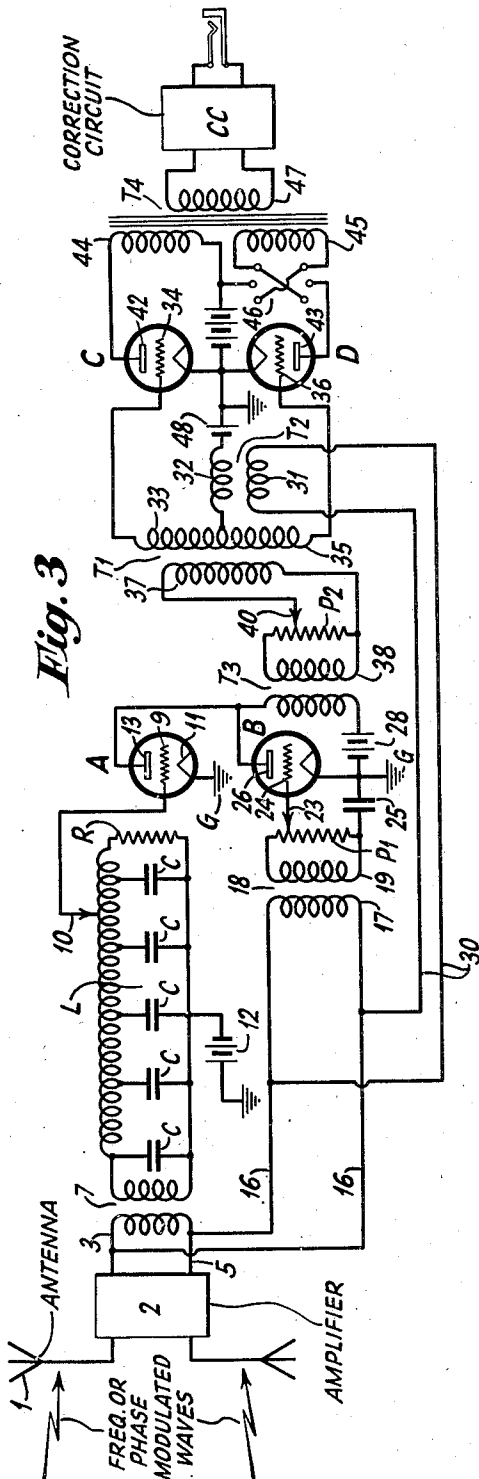
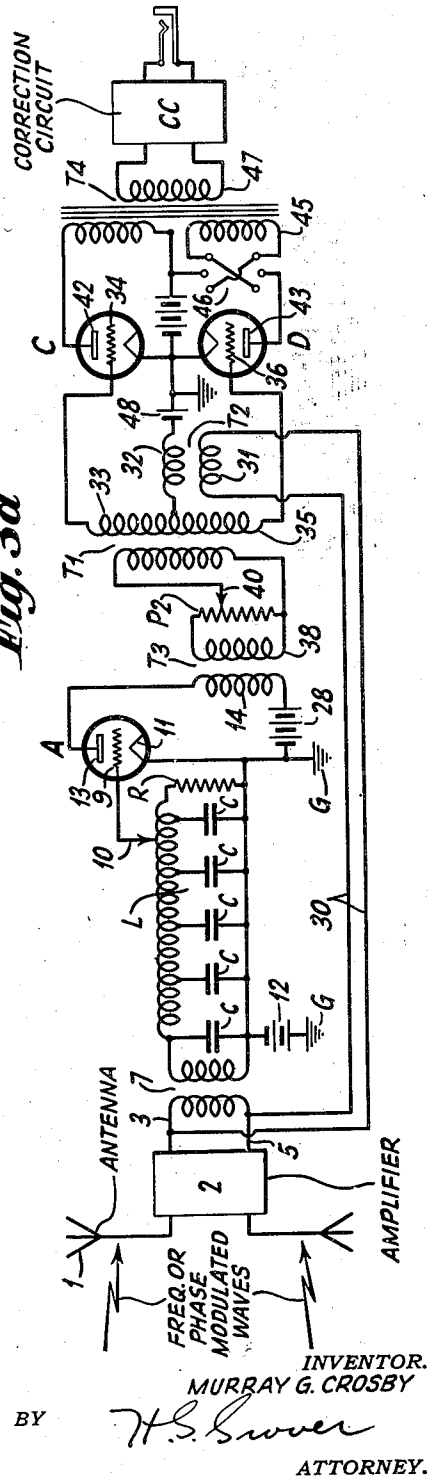


Fig. 3a



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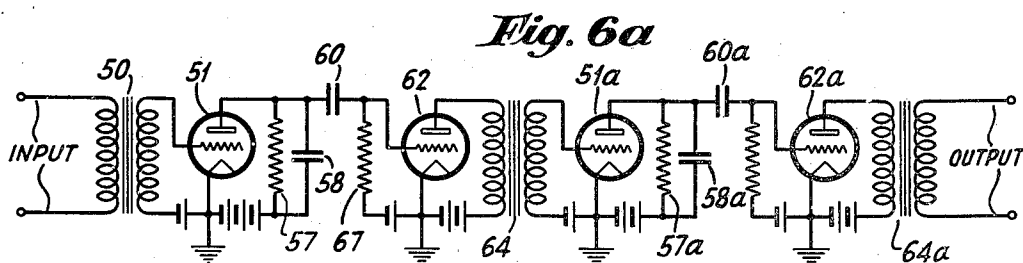
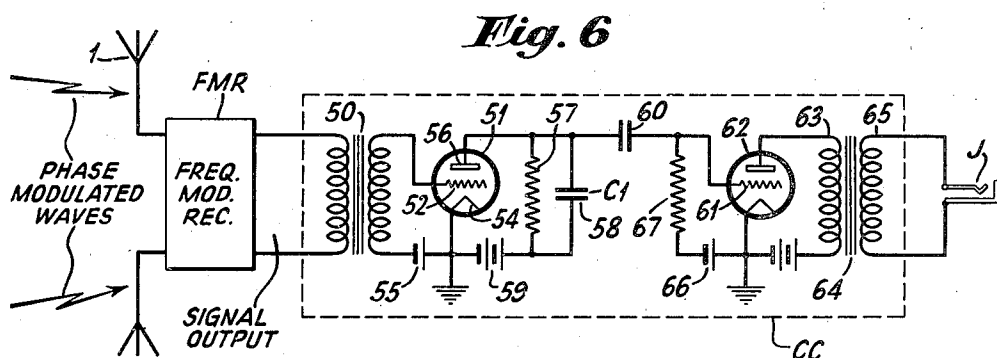
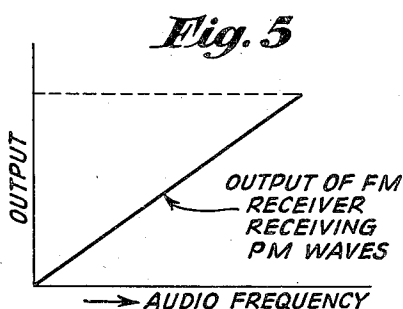
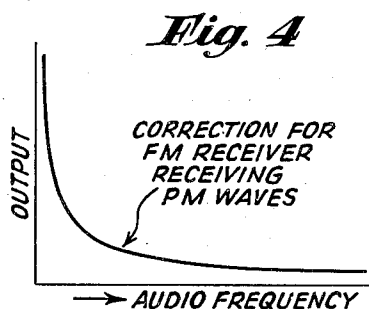
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SIGNAL RECEIVER

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Fig. 7

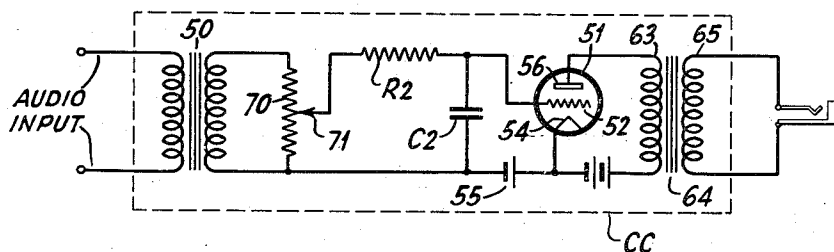


Fig. 7a

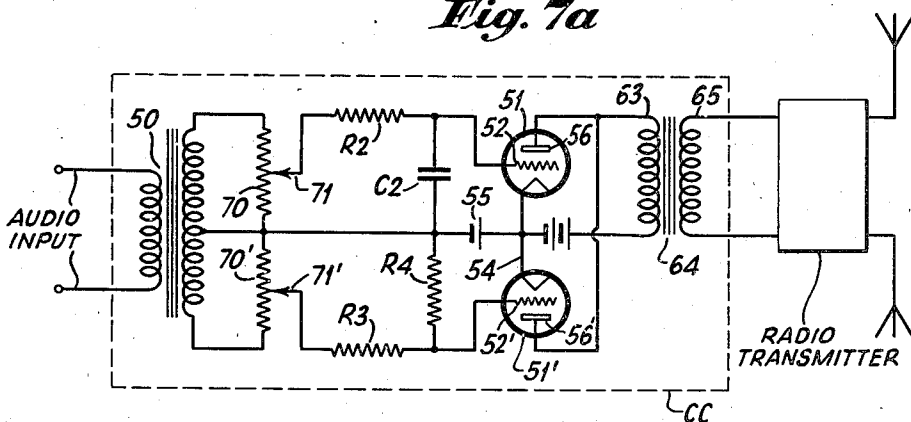
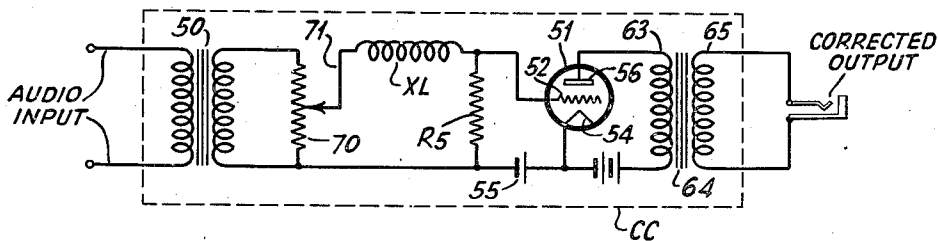


Fig. 8



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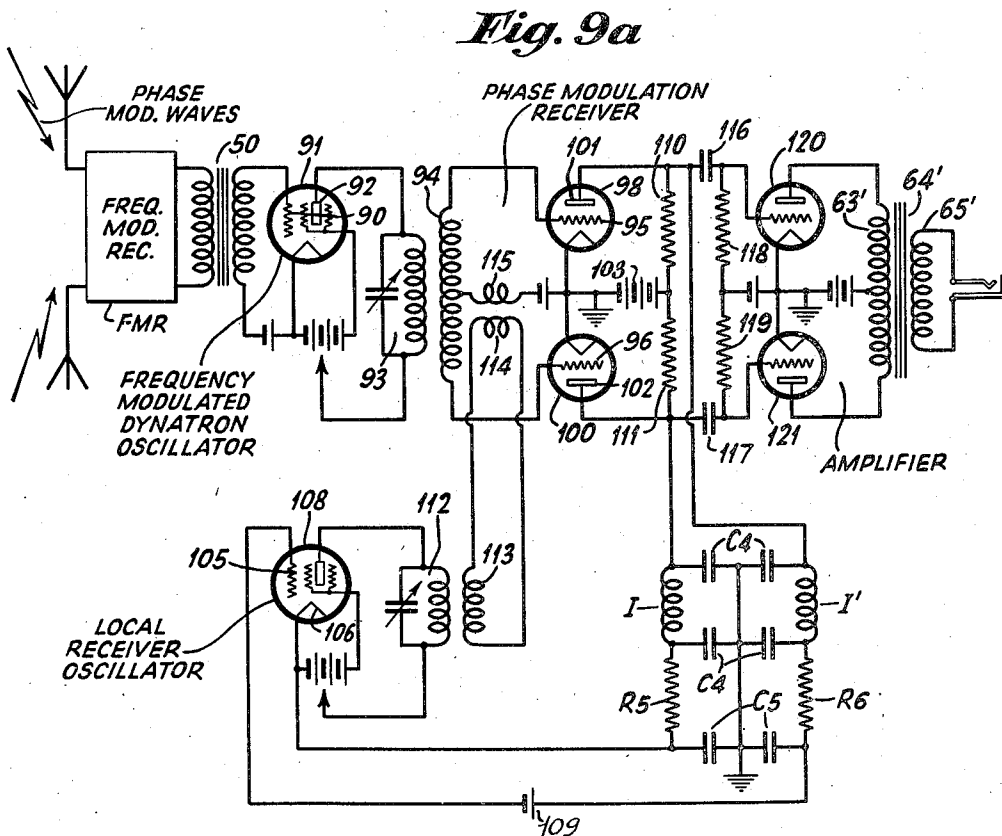
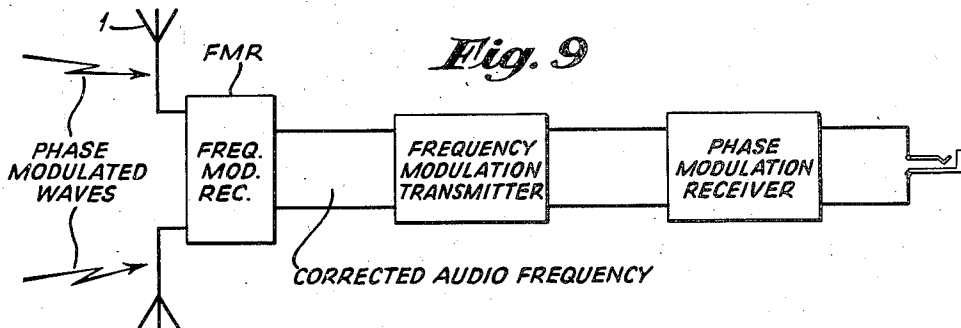
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SIGNAL RECEIVER

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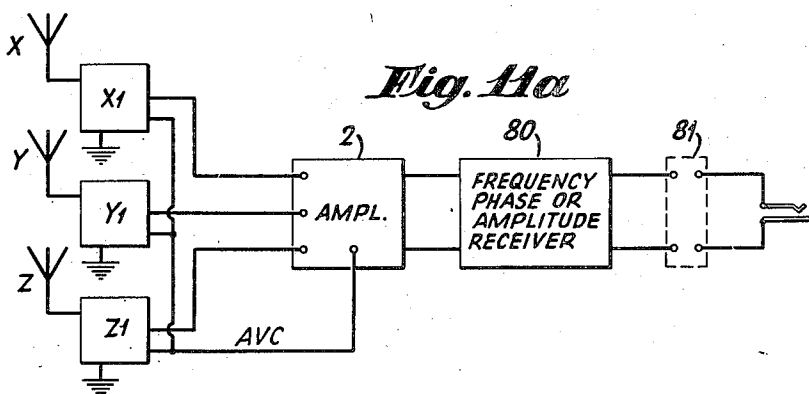
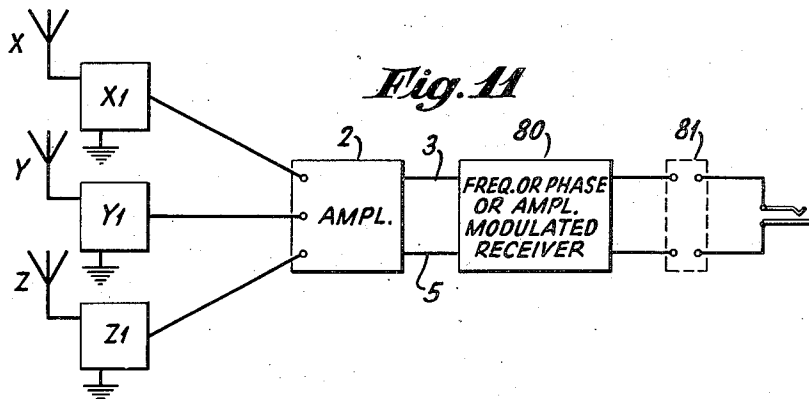
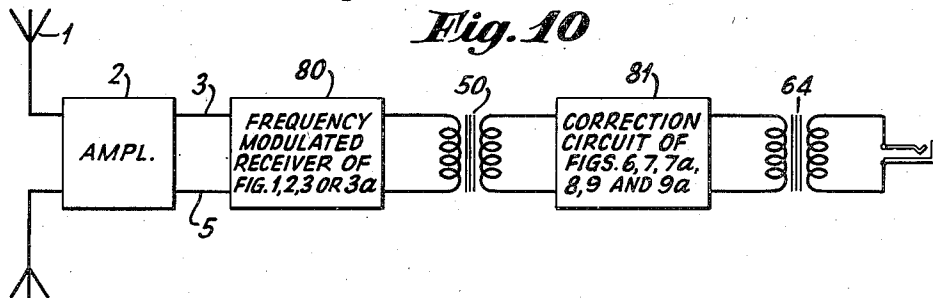
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SIGNAL RECEIVER

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6 Sheets-Sheet 6



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UNITED STATES PATENT OFFICE

2,230,212

SIGNAL RECEIVER

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Original application June 20, 1932, Serial No.
618,154. Divided and this application March
9, 1940, Serial No. 323,077

22 Claims. (Cl. 250—20)

This is a division of my copending application
Serial No. 618,154, filed June 20, 1932.

My present invention relates to frequency and
phase modulation systems and apparatus. Ob-
jects of my invention are broadly to provide im-
proved arrangements for receiving phase and
frequency modulated waves; to provide systems
for adapting frequency modulation apparatus to
the reception of phase modulated waves or ampli-
tude modulated waves, and to provide circuits
generally useful for phase and frequency modu-
lated waves. Other objects as well as advan-
tages flowing from my invention will appear as
the more detailed description thereof proceeds.

In the drawings, Fig. 1 shows diagrammati-
cally a receiver by means of which frequency
and phase modulated signals may be demodu-
lated;

Figs. 2, 3 and 3a show modifications of the
arrangement of Fig. 1;

Figs. 4 and 5 are curves explanatory of the
operation of Figs. 1, 2 and 3 when receiving phase
modulated waves.

Figs. 6, 6a, 7, 7a and 8 illustrate filter circuits
which may be included in the frequency modu-
lated signal receivers of the prior figures to adapt
them to efficient reception of phase modulated
signals;

Figs. 9 and 9a are conversion systems utilizing
both frequency and phase modulation appa-
ratus;

Fig. 10 shows diagrammatically how the cor-
rection circuits of Figs. 6, 7, 7a, 8, 9 and 9a may
be incorporated with the frequency modulation
receivers of Figs. 1, 2, 3 and 3a;

Figs. 11 and 11a show diagrammatically other
applications of the present invention.

The operation of all of the receivers disclosed
in Figs. 1, 2, 3 and 3a to receive frequency modu-
lated signals depends upon the fact that the
electrical length of a filter or a transmission line,
which consists of a series of sections composed
of inductive, capacitive and resistive elements in
a series and/or parallel arrangement or any one
or a combination of said elements in said ar-
rangement, varies with the impressed frequency.

In the following explanation, a transmission
line will be referred to although it will be under-
stood that a filter, such as a high pass, low pass,
band pass, band elimination, etc., may be used.
If the line is a given number of wave lengths
long for a certain predetermined frequency, at
a higher frequency the electrical length will be
greater and at a lower frequency the electrical
length of the line will be less. The fact that

this electrical length does change with fre-
quency makes the phase at the output of the
line change with respect to that of the input
of the line if the frequency of the signal trans-
mitted by the line is varied. Consequently, if
the signal impressed on the input of the line is
combined with the signal at the output of the
line, an adjustment of the line may be made
so that the phase difference between the voltage
of the signal impressed on the input of the line
and the voltage of the signal appearing on the
output of the line increases as the degree of
frequency modulation is increased. This phase
difference will cause a variation in the amplitude
of the resultant of the combined voltages so
that an amplitude modulation resultant is
formed, which amplitude modulation is truly
characteristic of the frequency modulation of the
original signal. In accordance with this inven-
tion, this amplitude modulation component is
then detected or rectified.

In particular, in the receiver of Fig. 1, the fre-
quency modulated energy appearing in lines 3
and 5 in the output of the heterodyning and
amplifying unit 2 is fed directly through cou-
pling tube A to the combining transformer T.
Simultaneously energy from 2 appearing in lines
3 and 5 is fed by way of lines 16 to transformer
18 and to the transmission line L. A lead 20,
connected to a movable point P on the line L,
transfers energy in the proper phase to the
potentiometer Pa, from whence the energy is sup-
plied to the coupling tube B. The output energy
from the line L, adjusted to the proper phase by
means of the sliding tap 20, P, or similar means,
is fed through the coupling tube B to the com-
bining transformer T. The above transformer T,
therefore, is energized by energy from A and
from B.

In operation, as the modulating signal changes
the frequency of the carrier, the energy appear-
ing in tube B and in particular in the output cir-
cuit thereof, changes more rapidly in phase or
in frequency than that from tube A. These re-
lative changes in phase of the energies from the
two coupling tubes results in a change in ampli-
tude of the combined energy in the primary
winding 14 of transformer T. This amplitude
change or modulation is impressed on the input
circuit of detector tube C and the demodulated
signal appears in the output circuit thereof, from
whence it may be utilized. When used for re-
ceiving phase modulated waves, a correcting cir-
cuit CC is added. This correcting circuit has the

characteristic shown in Fig. 4, as will be explained more fully later.

While this receiver of Fig. 1 has been illustrated as having a damped transmission line, it will be understood that in this receiver the transmission line L may be undamped, or open-circuited at the end. In this case, the tap 20, P is moved to a point on the line where the reflected wave cancels the incident wave. The operation of this modified receiver will be apparent from the description of the receiver of Fig. 3 which will be given later.

In the receiver of Fig. 2, use is made of the fact that when the line L, made up of series inductance and shunt capacity C, is open or short-circuited at the far end, a reflection of signal energy transmitted by the line L occurs along the line. The combination of this reflected energy with the incident energy results in combined energy, the amplitude of which varies. That is, when the signal frequency is changed with signal modulation a phase difference between the incident and reflected waves of line L is caused such that their resultant amplitude changes. Consequently, amplitude modulation of the energy in the line at different points therealong is effected by permitting far end reflections. By obtaining the output from the line L at two different points P₂, P₄ by way of leads 35, 37, connected at points such that at one point the incident and reflected waves combine to increase the resultant, while at the other point the two waves combine to decrease the resultant, two separate waves with modulation envelopes 180° out of phase may be obtained. These two waves may be, and are, applied as shown to the differential detectors A and B by way of leads 35 and 37, respectively.

The detected output appearing on the anode 42 of detector A is 180° out of phase with respect to the detected output appearing on the anode 43 of detector tube B. This necessitates the use of a push-pull transformer T connected to the outputs of tubes A and B. The demodulated signal may be utilized in circuit 47. Where this receiver is used to receive amplitude modulated signals the output electrodes 42 and 43 of demodulators A and B, respectively, must be connected in parallel relation so that the amplitude changes add rather than oppose each other.

The receiver of Fig. 2 has an important advantage which is that the differential detectors employed in the output produce a cancellation of distortion resulting from square law detection and consequently a reduction of noise appearing with the signal in the output circuit.

The transmission line L of the receiver of Fig. 2 may be undamped or open-ended, or short-circuited at its far end, or end away from its input terminals.

When the receivers of Figs. 2, 3 and 3a are used to receive phase modulated waves, switch 46 is thrown to its frequency modulation position, i. e. so that the detector outputs are combined in phase opposition. Also, a correcting circuit CC, which will be described in detail more fully hereinafter, is added. Briefly, the correcting circuit has a characteristic of output of frequency as shown in Fig. 4. Incidentally, for a more detailed description of the receivers shown in Figs. 1, 2, 3 and 3a, reference is made to my parent application Serial No. 618,154, filed June 20, 1932.

In Fig. 3a, the grids 34, 36 of differential detectors C and D are fed, by means of a transformer T₂, cophasally with signal energy from

the output of the unit 2. Lines 3 and 5 also feed detectors C and D in phase opposition with frequency or phase modulated energy by way of transformer T₁, the input of which is connected with the output of the coupling tube A. Tube A in turn has its input circuit connected to a point 10 on transmission line L. The resultant amplitude modulation components fed to the detectors C and D are effectively 180° out of phase. By means of the push-pull output transformer T₄, connected with the anode circuits of C and D respectively, the rectified energies appearing in the output circuits of C and D are combined in proper phase when frequency modulation is received.

The receiver illustrated in Fig. 3a may be readily altered to receive either frequency modulated or amplitude modulated signals by merely connecting the outputs of tubes C and D in push-pull relation for frequency modulated waves, or in parallel relation for amplitude modulated waves. This is accomplished by switch 46.

While the receiver of Fig. 3a has been illustrated as utilizing a damped transmission line, it will be understood that in this receiver the transmission line L may be undamped, that is, open-circuited or short-circuited. In this undamped case the tap 10 is adjusted to a point on the line where the reflected wave cancels the incident wave at the carrier frequency.

Volume controls, coupling tubes, and additional amplifiers may be added to the receivers in appropriate places. Since the use of such elements will be obvious to those skilled in the art, and for the sake of simplicity, such elements have been omitted from the present disclosure.

The receivers of Figs. 2, 3 and 3a may, of course, be operated with one detector tube switched off.

The receivers described above may, in accordance with the present invention, be used for the reception of phase modulation waves. As already explained to some extent, this is accomplished by adjusting the circuits for frequency modulation as described above and using a correcting filter or circuit at the receiver which has its output voltages inversely proportional to its input frequency so that its characteristic is as shown in Fig. 4, wherein audio frequency impressed on the input terminals of the correction circuit is plotted against voltage output.

When phase modulated signals are received on a frequency modulation receiver, the signal output of the frequency modulated receiver varies in amplitude directly with the frequency of the signal at the input of the frequency modulated signal receiver. Consequently, the audio frequency output of this receiver would be distorted and would be lacking in low frequencies. The output of the receiver instead of being the same for all audio frequencies, as shown by the dotted line of Fig. 5, would be directly proportional to the frequency of the signals impressed on the input of the receiver, as shown by the full line of Fig. 5. In order to compensate for this distortion of the signal frequency when phase modulated signals are received on a frequency modulated signal receiver, a filter circuit or correction circuit, the amplitude of the signal frequency in the output of which is inversely proportional to the frequency of the signals impressed on the input of the circuit, as indicated in Fig. 4 of the drawings, is utilized in accordance with the present invention to adapt a frequency modulated receiver for reception of phase modulated sig-

nals. The combination of the effect of a filter circuit or correction circuit having characteristics as illustrated by Fig. 4 with the effect of the inherent characteristics of a frequency modulated receiver on phase modulated signals gives an over-all characteristic such as the dotted line of Fig. 5, which is a true reproduction of the signal wave applied as phase modulation to the carrier at the transmitter.

This correction filter or circuit CC is used with the receiver and is connected at a point following the detector, as shown in Figs. 1, 2, 3 and 3a.

Various forms of filter or correction circuits, which will affect the signal frequencies passed therethrough in such a manner as to make the amplitude of the signals at the output thereof inversely proportional to the frequency of the signals applied to the input, may be used. Several preferred forms of correction circuits, will now be described.

In Fig. 6, phase modulated waves picked up on the antenna are translated into signal waves by the frequency modulation receiver FMR such as described in Figs. 1, 2, 3, or 3a. The correcting circuit CC is added to reproduce an undistorted signal in Jack J. That is, in Fig. 6 the signal frequencies to be corrected are applied to the primary winding of a transformer 50 and are impressed from the secondary winding of said transformer to the input electrodes 52, 54 of a thermionic tube 51 to energize the same. The control electrode 52 of tube 51 is maintained at the desired operating potential by means of a biasing source 55. The anode electrode 56 of tube 51 is connected through a parallel circuit comprising a resistance 57 and capacity 58 to the cathode 54 by way of a high potential charging source 59. The low frequencies of the signal potentials are emphasized by means of the capacity 58 connected across the resistor 57. The impedance of this resistance 57 and capacity 58 in parallel is high at the lower signal frequencies and low at the higher signal frequencies. The amplification factor of the tube 51, which depends upon the external impedance of its anode cathode circuit, will be high at the lower signal frequencies and low at the higher signal frequencies. The signal frequency oscillations appearing on the anode of tube 51 are impressed therefrom by way of a coupling condenser 60 to the control grid 61 of a thermionic amplifier 62. These distorted or corrected signal frequency potentials are amplified in 62 and appear in the primary winding 63 of the transformer winding 64. The corrected signal frequencies may be utilized from the secondary winding 65 of the transformer 63. In order to operate 62 at the desired point on its characteristic curve, biasing potential is supplied from the source 66 by way of resistance 67 to the control electrode 61 of tube 62.

If the single distortion or correction tube 51 does not effect sufficient distortion or correction of the signal frequencies passed therethrough, a second tube, connected in circuit and operated similar to tube 51, may be connected in cascade with 51 to apply more distortion or corrective effect to the signal. This arrangement is shown in Fig. 6a.

In Fig. 7, the signals to be corrected are impressed on the input winding of a transformer 50 and utilized from the secondary winding 65 of transformer 64 in the same manner as in the arrangement of Fig. 6. In Fig. 7, however, no amplifier is shown connected with the correction

tube 51, although it is understood that the corrected signals can be further amplified, if necessary, by connecting the output of tube 51 with the input of a thermionic amplifier. The secondary winding of the transformer 50 is connected in parallel with the potentiometer resistance 70 in order that the desired signal amplitude may be impressed on the input electrode 52 by way of the tap 71. In this arrangement the resistance R_2 is of such a high impedance to the signal current as compared to the impedance of the capacity C_2 to the signal current that the current passed through the circuits R_2 , C_2 is governed mainly by the resistance of R_2 . This makes the current through the circuit elements C_2 , R_2 constant with frequency so that the voltage across C_2 will be inversely proportional to the frequency of the applied signal due to the fact that the impedance of the condenser C_2 varies inversely as the frequency of the signals applied across the terminals thereof vary. The potentials appearing at the terminals of C_2 are impressed on the input electrodes 52, 54 of correction tube 51.

In the arrangement shown in Fig. 7a correction is applied to the signal in the same manner in which correction is applied thereto by the arrangement shown in Fig. 7. However, in Fig. 7a, a second tube 51' is added for the purpose of varying the amount of distortion or corrective effect applied to the signal waves relayed therethrough. When tube 51' is switched off full correction will be obtained by means of the tube 51 in the same manner in which correction is obtained in the arrangement of Fig. 7. With the tube 51' turned on signal potentials, the amplitude of which may be determined by the tap 71', will be applied from the parallel resistance 70' to the terminals of the resistance R_4 by way of resistance R_3 . The resistances R_3 , R_4 will affect all of the frequencies of the signal impressed thereon in like manner so that no corrective effect will be applied to the signal appearing on the input electrodes 52' of the tube 51'. Consequently, the oscillations at signal frequency, appearing on the anode 56' of tube 51' and applied therefrom to the transformer 64, will be the same for all frequencies and will represent in a normal manner the signal potentials applied at the input of the correction circuit. By moving the 50 taps 71 and 71' along the resistances 70 and 70', the amount of corrected signal and uncorrected signal reaching the output circuit 63 can be adjusted to give the desired characteristic to the signal frequency in the output circuit, which characteristic may be somewhere between full correction of the signal and no correction.

This type of correction circuit is useful where it is desired that the transmitter radiate a combined frequency and phase modulated signal or a cross between frequency and phase modulated signal. Furthermore, such an arrangement is especially desirable where a correction circuit of this type is used in the signal amplifier circuits of the transmitter and a second correction circuit of this type is used subsequent to the detector in the receiver receiving signals from said transmitter.

In the correcting circuit shown in Fig. 8, as in the prior arrangements, the signals to be corrected are impressed on the transformer 50 and the corrected signals are utilized from the transformer 64. In this arrangement, however, a different means is provided for emphasizing the

lower frequencies of the signal. The value of the inductance XL in series with the control electrode is so chosen that its impedance to the signal frequency is high as compared to the impedance of the resistance Rs to the signal frequencies. The inductance XL then is the governing factor of the circuit and determines the intensity of the current passed through the circuits XL, Rs. Since the inductance XL offers a higher impedance to the higher frequencies than to the lower frequencies, the current passing through the inductance XL will be inversely proportional to the frequency of the impressed signals. Consequently, the voltages at signal frequency, appearing across the resistance Rs, which are fed to the control electrode 52 of tube 51, will be inversely proportional to the frequency of the impressed signals.

In Figs. 9 and 9a has been shown an arrangement in which, by means of a novel circuit, a corrective effect, which is the converse of the manner in which phase modulated signals are distorted in a frequency modulation receiver, is applied to the signals. The distortion of the signal wave discussed hereinbefore is created by virtue of the fact that that phase modulated waves are being received on a frequency modulated signal receiver. On the other hand, if a circuit is set up which receives frequency modulation on a phase modulation receiver, a distortion is created which is the inverse of the undesired distortion obtained when phase modulation is received on a frequency modulation receiver. Obviously, if the phase modulated signal is passed through these circuits in sequence, the distortion effects, which are the inverse of each other, will add or cooperate to give a resultant signal which is truly representative of the initial signal to be worked with. This might seem like a devious route to follow to receive phase modulation. Actually, it is not, however, and is, on the contrary, a convenient manner to receive phase modulated signals under certain conditions. The phase modulated signals are first received on a frequency modulated receiver, then converted by means of a local modulating means (transmitter) to frequency modulation, and received on a phase modulation receiver as shown in Fig. 9.

The logical assumption may be that, since a phase modulated signal receiver is used in this correction circuit, the phase modulations should be received directly on that unit. However, there are reasons for following the present course. First, the received signal output from phase modulated signals received on a frequency receiver, including correcting means as illustrated in Figs. 6, 7, 7a and 8, is different from that received directly on a phase modulation receiver with respect to interference, fading, and tuning characteristics. Consequently, a corrected frequency modulation receiver (receiving phase modulated signals) will feed a certain circuit more suitably than a phase modulation receiver receiving the same signals directly. Second, the phase modulation system, including the local frequency modulation transmitter, when used for a correction circuit, in accordance with the present invention, is far more simplified than when the transmitter and receiver are at widely separated points. This may be realized by an inspection of the circuit of Fig. 9a, which shows a correction circuit of this type in detail.

In Fig. 9a the signal frequencies to be corrected are applied from the detector of the frequency modulation receiver FMR tuned to and receiving

the phase modulated signal picked up by the antenna to the input terminals of a transformer 50. The secondary winding of transformer 50 is connected to the control electrode 90 of an oscillation generator 91 of the dynatron type. The anode 92 is connected with an oscillatory circuit 93 in which oscillations at high frequency are developed by producing a negative resistance effect in the anode cathode circuit, as disclosed more in detail in United States application Ser. No. 508,383, filed April 30, 1932, now Patent No. 2,085,739, issued July 6, 1937. The high frequencies generated by the dynatron oscillator are modulated in frequency, as disclosed more in detail in the above identified application. The modulated oscillations are impressed from the circuit 93 on to a winding 94, and from winding 94 in opposition to the control electrodes 95 and 96 of thermionic differential detectors 98 and 100 of a phase modulation receiver. The anodes 101 and 102 of differential detectors 98 and 100 are connected in series through resistances 110 and 111, as shown. Charging potential for the anodes is supplied from a source 103 connected between the terminals of resistances 110 and 111 and the cathodes of tubes 98 and 100. The different currents resulting from the signal frequencies impressed oppositely to the control electrodes of tubes 98 and 100 flow in the resistances 110 and 111. These different currents are applied from the high potential terminals of resistances 110 and 111 to the input terminals of a radio filter circuit comprising series inductances I, I' and parallel condensers C4 connected as indicated. After passing through the filter circuits I, I', C4 the different currents flow through resistances Rs, Rr to the control electrode 105 and cathode 106 of a second dynatron oscillation generator 108. Capacities Cs are connected between the terminals of the resistances Rs, Rr and ground. These resistances and capacities regulate and determine the time constant of the circuit interposed between the differential resistors 110, 111 and the input electrodes of the oscillation generator 108 to regulate the sensitivity and rapidity of the control effect of the different currents on the oscillator 108.

A source 109 supplies direct current biasing potential to the grid electrode of tube 108. The differential currents from resistances 110 and 111 are superposed on this direct current potential. The output circuit 112 of the dynatron oscillation generator and modulator 108 is coupled through a link circuit 113 with a transformer 114, the secondary winding 115 of which is connected in series with the control electrodes 95 and 96 of differential detectors 98 and 100 so that the carrier frequencies developed in 112 and modulated by the differential currents in 108 are applied cophasally to the control electrodes of the differential detectors 98 and 100. This entire arrangement of the differential detectors and the frequency control means for the supplemental modulator and generator 108 is, in many respects, similar to the automatic frequency control device disclosed in United States Appn. Ser. No. 616,803, filed June 13, 1932, now Patent #2,065,565, issued on Dec. 29, 1936.

The detected signals appearing in the anodes of differential detectors 98 and 100 are applied by way of coupling condensers 116 and 117 to the terminals of series resistances 118, 119 and from the terminals of said resistances to the control electrodes of a pair of amplifier tubes 120 and 121 having their anodes connected through 75

the primary winding 63' of a transformer 64'. This phase modulation receiver, including the differential detectors 98 and 100, the frequency control means 108, and the repeaters 120 and 121, impart to the modulated signals from frequency modulated dynatron 90, a distortion which is the converse of the distortion given to the initially received phase modulated signal by the frequency modulation receiver FMR. The two distortion effects add to provide in the output of transformer 64' a signal which is truly representative of the signal impressed on the original phase modulated wave. The corrected signal frequencies may be utilized from the secondary winding 65' of this transformer.

Any one of the correction circuits illustrated in Figs. 6, 7, 7a, 8, 9, and 9a, may be utilized with the frequency modulated receivers of Figs. 1, 2, 3 and 3a, as indicated in Fig. 10, in which 1 is the aerial system, 2 is a signal amplifier of any type, and 80 indicates any one of the phase or frequency or amplitude receivers of Figs. 1, 2, 3 and 3a connected to 2 by way of leads 3 and 5. The correction circuits of Figs. 6, 7, 7a, 8, 9 and 9a may be incorporated in the receivers by merely connecting the primary winding of the transformer 50 of any of the correction circuits to the output terminals of the detectors C, AB, or CD of the receivers of Figs. 1, 2, 3 and 3a, respectively. When the receivers are so modified phase modulated signals may be received thereon without distortion.

In Fig. 11, a plurality of aerial systems, X, Y and Z may be coupled through radio frequency amplifiers X₁, Y₁ and Z₁ to the amplifier and/or combining unit indicated diagrammatically at 2. The units X₁, Y₁ and Z₁ may be heterodyne receivers which reduce the signals to an intermediate frequency for transmission over the lines to the unit 2. The unit 2 may include the radio frequency amplifiers or a heterodyne receiver in addition to the combining unit. The output of the unit 2 is, as indicated, connected by way of leads 3 and 5 to a frequency or phase or amplitude modulated signal receiver 80 of the type shown in any of the Figs. 1, 2, 3 and 3a.

When the unit 80 includes a frequency modulation receiver, a correction circuit, as illustrated in Figs. 6, 7, 7a, 8, 9, or 9a, may be included in the unit 80 shown dotted between the receiver 80 and the output jack in order to enable distortionless reception of phase modulated waves.

Furthermore, it will be obvious that the present invention is especially applicable to diversity receiver systems in which automatic volume control for the radio frequency amplifiers is provided. Such a system then might take the form of the arrangement disclosed diagrammatically in Fig. 11a. In this arrangement, a direct current component is derived from the output of the demodulation tube or rectifier and fed back to the radio frequency amplifiers of the units X₁, Y₁ and Z₁ where it is used to determine the biasing potential applied to the tubes therein thereby determining the amplification factor of the tubes. The arrangement is such that the desired relation between received signal strength and biasing potential may be maintained. A more complete understanding of the details of this volume control may be had by referring to Moore U. S. Pat. #1,849,632, and Crosby U. S. Pat. #1,835,761.

Although in the arrangement of the present invention as illustrated above, in general tubes of the triode type, except for the dynatrons of Figs. 9 and 9a are used, it will be understood that said

circuits may obviously be modified to use any of the types of tubes in general use today. For example, tubes of the screen grid type may be inserted in place of the triodes illustrated without departing from the spirit of the present invention. Furthermore, other tubes also may be utilized, the only provision being that the tubes have the desired operating characteristics.

I claim:

1. The method which includes subjecting a phase modulated wave to a frequency demodulation and amplifying the higher frequencies of the demodulated waves to a lesser extent than the lower frequencies of the demodulated waves.

2. Means for receiving and demodulating waves of substantially constant amplitude the phase of which is varied substantially in accordance with signals comprising, wave absorption means, signal combining means, a plurality of transmission channels of different electrical character connecting said absorption means to said combining means, signal demodulating means connected to said combining means, and a circuit, for intensifying the higher modulation frequencies resulting from said demodulation relative to the lower modulation frequencies resulting from said demodulation, connected with said demodulating means.

3. Receiving means including the combination of signal responsive means, combining means, a plurality of channels connecting said combining means to said responsive means, one of said channels including signal wave phase shifting means, and a filter circuit connected to said combining means, the character of said filter circuit being such that the amplitude of the signal in the output thereof is inversely proportional to the frequency of the signal applied to the input thereof from said combining means.

4. Means for demodulating high frequency oscillations modulated in phase at signal frequency comprising, signal collecting means, signal combining means, a plurality of channels of different electrical length connecting said combining means to said collecting means, the electrical length of one of said channels varying with the phase of the received signal, indicating means, and a correction circuit interposed between said demodulating means and said indicating means, said correction circuit including a frequency discriminating reactance whereby the voltages applied from said correction circuit to said indicating means vary inversely as the frequency of the signal components impressed from said demodulating means on the input of said correction circuit.

5. Means for demodulating high frequency oscillations modulated in phase at signal frequency comprising, signal collecting means, signal combining means, a plurality of channels of different electrical length connecting said combining means to said collecting means, signal demodulating means coupled to said combining means, signal indicating means, and a correction circuit interposed between said demodulating means and said indicating means, said correction circuit including a thermionic tube having its input electrodes connected to said demodulating means and its output electrodes connected to said indicating means by means of ohmic resistance and reactance so related that the output voltages vary inversely as the frequency of the audio frequency signals on the input of said correction circuit.

6. In a system for amplifying and demodulating waves modulated at signal frequency, wave

amplifying and amplitude limiting means, a circuit for impressing the waves to be demodulated on said means, an output circuit connected to said means, a combining circuit, a plurality of signal transmission lines of different electrical length connected to said output circuit, means connecting each of said lines to said combining circuit, and a rectifier connected at its input to said combining circuit and at its output to signal indicating means, and a correction circuit interposed between said rectifier output and said signal indicator, said correction circuit comprising reactances which modify the amplitude of potentials passed thereby substantially in inverse proportion to their frequency.

7. A phase modulated signal receiver comprising, signal absorption means, signal combining means, a plurality of transmission channels connected with said absorbing means, at least one of said channels comprising a filter circuit of appreciable electrical length, which length varies as the character of the received signal varies, means for coupling points on each of said channels at which the signal waves travelling therein are of different phase to said combining means, and a signal frequency discriminating circuit connected to said combining means, the character of said frequency discriminating circuit being such that it modifies the amplitudes of the potentials passed thereby substantially in inverse proportion with respect to the frequency of said potentials passed thereby.

8. Receiving means including the combination of signal responsive means, signal combining means, a plurality of channels of appreciable electrical length connecting said responsive means to said combining means, and a filter circuit connected to said combining means, the character of said filter circuit being such that the amplitude of the signals in the output thereof is inversely proportional to the frequency of the signals impressed from said combining means on the input of said filter.

9. A receiving system for translating carrier waves of constant amplitude modulated in accordance with a signal to be transmitted comprising means for receiving wave energy so modulated, means for transforming the wave energy received into waves of varying amplitude, means for rectifying the wave energy of varying amplitude so as to produce wave energy of modulation frequency, and means for amplifying said last mentioned wave energy an amount inversely proportional to the modulation frequency thereof.

10. A receiving system for translating carrier waves of constant amplitude modulated in accordance with a signal to be transmitted comprising means for receiving wave energy so modulated, means for transforming the wave energy received into waves of varying amplitude, means for rectifying the wave energy of varying amplitude so as to produce wave energy of modulation frequency, and means for amplifying said last mentioned wave energy an amount which bears an inverse relation to the modulation frequency thereof.

11. In combination, means for picking up phase modulated waves, a frequency modulation receiver coupled to said pick-up means for translating the phase modulated waves into waves of modulation frequencies, a correcting circuit, and means for passing said waves of modulation frequencies through said correcting circuit, said correcting circuit having a characteristic such that

its output varies inversely with the frequency of the input applied thereto.

12. The method which includes subjecting a phase modulated wave to a frequency demodulation, and attenuating the resulting demodulated waves of lower frequency to a lesser extent than the demodulated waves of higher frequency.

13. The method of radio reception which includes receiving phase modulated high frequency carrier wave energy, subjecting the received energy to a frequency demodulation, and amplifying the resulting demodulated waves in such a way that the demodulated waves of lower frequency are amplified to a greater extent than the demodulated waves of higher frequency.

14. The method of radio reception which includes receiving phase modulated high frequency carrier wave energy, heterodyning the received waves to a convenient intermediate frequency, subjecting the waves of intermediate frequency to a frequency demodulation, and attenuating waves resulting from the said frequency demodulation in such a way that the demodulated waves of higher frequency are attenuated to a greater extent than the demodulated waves of lower frequency.

15. The method of radio reception which includes heterodyning received phase modulated high frequency carrier waves to a convenient intermediate frequency, subjecting the waves of intermediate frequency to a frequency demodulation to obtain a band of low frequency currents, and amplifying the low frequency currents of said band to a substantially greater degree than the high frequency currents thereof.

16. The method of radio reception which includes receiving phase modulated wave energy, subjecting the received energy to a frequency demodulation and attenuating the higher frequencies of the demodulated waves to a greater extent than the lower frequencies of the demodulated waves.

17. The method of radio reception which includes receiving modulated signal waves, subjecting the received waves to a frequency demodulation, and amplifying the demodulated waves in such a way that the amplification varies inversely with the frequency of the demodulated waves.

18. In a system for demodulating high frequency wave energy which has its phase swung with respect to a reference phase an amount substantially proportional to the modulation voltage over a portion of the frequency range of the modulation voltage, means for receiving wave energy so modulated, a frequency modulation demodulation system having an input coupled to said aforesaid means and having an output, signal indicating means having an input, and a circuit, having a characteristic such that voltages of higher modulation potential frequencies are attenuated thereby an amount greater than voltages of lower modulation potential frequencies, coupling said frequency modulation demodulator to said signal indicating means input.

19. The method of demodulating wave energy of constant amplitude which has been varied in wave length by modulating potentials modified in such a manner that the resulting wave length modulation includes phase and frequency modulation components comprising, receiving energy so modulated, subjecting the received energy to a frequency demodulation and amplifying the resulting demodulated waves in such a way that the demodulated waves of lower signal frequency

are amplified to a greater extent than the demodulated waves of higher signal frequency.

5 20. The method of signalling which includes, receiving a wave which has been modulated so as to include frequency and phase modulated components, substantially eliminating amplitude changes in said wave, subjecting said wave to a frequency demodulation, and attenuating the resulting demodulated waves of lower frequency to a lesser extent than the demodulated waves of higher frequency.

10 21. The method which includes, subjecting a modulated wave, modulated so as to be a combined frequency and phase modulated wave, to a frequency demodulation, and attenuating waves of lower frequency resulting from the demodula-

tion to a lesser extent than waves of higher frequency resulting from the demodulation.

22. The method of radio reception which includes, receiving high frequency carrier wave energy which wave energy is modulated so as to include frequency and phase modulated signal components, heterodyning the received energy, substantially eliminating amplitude changes in the heterodyned energy, subjecting the heterodyned energy to a frequency demodulation and amplifying the resulting demodulated waves in such a way that the demodulated waves of lower frequency are amplified to a greater extent than the demodulated waves of higher frequency.

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