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2,114,335

RECEPTION OF PHASE MODULATED WAVES

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Fig. 1

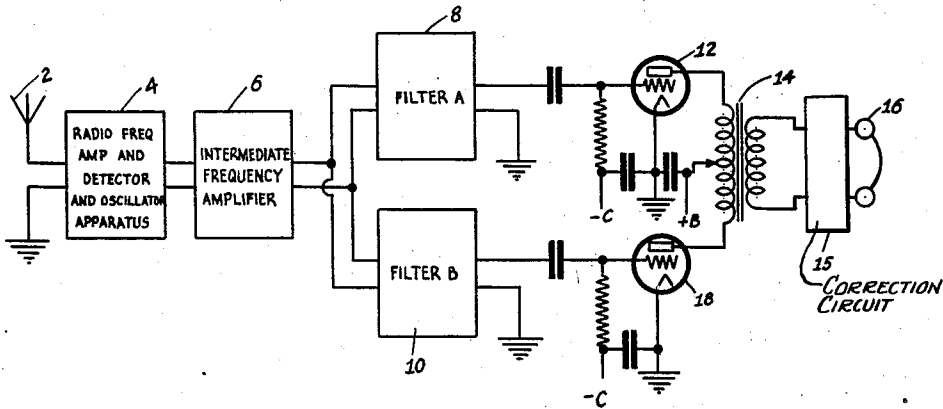


Fig. 2

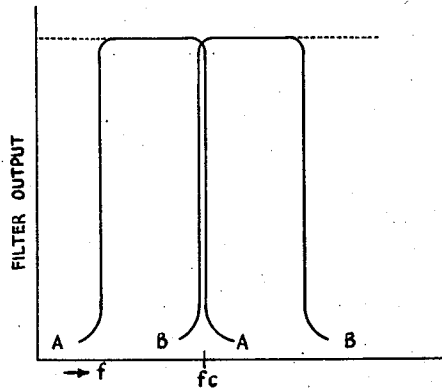


Fig. 3

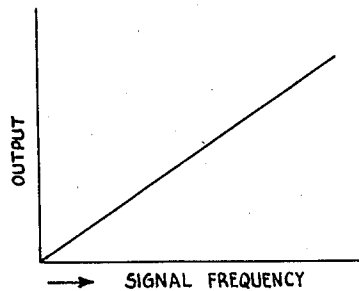
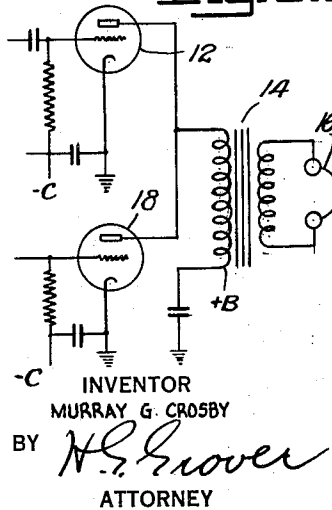


Fig. 1 A.



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RECEPTION OF PHASE MODULATED WAVES

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9 Claims. (Cl. 250—20)

This invention relates to the reception and translation of signal modulated carrier energy and appertains in particular to a system for the reception and translation of phase modulated carrier waves.

I have discovered, by analyzing phase modulated waves, that by separating one set of sidebands from a phase modulated signal, an amplitude modulated envelope corresponding to the signal modulation is introduced. It is an object of my present invention to utilize this phenomenon for the translation of received phase modulated waves. Briefly to do so, I separate one set of sidebands and carrier energy from the collected energy and detect the energy so separated.

To increase the strength of the final signal output, is a further object of my present invention and to do so a portion of the carrier energy and the other set of sidebands of the received waves are separated and separately detected. However, the signal envelope so obtained, I have found, is 180 degrees out of phase with the signal envelope obtained by the first detection referred to above, when the collected waves are of the phase modulated type. Accordingly, a further object of my present invention is to combine the detected outputs out of phase whereby the resultant signal adds vectorially. To do this briefly, the detected signals are combined out of phase.

The foregoing system is not only useful for phase modulation but may be utilized equally as well for frequency modulated waves. For amplitude modulated waves, the system may be used, but in that event, the final detected outputs should be combined cophasally, for with amplitude modulated waves, the separate detections of carrier energy with single sets of sidebands on opposite sides of carrier in frequency, produces cophasal envelopes.

Regardless of the type of wave received and translated, my present invention offers the advantage that the horrible distortion due to fading of the carrier is substantially eliminated. That is to say, with fading of the carrier to a value less than the value of the sidebands, distortion occurs. However, by separating carrier energy and sideband energy and separately detecting the same, the relative value of the carrier energy as compared to side band energy in each of the separate detection systems, is maintained high, as a result of which the distortion referred to is substantially eliminated.

It is a further object of the present invention to utilize, in connection with the system de-

scribed above, filters having square topped or rectangular characteristics overlapping at the carrier frequency. The use of such filters in connection with my present system, offers the advantage that effectively there is no change in percentage of modulation. Otherwise, distortion would be introduced at the receiving end.

With a phase modulation receiver such as described, all of the advantages with respect to limiting, power amplification and frequency multiplication may be obtained at the transmitting end. Moreover, phase modulation offers the additional advantage that it may be applied to a highly stabilized master oscillator at the transmitting end such as, for example, a crystal controlled oscillator.

An examination of the sidebands resulting from phase modulation of a wave to an effective 100% modulation indicates a second sideband of about 16% of the unmodulated carrier voltage. From this it might be assumed that were the modulation passed through the normal band pass equivalent to that of an amplitude modulation receiver, that for the higher modulation frequencies, this second sideband and all those above it in order might be eliminated and a distortion result. As a matter of fact I have found the elimination of such extraneous sidebands actually improves the linearity of the receiver so that harmonic distortions are decreased at the higher modulation frequency. Consequently, phase modulation, as used in the present invention, does not require a combined width any greater than that required by an ordinary double sideband amplitude modulated wave.

Other advantages and objects of my present invention will readily manifest themselves as the description thereof proceeds. This description will be given further with the aid of the accompanying drawing which, it is to be clearly understood, is given merely by way of illustration and in no way is to be considered limitative.

Figure 1 of the drawing indicates a "back-to-back" (so called because of separate detection of carrier energy and sideband energy lying on opposite sides of the carrier) receiving system embodying the principles of my present invention outlined briefly above.

Fig. 1A is a modification of the arrangement of Fig. 1. In Fig. 1, phase or frequency modulated wave receiving means is shown, whereas in the modification of Fig. 1A amplitude modulated wave receiving means is shown.

Figure 2 is a graph illustrating characteristics

of filters utilized in the system shown in Figure 1, and.

Fig. 3 is a curve illustrating the characteristics of the correction circuit of Fig. 1.

Turning to Figure 1, energy, preferably phase modulated carrier energy, is collected upon a suitable energy collector or antenna 2 and fed to a radio frequency amplifier 4 which may include, if desired, a local oscillator for heterodyning the received waves to an intermediate frequency band. The intermediate frequency energy is amplified by suitable intermediate frequency amplifier 6 whose output is fed to two filters 8, 10, marked respectively filter A and filter B. The filters are so designed as to have characteristics as shown in Figure 2, or in other words to have rectangular or square topped characteristics overlapping at the carrier frequency which corresponds to the transmitted frequency. An alternative to the two band-pass filters would be a high and a low pass filter having the characteristic as shown by the dotted lines in Figure 2. The band pass action for eliminating interference could then be obtained from the band pass characteristic of the superheterodyne receiver. This sort of an arrangement simplifies filter design. The square top or square cornered filter is of course only the theoretical ideal. In actual practice an approximation with rounded corners and somewhat sloping sides has to be tolerated. In the event that heterodyning is not used at the amplifier 4, the overlapping frequency corresponds to the mean frequency amplified by the radio frequency amplifier 6.

Carrier energy and one set of sidebands or energy lying in frequency to one side of the carrier becomes changed effectively by the action of filter A to an amplitude modulated wave which by detection in detector 12 produces a signal modulation wave in the primary of transformer 14. By virtue of the fact that the carrier relative to one sideband will, in general, be always large, and also that the other sideband is not present in each detector the effect of distortion due to fading of the carrier is minimized. That is, with the presence of only one sideband and the carrier in each detector input the two sidebands do not have a chance to beat together to cause second harmonic distortion. The output of transformer 14 may be fed to a suitable translating device such as ear phones 16 for rendering intelligible the transmitted signal.

The system as described without filter 10, and detector 18 connected with the output of filter 10, is completely operative for phase modulated, frequency modulated, or amplitude modulated waves and as already indicated will minimize distortion due to fading of the carrier. Better results however should be obtained where a filter B and detector 18 are connected as shown to supplement the action of filter A and detector 12.

However, in case the receiver is used on frequency modulation a correcting filter will be required for the signal wave or a distortion will be introduced, irrespective of whether or not both filters A and B and detectors 12 and 18 are included in the circuit. The correction filter has a characteristic such that the amplitude of the signals at its output is directly proportional to the signal wave frequency applied to its input. Thus, at zero signal wave frequency the filter output will be zero and will increase linearly with the signal wave frequency. The characteristic of such a filter is shown in Figure 3. When this correction circuit is applied to the receiver, it

is inserted between the transformer 14 and the phones 16 as shown by rectangle 15. The correction circuit used here may take various forms. For example, a correction circuit as illustrated in Figs. 5, 6, 7, 7A and 8 of my U. S. application Ser. No. 608,383, filed April 30, 1932, may be utilized in the unit 15.

To utilize both sets of sidebands resulting from phase modulation of a carrier and to take advantage of the improved action due to the separation in the receiver of part of the carrier and one sideband from the other part of the carrier and the other sideband, the filter B and detector 18 should be connected in circuit as shown in Fig. 1 so that the output of detector 18 or filter B is added out of phase with respect to the output of filter A when frequency modulated or phase modulated waves are to be received. This action is obvious from an inspection of the drawing as already indicated. The reason for connecting the outputs of the detectors 12, 18 out of phase is due to the fact that separate detection of carrier energy and each set of sidebands due to phase modulation or frequency modulation will produce signal modulated envelopes 180 degrees out of phase. To render an intelligible signal, the detected waves must, therefore, be added out of phase.

For amplitude modulated waves the anodes of the two detectors should be connected in parallel as shown in Fig. 1A and the primary of transformer 14 connected in series with the source of B or anode potential. As this connection will be obvious to those skilled in the art, further description of the same is deemed unnecessary.

An additional advantage of the system shown resides in the fact that even harmonics due to the second harmonic square law detector characteristic of the detectors are balanced out when the system is used for phase or frequency modulated waves.

Having thus described my invention, what I claim is:

1. In a system wherein communication is carried on by means of phase modulated waves, the method of receiving the phase modulated waves which includes, collecting phase modulated energy, heterodyning the collected energy to lower intermediate frequencies, separating the intermediate frequency energy into two portions one of which includes carrier frequency energy and energy lying within a band of frequencies having uniform amplitude to one side of the carrier frequency energy and the other of which includes carrier energy and energy lying within a band of frequencies having uniform amplitude on the other side of the carrier frequency energy whereby to minimize distortion due to fading of the transmitted phase modulated energy, translating all frequencies of each of said portions uniformly, separately detecting the energy portions so separated, combining the detected portions in phase opposition, and, translating the combined detected energies.

2. A phase modulated wave demodulator comprising, means for collecting phase modulated energy, a filter having a rectangular or square topped characteristic for separating carrier energy and energy corresponding to one sideband from said collected energy, another filter having a rectangular or square topped characteristic for separating carrier energy and energy corresponding to the other sideband of said collected energy, means for separately detecting the filtered energies, means for combining the detected en-

ergies, means for translating the combined energies, connected with said combining means, and means for adapting said receiver to the reception of frequency modulated waves comprising a filter circuit having an input connected to said combining means and an output connected to said translating means, said filter being such that the amplitude of the signal frequencies at the output thereof vary linearly as the frequency of the signals impressed on the input thereof vary, said filter circuit being in said connection between said combining means and said translating means.

3. A radio receiving means for translating signal modulated carrier frequency wave energy of constant amplitude comprising, signal collecting means, a pair of filters coupled to said signal collecting means, one of said filters passing energy characteristic of carrier frequency wave energy and of waves the frequencies of which lie to one side only of said carrier frequency wave energy, the other of said filters passing energy characteristic of carrier frequency wave energy and of waves the frequencies of which lie to the other side of said carrier frequency wave energy, a pair of thermionic detectors, each having input and output electrodes, a circuit coupling the input electrodes of one of said detectors to one of said filters, a circuit connecting the input electrodes of the other of said detectors to the other of said filters, means associated with the output electrodes of said detectors for combining the detected energy, translating means, and a correction circuit having output terminals coupled to said translating means and having input terminals coupled to said detectors, said correction circuit being such that the amplitude of the signal frequencies in the output thereof varies linearly as the frequency of the signal frequencies impressed on the input thereof varies.

4. A radio receiving system for translating signal modulated waves of constant amplitude comprising, signal collecting means, a pair of filters connected to said signal collecting means, said filters having rectangular or square topped characteristics, portions of the energy passed by said filters overlapping, one of said filters passing energy characteristic of the carrier energy and of energy lying to one side of said carrier energy, the other of said filters passing energy characteristic of the carrier energy and of energy lying to the other side of said carrier energy, a thermionic rectifier for each filter, each rectifier having input and output electrodes, a circuit connecting the input electrodes of one of said rectifiers to one of said filters, a circuit connecting the input electrodes of one of said rectifiers to the other of said filters, and means connected with the output electrodes of said rectifiers for combining in out of phase relation the energy passed by said rectifiers.

5. A radio receiving means for translating signal modulated wave energy of constant amplitude comprising, means for collecting signal modulated energy, a high pass filter and a low pass filter for separating said energy into two portions, said filters having square topped or rectangular topped characteristics, the energy passed by one of said filters including energy representative of the carrier and one side band, the energy passed by the other of said filters including energy representative of the carrier and other sideband, circuits connecting said filters to said signal energy collecting means, a pair of thermionic rectifiers each having input and output elec-

trodes, means for connecting the input electrodes of one of said rectifiers to one of said filters, means for connecting the input electrodes of the other of said rectifiers to the other of said filters, a circuit connecting the output electrodes of said rectifiers in push-pull relation, and translating means coupled to the output circuit of said rectifiers.

6. The combination with a phase modulated signal wave receiving device comprising, a radiant energy absorption member, an amplifier connected therewith, a filter system connected with said amplifier, and a demodulator connected with said filter system, of means for converting said device to the reception of frequency modulated signal waves comprising a correction circuit connected to the output of said demodulator, said correction circuit being such that the amplitude of the signal potentials at the output thereof vary linearly as the frequency of the signals impressed from said demodulator on the input thereof vary.

7. A receiving and translating system for frequency modulated waves, comprising a circuit receiving frequency modulated waves, a filter connected to said circuit, said filter having a substantially rectangular characteristic and passing frequency modulated waves of carrier frequency and of frequencies lying in only one sideband of the waves received in said circuit, a detector connected to the output circuit of said filter, a correction circuit whose output varies linearly with the frequency of the input supplied thereto, connected to the output electrodes of said detector, and translating means connected to the output of said correction circuit.

8. A receiving and translating system adapted to receive and translate frequency modulated waves, comprising a circuit, means for impressing frequency modulated waves on said circuit, a filter having an input connected to said circuit, said filter having an output and having substantially a rectangular characteristic and passing frequency modulated waves of carrier frequency and frequencies lying in only one sideband of the received waves, a detector having input electrodes connected to the output of said filter, said detector having output electrodes, a correction circuit whose output varies linearly with the frequency applied to the input thereof, connected to the output electrodes of said detector, and translating means connected to the output of said correction circuit.

9. In a system for receiving and translating frequency modulated wave energy comprising carrier energy and at least one sideband, a circuit responsive to said frequency modulated wave energy, a filter circuit for passing only wave energy of carrier wave frequency and of frequencies corresponding to the frequency in said one sideband, said filter having an input and having an output, means connecting the input of said filter circuit to said first circuit, a detector having input and output electrodes, means connecting the input electrodes of said detector to the output of said filter, a correction circuit having an input and an output, the character of said correction circuit being such that the voltages at its output vary linearly in accordance with the frequency of wave energy impressing on its input, means connecting the input of said correction circuit to the output electrodes of said detector, and translating means connected to the output of said correction circuit.