March 17, 1942. E. PETERSON 2,276,863

SIGNALING BY MODULATED WAVES

Filed Jan. 4, 1941

FIG. 1

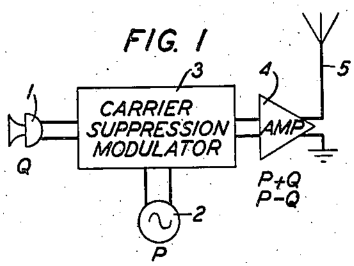
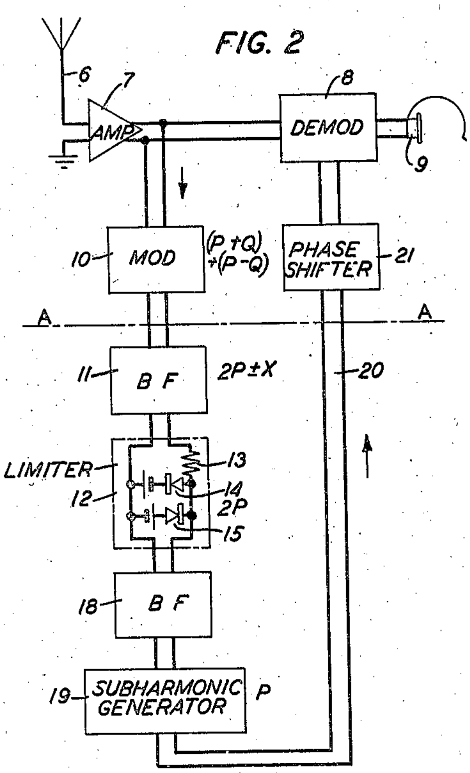


FIG. 2



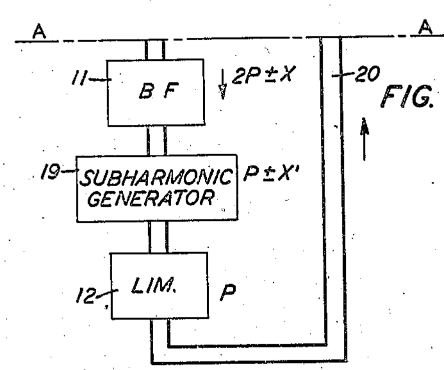


FIG. 3

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SIGNALING BY MODULATED WAVES

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3 Claims. (Cl. 250—20)

The present invention relates to the reception of modulated waves and to the derivation of waves of the frequency of the carrier component for use in demodulating the modulated waves.

An object of the invention is to improve the purity of the received signal wave and increase the signal-to-noise ratio.

When the received wave consists only of side-band components it is necessary to supply to the demodulator a wave of carrier frequency in order to demodulate the received waves and recover the signal. This carrier wave may be produced in any of several ways such as by means of an oscillation generator of suitably controlled frequency and phase. When the received wave consists of both side-bands without the carrier it has been proposed to modulate the two side-bands with each other to produce a wave of twice the carrier frequency and then derive from this wave the half-frequency wave, that is, a wave of the carrier frequency. If the side-bands are represented as P—Q and P+Q, P being the carrier frequency and Q the signal frequency, the summation frequency is seen to be 2P, which is halved in a sub-harmonic frequency generator to produce the frequency P.

Applicant has discovered that in the practice of this method as broadly outlined above a considerable amount of distortion and noise is derived along with the carrier frequency component and that this noise appears in the final output signal, being of such frequency that it cannot be filtered out. Applicant has discovered in accordance with this invention that this noise can be reduced by passing the waves of summation side-band frequency, or of this frequency halved, through an amplitude limiting device in order to eliminate certain amplitude modulation components which otherwise would produce distortion in the subsequent steps of the demodulating process.

The nature and objects of the invention will be more fully understood from the following detailed description in connection with the accompanying drawing in which:

Fig. 1 is a simplified diagram of a radio transmitter for speech or other types of intelligence waves;

Fig. 2 is a simplified diagram of a receiver for the waves from the station of Fig. 1 in accordance with the invention; and

Fig. 3 shows a modification that may be made in Fig. 2 by replacing the portion of the Fig. 2 circuit below the broken line A—A.

Referring to Fig. 1, speech to be transmitted by radio is spoken into microphone **1** and combined with carrier waves from source **2** in a carrier suppression modulator **3**. As indicated on the drawing, both side-bands are transmitted from transmitting antenna **5** after suitable amplification, if desired, at **4**. It will be observed that Fig. 1 is a diagram of the general features of a transmitter the specific construction of which may take on any one of many forms known to the art. It illustrates the fact that both side-bands are transmitted and that the unmodulated carrier component P is suppressed in the modulator which may be assumed to be of balanced circuit type. The transmission need not necessarily be by radio but may be by any form of guided or unguided transmission.

The waves transmitted from the station in Fig. 1 are received on antenna **6** (or other suitable input circuit in case of guided wave transmission), are amplified at **7**, demodulated at **8** and received at **9** either locally or over a telephone line. In order for demodulator **8** to operate satisfactorily to demodulate the waves, a wave of carrier frequency P must be supplied.

To provide such wave, certain auxiliary circuits are needed. Modulator **10** of any suitable amplitude-modulation type has supplied to it a part of the incoming upper and lower side-bands of frequencies P+Q and P—Q, and produces as one output component the summation frequency 2P which is assumed to be accompanied by certain undesired components including noise or distortion which can be lumped together as a quantity x giving actually an output component expressible as $2P \pm x$. This component is selectively passed through band-pass filter **11** which suppresses the other components in the output of modulator **10**.

Limiter **12** preferably has a symmetrical characteristic such as to cut off both positive and negative waves alike in excess of a given amplitude. The limiter may take on a variety of forms but is illustrated as comprising two shunt solid-element rectifiers **14** and **15** oppositely poled and each biased by a battery to the same value of opposing voltage. These are used in combination with series resistor **13**. When the amplitude of the voltage exceeds a value determined by the bias voltage and the cut-off characteristic of the rectifier, the excess voltage is suppressed because of the low shunt impedance in relation to the series resistance **13**. This is true for voltages of both signs.

The undesired quantities which go to make up the quantity x as used above may be due to some noise N picked up in the system and to modulation products arising in modulator **10** including:

$$2P+2Q$$
$$2P-2Q$$
$$2P+2N$$
$$2P+2N+Q \text{ and}$$
$$2P+2N-Q$$

all of which are seen to be modulations of the component 2P. In addition to these there is the wanted component 2P. The limiter is set so as to eliminate so far as possible all amplitude fluctuations in the wave 2P. In this step it is possible to eliminate the amplitude side-bands $2P+2Q$ and $2P-2Q$ without producing phase modulation, these side-bands being symmetrical about the frequency 2P and having smaller amplitude since they are third order products. The other components noted are unsymmetrical about the frequency 2P and the limiter will suppress their amplitudes but will produce some phase modulation. These will be without substantial effect, however, as will be noted.

The output of the limiter is filtered at **18** and impressed on a subharmonic producer **19** for the purpose of halving the frequency of the 2P component and yielding the component P. This device may be of the type disclosed in R. L. Miller Patent 2,159,595, May 23, 1939, for example, and it is proportioned and constructed in the manner disclosed so that an input wave of frequency 2P is translated to a frequency P. The phase symmetry of the resulting noise and distortion components is such as to balance out extraneous products in an amplitude detector. The resulting wave of frequency P is sent through circuit **20**, which may advantageously include a phase adjusting circuit **21**, to the demodulator **8** for demodulating the received speech side-bands. If the limiter were not used, the distortion x would be transmitted in some form through the subharmonic producer and into the demodulator **8** causing disturbing currents in the receiver.

Instead of locating the limiter ahead of the subharmonic generator it can be placed after the subharmonic generator as shown in Fig. 3. Here the output of the subharmonic producer **19** is indicated as comprising components $P\pm x'$ where x' is derived from the x assumed to accompany the 2P component as applied to the subharmonic generator. The limiter **12** suppresses amplitude fluctuations in wave P, giving a purified wave for application through branch **20** to the demodulator **8**.

The invention is of particular advantage in ultra-high frequency transmission where it is difficult to discriminate between a desired component such as the 2P component and undesired components of neighboring frequencies. The invention is capable, however, of general application.

What is claimed is:

1. In a system for receiving amplitude modulated waves consisting of the two side-bands only, in which means is provided for producing the summation frequency of the two side-bands and in which the unmodulated carrier component is derived from halving the summation frequency of said side-bands, a symmetrical amplitude limiter following the frequency summation means, for eliminating the amplitude modulation of the summation frequency wave, and means following said limiter for halving the frequency to recover the unmodulated carrier frequency.

2. In a receiving system for amplitude modulated waves consisting of two side-bands without the unmodulated carrier component, a modulator for producing frequency summation of said side-bands whereby a wave of the double frequency of the carrier frequency is produced with accompanying amplitude variations, means to pass said wave through an amplitude limiter to cut off positive and negative amplitude peaks, means comprising a subharmonic producer for producing a two-to-one frequency reduction of the resulting wave to reproduce the carrier and means to demodulate said modulated waves with said reproduced carrier.

3. In a receiving system for modulated waves whose amplitude varies in accordance with a signal, said waves consisting of two side-bands without the unmodulated carrier component, a modulator for producing frequency summation of said side-bands whereby a wave of double the frequency of the carrier wave is produced with accompanying amplitude variations, means comprising a subharmonic producer for producing a two-to-one reduction in frequency in the wave from said modulator in order to derive a wave of the carrier frequency, means to use said derived wave of the carrier frequency to demodulate said side-bands to recover the signal, and means to suppress noise or interference comprising an amplitude limiter included between the output of said modulator and said means to use said derived wave, said limiter having a sufficiently narrow amplitude transmission range to provide a substantially constant amplitude wave for application to said last means.

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