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MEANS FOR ELIMINATING PHASE AND FREQUENCY MODULATION

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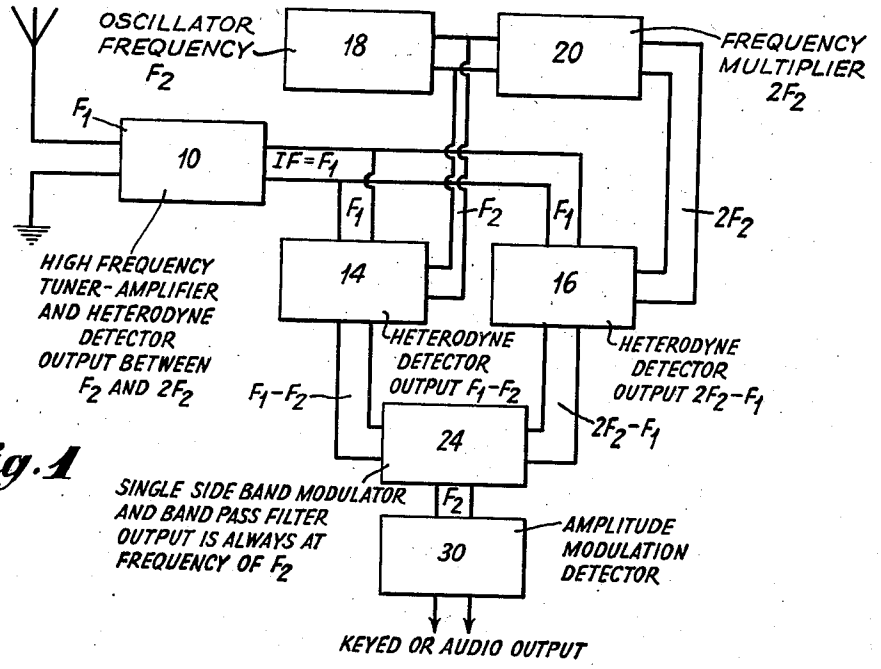


Fig. 1

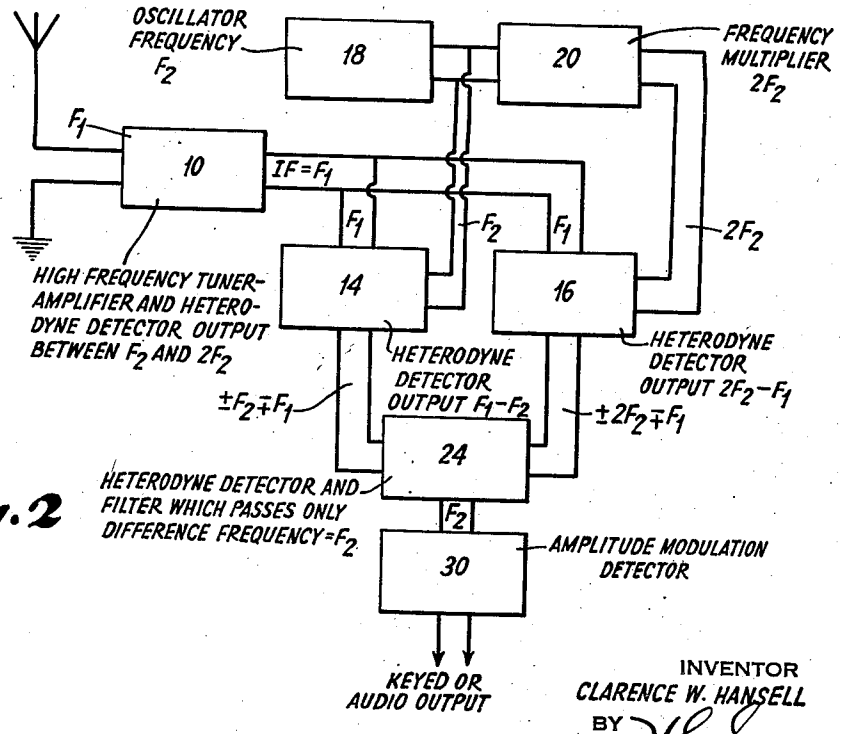


Fig. 2

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MEANS FOR ELIMINATING PHASE AND FREQUENCY MODULATION

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12 Claims. (Cl. 250—20)

This application relates to a new and improved system for and method of reducing or eliminating components of phase or frequency modulation from an amplitude modulated carrier wave, in such a manner that the amplitude modulation components thereof are retained unaffected by the reducing or eliminating process.

My invention, as applied to amplitude modulated waves and currents, is analogous in some respects to amplitude limiting, which has been applied to phase and frequency modulated waves and currents with very beneficial results. The effects of limiting in the case of reception of phase and frequency modulated waves have been studied at considerable length, and a considerable amount of material pertaining thereto will be found in publications.

Whereas, in the reception of phase or frequency modulated waves it is customary to employ limiting amplifiers, or instantaneous volume control, in order to eliminate all amplitude modulations before final detection, my present invention contemplates eliminating all phase or frequency modulation before final detection.

In describing my invention reference will be made to the attached drawing wherein:

Figure 1 illustrates diagrammatically the essential elements of a receiver arranged in accordance with my invention, while;

Figure 2 illustrates a modification of the arrangement of Figure 1.

Figure 1 shows a block diagram of a radio receiving system made up of elements for carrying out definite functions each of which is well known in the radio art. These elements as arranged comprise the principal elements included in one form of my invention. In Figure 1, I have shown a receiving antenna A for picking up amplitude modulated radio energy and for delivering this energy to a first unit **10** of a receiver. This unit includes a heterodyne detector by means of which received currents may be beat down to a lower or intermediate frequency of a value which is readily controllable, just as in any superheterodyne receiver. The first receiver unit should preferably include high frequency selective circuits, high frequency amplification, output or intermediate frequency amplification and any other desirable features commonly used in superheterodyne receivers.

The output of the first receiver unit **10**, which is at an intermediate frequency of say F_1, is applied to two separate heterodyne detectors **14** and **16**. One of these detectors, say **14**, is supplied by an oscillator **18** with beating energy, of a frequency say F_2, which is lower than the frequency F_1. The other detector, **16**, is supplied by frequency multiplier **20** with beating energy of a frequency which is a harmonic or multiple of F_2, say $2F_2$, which is higher than F_1. The unit **18** includes an oscillation generator of the constant frequency type, and, if desired, a frequency multiplier to permit the constant frequency oscillator to operate at a frequency lower than F_2, while the unit **20** includes any means for producing wave energy which is a harmonic or multiple of the energy from **18**. The output of one of the pair of detectors, say **14**, is then at a frequency of F_1-F_2 and the output of the other detector, **16**, is $2F_2-F_1$.

The outputs of the pairs of detectors are combined in a single side band modulator **24** consisting of a balanced modulator and band-pass filter of the type commonly used in carrier current wire line telephony and in long wave transoceanic telephone transmitters. The balanced modulator **24** may be of the Carson type, modified and improved to include present day refinements. In this balanced modulator the applied waves cancel or are shunted out leaving the components resulting from the modulation process. Alternatively, the modulator may be of the types described in my United States Patents Nos. 1,838,763 or 2,163,680. The output from the balanced modulator **24** contains frequencies equal to the sum and difference of the input frequencies from the two detectors.

The difference frequency is equal to

$$D=(2F_2-F_1)-(F_1-F_2)=3F_2-2F_1$$

Since $3F_2$ is a constant, it can be seen that when the frequency of F_1 is varied or modulated, then the difference frequency in the output of the balanced modulators **24** varies twice as much in cycles per second. As will be seen later, the difference frequency has all of the frequency variation present in the output of the balanced modulator. Consequently, the unit **24** includes a band-pass filter and the band-pass filter is so designed and the relative frequencies so chosen that the difference frequency, with its phase and frequency variations, is eliminated or rejected by the band-pass filter which follows the balanced modulator, in the single side-band modulator system. Thus, we eliminate the effects of all variations in the phase or frequency of F_1.

The sum frequency in the output of the balanced modulator is equal to:

$$S=(2F_2-F_1)+(F_1-F_2)=F_2$$

since F_2 is constant we allow this component of

frequency to pass through the band-pass filter and from it has been eliminated all components of phase or frequency modulation or variation. This result is accomplished because the outputs from the two heterodyne detectors 14 and 16, which are added together in the single side-band modulator, contain equal and opposite phase and frequency modulations or variations, which balance out to zero in the output of the single side-band modulator.

On the other hand, assuming that all the detectors and the balanced modulator are linear devices, which they normally are, the amplitude of output from the single side band modulator 24 will be proportional to the amplitude of the carrier wave picked up by the receiving antenna A. Therefore, amplitude modulations of the carrier wave will be faithfully reproduced in the output of the single side-band modulator, except for changes in wave form due to frequency selective circuits which would be alike in character for any amplitude modulation receiving equipment.

The arrangement of Figure 1 may be modified as shown in Figure 2 by making the unit 24 a heterodyne detector, instead of a single side-band modulator, if we choose the frequencies F_2 and $2F_2$ so that both lie above, or both lie below the frequency F_1. Then the difference between the output frequencies of units 14 and 16 will be constant in spite of variations in F_1 and all the frequency variations will appear in the sum of the outputs from units 14 and 16, which is rejected by the frequency selective circuits in the output of the heterodyne detector.

A desirable feature of my novel method and means is that since the side-band, or the beat frequency, selected is of a frequency of unvarying phase or frequency irrespective of phase or frequency modulation of the received amplitude modulated wave, it is not necessary to provide means for retuning the receiver in the event the signal carrier drifts within relatively wide limits.

In practicing my invention it will be necessary, for obtaining best results, to choose input and output frequencies from the two heterodyne detectors 14 and 16 so that none of their output frequencies lie within the pass band of the filter in the output of the single side-band modulator, or heterodyne detector, 24. In other words, the frequency relations must be chosen to give a minimum of interference to the normal amplitude modulation of the carrier in the output of the single side-band modulator. This can be done readily by one skilled in the art.

One promising field for application of my invention is in long distance short wave telegraph communication. My system, by eliminating effects of relative frequency changes between the transmitter and the first heterodyne oscillator of the receiver, can eliminate the need for passing received beat note signals into a keyer unit, for keying output of a constant frequency oscillator, in order to obtain a constant frequency for transmission over a wire line. In my system the intermediate frequency oscillators are the only oscillators which must have constant relative frequency in order to hold a constant beat note output from the receiver. There, oscillators being close together in the same receiver, may easily be made to hold sufficiently constant relative frequencies.

Although I have shown a preferred receiver arrangement, it will be understood that all components of phase or frequency modulation may be reduced or eliminated by other means. We may, for example, employ a limiter and phase or frequency modulation detector, at the intermediate frequency, for deriving phase or frequency modulation energy and use the energy so obtained to frequency modulate the first beating oscillator in a direction to act degeneratively upon the phase and frequency modulation of the intermediate frequency carrier. See my application Serial No. 111,050, filed November 16, 1936, now Patent #2,205,762 dated June 25, 1940. Then, we may take another portion of intermediate frequency energy from the intermediate frequency circuits ahead of the limiter and apply it to an amplitude modulation detector. Thus, we may accomplish almost the same result as in the system of Figure 1.

What I claim is:

1. The method of demodulating amplitude modulated wave energy and limiting the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said wave energy with oscillatory energies of a first and second harmonically related frequencies and combining the energies resulting from said beating action to obtain a resultant of constant phase and frequency for demodulation purposes.

2. The method of demodulating amplitude modulated wave energy and eliminating the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said wave energy with oscillatory energy of a first and second harmonically related frequencies and adding the energies resulting from said beating action to obtain the sum of components thereof for demodulation purposes.

3. The method of demodulating amplitude modulated wave energy and eliminating the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said wave energy with oscillatory energy of a first and second harmonically related frequencies and combining the energies resulting from said beating action subtractively to obtain the difference of components thereof for demodulation purposes.

4. The method of demodulating amplitude modulated wave energy and eliminating the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said wave energy with oscillatory energy of a first and second harmonically related frequencies and adding the difference frequency energy components resulting from said beating actions to obtain a resultant of constant phase and frequency for demodulation purposes.

5. A method as recited in claim 1 wherein one of said energies of harmonically related frequencies is of a frequency equal to twice the frequency of the other thereof.

6. A method as recited in claim 1 wherein said energies of harmonically related frequencies are both of lower frequency than the amplitude modulated wave energy.

7. A method as recited in claim 1 wherein said energies of harmonically related frequencies are both of higher frequency than the amplitude modulated wave energy.

8. The method of demodulating amplitude modulated wave energy and reducing the effect of noise components thereon and simultaneously substantially eliminating the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said

wave energy with oscillatory energies of first and second harmonically related frequencies, deriving the difference frequencies from the energies resulting from said beating actions, intermodulating said energies of difference frequency to produce resultant energy in which noise components are symmetrically related with respect to a signal carrying component of constant frequency, and selecting said signal carrying component of constant frequency and a side-band for demodulation purposes.

9. The method of demodulating amplitude modulated wave energy, reducing the effect of noise components thereon and simultaneously substantially eliminating the effect of extraneous phase and frequency modulation of said wave energy which includes the steps of, beating said wave energy with oscillatory energy of a first frequency, beating said wave energy with oscillatory energy of a second frequency harmonically related to said first frequency, combining the energies resulting from said beating action to obtain resultant energies of frequencies equal to the differences between said wave energy and said oscillatory energies, intermodulating said energies of difference frequency to obtain modulated energy wherein said noise components are symmetrically related with respect to one of said oscillatory energies, and selecting a component characteristic of said one oscillatory energy and a side-band for demodulation purposes.

10. In a receiving system adapted to receive amplitude modulated wave energy and eliminate any phase and frequency modulation on said wave energy, the combination of a pair of heterodyne detectors each having inputs and outputs, a pair of harmonically related oscillators coupled with the inputs of said heterodyne detectors, means for impressing modulated wave energy on the inputs of each of said heterodyne detectors, and wave component combining means having an input coupled with the output of said heterodyne detectors and means for selecting a side-band and carrier from the output of said combining means for demodulation purposes.

11. A receiving system as recited in claim 10 wherein said combining means is a balanced modulator.

12. A receiving system as recited in claim 10 wherein said combining means is a heterodyne detector.

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