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G. M. WRIGHT
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MODULATED CARRIER WAVE RECEIVER

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Fig. 1

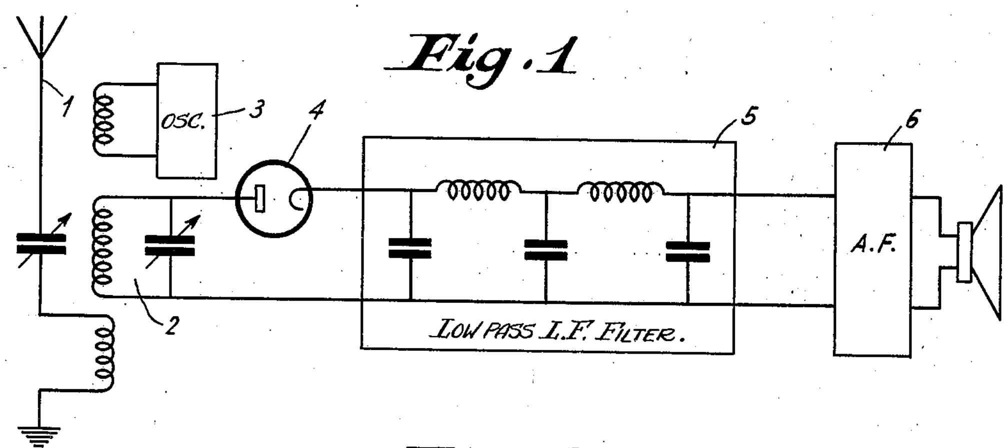


Fig. 2

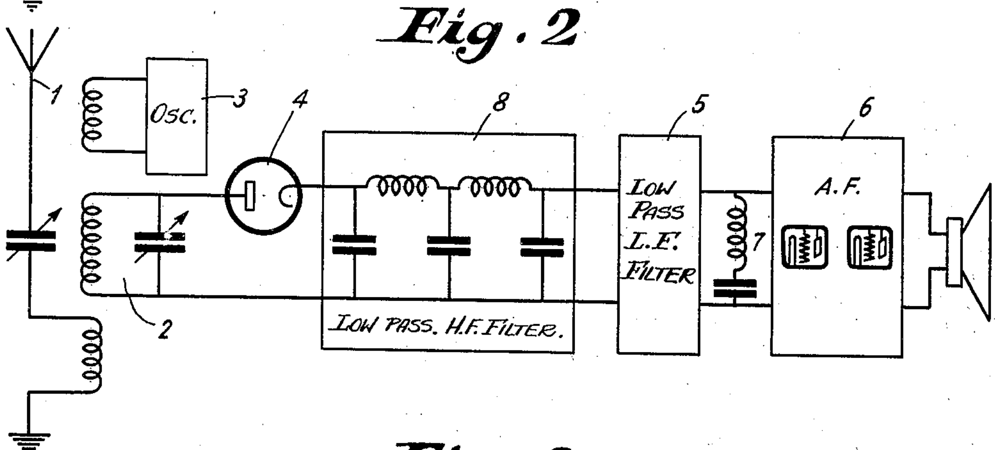
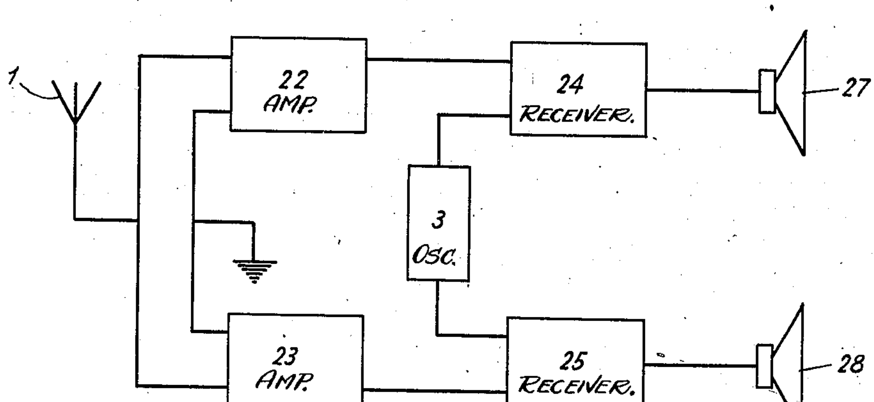


Fig. 3



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MODULATED CARRIER WAVE RECEIVER

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4 Claims. (Cl. 250—20)

This invention relates to modulated carrier wave receivers and more specifically to radio receivers of the so-called homodyne type, i. e. of the type wherein the received modulated carrier energy is mixed with a locally generated oscillation of the same frequency as the carrier in the received energy.

Two serious practical operating defects commonly met with in known homodyne receivers are (1) interference and (2) fading and distortion effects due to failure to maintain synchronism between incoming and locally generated oscillations. As will be seen later, the present invention, by its various features, enables these operating defects to be substantially reduced or practically eliminated.

The question of interference will first be considered. If, in a homodyne radio receiver, one or more tuned circuits (e. g. a tuned radio frequency amplifier) be included between the aerial or other input circuit and the first detector so that only the desired carrier signal with its side bands are receivable, then another station radiating a carrier of frequency outside the limits of the frequency band occupied by the desired station should not give rise to interference at the receiver, even although said other station be of strong signal strength at the receiving point. In practice, however, it is found that, owing to the non-rectilinearity of the characteristic curves of thermionic valves available for use in radio frequency amplifiers, it is possible for a powerful undesired carrier of frequency differing from that of a desired carrier by some relatively small difference of the order of 9,000 cycles per second or less, to give rise to interference by producing beats of the difference frequency, these beats, after rectification by the rectifier valve of the receiver, being passed on to the audio frequency portion of the said receiver.

In accordance with one feature of this invention the above difficulty in a homodyne receiver is substantially reduced by interposing a filter between the rectifier stage and the low frequency portion—usually an audio amplifier—following said stage, said filter being designed to pass only those frequencies lying within a predetermined band corresponding to the band of frequencies to be received. For the case of high quality broadcast receivers the filter will be arranged to cut off all frequencies above about 8,000 or 9,000 cycles per second. The filter circuit, which may be a low frequency low pass filter circuit of any suitable design known per se, may have its input terminals coupled directly to the rectifier and its output terminals coupled to the audio frequency amplifier.

At first sight, the provision of the low frequency low pass filter after the rectifier should be sufficient to prevent interference, for, since the local oscillations may be assumed to be strong relative to the incoming signals, if the rectifier has a substantially rectilinear characteristic, all interfering carriers which beat with the local oscillations to produce frequencies outside the pass range of the low frequency low pass filter should not affect the audio part of the apparatus. In practice, however, it is often found that interference—sometimes quite serious—does persist despite the provision of the low frequency low pass filter. In the first place a certain "carry-through" of the original high carrier frequencies occurs owing to electrostatic leakage in the coils of the low frequency low pass filter. This "carry-through" results in modulated unwanted carriers producing high frequency voltages at the input of the audio frequency amplifier. Although these high frequency potentials may not in themselves give rise to interference, yet because they are modulated and because the audio frequency amplifier is never perfectly rectilinear in characteristic, the resulting rectification occurring in the amplifier renders the modulation audible in the loud speaker and may cause serious interference even when the unwanted carrier has a frequency difference with the homodyne lying well outside the pass region of the low frequency low pass filter. In the second place a defect arises by reason of the obvious desire to make the pass range of the low frequency low pass filter as wide as possible in order to secure good quality reproduction. Consider the position which arises at the present time in Europe where broadcast channels are separated by 9 kc. Even if the pass range of the low pass filter be as low as 6 kc. wide—and this will involve some sacrifice of quality—in practice a very strong signal in an adjacent channel will give rise to appreciable voltages at the output of the low frequency low pass filter. These voltages, though not directly a cause of serious trouble, may be indirectly so, for, owing to the fact that the beat carrier is modulated, the modulation may appear at the output of the audio amplifier in the same manner as described for high frequency leakages through the filter.

An important further feature of the invention therefore aims at avoiding the above defects and according to this further feature the first of these defects is eliminated or reduced by including between the rectifier and the low frequency amplifying portions of the receiver, a low frequency low pass filter for channel separation and a high frequency low pass filter having its cut-off point well above the limits of human audibility, e. g. at 100 kc., which is well below the lowest carrier frequency the receiver is intended to receive. Such a high frequency low pass filter can be readily assembled from standard broadcast receiver components, so-called high tension feed chokes of normal construction (such chokes are available with very low self-capacities) and small fixed condensers of about .0005 mfd. being very suitable. Two such chokes in series in one line of the filter, and three such condensers in shunt between the lines of the filter (so as to constitute a two-stage filter) will provide a very effective high frequency low pass filter for use between the rectifier and the low frequency low pass filter.

The second defect may be substantially reduced according to the invention by shunting either the input or the output circuit of the low frequency low pass filter by a fixed shunt circuit having a low impedance at the channel difference frequency (9 kc. in Europe)—e. g. an acceptor or series tuned circuit resonant at 9 kc. Since the channel difference frequency is fixed by international agreement there is no need to make the acceptor circuit adjustable.

The provision of an acceptor circuit tuned to the channel difference frequency presents the additional advantage that it enables the low pass low frequency filter employed to be simplified as to its design and construction.

The question of fading and distortion due to failure to maintain exact synchronism between incoming and locally generated (homodyne) oscillations will now be considered. It is in practice very difficult in a homodyne receiver to maintain exact synchronism between the locally generated carrier energy and the carrier component in the incoming signals. With known homodyne receivers it is found that there is a great tendency for received speech or music to be distorted by a rapid and regular variation of ampltiude between zero and a maximum value, the result resembling that of a regular periodic fading, the frequency of the fading being found to be twice the difference between the frequencies of the incoming carrier and the locally impressed carrier. This fading effect is due to shifting phase relations between the locally generated oscillations and the received energy.

Consider the nature of the interaction between the locally generated oscillations and the received energy for three different phase relations, taking first the case which arises when the locally generated oscillation is in phase with the carrier component in the received energy. In this case the two oscillations will be additive at all times and accordingly, after mixing and rectification, the audio frequency component will follow the modulation in the received carrier energy as regards phase, amplitude and frequency. Similarly when the locally generated oscillation is 180° out of phase with the carrier component in the received energy, the two oscillations will subtract at all times and accordingly, after mixing and rectification, the audio frequency components will follow the modulation of the incoming carrier as to frequency and amplitude but will be in reversed phase. When, however, the locally generated oscillation is in quadrature with the carrier component in the received energy, i. e. when the phase relationship is 90° or 270°, a different result takes place. If it be assumed that the locally generated oscillation is very strong as compared to the received carrier energy (as is normally the case) it is only necessary to consider the effects produced as regards the positive half waves of the locally generated oscillation. At the commencement of a positive half wave of the locally generated oscillation the amplitude thereof is of course zero and the received carrier component amplitude will be at a maximum value since the quadrature relationship exists. The locally generated oscillation amplitude commences from this point to increase in the positive direction and the received carrier component amplitude to decrease but since both amplitudes are in the positive direction they will add until the received carrier component amplitude has fallen to zero and the local oscillation amplitude has risen to its maximum. After this point the local oscillation amplitude, while still positive, begins to diminish but the received carrier component amplitude becomes negative so that the interaction is now subtractive instead of additive. This subtractive interaction continues until the locally generated amplitude has fallen to zero and the received carrier component amplitude has reached its negative maximum value. The interaction for the next half-cycle need not be considered since the large negative amplitude of the locally generated oscillation effectively cuts off the rectifier and no current flows. The above described cycle of operation is therefore repeated for every positive half-wave of the applied locally generated oscillation. It will now be appreciated that since the increment obtained when the interaction is additive in nature, i. e. during the first quarter wave of the locally generated oscillation, is quantitatively equal to the decrement obtained when the interaction is subtractive, i. e. during the second quarter wave, the result is that after rectification the audio frequency components which would appear in the absence of the local carrier are lost, and no modulation occurs. It will be obvious that this condition will exist whenever the locally generated oscillation and the receiver carrier component are in quadrature.

Now, having considered the three typical conditions, namely, the in-phase condition, the antiphase condition, and the quadrature condition, imagine the phase relation between the received carrier component and the locally generated oscillation to vary—as in practice it often does, and must in fact do unless there is perfect synchronism between the local oscillator and the received energy.

When the received and local oscillations are in phase the audio frequency output will be of full amplitude and in phase with the modulation in the received energy. As the phase relation between the local and received energy varies towards the first quadrature position (90°) audio frequency modulation currents in the rectifier output will be reduced until, in the quadrature position, the modulation is lost. The modulation amplitude in the rectifier output then increases as the antiphase condition is approached until, when the phase relation is 180°, the full amplitude is again obtained though the modulation phase is reversed as compared with the phase of the modulation in the incoming received wave. After that, as the phase difference increases towards the second quadrature position (270°), the modulation output again reduces towards zero and so on.

The object of yet another feature of this invention is to overcome this difficulty and in accordance with this feature a homodyne radio receiver comprises two independent receiving circuits in conjunction with a common local oscillator providing a single oscillation output or two outputs in fixed phase relationship, and means are provided for causing the phase relation between received carrier in one of the two circuits and the local oscillation mixed therewith to be always 90° different from the phase relation between the received carrier in the other circuit and the local oscillation mixed therewith. With such an arrangement although the effects above described will occur as regards each of the two circuits, the said effects will be in phase opposition in the said two receiving circuits and accordingly therefore if both receiving circuits are employed for reproduction the fading effect hereinbefore referred to will be substantially eliminated.

The invention will be better understood from the following description read in conjunction with the accompanying drawing in which Figure 1 represents diagrammatically one embodiment of the invention designed to reduce interference; Figure 2 shows diagrammatically a preferred embodiment for reducing interference, and Figure 3 shows in block diagram form an embodiment wherein the practical difficulties in maintaining synchronism between incoming and local oscillations are avoided.

All the figures are much simplified, only those parts being shown which are necessary to a proper understanding of the invention.

Referring first to Figure 1, the receiving aerial **1**, shown as in the usual tuned aerial circuit arrangement, is coupled to the coil of a radio frequency tunable circuit **2**, oscillations from a local homodyne oscillator **3** being also fed to this coil. The rectifier, represented as a diode **4** is followed by a low frequency low pass filter **5** having its upper limit somewhat below the channel difference frequency—e. g. at 6 kc.—this filter in turn feeding into the usual audio frequency amplifier **6**. In the arrangement shown in Figure 1, serious interference can occur from both the causes hereinbefore set forth.

In the preferred embodiment shown in Figure 2, in which parts corresponding to Figure 1 are indicated by the same reference characters, a low pass high frequency filter **8** is interposed between the rectifier **4** and the low pass low frequency filter **5**. The filter **8** may cut off, for example, at 100 kc. Furthermore a series resonant circuit or acceptor circuit **7** tuned (though not too sharply) to the channel difference frequency, e. g. to 9 kc. is provided.

In the receiver of Figure 3, the single receiving aerial **1** feeds in parallel into two isolator circuits **22**, **23**, of any kind known per se. The isolator circuits may, for example, be each constituted by a simple single stage thermionic valve amplifier which serves as a blocking tube to prevent re-radiation of oscillations from the homodyne oscillator. The isolator circuit **22** feeds into a receiver circuit **24** and the isolator circuit **23** feeds into another receiver circuit **25**. The receiver circuits **24**, **25** may each comprise the usual elements such as radio frequency amplifiers, detector and audio frequency amplifiers. The two receiver circuits **24** and **25** are so arranged that the received carrier in one is in quadrature with that in the other. For example, the receiving circuit **24** may be arranged to give a phase lead of 45° and the receiver circuit **25** arranged to give a phase lag of 45°, these phase shifts being obtained in any known manner, for example, by so-called "mistuning." A common local oscillator **3** is provided, this oscillator being arranged to give a single oscillation output which is fed, in the same phase, to both the receiver circuits. Mixing and rectification occurs in the usual way in each of the receiver circuits **24** and **25** and the resultant audio frequency energy from each receiver circuit is fed to its own reproducer, e. g. to its own loudspeaker **27** or **28**. It should be noted that it is not possible to combine the audio frequency outputs in a common transformer or output circuit, since at certain times the audio frequency phases and amplitude will be such as to give cancellation and it is for this reason that two independent loud speakers or like reproducers are used. These loudspeakers should be placed side by side.

In another arrangement the two receiving circuits are not mistuned but are so arranged that the received carrier in one is in phase with that in the other and the local oscillator is arranged to give two output oscillations of the same frequency but in quadrature with one another, one output being fed to one receiver circuit and the other to the other. In view of the preceding description and the illustration of Figure 3, it is not thought necessary to illustrate the last described arrangement.

What I claim is:—

1. A modulated carrier wave homodyne receiver comprising a carrier frequency circuit for received signals, a source of homodyne oscillations, a rectifier circuit, means for applying oscillations from said carrier frequency circuit and oscillations from said source as input to said rectifier circuit, an audio frequency circuit, and a high frequency low pass filter and a low frequency low pass filter interposed between the output side of said rectifier circuit and the input side of said audio frequency circuit, the high frequency filter cutting off below the lowest carrier the receiver is intended to receive and the low frequency filter adapted to pass a frequency band of the order of the frequency separations between adjacent carriers.

2. A modulated carrier wave homodyne receiver comprising a carrier frequency circuit for received signals, a source of homodyne oscillations, a rectifier circuit, means for applying oscillations from said carrier frequency circuit and oscillations from said source as input to said rectifier circuit, an audio frequency circuit, a high frequency low pass filter cutting off at or near 100 kc., and a low frequency low pass filter cutting off at or below 9 kc., said two filters being interposed in the order stated between the output side of said rectifier circuit and the input side of said audio frequency circuit.

3. A modulated carrier wave homodyne receiver comprising a carrier frequency circuit for received signals, a source of homodyne oscillations, a rectifier circuit, means for applying oscillations from said carrier frequency circuit and oscillations from said source as input to said rectifier circuit, an audio frequency circuit, a high frequency low pass filter cutting off at or near 100 kc. and a low frequency low pass filter cutting off at or near 9 kc., said two filters being interposed in the order stated between the output side of said rectifier circuit and the input side of said audio frequency circuit, a circuit of low impedance at the channel difference frequency being shunted across the terminals of the low frequency low pass filter.

4. A receiver as set forth in claim 3 and wherein the low impedance circuit is a series tuned circuit.

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