

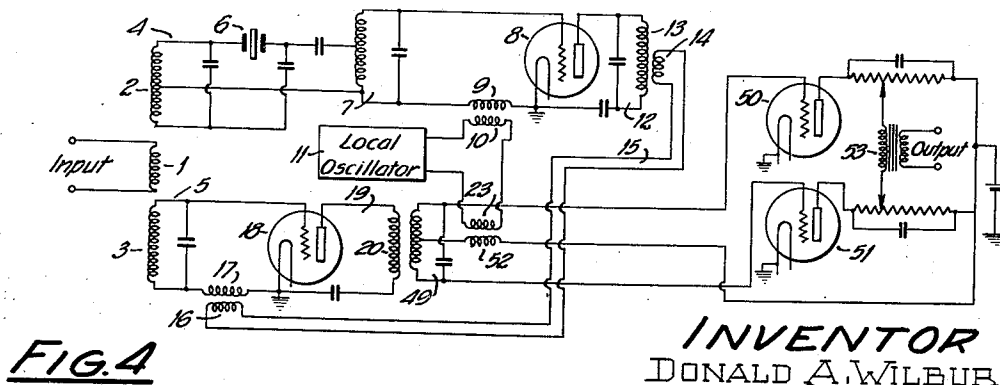
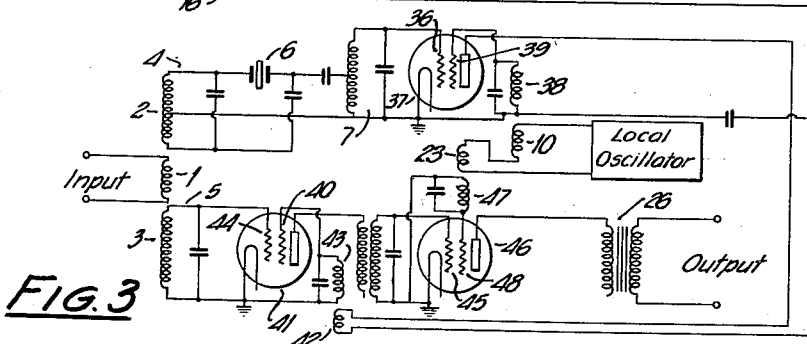
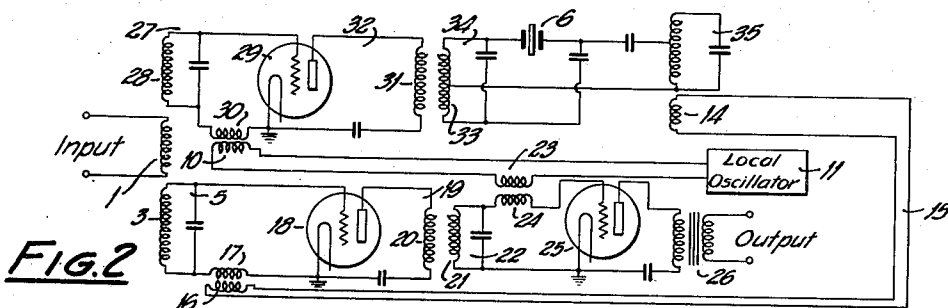
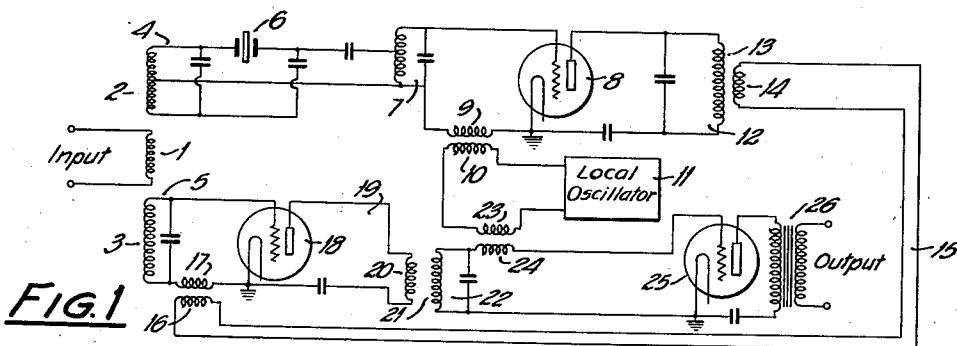
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APPARATUS FOR AND METHOD OF REDUCING DISTORTION IN
THE RECEPTION OF ELECTROMAGNETIC WAVES

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APPARATUS FOR AND METHOD OF REDUCING DISTORTION IN THE RECEPTION OF ELECTROMAGNETIC WAVES

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My invention relates to a radio receiving device and more particularly to means and methods of reducing or eliminating distortion in the reception of radio signals or electromagnetic waves such, for example, as those employed for transmission purposes in radio broadcasting.

Distortion of detected radio signals results from various causes, and the principal object of my invention resides in the provision of a radio signal-receiving device, including a demodulator, in which the frequencies of the carrier of a received signal, comprising a carrier component and side band components, and a local oscillator are synchronized, or, correspondingly, the frequency of a local oscillator may be synchronized with the transformed frequency of the carrier as derived from an oscillator, with the result that in both cases energy, from the local oscillator, may be added to the received signal at its carrier frequency and in an amount sufficient that, upon detection, the difference frequencies resulting between components of the signal, other than those due to reactions between any component and the carrier, are effectively reduced or eliminated.

The principal object of my invention, broadly, is attained by dividing the radio signal, as received, or, as obtained in a different part of the frequency spectrum by a reaction between the received signal and the output or energy from a local oscillator, into two separate signals, separating the carrier from one of these separated signals, modulating this carrier by energy from a second local oscillator, separating one of the side components produced by this modulation, modulating the other of the original separated signals, by this separated side component, separating the resulting modulation components which correspond in form to the original signal but have as their carrier a component corresponding in frequency to that of said second local oscillator, adding energy from said second local oscillator to these components in an amount such that upon detection the difference frequencies due to reactions between side components of the signal are effectively reduced or eliminated.

With the foregoing and other objects in view, my invention includes the novel elements and the combinations and arrangements thereof described below and illustrated in the accompanying drawing in which—

Fig. 1 is a wiring diagram of a circuit embodying the principles of my invention;

Fig. 2 illustrates a modification of the circuit of Fig. 1;

Fig. 3 shows a further modification of the circuit of Fig. 1 illustrating its adaptation for use with multi-electrode tubes; and

Fig. 4 illustrates a still further modified circuit for use with a balanced detector.

For the purpose of describing my method of procedure and the operation of my circuit, it will be assumed that the carrier of the received radio wave is of the form $E_0 \sin wt$, where f_w , the carrier frequency, equals $w/2\pi$, and that the carrier is modulated by a signal $E \sin pt$, where f_p , the modulating frequency, equals $p/2\pi$. The resulting modulated signal e_1 may be expressed,

$$e_1 = E_2 \cos(w-p)t + E_1 \sin wt - E_2 \cos(w+p)t$$

The term $E_1 \sin wt$ will be referred to as the carrier component, and any term involving a frequency other than that of the desired carrier, regardless of its source, will be referred to as a side band component or a side component. In this case, then, the terms $E_2 \cos(w-p)t$ and $E_2 \cos(w+p)t$ are side components.

In practice, the signal e_1 is the signal applied to the input, whether it be the signal as received from the station or as applied to the input after intermediary processes such as occur in a superheterodyne in which the entire frequency range is shifted.

Referring first to Fig. 1, a received signal, represented by the above noted modulated signal e_1 , is separated into two like signals by means of coils 1, 2 and 3 and the respective signals are induced into the two circuits indicated generally at 4 and 5. Circuit 4 includes a selective filter 6 which is designed to pass only the carrier component to the circuit indicated generally at 7. Circuit 7 supplies the carrier component to the grid of a modulator 8. Furthermore, energy in the form of a signal of any suitable frequency is induced in coil 9 in the grid circuit of modulator 8, which energy is induced from coil 10 in the circuit of a local oscillator 11. The oscillator 11 creates an electrical oscillation which may be substantially of any frequency though preferably one which when combined with the carrier of a received signal or the transformed carrier of a received signal produces components differing appreciably in frequency from that of the carrier of the received signal or its transformed carrier frequency. The plate circuit of modulator 8 preferably comprises a resonant circuit 12 which includes a coil 13 and it will be understood that circuit 12 is designed to be tuned to separate out a predetermined component of the signal from modulator 8 which separated component, by means of coils 13 and 14, is imparted through

circuit 15 and coils 16 and 17 to circuit 5. A signal, therefore, of the form of the received signal and the separated component from circuit 12 is supplied to the grid of modulator 18 of circuit 5. The plate circuit 19 of modulator 18 comprises a coil 20 which induces the signal in coil 21 of the resonant circuit 22. The local oscillator 11 is also connected to a coil 23 which serves to induce energy from the oscillator to coil 24 in the grid circuit of detector 25. The resultant signal is applied to the grid of detector 25 where the signal is demodulated and supplied to the output, illustrated for example as a transformer 26.

In the foregoing, I have described the circuit embodied in one form of my invention for eliminating from the detected signal difference frequencies resulting between components of the signal other than those due to reactions between any component and the carrier and in the following I will mathematically illustrate the operation of said circuit.

For purposes of illustration, we shall use square law detection and modulation and consider the distortion or detection terms only, although it is to be understood that my invention is in no sense limited to detectors or modulators, which operate according to this principle.

Referring again to Fig. 1, let the received or modulated signal e_1 be supplied by means of coil 1 to circuits 4 and 5. The signal in circuit 4 is applied to the selective filter 6, which is designed to pass only the carrier frequency to circuit 7 which carrier is then applied to the grid of modulator 8. Also energy from the local oscillator at a frequency f_q , where $f_q = q/2\pi$, is applied through coil 10 to coil 9 and thence to the grid of modulator 8.

Considering the action of this modulator we have for the modulation components in terms of current—

$$i_1 = c_0(E_1 \sin wt + E_3 \sin qt)^2$$

and omitting other than radio frequency terms we have

$$i_1 = c_1\{E_1E_3 \cos(w-q)t - E_1E_3 \cos(w+q)t + 1\text{st and 2nd harmonic terms of both frequencies}\}$$

By making f_q differ appreciably from f_w these terms may be separated by the usual resonant circuit. Hence, resonant circuit 12 may be used to separate out individually any of these components and for purposes of illustration let it be resonant to and separate out the term

$$c_1E_1E_3 \cos(w-q)t$$

which is then, by means of coils 13, 14, circuit 15 and coil 16, induced into coil 17 and thence applied to the grid of modulator 18. We also introduce the original signal, by means of coils 1 and 3, into circuit 5. We thus have applied to the grid of modulator 18 a signal of the form

$$e_2 = E_2 \cos(w-p)t + E_1 \sin wt - E_2 \cos(w+p)t + E_4 \cos(w-q)t$$

Considering the action of this modulator we have for the modulation components in terms of current

$$i_2 = c_3\{E_2 \cos(w-p)t + E_1 \sin wt - E_2 \cos(w+p)t + E_4 \cos(w-q)t\}^2$$

and q may be made to differ from w by any desired amount. Let us consider now, the modulation components due to reactions between

$E_4 \cos(w-q)t$ and the remainder of the signal. These will be

$$i_2 = c_3\{E_2E_4 \cos(q-p)t + E_1E_4 \sin qt - E_2E_4 \cos(q+p)t + E_2E_4 \cos(2w-q-p)t + E_1E_4 \sin(2w-q)t - E_2E_4 \cos(2w-q+p)t\} \quad 5$$

The terms containing q and $(2w-q)$ respectively, as carriers, may be separated as separate groups by means of resonant circuits since q and w and hence q and $(2w-q)$ may be made to differ by any desired amount in frequency.

Therefore, we have induced in circuit 22, resonant to the terms with q as a carrier, by means of coil 20, only the terms

$$c_3\{E_2E_4 \cos(q-p)t + E_1E_4 \sin qt - E_2E_4 \cos(q+p)t\} \quad 15$$

and it is evident that this signal is of the same form as the original signal but that the frequency of the carrier is now f_q where f_q equals $q/2\pi$, or, is the same as that of the local oscillator and that this will always be true even though the local oscillator tends to drift in frequency since this would only mean that the signal would drift exactly in synchronism with it. Thus, since the carrier component of the signal we now wish to demodulate is of the same frequency as that of the local oscillator, we may induce in coil 24 by means of coil 23 energy from the local oscillator at the carrier component frequency and in any amount desired.

The signal applied to the grid of detector 25 in circuit 22, through the medium of coils 21 and 23, is then of the form

$$e_3 = E_7 \cos(q-p)t + E_8 \sin qt - E_7 \cos(q+p)t + E_9 \sin qt \quad 35$$

where $E_9 \sin qt$ is the component added from the local oscillator and may be of any desired magnitude and phase. This signal is then detected by detector 25 in the usual manner and the demodulation components appear in the output of transformer 26.

Now since in the usual detector the distortion due to reactions between the side components depends upon the amplitude of the side components and is independent of the amplitude of the carrier and since the desired signal depends upon the amplitude of the side components and the amplitude of the carrier we may, therefore, by this addition of carrier reduce the distortion due to reactions between side components.

In Fig. 2, I have illustrated a modified circuit wherein the received signal is combined with a component from a local oscillator, then applied to the grid of a demodulator, and thereafter applied to a selective filter. In their construction, the circuits of Figs. 1 and 2 are essentially alike except for the rearrangement of the modulator and filter circuits to accomplish the above. The circuit 27 of Fig. 2 comprises coil 28, in which is induced the signal from input coil 1, modulator 29 and coil 30, in which is induced a component from the local oscillator 11 through coil 10 of the oscillator circuit. From coil 31 of the plate circuit 32 of modulator 29, the modulated signal is induced in coil 33 of a resonant circuit 34. Circuit 34 also includes a selective filter 6 whereby to circuit 35 is applied only the carrier component of the signal. This component is supplied to circuit 3 through the medium of coils 36, 14, circuit 15 and coils 16 and 17. The balance of the circuit illustrated in Fig. 2, starting with coil 14 and circuit 15 is substantially identical with the corresponding portions of the circuit of Fig. 1, as

above described; hence, further description thereof is deemed unnecessary.

A mathematical illustration of the operation of Fig. 2 is as follows. Let the signal applied to the input be of the form

$$e_1 = E_2 \cos (w-p)t + E_1 \sin wt - E_2 \cos (w+p)t$$

where the terms have the same significance as before. This modulated signal e_1 is then applied by means of coil 1 to circuits 27 and 5 and thence to the grids of modulators 29 and 18. There is also applied to the grid of modulator 29 a component from the local oscillator by means of coils 10 and 30. We thus have as the signal applied to the grid of modulator 29

$$e_2 = E_2 \cos (w-p)t + E_1 \sin wt - E_2 \cos (w+p)t + E_3 \sin qt$$

By the process of modulation we have in coil 31, in terms of current, the following components

$$i_1 = I_2 \sin (w-q-p)t + I \cos (w-q)t + I_2 \sin (w-q+p)t + I_2 \sin (w+q-p)t - I \cos (w+q)t - I_2 \sin (w+q+p)t$$

Since these two groups correspond to the original modulated signal but with carriers of frequency $(w-q)$ and $(w+q)$ respectively they may be separated since q may be made to differ from w by any desired amount. For purposes of illustration let the circuit 34 be resonant to those with $(w-q)$ as a carrier. Thus we have applied to selective filter 6 only those terms with the component $I_1 \cos (w-q)t$ as a carrier. Let selective filter 6 be resonant to and pass only the carrier component. We have thus in circuit 35 only the component $I_1 \cos (w-q)t$. This is then applied by means of coil 14, circuit 15 and coils 16 and 17 to circuit 3 and thence to the grid of modulator 18. Thus we have applied to the grid of modulator 18 the original signal plus a component $E_4 \cos (w-q)t$. The voltage applied to the grid of modulator 18 may then be represented by a signal of the form

$$e_2 = E_2 \cos (w-p)t + E_1 \sin wt - E_2 \cos (w+p)t + E_4 \cos (w-q)t$$

Considering the action of this modulator we have for the modulation components in terms of current

$$i_2 = c_4 \{ E_2 \cos (w-p)t + E_1 \sin wt - E_2 \cos (w+p)t + E_4 \cos (w-q)t \}$$

and it is well to note again that q may be made to differ from w by any desired amount.

Let us consider now the modulation components due to reactions between $E_4 \cos (w-q)t$ and the remainder of the signal. These will be

$$i_2 = c_4 \{ E_2 E_4 \cos (q-p)t + E_2 E_4 \sin qt - E_2 E_4 \cos (q+p)t + E_2 E_4 \cos (2w-q-p)t + E_1 E_4 \sin (2w-q)t - E_2 E_4 \cos (2w-q+p)t \}$$

The terms containing q and $(2w-q)$ respectively, as carriers, may be separated as distinct groups by means of resonant circuits since q and w and hence q and $(2w-q)$ may be made to differ by any desired amount in frequency.

Therefore, we have induced in circuit 22, resonant to the terms with q as a carrier, by means of coils 20 and 21 only the terms

$$c_4 \{ E_2 E_4 \cos (q-p)t + E_1 E_4 \sin qt - E_2 E_4 \cos (q+p)t \}$$

and it is evident that this signal is of the same form as the original signal but that the frequency of the carrier is now f_q , where f_q equals $q/2\pi$,

or, is the same as that of the local oscillator. This signal relationship will always be true.

Thus since the carrier component of the signal we wish to demodulate is of the same frequency as that of the local oscillator we may induce in coil 24 by means of coil 23 energy from the local oscillator and at the carrier component frequency and in any amount desired.

The signal applied to the grid of detector 25 by means of circuit 22 and coil 24 is then of the form

$$e_3 = E_7 \cos (q-p)t + E_3 \sin qt - E_7 \cos (q+p)t + E_3 \sin qt$$

where $E_3 \sin qt$ is the component added from the local oscillator and may be of any desired magnitude and phase. This signal is then detected by detector 25 in the usual manner and the demodulating components appear in the output of the transformer 26.

It is believed evident that the conclusions drawn for the operation of the circuit shown in Fig. 1 may be applied to the operation of the circuit shown in Fig. 2 and above described.

Fig. 3 discloses a circuit which functions in substantially like manner to the circuit shown in Fig. 1 but in the embodiment of my invention disclosed in Fig. 3 the various signals are applied to separate electrodes in multi-electrode tubes. The action however is the same and the results are the same as for the circuit shown in Fig. 1 as should be evident to those skilled in the art.

For example, the carrier component of the separated, received signal in circuit 4 is supplied from filter 6 to circuit 7 and thence to one grid 36 of modulator 37. A component from the local oscillator 11 is induced through coils 10 and 38 and applied to the other grid 39 of modulator 37. Components of the output of modulator 37 are separated through a resonant circuit associated with the plate of said modulator and desired components supplied to the grid 40 of modulator 41 by means of coils 42 and 43. Circuit 5, of course, supplies the other of the separated, received signals to the other grid 44 of modulator 41. The output of modulator 41 is supplied to grid 45 of detector 46 and a component from the local oscillator is supplied through coils 23 and 47 to the other grid 48 of detector 46, the output of detector 46 being fed to transformer 26. The similarity of the circuits of Figs. 1 and 3 should be apparent from a comparison thereof and, as above stated, their operations are identical.

Fig. 4 illustrates a circuit which is substantially the same as the circuit shown in Fig. 1 except for the final detector. In this case a balanced detector is used. The signal corresponding in form to the original signal but having as its carrier a component having the same frequency as that of the local oscillator is induced by means of coil 20 into circuit 49 and thence applied to the detectors 50 and 51. Energy from the local oscillator is induced by means of coil 23 into coil 52 and thence is applied to detectors 50 and 51. The detectors operate in the usual manner and the demodulation components thus appear in transformer 53. However, due to the arrangement of the plate circuits of detectors 50 and 51, only those demodulation components corresponding to reactions between the side components of the signal in circuit 49 and the carrier components in coil 52 appear in the output of transformer 53.

By my method of reception, distortion, due to a lowering of the level of the carrier and a conse-

quent relative increase in amplitude of the difference frequency terms due to reactions between side band components, as compared with reactions between carrier and side band components, cannot occur due to the fact that the carrier may be maintained at any desired level by means of its introduction from the local oscillator. Also that distortion resulting from a change in the envelope of the signal produced by a decrease in the amplitude of the carrier regardless of its cause cannot occur since the original shape of the envelope may be recreated by the addition of carrier from the local oscillator. Distortion of the type described above is ordinarily noticeable when interference occurs between the ground and sky waves of a station or when interference occurs between the signals from synchronized stations. It should be noted that distortion due to the above noted causes occurs regardless of the type of detector used and, hence, by employing the method herein described, such distortion will be eliminated or, in any event, considerably reduced regardless of the type of detector used.

Another desirable feature of my invention lies in the fact that synchronization between the signal applied to the final detector and the local oscillator is independent of any reaction of the incoming signal upon the local oscillator and that it will always take place independent of the amplitude of the incoming signal or of frequency changes of the local oscillator.

Still another desirable feature of my invention resides in the fact that extremely sharp tuning may be obtained since there is no modulated signal applied to the final detector and, therefore, no output from the detector except when the carrier is tuned to the resonant frequency of the filter. Hence, my invention will provide automatic, inter-station noise suppression with no loss of sensitivity.

It is also well to note that the resonant and selective circuits may be fixed in their tuning since in the superheterodyne type of receiver the incoming signal may be shifted to any desired frequency and hence may have its carrier tuned to the selective filter mentioned in the above descriptions.

While the condensers illustrated in the drawings are shown as fixed condensers, it is to be understood that, in the first instance, in order to secure proper tuning, these condensers may be adjustable. But once the circuits are properly tuned the condensers may be permanently set and it will not be necessary thereafter to adjust them.

Furthermore, it is to be understood that the term "oscillator" as used in the foregoing description and appended claims is intended to designate any means for producing electrical oscillations.

While I have described my invention in its preferred embodiment, it is to be understood that the words which I have used are words of description rather than of limitation. Hence, changes within the purview of the appended claims may be made without departing from the true scope and spirit of my invention in its broader aspects.

What I claim is:

1. In a device for receiving modulated radio signals comprising carrier and side band components, the combination with an oscillator for creating electrical energy, of means for creating a signal component by a reaction between the

carrier component of a received signal and said created electrical energy, means for modulating the signal, as received, by said created signal component, means for separating from the received signal, so modulated, components thereof corresponding in form to the received signal but having a carrier component of a frequency substantially equal to that of said created energy and means for adding to said last mentioned signal components energy from said oscillator.

2. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received signal first and second separate signals having corresponding carrier and side band components, an oscillator for creating electrical energy, means for transforming the first of said separated signals into a signal having a component produced by a reaction between the carrier component of said separated signal and said created electrical energy, means for separating out said last mentioned component, means for modulating the second of said two signals by said last mentioned component, means for separating from said second signal, so modulated, components thereof corresponding in form to the received signal but having a carrier component of a frequency substantially equal to that of said created energy, means for adding energy from said oscillator to said signal components separated from said second signal, and means for demodulating the resultant signal.

3. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received signal two separate signals having corresponding carrier and side components, means for modulating the carrier component only of the first of said two signals, means for separating the side band components of the modulated carrier of said first signal, means for modulating the second of said two signals by one of said separated side band components, means for separating from said second signal, so modulated, components thereof corresponding in form to the received signal, means for adding to said last mentioned components a signal component derived from said first mentioned modulating means and means for demodulating the resulting signal.

4. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received signal two separate signals having corresponding carrier and side components, means for separating the carrier component from one of said two separate signals, an oscillator for creating electrical energy, means for modulating said separated carrier component by said created electrical energy, means for separating individually the side band components produced in said modulation, means for modulating the other of said separated signals by one of said separated side band components whereby a signal is produced having side band components corresponding in form to the original, received signal but having as their carrier a component having a frequency substantially equal to that of said created electrical energy, means for separating, from said last mentioned signal, components corresponding in form to the original, received signal but having at their carrier component a component having a frequency substantially equal to that of said created electrical energy, means for adding to said last mentioned, separated side components a component

from said created electrical energy, and means for demodulating the signal so produced.

5 In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received
10 signal two separate signals having corresponding carrier and side components, means for separating the carrier component from one of said two
15 separate signals, an oscillator for creating electrical energy, means for modulating said separated carrier component by said created electrical energy, means for separating the difference
20 frequency component of said separated and modulated carrier, means for modulating the other of said separated signals by said difference frequency component, means for separating the side
25 band components from said last modulated signal that correspond in form to the original, received signal but have as their carrier component a component having a frequency substantially
equal to that of said created electrical energy, means for adding to said separated side band components a component from said created
electrical energy, and means for demodulating the signal so produced.

6. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received
20 signal two separate signals having corresponding carrier and side components, means for separating the carrier component from one of said two separate signals, an oscillator for creating electrical energy, means for modulating said separated
25 carrier component by said created electrical energy, means for separating the summation frequency component of said separated and modulated carrier, means for modulating the other of said separated signals by said separated summation
30 frequency component, means for separating the side band components from said last modulated signal that correspond in form to the original signal but have as their carrier component a component having a frequency substantially
35 equal to that of said created electrical energy, means for adding to said separated side band components a component from said created electrical energy, and means for demodulating the
40 signal so produced.

7. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received signal two separate signals having corresponding
45 carrier and side components, an oscillator for creating electrical energy, means for modulating one of said separated signals by said created electrical energy, means for separating a component produced by a reaction between the carrier
50 component of said separated signal and said created electrical energy, means for modulating the other of said separated signals by said separated component, means for separating from said last modulated signal components corresponding
55 in form to the original, received signal but having as their carrier component a component having a frequency substantially equal to that of said created electrical energy, means for adding to said last mentioned components a component from said created electrical energy,
60 and means for demodulating the signal so produced.

8. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received
75 signal two separate signals having correspond-

ing carrier and side components, an oscillator for creating electrical energy, means for modulating one of said separated signals by said created electrical energy, means for separating the
5 difference frequency component of said modulated, separated signal whereby a side band component is separated having a frequency substantially equal to the difference between the frequency of the carrier of said separated signal and the frequency of the said created electrical energy, means for modulating the other of said
10 separated signals by said separated side band component whereby side components are produced corresponding in form to the original, received signal but having as their carrier a component having a frequency substantially equal to that of said created electrical energy, means for separating from said last modulated signal said last mentioned side components, means for
15 adding to said separated, last mentioned side components a component from said created electrical energy, and means for demodulating the signal so produced.

9. In a device for receiving modulated radio signals comprising carrier and side band components, means for producing from the received
25 signal two separate signals having corresponding carrier and side components, an oscillator for creating electrical energy, means for modulating one of said separated signals by said created electrical energy, means for separating the summation frequency component of said modulated, separated signal whereby a side band
30 component is separated having a frequency substantially equal to the sum of the frequency of the carrier of said separated, received signal and the frequency of said created electrical energy, means for modulating the other of said separated, received signals by said separated side band component, means for separating from said
35 last modulated signal components corresponding in form to the original, received signal but having as their carrier component a component having a frequency substantially equal to that of said created electrical energy, means for adding to said separated, last mentioned components a component from said created electrical energy and means for demodulating the signal so produced.

10. In a device for receiving modulated radio signals comprising carrier and side band components, an electric circuit including means for producing from the received signal two separate
40 signals of like characteristics, an oscillator, means for creating a signal having a side band component having a frequency dependent upon the frequencies of the carrier of said received signal and said oscillator, means for modulating one of said two separated signals with said created side band component whereby a signal
45 component is produced corresponding in form to said received signal but having a carrier of the frequency of said oscillator, means for adding a component derived from said oscillator to said last mentioned signal component, and means for demodulating the resultant signal.

11. Those steps in the method of reducing distortion in the reception of modulated radio signals comprising carrier and side band components which comprise dividing the received
70 signal into two separate signals, creating oscillating electrical energy, combining one of said separated signals and said electrical energy and separating a side band component from the signal so formed, modulating the other of said sep-
75

arated, received signals by said separated, side band component, separating from said last modulated signal a component corresponding in form to the received signal but having a carrier component of a frequency substantially equal to that of said electrical energy, combining with said separated, last mentioned component a component from said electrical energy and demodulating the resultant signal.

10 12. Those steps in the method of reducing distortion in the reception of modulated radio signals comprising carrier and side band components which comprise creating oscillating elec-

trical energy, producing a signal component by effecting a reaction between the carrier component of a received signal and said created electrical energy, modulating the signal, as received, by said signal component whereby signal components are produced corresponding in form to the received signal but having a carrier component of a frequency substantially equal to that of said created electrical energy, separating said last mentioned signal components and adding thereto energy from said created electrical energy.

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