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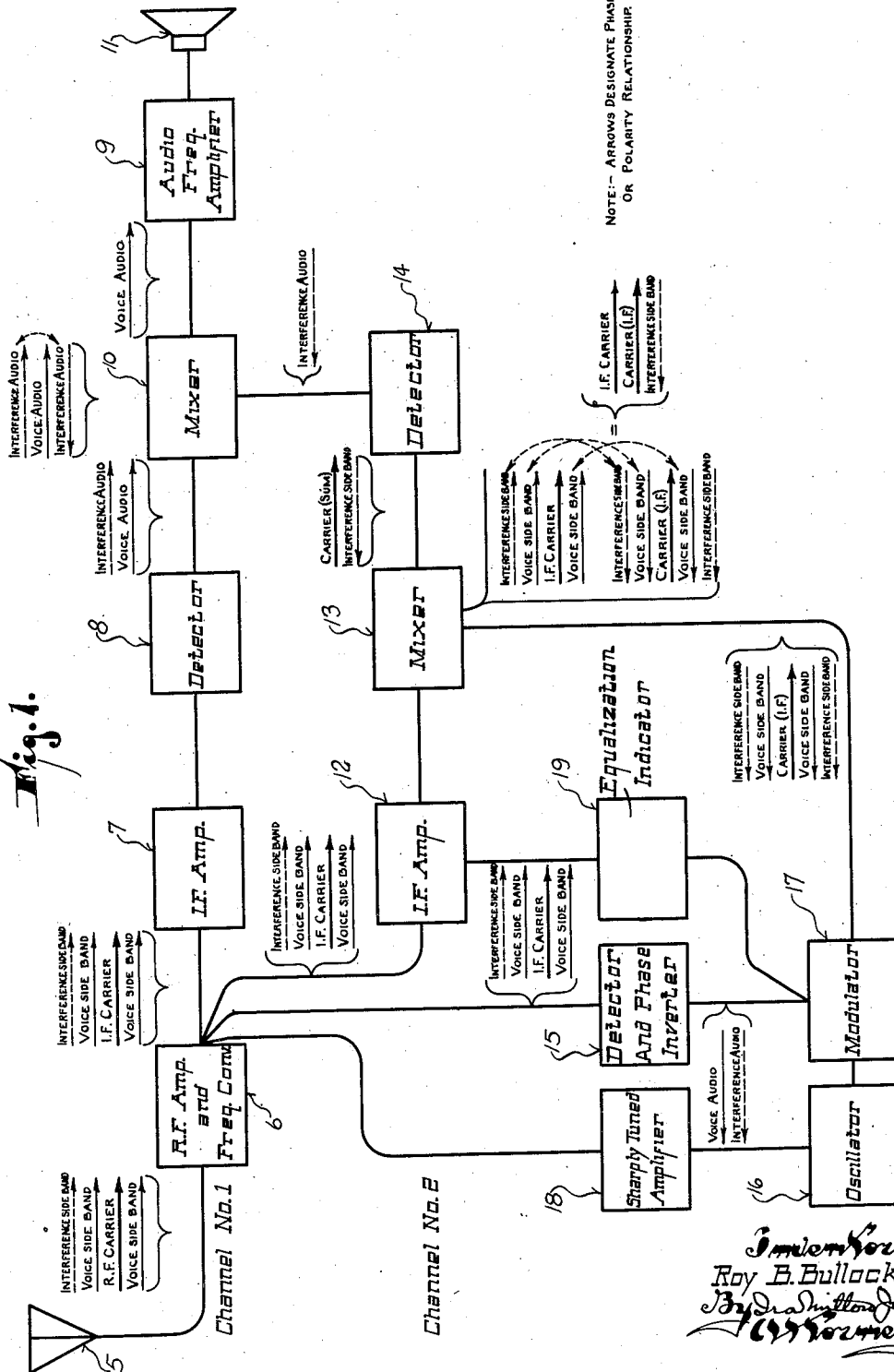
R. B. BULLOCK

2,468,030

INTERFERENCE REDUCING RADIO RECEIVER

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2 Sheets-Sheet 1



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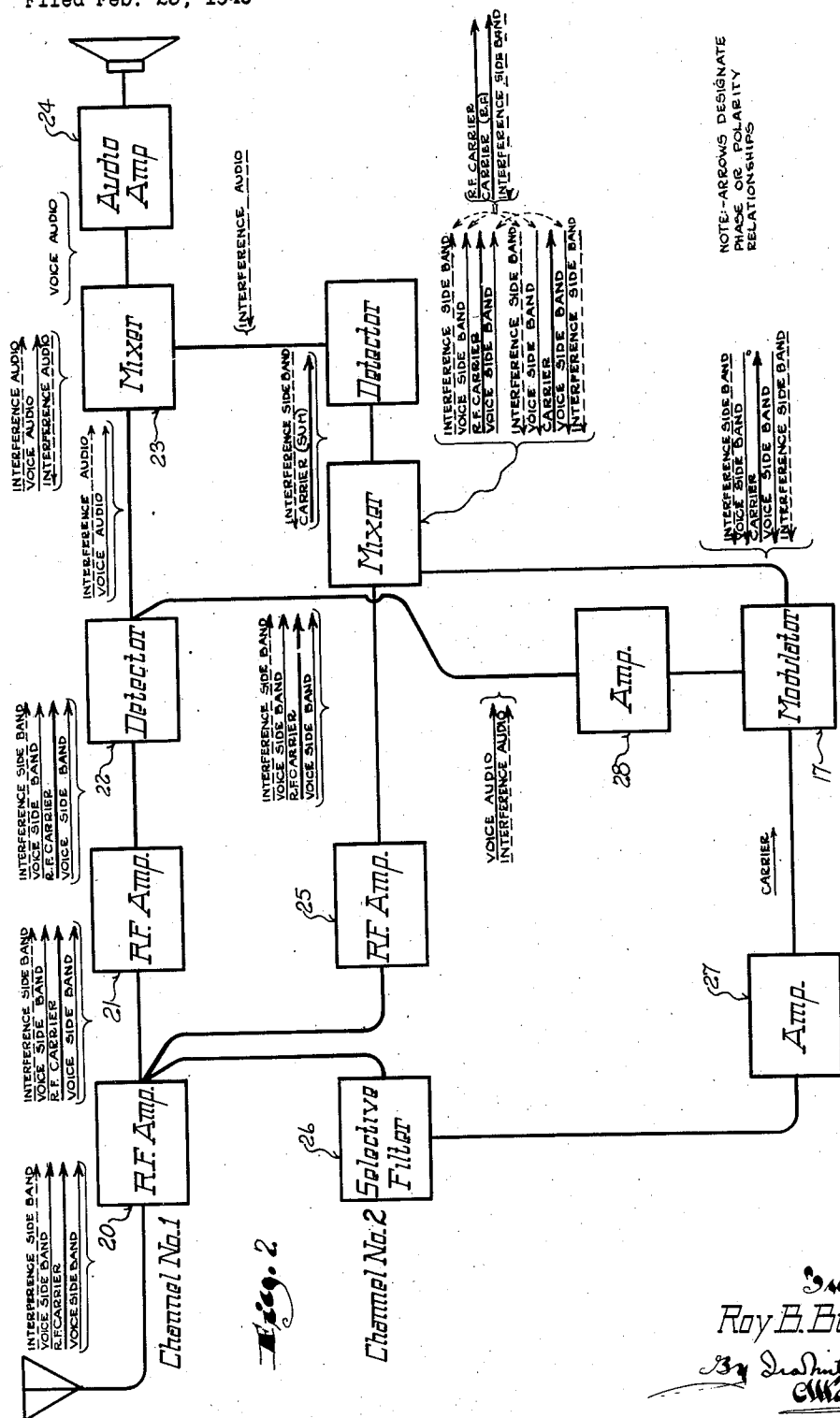
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,468,030

INTERFERENCE REDUCING RADIO
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This invention relates to a method of and apparatus for receiving transmitted radio waves. The object of this invention is to accomplish radio reception free from the effects of static or interference.

It is a commonly known and accepted fact that since the inception of radio it has been the desire and the ambition of engineers, radio technicians, and others, to find a practical and practicable means for eliminating atmospheric or man-made interference. It has further been the hope of everyone who listens to radio communications that the elimination of such interference would be accomplished. This hope has been based upon practical need, as well as upon the wish for interference free program reception; for the elimination of interference would effect not only a better but a far more extended purpose.

However, authorities agree that heretofore no one has succeeded in achieving radio reception actually free from the disturbing effects of atmospheric or man-made interference.

The elimination of the effects of atmospheric or man-made interference increases the effective broadcast range because when these disturbing effects are eliminated any existing static field or other disturbance at the point of reception will not obliterate signals weakened by transmission for great distances.

Frequency modulation, in spite of its ability to be transmitted and received so that the audio intelligence can be detected with diminished interference from ordinary static, has inherent limitations. By virtue of its need for a wide band it has been of necessity ruled out of the standard broadcast spectrum and assigned to a high frequency zone. The characteristics of the high frequency spectrum in which FM now generally operates restrict the effective service area of a transmitter broadcasting at such frequencies. Thus FM as now used has a relatively small service area, the radius of which usually does not exceed sixty miles.

Therefore, in order to cover any large area effectively and so make FM transmission and reception practicable and practical the establishment of numerous broadcast and/or relay stations is necessary. To do so involves tremendous initial expenditures and continued correspondingly high operating and maintenance costs. Furthermore, standard radio receiving equipment for use on standard broadcasting bands is incapable of receiving frequency modulated broadcasts and therefore new receiving equipment is necessary.

This invention requires no change from present day amplitude modulated broadcasting, which is considered the most advantageous form of radio transmission. The entire purpose of the

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invention is effected in the receiver. Thus the vast expenditure which would be entailed by any plan affecting the transmitter is obviated.

Moreover, the method of this invention permits using either the superheterodyne or the tuned radio frequency type of receiver circuit; and, if desired, the apparatus necessary to embody this invention in a receiver may be constructed as a separate unit for connection to a receiver already in use.

As will appear more fully hereinafter this invention is predicated upon the fact that insofar as present knowledge is concerned, static and/or other interference, either atmospheric or man-made, will appear as only a single side band at any given frequency. Thus, if the transmission is of the double side band amplitude modulated type, and if interference side bands are present, an inequality exists as to the number of voice side bands and interference side bands for any given frequency accepted by the receiver, and this condition is utilized by this invention to eliminate the interference.

It is, therefore, more specifically an object of this invention to provide a method and apparatus for receiving double side band amplitude modulated radio waves so as to eliminate the effect of atmospheric or man-made interference; but it must be understood, of course, that any static or interference which is coherently related—in the form of double side-band amplitude modulation—to the carrier of the station to which the radio receiver is tuned will not be affected.

With the above and other objects in view, which will appear as the description proceeds, this invention resides in the novel method and sequence of operation as well as the novel construction, combination and arrangement of parts substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the herein disclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate two complete examples of the method and physical embodiment of the invention, propounded and constructed in accordance with the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 diagrammatically illustrates an application of this invention as applied to a superheterodyne type of receiver; and

Figure 2 diagrammatically illustrates an application of this invention as applied to the tuned radio frequency type of receiver.

Before specifically expounding the embodiments of the invention diagrammatically shown in the drawings, it will be helpful to consider the nature of the transmitted wave in conventional

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amplitude modulated radio transmission. As is well known to those skilled in the art, the intelligence to be transmitted is first translated into its electrical counterpart. The frequency of the wave thus produced is that of the original intelligence, so that in the transmission of sound (speech, music, etc.) it is at audio frequency and may be termed the voice wave. This voice wave is used to modulate a radio frequency carrier wave which in turn is radiated from the broadcasting transmitter.

The modulated radio frequency carrier wave contains components of at least three radio frequencies, namely, the frequency of the original carrier wave, and the sum and difference of the original carrier frequency and the modulation or voice wave frequency.

These additional frequencies are called the side band frequencies, while the original radio frequency component is called the carrier. For example, assume that the carrier frequency of a transmitter is 600 kc. and that it is modulated by a 5000 cycle audio signal. The sum and difference frequencies thus are 605 kc. and 595 kc., respectively.

In order for these three frequencies to create the desired signal envelope they must bear the well-known phase and amplitude relationship to each other that gives rise to pure amplitude modulation.

The existence of the two side bands, which hereinafter will be referred to as voice side bands, is important to this invention. Static or other interference capable of affecting radio reception and not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmitting station is manifested in the receiver and before detection as a single frequency band for any given frequency of its audio characteristic inasmuch as there is no modulation involved in its creation.

Another observation important to this invention is that such interference will produce an audio frequency wave upon detection or demodulation. Thus by combining the audio component of each received interference frequency band which for convenience will be designated hereinafter as the "interference side-band" notwithstanding the connotation of duplication which the term "side-band" has with an identical audio component derived in some suitable way and which is 180° out of phase therewith, it is possible to cancel the effect of the static or interference.

Attention is now specifically directed to Figure 1 of the drawings which illustrates in block diagram an application of this invention to a superheterodyne type of receiver. As here shown the receiver proper comprises an antenna 5 connected to an RF amplifier and frequency converter unit 6. The output of this unit 6 is fed into a conventional I. F. amplifier unit 7 and from there to a detector or demodulator 8. The output of the detector or demodulator ordinarily is fed directly to an audio frequency amplifier unit 9, but for the purpose of this invention a mixer stage or unit 10 is interposed between the units 8 and 9. The output of the audio frequency amplifier 9, of course, is fed to the conventional speaker 11.

These component parts which make up the conventional superheterodyne receiver have been designated in Figure 1 as channel #1, but as will appear hereinafter, this channel #1 more specifically terminates at the input of the detector or demodulator unit 8.

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The output of the R. F. amplifier and frequency converter unit 6, in addition to being fed into the amplifier 7, is fed into another channel designated channel #2 and comprising an I. F. amplifier unit 12 which is a counterpart of the unit 7. The output of the I. F. amplifier 12 is fed into a mixer unit 13 which feeds a detector or demodulator unit 14. This detector or demodulator 14 is connected with the mixer unit 10 in channel #1 so that the demodulated outputs of the two channels may be combined.

The incoming modulated carrier, together with any accompanying interference side bands, in addition to being fed into the channels #1 and #2 is also fed into a detector or demodulator and phase inverter 15 the output of which is used to modulate a locally produced carrier emanating from an oscillator 16, this modulation taking place in a modulator unit 17. The oscillator produces a carrier wave hereinafter referred to as the locally produced or provided carrier which is a duplicate of the carrier component of the modulated carrier progressing through channels #1 and #2.

Assurance that the output of the oscillator will be this desired duplicate is provided by a sharply tuned amplifier unit 18 connected between the oscillator and the output of the R. F. amplifier and frequency converter unit 6. Through the provision of this sharply tuned amplifier the output of the oscillator is constrained to the frequency and phase characteristics of the carrier component of the modulated carrier emanating from the R. F. amplifier and frequency converter and fed into the I. F. amplifiers 7 and 12.

As depicted by the arrows in the legends applied to the block diagram, the phase (or polarity) of the voice and interference side bands as well as the R. F. carrier is the same in the I. F. amplifiers 7 and 12 and the input of the detector or demodulator 15. However, due to the manner in which the detector and phase inverter 15 is arranged and connected the phase of the voice audio and interference audio components coming from the demodulator 15 is inverted. For perfect results this phase inversion must be complete; that is, the voice audio and interference audio, which constitute the product of the demodulator 15, must be 180° out of phase with the side bands fed into the mixer unit 13 from the I. F. amplifier 12.

In view of the phase inversion which characterizes the product of the detector unit 15, the polarity of the two voice side bands and the two interference side bands—all in the output of the modulator unit 17—is opposite to the polarity of the two voice side bands and the single interference side band in channel #2. This phase opposition, or opposite polarity relationship between the side bands in the output of the modulator 17 and those in channel #2, is depicted in Figure 1 by the three "side band" labeled arrows shown above the I. F. amplifier unit 12, which point to the right, and the four "side band" labeled arrows shown to the right of the modulator unit 17, which point to the left. The carrier component of the output of the modulator unit 17, however, is in phase with the carrier in channels #1 and #2 as depicted by the arrows labeled "I. F. carrier" and "carrier (I. F.)," all of which point to the right.

The frequency and amplitude of the output of the modulator 17 is identical with that of the amplifier 12, this condition being assured by an equalization indicator 19 connected between the amplifier 12 and the modulator 17.

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This equalization indicator 19 may employ a cathode ray tube or an electron ray tube, either of which can be used with appropriate well known circuits to serve as a means for tuning adjustment and equalization between the outputs of the I. F. amplifier 12 and modulator 17.

The combination of the locally produced modulated carrier (the output of the modulator unit 17) with the received modulated carrier progressing through channel #2 in the mixer unit 13 results in cancellation of the voice side bands and the cancellation of one of the two interference side bands of the modulated locally produced carrier by the single interference side band in channel #2 as depicted in the legend applied to the mixer unit block 13. The combining of these two modulated carriers thus leaves a carrier which is the sum of the two carrier components of the combined modulated carriers and one interference side band which is opposite in phase to the interference side band of channel #1. It is this wave combination, namely carrier and interference side band, which is fed into the detector or demodulator unit 14 which eliminates the carrier.

The output of the demodulator unit 14 which is fed into the mixer unit 10 is only interference audio out of phase with the interference audio leaving the detector or demodulator unit 8. Consequently, by mixing or combining the outputs of the detectors or demodulators 8 and 14 the out-of-phase interference audio components cancel each other leaving the interference-free voice audio to pass on to the audio frequency amplifier.

As will be readily apparent to those skilled in the art, the use of the superheterodyne circuit has the advantage of facilitating the maintenance of the necessary synchronism between the carrier wave locally produced by the oscillator 16 and the carrier component of the modulated carrier progressing through the two I. F. amplifiers 7 and 12.

It is also possible, as shown in Figure 2, to adapt this invention to the conventional TRF type of receiver. In this case channel #1 comprises successive R. F. amplifier units 20 and 21, a detector or demodulator 22, a mixer unit 23, and an audio amplifier 24. Channel #2 comprises an R. F. amplifier 25 which is a duplicate of the amplifier unit 21.

The incoming energy received by the antenna is first amplified by the R. F. amplifier unit 20 and is then fed into the R. F. amplifiers 21 and 25 and also into a selective filter unit 26. This selective filter unit is constructed so as to eliminate all side bands from the energy fed into it so that its output consists of only the carrier component of the received modulated carrier. Thus the selective filter unit 26 serves the function of the oscillator in the previously described embodiment of the invention in that it locally provides a carrier having the same frequency and phase characteristics as the carrier component of the modulated carrier progressing through channels #1 and #2. The output of the selective filter unit 26 is brought to an adequate amplitude in a conventional amplifier unit 27 the output of which is fed into the modulator 17.

The locally provided carrier must be modulated by the voice audio and interference audio components of the energy progressing through the channels #1 and #2, but any means whereby this is accomplished can be employed. In the embodiment of the invention illustrated in Figure 1 the modulation frequencies were the product

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of the demodulator unit 15. The same result can be achieved by extracting voice audio and interference audio components from the modulated carrier progressing through channel #1 at the output of the detector or demodulator unit 22 as shown in Figure 2. This output preferably should be amplified as by an amplifier unit 28 before being fed into the modulator 17, but either in the amplifier unit 28 or some suitable adjunct the phase of the voice audio and interference audio components fed into the modulator must be inverted.

The modulation of the locally provided carrier in the modulator unit 17, the combination of the product of this modulation with the output of channel #2, the demodulation of the combined result and the combination of the demodulated outputs of channels #1 and #2 in the mixer unit 23, all proceeds as has been described in connection with the embodiment of the invention illustrated in Figure 1.

From the foregoing description, taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art, that this invention provides means for completely eliminating the effect of atmospheric or man-made interference in the reception of double side band amplitude modulated radio waves; that the achievement of this objective entails no modification of present day amplitude modulated broadcasting practice except that in all instances both side bands of the modulated carrier must be transmitted; that being able to eliminate any disturbance which is represented in the pattern of the incoming energy as a single side band for any given frequency of its audio component, the invention permits an overlap of adjacent broadcast channels, thus (if desired) allowing the present 10 kc. channels to be widened to encompass more nearly the full range of audible frequencies and thereby achieve higher fidelity without revision of present channel allocations; that the extent of the permitted overlap is great enough to allow for a desirable widening of the 10 kc. channels and at the same time make possible an increase in the number of broadcast stations within the present broadcast band; and further, that utilization of the invention is not limited to any prescribed type of receiver.

What I claim as my invention is:

1. A method of receiving double side band amplitude modulated radio waves so as to eliminate the effect of interference manifested as a single side band frequency for any interference audio component, and which is not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmission which comprises: simultaneously amplifying the received modulated carrier and accompanying single side band (for each frequency) of the interference in two separate amplifying channels; extracting voice audio and interference audio components of the received energy; inverting the phase of the voice audio and interference audio components so extracted; providing a carrier which is a duplicate of the carrier component of the modulated carrier progressing through each of the two amplifying channels; locally modulating said provided carrier with the phase inverted voice audio and interference audio components of the received energy so that the two voice side bands and two interference side bands resulting from said modulation are opposite in phase to the voice and single interference side bands in one of said two channels; combining the locally

modulated carrier with the received modulated carrier and single interference side band in said mentioned one of the two amplifying channels so that the voice side bands of said combined modulated carriers are cancelled and the single interference side band of said mentioned channel cancels one of the interference side bands of the locally modulated carrier leaving the sum of the combined carriers and one interference side band as the output of said mentioned one of the two channels; demodulating the outputs of the two amplifying channels so as to provide interference audio and voice audio in one channel and only interference audio in the other channel; and combining the products of said last named demodulations with the interference audio of one channel opposite in phase to that of the other channel.

2. A method of receiving double side band amplitude modulated radio waves so as to eliminate the effect of interference manifested as a single side band frequency for any interference audio component, and which is not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmission which comprises: simultaneously amplifying the received modulated carrier and accompanying single side band (for each frequency) of the interference in two separate amplifying channels; extracting voice audio and interference audio components of the received energy; inverting the phase of said extracted voice audio and interference audio components, locally producing a carrier which is a duplicate of the carrier component of the modulated carrier progressing through each of the two amplifying channels; modulating said locally produced carrier with the phase inverted voice audio and interference audio components so that the two voice side bands and two interference side bands resulting from the modulation are opposite in phase to the two voice and single interference side bands in one of said two channels; combining the modulated locally produced carrier with the received modulated carrier and single interference side band in said mentioned one of the two amplifying channels whereby the voice side bands of said combined modulated carriers are cancelled and the single interference side band of said mentioned channel cancels one of the interference side bands of the modulated locally produced carrier leaving the sum of the combined carriers and one interference side band as the output of said mentioned one of the two channels; demodulating the outputs of the two amplifying channels so as to provide interference audio and voice audio in one channel and only interference audio in the other channel; and combining the products of said last named demodulations with the interference audio of one channel opposite in phase to that of the other channel.

3. A method of receiving double side band amplitude modulated radio waves so as to eliminate the effect of interference manifested as a single side band frequency for any interference audio component, and which is not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmission which comprises: selectively filtering a portion of the energy of the received modulated carrier and accompanying single side band (for each frequency) of the interference to remove all side bands from the carrier; simultaneously amplifying the remainder of the energy of the received modulated carrier in a first amplifying channel

and a second amplifying channel; extracting voice audio and interference audio components from the first amplifying channel; inverting the phase of the extracted voice audio and interference audio components, locally modulating the side-band-free carrier (obtained through the selective filtering) with the phase-inverted voice audio and interference audio components so that the two voice side bands and two interference side bands resulting from the modulation are opposite in phase to the two voice and single interference side bands in the second amplifying channel; combining the locally modulated carrier with the received modulated carrier and single side band in the second amplifying channel whereby the voice side bands of said combined modulated carriers are cancelled and the single interference side band of said second amplifying channel cancels one of the interference side bands of the locally modulated carrier leaving the sum of the combined carriers and one interference side band as the output of the second amplifying channel; demodulating the outputs of the two amplifying channels so as to provide interference audio and voice audio in the first amplifying channel and only interference audio in the second amplifying channel; and combining the products of said last named demodulations with the interference audio of one channel opposite in phase to that of the other channel.

4. In a radio receiver for receiving double side band amplitude modulated radio waves, means for eliminating the effect of interference manifested as a single side band frequency for any interference audio component, and which is not coherently related—in the form of a double side-band amplitude modulation—to the carrier of the selected transmission comprising: a first amplifying channel; a second amplifying channel; means for feeding the received energy into said two amplifying channels; means for providing a carrier wave which is a duplicate of the carrier component of the modulated carrier fed into the second amplifying channel as part of the received energy; means for locally modulating the provided carrier with voice audio and interference audio components of the received energy; means for effecting phase opposition between the voice side bands and two interference side bands resulting from said modulation (as one factor) and the voice and interference side bands in said second amplifying channel (as the other factor); means for combining the locally modulated carrier with the received modulated carrier and interference side band in said second amplifying channel to effect cancellation of the out-of-phase voice side bands of the combined modulated carriers, and also effect cancellation of the interference side band in said second amplifying channel and one of the two interference side bands of the locally modulated carrier thereby leaving the sum of the combined carriers and said remaining interference side band as the output of the said second channel; means for demodulating the outputs of the two amplifying channels so as to provide interference audio and voice audio in one channel and only interference audio in the other channel; and means for combining the products of said demodulating means with the interference audio of one channel opposite in phase to that of the other.

5. For use with a radio receiver for receiving double side band amplitude modulated radio waves, means for eliminating the effect of interference manifested as a single side band frequen-

cy for any interference audio component, and which is not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmission comprising: an amplifier; means for connecting the input of said amplifier with the receiver circuit at a point ahead of the detector of the receiver so that said amplifier and the receiver circuit ahead of the detector will constitute two channels for the received energy; means for providing a carrier wave which is a duplicate of the carrier component of the modulated carrier fed into said amplifier as part of the received energy; means for locally modulating the provided carrier with voice audio and interference audio components of the received energy; means for effecting phase opposition between the two voice side bands and two interference side bands resulting from said modulation (as one factor) and the voice and interference side bands in the energy progressing through said amplifier (as the other factor); means for combining the locally modulated carrier with the output of said amplifier to thereby effect cancellation of the out-of-phase voice side bands of the modulated carriers thus combined, and also effect cancellation of the interference side band in the output of said amplifier and one of the two interference side bands of the locally modulated carrier, thereby leaving the sum of the combined carriers and said remaining interference side band as the final output of said amplifier; means for demodulating said final output of the amplifier so that only interference audio remains; and means for combining said interference audio with the product of the detector in the receiver in such a manner that the interference audio components thus combined are 180° out of phase and cancel each other.

6. In a radio receiver for receiving double size band amplitude modulated radio waves, means for eliminating the effect of interference manifested as a single side band frequency for any interference audio component, and which is not coherently related—in the form of double side-band amplitude modulation—to the carrier of the selected transmission comprising: a first amplifying channel; a second amplifying channel; a demodulator; means for feeding the received modulated carrier and accompanying single side band (for each frequency) of the interference to each of said amplifying channels and said demodulator; an oscillator; means for controlling the oscil-

lator so that its output is a duplicate of the carrier component of the modulated carrier fed into the two amplifying channels; means for locally modulating the output of the oscillator by voice audio and interference audio components of the modulated carrier fed to said two amplifying channels; means for effecting phase opposition between the two voice side bands and two interference side bands resulting from said modulation (as one factor) and the voice and interference side bands in one of said two amplifying channels (as the other factor); means for combining the locally modulated carrier with the received modulated carrier and interference side band in said mentioned one of the two amplifying channels to effect cancellation of the out-of-phase voice side bands of the combined modulated carriers, and also effect cancellation of the interference side band in said mentioned one of the two amplifying channels and one of the two interference side bands of the locally modulated carrier, thereby leaving the sum of the combined carriers and said remaining interference side band as the final output of said mentioned one of the two channels; means for demodulating the outputs of the two amplifying channels so as to provide interference audio and voice audio as the final output of one channel and only interference audio as the final output of the other channel; and means for combining said final outputs of the two channels with the interference audio of one opposite in phase to that of the other.

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