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SINGLE SIDE BAND TRANSMISSION SYSTEM

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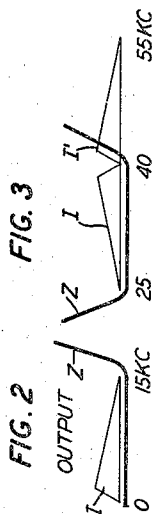
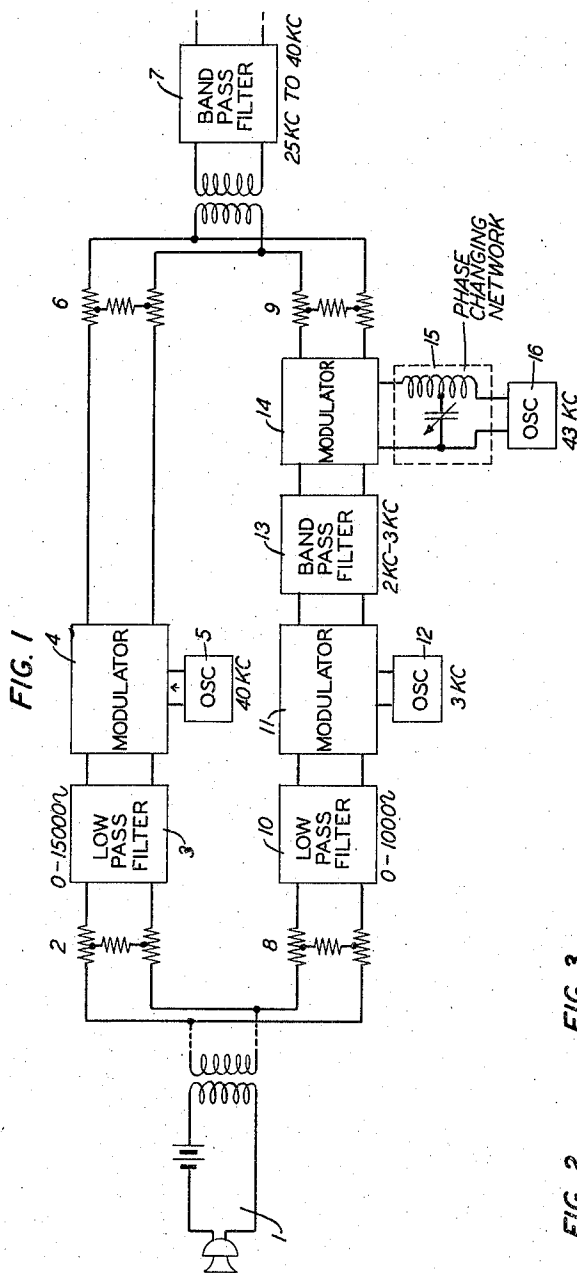


FIG. 3

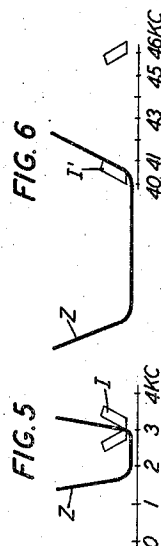


FIG. 6

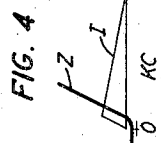


FIG. 5

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SINGLE SIDE-BAND TRANSMISSION SYSTEM

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7 Claims. (Cl. 179—171)

This invention relates to single side-band transmission systems and more particularly to suppression of an unwanted side-band of a modulated high frequency carrier wave.

5 In carrier wave transmission in which a carrier frequency wave is modulated in accordance with modulating waves such as, for example, speech current waves, to produce upper and lower side-bands lying on opposite sides of the carrier frequency, it is frequently desirable to be able to transmit one of the side-bands and at the same time to eliminate or suppress the other. Band-pass filters may be employed for this purpose, the filters having a transmission range such that the
10 wanted side-band is freely transmitted but the unwanted side-band is outside the transmission range and is suppressed.

The effectiveness of a filter in transmitting currents of one range and at the same time excluding those of a contiguous range depends upon a number of factors including the complexity and cost of the filter and the frequency difference between the most closely adjacent frequency components of the passed and suppressed bands relative to their absolute frequencies. If, for example, the currents of a range extending in their absolute frequencies from 2000 to 3000 cycles are to be separated from currents of a range extending from 3000 up to 4000 cycles, the percentage difference in frequency is relatively large and the separation may be effectively accomplished by rather simple and inexpensive filters. However, if a band of currents of a frequency range extending between 39,000 and 40,000 cycles
30 is to be separated from a band of currents in the frequency range between 39,000 and 41,000 cycles, the percentage frequency difference is very much lower and, consequently, a much more elaborate and costly selective system is required.

40 An object of the invention is to enable the use of a simple and inexpensive filter in side-band suppression systems for modulated high frequency carrier waves with the same effectiveness as a more elaborate and expensive filter by supplementing the filtering action of the relatively simple filter by a neutralization or balancing out of the residual components of the undesired side-band which the filter does not wholly suppress.

50 Another object of the invention is to secure a more effective suppression of an undesired side-band than can be had with single stage-band suppression systems of the type hitherto employed and to attain this result with less distortion in the desired side-band of a modulated high fre-

quency carrier wave than has attended the use of filter suppression systems hitherto known.

The components of the wanted and unwanted side-bands which are most difficult to separate are those adjacent the carrier frequency which result from the lowest frequency modulating currents. If, therefore, a relatively simple filter be used to separate the wanted and unwanted side-bands, it will suppress the major portion of the unwanted side-band but will not fully suppress that portion resulting from the lowest frequency modulating components. In accordance with the invention that portion of the unwanted side-band which the filter does not entirely eliminate is neutralized by a corresponding band portion, the components of which are respectively equal in amplitude but opposite in phase to the components of the unsuppressed band portion to be neutralized. The neutralizing band is produced by an independent modulation process starting with the same lowest frequency modulation components. The neutralizing band is preferably superimposed upon the wanted and unwanted side-bands which are to be separated and is caused to neutralize the components which the separating filter does not fully suppress so that the output of the separating filter is substantially free from any component of the unwanted bands.

The novel features which are believed to be characteristic of the invention are set forth in the appended claims. The invention, itself, however, as to its organization and method of operation together with further objects and advantages thereof will best be understood by reference to the following description taken in connection with the accompanying drawing in which there is illustrated diagrammatically one way in which the invention may be carried into effect.

In the drawing, Fig. 1 illustrates a system in accordance with the invention for separating a wanted side-band of a signal modulated carrier wave from an unwanted side-band, and Figs. 2 to 6 inclusive, are graphs illustrating the attenuation characteristics of various portions of the system illustrated in Fig. 1 together with the amplitude frequency characteristics of the band which these portions respectively transmit.

Referring to Fig. 1, a source 1 of low frequency modulating or signal currents which may, for example, comprise a broadcast transmitting microphone with its associated uni-directional current source as shown is connected to a circuit having two parallel branches. The one branch may include any suitable terminating or attenuation network 2 of well-known type, a low-

pass filter 3 having a transmission range sufficient to include the modulating currents, a modulator 4 of any well-known type and an oscillator 5 connected to the modulator to supply carrier oscillations thereto. The output terminals of the modulator 4 are connected through any suitable circuit which may include an attenuating or terminating network 6 to the input terminals of a band-pass filter 7. The attenuating characteristic of the low-pass filter 3 and the energy of the modulating waves transmitted therethrough are indicated in Fig. 2 in which the curve Z indicates the attenuating characteristic of the low-pass filter and I represents the relative amplitudes of the modulating currents in the frequency range of interest. If, for example, the oscillator 5 produces oscillations of 40 kilocycles frequency, the band-pass filter 7 may be designed to transmit freely and with substantially uniform attenuation a range of currents extending from somewhat lower than 25 kilocycles to a frequency slightly greater than 40 kilocycles as indicated by the attenuation characteristic Z of the band filter 7 as shown in Fig. 3. As shown by Fig. 3, the filter 7 will transmit in addition to the entire wanted side-band I a small portion I' of the unwanted upper side-band.

The second branch to which reference has been made is that employed for production of a neutralizing band. It is also connected to the source 1 of modulating currents and to the band-pass filter 7 and it includes networks 8 and 9 similar in their respective functions to networks 2 and 6. This second branch also includes a low-pass filter 10 which freely transmits only the lowest frequency components of the modulating signal as, for example, from 0 to 1000 cycles as indicated in Fig. 4. The transmission range of filter 10 is so predetermined that the range of the frequency components which it transmits will correspond substantially to that portion I' of the upper side-band transmitted by filter 7 as indicated in Fig. 3. In other words, if the effective cut-off frequency of filter 7 is 1000 cycles above the carrier frequency of 40 kilocycles the effective cut-off frequency of the filter 10 should be 1000 cycles. The low frequency components selected by filter 10 are impressed upon modulator 11 to modulate oscillations produced by oscillator 12 and which may be of 3 kilocycles frequency. The resulting side-bands supplied by modulator 11 to band-pass filter 13 will extend from 2 kilocycles to 3 kilocycles and from 3 kilocycles to 4 kilocycles as indicated in Fig. 5. If the band-pass filter 13 has a transmission range extending between 2 kilocycles and 3 kilocycles as indicated by the curve Z in Fig. 5, it may readily suppress the upper side-band and transmit from its output terminals to the modulator 14 a side-band ranging from 2 kilocycles to 3 kilocycles. Associated with modulator 14 through a transmission path including a phase-changing network 15 of well-known type is a carrier wave oscillator 16 of 43 kilocycles frequency. The modulator 14 serves to produce a lower side-band extending from about 40 kilocycles to 41 kilocycles and an upper side-band extending from 45 kilocycles to 46 kilocycles. The upper side-band transmitted from the modulator 14 to the band-pass filter 7 will lie entirely outside the transmission band range of the filter 7 as indicated in Fig. 6 and will be eliminated. The lower side-band I' extending between 40 and 41 kilocycles, it will be seen, corresponds to the portion of the unwanted side-band I' of Fig. 3

which it is desired to neutralize. If the amplification or gains of the two branches, the one branch including the modulator 4 and the second branch including the neutralizing modulators 11 and 14, are properly adjusted by means of the networks 2, 6, 8 and 9, or in any other well-known manner, and if the neutralizing band constituted by the lower side-band in the output of modulator 14 be oppositely phased with respect to the components which it is desired to neutralize, these components of the unwanted band will be eliminated. It is, of course, readily feasible by reversal of the connections of one of the pairs to secure an approximate phase opposition of the unwanted band portion and the neutralizing portion. However, in order to be able to accurately adjust the phase of a neutralizing band, the network 15 is provided to enable the phase of the oscillations supplied by source 16 to be suitably adjusted. As is well known a phase shift of the carrier oscillations supplied by the source 16 will be attended with an equal phase shift in the modulated wave in the side-bands resulting from the modulation operation in modulator 14. It follows that there will be impressed upon the band-pass filter 7 both desired and undesired side-bands derived from the output circuit of the modulator 4 and a neutralizing band from the modulator 14 which opposes and cancels the low frequency portion of the undesired upper side-band which would otherwise pass through the filter 7 and be transmitted to its output circuit. Consequently, the output circuit of the band-pass filter 7 contains only the desired side-band.

As previously stated it may be too expensive or it may even be impossible to secure a steep enough cut-off for the filter 7 to enable it to effectively suppress the unwanted side-band without the assistance of the neutralizing branch. It is, therefore, possible by the use of circuits in accordance with the use of this invention to obtain a greatly improved result which was hitherto not possible when using filter circuits previously known or, in other cases, to obtain the desired result with filter systems which are much less exacting in their requirements and hence less difficult and expensive to construct and adjust than is the case when using filters of the prior art.

It is to be understood that the principle of the invention may be employed in various types of circuits and that the invention is not to be restricted in any way to the details of the particular example illustrated but only by the scope of the appended claims.

What is claimed is:

1. A system for separating a desired side-band of an amplitude modulated carrier wave from the complementary side-band comprising means for producing a neutralizing band of waves equal in amplitude and opposite in phase to that portion of the unwanted side-band most closely adjacent the wanted band, a filter having a transmission range including the wanted band and a portion of the unwanted side-band corresponding to said neutralizing band, and means for superposing together upon the input terminals of the filter the two bands to be separated together with the neutralizing band whereby only the wanted band may appear in the output of the filter.

2. A system for separating one desired side-band of a high frequency modulated wave from the other undesired and closely adjacent in frequency side-band of the same high frequency

modulated wave which comprises a system for producing side-bands of a relatively low frequency carrier wave by modulating components similar to those by which the high frequency modulated wave is modulated, a selective network having a steep frequency cut-off characteristic for transmitting one of the low frequency carrier wave side-bands and suppressing the other, means for increasing the frequency and controlling the amplitude of the transmitted low frequency side-band to make them correspond to a corresponding portion of the undesired side-band and means for superimposing the increased frequency side-band in opposite phase upon the undesired side-band to neutralize a portion thereof.

3. A system in accordance with claim 2 including a suppression filter for suppressing the remaining portion of the undesired side-band.

4. In a system comprising a source of signal waves, a source of carrier waves, and means for modulating the amplitude of the carrier waves in accordance with the signal waves, a selective system for transmitting one side-band of the modulated carrier wave and for suppressing the other comprising a selective network which excludes a portion of the unwanted band, means for selecting from the said signal waves neutralizing waves corresponding to the unsuppressed portion of the unwanted side-band, modulation means for translating the frequencies of said neutralizing waves to correspond to the frequencies of the unsuppressed portion of the unwanted side-band, and circuit connections for combining said frequency translated neutralizing waves in opposite phase with the unsuppressed waves of the unwanted side-band.

5. A system in accordance with claim 4 in which the modulating means for translating the frequencies of the neutralizing waves comprises a low frequency carrier source, a modulating device wherein the waves from said source are modulated by the neutralizing waves, filtering means for selecting a single side-band of the resulting modulated wave, and a second modulating means for completing the frequency translation of the neutralizing waves.

6. In a system comprising a source of signal waves, a source of carrier waves, and means for modulating the amplitude of the carrier wave in accordance with the signal wave, the method of selecting a single side-band from the signal modulated carrier wave which comprises selecting by frequency discrimination the desired side-band and a portion of the undesired side-band adjacent the carrier wave, selecting from the signal wave frequency components corresponding to the selected portion of the undesired side-band, modulating a relatively low frequency carrier wave by said selected signal components and filtering out one side-band of the low frequency modulated wave, translating the frequency of the filtered low frequency modulated wave to correspond to the frequencies of the portion of the undesired side-band included in the first selection, and balancing said translated wave against the selected portion of the undesired side-band.

7. In a system comprising a source of signal waves of a wide frequency range, a source of carrier waves, and means for modulating the amplitude of the carrier wave in accordance with the signal waves, means for selecting a single side-band from the signal modulated wave comprising a wave filter adapted to transmit selectively the desired side-band and a portion of the undesired side-band adjacent thereto, filtering means for selecting a portion of said signal waves corresponding to the selected portion of the undesired side-band, a source of auxiliary carrier waves of frequency within the range of said signal waves and greater than the frequencies of said selected signal components, means for modulating said auxiliary wave in accordance with said selected signal components, filtering means for selecting a single side-band of the resulting modulated wave, means for translating the frequency of the filtered low frequency modulated wave to correspond to the frequencies of the first selected portion of the undesired side-band, and means for balancing said translated wave against the said selected portion of the undesired side-band.

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