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CARRIER SIGNALING SYSTEM

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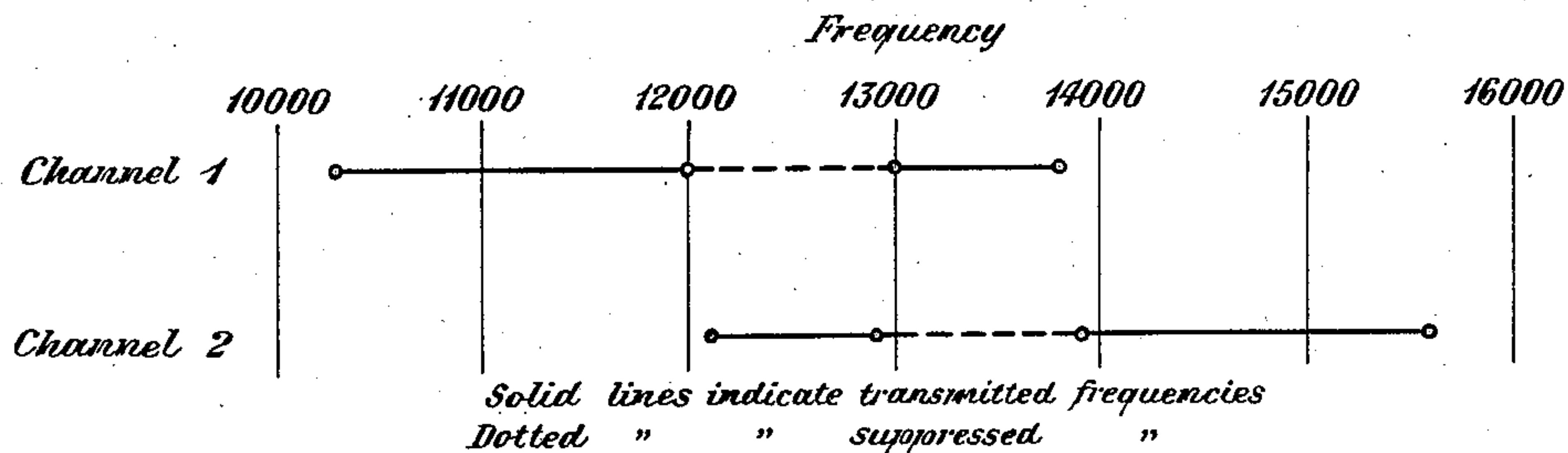


Fig. 1

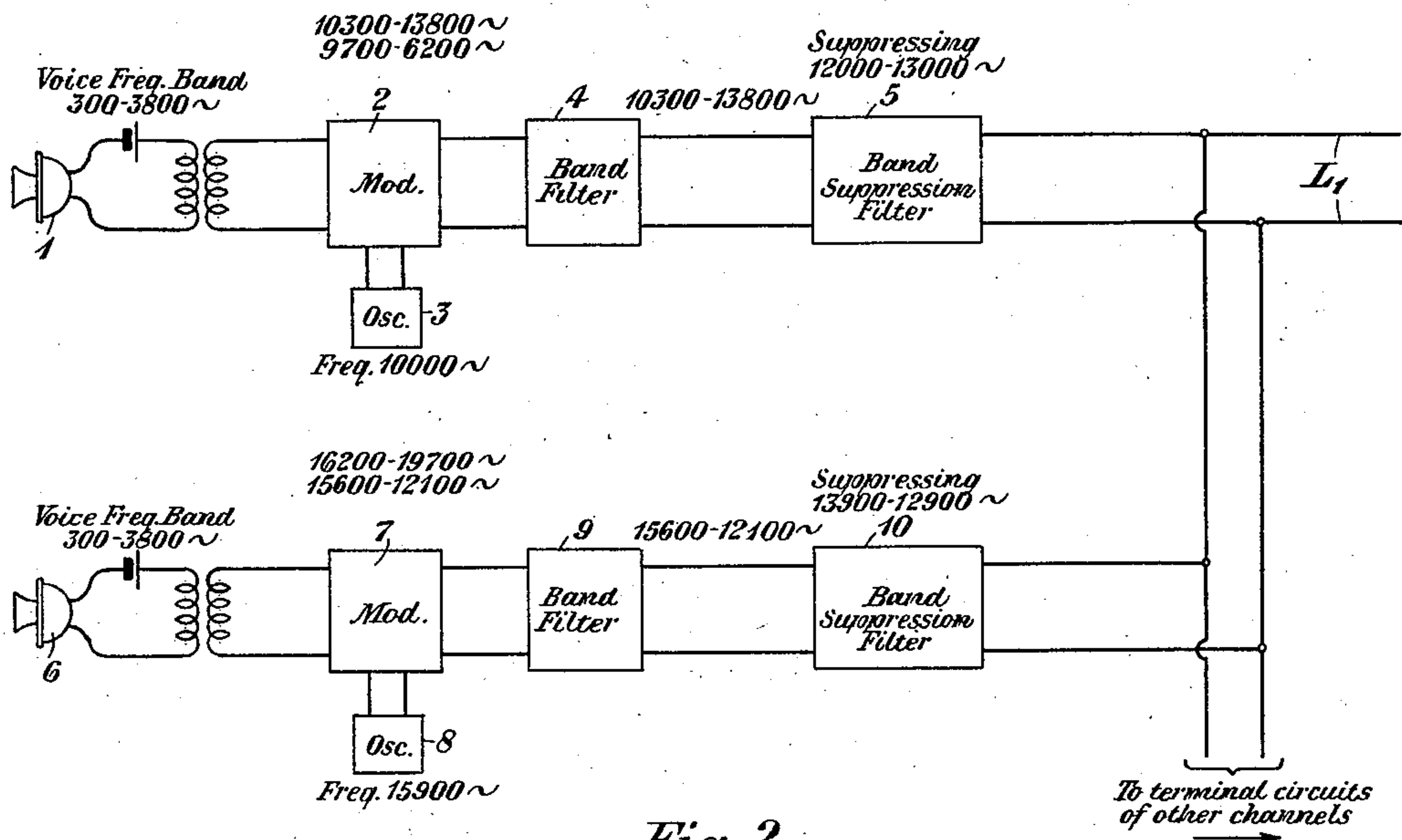


Fig. 2

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CARRIER SIGNALING SYSTEM.

Application filed November 17, 1925. Serial No. 69,681.

This invention relates to carrier signaling systems, and particularly to a multiplex system having a plurality of channels, the system being characterized by an interleaving of the bands of two or more channels, which interleaving is effected by the suppression of a frequency or a group or groups of frequencies in the side band of one of the interleaved channels which effects a closer spacing of the channels, and thus more efficiently uses the frequency spectrum.

In carrier or radio signaling systems over which a plurality of separate channels of communication are transmitted, it is, of course, essential, in order to avoid crosstalk between the several channels, that the frequencies appearing in the several channels shall be different. This not only requires the selection of carrier frequencies widely separated in the frequency spectrum, but it is also essential that the frequencies appearing in any side band of one of the carriers shall not be the same as those appearing in the side band of another carrier. In the systems of the prior art a relatively wide separation was necessary between the carriers of the several channels, so that relatively few channels were available within the range of frequencies transmittable over a wire circuit.

Response characteristics of transmission apparatus, particularly telephone transmitters and receivers, as well as the frequency characteristics of speech itself, are such that the relative importance of different frequencies for the transmission of intelligence may vary widely. Consequently it may be possible to omit a group or groups of frequencies in one of the side bands represented by the modulation of a carrier frequency by the frequencies employed in the transmission of speech, without materially impairing the quality of the received speech signal.

This invention resides in a method and means for conserving the frequency spectrum by suppressing a part of the frequencies in the side band representing a channel of communication, and by so spacing the carrier frequencies that the side band of adjacent channels will tend to overlap, but the same frequencies will not appear in different channels.

The invention will be clearly understood from the following description when read in connection with the attached drawing, of

which Figure 1 shows the distribution of the frequencies in two side bands representing different channels of communication, and Fig. 2 shows schematically a circuit embodying the invention.

As briefly referred to hereinbefore, the importance of different parts of the frequency range for speech varies widely. Certain data indicate, for example, that vowel sounds may be reproduced satisfactorily by transmitting frequencies between, say, 300 and 2,000 cycles, and consonant sounds may be reproduced more effectively by the additional transmission of frequencies between 3,000 and 3,800 cycles than by the band of frequencies between 2,000 and 2,800 cycles. Consequently, it is possible to suppress the group of frequencies between 2,000 and 2,800 or 2,900 cycles without causing any substantial diminution in the quality of the received speech band represented by the frequencies from 300 to 2,000 cycles and from 3,000 and 3,800 cycles. Since it is practical to suppress this group of frequencies in each speech band of a communication channel, it is practical to squeeze the channels more closely together in the frequency spectrum and consequently to utilize the available range of frequencies much more efficiently than was possible heretofore. This will be apparent if we assume certain frequencies for the purpose of illustrating the invention. If 10 kilocycles is assumed to be the carrier for one telephone channel, one side band thereof would be represented by the range of frequencies between 10,300 cycles and 13,800 cycles, and the other side band by the range between 9,700 cycles and 6,200 cycles. Since the group of frequencies between 2,000 and 2,800 or 3,000 cycles is seemingly less important for clear articulation than the other frequencies mentioned, this group of frequencies may be suppressed and the other groups transmitted. This is indicated in Fig. 1 by the solid line extending along the frequency scale from 10,300 to 12,000 cycles, and from 13,000 to 13,800 cycles representing the transmitted frequencies, and by the dotted line between 12,000 and 13,000 cycles representing the suppressed frequencies. In order to carry out this invention the carrier frequency of the adjacent channel must be so chosen that one of the speech bands of frequencies based upon that carrier which

will tend to overlap the band based upon the carrier frequency of 10 kilocycles, such overlapping being prevented by an interleaving of the bands, which will be so positioned that the frequencies suppressed in the first band will be transmitted in the second band, and vice versa, the frequencies suppressed in the second band will be transmitted in the first band. Accordingly, if we select the frequency of 15,900 cycles as the carrier of the adjacent channel the lower side band thereof will extend from 15,600 cycles to 12,100 cycles. This band of frequencies, which is designated in Fig. 1 as channel #2, may be considered as made up of three groups, two of which are transmitted and the other suppressed. The transmitted groups, represented by the solid line, comprise the frequencies between 15,600 cycles and 13,900 cycles, and from 12,900 cycles to 12,100 cycles. The suppressed group embraces the frequencies between 12,900 and 13,900 cycles. From Fig. 1 it will be seen that while the bands of frequencies (as produced by the speech modulation of the carrier frequencies) overlap, there are no frequencies in common in the two bands as transmitted, that is to say, before transmission of the selected band (that is, either the upper band or the lower band resulting from speech modulation of the carrier) a certain group or groups of frequencies will be suppressed and the other groups of the selected band are transmitted. Since, however, there are no frequencies in common in adjacent bands as transmitted, there will be no cross-talk between the adjacent channels of communication and furthermore selection of the channels may be readily made at the receiving end of the system. The importance of this invention resides in its ability to crowd together the channels of communication within the available frequency range without producing or permitting interference between the several channels. This advantage will be apparent when it is realized that under the systems of the prior art, in order to transmit an upper limiting frequency of, say, 3,800 cycles as contemplated in the above illustration, it is necessary to space the adjacent channel bands by at least this amount to avoid overlap, whereas the proposed arrangement provides for the transmission of two such bands within a total frequency space of about 5,300 cycles, as shown above, by means of the omission of such parts of each band as are found to be relatively of least importance for the reproduction of the signal.

The manner in which this invention may be carried out is shown clearly in Fig. 2 in which L_1 represents a line over which a plurality of channels may be transmitted, each based upon a different carrier frequency. While only two terminal circuits have been

shown connected with the line L_1 , it is to be understood that the number may be different, depending upon the number of channels to be transmitted. The transmitter 1 is connected with the input side of modulator 2, which may be of the balanced type, having a source of oscillations 3 for supplying the carrier frequency for the channel represented by the transmitter 1. The output side of the modulator is connected with the band filter 4, which in turn is connected with the band suppression filter 5. This filter is connected with the line L_1 . In like manner the transmitter 6 is connected with the input side of the modulator 7 having a source of carrier frequencies 8 connected therewith. The output of the modulator 7 is connected with the band filters 9 and 10 in sequence, the latter being connected with the line L_1 . The speech frequencies set up by the transmitter 1 having an assumed useful range of 300 to 3,800 cycles will be impressed upon the modulator 2, together with oscillations of the carrier frequency of 10 kilocycles from source 3. The frequencies resulting from such modulation, namely, the bands represented by 10,300 to 13,800 cycles, and from 9,700 to 6,200 cycles would be impressed upon the band filter 4 which would transmit the band represented by 10,300 to 13,800 cycles, and suppress the other frequencies. The selected band, namely, the upper side band of the carrier frequency of 10 kilocycles will be impressed upon the band suppression filter 5 which will transmit therethrough to the line L_1 , two groups of frequencies, namely, those between 10,300 and 12,000 cycles, and those between 13,000 and 13,800 cycles, and would suppress the group between 12,000 and 13,000 cycles. The frequencies going out on the line representing the channel originating in the transmitter 1 are indicated by channel 1 on Fig. 1. It is important to note that instead of using two filters 4 and 5 to perform the required filtering of the band of frequencies, the same result may be effected by a single filter, having a characteristic passing two separated bands, and, of course suppressing other frequencies. In like manner the assumed useful speech band of 300 to 3,800 cycles originating in the transmitter circuit 6 will be impressed upon the modulator 7 together with oscillations of the carrier frequency of 15,900 cycles. Of the products of modulation only the side band represented by 15,600 to 12,100 cycles would be transmitted by the band filter 9, the other frequencies being suppressed. The selected side band, viz, the lower side band of the carrier frequency of 15,900 cycles will be impressed upon the band suppression filter 10 which will transmit two groups of frequencies between 15,600 and 13,900 cycles and between 12,900 and 12,100 cycles, and will suppress

the group between 13,900 and 12,900 cycles. The selected groups which represent the second channel of transmission will be impressed upon the line L_1 for transmission to the distant end. At the distant end there would, of course, be a terminal circuit for each channel of transmission, each terminal circuit having therein suitable filters capable of passing the groups of frequencies lying within the selected band representing particular channels of transmission. These frequencies would, of course, be demodulated and the resulting groups of speech frequencies would be impressed upon the speech receiving apparatus. There will, of course, be absent in each received speech band a group of frequencies lying between 2,000 and approximately 3,000 cycles. Since, however, this group is relatively unimportant from the articulation standpoint, the clearness of the received speech signal would not be materially affected by the absence of these frequencies. Instead of suppressing the frequencies to be omitted in each band by means of filters in the output circuit of the several modulators, these frequencies may also be prevented from reaching the modulator by means of suitable suppression filters interposed between the transmitters 1 and 6 and the modulators 2 and 7, respectively.

While the invention has been disclosed as embodying in a particular form, it is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. The method of transmitting a plurality of signals, each embracing a plurality of frequencies without causing interference between the said signals which consists in modulating a carrier frequency by a plurality of frequencies representing one signal, selecting one of the side bands of such modulation, suppressing one of the frequencies within the said side band and transmitting the other frequencies of the said band, modulating a second carrier by a plurality of frequencies representing another signal, the frequency of the said second carrier being so chosen that one of the bands of modulation overlaps the selected band of the first carrier, selecting the said overlapping band of the second carrier and suppressing such frequencies therein as appear in the transmitted frequencies of the selected band of the first carrier.

2. In a carrier signaling system, the

method of transmitting a plurality of signals, each embracing a band of frequencies without causing interference between the said signals which consists in modulating a carrier frequency by the band representing the first signal, selecting one of the bands of the said modulation, suppressing a group of frequencies within the selected band and transmitting the unsuppressed frequencies, modulating a second carrier by the band representing the second signal, the frequency of the said second carrier being so chosen that one of the bands resulting from its modulation by the second signal will overlap the selected band of the first carrier, selecting the overlapping band of the second carrier, suppressing that group of frequencies in the said overlapping band that appears in the transmitted frequencies of the selected band of the first carrier, and transmitting the resulting frequency of the said selected band of the second carrier.

3. In a carrier signaling system, the method of transmitting a plurality of signals, each embracing a band of frequencies without causing interference between the said signals which consists in modulating a carrier frequency by the band representing the first signal, selecting one of the bands of said modulation, suppressing an intermediate group of frequencies within the selected band and transmitting the unsuppressed frequencies, modulating another carrier by the band of the second signal, the frequencies of the said other carrier being so chosen that one of the bands resulting from such modulation will overlap the selected band of the first carrier, selecting the overlapping band of the second carrier, suppressing that group of frequencies in the overlapping band having the same frequency as the group in the selected band of the first carrier and transmitting the unsuppressed frequencies.

4. The method of conserving the frequency range in carrier transmission which consists in transmitting certain portions of the speech band which are most important for articulation, suppressing intervening less important portions, and arranging the carrier frequencies of adjacent channels so that the transmitted frequencies of one channel correspond with the suppressed frequencies of the other channel.

In testimony whereof, I have signed my name to this specification this 16th day of November, 1925.

ALLEN CARPE.