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SINGLE-SIDE-BAND CARRIER SYSTEM

Application filed September 20, 1926. Serial No. 136,672.

This invention relates to high frequency signaling systems, and particularly to a method and means for eliminating an undesired product of modulation.

In high frequency signaling systems, as, for example, a carrier or radio system in which it is desired to transmit only one side band over the system, it is customary to eliminate by means of a filter the other side band produced by the modulation of a carrier by the signal to be transmitted. Except for the loss of energy represented by the suppressed side band, this method of elimination is satisfactory where the frequencies involved are of the order now employed upon carrier systems. As the frequencies increase, the difficulty in eliminating the unwanted side band by means of a filter becomes more pronounced, and with frequencies of the order of 1,000 kilocycles it is practically impossible to eliminate the unwanted side band by filters unless the signal currents are raised to that frequency through two or more stages of modulation with filters in each stage to eliminate the unwanted side band. Apart from the question of cost, there are other reasons why this practice is undesirable.

This invention resides in a method and means for the elimination of an undesired product of modulation, and particularly in the production of one side band only, by the direct modulation of the high frequency carrier by a low frequency signal.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing showing schematically a form of embodiment of the invention.

In the drawing, a source 1 of modulating current which may be that produced by speech, music or other sound, is impressed across the input circuit of the balanced modulator M_1. A source of carrier oscillations 2 of the frequency $\frac{q_1}{2\pi}$ is connected with the common conductor of the input circuit of the modulator M_1, thereby furnishing a carrier current to be modulated by the source 1. The modulating current represented by sin pt will modulate the carrier oscillations represented by sin $q_1 t$, and there will appear in the circuit connected with the secondary of the transformer 3, in addition to the direct current effects, and double frequency and unmodulated currents, two side bands represented by

$$\cos(q_1 - p)t - \cos(q_1 + p)t.$$

A band filter 4 is inserted therein, which excludes from the subsequent translating circuit the direct current effects and double frequency and unmodulated currents, and also one of the side bands, transmitting, for example, only the side band represented by

$$-\cos(q_1 + p)t.$$

This side band is impressed across the resistance 5 in series with the condenser 6. It is, of course, apparent that the drop in potential across the condenser will be 90° out of phase with the drop across the resistance 5. These two potentials representing the side band transmitted by the filter 4 will be impressed upon the balanced tube structure A_1 comprising the tubes 7 and 8. The output circuit of tube 7 contains the primary winding of the transformer 9, the secondary winding of which is connected across the input circuit of the balanced modulator M_2. In like manner, the output circuit of tube 8 contains the primary winding of transformer 10, the secondary winding of which is connected across the input circuit of the balanced modulator M_3. A source of carrier oscillations 11 of frequency $\frac{q_2}{2\pi}$ is connected with a resistance 12 and a condenser 13 in order to produce two carrier waves of the same frequency differing in phase by 90°. The drop in potential of the current from the source 11 through the resistance 12 is connected with the common conductor of the modulator M_2, and the drop across the condenser 13 with the common conductor of M_3. These drops in potential are represented by sin $q_2 t$ and cos $q_2 t$, respectively. The voltages impressed upon the primary windings of transformers 9 and 10 are $-\cos(q_1 + p)t$ and $-\sin(q_1 + p)t$, respectively. As the result of modulation by M_2, there

will appear in the common output circuit two side bands represented by

$$-\sin(q_2+q_1+p)t-\sin(q_2-q_1-p)t$$

and, in like manner, the modulator M_3 will impress upon the common output circuit side bands represented by

$$-\sin(q_2+q_1+p)t+\sin(q_2-q_1-p)t.$$

Since the latter side bands have the opposite signs, they will be cancelled, and there will be transmitted over the line 14 only a single side band represented by

$$-\sin(q_2+q_1+p)t.$$

As has been stated hereinbefore, in order to produce but a single side band by the modulation of the high frequency carrier by a lower frequency modulating current, it is not only necessary that the modulating currents shall be different in phase by exactly 90°, but also the magnitudes of each frequency in each of the modulating currents must be the same. In the arrangement shown in the co-pending application of Green, Serial No. 136,671, filed September 20, 1926, Patent No. 1,719,052, July 2, 1929, this equality of magnitude of the various frequencies is practically assured by the similar structures traversed by currents from the same source for the production of the modulating currents 90° out of phase. In the present invention, the various frequencies represented in the voltage drop across the resistance 5 may differ slightly in magnitude from the same frequencies in the drop across the condenser 6, for the reason that the voltage drop across a condenser varies with the frequency. This may result in the presence in the common output circuit of a small amount of the undesired side band, namely, that represented by

$$\sin(q_2-q_1-p)t.$$

If the first carrier, namely, that produced by the source 2, is fairly high, for example, of the order of 30,000 cycles, the difference in magnitude of the two unwanted side bands impressed by the modulators M_2 and M_3 upon the common output circuit will be relatively small, so that the net result could probably be eliminated by a simple tuned circuit or filter, such as 15, inserted in the line 14.

It will be understood that although phase differences of 90° between the two carriers and also between the two modulating currents applied to the single side band modulator have been referred to in the above description the desired result may be accomplished by using other phase differences selected in such a way as to concel out one side band without cancelling the other. Thus, a phase difference of 100°, for example, between the two carriers, and one of 80° between the two modulating currents might be employed. This would give the desired 180° relation for one of the side bands, while for the other side band two components differing in phase by 20° would be obtained. The 90° phase relation, however, is for ordinary purposes the most efficient one.

It will also be evident that the invention may be used to eliminate other undesired modulation products, as, for example, those produced by the higher powers represented in the modulator characteristic, and that it may be used with other types of modulators, as, for instance, magnetic modulators, as well as with vacuum tube modulators.

While this invention has been disclosed as embodied 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 producing a single side band in a carrier signaling system, which consists in the modulation of a carrier current by a signaling current, selecting one of the side bands resulting from such modulation, producing out-of-phase components of the selected side band, producing components of a second carrier current which differ in phase to the same extent as the components of the selected side band, modulating one of these carrier components by one component of the side band, and the other carrier component by the other side band component, and combining the products of modulation.

2. In a single side band carrier system the combination with a source of signaling current, of a modulator having a source of carrier current connected therewith, means to select one of the side bands resulting from modulation, means to produce components of the selected side band which differ in phase by 90°, a plurality of modulators each connected with a source of carrier frequency, the connection including means to shift the phase of the carrier applied to one of the modulators by 90° from that applied to the other modulator, means to apply to each modulator one of the components of the selected side band, and means to combine the products of modulation.

3. In a single side band carrier system the combination with a source of signaling current of a balanced modulator having a source of carrier current connected symmetrically with the input circuit thereof, a band filter connected with the output of said modulator to transmit a predetermined band resulting from modulation, means to produce components of the selected band differing in phase by 90°, means to amplify the selected components, a balanced modulator connected with the output of one of said amplifiers and also with a second source of carrier current, a second balanced modulator connected with the output of the other amplifier and also with the said source of carrier current, means con-

nected between said carrier current source and said balanced modulators to produce a phase difference of 90° between the currents applied to the said modulators, and a com-
5 mon output circuit connected with both modulators.

In testimony whereof, I have signed my name to this specification this 17th day of September, 1926.
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