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SINGLE SIDE BAND CARRIER SYSTEM

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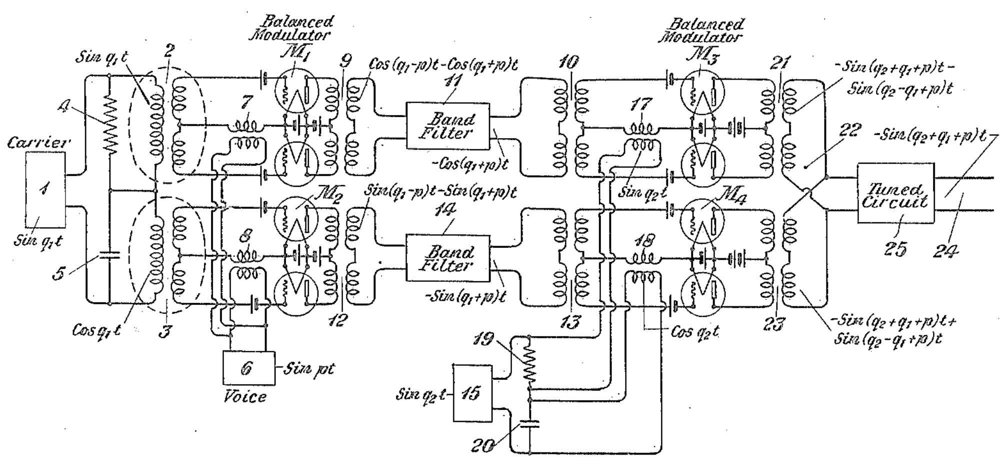

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SINGLE-SIDE-BAND CARRIER SYSTEM.

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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 carrier oscillations of the frequency $\frac{q_1}{2\pi}$ is connected with the primary windings of the transformers 2 and 3. The primary winding of transformer 2 is connected across the resistance 4, and a similar winding of transformer 3 across the condenser 5. The carrier frequency oscillations which traverse the resistance 4 and the condenser 5 will cause the voltages impressed across the secondary windings of the transformers 2 and 3 to differ in phase by 90°. The secondary winding of 2 is connected with the input side of the balanced modulator M_1, and the similar winding of transformer 3 with the input side of the balanced modulator M_2. A source of modulating current 6, which may be that produced by speech, music or other sound, is impressed across the windings 7 and 8 in the common branches of the balanced modulating circuits.

The modulator M_1 is connected by the transformers 9 and 10 with the input side of the balanced modulator M_3, the connection including the band filter 11 which is adapted to transmit one of the side bands resulting from modulation. Similarly, the modulator M_2 is connected by the transformers 12 and 13 with the input side of the balanced modulator M_4, the connection including the band filter 14 adapted to pass one of the side bands of modulation. A source 15 of carrier oscillations of the frequency $\frac{q_2}{2\pi}$ is connected with the windings 17 and 18 in the common input conductors of the modulators M_3 and M_4. By means of the resistance 19, the carrier oscillations applied to M_3 are in phase with those produced by 15, whereas, by virtue of the condenser 20, the oscillations applied to M_4 are 90° different in phase from those produced by 15. The output circuit of M_3 is connected by the transformer 21 with the common circuit 22 to which the output circuit of M_4 is likewise connected by the transformer 23.

The manner in which this arrangement operates in order to attain the object of the invention, namely, the production of a single side band representing a high frequency carrier modulated by a low frequency current is as follows: Oscillations of the frequency $\frac{q_1}{2\pi}$ will be set up by the carrier source 1 and will cause a current to flow through the resistance 4 and the condenser 5. The drop in potential across 4, which is impressed across the primary winding of transformer 2, is in phase with the current produced by 1, and is represented by sin q_1t. The drop in potential across the condenser 5, which is impressed across the primary of transformer 3, is 90° different in phase from the current from the source 1, and is represented by cos q_1t. The carriers therefore that are impressed across the input circuits of the modulators M_1 and M_2 are 90° apart in phase. The modulating current from the source 6, which for purposes of discussion, may be represented by sin pt, is in phase as applied to both modulators. Disregarding double frequencies, direct current components in other frequencies that are of no concern, the frequencies which are applied to the input side of the band filter 11 are represented by

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

and, similarly, the frequencies appearing at the input side of the band filter 14 are represented by

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

These filters are adjusted to eliminate one side band, as for example, the lower side band, so that the current flowing through the primary winding of transformer 10 is represented by

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

and, similarly, the current in the primary winding of 13 is

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

These currents are obviously 90° apart in phase, and they are applied to the balanced modulators M_3 and M_4, respectively, for the purpose of modulating carrier currents of the same frequency produced by the source 15, but differing in phase by 90°. That is to say, the voltage applied across 17 is represented by $\sin q_2t$, and that across 18 by $\cos q_2t$. The product of modulation of M_3 in which we are interested is represented by

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

and, similarly, the output of modulator M_4 includes the bands represented by

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

When currents representing these frequencies are combined in the common output circuit 22, the side bands represented by

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

being of opposite sign are eliminated, and there will appear in the output circuit 24 only the band represented by

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

The tuned circuit 25 is included in the output circuit in order to eliminate the double frequency and unmodulated components and other undesired products of modulation.

This arrangement differs from that disclosed in the copending application of Carpe, Serial No. 137,134, filed September 22, 1926, in that the high frequency oscillations from the source 15 are modulated by carrier side bands which are out of phase by 90°. In the Carpe arrangement, a carrier was employed in the first instance to effect a shifting in phase by 90° of the currents by which the ultimate carrier is modulated, but this final modulating current is the same frequency as that used in modulating the first carrier, namely, sin *pt*.

My invention is characterized by a balanced arrangement for the production of the modulating currents 90° out of phase, by means of which the final carrier is modulated. Any change in phase that may be produced in the branch including M_1 and 11 will be off-set by the change, if any, produced in the branch including M_2 and 14. In other words, the similarity of structure tends to ensure a 90° phase displacement of the currents impressed across the secondary windings of the transformers 10 and 13.

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 cancel 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 othe types of modulators, as, for instance, magnetic modulators, as well as with vacuum tube modulators.

While the 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 predetermined phase difference between two portions of a modulating current, which consists in creating a carrier current, producing therefrom two components differing in phase by a predetermined degree, modulating each component by the same modulating current, selecting one of the side bands of one component, similarly selecting that side band of the other component lying on the same side of the carrier as the first selected band.

2. The method of producing a predetermined phase difference between two portions of a modulating current, which consists in modulating by a signal frequency each of two components of a carrier frequency differing in phase by 90°, selecting a side band

from each modulating process, which bands lie on the same side of the carrier frequency.

3. In a single side band carrier system the combination with a source of carrier frequency, of means to produce components differing in phase by a predetermined degree, a source of modulating current, means to modulate each component of the carrier by the modulating current, means to select a side band of each component, the selected side bands lying on the same side of the carrier frequency, means to modulate one component of another carrier frequency by one side band and another component by the other band, the components differing in phase by a predetermined degree, and means to combine the products of modulation of the components of the last mentioned carrier.

4. In a single side band carrier system the combination with balanced modulators of a source of signaling current connected symmetrically with the input circuit of each modulator, a source of carrier current also connected with the input circuit of each modulator having means to produce a phase differnece between the carrier currents applied to the said modulators, means connected with the output circuits of each modulator to select one of the bands resulting from each modulating process, the selected bands lying on the same side of the carrier frequency, a second group of balanced modulators having a source of carrier current connected therewith, the frequency of which differs from that produced by the first mentioned source, the said connection having means to produce a phase difference between the carrier currents applied to each balanced modulator of the last mentioned group, and means to combine the products of modulation resulting from the last mentioned modulating processes.

5. The method of eliminating an undesired product of modulation, which consists in creating a carrier current, producing therefrom two components differing in phase by a predetermined degree, modulating each component by the same modulating current, selecting one of the side bands of one component, similarly selecting that side band of the other component lying on the same side of the carrier as the first selected band, modulating by one of the selected bands one component of a carrier frequency and by the other band another component thereof differing from the first component by a predetermined phase angle and combining the products of modulation.

6. The method of eliminating an undesired product of modulation, which consists in modulating by a signal frequency each of two components of a carrier frequency differing in phase by 90°, selecting a side band from each modulating process, which bands lie on the same side of the carrier frequency, modulating one component of a carrier frequency by one side band and another component by the other side band, the said components differing in phase by 90°, and combining the products of modulation.

7. The method of producing from a single carrier current and a single modulating current a plurality of carrier currents differing in phase by a predetermined degree and accompanied by side bands differing in phase by a predetermined degree which consists in creating a carrier current, producing therefrom a plurality of components differing in phase by a predetermined degree and modulating each component by the same modulating current.

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

ESTILL I. GREEN.