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SYSTEM FOR BINAURAL TRANSMISSION OF SOUND

Filed Dec. 31, 1925

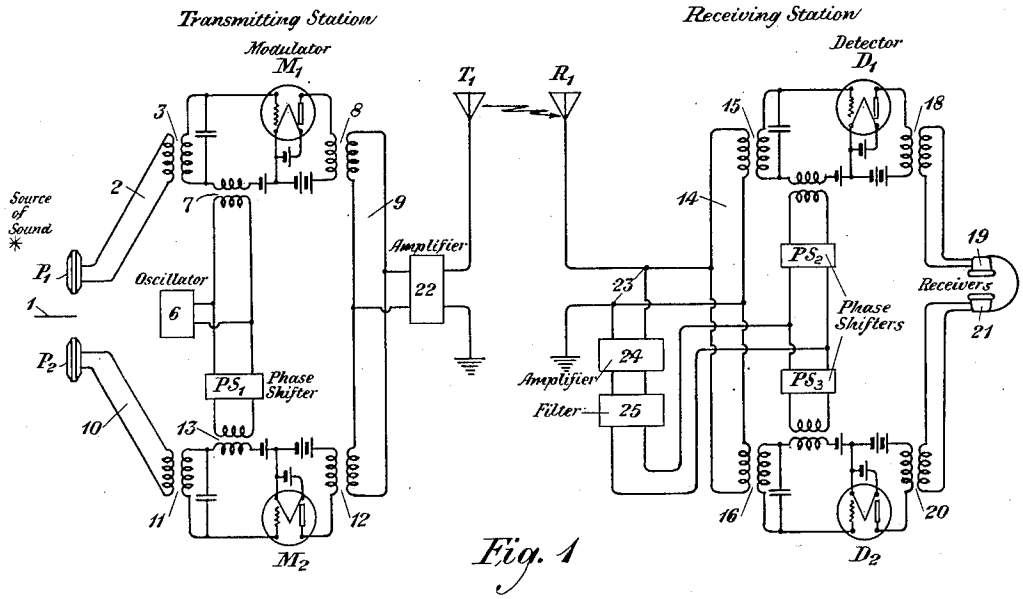


Fig. 1

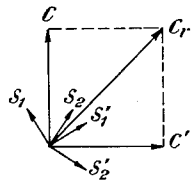


Fig. 2

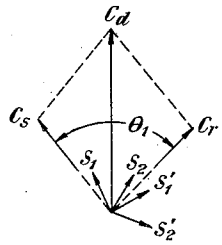


Fig. 3

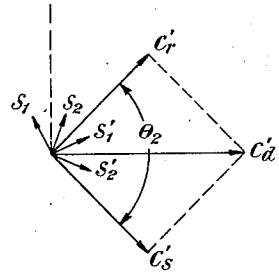


Fig. 4

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UNITED STATES PATENT OFFICE.

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SYSTEM FOR BINAURAL TRANSMISSION OF SOUND.

Application filed December 31, 1925. Serial No. 78,648.

This invention relates to high frequency signaling systems, and particularly to a system of the binaural type by means of which it is possible to give to a listener an idea of the position of the source of sound producing the transmitted signal.

In a system for the dissemination of speech, music or other sounds such as a radio broadcast or a wire distributing system, it is desirable to create within the listener a sense of the position from which the sound emanates; for example, it is particularly satisfying to be able to follow the movements of participants during the broadcasting of a play or to know the source of individual elements entering into the orchestration of a musical selection.

This invention resides in a high frequency transmission system which may be either of the radio broadcast or the wire distributing type which is adapted to give to the listener at the receiving station a sense of the relative position of the sound that is conveyed electrically over the transmission system.

The conveyance of such sense of position requires the transmission of two signals practically identical when separately considered but containing a small phase and amplitude difference such as is necessary to produce the same position discrimination as is afforded by the direct transmission of sound to the ears. The electrical circuit must therefore be capable of conveying these relations with a perfect balance of phase and amplitude, because if one channel of transmission is distorted in somewhat different manner from the other the result is somewhat negatived.

This invention will be clearly understood from the following description when read in connection with the attached drawing of which Figure 1 shows schematically a form of embodiment of the invention and Figs. 2, 3 and 4 serve to make clear the description of the principle of operation of the invention.

In Fig. 1 the transmitting station comprises the microphones P_1 and P_2 which are separated preferably by a distance equal to the distance between the ears of the average person. A barrier such as 1 may also be inserted between the microphones in order to further simulate the separation existing between the ears of human beings. Microphone P_1 is connected by the circuit 2 with the primary winding of the transformer 3, which has its secondary winding connected with the input circuit of the modulator M_1. This modulator may be of any well known type. In the form shown in the drawing it comprises a vacuum tube 4 having its input circuit connected not only with the circuit 2 but also by means of the transformer 7 with a source of carrier oscillations 6. The output side of this modulator is connected by the transformer 8 with the circuit 9, which in turn is connected with the input side of the power amplifier 22, whose output side is connected with the antenna T_1. In like manner the microphone P_2 is connected by the circuit 10 with the primary winding of the transformer 11 which has its secondary winding connected with the input side of the modulator M_2. Also connected with this input side through the transformer 13 is a source of oscillations 6, the connection including the phase shifter PS_1. The output side of the modulator M_2 is connected by the transformer 12 with the circuit 9, which is connected through the amplifier 22 with the antenna T_1. In order to carry out this invention, the modulators M_1 and M_2 should be of the type that effects the transmission not only of the side bands but also of the carrier frequency oscillations themselves.

The receiving station comprises the antenna R_1, which is connected by means of the input circuit 14 with the detectors D_1 and D_2 through the transformers 15 and 16. The output sides of these detectors are connected by the transformers 18 and 20 with the receivers 19 and 21, respectively. Bridged across the receiving circuit at the points 23 is a branch circuit comprising an amplifier 24, a filter 25 adapted to transmit therethrough the carrier frequency and to suppress the side bands. The output side of this filter is connected with the input side of the detectors D_1 and D_2. A phase shifter PS_2 is connected between the filter 25 and the detector D_1, and in like manner the phase shifter PS_3 is connected with the input side of the detector D_2.

The manner in which this circuit functions in order to attain the objects of the invention is as follows:

Sound emanating from a source (as indicated by a star) in the vicinity of the microphones P_1 and P_2 will affect these devices so as to produce variations in the currents in

the circuits 2 and 10. These current variations when impressed by the transformers 3 and 11 upon the input circuits of the modulators M_1 and M_2 will modulate oscillations of the carrier frequency supplied to the modulators by the source 6. The oscillations supplied to M_2 are 90 degrees out of phase with the oscillations impressed by the source 6 upon the modulator M_1. The phase relationships of the various currents are represented in Fig. 2 where C represents the oscillations applied to M_1, and S_1 and S_2 represent the side bands of that carrier. Similarly C′ represents the carrier applied to M_2, and S'_1 and S'_2 represent the side bands of that carrier. Both carriers and side bands will be transmitted and will be received by the receiving antenna R_1. The currents in this antenna at any instant are substantially shown by Fig. 2, and comprise two sets of side bands and the resultant carrier C_r. These currents will be impressed upon the input circuit 14 and in turn upon the detectors D_1 and D_2. A portion of the oscillations of the carrier frequency will be amplified by 24 and selected by the filter 25, and will be impressed upon the input circuits of the detectors D_1 and D_2 through the phase shifters PS_2 and PS_3, respectively. It is desirable to make clear that both sets of side bands are present in the input circuits of both detectors, and if the resultant carrier C_r alone were applied to the input circuits of the detectors it would serve to detect the signal carried by both sets of side bands in each detector. This is so because as shown in Fig. 2 the resultant carrier is not 90 degrees out of phase with the symmetrical mean of either set of side bands. For that reason it has a component in phase with the symmetrical mean of each side band which would serve to detect both sets of side bands and this would result in the loss of the binaural effect in the receivers 19 and 21. For that reason it becomes necessary to derive from the resultant carrier secondary carriers of the same frequency but differing in phase from the resultant carrier so that it will be possible to combine the resultant carrier with each secondary carrier to produce carriers which are in phase with the symmetrical mean of one set of side bands, and 90 degrees out of phase with the mean of the other set of bands. This desirable result is attained in the following manner: The resultant carrier C_r is impressed with the side bands upon the input sides of the detectors D_1 and D_2. At the same time a carrier of the same frequency will be impressed upon the input circuits of these detectors but will be shifted in phase by the phase shifters. To be specific, a portion of the resultant carrier which is selected by the filter 25 will be shifted in phase by PS_2 to the degree represented by θ_1 and the carrier frequency thus produced, which is designated C_s in Fig. 3, will be impressed upon the input side of detector D_1. The angle θ' is of such magnitude that the resultant of C_r and C_s, which is represented by C_d in Fig. 3, is in phase with the symmetrical mean of the side bands S_1 and S_2. It will accordingly detect the signal impressed upon the side bands S_1 and S_2, which detected signal will be impressed upon the receiver 19. Since, however, the carrier C_d is 90 degrees out of phase with the symmetrical mean of the side bands S'_1 and S'_2 it will not detect the signal borne by these side bands. The phase shifter PS_3 is adjusted to produce a carrier such as is represented by C'_s in Fig. 4, which carrier makes an angle θ_2 with the resultant carrier C_r. The resultant of C_r and C'_s, designated C'_d is in phase with the symmetrical mean of S'_1 and S'_2, and therefore will detect the signal upon these side bands but will not detect the signal upon S_1 and S_2 inasmuch as it is 90 degrees out of phase with the symmetrical mean of the latter bands. The signal resulting from the detection of D_2 will be impressed upon the receiver 21 and the listener will be enabled to determine the relative position of the source of sound in the vicinity of the microphones P_1 and P_2 by the effect produced upon his sense of hearing by the sound in the receivers 19 and 21.

The amplifier 24, which is preferably a unilateral device such as a vacuum tube, serves to prevent reaction between the detectors and the input circuit extending from the antenna R_1 to the said detectors.

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. In a system for the binaural transmission of signals, the combination with a transmitting station, of a receiving station, a transmitting medium connecting the said stations, the transmitting station comprising two branch circuits, each having a transmitter and a modulator adapted to transmit side bands and carrier oscillations, of a source of carrier oscillations common to both modulators, and a phase shifter interposed between the said source and one modulator to vary the phase of the carrier oscillations applied to that modulator with respect to the carrier applied to the other modulator, the receiving station comprising two branch circuits connected with the said transmitting medium, each having a detector and a receiver, a by-pass circuit having a filter adapted to transmit the carrier frequency, and phase shifters interposed between the said filter and each of said detectors.

2. In a system for the binaural transmission of signals, the combination with a trans-

mitting station comprising a transmitting circuit having two branch circuits connected in parallel therewith, each having a transmitter and a modulator of the carrier transmitting type, a source of carrier oscillations connected with both modulators, one of the connections including a phase shifter adjusted to render the oscillations applied to one modulator 90° out of phase with the oscillations applied to the other modulator, of a receiving station comprising a receiving circuit having two branches connected in parallel therewith, each branch having a detector and a receiver, and a frequency selective circuit responsive to the carrier frequency bridged across the said receiving circuit to filter out a portion of the carrier frequency, the said frequency selective circuit having branches connecting with each detector, each branch having a phase shifter therein to control the phase angle of the selected carrier frequency with respect to the resultant carrier impressed by the receiving circuit upon each detector.

3. In a system for the binaural transmission of signals, the combination with a transmitting station having means to separately modulate carrier oscillations by the signal variations resulting from the same sound, the carrier oscillations being of the same frequency but differing in phase by 90°, of a receiving station having means to receive the resultant carrier and both sets of side bands, means to produce from the resultant carrier secondary carriers of the same frequency but displaced in phase from the resultant carrier, means to separately beat the resultant carrier and sets of side bands with each of the secondary carriers, and separate receivers for each audio-signal resulting from such detection.

4. In a system for the binaural transmission of signals, the combination with a transmitting station having means to separately modulate carrier oscillations by the signal variations resulting from the same sound, the carrier oscillations being of the same frequency but differing in phase by 90°, of a receiving station having means to receive the resultant carrier and both sets of side bands, means to produce from the resultant carrier secondary carriers of the same frequency but displaced in phase from the resultant carrier and from each other, means to amplify the said secondary carrier, means to separately beat the resultant carrier and side bands with each of the secondary carriers as amplified, and separate receivers for each audio-signal resulting from such detection.

5. In a system for the binaural transmission of signals, the method which consists in the modulation of a carrier by electrical variations resulting from sound waves, and separately modulating by another set of electrical variations resulting from the same sound waves carrier oscillations of the same frequency as employed in the first mentioned modulation operation but differing in phase by 90° therefrom, and transmitting both sets of side bands and the resultant of both carriers.

6. In a system for the binaural transmission of signals, the method which consists in the modulation of a carrier by electrical variations resulting from sound waves, separately modulating by another set of electrical variations resulting from the same sound waves oscillations of the same frequency as employed in the first mentioned modulation operation but differing in phase by 90° therefrom, selecting at a receiving station a portion of the said carrier, changing the phase of a portion of the selected carrier, and combining it in a detector with the received side bands and the resultant carrier, simultaneously changing the phase and impressing the remainder of the selected carrier on a second detector together with the side bands and the resultant carrier, and receiving the resultant audio frequency signals from both detecting operations.

7. In a system for the binaural transmission of signals, the combination with a transmitting station having means to produce two sets of side bands, based upon carriers of the same frequency and differing in phase by 90° of a receiving system having means to produce carriers from the transmitted carrier, the said produced carriers being in phase with the mean of each set of side bands.

In testimony whereof, I have signed my name to this specification this 30th day of December, 1925.

RALPH K. POTTER.