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ELECTRIC WAVE TRANSMISSION SYSTEM

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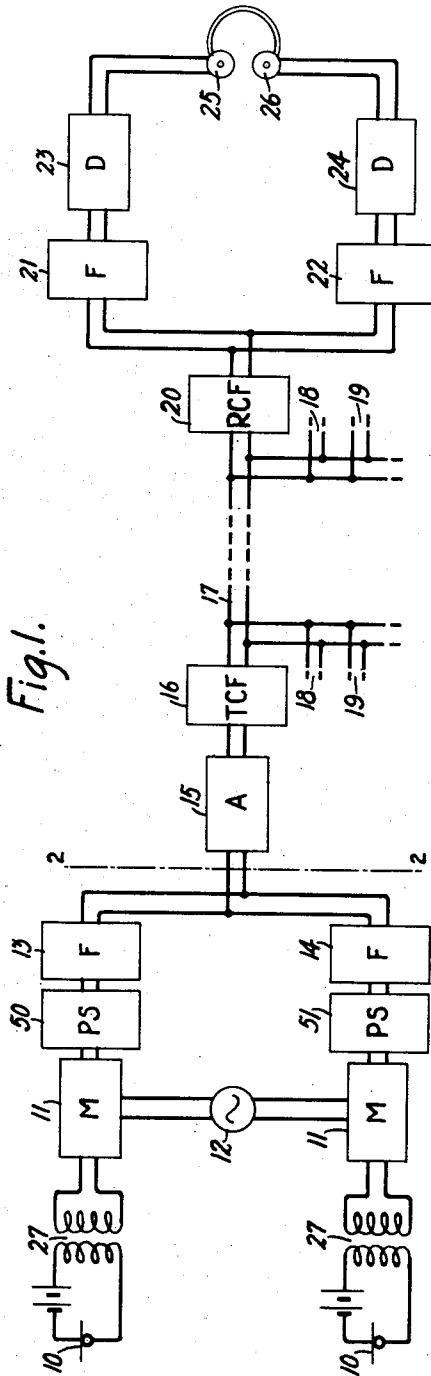


Fig. 1.

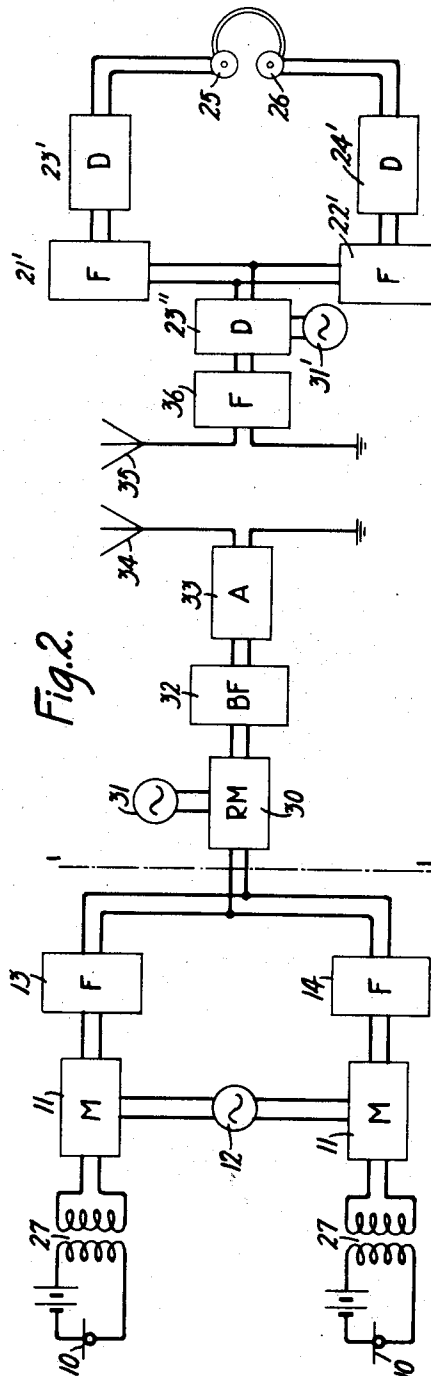


Fig. 2.

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UNITED STATES PATENT OFFICE.

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ELECTRIC-WAVE TRANSMISSION SYSTEM.

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This invention relates to electric wave transmission systems, and more particularly to systems for transmitting binaural effects.

It is well known that a listener determines the location of sound at least in part by virtue of the difference in intensity and the difference in phase of the sounds reaching his two ears.

From this discovery it was also found that by providing, at a pick-up point, speech transmitters separated a distance approximately equal to the distance between the ears of a human being and by connecting the transmitters to separate telephone receivers, binaural or location effects could be transmitted to a distance.

It has further been disclosed that binaural effects may be transmitted by radio by supplying the waves from the separate pick-up transmitters to two individual radio transmitters operating on different carrier frequencies, or wave lengths, with separate radio receivers.

The present invention constitutes an improvement over prior known systems and has for an object the transmission of binaural or location effects by means of a single carrier frequency wave or channel.

Another object is to transmit binaural effects over a multiplex signaling circuit by means of a single carrier frequency wave.

A further object is to transmit binaural effects by means of separate side-bands of a common carrier frequency wave.

A feature of the invention is a multiplex carrier current system for transmitting binaural effects over wires by means of a single carrier frequency wave.

Another feature is a system operating on the successive modulation principle for transmitting binaural effects by radio on a single wave length or carrier frequency wave.

This invention provides novel means for utilizing electric waves for the transmission of binaural or location effects. The means provided is adapted to permit waves from separate pick-up transmitters, spaced apart a suitable distance, for example, having a separation about equal to that of the human ears, to separately modulate the same carrier frequency wave. Suitable filters are

adapted to effect a selection of one side-band from one wave modulation and the opposite side-band from the other wave modulation, which side-bands may be transmitted together with an unmodulated carrier frequency component, over a wire line. At the receiving end, other filters are adapted to separate the side-bands into two receiving channels including associated detectors and telephone receivers for reproducing the sounds impressed upon the pick-up transmitters.

If a listener applies the telephones to his ears a true impression of the location of the original sounds is received, because the sounds received in his two ears have substantially the same difference in intensity and phase as the original sounds at the two pick-up transmitters.

In another application of the invention, adapted for radio transmission of binaural effects, the side-bands selected from the first modulations may be caused to modulate a radio frequency carrier wave. Means is provided to select the opposite side-bands respectively of each of the second modulations and also an unmodulated component, having the proper frequency to enable detection of the side-bands. The selected waves may if desired be amplified and supplied to an antenna.

A receiving station including a selective network and radio frequency detector, two separate receiving channels each comprising individual filters, detectors, and receiving devices, is adapted to receive the transmitted waves and to derive therefrom separate sound waves conveying the binaural effect.

The invention is illustrated in the attached drawings wherein:

Fig. 1 shows a wire binaural transmission system.

Fig. 2 shows a binaural radio transmitting system.

Like reference characters have been used throughout the figures of the drawings to indicate like parts.

The system of Fig. 1 includes the separate pick-up transmitters adapted to supply currents corresponding to sound waves to the modulators 11 which are supplied from a common source with a carrier wave of

frequency suitable for transmission over a wire line. The modulators 11 may be of any well-known type preferably employing space discharge tubes, such, for example, as is described in Patent 1,350,752 to Van Der Bijl, August 24, 1920. The source 12 is preferably a space discharge oscillator of any well-known form. The modulating devices 11 have their output terminals connected to respective filters 13 and 14. These filters may be of any well-known type designed to pass waves included within a desired band and to exclude waves outside this band. Filters of this type are described in Patent 1,227,113 to Campbell, May 22, 1917. More specifically, filter 13 is preferably designed to pass the upper side-band component of the modulated wave produced by the associated modulator 11 and filter 14 is preferably designed to pass the lower side band component of the modulated wave produced by the modulator associated with it. Each filter may also pass a wave component of the carrier frequency. All other waves are preferably excluded by these filters.

The filters 13 and 14 both have their output terminals connected to the input terminals of an amplifier 15, which may be of any well-known type but preferably employing space discharge tubes. An amplifier of this type is disclosed in Arnold Patent 1,448,550, March 13, 1923. Another band-pass filter 16 is connected between the output terminals of amplifier 15 and a wire line 17.

Any number of other signal channels such as 18 and 19 may also be connected to the wire line 17 at the points indicated.

The filter 16 is of the well known band-pass type and is preferably designed to transmit the side-band components and the unmodulated component of carrier frequency selected by filters 13 and 14, which components constitute the frequencies assigned to the binaural channel, and to exclude any waves having frequencies corresponding to the frequencies assigned to the channels 18 and 19.

The wire line 17 is connected at its receiving end to a second channel filter 20, adapted to pass waves assigned to the binaural channel and to exclude waves assigned to the channels 18 and 19. The output terminals of filter 20 are connected to separate branches of the receiving circuit, which branches include separate filters 21 and 22, separate detectors 23 and 24, and separate telephone receivers 25 and 26.

The filters 21 and 22 are adapted to select the respective side-bands of the binaural channel and to supply these side-bands to the respective detectors 23 and 24. The filters 21 and 22 may be identical with the filters 13 and 14, respectively. The detectors 23 and 24 may be of any desired type such

as crystal detectors or space discharge tube detectors adapted to derive signals from the respective side-bands.

The system shown in Fig. 1 may be extended to any desired degree to transmit binaural signals to a plurality of receiving stations. Other receivers may be connected, for example, to the output of detectors 23 and 24 or other receiving circuits including suitable detectors or detectors and filters may be connected respectively to the output terminals of filters 21 and 22 or filter 20. Channels 18 and 19 may be used to transmit binaural signals, telephone or telegraph messages.

When the system of Fig. 1 is in operation, the transmitters 10 are separated by a distance suitable to the production of binaural effects. In the simplest case this distance will be approximately equal to the separation between the ears of a human being. The sounds supplied to these transmitters, from any source, accordingly have substantially the same differences in intensity and phase as when supplied to the ears of a listener located at the same point. The waves from transmitters 10 are supplied through respective transformers 27 to the input circuits of the modulators 11. The modulating devices 11 cause the carrier wave from the source 12 to be modulated in accordance with the waves from transmitters 10 and cause the modulated waves to be transmitted to the filters 13 and 14 respectively. As already stated, filter 13 transmits the upper side-band and attenuates the lower side-band, whereas filter 14 transmits the lower side-band and attenuates the upper side-band. Both filters transmit the carrier frequency waves. Consequently, the upper side-band of one modulation and the lower side-band of the other modulation, with an unmodulated carrier component, after being amplified by the amplifier 15, are transmitted through the filter 16 to the line 17 to constitute a carrier wave adapted to produce binaural effects at the receiving station.

The binaural carrier wave may be transmitted over the line 17 simultaneously with other signals, consisting of carrier modulated waves or unmodulated waves, transmitted over the separate channels 18 and 19. In order to separate the two side-bands from waves corresponding to the other channels, the filter 20 is provided. This filter transmits the side-bands of the binaural channel and attenuates the waves assigned to other channels. In the branch receiving circuits, filter 21 selects the upper side-band, whereas filter 22 selects the lower side-band of waves transmitted by filter 20. These side-bands which are each accompanied by a certain amount of the unmodulated carrier frequency component are detected in the

devices 23 and 24, respectively, and yield sound waves having the characteristic difference in intensity and phase of the original sounds at the transmitters 10 provided the total phase shift in each transmitting branch and each receiving branch is identical. If necessary or desirable, phase shifting devices 50 and 51 may be inserted in the respective transmitting branches to bring about the required phase displacement. One of these phase shifters may however, be omitted, again either or both may be included in one or both of the branches between the detectors 23 and 24 and the receivers 25 and 26. Furthermore, they may be introduced at any other point in the circuits, for example, they may be associated with the filters 13, 14 or 21 and 22.

Phase shifting circuits being well known, it is believed unnecessary to describe them in detail since any suitable arrangement for this purpose may be used.

A listener by applying the telephone receiver 25 to one ear and the telephone receiver 26 to the opposite ear, will receive an impression of the location of the source of sound waves relatively to the transmitters 10.

In Fig. 2 a system for binaural broadcasting by radio is illustrated. The portion of this system to the left of the dotted line 1—1 is like the corresponding portion of Fig. 1 on the left of the dotted line 2—2 with the omission of phase shifters 50 and 51 and accordingly will not be again described in detail.

The output terminals of filters 13 and 14 in Fig. 2 are both connected to the input terminals of a high frequency modulator 30, which may be of any well known type, preferably using space discharge tubes. A modulator of this type, which may be used, is disclosed in U. S. Patent 1,448,216 issued March 13, 1923 to Heising. A source 31 of oscillations having a frequency suitable for radio transmission is also connected to the input circuit of modulator 30 in which the high frequency wave is combined with and modulated in accordance with the selected side-band. A band filter or selective network 32 of any well known type is connected to the output terminals of modulator 30 and is adapted to select one side band, for example, the lower side-band of the modulated wave produced by the modulator 30 and also to select an unmodulated component having a frequency represented by the sum or difference of the carrier oscillations supplied by sources 12 and 31. The filter 32 is designed to attenuate waves above or below the range including the selected side-band and carrier component. The selected waves transmitted by filter 32 are supplied to the amplifier 33 which may be a power amplifier employing space discharge tubes

and arranged in any one of many well known manners. The output circuit of amplifier 33 is coupled to an antenna 34.

A radio receiving circuit including an antenna 35 is adapted to cooperate with the transmitting circuit just described, for the reception of the radiated waves. This circuit includes a band-pass filter or selective network 36 adapted to select the waves transmitted from antenna 34 and to exclude waves of different frequency which may be received by the antenna 35 from any other source. The waves selected by filter 36 are transmitted to a radio frequency detector 23'' the output terminals of which are connected to separate receiving branches including filters 21' and 22', detectors 23' and 24' and telephone receivers 25 and 26. A source of oscillations, for enabling detection of the received waves is connected to the detector. This source preferably supplies waves of the same frequency as source 31. The filters 21' and 22' may be in general like the filters 21 and 22, respectively, of Fig. 1 and designed to transmit the respective upper and lower side-bands derived from the radio frequency waves by detector 23''. The detectors 23' and 24' may be in general, like the detectors 23 and 24.

In the operation of the circuit of Fig. 2, the transmitters 10 are supplied with sound waves having frequencies, for example, included within the range from 0-5 kilocycles. The carrier wave source 12 may be designed to supply oscillations of 60 kilocycles. The filter 13 may transmit waves within the band of substantially 60 to 65 kilocycles, whereas filter 14 may transmit waves within the band of 55 to 60 kilocycles. The high frequency carrier source 31 may supply oscillations of 1000 kilocycles and the band filter 32 may be designed to transmit a band of waves from 935 to 945 kilocycles.

This latter range of frequencies includes the lower side-band transmitted from the modulator 30 and also the frequency of an unmodulated component represented by the difference in frequency of the two carrier sources 12 and 31.

The side-band and unmodulated carrier waves received by antenna 35 are supplied to detector 23''. From the combination of waves from the source 31' with the side-band waves, there are produced waves constituting side-bands of 55 to 60 kilocycles and 60 to 65 kilocycles, and from the combination of waves from the source 31' with the unmodulated component of carrier frequency, there is produced a carrier component of 60 kilocycles. The filters 21' and 22' select these respective side-bands together with a certain amount of the unmodulated component of 60 kilocycles and supply these waves to detectors 23' and 24' respectively from which are derived the re-

spective signal waves for actuating the receiving devices 25 and 26.

An advantage of the invention herein described is that by transmitting signals as modulations of a single carrier frequency wave, as distinguished from prior arrangements wherein a plurality of channels employing different carrier frequency waves are required, the number of channels in a given system within a given frequency band may be materially increased, the system may be greatly simplified, and the cost of construction and operation materially reduced.

The arrangement described also possesses the advantage that the frequency range required for binaural transmission is substantially the same as that used for broadcasting, namely 10 kilocycles. Moreover, ordinary signals can be reproduced from the transmitted waves by using an ordinary heterodyne radio receiver. The signal waves with binaural effects can be produced from the same transmitted waves by merely remodeling the receiver to provide separate circuits for selecting and detecting the intermediate frequency waves.

What is claimed is:

1. In a multiplex system adapted to transmit binaural effects, two pick-up transmitters, two receiving devices, a line extending between said transmitters and said devices and adapted to transmit waves assigned to a plurality of signal channels, means for causing the reproduction of sounds at said separate receivers having the characteristics of the sounds impressed upon said separate transmitters, comprising a source for a carrier wave, means for separately modulating said carrier wave by audio frequency waves from both of said transmitters and means comprising a filter for exclusively transmitting said carrier wave and the two side bands to the line.

2. In a multiplex system, a transmission line adapted to transmit waves assigned to a plurality of signal channels, a binaural pick-up system including separate transmitters of audio frequency waves, means to exclusively transmit to the transmission line a carrier wave having the side bands thereof respectively modulated by waves from said transmitters, a binaural receiving system including separate receiving devices connected to said line, and filters for separating waves assigned to the binaural channel from waves assigned to other channels.

3. In a binaural transmission system, means for producing two electric waves within the same frequency range having the characteristics of sound waves at two points in space, means for producing two side bands corresponding to a single carrier frequency wave modulated by both said first mentioned

waves, a wire line for transmitting said side bands to a receiver, a filter at the receiving end of said line for separating the waves assigned to the binaural channel from waves assigned to other channels, said receiver comprising means for separately deriving, from said side bands, signal waves having the characteristics of the original sound waves.

4. In a multiplex transmission system, a binaural transmitting station having means for producing two electric waves within the same frequency range, means for separately modulating a single carrier wave with said two electric waves, a binaural receiving station, a line, means comprising a channel filter for exclusively transmitting to the line between said stations, said carrier wave of single frequency and two side bands derived therefrom, whereby binaural effects may be produced at said receiving station.

5. In a multiplex system for transmitting binaural sound effects, two paths transmitting waves within the audio-frequency range, a common line connected to said paths, two receiving paths also connected to said line, means for separately modulating a single carrier wave in accordance with the audio frequency waves in the two transmitting paths, and means for exclusively transmitting to said receiving paths said carrier wave separately modulated in accordance with the waves transmitted over said two transmitting paths.

6. In a multiplex system the method of binaural signaling which comprises, deriving two waves from a source of sound, separately modulating a carrier wave by said two waves to produce two modulated waves, separately selecting opposite side bands of said modulated waves, transmitting said selected side bands over a wire line and filtering said waves from waves assigned to other channels.

7. In a multiplex system for binaural transmission and reception, the method which comprises producing a single carrier wave, separately modulating said carrier wave with two separate signal audio frequency waves representing sounds having binaural characteristics, impressing said modulated carrier wave and waves of other frequencies in a common restricted path, selectively receiving said modulated wave and deriving therefrom said separate signal waves to reproduce sounds having binaural characteristics.

8. In an electric wave transmission system, a sound source, a plurality of sources of signal waves spaced different distances from said sound source, means for separately modulating a carrier wave by signal waves from said sources to produce two modulated waves, means for changing the phase relation of the modulated waves, means for selecting opposite side-band components of the

modulated waves, and means for transmitting said side band components to a receiving device.

5 9. In a multiplex binaural transmission system, means for producing two sets of electric waves within the same frequency range and having the characteristics of sound waves at two points in space, means for producing two side-bands corresponding to a

single carrier frequency wave, respectively 10 modulated by said first mentioned sets of waves, a transmission line, and a band pass filter for exclusively transmitting each of said side-bands and the unmodulated carrier wave to the transmission line. 15

In witness whereof, I hereunto subscribe my name this 6th day of October, A. D. 1925.

FRANCIS X. RETTENMEYER.