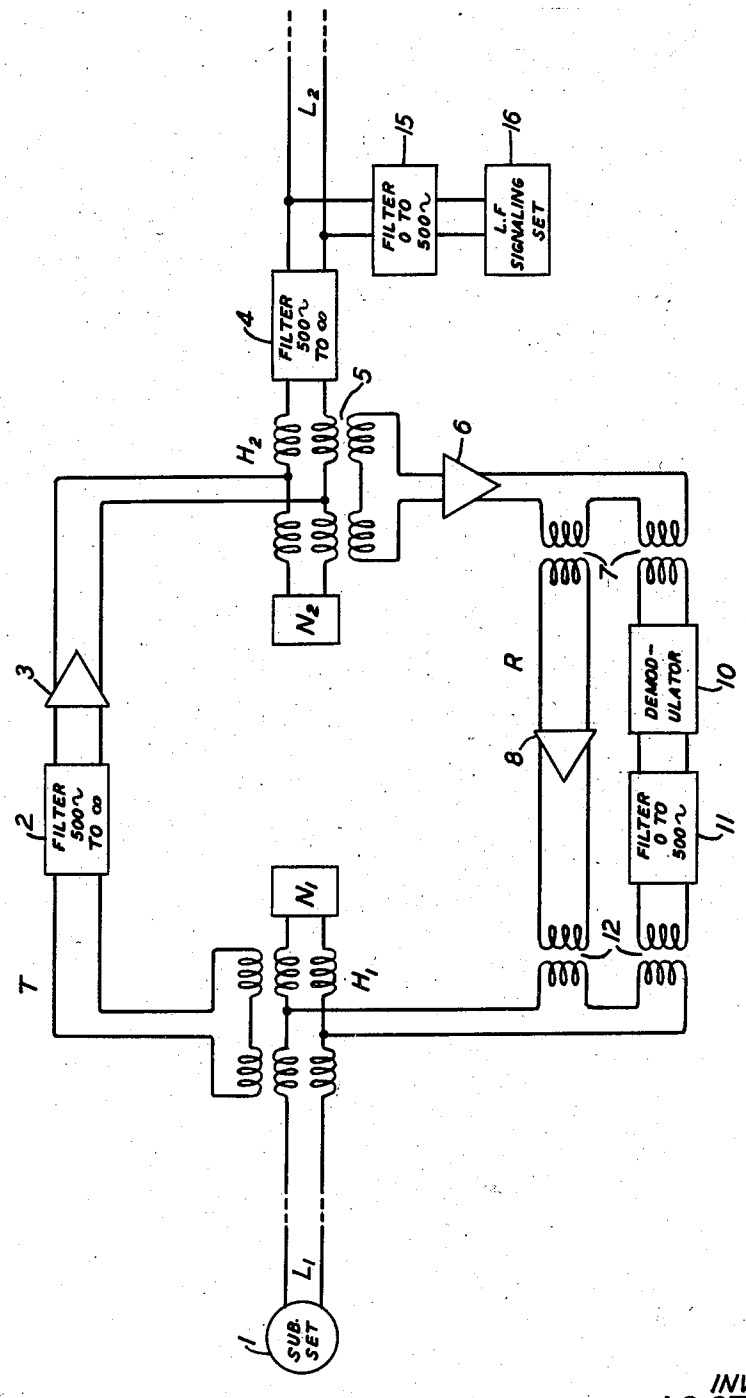
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METHOD AND SYSTEM OF SPEECH TRANSMISSION

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METHOD AND SYSTEM OF SPEECH TRANSMISSION

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The present invention relates to the transmission of speech or similar waves, and permits the use of a narrowed frequency band for transmission purposes, with the same degree of understandability and naturalness in the received speech.

Articulation tests show that all frequencies below 400 or 500 cycles can be eliminated from speech with practically negligible loss in articulation or understandability compared with the loss caused by elimination of an equal range from near the upper edge of the band usually employed in commercial telephone transmission which may be around 2800 cycles or less. It is usual to transmit frequencies down to 250 cycles, however, on account of the importance of these low frequencies in imparting naturalness to the received speech. The importance of these lower frequencies seems to be due to the fact that the fundamental or vocal cord frequency in the case of a woman's voice and the first harmonic in the case of a man's voice lies in this region.

It is an object of the present invention to permit use of a narrower range in transmission of speech while restoring the naturalness of the received speech by restoring the frequencies not actually transmitted.

A further object of the invention is to raise the efficiency of a speech transmission line or channel by providing signal channels employing some of the frequency range heretofore used for speech, while at the same time maintaining the articulation and naturalness of the speech transmitted over such line or channel.

According to the invention the low frequencies are eliminated before transmission and are restored at a receiving point by deriving them from the higher frequency components of the speech. The frequency range thus saved on the line can be used for telegraph or other forms of low frequency signaling or other transmission.

An illustrative example of how the invention may be practiced is given in the accompanying drawing, the single figure of which shows a two-way terminal of a composited telephone line or channel embodying one form of the invention.

In the drawing provision is made for repeating, in accordance with the invention, between the subscriber's line L_1 and the main or toll line L_2. Speech received over the line L_1 from the subscriber's set 1 is repeated through the branch T into line L_2. Speech passing in the opposite direction is transmitted through the receiving branch R. The line L_2 may be a toll telephone line, a submarine telephone cable or a line in which it is desirable to make efficient use of the frequency range by providing additional terminal apparatus.

Line L_1 is balanced by the usual network N_1 and includes hybrid coil H_1. A balancing network N_2 and hybrid coil H_2 are provided for line L_2.

The transmitting branch T includes a high-pass filter 2 which permits the transmission of all frequency components in excess of some lower limiting frequency, for example 500 cycles, but prevents transmission of frequencies below such limit. This filter in practice may be a multi-section electrical wave filter of a type well known in the art. An amplifier 3 is also shown in this branch. The filter 4 in the line L_2 may be in all respects identical with filter 2.

Receiving branch R is divided into two parallel paths one of which includes merely an amplifier 8 where necessary and the other of which includes a demodulator device 10 and a filter which is the conjugate of filters 2 and 4, that is, a low-pass filter which suppresses transmission of frequencies in excess of 500 cycles but allows the transmission of frequencies lower than 500 cycles.

The device which has been called demodulator 10 is any suitable element for deriving from higher frequencies of speech a frequency component corresponding to speech frequencies that are eliminated by filter 2. It may be, for example, a vacuum tube detector circuit or in general any transmission element which has a non-linear relation between input and output.

It is known that speech sounds which contain a fundamental or first harmonic of about 250 cycles also contain a number of harmonics or overtones of this same fundamental or basic frequency. Demodulator 10 reproduces this fundamental frequency component by deriving the difference frequency between harmonically related components of the speech waves.

In order to provide for composite signaling on the line L_2 a filter 15 which suppresses the range of frequencies transmitted through filter 4 but allows transmission of lower frequencies serves to connect line L_2 with any suitable low frequency signaling set 16 such as a low frequency carrier telegraph transmitting and receiving channel or the like.

In operation speech waves from the subscriber's set 1 transmitted over line L_1 are transmitted in part into branch T. The lower frequencies of the speech waves are eliminated in high-pass fil-

ter 2 so that only those components of the speech waves in excess of about 500 cycles are allowed to pass through amplifier 3 and into the line L_2, by way of hybrid coil H_2 and filter 4.

It is found that speech waves transmitted in this manner have lost little, if anything, in articulation or understandability, the main effect of eliminating these low frequency components being loss of naturalness or quality. The manner in which these waves are received is seen by considering the receiving side of the station shown in the drawing, which may be identical with the station at the distant end of line L_2.

Waves transmitted in the manner described and received at the station shown pass through filter 4 and in part through transformer 5, amplifier 6, and transformer 7 into the two paths making up the receiving branch proper. The waves constituting the entire received band pass directly through amplifier 8, transformer 12 and out into the line L_1. A portion of the waves of this same frequency range pass into demodulator 10 which serves to derive from certain of the harmonically related components lying within this range, as by producing the beat- or difference-frequency between such components, a component of fundamental frequency of about 250 cycles in the case of a woman's voice or a first harmonic of about this same frequency in the case of a man's voice. If, for example, the received waves at any given instant contain components having frequencies of 1250 cycles and 1500 cycles per second, the demodulator 10 produces from these two frequencies occurring simultaneously a derived component of 250 cycles. This derived component of lower frequency is permitted to pass through low-pass filter 11 while the direct transmission of the frequency band received over the line is prevented from passing through this filter. The wave component of such lower frequency is blended with the speech waves from amplifier 8 in the output transformer 12 so that the speech waves finally impressed on line L_1 contain the low frequency component corresponding to that which was suppressed at the distant station. The subscriber at station 1 hears the received speech with a higher degree of naturalness than as though this low frequency component were absent.

It is evident that the frequencies of the fundamental and overtone in the restored portion will be exactly equal to the frequencies that were eliminated from the original speech which vary from instant to instant during utterance. Also the level of the restored portion will vary in accordance with the level of the incoming speech. By properly choosing the characteristics of the low-pass filter and demodulator 10 and adjusting the gain of one or both channels in the receiving branch R, the level of the restored portion is blended with the level of the incoming speech. Thus the rhythm and timbre of the original speech may be restored to a degree of perfection depending upon the care in choosing the above characteristics. Just what these characteristics should be in any particular case can best be determined by trial.

Simultaneously with and independently of the speech transmission as above described, other kinds of signaling may take place over line L_2 from the terminal apparatus 16 in the manner generally indicated.

It is within the invention to transmit the narrowed speech band otherwise than directly over a line; for example, over a radio or carrier channel. It is also within the invention to modulate the band 500 to 2800 cycles down to a lower position in the frequency spectrum, such as 100 to 2400 cycles and to transmit it at such lowered frequencies. This may be advantageous where the attenuation is excessively high at the upper edge of the band. The band is then raised in frequency at the receiver.

What is claimed is:

1. The method of increasing naturalness in received speech comprising deriving low frequency components from the higher frequency components of speech waves and blending the derived low frequency components with the speech waves.

2. The method of speech transmission comprising suppressing the lower frequencies of speech from transmission and restoring the effect of these suppressed components at a receiving point by deriving similar components from the frequencies actually transmitted.

3. The method of speech transmission comprising transmitting a band representing speech frequencies extending from 400 or 500 cycles upwards, deriving from this range components having frequencies in the region of 250 cycles and adding the derived components at a receiving point to the waves that are transmitted.

4. In a telephone system, a line, a speech transmitting circuit and a speech receiving circuit connected thereto, means in the speech transmitting circuit to eliminate from the speech waves before they reach the line, the lower frequency components, and means in the receiving circuit for deriving from and adding to the received speech waves, components having the frequencies of those eliminated in the transmitting circuit.

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