April 8, 1969 R. W. STEELE 3,437,761
SPEECH APPARATUS WHICH PRODUCES A TIME-MULTIPLEX SIGNAL HAVING AN INTERLACE PATTERN
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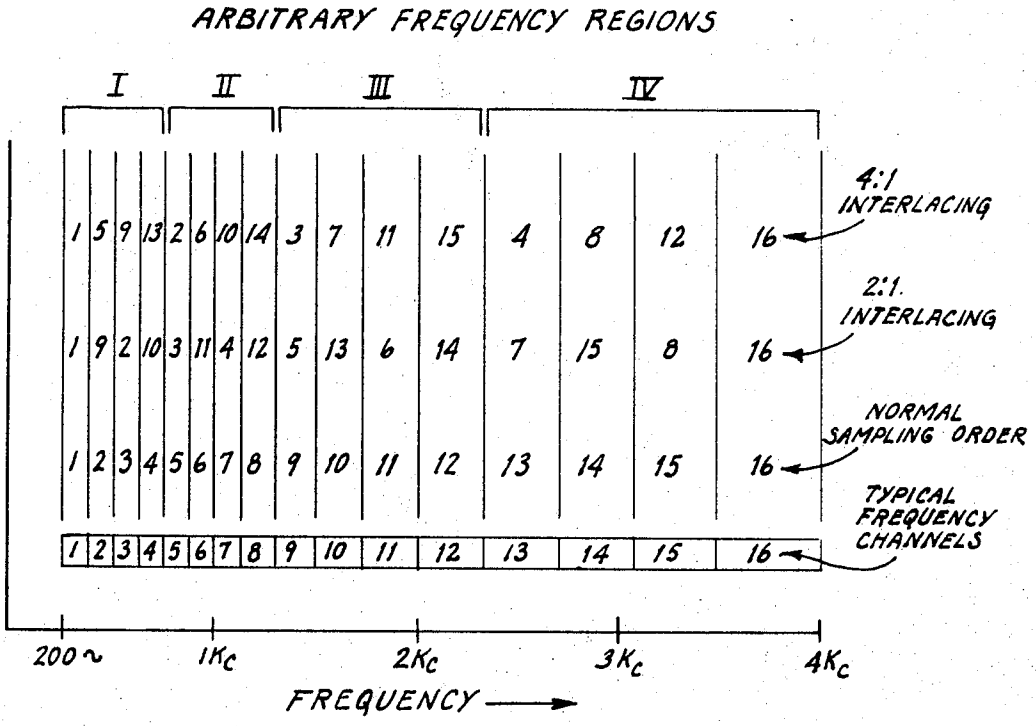


FIG. 1.

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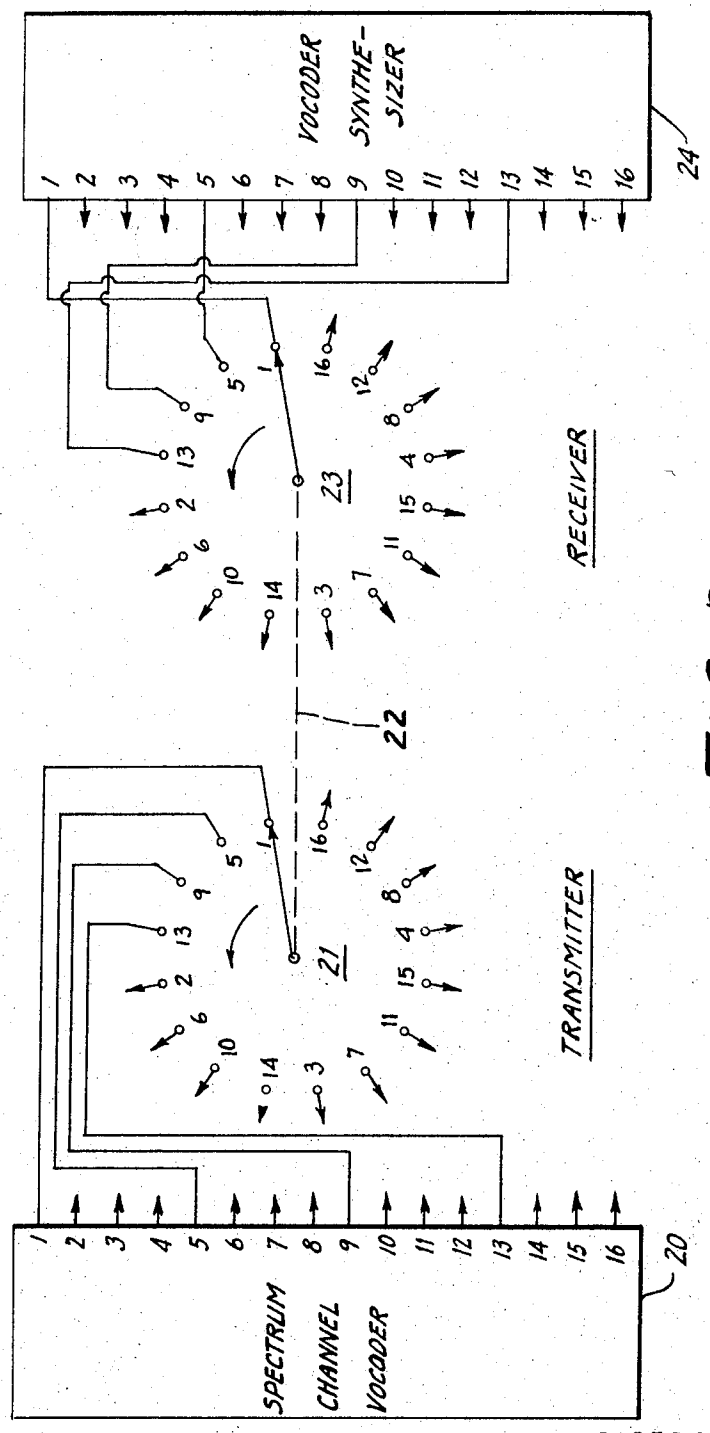


FIG. 2.

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SPEECH APPARATUS WHICH PRODUCES A TIME-MULTIPLEX SIGNAL HAVING AN INTERLACE PATTERN

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ABSTRACT OF THE DISCLOSURE

Time-multiplex speech transmission method and apparatus in which the frequency spectrum of a speech signal is divided into a plurality of frequency bands each having a plurality of frequency channels and in which the channels are sampled in an interlace pattern.

In the well-known channel vocoder system, the spectrum-channel vocoder produces the "channel signals" which are time multiplexed into a single signal for transmission. At the receiver the individual signals are recovered by inverse sampling and are supplied to a synthesizer. For a concise description of this well known system, reference may be had to pages 927 and 928 of the book entitled The Encyclopedia of Electronics published in 1962 by Reinhold Publishing Corporation of New York.

The principal object of the present invention is to improve the time multiplex transmission of speech in such a system.

A more specific object of the invention is to effect more rapid transmission of useful signal information.

This invention is based on the recognition that certain speech sounds are perceptible from spaced samples of the speech frequency spectrum. In accordance with this invention, in a time-multiplex system as briefly described above, the channels at the transmitter are sampled in an "interlace" pattern and the transmitted signal is correspondingly sampled at the receiver. This involves rapid sampling of spaced portions of the speech spectrum, and it improves the perception of sounds such as the stop consonants.

Since the time-multiplex speech transmission system is well known, and since the present invention is concerned only with the order in which channels are sampled, it is unnecessary to illustrate or describe in detail the complete system. Reference may be had to the aforementioned book for details of the system. The invention may be clearly understood from the following description with reference to the accompanying drawings in which

FIG. 1 is a chart showing examples of interlace sampling according to the present invention in contrast to the normal sampling; and

FIG. 2 is a diagrammatic illustration of a system employing the interlace feature of this invention.

Referring first to FIG. 1 of the drawings, the speech frequency spectrum is represented as extending from 200 cycles to 4 kilocycles. By way of example, as shown at the bottom of the figure, the spectrum is divided into contiguous channels numbered **1** to **16** as determined by the bandpass filters of the channel vocoder. As indicated at the top of the figure, the spectrum may also be divided into four frequency regions or bands designated I to IV, each of which includes four of the sixteen channels.

As indicated, in the normal sampling the sixteen channels are sampled in the consecutive order **1**, **2**, **3**, **4**, etc. If the frame rate (i.e. the rate of successive complete samplings) is one frame each 25 milliseconds, then each of the four frequency regions I to IV will have some representation each 25 milliseconds.

In accordance with the present invention, the sampling is performed in an interlace pattern. FIG. 1 shows two examples, i.e. four-to-one interlacing and two-to-one interlacing. It will be seen that interlace sampling involves sampling of channels in successive different series each comprising non-consecutive channels and each including channels of different ones of the frequency bands I to IV. Thus four-to-one interlace sampling involves sampling a first series of channels **1**, **5**, **9** and **13**, then a second series **2**, **6**, **10** and **14**, then a third series **3**, **7**, **11** and **15**, and finally a fourth series **4**, **8**, **12** and **16**. Similarly two-to-one interlace sampling of the sixteen channels involves two successive series each comprising non-consecutive channels.

With four-to-one interlace sampling, each of the four frequency regions I to IV has some representation in one-fourth the time that it does with normal sampling. Thus with a frame rate of one frame each 25 milliseconds, each of the four frequency regions has some representation each 6.25 milliseconds. With two-to-one interlace sampling, each of the four frequency regions has some representation each 12.5 milliseconds.

Referring now to FIG. 2, block **20** represents a conventional spectrum-channel vocoder having sixteen consecutively numbered output channels corresponding to the sixteen channels of FIG. 1. A conventional sampling arrangement is represented at **21**, and while the representation is in the form of a rotary distributor, in practice the sampling arrangement is electronic as well understood in the art.

In accordance with this invention the connections between the sixteen channels and the sampler are such as to provide interlace sampling. In the specific illustration, the connections are such as to give four-to-one interlace sampling as shown in FIG. 1. For the sake of clarity, only the four connections for sampling the first series **1**, **5**, **9** and **13** are shown complete, but it will be understood that each of the numbered channels is connected to the correspondingly numbered contact of the sampler.

The broken line **22** represents a transmission line or other medium of transmission of the time-multiplex signal to the receiver at which there is a conventional inverse sampler **23** which in practice is of electronic form. As well understood, the inverse sampler **23** operates in synchronism with the sampler **21**. Block **24** represents a conventional vocoder synthesizer which has sixteen consecutively numbered input channels corresponiding to those at the transmitter.

In accordance with this invention, the connections between sampler **23** and the vocoder synthesizer **24** correspond to those at the transmitter for four-to-one interlace sampling. Again for the sake of clarity, only the connections for the first series **1**, **5**, **9** and **13** are shown complete, it being understood that each of the numbered contacts of the sampler **23** is connected to the correspondingly numbered input channel of the vocoder synthesizer.

While the arrangement illustrated in FIG. 2 is for four-to-one interlace sampling, it will be understood that interlacing of any other practical ratio, such as two-to-one may be employed.

I claim:

1. In a speech transmission system wherein a speech signal is translated into a plurality of electrical signals which are supplied to a plurality of consecutive channels substantially coextensive with the speech frequency spectrum, a method of transmission which comprises dividing said spectrum into a plurality of frequency bands each containing the same number of said channels, sampling said channels separately in successive different series each comprising non-consecutive channels and each including channels of different ones of said bands, thereby to produce a time-multiplex signal containing samples of said

electrical signals in an interlace pattern, and transmitting said time-multiplex signal.

2. In a speech transmission system wherein a speech signal is translated into a plurality of electrical signals which are supplied to a plurality of consecutive channels substantially coextensive with the speech frequency spectrum, a method of transmission which comprises dividing said spectrum into a plurality of frequency bands each containing the same number of said channels, sampling said channels separately in successive different series each comprising non-consecutive channels and each including a channel of each of said bands, thereby to produce a time-multiplex signal containing samples of said electrical signals in an interlace pattern, and transmitting said time-multiplex signal.

3. Apparatus for transmission of speech, comprising a spectrum-channel vocoder having a plurality of consecutive output channels at which electrical signals appear, adjacent ones of said channels being adapted selectively to transmit contiguous portions of the speech frequency spectrum, means for sampling said channels separately in successive different series each comprising non-consecutive channels, thereby to produce a time-multiplex signal containing samples of said signals in an interlace pattern, and means for transmitting said time-multiplex signal.

4. Apparatus for transmission of speech, comprising a spectrum-channel vocoder having a plurality of consecutive output channels at which electrical signals appear, adjacent ones of said channels being adapted selectively to transmit contiguous portions of the speech frequency spectrum, means for sampling said channels separately in successive different series each comprising non-consecutive channels and each including channels of different frequency bands or regions of said spectrum, thereby to produce a time-multiplex signal containing samples of said signals in an interlace pattern, and means for transmitting said time-multiplex signal.

5. In a speech transmission system, a spectrum-channel vocoder having a plurality of consecutive output channels at which electrical signals appear, adjacent ones of said channels being adapted selectively to transmit contiguous portions of the speech frequency spectrum, means for sampling said channels separately in successive different series each comprising nonconsecutive channels, thereby to produce a time-multiplex signal containing samples of said signals in an interlace pattern, means for transmitting said time-multiplex signal to a receiver, a vocoder synthesizer at the receiver having a plurality of input channels corresponding to the first-mentioned channels, and means at the receiver for deriving said signals and for supplying them to the proper ones of said input channels.

6. In a speech transmission system, a spectrum-channel vocoder having a plurality of consecutive output channels at which electrical signals appear, adjacent ones of said channels being adapted selectively to transmit contiguous portions of the speech frequency spectrum, means for sampling said channels separately in successive different series each comprising non-consecutive channels and each including channels of different frequency bands or regions of said spectrum, thereby to produce a time-multiplex signal containing samples of said signals in an interlace pattern, means for transmitting said time-multiplex signal to a receiver, a vocoder synthesizer at the receiver having a plurality of input channels corresponding to the first-mentioned channels, and means at the receiver for deriving said signals and for supplying them to the proper ones of said input channels.

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