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CARRIER-WAVE TELEPHONY TRANSMITTERS FOR THE TRANSMISSION OF SINGLE-SIDEBAND SPEECH SIGNALS

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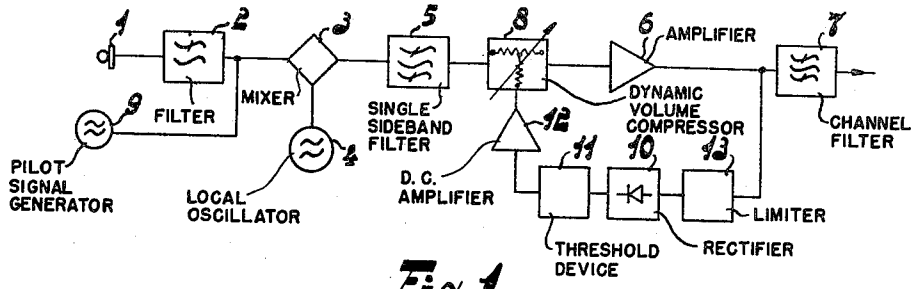

Fig. 1

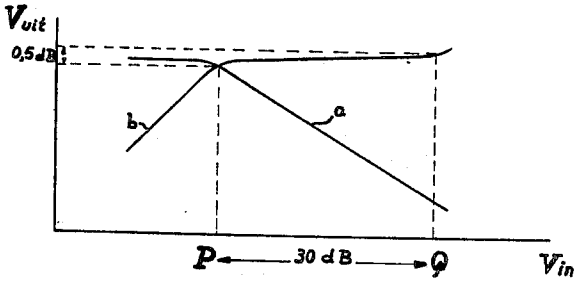

Fig. 2

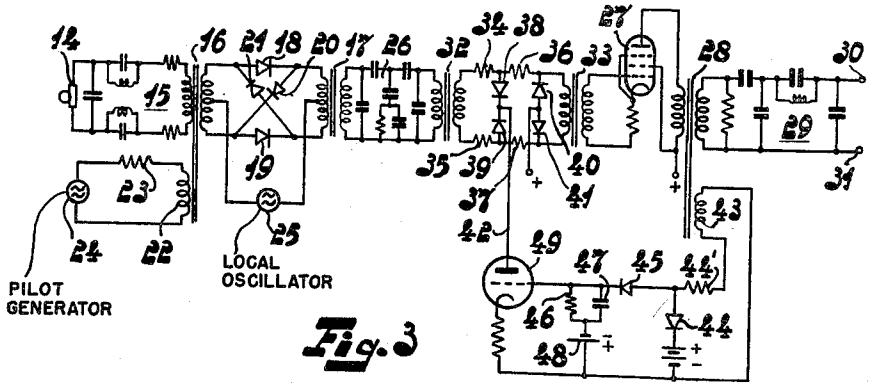

Fig. 3

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CARRIER-WAVE TELEPHONY TRANSMITTERS FOR THE TRANSMISSION OF SINGLE-SIDE-BAND SPEECH SIGNALS

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The invention relates to a carrier wave telephony transmitter for the transmission of single-sideband speech signals in which each speech channel is provided with a dynamic control circuit in order to produce volume compression.

It is an object of the invention to provide a particularly advantageous carrier wave telephony transmitter of the kind described in the preamble, by means of which inter alia a high quality signal transmission can be realized in practice.

According to the invention, in each speech channel the single-sideband signal to be transmitted is supplied together with a pilot signal having a frequency adjacent the signal frequency band and supplied by a pilot generator to the dynamic control circuit which is controlled by a compression voltage derived from a compression voltage rectifier which is fed by the single-sideband speech signal and the pilot signal.

In order to obtain quiet control it has proved of advantage for the single-sideband speech signal and the pilot signal to be supplied to the compression voltage rectifier via a limiter.

In order that the invention may be readily put into practice, one embodiment thereof will now be described in detail with reference to the accompanying drawing, in which:

FIG. 1 is a block diagram of a speech channel of a carrier wave telephony transmitter in accordance with the invention;

FIG. 2 shows a control characteristic of the compression circuit arrangement used, whilst

FIG. 3 is a diagram in greater detail of the speech channel shown in FIG. 1.

The speech channel shown in FIG. 1 must transmit speech signals which are situated, for example, in the speech band of from 0.3 kc./s. to 3.2 kc./s. For the speech channel concerned a band width of 4 kc./s. is reserved.

In this circuit arrangement the speech signals supplied by a microphone **1** are supplied via a filter **2** having a pass band of from 0.3 kc./s. to 3.2 kc./s., which filter passes the speech signals, to a single-sideband modulator. This modulator comprises a mixer stage **3** which is connected to a local oscillator **4** of frequency, for example, 30 kc./s. and a single-sideband filter **5** which passes the upper side band of from 30.3 to 33.2 kc./s. This single-sideband signal is supplied after amplification in a channel amplifier **6** through a channel filter **7** for further manipulation to a group modulator which is not shown in the figure.

In order to obtain volume contrast compression a dynamic control circuit **8** is connected between the single-sideband filter **5** and the channel amplifier **6**. This dynamic control circuit comprises an adjustable damping network which is controlled by a compression voltage and is constituted by rectifier cells. To this dynamic control circuit are supplied the single-sideband speech signals of from 30.3 to 33.2 kc./s. and also through the single-sideband modulator **3**, **4**, **5** a pilot signal supplied by a pilot generator **9**, the frequency of which signal is situated adjacent to the frequencies of the signal band. This

level of the pilot signal is arranged to be substantially lower, for example 20 db lower, than the speech signals at the normal speech level, whilst the frequency of the pilot signal is made to be higher than the speech frequency band, and for example is 3.7 kc./s. After frequency conversion in the single-sideband modulator **3**, **4**, **5** the pilot signal has a frequency of 33.7 kc./s. and is supplied to the dynamic control circuit **8**.

In order to generate the compression voltage for the dynamic control circuit **8** the arrangement described contains a compression voltage rectifier **10** which is fed by the output voltage of the channel amplifier **6** and has an adjusting time constant of, say, 3 msec. and a readjusting time constant of 30 msec. By rectification of the single-sideband speech signal, across the output circuit of the rectifier **10** a voltage is produced which varies with the envelope of the single sideband signal, which voltage follows the envelope of the speech signals with a higher degree of accuracy than the envelope signal which would have been obtained by direct rectification of the low frequency speech signals. The output voltage of the rectifier **10** is supplied through a threshold device **11** and a direct current amplifier **12** as the compression voltage to the dynamic control circuit **8** which, due to variation in the damping, provides a compression of the single-sideband speech signal supplied to it.

When, in the arrangement described, the level of the speech signals is increased, this level increase produces a corresponding increase in the output voltage of the compression voltage rectifier **10** which is supplied through the threshold device **11** and the direct current amplifier **12** to the dynamic control circuit **8**. Thus, the damping of the dynamic control circuit **8** is increased, which results in a damping increase counteracting the level increase, whilst conversely a decrease in the level of the speech signals produces a decrease in the damping of the dynamic control circuit **8**. In the dynamic control circuit **8** the pilot signal is subjected to a corresponding variation in damping and consequently by its amplitude characterizes the compression of the single-side-band speech signal supplied to the dynamic control circuit **8**.

In the circuit arrangement shown the output signals of the channel amplifier **6** are supplied to the rectifier **10** via a limiter **13** which must limit any sudden voltage peaks. The level at which limiting sets in is chosen such that with continuous signals corresponding to loud speech no limiting occurs, for example in the embodiment shown the limiting voltage is approximately 1.0 volt higher than the threshold voltage of the threshold device **11**. This limiter ensures quiet control whilst, in addition, distortions produced by these voltage peaks are prevented.

The above explanations are based on the condition of operation in which the speech level exceeds the pilot signal level. When the speech level falls below the pilot level or when no speech signals are produced, the compression voltage is substantially determined by the constant pilot voltage which determines the minimum damping of the dynamic control circuit **8**. Thus, the lower limit of the compression control range is determined by the level of the pilot signal or, in other words, adjustment of the pilot level, for example by means of a voltage divider, permits of adjusting the control range of the compression arrangement at will.

In this compression arrangement reduction of the control range ensures that interference signals, for example room noise, which occur during speech intervals are transmitted with restricted amplification only.

FIG. 2 shows the control characteristic of the described compression arrangement in which in db the pilot level which occurs at the output of the dynamic control circuit and the level of the single-sideband speech signal are plotted as a function of the level of the single-sideband

signal V_{in} which is supplied to the input of the dynamic control circuit. In this control characteristic the pilot level at the input of the dynamic control circuit **8**, which for example is lower by 20 db than the normal speech level, is shown by the point P.

As has been described above, at an input level of the single-sideband speech signal which is less than the input level of the pilot signal, the dynamic control circuit **8** exhibits a constant damping, whilst in addition to damping of the dynamic control circuit **8** increases with the level of the said single-sideband signal. In this event in the control characteristic shown the variation of the pilot level is shown by the line *a*, whilst the line *b* shows the level variation of the single-sideband speech signal. The compression control range is shown in the figure by PQ and comprises approximately 30 db.

In the example shown the compression factor is chosen very high, which is of particular advantage in view of crosstalking between the various channels, since as a result level variations between the signals associated with the various transmitter channels are reduced to a minimum. Thus, for example, in the compression control range PQ of approximately 30 db the level of the single-sideband speech signal which occurs at the output of the dynamic control circuit varies only by 0.5 db. If required, the remaining level variations may be completely avoided by the use of a limiter connected between the dynamic control circuit and the end of the channel.

In spite of the very high compression factor the quality of transmission proves to be excellent and, as has been found experimentally, materially better than the transmission quality with the use of direct compression of the low frequency speech signals. At the receiver end an expansion control dependent upon the amplitude of the pilot which characterizes the level variations of the initial signal permits of recovering the initial speech signal substantially completely. The use of the pilot signal has the additional advantage that even high variations in damping of, for example, from 10 to 20 db in the transmitting channel do not affect the quality of transmission, whilst in addition the rectifier cells of the dynamic control circuit need not satisfy exacting requirements.

It should be noted here that in the compression arrangement shown, the back control may be replaced forward control, for example by connecting the compression voltage rectifier to the output of the single-sideband filter **5**.

FIG. 3 shows in detail the transmitting channel shown in block-schematic form in FIG. 1.

In the arrangement shown in FIG. 3 the speech signals supplied by a microphone **14** are supplied via a filter **15** having a pass-band of from 0.3–3.2 kc./s. to a single-sideband modulator in the form of a ring modulator which comprises an input transformer **16** and an output transformer **17**, rectifier cells **18, 19, 20 21** being provided between the ends of the secondary winding of the input transformer **16** and the primary winding of the output transformer **17**. The input transformer **16** has a second primary winding **22** to which via a series resistor **23** a pilot signal of 3.7 kc./s. supplied by a pilot generator **24** is supplied, whilst a local carrier wave oscillator **25** of 30 kc./s. is connected to the centre taps on the secondary winding of the input transformer **16** and the primary winding of the output transformer **17**. The output signals of the ring modulator are supplied via a single-sideband filter **26** which passes the upper side band of from 30.3–33.2 kc./s. and the converted pilot signal of 33.7 kc./s. and via a dynamic control circuit to a channel amplifier **27** which through an output transformer **28** is connected to a channel filter **29**. Thus, at the output terminals **30, 31** of the channel filter the single-sideband speech signal and the pilot signal are produced.

In the embodiment shown the dynamic control circuit is provided with an input transformer **32** and an output transformer **33**, whilst between the ends of the secondary winding of the input transformer **32** and the primary winding of the output transformer **33** a damping network is connected comprising the cascade connection of two voltage dividers which comprise resistors **34, 35** and **36, 37** respectively and rectifier cells, for example germanium cells **38, 39** and **40, 41** respectively which are connected between said resistors, whilst the compression voltage lead **42** is connected to the junctions of the germanium cells **38, 39** and **40, 41** respectively. The germanium cells **38, 39** and **40, 41** respectively act as variable resistors which for compression control are controlled by the compression voltage.

In order to generate the compression voltage the output transformer **28** has a coil **43** connected to it which through a limiter arrangement comprising a series resistor **44'** and a biassed rectifier cell **44** for limiting sudden voltage surges is connected to a compression voltage rectifier **45** provided with an output impedance comprising a capacitor **47** which is bridged by a resistor **46**, the charge time constant and the discharge time constant (adjustment and readjustment constant respectively) being, for example, 3 and 30 msec. respectively. The output voltage of the rectifier **45** via a direct current amplifier **49**, which by means of a grid voltage battery **48** connected in series with the rectifier output impedance is connected in class C and consequently also acts as a threshold device, is supplied as compression voltage to the dynamic control circuit, which compression voltage, as has been described with reference to FIG. 1, ensures a compression of the single-sideband speech signal in the dynamic control circuit. Thus, the compression control direct voltage supplied to the dynamic control circuit cannot penetrate into the compression control circuit through the channel amplifier which passes only higher frequencies, so that instabilities are prevented.

It should be noted here that it is not absolutely necessary to use expansion control at the receiver end, for the intelligibility and recognizability of voices is very satisfactory without the provision of an expansion control at the receiver end.

What is claimed is:

1. A transmitter comprising a plurality of signal channels, each signal comprising a source of a single-sideband signal lying in a frequency band, a source of a pilot signal having a frequency adjacent to said frequency band, a dynamic compression control circuit having input and output circuits for signals to be controlled and having a control signal input terminal, means connected to apply both of said single-sideband and said pilot signals to said input circuit, means including a rectifier for producing a control signal from both of said single-sideband and said pilot signals, means connected to apply said control signal to said control signal input terminal, a limiter, and means connected to apply said single-sideband and said pilot signals to said rectifier through said limiter.

2. A transmitter for the transmission of a plurality of single-sideband speech signals originating from a plurality of separate speech channels, each of said channels comprising a source of a single-sideband signal, a source of a pilot signal having a frequency adjacent said single-sideband signal, dynamic compression means having input and output circuits for signals to be controlled and a control signal input terminal, means connected to apply said single sideband signal and pilot signal to said input circuit, means producing a control signal from said single-sideband signal and pilot signal comprising limiter means and rectifier means, and means applying said control signal to said input terminal, and means combining the signals from the output circuits of the compression means of each of said channels.

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