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SIGNALING SYSTEM

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FIG. 1

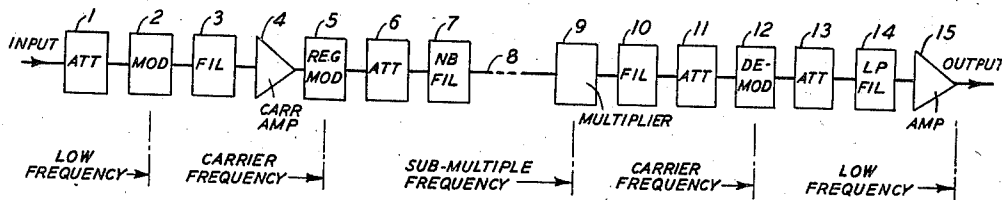
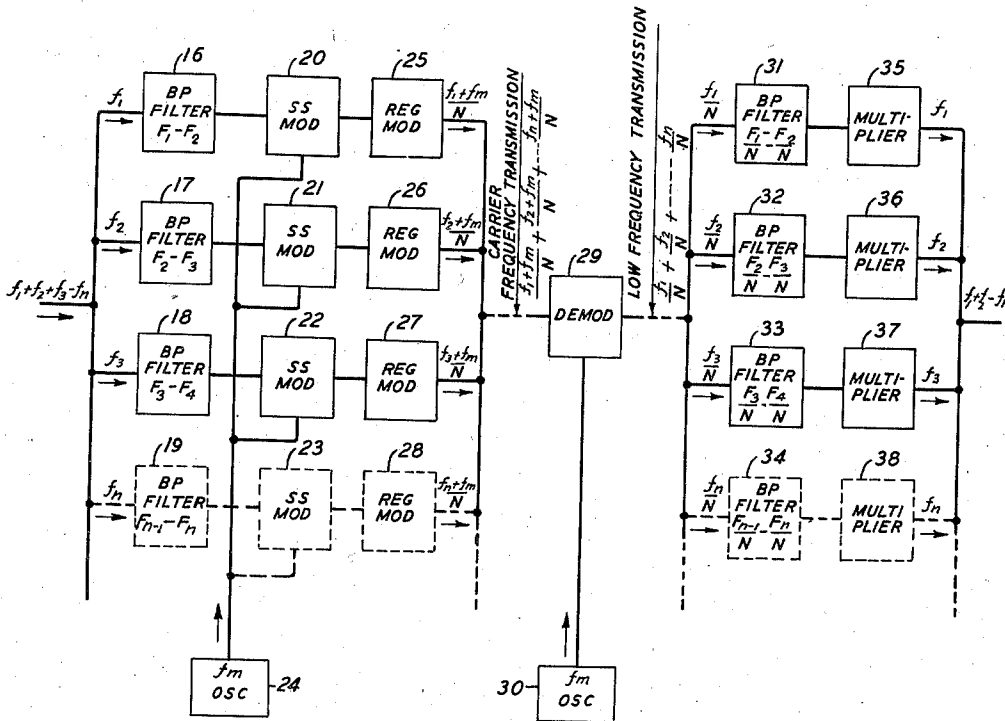


FIG. 2



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SIGNALING SYSTEM

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4 Claims. (Cl. 178—44)

This invention relates to systems for the transmission of signals and more particularly to systems in which the signals are transmitted in the form of a modulated carrier wave.

An object of the invention is to effectively reduce the width of the frequency band required for the transmission of a given signal wave.

A further object of the invention is to produce a signal-modulated carrier wave in which the frequency of the carrier wave varies in accordance with the predominant frequency of the original signal.

It was shown in U. S. Patent 1,690,299 patented November 6, 1928 to J. W. Horton, that when a single sinusoidal wave of a given frequency is applied to the input of a regenerative modulator, the output of the regenerative modulator will contain a submultiple of the input frequency. In the embodiment of the present invention to be disclosed herein, a plurality of sinusoidal waves of different frequencies are applied to the input of a regenerative modulator. The regenerative modulator will be controlled by the predominant frequency of the input wave, that is, the frequency which at any instant has the largest amplitude, and will produce in its output circuit a desired submultiple of the predominant frequency. When this submultiple frequency of the predominant frequency is fed back to the input of the regenerative modulator it will beat with the waves of the other frequencies in the input wave to produce a number of components which may be supplied to the output circuit. The output current will then comprise the submultiple of the predominant frequency, which corresponds to a carrier current, and side-bands distributed about this carrier frequency. As the predominant frequency of the input wave is at all times that frequency which may happen to have the greatest amplitude, the output wave of the regenerative modulator will then be similar to a carrier current and its side-band currents in which the frequency of the carrier is continually changing in accordance with the amplitude of the predominant frequency of the input current. The width of the band of frequencies occupied by this varying carrier and its side-bands will be the same as the width of the band of frequencies occupied by the original signal currents. The output wave may then be transmitted over any ordinary transmission channel and if detected by ordinary methods will be practically unintelligible. This method of modulation thus provides a considerable degree of secrecy in the transmission of messages over a transmission system. At the receiving station,

the transmitted currents are applied to the input of a harmonic multiplier which produces a harmonic of the applied frequencies of the reciprocal order of the submultiple produced by the regenerative modulator. The output of the multiplier may then be detected by known methods.

In a modification of the invention, the method of transmission may be slightly changed in order to produce an actual reduction in the width of the frequency range transmitted over the communication channel. In this case the signal currents are applied to the inputs of a plurality of narrow band pass filters. The pass bands of the filters are sufficiently narrow that at any instant on the average there will be only one frequency passing through any given filter. The outputs of the band pass filters may be individually applied to the inputs of individual regenerative modulators, or may be individually modulated by a carrier of suitable frequency and the products of modulation individually applied to the inputs of individual regenerative modulators. Each regenerative modulator will produce a submultiple of the frequency applied to the modulator. Thus, if the outputs of all the regenerative modulators are combined and supplied to a communication channel, the frequency range of the current in the communication channel will be reduced in accordance with the order of the submultiple produced by the regenerative modulator. At the receiving station if the side-band currents are demodulated by means of a carrier current of suitable frequency, low frequency currents will be produced. The frequency range of the low frequency currents will be reduced in accordance with the submultiple of the regenerative modulator. The low frequency currents are selected by a plurality of band pass filters and applied to the inputs of a plurality of harmonic multipliers which produce harmonics of the same order as the submultiple produced by the regenerative modulator. The outputs of the multipliers are then combined together to reproduce the original signal current.

In the drawing:

Fig. 1 shows diagrammatically the essential elements of a variable carrier system embodying the invention; and

Fig. 2 shows diagrammatically a frequency range reduction system embodying the invention.

In Fig. 1, signal currents from any suitable source, such as a microphone, telephone line, telegraph line, radio receiver or similar device, are supplied through an attenuator 1 to a modulator 2 where they modulate a carrier current of suitable frequency. The carrier current may be

modulated in amplitude, frequency or phase. The band pass filter 3 selects a desired band from the products of modulation which is suitably amplified in the amplifier 4 and supplied to a regenerative modulator 5, which may be of the type disclosed in U. S. Patent 1,690,299, November 6, 1928 to J. W. Horton. The regenerative modulator is arranged to be controlled by the applied frequency which at any instant is of the greatest amplitude, and will produce a predetermined submultiple of this frequency which is fed back to the input to beat with the other frequencies of the input wave. The products of this modulation, attenuated, if desired, by an attenuator 6, are supplied to the band pass filter 7 which may be designed to select one side-band of the carrier, or the submultiples of the frequencies of the original modulation for transmission over the channel represented by the dotted line 8. The transmission channel may be a wire link, such as a telephone line, or a radio link, or it may be a recording and reproducing equipment of any one of the types well known in the sound recording art.

The received waves are applied to a frequency multiplier 9 of any known type, having a multiplying factor which is the reciprocal of the submultiple factor of the regenerative modulator. The multiplied frequencies are supplied through a band pass filter 10 and attenuator 11 to a demodulator 12 where the multiplied frequencies beat with a carrier having the same frequency as the carrier supplied to the modulator 2. The products of demodulation are supplied through an attenuator 13 to a low pass filter 14 and thence through a low frequency amplifier 15 to a receiving line or other utilization device.

Assume that there are two frequencies f_1 and f_2 transmitted through the filter 3, of which f_1 has the greater amplitude, and that the regenerative modulator 5 is adjusted to halve the applied frequency. The output of the regenerative modulator 5 will have the frequencies

$$\frac{f_1}{2} \text{ and } f_2 \pm \frac{f_1}{2}$$

The frequency

$$f_2 + \frac{f_1}{2}$$

may be eliminated by the filter 7, and the other frequencies transmitted to the multiplier 9. The multiplier 9 will produce the second order products

$$f_1; 2\left(f_2 - \frac{f_1}{2}\right); \text{ and } \frac{f_1}{2} \pm \left(f_2 - \frac{f_1}{2}\right)$$

or

$$f_1; 2f_2 - f_1; f_2; f_1 - f_2$$

The frequency $f_1 - f_2$ will be of low frequency and may be arranged to fall below the pass band of the filter 10 and will thus be eliminated. The products applied to the demodulator 12 will then be f_1 ; f_2 and $2f_2 - f_1$. The unwanted product $2f_2 - f_1$ cannot be eliminated, but, fortunately is small with respect to f_1 and f_2 and thus does not produce much distortion.

The frequencies transmitted over the channel, when f_1 has the larger amplitude, are, as shown above,

$$\frac{f_1}{2}$$

and

$$f_2 - \frac{f_1}{2}$$

If, at a later instant, f_2 should be of larger am-

plitude than f_1 , the frequencies transmitted over the channel will then be

$$\frac{f_2}{2}$$

and

$$f_1 - \frac{f_2}{2}$$

The system is, in effect, a system which has a variable carrier, the frequency of which is proportional to a submultiple of the major component of the wave. Such a transmitted wave cannot be detected by the usual methods.

A study of the complex waves corresponding to speech or music will show that, at any instant, the component frequencies are rather widely spaced. Thus, if such a complex wave be supplied to a number of band pass filters in multiple, if the pass bands of the filters are fairly small, only one frequency will pass through a filter at any given instant. For the transmission of speech, in the lower part of the range, the pass band may be of the order of 100 cycles, and the pass band may be considerably wider in the upper part of the range.

In Fig. 2, the signal currents comprising frequencies $f_1, f_2, f_3 \dots f_m$ are supplied to a plurality of band pass filters 16, 17, 18, 19. Filter 16 has a pass band F_1 to F_2 which passes f_1 ; filter 17 has a pass band F_2 to F_3 which passes f_2 ; and so on for the series of filters. After selection by the band pass filters, the single frequencies may be supplied to individual single side-band modulators 20, 21, 22 and 23 supplied with a carrier frequency f_m from an oscillator 24. One group of side-bands, which may be the upper side-bands $f_1 + f_m, f_2 + f_m, \dots f_n + f_m$, are supplied to regenerative modulators 25, 26, 27, 28, which produce the submultiple frequencies

$$\frac{f_1 + f_m}{N}, \frac{f_2 + f_m}{N}, \frac{f_n + f_m}{N} \dots$$

which are supplied to a carrier frequency transmission line.

The frequency range normally taken by the upper side-band of the carrier modulator would extend from $f_1 + f_m$ to $f_n + f_m$. In the present system, the frequency range is reduced or compressed to a range which only extends from

$$\frac{f_1 + f_m}{N} \text{ to } \frac{f_n + f_m}{N}$$

The reduced range currents at some point in the carrier transmission line may be impressed on a carrier demodulator 29 supplied with carrier frequency f_m from the oscillator 30. The products of demodulation will contain the frequencies

$$\frac{f_1}{N}, \frac{f_2}{N}, \frac{f_3}{N}, \dots \frac{f_n}{N}$$

The demodulator may be located at the receiving station, and the transmission is then in the form of a current of reduced frequency range; or, the demodulator may be at the sending end and the transmission is then in the form of signal currents of reduced frequency range. The signal currents of reduced range may also be recorded by known methods and later reproduced.

The signal currents of reduced frequency range

are supplied to a plurality of band pass filters 31, 32, 33 and 34. Filter 31 has a pass band

$$\frac{F_1}{N} \text{ to } \frac{F_2}{N}$$

which passes

$$\frac{f_1}{N}$$

filter 32 has a pass band

$$\frac{F_2}{N} \text{ to } \frac{F_3}{N}$$

which passes

$$\frac{f_2}{N}$$

and so on for the series of filters. The reduced frequencies selected by the filters 31, 32, 33 and 34 are supplied to individual multipliers 35, 36, 37 and 38 having a multiplying factor N which is the inverse of the factor

$$\frac{1}{N}$$

of the regenerative modulators 25, 26, 27 and 28. The signal currents, restored to their original frequencies, are then combined and supplied to a utilization device.

If desired, modulation in the modulators 20, 21, 22, 23 and the subsequent demodulation in the demodulator 29 may be omitted, and the subbands from the filters 16, 17, 18, 19 supplied directly to the regenerative modulators 25, 26, 27, 28. In this case, the output from the regenerative modulators 25, 26, 27, 28 will have the frequencies

$$\frac{f_1}{N}, \frac{f_2}{N}, \frac{f_3}{N}, \frac{f_n}{N}$$

and may be transmitted over a low frequency transmission line directly to the band pass filters 31, 32, 33, 34. The frequency range of the low frequency components will be reduced to

$$\frac{1}{N}$$

of the original range.

What is claimed is:

1. The method of reducing the frequency range required to transmit a given signal comprising a band of frequencies which consists in selecting from said signaling frequencies a plurality of narrow bands of frequencies, individually modulating a common carrier frequency with each of said narrow bands, selecting from the product of each such modulation a single side-band, deriving from the frequency in each side-band having at any instant the greatest amplitude a submultiple of that frequency, and transmitting all of the derived submultiple frequencies simultaneously over the same communication channel.

2. The method of reducing the frequency range of a band of signaling frequencies which comprises selecting a plurality of narrow bands from said frequencies, individually modulating a common frequency with each of said narrow bands, selecting from the product of each such modulation a single side-band, deriving from the frequency in said side-band having at any instant the greatest amplitude a submultiple of such frequency, transmitting the products of said submultiplication to a demodulator, demodulating all said submultiple frequencies with a common frequency equal to said first named common frequency, supplying the products of demodulation to a medium, deriving said products from said medium, selecting a plurality of narrow bands from said submultiple frequencies corresponding to said first named narrow bands, individually multiplying said latter frequency bands by a factor which is the reciprocal of the factor of submultiplication, and supplying the products of such multiplication to a receiving device.

3. The method of reducing the range of a band of signaling frequencies which comprises selecting from said band a plurality of narrow subbands, deriving from the frequency in each subband having at any instant the greatest amplitude a submultiple of such frequency, modulating each subband with the submultiple frequency derived from said band, transmitting the products of said modulation over a communication channel, selecting at a receiving point the transmitted modulated products of each subband, multiplying the frequencies of each subband by a factor which is the reciprocal of said submultiple and supplying the products of said multiplication to a receiving device.

4. In a carrier wave signaling system, a carrier wave transmission line, a source of signal waves of a band of low frequencies, a source of waves of a signal carrier frequency, means for splitting up the frequency band of the signal waves from said signal wave source into a plurality of narrow bands of frequencies, means for individually modulating a carrier wave from said carrier wave source with each of said narrow bands, means for selecting from the products of each modulation a single side-band, deriving from the frequency in each side-band having at any instant the largest amplitude a wave of a submultiple frequency, means for impressing all of the derived submultiple frequencies on said carrier wave line, for simultaneous transmission thereof, and means at a receiving point for transforming the received waves into signal waves of frequencies corresponding to the original band of signal frequencies at the transmitting end of the system.

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