Nov. 29, 1949 G. H. BAST 2,489,361

MULTICHANNEL CARRIER WAVE SYSTEM EMPLOYING MULTIPLE MODULATION

Filed July 31, 1946 2 Sheets-Sheet 1

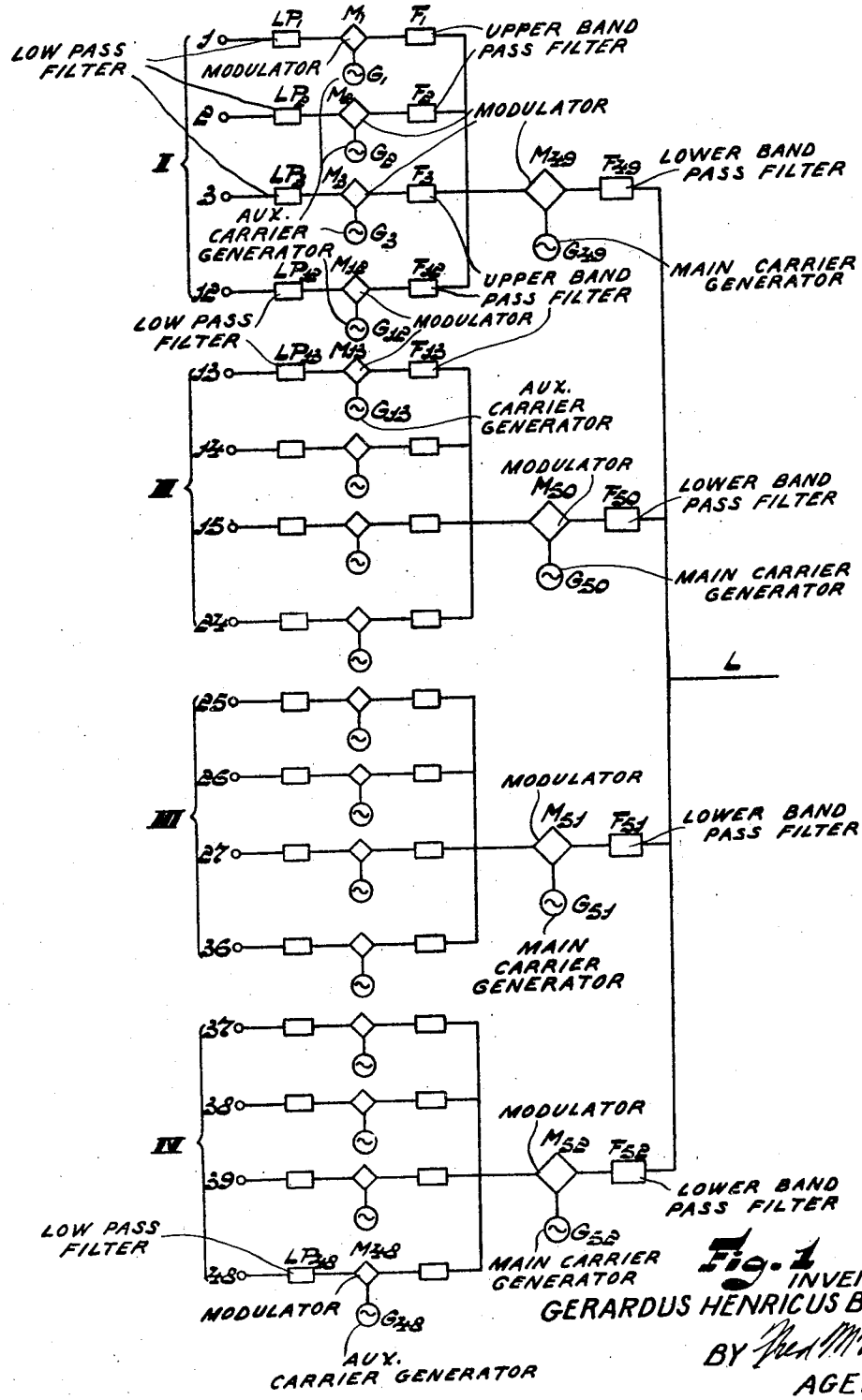


Fig. 1

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MULTICHANNEL CARRIER WAVE SYSTEM EMPLOYING MULTIPLE MODULATION

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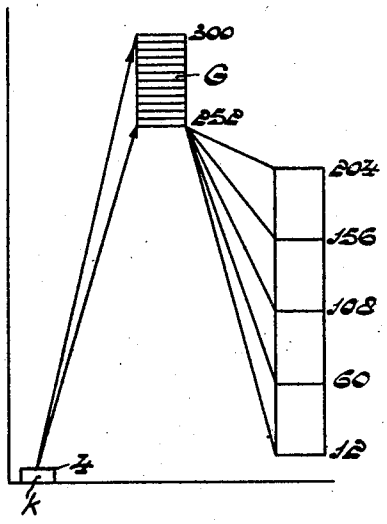


Fig. 2

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2,489,361

MULTICHANNEL CARRIER WAVE SYSTEM EMPLOYING MULTIPLE MODULATION

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5 Claims. (Cl. 179—15)

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This invention relates to a multiple carrier-wave telephony system for the simultaneous transmission of a certain number of telephonic conversations through a common transmission medium, such as a telephone cable or a radio connection. According to the requirements of one known multiple carrier wave system, the frequency band available for the transmission of the conversations is split up into a certain number of adjoining bands having a width of 4 kilocycles and in each of these bands a telephonic conversation takes place. Each of the telephonic messages which comprise a frequency band of, for example, from 300 to 3000 cycles is conveyed by one or more modulation processes to the band destined for the conversation, the carrier-wave and a sideband being suppressed.

If the system consists of a large number of channels, it is advantageous for economical reasons, and more particularly with a view to saving filters, modulators and carrier-wave generators, to divide the channels into groups and to make use of multiple modulation. In a well-known 100-channel system the channels are divided, for example, into 10 groups of 10 channels. In the first modulation process the conversations of one group are respectively modulated on 10 different carrier-waves and one of the sidebands is selected. The carrier-wave frequencies are so chosen that the 10 side bands which together comprise one group form part of the frequency band of from 60 to 100 kilocycles (group frequency band). This modulation process may be called channel-group spread modulation. The 10 groups are then modulated in a second modulation process on 10 different carrier waves respectively and one of the sidebands is selected again. The carrier-waves in this second modulation process are so chosen that the adjoining sidebands lie in the ultimately desired band of from 100 to 500 kilocycles. In the second modulation process the group-frequency band of from 60 to 108 kilocycles for each group is shifted or spread to another area in the ultimately desired frequency band of 100 to 500 kilocycles, which may be called group-spread modulation. This system suffers from the drawback that the frequency range below 100 kilocycles remains unexploited, due to which this system is less suitable to be used for telephone cables, since it is the frequency range below 100 kilocycles which forms a considerable part of the total frequency range available in these cables for transmission.

In a further well-known system the channels are shifted in groups of 12 by channel-group

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spread modulation to the group frequency band 60 to 108 kilocycles, the groups, except for the first, then being shifted by group spread modulation to their area in the ultimately desired frequency band of 60 to 108 kilocycles. The first group is not shifted in frequency, so that this extends in the ultimately desired frequency-band of from 60 to 108 kilocycles. The second, third group and so on are shifted by group spread modulation to 108 to 156, 156 to 204 kilocycles and so on.

Since modulators always exhibit a certain leakage, i. e. both modulated and modulating oscillations appear in the output circuit, it will be evident that the output circuits of the modulators used in group spread modulation of the second, third group and so on also contain interfering oscillations of from 60 to 108 kilocycles to these consequently form part of the band destined for the channels of the first group and cross talking of all channels associated with the second, third group and so on occurs on the channels of the first group.

The object of the invention is to provide a multiple carrier-wave telephony system involving multiple modulation and channels divided into groups, in which the disadvantages inherent to the conventional systems are avoided.

According to the invention this is achieved by the fact that the group frequency band exceeds the highest frequency of the ultimately desired frequency band.

The group frequency band consequently lies beyond the ultimately wanted frequency band so that cross-talk due to leakage of the group spread modulators cannot occur. Furthermore, it will be readily appreciated that with telephone cables the total available frequency band can be utilised.

In order that the invention will be clearly understood and readily carried into effect, it will now be explained more fully with reference to the accompanying drawing, given by way of example, in which

Fig. 1 represents diagrammatically a 48 channel-system and

Fig. 2 illustrates the position of the group frequency band with respect to the ultimately wanted band.

The system shown in Fig. 1 by a block diagram comprises 48 channels 1 to 48 which are subdivided into 4 groups I to IV of 12 channels. Each channel comprises a low-pass filter LP_1—LP_{48} which suppresses the incoming speech frequencies exceeding 3000 cycles, modulators M_1—M_{48} fed by carrier-wave generators G_1—G_{48} said mod-

ulators serving for the channel-group spread modulation, and band-pass filters F_1—F_{48}. The modulators are of the bridge-type, in which the carrier-wave is suppressed, so that only the two sidebands appear in the output circuit. One of these side-bands is suppressed by the band-pass filter following the modulator, which has a band width of 4 kilocycles, whereas the other is allowed to pass.

For purposes of clarity separate carrier-wave generators are shown for the groups II, III and IV. Since, however, the carrier-waves used in the various groups are the same, the carrier-wave generators G_1—G_{12} of the first group will at the same time feed the modulators of the second, third and fourth groups.

The transmitted 12 sidebands adjoining each other are united to form one frequency band, the group-frequency band, in the common output circuits of the band-pass filters forming part of the same group. This group frequency band is the same for the four groups and extends from 252 to 300 kilocycles. For each group there is provided a group modulator M_{49}—M_{52}, which is fed by a carrier-wave generator G_{49}—G_{52}, and a band-pass filter F_{49}—F_{52} which transmits one of the sidebands produced by the group modulators and supplies it to the telephone cable L. The group spread modulation takes place in the modulators M_{49}—M_{52}. The group frequency band 252 to 300 kilocycles is shifted for the various groups to 12–60, 60–108, 108–156 and 156–204 kilocycles, respectively.

Fig. 2 shows the position of a channel of the group frequency band and of the ultimately wanted frequency band in the spectrum. The 12 channels K having a width of 4 kilocycles in each of the four groups and are spread by channel group spread modulation over the group frequency band G of 252 to 300 kilocycles. The four groups are then spread by group spread modulation over the ultimately wanted frequency band of from 12 to 204 kilocycles.

This figure shows that the group frequency band exceeds the highest frequency of the ultimately desired band.

So far it has been assumed that the spreading of the channels over the group frequency band is effected in a single modulation process. The group dividing modulation may, however, be preceded by further modulation processes. For instance, in the arrangement given by way of example in Fig. 1 it will involve difficulties, in connection with the comparatively high frequency of the group-frequency band, to separate the desired from the undesired sideband in the filters F_1—F_{48}. In this case it is advantageous first to modulate all conversations on one and the same comparatively low-frequency carrier-wave of, for example, 60 kilocycles, where the separation of the sidebands does not impose very stringent conditions on the filters and thereafter to spread the transmitted sidebands by channel-group spread modulation over the group frequency band.

Though, in principle, the frequency distance between the group frequency band and the ultimately desired frequency band is arbitrary, it may be advantageous to choose this distance in a definite manner, since if in a system according to the invention, the frequencies of the carrier waves used for the channel-group spread modulation are multiples of one and the same fundamental frequency, the frequency distance between the group frequency band and the ultimately desired frequency band is, according to another feature

of the invention, so chosen as that the carrier-waves used in the group spread modulation are multiples of the same multiple of the said fundamental frequency.

This measure is based on the following line of thought.

With multiple carrier-wave telephony systems it is common practice to derive the carrier-waves from impulses produced by a multivibrator. This is accomplished by separating the harmonics contained in the multivibrator impulses by means of filters and then using the harmonics as carrier-waves. In a system described above, in which the conversation band width is 4 kilocycles, the carrier-waves used in channel group spread modulation will differ by 4 kilocycles and consequently they should be obtained from a multivibrator having a fundamental frequency of 4 kilocycles. The carrier-waves used in group spread modulation, which are spaced apart by 48 kilocycles, could be obtained from the same multivibrator. The last-mentioned carrier-waves have, as a rule, a comparatively high frequency, so that the order of the harmonics is high, due to which the amplitude of these harmonics is too small to be used in practice, owing to the fact that the amplitude of the harmonics rapidly decreases as the order goes higher. This drawback can be avoided, or at least reduced, by taking the carrier-waves for the group spread modulation from a separate multivibrator which, in the arrangement described above by way of example, has a fundamental frequency of 24 kilocycles. This multivibrator is then synchronised with the sixth harmonic (24 kilocycles) of the 4 kilocycle multivibrator which produces the carrier-waves for the channel group spread modulation. Carrier-waves for the group spread modulation 240, 360, 408 and 456 kilocycles are chosen, these carrier-waves being the 10th, 15th, 17th and 19th harmonics of the fundamental frequency of the 24 kilocycle multivibrator. In this case the distance between the group frequency band 250–300 kilocycles and the ultimately desired system band 12–204 kilocycles is 48 kilocycles and is consequently such that the carrier-waves (240, 360, 408 and 456 kilocycles) of the group spread modulation are multiples (the 10th, 15th, 17th and 19th) of the same 6th multiple (24 kilocycles) of the fundamental frequency (4 kilocycles) from which the carrier-waves for the channel-group spread modulation are derived.

It will be evident that the distance between the group frequency band and the ultimately desired band must be chosen in a special manner in order that the fundamental frequency of the multivibrator for the carrier-waves for the group spread modulation is preferably as large as possible a multiple of the fundamental frequency of the multivibrator in respect of the carrier-waves of the channel-group spread modulation. In the case of a distance of 52 kilocycles, for instance (group frequency band 256 to 304 kilocycles), this could not be realized, because in this case the group spread carrier-waves would be 244, 364, 412 and 460 kilocycles, which are only multiples of 4 kilocycles, but not multiples of a multiple of 4 kilocycles.

What I claim is:

1. A multichannel carrier-wave system comprising a multiplicity of identical groups each having a plurality of channels greater than two for transmitting subscriber signals, each channel including a source of auxiliary carrier, means for modulating said auxiliary carrier with the sub-

scriber signals of said channel, means for deriving a single side band from said modulated auxiliary carrier which is in correspondence to the respective single side bands derived in the other channels of said group, and means including a common group output circuit for combining the side bands derived from the modulated auxiliary carriers in the respective channels of said group, the sources of the auxiliary carriers in said group having respective frequency values at which said single side bands derived from said modulated auxiliary carriers occupy adjoining spaces within a predetermined group frequency range, a like multiplicity of main carrier sources, means for modulating each of said main carriers with the frequencies of a respective group range, means to derive the lower side band from each of said modulated main carriers, and means including a common system output circuit for combining the lower side bands derived from said modulated main carriers, the sources of said main carriers having respective frequency values at which the lower side bands derived from said modulated main carriers occupy adjoining spaces within a predetermined system frequency range whose highest frequency is less than the lowest frequency in said group frequency range.

2. A multichannel carrier-wave system comprising a multiplicity of identical groups each having a plurality of channels greater than two for transmitting subscriber signals, each channel including means for confining the subscriber signals of said channel within a prescribed band, a source of auxiliary carrier, means for modulating said auxiliary carrier with said prescribed band of subscriber signals, means for deriving a single side band from said modulated auxiliary carrier which is in correspondence to the respective single side bands derived in the other channels of the group, and means including a common group output circuit for combining the single side bands derived from the modulated auxiliary carriers in the respective channels of said group, the sources of the auxiliary carriers in said group having respective frequency values at which said single side bands derived from said modulated auxiliary carriers occupy adjoining spaces within a predetermined group frequency range, a like multiplicity of main carrier sources, means for modulating each of said main carriers with the frequencies of a respective group range, means to derive the lower side band from each of said modulated main carriers, and means including a common system output circuit for combining the lower side bands derived from said modulated main carriers, the source of said main carriers having respective frequency values at which the lower side bands derived from said modulated main carriers occupy adjoining spaces within a predetermined system frequency range whose highest frequency is less than the lowest frequency in said group frequency range.

3. A multichannel carrier-wave system comprising a multiplicity of identical groups each having a plurality of channels greater than two for transmitting subscriber signals, each channel including means for confining the subscriber signals of said channel within a prescribed band, a source of auxiliary carrier, means for modulating said auxiliary carrier with said prescribed band of subscriber signals, means for deriving a single side band from said modulated auxiliary carrier which is in correspondence to the respective single side bands derived in the other channels of the group, and means including a common group

output circuit for combining the single side bands derived from the modulated auxiliary carriers of the respective channels in said group, the sources of the auxiliary carriers in said group having respective frequency values which are multiples of one and the same fundamental frequency whereby the single side bands derived from said modulated auxiliary carriers occupy adjoining spaces within a predetermined group frequency range, a like multiplicity of main carrier sources, means for modulating each of said main carriers with the frequencies of a respective group range, means to derive the lower side band from each of said modulated main carriers, and means including a common system output circuit for combining the lower side bands derived from said modulated main carriers, the sources of said main carriers having respective frequency values which are multiples of one and the same multiple of said fundamental frequency so that the lower side bands derived from said modulated main carriers occupy adjoining spaces within a predetermined system frequency range whose highest frequency is less than the lowest frequency in said group frequency range.

4. A multichannel carrier-wave system comprising a multiplicity of identical groups each having a plurality of channels greater than two for transmitting subscriber signals, each channel including a low-pass filter for confining the subscriber signals of said channel within a prescribed band, an auxiliary carrier generator, a first modulator for mixing the frequency of said auxiliary carrier generator with said prescribed band of subscriber signals, a first band-pass filter for deriving the upper side band from the output of said first modulator, and means including a common group output circuit for combining the single side bands yielded by the first band-pass filters of the respective channels of said group, the generators of the auxiliary carriers in said group having respective frequency values at which said single side bands yielded by said first band-pass filters occupy adjoining spaces within a predetermined group frequency range, a like multiplicity of main carrier generators, a second modulator for mixing the frequency of each of said main carrier generators with the frequencies of a respective group range, a second band-pass filter for deriving the lower side band from the output of said second modulator, and means including a common system output circuit for combining the lower side bands yielded by the respective second band-pass filters, the generators of said main carrier generators having respective frequency values at which the lower side bands yielded by the respective second band-pass filters occupy adjoining spaces within a predetermined system frequency range whose highest frequency is less than the lowest frequency in said group frequency range.

5. A multichannel carrier-wave system comprising a multiplicity of identical groups each having a plurality of channels greater than two for transmitting subscriber signals, each channel including a low-pass filter for confining the subscriber signals of said channel within a prescribed band, an auxiliary carrier generator, a first modulator for mixing the frequency of said auxiliary carrier generator with said prescribed band of subscriber signals, a first band-pass filter for deriving the upper side band from the output of said first modulator, and means including a common group output circuit for combining the single side bands yielded by the first band-pass fil-

ters of the respective channels in said group, the generators of the auxiliary carrier generators in said group having respective frequency values which are multiples of one and the same fundamental frequency whereby the single side bands yielded by said first band-pass filters occupy adjoining spaces within a predetermined group frequency range, a like multiplicity of main carrier generators, a second modulator for mixing the frequency of each of said main carrier generators with the frequencies of a respective group range, a second band-pass filter for deriving the lower side band from the output of said second modulator, and means including a common system output circuit for combining the lower side bands yielded by the respective second band-pass filters, generators of said main carrier generators having respective frequency values which are multiples of one and the same multiple of said fundamental frequency so that the lower side bands yielded by the respective second band-pass filters

occupy adjoining spaces within a predetermined system frequency range whose highest frequency is less than the lowest frequency in said group frequency range.

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