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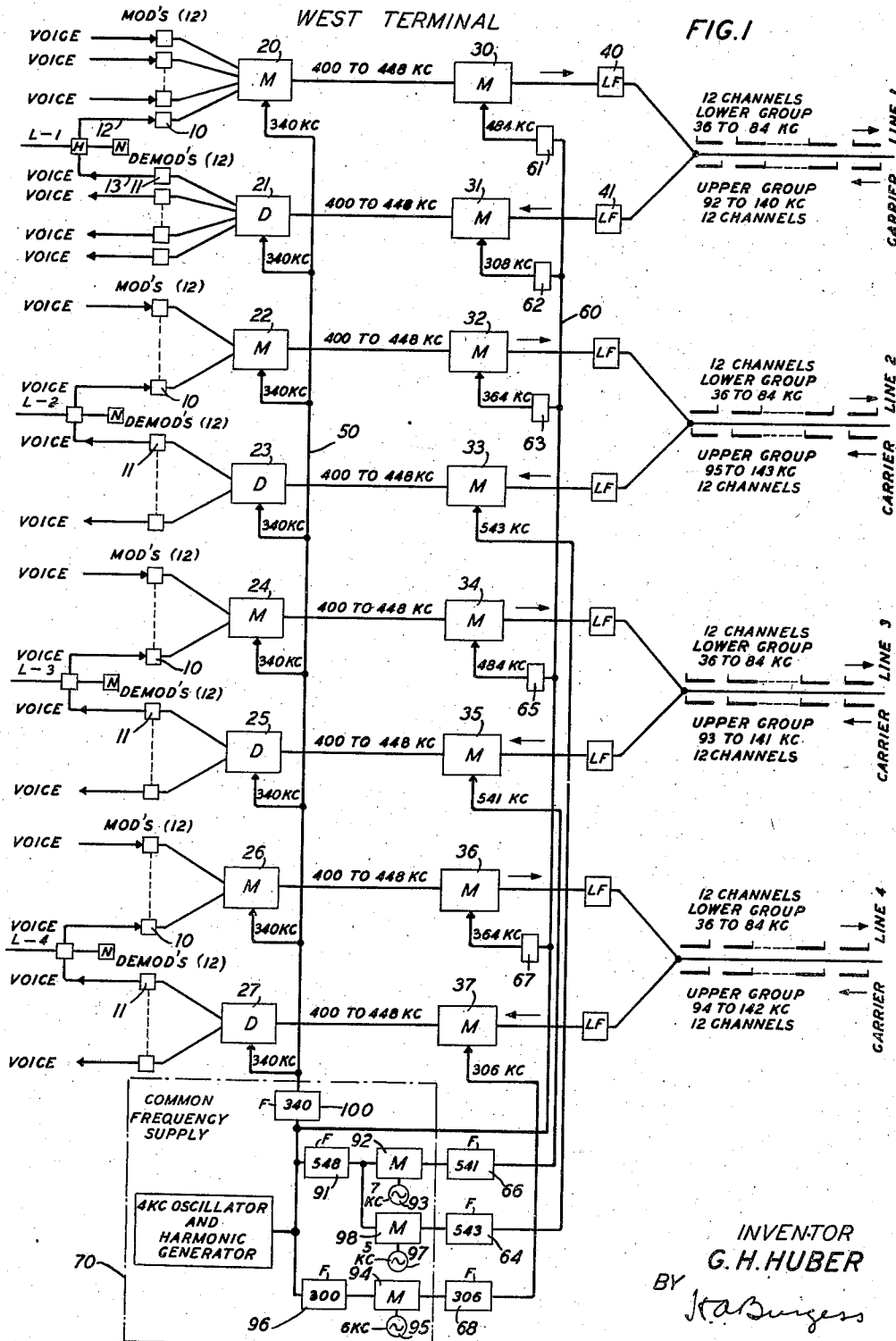
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2,142,316

MULTIPLEX MULTILINE CARRIER SYSTEM

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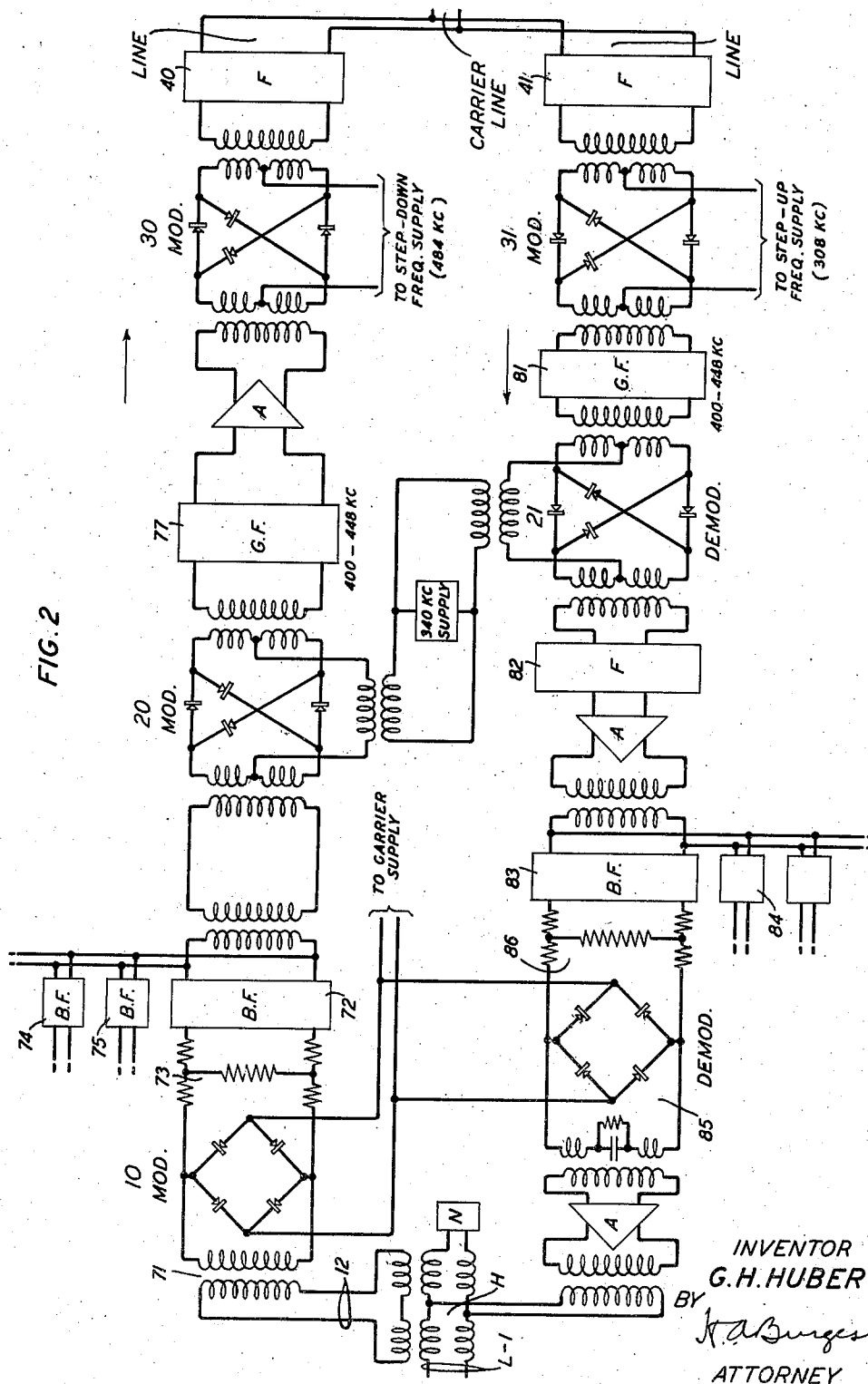
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2 Sheets-Sheet 2



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MULTIPLEX MULTILINE CARRIER SYSTEM

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3 Claims. (Cl. 179—78)

The present invention relates to multiplex carrier transmission and particularly to the terminal circuits for translating the voice frequency waves to the high frequency waves for the individual carrier channels and vice versa.

Where open wire multiplex lines parallel one another on the same poles, the problem of cross-talk becomes increasingly severe as higher and higher frequencies are used. It has been found heretofore that cross-talk can be reduced by staggering or interleaving the channel frequencies on neighboring pairs so that the frequencies on one pair coincide with the spaces between channel frequencies on an adjacent pair. Where more than two lines are to be used adjacent one another the frequency arrangement becomes more complex. For example, with four lines it may be necessary to adopt four different frequency arrangements for some of the channels instead of using only two arrangements. With a still larger number of lines strung so as to have a cross-talk factor from each to each, a still more complex frequency pattern may be required.

Such arrangements of frequencies on the different lines require different terminal circuits for the different lines both for transmitting and receiving. Direct modulation and demodulation between the voice and carrier lines would require the use of circuits of individual design, especially filters, for each frequency arrangement.

It is an object of the present invention to provide for any one of a required number of frequency patterns or arrangements by terminal circuits requiring a minimum of apparatus of individual type.

In accordance with the invention any one of several frequency arrangements or patterns can be used with terminal circuits which are identical except for the frequency of a wave which is used to shift the frequency of an entire group of waves just before they are applied to the multiplex line or as they are received from the multiplex line. This difference requires merely the use of a particular selective circuit in most cases since the frequency-shifting waves are generated in a common circuit involving production of harmonics of a single base frequency wave.

The nature and objects of the invention will be more fully understood from the following detailed description of a typical multiplex carrier telephone system using twelve channels in each direction over each line. While open wire lines will be referred to in the description, it is to be understood that they may be any circuits on which it is desired to have different arrays or patterns of

frequencies such as radio antenna systems or lines not necessarily the conventional open wire lines strung on poles.

In the drawings, Fig. 1 shows a block schematic form the layout of the terminal circuits for four multiplex lines by way of example and Fig. 2 shows in greater detail in schematic form the modulating and demodulating circuits of one complete channel of one line.

Referring to Fig. 1, four multiplex carrier lines are shown at the right of the drawing labeled carrier lines 1 to 4 and all terminating at the west terminal shown generally in this figure. Twelve channels comprising a lower group of frequencies transmit west to east over each carrier line and twelve channels comprising a higher group of frequencies transmit east to west over each carrier line. From the frequencies marked on the drawing it will be observed that a staggered relation is used from line to line. In the case of the lower group two different frequency arrangements are used comprising frequencies 36 to 84 kilocycles, with one inverted with respect to the other. In the upper groups where the cross-talk problem is more severe because of the higher frequencies, four different frequency arrangements for the four different lines are used. In the case of carrier line 1 the upper group comprises frequencies from 92 to 140 kilocycles. The upper group of carrier line 2 uses frequencies from 95 to 143 kilocycles. The upper group of carrier line 3 uses frequencies from 93 to 141 kilocycles. The upper group of carrier line 4 uses frequencies from 94 to 142 kilocycles. In each case the spacing between the individual channel carrier frequencies is four kilocycles and it is understood that the side-band width of each channel is 3000 cycles representing speech waves from 200 to 3200 cycles.

In addition to the staggered frequency arrangement from line to line the frequency order within the channels is in some cases inverted, that is, the frequencies in the channel are either in the same order as they occur in speech or they are in inverse order. This is represented in the drawing by showing the width of the channel band by a heavy horizontal dash with a short vertical mark at one end. Where the vertical mark is at the left end of the dash it indicates a normal frequency order and where it is at the right-hand end of the dash it represents an inverted order. Since the maximum speech energy occurs in the region below 1000 cycles, an advantage from the cross-talk standpoint is obtained by inverting the frequencies in some cases, as well as staggering

them in order to determine the most advantageous relative frequency positions of the speech band spectra on the neighboring lines.

At the left side of Fig. 1 four telephone lines 5 L—1, L—2, L—3 and L—4 are shown, these being ordinary two-way voice frequency lines. Line L—1 is one of a group of twelve similar lines only one of which has been shown to avoid undue complication of the drawing. Similarly, line L—2, 10 L—3 or L—4 is in each case one of a group of twelve similar lines.

Each voice frequency line of which L—1 is typical is provided with a hybrid coil H and balancing network N to provide a transmitting branch 12 and a receiving branch 13. The transmitting branch 12 leads to a modulator 10 for producing a speech modulated wave. Similarly, receiving branch 13 leads from a demodulator 11 for deriving speech waves from received carrier 20 waves and supplying the demodulated waves to the line L—1. As the drawing indicates, modulator 10 is one of a group of twelve modulators and demodulator 11 is one of a group of twelve demodulators which would be associated in pairs with twelve voice frequency lines similar to line L—1.

It is assumed that modulators 10 and demodulators 11 are arranged to be supplied with suitable carriers, that the unmodulated carrier component is suppressed and that only the lower side-band of the modulated wave is utilized as will be disclosed more in detail in connection with Fig. 2.

The carrier frequencies that are supplied to the twelve modulators 10 range in frequency from 64 to 108 kilocycles at four kilocycle intervals. A similar range of frequencies is impressed on the demodulators 11.

Twelve modulated waves from modulators 10 are impressed in common on group modulator 20 where they are stepped up in frequency by 340 kilocycles supplied through filter 100 from supply line 50 which comes from the common frequency supply 70 of any suitable type for supplying the necessary frequencies for the system.

The output of group modulator 20, therefore, comprises twelve channels which have been stepped up to the range of 400 to 448 kilocycles and these are impressed on the second group modulator 30 where they combine with a frequency of 484 kilocycles supplied over circuit 60 from the common frequency supply 70 and selectively transmitted through filter 61. As a result of the action of group modulator 30 the twelve channels are stepped down to occupy a frequency range of 36 to 84 kilocycles which is selectively passed by the line filter 40, a low-pass filter, to carrier line 1.

The upper group of frequencies in a range of 92 to 140 kilocycles received over carrier line 1 is selectively passed through line filter 41 to the input side of group modulator 31 where they combine with a frequency of 308 kilocycles selected by filter 62 from supply circuit 60. The output of group modulator 31 comprises frequencies from 400 to 448 kilocycles which are impressed on group demodulator 21. They combine in demodulator 21 with a wave of 340 kilocycle frequency obtained from supply circuit 50 and produce in the output of demodulator 21 a group of channel frequencies extending from 60 to 108 kilocycles representing twelve separate messages modulated on twelve different carriers. These are selected by suitable filters to be described later and are individually supplied to the

demodulators 11 from which the demodulated voice waves are obtained as already indicated.

In the case of carrier line 2 the twelve modulators 10 separately modulate twelve carrier waves of frequencies 64 to 108 kilocycles, respectively, and their outputs are impressed on group modulator 22 in the same way as described for carrier line 1. A frequency of 340 kilocycles is supplied to group modulator 22 resulting in an output frequency range the same as in the previous case. In this case, however, the second group modulator 32 is supplied with a wave of a frequency of 364 kilocycles selected by filter 63 from carrier supply circuit 60 so that the twelve channels outgoing to the carrier line 2 range in frequency from 36 to 84 kilocycles and have their frequency orders inverted.

In the case of carrier line 2 it is assumed that the upper group comprises the range 95 to 143 kilocycles which are modulated in group modulator 33 by combining them with a wave of 543 kilocycles selected by filter 64 from the common supply circuit. The output of modulator 33 embraces the same frequency range as the output of modulator 31. Group demodulator 23 is supplied with a wave of 340 kilocycles and the output comprises twelve individually modulated waves of the same ranges of frequencies as in the case of demodulator 21.

In view of the foregoing description, the drawings make it clear how the waves are treated in the case of carrier line 3 and carrier line 4. It will be observed that all of the modulators 20, 22, 24, and 26 are identical and are supplied with the same shifting frequency of 340 kilocycles. All of the demodulators 21, 23, 25 and 27 are also identical and supplied with the same shifting frequency of 340 kilocycles. The range of frequencies existing between each first group modulator and second group modulator, such as 20 and 30, and the range existing between each receiving group modulator and group demodulator, such as 21 and 31, are all identical, namely 400 to 448 kilocycles. This means, of course, that filters for selectively passing the output of the first stage grouping modulator either transmitting or receiving can all be identical. The receiving group modulator 35 of carrier line 3 is supplied with a wave frequency of 541 kilocycles selectively passed by filter 66; while receiving first group modulator 37 of carrier line 4 is supplied by the wave of 306 kilocycles selected by filter 68 from the common frequency supply 70. The only apparatus of individual design required for the different frequency patterns are the filters 61 to 68 used for selecting the individual frequency-shifting waves from the supply circuit 60.

The common carrier supply circuits may involve a base frequency wave of 4 kilocycles with a harmonic generator for deriving the required harmonic frequencies of the base wave in a manner well understood in the art. The three non-harmonic frequencies, 306 kilocycles, 541 and 543 kilocycles, may be derived in any of several ways. As an example for illustration, three separate oscillators 93, 95 and 97 of respectively 7, 6 and 5 kilocycle frequency are used together with modulators 92, 94 and 98 and filters 91 and 96 as indicated. Filter 91 selects harmonic frequency 548 kilocycles which modulates at 92 with 7 kilocycles from 93 to give 541 kilocycles. The 548 kilocycle wave modulates at 98 with 5 kilocycles from 97 to give 543 kilocycles. Filter 96 selects harmonic frequency 300 kilocycles which modu-

lates at 94 with 6 kilocycles from 95 to produce 306 kilocycles. Filter 64, 66 and 68 select the wanted frequencies. The frequency supply circuit may be common to several groups of carrier lines.

Referring to Fig. 2, the necessary circuits are shown complete for transmitting between a low frequency line, such as L—1, and carrier line 1. Low frequency line L—1 is shown at the left with its hybrid coil H and balancing network N. The transmitting branch 12 is shown leading through repeating coil 71 to the modulator 10 which may be of a type disclosed and claimed in United States patent to F. A. Cowan 1,959,459, May 22, 1934, comprising four copper oxide rectifiers arranged in the form of a bridge with the speech waves applied across one diagonal and the carrier waves applied across the other diagonal as shown. Such a modulator when properly balanced suppresses the unmodulated carrier component. The lower side-band is selected by the band filter 72, the other side-band being suppressed. Resistance pad 73 improves the impedance in which the band filter 72 is terminated on the side toward modulator 10. Other band filters for the remainder of the group of twelve lines similar to L—1 have their outputs connected in parallel with filter 72, two such filters being indicated for illustration at 74 and 75. The band filters 72, 74, 75, etc., may advantageously be of the type employing piezoelectric crystals for obtaining sharp selectivity, such filters being particularly efficient in the range 60 to 108 kilocycles occupied by these twelve side-bands.

The group of twelve side-bands from these filters is impressed on group modulator 20 which is indicated as of the general type disclosed and claimed in F. A. Cowan Patent 2,025,158, December 24, 1935. This is a double balanced modulator which suppresses the 340 kilocycle component used as the shifting frequency as well as the 60–108 input frequencies and the group filter 77 selectively passes the range 400 to 448 kilocycles through suitable amplifier as indicated to the second group modulator 30 of the same type as modulator 20. Group modulator 30 is supplied at its conjugate terminals with a suitable shifting frequency, in this case 484 kilocycles, which causes the frequencies to be stepped down to the range 36 to 80 kilocycles for transmission over carrier line 1. This latter range is selectively passed by the line filter 40 which suppresses the unused upper side-band.

Referring now to the receiving circuits, the line filter 41 selectively passes the frequencies received from carrier line 1 to the group receiving modulator 31 which is of the same type as modulators 20 and 30 and which is supplied with a proper frequency-shifting wave, in this case of 308 kilocycles. Group filter 31 is the same as filter 77 and passes the range of 400 to 448 kilocycles. Receiving group demodulator 21 is supplied with a 340 kilocycle wave as indicated and steps the frequencies down to the range of 60 to 108 kilocycles which are selectively passed by

filter 82. These are suitably amplified and impressed on the channel filters 83, 84, etc., leading to the twelve individual demodulators for the twelve voice lines of the group. Filter 83, pad 86 and demodulator 85 are similar to the corresponding elements previously described in the case of the transmitting channel. The resulting voice frequency waves after suitable amplification are impressed on the line L—1.

The various circuit details that have been disclosed herein and the specific frequency values are to be taken as illustrative rather than limiting. The invention is not to be construed as limited to the detailed features of the disclosure but its scope is indicated in the attached claims.

What is claimed is:

1. In a carrier signaling system, a plurality of lines adjacent one another and having an appreciable cross-talk factor, message input circuits for each line, modulators of interchangeable type for the message input circuits of respective lines, for producing a similar group of message-modulated carrier waves for each line, interchangeable first group-modulators for the respective lines for translating the respective groups of message-modulated carrier waves to similar higher frequency bands, interchangeable second group-modulators and frequency supply circuits therefor for stepping the frequencies of the groups of modulated waves downward by a different amount in the case of each line and applying the waves of stepped-down frequency to the respective lines so that the individual message-modulated waves traversing the lines are interleaved in the frequency spectrum.

2. A system according to claim 1 in which certain of said second-group modulators in stepping down the frequencies of the group of modulated waves also inverts the frequency order within the side-bands so that the latter are applied to the carrier line with their frequency order inverted.

3. In a carrier signaling system, a plurality of carrier lines adjacent one another and having an appreciable cross-talk factor, a receiving station for such lines, each line being traversed by carrier channels some of which are in off-set frequency relation from line to line, group modulators of interchangeable type for the several lines and frequency supply circuits therefor for receiving the channel waves from the respective lines and stepping them upwards in frequency by a different amount where necessary to translate them to the same high frequency range, interchangeable group-demodulators for the several lines for stepping the frequencies of the groups of channel waves from such high frequency range downward by the same amount, individual interchangeable message demodulators for deriving message waves from the channel waves of stepped down frequency, and line circuits leading from said message demodulators to the eventual receiving points.

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