Aug. 20, 1946. W. A. PHELPS 2,406,034

CARRIER WAVE SIGNALING SYSTEM

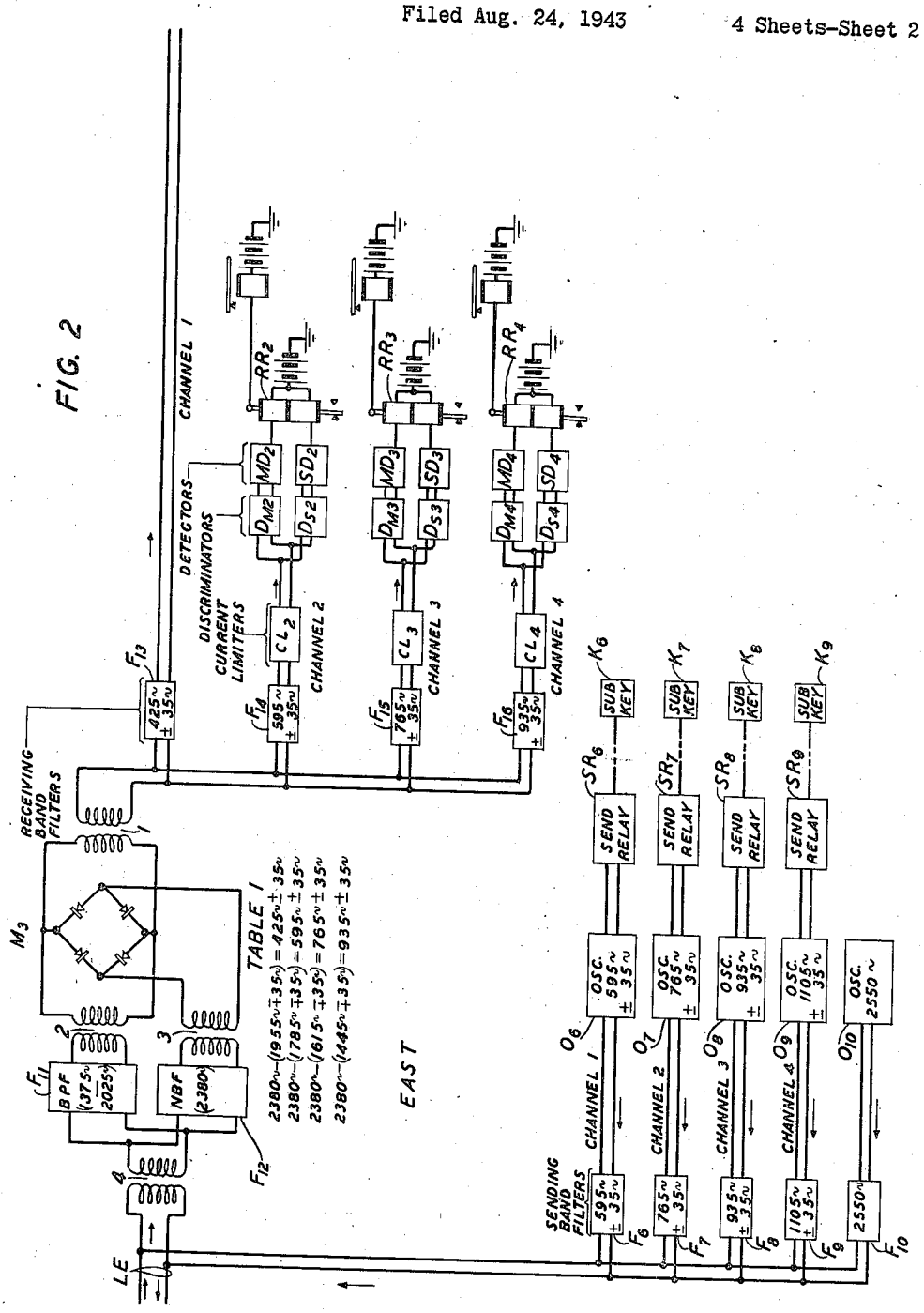
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CARRIER WAVE SIGNALING SYSTEM

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FIG. 2



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CARRIER WAVE SIGNALING SYSTEM

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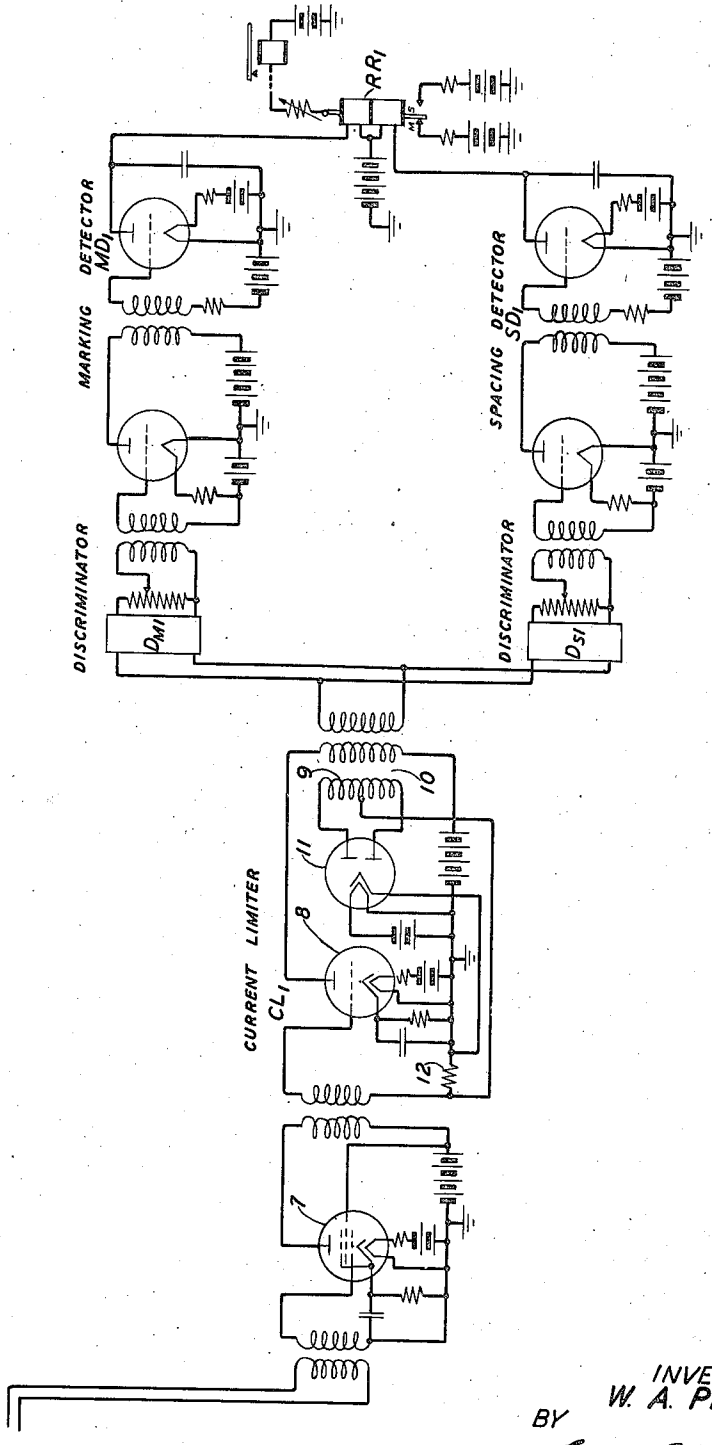


FIG. 3

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CARRIER WAVE SIGNALING SYSTEM

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FIG. 4

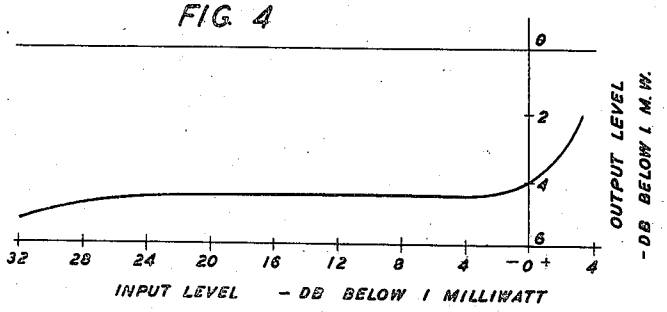


FIG. 6

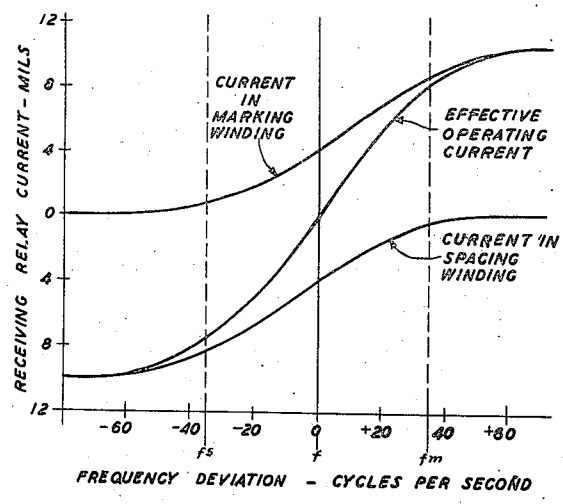


FIG. 5

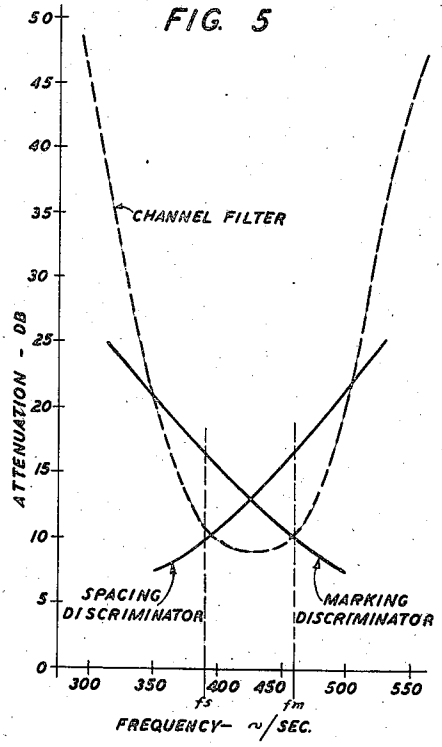
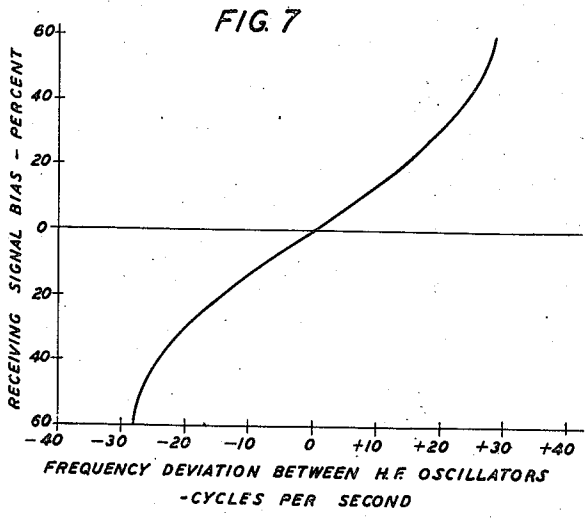


FIG. 7



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UNITED STATES PATENT OFFICE

2,406,034

CARRIER WAVE SIGNALING SYSTEM

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Application August 24, 1943, Serial No. 499,773

5 Claims. (Cl. 179—4)

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The invention relates to carrier wave signaling systems and particularly to carrier telegraph systems.

The invention is particularly applicable to, although not limited to, such a system including as a link therein, a multichannel voice-frequency carrier telegraph system utilizing in each channel two tones of voice frequency slightly separated in the frequency spectrum, respectively for the transmitted "marking" and "spacing" telegraph signal impulses representing a telegraph message, which are separately detected at the receiving end of the system and applied to the opposing windings of the channel polar receiving relay causing its operation to repeat the marking and spacing signals. Where it is desired to transmit the voice-frequency telegraph signals of such systems between widely separated points efficiently and cheaply, one of the voice-frequency carrier telegraph terminals may be located at each of those points, and a portion of an existing high frequency transmission system extending between those points, for example, a high frequency channel of a single side-band (suppressed carrier) telephone system, utilized for transmitting the telegraph signals between the voice-frequency terminals. In that case, a group modulator with an associated high frequency carrier source at the transmitting end of the high frequency channel would be utilized for stepping up the fundamental voice-frequency carrier channels to the higher frequencies required for transmission over it, and a group demodulator with an associated high frequency carrier source at the receiving end of the high frequency channel, for stepping down the received carrier telegraph channels to voice frequencies for reception.

In certain of the existing high frequency systems which may be used in such a combination system, the high frequency oscillators associated with the group modulator and demodulator in the high frequency channel for each direction are normally operated unsynchronized. They may, therefore, have instantaneous frequency differences between them at times which may be sufficient, particularly where the telegraph signals are applied to the voice-frequency carriers by frequency modulation, to introduce intolerable signal bias variations in the received telegraph channels.

An object of the invention is to reduce signal distortion in carrier telegraph systems.

A more specific object is to reduce to an unobjectionable amount signal bias variations in the telegraph channels of a multichannel voice-frequency carrier telegraph system employing frequency modulation, operated over a high frequency channel employing unsynchronized high frequency carrier sources associated with the group modulation and demodulation apparatus at its opposite terminals.

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These objects are attained in accordance with the invention by sending out over the high frequency line of such a system, along with the telegraph signal-modulated carriers, an unmodulated pilot wave of suitable frequency, which at the receiving end of the system is combined in a modulator with the received signal-modulated carriers prior to their separation and detection, to transform them to desired low frequencies. The final modulation process effectively cancels out from the received signals any variations introduced by deviations between the frequencies of the unsynchronized high frequency carrier sources associated with the group modulator and demodulator in the high frequency link.

The various features and objects of the invention will be better understood from the following detailed description when read in conjunction with the accompanying drawings in which:

Figs. 1 to 3 in combination show schematically a two-way carrier telegraph system employing frequency modulation, embodying the invention; and

Figs. 4 to 7 show curves used to explain the invention.

Figs. 1 to 3, when placed side by side in that order with Fig. 1 at the left, show a complete two-way carrier telegraph system providing four message channels in each direction, consisting of a west and an east two-way voice frequency carrier telegraph terminal and an intermediate two-way high frequency transmission link HFL, which may be one two-way high frequency channel of a multichannel single side-band carrier telephone system, converted to telegraph use.

The high frequency transmission link HFL of the combination system, as shown in Fig. 1, comprises a west-to-east one-way high frequency repeating path EA and an east-to-west one-way high frequency repeating path WA coupled at their west and east terminals in conjugate relation with each other and in energy transmitting relation with the west two-way line section LW and the east two-way line section LE by means of the hybrid repeating coil HC_W and the associated line balancing network N_W, and the hybrid repeating coil HC_E and associated line balancing network N_E, respectively. The path EA includes in its input and output the band-pass filters F_{23}

and F_{24} respectively adapted to pass only a band of frequencies corresponding to the total frequency range of the modulated voice-frequency carriers and pilot wave generated at the west voice-frequency carrier telegraph terminal, and the path WA in its input and output the band-pass filters F_{25} and F_{26} respectively adapted to pass only a band of frequencies corresponding to the total frequency range of the modulated voice frequency carriers and pilot wave generated at the east voice frequency carrier telegraph terminal in the manner to be described. The path EA also includes in its input, to the east of filter F_{23}, a group modulator M_1 and associated carrier source O_{11} generating the high frequency f_1, and in its output, to the west of band-pass filter F_{24}, a group demodulator D_1 with an associated carrier source O_{12} of corresponding nominal high frequency f_1. The path WA also includes in its input, to the west of filter F_{25}, a group modulator M_2, with an associated carrier source O_{13} of the high frequency f_2; and in its output to the east of filter F_{25} a group demodulator D_2 with an associated carrier source O_{14} of the nominal high frequency f_2.

The transmitting circuits of the two-way voice frequency carrier telegraph terminal at the west and of the combined system, as shown in Fig. 1, include four oscillators O_1 to O_4 normally generating carrier currents of the voice frequencies 1445, 1615, 1785 and 1955 cycles for the four transmitting channels 1 to 4. These oscillators may be of the vacuum tube type illustrated for the oscillator O_1 in channel 1 which is shown in more detail. These carrier currents are respectively modulated by separate sending circuits associated with the respective oscillators, to impress telegraph signals constituting a separate message on each carrier. The sending circuit in channel 1 comprises the polar telegraph sending relay SR_1 which is controlled by the telegraph key K_1 or its equivalent in one subscriber's loop. Similarly, the sending circuit in each of the other three channels comprises one of the polar telegraph sending relays SR_2 to SR_4 respectively controlled by one of the operating keys K_2 to K_4, or the equivalent, in other respective subscribers' loops.

When the key K_1 in channel 1 is closed to provide an energizing circuit from the associated battery to the operating winding of sending relay SR_1, that relay is operated to its marking contact m, and when the key K_1 is opened to de-energize the operating winding, that relay is operated to its spacing contact s. The relay connections to oscillator O_1 are such that the capacitance in the tuned circuit of that oscillator is changed by a sufficient amount for the two operating conditions of relay SR_1 to swing the carrier generated by the oscillator 35 cycles to one side of the normal carrier frequency (1445 cycles) for a marking signal and 35 cycles on the other side of the normal carrier frequency for a spacing signal. Thus, by alternately closing and opening the key K_1, the carrier wave of nominal frequency 1445 cycles in channel 1 may be frequency modulated in accordance with a telegraph message to be transmitted.

Similarly, the frequencies of the carriers generated by the similar oscillators O_2 to O_4, indicated by boxes, in channels 2 to 4, respectively, may be shifted ± 35 cycles from the nominal values of 1615, 1785 and 1955 cycles, respectively, by operation of the associated sending relay SR_2 to SR_4 alternately to their marking and spacing contacts under control of the telegraph keys K_2 to K_4 in the associated subscriber's loops, to provide frequency-modulated voice-frequency carrier waves representing respectively different telegraph messages to be transmitted. The frequency-modulated carriers in the output of oscillators O_1 to O_4 in the four channels 1 to 4 pass respectively through the associated sending band filters F_1 to F_4, respectively adapted to pass the frequency bands 1445 ± 35 cycles, 1615 ± 35 cycles, 1785 ± 35 cycles and 1955 ± 35 cycles.

In addition to the four carrier oscillators O_1 to O_4 at the west terminal, there is provided a fifth oscillator O_5 which generates another voice-frequency of 2380 cycles which passes unmodulated through the associated filter F_5 selective to its frequency. The outputs of the five filters F_1 to F_5 are bridge in parallel across the common two-way line section LW so that the four frequency-modulated carriers and the unmodulated pilot wave of a frequency of 2380 cycles are superposed in that line section and pass thereover to the west terminal of the high frequency transmission link HFL.

Similarly, at the east end of the system the transmitting circuits of the east voice-frequency carrier telegraph terminal, as shown in Fig. 2, include four oscillators O_6 to O_9 normally generating carrier currents of the different voice frequencies 595, 765, 935, 1105 cycles for the four carrier telegraph channels in the east-to-west direction. The oscillators O_1 to O_9 are adapted to be respectively controlled by the associated sending circuit comprising sending relay SR_6 and the associated subscriber's key K_6, the sending relay SR_7 and the associated subscriber's key K_7, the sending relay SR_8 and the associated subscriber's key K_8, or the sending relay SR_9 and the associated subscriber's key K_9 in a manner similar to that described for the similar channels at the west terminal of the system, to swing the carrier for each channel 35 cycles to one side of its normal frequency value for a marking signal and 35 cycles to the other side for a spacing signal. In addition to the four carrier oscillators O_5 to O_9 at the east terminal, there is a fifth carrier oscillator O_{10} generating a frequency of 2550 cycles which is unmodulated by telegraph signals. The marking and spacing telegraph signal outputs of the carrier oscillators O_6 to O_9 and the unmodulated output of the 2550-cycle oscillator O_{10} are respectively selected by the transmitting band filters F_6 to F_{10} and are superposed in the two-way line section LE over which they pass to the east terminal of the high frequency transmission line HFL.

The voice-frequency carrier telegraph receiving circuits at the east terminal of the system, shown in Figs. 2 and 3, include a balanced modulator M_3 which may be of the second order type, such as disclosed, for example, in F. A. Cowan Patent 1,959,459. The modulator M_3 includes four copper-oxide rectifier units connected in a Wheatstone bridge formation; an output transformer 1 connected across one diagonal of the bridge, one input circuit, including the band-pass filter F_{11}, passing the frequency range 1375–2025 cycles corresponding to the frequency range occupied by both the marking and spacing signals of all four voice-frequency carrier telegraph channels generated at the west terminal, connected by transformer 2 across that same diagonal of the bridge, and a second input circuit, including the narrow band filter F_{12} selective to the frequency 2380 cycles produced by the pilot

wave oscillator O_5 at the west terminal, connected by transformer **3** across the other "conjugate" diagonal of the bridge. The two input circuits of modulator M_3 are fed in common through transformer **4** from the two-way line section LE terminating the east end of the high frequency channel HFL with the waves of voice frequency received from that channel, the pass frequency ranges of filters F_{11} and F_{12} being such as to prevent the outgoing signal outputs of the transmitting band filters F_6 to F_{10} bridged across the line section LE from feeding into the input of the modulator M_3.

Neglecting for the moment the effect of any variations produced in the transmitted signal-bearing voice frequency carriers because of variations between the frequencies of the unsynchronized high frequency carrier oscillators in the intermediate high frequency carrier link HFL, the operation of the voice frequency carrier telegraph receiving circuits at the east terminal is as follows: The four frequency-modulated carrier waves of the frequencies 1445±35 cycles, 1615±35 cycles, 1785±35 cycles and 1955±35 cycles and the one unmodulated pilot wave of 2380 cycles received in the line section LE over the high frequency carrier link HFL from the west terminal of the system will pass through the transformer **4** to the conjugate input circuits of modulator M_3. The four signal bearing waves will be selected by the band filter F_{11} and will be impressed by transformer **2** on one diagonal of the copper-oxide rectifier bridge of the modulator M_3 and will combine with the 2380-cycle unmodulated pilot wave, selected by filter F_{12} and impressed by transformer **3** on the other conjugate diagonal of the bridge, to produce the desired output frequencies shown in Table 1 to the right of modulator M_3. These desired frequencies are respectively selected and passed on by the narrow receiving channel band filters F_{13}, F_{14}, F_{15} and F_{16} connected in parallel to the output of modulator M_3, the undesired products of modulation in modulator M_3 being rejected by those filters. From this point it will be sufficient to trace the path in one channel only as all perform in a similar manner.

Considering receiving channel **1**, the current out of the 425-cycle filter F_{13} swings back and forth between 425+35 cycles and 425−35 cycles for the received marking and spacing signals. This current of varying frequency then passes into the current limiter CL_1 comprising the two transformer coupled-amplifying vacuum tube stages **7** and **8**, a portion of the output of the second stage tube **8** being picked off through a third winding **9** on output transformer **10**, rectified by the full-wave rectifier **11** and passed through the series resistance **12** in the control grid-cathode circuit of tube **8** to provide a varying direct current bias on its control grid. The circuit constants of the current limiter CL_1 and those of the similar current limiters in the other receiving channels at both terminals of the system are selected such as to produce a current input-current output characteristic resembling that of Fig. 4. It will be observed that for a wide range of input levels, the output is nearly constant. The purpose of this limiter circuit is to provide at its output current of closely constant amplitude, regardless of the frequency variation of its current input and regardless of the rather wide swings in amplitude which may be caused by line equivalent variations. There then will be impressed on the marking discriminator D_{M1} and the spacing discriminator D_{S1} having their inputs connected in parallel to the output of the current limiter CL_1, a current of constant amplitude and of a frequency which may be steady or variable, depending on whether the channel is standing idle or transmitting signals.

The discriminators D_{M1} and D_{S1} consist merely of high- and low-pass filters or tuned circuits, respectively, of simple design. Their characteristics are shown in Fig. 5 with that of the receiving channel band filter F_{13}, drawn in dotted lines to show the band limits. When the received carrier current is at the marking frequency *fm*, the loss through the marking discriminator D_{M1} is low and the loss through the spacing discriminator D_{S1} is high. Therefore, the marking current out of the discriminator D_{M1} is at a maximum and the spacing current out of the spacing discriminator D_{S1} is at a minimum. As the frequency is shifted from *fm* to *fs*, the loss through the discriminator D_{M1} increases and that through the discriminator D_{S1} decreases. When the carrier reaches *fs*, the current out of the discriminator D_{S1} has reached a maximum and that out of the discriminator D_{M1} has reached a minimum. It will be noted that the modulation process in M_3 has turned over the frequency deviation. The marking frequency in channel **1** started out from the west terminal as 1955—35 cycles and became 425+35 cycles in the output of modulator M_3.

The currents out of the discriminators D_{M1} and D_{S1} are amplified and rectified in the marking detector MD_1 and the spacing detector SD_1, respectively, and the result is a push-pull current in the marking and spacing windings of the polar receiving relay RR_1, respectively connected to the outputs of those detectors. Typical marking and spacing winding currents in the receiving relay RR_1 are shown in the curves of Fig. 6.

The push-pull currents in the windings of the relay RR_1, produced by the detected marking and spacing currents, cause the armature of that relay to move back and forth between its marking contact *m* and its spacing contact *s*, which repeats the telegraph signals to the subscriber's receiving loop connected to those contacts causing the operation of the printer, sounder or other receiving or recording device in that loop in accordance with the repeated signals. In receiving channels **2**, **3** and **4**, the receiving apparatus is similar to the receiving apparatus in channel **1**, as indicated by the use of the same identification characters but with suitable subscripts corresponding to the number of the channel, and operates in response to the marking and spacing signals in the output of modulator M_3 of the frequencies 595±35 cycles, 765±35 cycles and 935±35 cycles, respectively, in a manner similar to that which has just been described for channel **1** to cause operation of the channel receiving relays RR_2 to RR_4 to repeat these signals to the subscriber's receiving loops respectively connected to the channels.

Similarly, the voice-frequency telegraph receiving circuits at the west terminal of the system, as shown in Fig. 1, include a balanced second order modulator M_4 of the copper-oxide rectifier bridge type, similar to the modulator M_3 at the east terminal, having its conjugate input branches respectively including a band-pass filter F_{17} and the narrow band-pass filter F_{18} fed in common through transformer **5** from the two-way line section LW terminating the west end

of the high frequency transmission link HFL, and its single output circuit coupled by output transformer 6 in parallel to the inputs of the four receiving band filters F_{19} to F_{22} in the receiving carrier telegraph channels 1 to 4. The four frequency-modulated carrier waves of the frequencies 595±35 cycles, 765±35 cycles, 935±35 cycles and 1105±35 cycles generated by the sending circuits at the east terminal and the accompanying unmodulated pilot wave of the frequency 2550 cycles generated at that terminal pass from the two-way line section LW through the input transformer 5 to the modulator M_4. The four signal bearing waves are selected out by the band filter F_{17} passing the frequency range 525 to 1175 cycles in one input branch, and are combined in the modulator M_4 with the 2550-cycle pilot current selected by the filter F_{18} in the other conjugate input branch, to produce the four desired output frequencies in the output of the modulator, shown in Table 2 to the left of that modulator. These desired frequencies pass through output transformer 6 and are respectively selected by the receiving band filters F_{19} to F_{22} in the four receiving channels, the undesired products of modulation in the output of the modulator M_4 being rejected by these filters.

In receiving channel 1 at the west terminal, the current output of filter F_{19} swings back and forth between 1445+35 and 1445−35 cycles with the marking and spacing signals. This current of varying frequency then passes through the individual current limiter CL_5 for channel 1, which provides an output current of substantially constant amplitude regardless of the frequency variation and regardless of the wide swings in amplitude in the current input caused by line equivalent variations. The output of the current limiter CL_5 is impressed on the parallel-connected inputs of the marking and spacing discriminators D_{M5} and D_{S5}, similar to the corresponding discriminators in each receiving channel at the east terminal just described and operating in similar manner. The currents out of the discriminators D_{M5} and D_{S5} are respectively amplified and detected in the marking detector MD_5 and the spacing detector SD_5, and the resulting detected currents are applied in push-pull to the marking and spacing windings of the polar receiving relay RR_5 to cause alternate operation of its armature to its marking and spacing contacts to repeat the telegraph signals to the subscriber's receiving loop associated with that channel.

Similarly, the frequency-modulated carrier outputs of the filters F_{20} to F_{22} in the telegraph receiving channels 2 to 4 at the west terminal, of the frequencies 1615±35 cycles, 1785±35 cycles and 1955±35 cycles, are respectively operated on by the current limiter, marking and spacing discriminators, and the marking and spacing detectors of the corresponding channels in a manner similar to that which has been described for the similar elements in channel 1, to provide respective alternate operation of the channel receiving relays RR_6 to RR_8 to their marking and spacing contacts, to repeat the marking and spacing telegraph signals for those channels to the connected subscriber's receiving loop to operate a printer, sounder or other receiving or recording device.

In the above description of the passage of the frequency-modulated carrier waves and of the unmodulated pilot wave from the transmitting apparatus at the west voice frequency carrier telegraph terminal to the voice frequency telegraph receiving apparatus at the east terminal, and vice versa, the action of the high frequency apparatus in the intermediate high frequency transmission link HFL, not previously described in detail, is as follows.

The easterly directed voice-frequency carrier channels and the accompanying unmodulated pilot wave generated by the voice-frequency carrier telegraph transmitting apparatus at the west terminal passing into the two-way line sections LW at that terminal, will be impressed by the hybrid coil HC_W on the input of the west-to-east repeating path EA in the link HFL in which they will be selected by the band-pass filter F_{23} having a pass range which includes all of those frequencies but excludes those of the westerly directed voice-frequency channels and pilot wave. The selected voice frequency-modulated carrier output of the filter F_{23} in the path EA will be impressed on the modulator M_1 in which it will be combined with the high frequency carrier of nominal value f_1 supplied from the associated oscillator O_{11}, to step up the voice-frequency carrier channels and the pilot wave, to frequencies suitable for transmission over that path. At the east terminal of the high frequency path EA, the received carrier channels of stepped-up frequencies are combined in the demodulator D_1 with a high frequency carrier wave of the same nominal frequency f_1 supplied to the demodulator from the associated oscillator O_{12}, to step the carrier channels down again to their original frequencies which are selected by the band-pass filter F_{24} in the output of the path EA, having the same pass range as the filter F_{23}, and are impressed by the hybrid coil HC_E on the two-way line section LE. The received voice-frequency channels and pilot wave will pass from the line section LE to the voice-frequency carrier telegraph receiving circuits of the east terminal described above.

Similarly, the westerly directed voice-frequency carrier channels and the unmodulated pilot wave generated in the voice-frequency carrier telegraph transmitting apparatus at the east terminal of the system of Fig. 1, passing into the two-way line section LE will be impressed by the hybrid coil HC_E on the east-to-west repeating path WA of the intermediate high frequency link HFL and will be selected by the band-pass filter F_{25} having a suitable frequency pass range. The selected frequencies in the output of the filter F_{25} will be combined in modulator M_2 in the input of the path WA with the high frequency carrier of nominal frequency f_2 supplied from the associated carrier oscillator O_{13}, to step-up all of the voice-frequency channels and the pilot wave to high frequencies suitable for transmission over that path, and at the west terminal of the high frequency link HFL the received waves will be combined in the demodulator D_2 with the high frequency carrier of nominal frequency f_2 supplied from the associated carrier oscillator O_{12} to step them down again to their original voice frequencies. These frequencies will be selected by the band-pass filter F_{25} of suitable transmission frequency range, and impressed by the hybrid coil HC_W on the two-way line section LW from which they will pass to the voice-frequency carrier telegraph receiving circuits of the west terminal described above.

Unless the high frequency carrier sources associated with the group modulator and the group demodulator in the repeating path for each di-

rection in the high frequency link HFL are definitely synchronized over the line, their frequencies are never exactly alike, and in the particular high frequency channel with which the voice-frequency carrier telegraph channels of the invention were actually combined, it was found that they may differ at times by as much as 15 cycles. It has been found by experiment that such a 15-cycle deviation between the high frequency carrier oscillators with a frequency-modulation voice frequency carrier telegraph system such as illustrated in Figs. 1 to 3, but not including the arrangements of the present invention, would result in a signal bias variation of about 20 per cent in the telegraph receiving channels. The characteristics from which this was deduced is shown in Fig. 7. The curve of that figure shows the percentage signal bias variation produced in a telegraph receiving channel of the system for different values of frequency deviation in cycles between the high frequency carrier oscillators associated with the group modulator and the group demodulator at the input and output, respectively, of the high frequency channel feeding it.

Let us assume that oscillator O_{11} associated with the group modulator M_1 in the west-to-east side of the high frequency link HFL in the system of Fig. 1, is at the correct frequency, and that the oscillator O_{12} associated with the demodulator D_1 in the output of that side is 15 cycles lower. The easterly directed channel 4 current at frequency 1445±35 cycles, after passing through the demodulator D_1 at the east terminal of the high frequency channel would, in a conventional frequency modulation system, have a frequency of 1445±35−15 cycles under the assumed condition of oscillator O_{12} being 15 cycles low. By the time this signal reached the receiving relay RR_1 in receiving channel 1 at the east terminal, it will have a light bias of about 20 per cent, as indicated by the curve of Fig. 7, above the point −15 on the frequency axis. But in the circuit illustrated in Figs. 1 to 3, a pilot wave of the frequency 2380 cycles has been transmitted along with the channel frequencies and this also emerges from the output of the demodulator D_1 15 cycles low. When these two currents are combined in the modulator M_3 in the common receiving circuit at the east terminal of the system, a combination of this type ensues:

$$(2380-15)-[(1445-15)\mp 35 \text{ cycles}]= 935\pm 35 \text{ cycles} \quad (1)$$

which is the same frequency as would be obtained when the frequencies from the oscillators O_{11} and O_{12} were considered to be exactly the same. Thus, the frequency variations introduced in the intermediate high frequency line have been effectively cancelled out in the final modulation process. The same would be true in the case of each of the other channels. Thus the scheme of the invention may be used to make the received frequency in any frequency-modulated carrier telegraph channel independent of any frequency variation between separate and unsynchronized carrier oscillators associated with the modulator and demodulator in any intermediate high frequency carrier link.

Various modifications of the circuits illustrated and described which are within the spirit and scope of the invention will occur to persons skilled in the art.

What is claimed is:

1. In combination, a group of low frequency carrier communication channels and a separate pilot channel, means at a transmitting point for combining each of said channels with a high frequency carrier for transmission, means at a receiving point for combining the received high frequency waves with a carrier of nominally the same high frequency as the high frequency carrier at the transmitting point, to demodulate the received communication channels and the received pilot channel, and modulating means for combining each of the demodulated carrier channels with the demodulated pilot channel to compensate for any frequency differences between the high frequency carriers at the transmitting and receiving points tending to distort the transmitted carrier communication channels.

2. In combination in a carrier signaling system, a high frequency transmission line, a plurality of sources respectively generating carrier waves of different low frequencies, another source generating a pilot wave of predetermined frequency, means to modulate each of said carrier waves with a different message, means to impress the modulated carrier waves and the unmodulated pilot wave on the input of said line, a group modulator with an associated high frequency carrier source in the input of said line for stepping up the frequencies of all of the impressed waves to those suitable for transmission over that line, a group demodulator with an associated high frequency carrier source of the same nominal frequency as the first high frequency carrier source, in the output of said line for stepping down the received waves to their original frequency values, a second modulator fed from the output of said line, for combining each of the applied low frequency-modulated carriers with the received unmodulated pilot wave to transform the former to desired lower frequencies, and to eliminate therefrom any variations therein caused by any frequency differences between the high frequency carrier sources associated with the group modulator and group demodulator of the high frequency line, and means to separate the resulting modulated carrier waves and to separately detect the message components therein.

3. In a carrier wave signaling system including low frequency carrier signal transmitting and receiving circuits at each terminal thereof and an intermediate two-way high frequency transmission link including group modulating and demodulating devices with associated high frequency carrier sources for respectively stepping up the low frequency carrier signals received by said link from the low frequency carrier signal transmitting circuits at each terminal to high frequencies suitable for transmission over that link, and for stepping down the high frequency carrier signals received at each terminal over said link to their original frequency values before supplying them to the low frequency carrier signal receiving circuits at that terminal, the low frequency carrier signal receiving circuits at each terminal including other modulating means for combining each of the received low frequency carrier signals with a carrier wave of suitable frequency to transform the former to desired low frequency values before they are separated and the signal components detected therefrom, and means to reduce distortion of the detected signal components due to relative instantaneous frequency differences between the high frequency carrier sources in the intermediate high frequency transmission link comprising means for supplying

said carrier waves of said suitable frequency combined with each received low frequency carrier signals in the low frequency carrier signal receiving circuit at each terminal, over said high frequency transmission link from the other terminal so that they are subjected to the same frequency variations in that link as the transmitted carrier signals.

4. In combination in a multiplex carrier telegraph system, means for producing a plurality of different voice frequency carriers respectively frequency modulated with a different telegraph message, a high frequency transmission line supplied with said modulated carriers and including in its input modulating means with an associated high frequency carrier source, for stepping up the supplied waves as a group to the high frequencies suitable for transmission thereover, and in its output demodulating means with an associated high frequency carrier source for stepping down the waves received over the line as a group to their original frequencies, another modulating means for combining the modulated carriers of low frequencies received over said line with a carrier wave of suitable frequency to transform the former to suitable frequency values, means for separating the resulting modulated carriers and separately detecting the telegraph message components therefrom, and means to reduce distortion in the detected message components resulting from fortuitous frequency differences between the high frequency carrier sources associated with the group modulating and demodulating means in said high frequency line, comprising means for supplying said carrier wave of suitable frequency combined with the modulated

carriers in said other modulating means, over said high frequency line so that it is subjected to the same frequency variations as the modulated carriers transmitted thereover.

5. The combination of claim 4 in which each of said plurality of different voice-frequency carriers frequency modulated with a different message is obtained by changing the tuning of a different voice-frequency carrier oscillator under control of associated keying means so that the generated carrier is swung a given number of cycles to one side of the normal carrier frequency to produce a marking signal and the same amount to the other side of the normal carrier frequency to produce a spacing signal, the receiving circuit of said system comprising separate filters for respectively selecting both the marking signal component and the spacing signal component in each modulated carrier wave in the output of said other modulation means at the receiving terminal, separate current limiters for respectively producing from the current output of each of said filters a current of substantially constant amplitude, regardless of frequency and amplitude variations therein, other filtering means for separating the marking and spacing signal impulses in the resulting wave, detectors for separately detecting said marking and spacing signal impulses and a receiving telegraph relay having opposing windings to which the detected marking and spacing impulses are respectively applied to cause the operation of said relay to repeat the marking and spacing signals of the message.

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