

Jan. 5, 1937.

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2,066,332

CARRIER WAVE TRANSMISSION SYSTEM

Filed Dec. 14, 1934

2 Sheets-Sheet 1

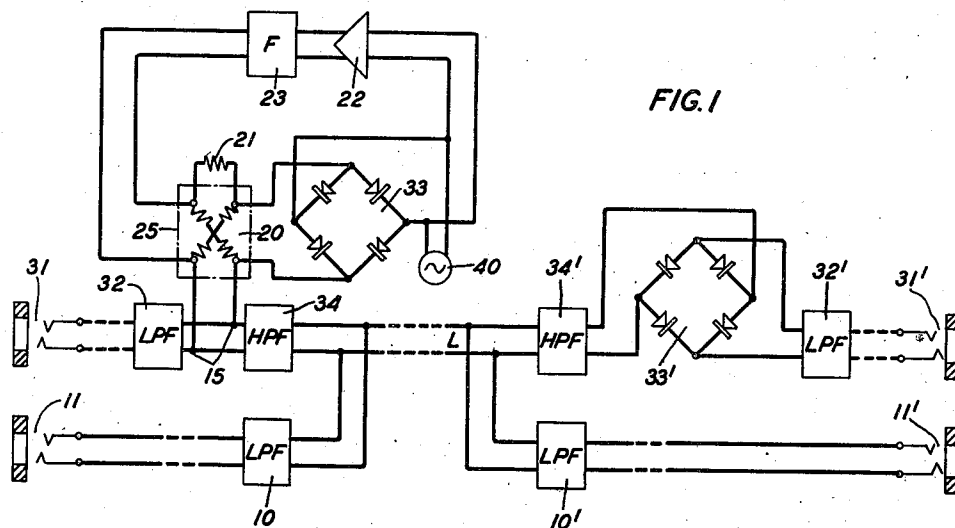


FIG. 1

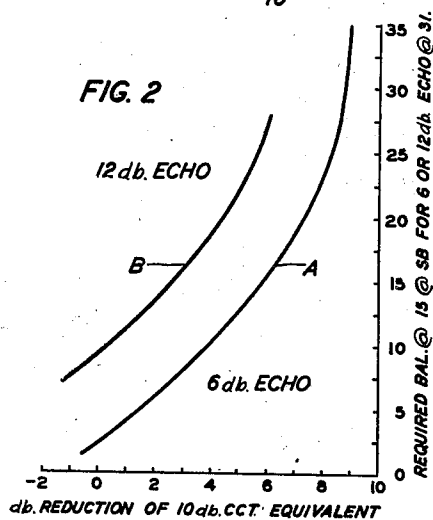


FIG. 2

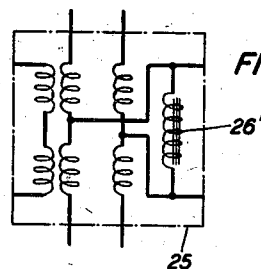


FIG. 1A

FIG. 3A

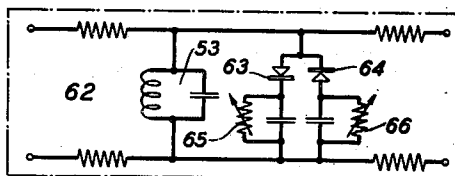
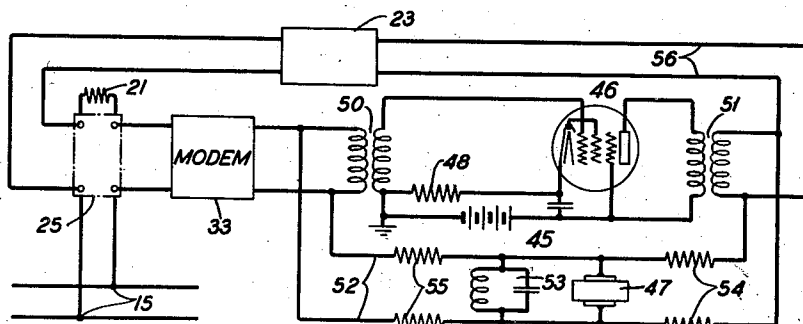


FIG. 3



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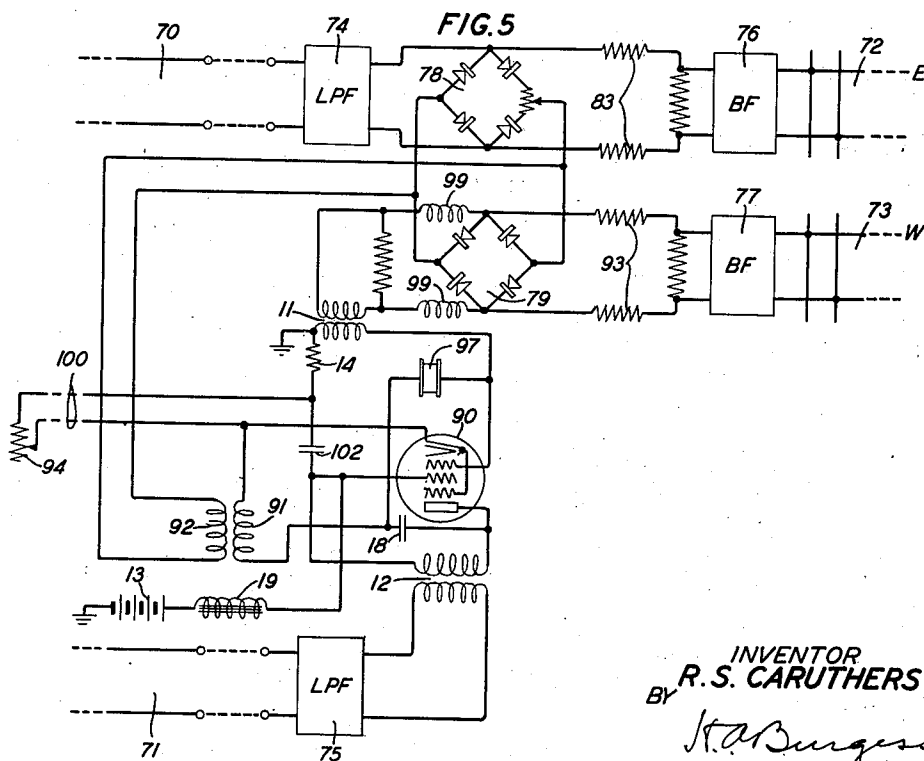
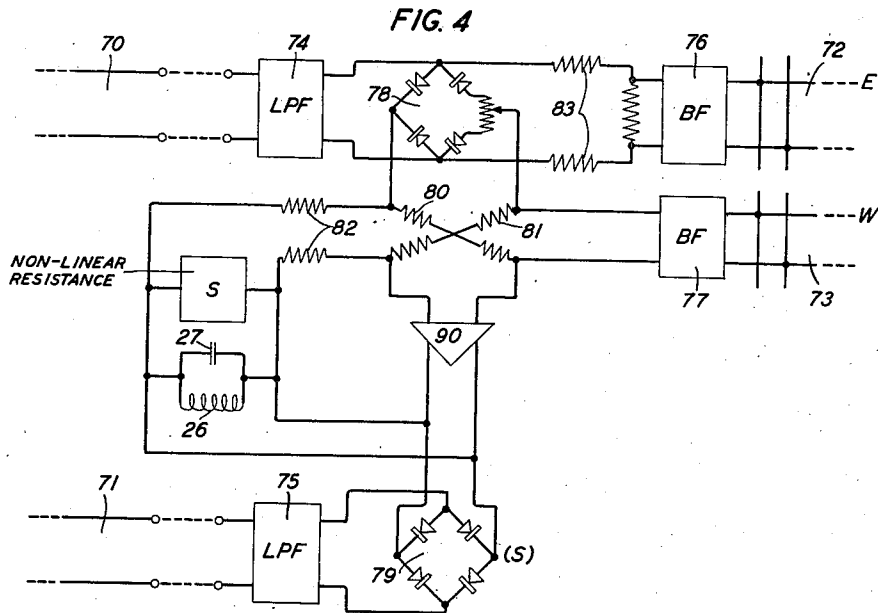
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2 Sheets-Sheet 2



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2,066,332

CARRIER WAVE TRANSMISSION SYSTEM

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Application December 14, 1934, Serial No. 757,421

12 Claims. (Cl. 179—1)

This invention relates to carrier line transmission of speech or other signals. It has particular reference to the transmission of modulated carrier current waves of the same frequency range in both directions over a system.

An object of the invention is to provide amplification in such a system in a simple and effective manner.

It becomes a difficult matter in practice to introduce two-way amplification into a carrier line transmitting in both directions within the same frequency range, because of the difficulty of maintaining suitable line balance.

A carrier channel utilizing a bilateral modulator-demodulator and the same frequency range for both directions generally includes a low-pass or voice filter on one side of the modulator-demodulator and a high-pass or other high frequency filter on the other side. It is practicable to design these filters to present an impedance across the line at a point between them approaching a constant resistance at all frequencies, the degree of approach depending on how accurately the impedances and other quantities involved satisfy the mathematical relations applicable to the problem. With ordinary carrier filters and with existing line impedances an effective impedance is obtained capable of being matched, in accordance with this invention, by a simple structure (such as a resistance) sufficiently well to permit a practical degree of amplification to be used. With some special attention to impedance relations, greater gains are permissible.

In one specific form of the invention a bridge or hybrid coil balance is obtained between the impedance presented at the common terminals of these channel filters and a balancing resistance, the mutually conjugate terminals of the hybrid coil being joined by a circuit including a bilateral modulator-demodulator and an amplifier.

This type of terminal two-way amplifier-modulator-demodulator is especially advantageous in a system of the type disclosed and claimed in U. S. patent to H. S. Black, No. 1,983,528, granted December 11, 1934, in which a source of carrier waves is supplied at one terminal only of the system. An advantage of that system is that the opposite terminal needs no attention for long periods of time, so that maintenance is confined practically to the station at which the carrier source is located. The amplification that is introduced in accordance with this invention is also accomplished by provision of the amplifier at only the attended station. The invention is not limited,

however, to the type of carrier channel or system of the Black patent.

A further feature of the invention comprises the use of an amplifier for both amplifying the transmitted and received waves and generating carrier waves for the system. This is made possible, by the invention, by using an element or device having non-linear resistance to limit the amplitude of the generated oscillations to a value below the overload point of the amplifier whereby the load carrying capacity of the amplifier is divided between the two functions of amplification and oscillation production. This feature of my invention is broadly disclosed and claimed in my application for U. S. patent Serial No. 757,422 filed of even date herewith.

A feature to be claimed in the present application and closely related to the last mentioned feature comprises a combination amplifier and oscillation generator in which the non-linear resistance referred to is furnished by the modulator or demodulator of a carrier system.

This application contains subject-matter transferred from my said application Serial No. 757,422.

A better understanding of the invention and manner of its application will be had from the following detailed description of a preferred embodiment as illustrated in the accompanying drawings.

In the drawings,

Fig. 1 is a schematic circuit diagram of a single channel carrier and voice channel system embodying the invention;

Fig. 1A shows a detail modification applicable to the circuit of Fig. 1;

Fig. 2 shows curves indicating the balance requirements of the terminal circuit of Fig. 1 under given conditions;

Fig. 3 shows a modified type of circuit for generating the carrier waves and amplifying according to the invention;

Fig. 3A shows a detail modification; and

Figs. 4 and 5 show the application of wave amplifying and generating circuits to carrier systems according to the invention.

Except for the provisions for introducing amplification the circuit of Fig. 1 may be considered the same as that shown more in detail in the above noted patent of H. S. Black, the corresponding parts being similarly numbered in the two drawings.

Referring to Fig. 1, the main line L is arranged to carry a direct voice transmission and another transmission at carrier frequency, the terminal

points of the voice channel being indicated at jacks 11, 11' and the voice frequency terminals of the carrier channel being shown at 31, 31'. Low-pass filters 10, 10' and high-pass filters 34, 34' serve to separate the voice and carrier transmissions to their respective circuits.

The carrier terminal at the left of the figure comprises low-pass filter 32 and high-pass filter 34, a "modem" unit 33 serving both as modulator and demodulator, a carrier source 40, such as a vacuum tube oscillator, a hybrid or bridge connection 20 and balancing resistance 21, and an amplifier 22. This circuit may also include a filter 23 to be referred to later.

The carrier terminal at the right of the figure comprises in addition to the high-pass filter 34', the modem unit 33' and the low-pass filter 32'.

In the operation of the system, speech waves from a line connected to jack 31 pass through low-pass filter 32 and into the branch at point 15 leading to bridge circuit 20. They are thence impressed on the modulator-demodulator 33 where they combine with carrier currents from source 40 to produce sideband waves. These sideband waves and the unmodulated carrier are amplified at 22 and pass through filter 23 to the bridge circuit terminals opposite to those to which modem 33 is connected, and thence across terminals 15, through high-pass filter 34 and out on line L.

After traversing line L, these carrier and sideband currents pass through filter 34' and are impressed on the modulator-demodulator 33' in which they produce voice waves that then pass through low-pass filter 32' to jack terminals 31' and into the connected line.

In the reverse direction voice waves from the line connected to jack 31' are impressed on the low frequency terminals of modulator-demodulator 33' after passing filter 32'. Carrier waves generated at 40 are also continuously present at the high frequency terminals of this modulator-demodulator 33' by virtue of the path just traced over line L for carrier and sidebands. The carrier and voice intermodulate to produce sideband waves which traverse line L to the station at the left where they are selectively transmitted through high-pass filter 34 and into the branch at 15 leading to the bridge connection 20. Thence they are impressed on the modulator-demodulator circuit 33 in which they interact with carrier waves from source 40 and produce voice waves. These are amplified at 22 and passed by filter 23 to the output bridge terminals and thence through low-pass filter 32 out into the connected voice line at 31.

It will be observed that the amplifier 22 introduces amplification into both the carrier and sideband waves outgoing on line L and into the demodulated voice waves that are to be impressed on the line at terminals 31. The modulator-demodulator 33 is a double balanced circuit by which is meant that its input terminals for speech, carrier and sideband waves are conjugate to its opposite or output terminals.

The impedance at terminals 15 as seen from bridge circuit 20 is the impedance of high-pass filter 34 and low-pass filter 32 in parallel. These filters as ordinarily designed and employed present an impedance at this point which approximates a constant resistance at all frequencies. Hybrid coil 20 may therefore be balanced by using a simple resistance 21 at its terminals opposite to 15. In some cases it may be necessary or desirable to use a network at 21 instead of the simple resistance shown. For example, a resist-

ance with a capacity in series or in parallel with the resistance may suffice, or in other situations a still different network may be needed. This can be determined by trial and measurement.

It is not necessary that filters 32 and 34 present an impedance at 15 which is constant at all frequencies, for a filter such as 23 in the amplifier path may be made to de-limit the frequency range that is amplified to the range for which the required degree of balance is realized. As one example, filters 32 and 34 may not have the same cut-off frequency or overlapping pass ranges, in which case there will be a region between the cut-off frequencies where an unbalance condition in the bridge connection exists. Filter 23 in that case may be a suppression type filter preventing the circulation of frequencies around the amplifier loop within the range over which the circuit has insufficient balance.

In typical short-haul systems, in which the invention will probably find greatest application, the line equivalent is of the order of 10 decibels and only such a degree of amplification is required as will reduce the equivalent to some value less than 10 decibels. For example, a gain which will produce a reduction of 6 decibels in transmission equivalent is all that may be needed in a practical case. The curves in Fig. 2 show that the balance requirements in such a case are well within the limits that can be readily met in a typical or ordinary system without resort to special refinements of filter or circuit design.

The curves of Fig. 2 are calculated curves showing the relation between the gain that is effective in reducing the assumed 10 decibel line equivalent and the required balance at point 15, assuming in the case of curve A a 6 decibel echo requirement at jack 31 and in the case of curve B a 12 decibel echo requirement at this point. These curves assume the usual 6 decibel terminal return loss at the far-end subscriber's line. It is seen from curve A that a 6 decibel reduction in equivalent is obtainable on the assumption of a 15 decibel balance at point 15 and a 6 decibel echo requirement at jack 31. For a 12 decibel echo requirement, a 27 decibel balance is needed for 6 decibel effective gain, that is 6 decibels reduction in equivalent.

In place of the bridge circuit 20 included in the dotted rectangle 25 of Fig. 1, the hybrid coil circuit of Fig. 1A may be used by direct substitution of the rectangle 25 and contents of Fig. 1A for that of Fig. 1. Choke coil 26' may be necessary or desirable in this case in order to afford a path for direct current resulting from rectification by the modem 33 of carrier from source 40.

In the case of either the bridge circuit or the hybrid coil circuit, inequality ratio of resistance arms or coil turns may be used such that the loss from the output of amplifier 22 to the line is low whereas the loss from the branch point 15 to the input side of the modem unit is high, while conjugacy is still maintained across the bridge or hybrid coil to prevent harmful feed-back that might cause singing around the repeater loop or excessive echo.

Referring to Fig. 3, a portion of a terminal circuit is shown which may replace the part of the left-hand terminal station of Fig. 1 above the branching point 15. The bridge or hybrid coil circuit is indicated by dotted rectangle 25 and the modem unit is indicated at 33. In this figure instead of using an oscillator (such as 40 of Fig. 1) which is separate and distinct from the am-

plifier (such as 22 of Fig. 1) both the functions of oscillation production and amplification are carried out in the same circuit 45 which may comprise, as in this instance, but a single vacuum tube 46.

Ordinarily if attempt is made in the same circuit both to generate oscillations and to amplify some currents other than the generated oscillations, it is found that only one of the two functions is accomplished. For example, the oscillations build up to a value limited by the overload characteristic of the tube and there is no load carrying capacity left for amplification of other waves.

Applicant is enabled to accomplish the two functions of generation and amplification in this circuit by employing a non-linear element indicated at 47, which exhibits an overload characteristic for the oscillations being generated, well below the overload point of the tube 46, thus leaving a useful load carrying margin to enable the tube to amplify speech and sideband currents. Element 47 may be a resistance material known as Thyrite comprising silicon carbide crystals and a binder as disclosed in U. S. Patent 1,822,742 to McEachron, September 8, 1931, or any other suitable non-linear resistance device.

The tube 46 has an input transformer 50 and an output transformer 51, capable of transmitting efficiently speech, sideband and carrier currents. Tube 46 is shown as a pentode having a grid bias resistor 48 through which the steady space current flows. A feed-back path 52 is provided from the secondary side of output coil 51 to the input side of input coil 50 for enabling the tube 46 to generate oscillations. The frequency of the generated oscillations is determined by the parallel resonant shunt path 53, which preferably has a very high ratio of reactance to resistance so as to discriminate against the feeding back of any except carrier frequency waves. Resistances 54 and 55 are connected in the feed-back path on either side of the Thyrite element and anti-resonant circuit as shown.

In the operation of this circuit, waves of the carrier frequency are built up in the usual manner until the loss around the closed loop equals the gain. By means of resistors 54, 55 the amplitude of the oscillations flowing in the feed-back path may be controlled, these resistors being preferably variable and adjusted to the values to give the desired ratio of oscillations transmitted through output coil 51 and those fed back. The loss in the loop circuit is determined in part by the shunt overload element 47 which, as stated, has a non-linear resistance such as to cause the loss to increase rapidly as the amplitude exceeds a certain value. By proper circuit design, the losses around the closed loop can be made to equal the gain at an amplitude much below the overload point of tube 46 and the circuit will continue to generate steady oscillations of that amplitude. These are supplied on the output side in small part to the feed-back and in larger part to the circuit 56 leading through filter 23 (if any) and eventually to the line L as in Fig. 1. A portion of the feed-back oscillations is supplied on the input side of the modem unit 33 where they serve to modulate or demodulate waves impressed on this unit, as described in reference to Fig. 1.

Sideband waves or speech waves appearing on the output side of the modem unit 33 as a result either of modulation or demodulation are impressed on the grid circuit of tube 46 through

input coil 50, are amplified and sent into the outgoing circuit 56 through output coil 51. The resistances 54 and 55 together with the shunts 53 and 47 prevent speech or sideband waves from traversing the feed-back path 52. Such waves are attenuated by the resistances 54, 55 and any speech or sideband components appearing across the terminals of shunt 53 are effectively shunted since this circuit has low impedance at all frequencies materially removed from the carrier frequency. Other means such as filters could be used to prevent waves present in the circuit other than carrier frequency waves from traversing feed-back path 52, but the means shown where adequate offer the advantage of simplicity and economy.

Fig. 3A shows an alternative type of feed-back path 62 which may replace feed-back path 52 of Fig. 3. The only difference is in the substitution of copper-oxide rectifiers as the overload element in place of Thyrite 47. Two oppositely poled copper-oxide rectifiers 63 and 64 are used. These might be unbiased or biased by batteries but the preferred circuit is as shown comprising resistor-condenser combinations 65 and 66 in series with respective rectifiers whereby the direct current component of the rectified current produces a potential drop in the resistances for bias purposes, the alternating components being passed by the shunt condensers. The operation of the circuit follows from the description given of Fig. 3, the copper-oxide rectifiers performing the load limiting function necessary to keep the oscillations below the load carrying limit of the amplifier 46.

In both Figs. 3 and 3A the overload elements 47 and 63, 64 can be omitted if the modem unit 33 is designed to introduce into the amplifier-oscillation generating circuit an overload characteristic at the proper amplitude of generated waves. This overload or limiting action should, as previously described, occur at an amplitude corresponding to a value well below that at which the amplifier itself begins to limit the current so that an effective load-carrying capacity is left for the amplifier. An economy and a simplification are introduced into the circuit by being able to omit these circuit elements.

Circuits embodying this feature are shown in Figs. 4 and 5 to which reference will now be made.

Fig. 4 indicates a terminal of a carrier telephone system comprising an eastward multiplex line 72 and a westward multiplex line 73. One branch for each line is shown in Fig. 4 and may be similar to other branches. For the transmitting line 72 band filter 76 leads to a modulating circuit connected on the other side to low frequency line 70 which may lead to an exchange where it is extended as a voice frequency line on either a four-wire or two-wire basis.

The westward or receiving line is shown with band filter 77 leading through resistance bridge network 81 and receiving amplifier 10 to demodulator 79, the output of which is connected through low-pass filter 75 to voice line 71 which may lead to the same point as voice line 70. These two voice lines 70 and 71 may be considered as eventually connected to a subscriber's line for two-way talking.

The modulator 78 and the demodulator 79 are each shown as of the bridge type employing non-linear resistances which may be copper oxide rectifiers, for example. The speech is applied across one diagonal of the bridge while the carrier used for modulating or demodulating purposes and, in

the case of demodulator 79, the sideband, are applied across the opposite diagonal.

The receiving amplifier 90 is provided with a feed-back circuit comprising frequency-determining combination 26, 27 and the non-linear resistance element S (which may comprise element 47 or elements 63, 64 of the previous figures) in a circuit similar to that of Fig. 4 of my copending application except that the bridge of that figure is omitted in this figure on the output side of the amplifier. The amplifier 90, therefore, serves as an oscillation generator producing waves of carrier frequency which are applied to the modulator 78 and the demodulator 79. The bridge comprising ratio arms 80 and 81 and as its other arms modulator 78 and input of amplifier 90 is balanced so that the oscillations generated by the tube 90 are not applied to band filter 77. The bridge is preferably adjusted so that the loss from the feed-back path into modulator 78 is low whereas the loss into the input of amplifier 90 is high. It is assumed that the same frequency carrier wave is used for a given channel on each line 72 and 73.

The operation of the circuit of Fig. 4 is as follows: Speech waves coming from the speech line to which line 70 is connected pass through low-pass filter 74 and modulate in the modulator 78 the carrier wave supplied from the amplifier-oscillator circuit 90, 26, 27. Modulator 78 is balanced so that the unmodulated carrier component is not transmitted. To aid in securing this balance a potentiometer is included between two of the copper oxide elements as shown, equipped with a slider to which one of the carrier input terminals is connected. One sideband of the resulting modulated wave is transmitted from resistance network 83 through band-pass filter 76 into the outgoing line 72. Resistance network 83 is a pad preventing transmission irregularities due to interaction of copper oxide and band filter reactances. In similar fashion waves from other lines similar to line 70 in other channels are used to modulate carrier waves of other frequencies and the resulting sideband frequencies are transmitted through other band filters to the same line 72.

By a terminal circuit which may be identically similar to that disclosed above but located at the other end of line 73, a number of sideband modulated waves are produced and transmitted over the line 73 to the station shown on the drawings. One of these sidebands passes through band filter 77 and is impressed on the bridge circuit previously described of which two of the arms are the resistances 80 and 81, and then on the input of receiving amplifier 90 where they are amplified and impressed on one diagonal of the modulator 79. Some of the carrier wave generated in the circuit comprising amplifier 90 is impressed together with the sideband components on the demodulator 79. The demodulated voice frequency components are then transmitted through the low-pass filter 75 and impressed upon the voice frequency line 71. The bridge including resistances 80 and 81 may be so proportioned that the loss from the output of band filter 77 to the input of amplifier 90 is low whereas the loss from the band filter 77 into the modulator 78 is high. A feature, already referred to, of considerable interest and importance in connection with a circuit of the type shown in Fig. 4, where the combination amplifier-oscillator 90 feeds into a non-linear resistance circuit such as 79, is that the element S may be omitted because of the non-

linear resistance characteristic of circuit 79; and the amplifier 90 may be made to perform the twofold function of generating oscillations and amplifying waves. For this purpose the non-linear circuit 79 furnishes the overload characteristic for determining the maximum amplitude of the oscillations generated in the circuit in the same manner as is described hereinbefore in connection with the element S. This represents a simplification.

Fig. 5 discloses a circuit generally similar to that of Fig. 4 but capable of greater accuracy in the frequency of the generated carrier wave. The type of oscillator circuit disclosed is essentially that of Fig. 2 of my copending application, a shunt type, but it includes a crystal 97 for accurately determining the frequency of the waves generated. It also makes use of the fact that the impedances of coils 11 and 12 are fairly pure capacity reactances at carrier frequencies on the sides facing the tube. Condenser 18 and coil 91 are arranged so that small shunting action is inserted across the high winding of coil 12 at voice frequencies. Also the junction between condenser 18 and coil 91 is effectively connected to the plate at carrier frequency and to cathode at voice frequency. This allows feed-back at carrier but none at voice frequency. Crystal 97 lies in the feed-back connection from the junction of coil 91 and condenser 18 to the grid. This makes for greater constancy of frequency of oscillations generated, as for example, with temperature changes. The output of tube 90 for the generated oscillations is from winding 91 to inductively coupled coil 92 which is connected to modulator 78 and demodulator 79.

The space current circuit for the tube 90 may be traced from ground through battery 13, choke coil 19, primary output coil 12 to the anode of tube 90, thence to the cathode, through one side of circuit 100, resistance 94, opposite side of circuit 100, resistance 14, for grid bias, back to ground. It is thus seen that both resistor 14 and variable resistance 94 are included between the cathode and ground or minus "B". The path that is traversed by speech waves is from anode through primary winding of output coil 12, condenser 102 and resistance 94 to the cathode, so that resistance 94 represents a coupling from plate to grid circuit for speech waves, this coupling being of such sign as to reduce the degree of amplification for the speech waves. The resistance 94 being variable offers a control for the gain of the amplifier tube 90 since variations in this resistance control the amount of voltage of voice frequency (as well as direct current) that is fed back reversely on the grid. The leads 100 may be extended to a convenient point for mounting the control 94 along with similar controls for other receiving channels.

It will be noted that the copper oxide rectifiers in modulator 78 are so poled with respect to those in demodulator 79 that carrier waves applied to both modulator and demodulator from the coil 92 flow alternately through 78 and 79 in opposite half waves of the carrier. This form of connection of the modulator and demodulator to the carrier supply circuit affords an impedance which is favorable to the suppression of second order harmonics from the carrier supply circuit. In some types of modulators such as those employing copper oxide rectifiers the second harmonic frequently has the largest amplitude of any harmonic. For efficiency reasons it is advantageous to have this relatively strong har-

monic current dissipated by circulating through the modulator and demodulator circuit as is done in the type of circuit of Fig. 5.

The operation of Fig. 5 is generally similar to that described in Fig. 4. Speech waves in line 70 are transmitted through the modulating apparatus and eventually into eastward carrier line 72 in the same manner as described in Fig. 4. Modulated carrier waves received over line 73 from the opposite station pass through band filter 77 and are demodulated at 79. The inductances 99 offer high impedance to the sideband current in shunt of the modulator 79 but permit the passage of speech waves with low loss. The resulting speech waves are impressed on the amplifier 90 through input coil 11 and from the output of the amplifier 90 they pass through output coil 12, low-pass filter 75 into line 71. By varying resistance 94 the gain of the amplifier 90 for the speech waves may be varied. The tube 90 continually produces oscillations of the carrier frequency as determined by the crystal 97 and the carrier frequency waves are supplied to both the modulator 78 and demodulator 79. The non-linear impedance which limits the maximum amplitude of the generated carrier oscillations is that of modulator 78 or demodulator 79 which are effectively connected across 91, by virtue of the coupling of coil 92 to this circuit. The maximum amplitude of the oscillations is limited to a point sufficiently below the overload point of amplifier 90 to permit the efficient amplification of the detected speech waves.

In a carrier system for several channels in each direction employing a terminal circuit of the type shown in either Fig. 4 or Fig. 5 each transmitting channel at a station is paired with a corresponding receiving channel, the same carrier frequency wave is used for both channels and is produced in a common oscillating circuit as disclosed. Oscillating circuits of identically the same carrier frequency are, of course, employed at the opposite terminal for each pair of channels.

The circuits that have been shown and described are to be taken as illustrative rather than as limiting, since the invention is capable of embodiment in many forms including forms other than those specifically shown. The scope of the invention is defined in the claims.

What is claimed is:

1. In a terminal circuit for a carrier current system, a voice current line terminating in a voice-frequency filter, a high frequency circuit terminating in a carrier frequency filter, a circuit having terminals connected to receive currents from both of said filters and other terminals connected to transmit carrier and sideband currents into each of said filters, said circuit including a source of carrier waves, a modulator-demodulator and an amplifier, a balanced connection for associating said sets of terminals in mutually conjugate relation to each other, with said filters, said filters presenting to said balanced connection a substantially constant impedance at all frequencies within the utilized ranges whereby the conjugacy between said sets of terminals exists for all of said frequencies.

2. In a carrier current system, a line having at a terminal a carrier frequency filter in series with a voice frequency filter, a frequency-converting circuit for receiving waves from either one of said filters and converting the waves so received to waves of suitable frequency to pass through the opposite filter, comprising a circuit

branched from a point between said filters having a balanced impedance and mutually conjugate branches and a circuit connected to said branches including a source of carrier waves, a modulator-demodulator and an amplifier.

3. In a two-way carrier system in which modulated waves of the same frequency are sent in both directions over a line, a source of carrier waves at only one terminal of the line, a bilateral modulator-demodulator at another station on the line for demodulating received waves and modulating carrier current received over said line by signals to be sent from that station, a local circuit at said one terminal having pairs of terminals connected in conjugate relation to each other and connected to the line for both transmitting to and receiving from the line, said source of carrier waves being connected to said local circuit, said local circuit including a modulator-demodulator and an amplifier, said amplifier amplifying the waves traversing the system in both directions.

4. A system according to claim 3 in which said modulator-demodulator in said local circuit is a balanced copper-oxide circuit.

5. A duplex signaling system comprising a high frequency transmission line connecting stations adapted for connection to subscribers' lines, a modulator-detector device at each station connected between said transmission line and a subscriber's line, each of said devices serving as a modulator for signals passing from the respective subscriber's line to said high frequency transmission line and as a detector for signals passing in the other direction through the device, a source of carrier current connected to the modulator-detector device at one only of said stations, said source supplying carrier current to said one device and over said transmission line to said device at the distant station, said source of carrier waves at said one station and the modulator-demodulator device at that station being included in a loop circuit, the ends of which are connected in energy transfer relation to said line but mutually conjugate to each other, and an amplifier in said loop circuit.

6. The combination with a carrier wave transmitting and receiving system having a modulating-demodulating circuit, of a space discharge device for both supplying carrier waves to said modulating-demodulating circuit and amplifying the products of the modulation and demodulation, said discharge device having input and output circuits and a feed-back connection for enabling the device to generate carrier waves, and means limiting the amplitude of the oscillations being generated to a value below the load-carrying limit of said discharge device.

7. In a carrier current terminal circuit, a combination amplifier-oscillation generator comprising a space discharge device having input, output and feed-back circuits, a modulator-demodulator, said device producing and supplying to said modulator-demodulator sustained oscillations to be modulated and demodulated, and amplifying the products of such modulation or demodulation, said feed-back circuit being effectively connected to an element having a limiting characteristic limiting the generated oscillations to an amplitude below the load-carrying limit of said device, thereby leaving a load-carrying margin for said device for amplification.

8. A two-way carrier terminal comprising a modulator-demodulator, an amplifier connected to said modulator-demodulator for amplifying

both transmitted and received signal waves, said amplifier having a feed-back circuit for causing the amplifier to generate carrier waves, circuit connections for supplying the waves so generated to said modulator-demodulator, said modulator-demodulator introducing a non-linear resistance into the amplifier-oscillation generating circuit and limiting the amplitude of the generated oscillations to a value below that corresponding to the effective load limit of said amplifier.

9. In combination, a wave modulator, an amplifier, a source of modulating waves, circuit connections for causing said amplifier to generate oscillations and supply them to said modulator for modulation therein by said modulating waves, circuit connections for impressing wave products of such modulation on said amplifier for amplification, said modulator serving to limit the amplitude of the oscillations generated by said amplifier to a point below the overload point of the amplifier whereby said amplifier is enabled to amplify said wave products of modulation.

10. In a carrier wave system, a wave modulating means, an amplifier connected to amplify waves in a circuit in series with said modulating means, a feed-back circuit for said amplifier for enabling the amplifier to generate carrier oscillations, means to supply the oscillations to said modulating means for modulation therein by signal waves, and means to limit the amplitude of the generated oscillations to a value below that corresponding to the upper limit of the load-carrying capacity of the amplifier.

11. In combination, a wave modulator, an amplifier, a source of modulating waves, circuit connections for causing said amplifier to generate oscillations and supply them to said modulator for modulation therein by said modulating waves, circuit connections for impressing said modulating waves on said amplifier for amplification before they are used to modulate said oscillations, said modulator serving to limit the amplitude of the oscillations generated by said amplifier to a point below the overload point of the amplifier whereby said amplifier is enabled to amplify said modulating waves.

12. A carrier wave system terminal comprising a transmitting channel including a modulator, and a receiving channel including a demodulator, said modulator and demodulator each being of the rectifying type, a demodulator amplifier connected in series relation with said demodulator in the receiving channel for amplifying received waves, a feed-back path forming with said amplifier a carrier wave generating system, means to supply the generated carrier waves to both said modulator and said demodulator, the circuit relations being such that the carrier wave is transmitted through the modulator and the demodulator alternately in successive half periods of the carrier wave, and means limiting the generated waves to a value sufficiently low to enable the amplifier to amplify received waves despite the use of the amplifier for simultaneously generating the carrier waves.

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