

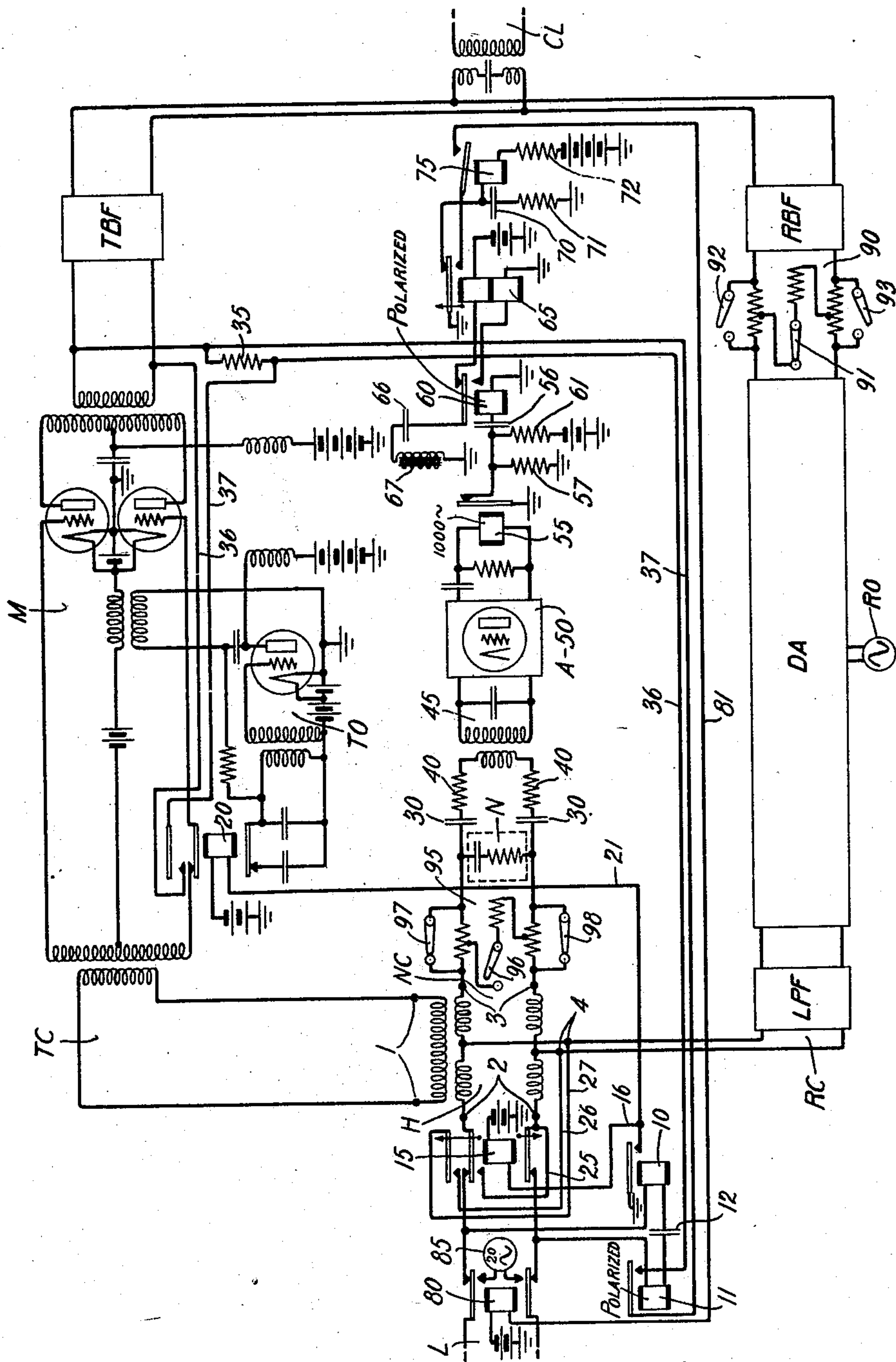
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ELECTRIC SIGNALING SYSTEM

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ELECTRIC SIGNALING SYSTEM

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This invention relates to signaling, and particularly to electric signaling systems for transmission of messages and call signals, as for example telephone messages and ringing signals.

An object of the invention is to avoid false operation of call signal means.

A hybrid coil or equivalent biconjugate network is often used in a telephone circuit to connect a two-way transmission circuit with two one-way circuits. The problem arises of preventing messages from operating call signal means intended for operation by call signals approaching the hybrid coil over one of the two-way circuits. In accordance with the invention, the call signal responsive means is connected to the balancing network circuit of the hybrid coil, so that it is in conjugate relation to the two-way circuit and therefore is in practically no danger of operation by energy from that circuit. Further, false operation by energy from the opposite direction is unlikely, since the transmission equivalent of the portion of the system at that side of hybrid coil is usually much greater than the transmission equivalent of the portion at the other side.

The call signal responsive means in the balancing network circuit of the hybrid coil can be of low impedance, and therefore inexpensive, since its impedance does not affect the impedance which the hybrid coil presents to the two-way line.

Other objects and aspects of the invention will be apparent from the following description and claims.

The single figure of the drawing is a circuit diagram of one terminal of a carrier telephone system embodying one form of the invention.

Values mentioned below for constants or quantities such, for instance, as frequencies and impedances, are given merely by way of example, and the invention is not limited thereto.

Line L may be a low frequency line as for instance an ordinary subscriber's telephone line or a toll line connected to a subscriber's loop through a telephone exchange or central office (not shown). Line CL may be a carrier

line extending to a distant carrier terminal circuit comprising apparatus such as the apparatus shown in the drawing, or may be a connection to a radio antenna if it is desired to employ radio transmission between the terminal shown and the distant terminal.

Line L is associated with a carrier transmitting channel TC and a carrier receiving channel RC through a hybrid coil H and an impedance balancing network circuit NC comprising a network N. N may be the usual network for balancing the impedance of line L, and may consist, for example, of a capacity and a resistance in series as shown.

The transmitting channel TC includes the modulator M, oscillator TO and band filter TBF. Receiving channel RC includes demodulator and amplifier DA, oscillator RO and band filter RBF.

The modulators associated with the transmitting channels of the system are of the balanced type disclosed in the U. S. Patent to Carson, No. 1,343,306, issued June 15, 1920, designed to suppress the unmodulated carrier from transmission.

The demodulators and amplifiers of the system may be of the well known vacuum tube detector type shown in Fig. 49 of an article entitled "Carrier current telephony and telegraphy" by Messrs. Colpitts and Blackwell, published in the Transactions of the American Institute of Electrical Engineers, vol. 40, 1921.

The carrier system outlined above is, as stated, of the type in which the carrier wave of each channel is suppressed from transmission when no signals are being sent, and when messages are being transmitted modulation components of the modulated wave are sent over the line but no unmodulated components of the carrier wave are transmitted.

In order to reproduce the signals from modulated waves of this character, it is necessary that the carrier wave supplied to the demodulator at the receiver be of substantially the same frequency as the carrier wave which was suppressed at the transmitter. A system of this general character is described in connection with Fig. 49 of the Colpitts and Blackwell article, supra.

The band filters TBF and RBF are so designed that they will transmit one of the side bands, either the upper or lower as desired, produced by modulation in the respective transmitting channels, and will suppress from transmission frequencies lying outside of such band. A low pass filter LPF in the output circuit of DA has its cut-off frequency at the upper limit of the range of speech or other frequencies to be transmitted to line L. These filters may be designed in accordance with the principles set forth in the U. S. patent to Campbell, No. 1,227,113, issued May 22, 1917.

The hybrid coil H is of the well known balanced type including three windings, inductively related to each other. One winding may be called a series winding. The other two are equal line and network windings. Tapped off from between the line winding and the network winding is a bridge circuit, which in the present case is connected to the receiving channel RC. The relation of these windings is such that, when the proper values of impedance are connected across the several terminals, energy impressed upon the hybrid coil from the bridge circuit will not affect the series winding and vice versa. For a further description of "hybrid coils" reference may be had to an article by Messrs. Gherardi and Jewett entitled "Telephone repeaters" published in the Transactions of the American Institute of Electrical Engineers, vol. 38, No. 11, October 1919.

Voice currents originating in the low frequency line L divide between channel RC and channel TC. There is also fed into the modulator the carrier current from the oscillator TO. Of the components of modulation appearing in the output circuit of the modulator M, the band filter TBF suppresses all except one side band, for example, the upper side band, which it transmits to the carrier line CL. The waves so transmitted over the line CL are picked up by the receiving band filter at the distant terminal and transmitted to the receiving channel.

The waves incoming over the line CL of the frequency assigned to channel RC pass through band filter RBF and are combined in the demodulator and amplifier DA with carrier waves from the source RO. The voice frequency components of demodulation pass through filter LPF to the bridge points of the hybrid coil H and divide substantially equally between the low frequency line L and the balancing network circuit NC.

The hybrid coil H has four pairs of terminals, terminals 1 being associated with the series winding, terminals 2 and 3 being associated with the line and network windings respectively, and terminals 4 comprising the bridge circuit terminals.

For convenience, transmission in the direction from line L to line CL will be called transmission east, and transmission in the

opposite direction in the system will be referred to as transmission west. Ringing or call signals, having a frequency of 20 cycles per second for example, transmitted east over line L operate relays 10 and 11 which have their windings connected across line L in series with each other and a tuning condenser 12 which tunes the windings to the twenty cycle ringing current and also prevents any direct current flow from line L through the windings of these relays. Relay 10 is an alternating current relay which remains operated as long as the 20 cycle current is received over line L. Relay 11 is a polarized relay, which operates at the rate of 20 cycles per second in response to the 20 cycle current.

The operation of relay 10 operates a slow release relay 15 from battery through conductor 16, and operates a relay 20 from battery through conductor 21.

The operation of relay 15 disconnects the line L and windings of relays 10 and 11 from hybrid coil H at the back contacts of the middle and lower tongues of the relay 15, and places a short circuit across the line terminals 2 of the hybrid coil through conductor 25, and places a short circuit across the bridge terminals 4 of the hybrid coil through conductors 26 and 27 and the uppermost tongue of the relay. The disconnection of line L from the hybrid coil and the short circuit through conductor 25 prevent harmonics of the 20 cycle signal current from line L from entering the hybrid coil and the transmitting channel TC and modulating in the modulator M. The modulation products would be transmitted to the line CL and would tend to spoil the quality of the signal current which is generated as specified in the following paragraphs. The short circuit across the bridge terminals of the hybrid coil, which receive the output from the demodulator or carrier receiving channel RC, prevents the call signaling current generated in channel TC as about to be described from circulating around the channels TC and RC while the call signaling circuits are in operation.

When relay 20 operates, its lower tongue decreases the tuning capacity of oscillator TO to shift the carrier frequency, for example from 10,000 cycles to 11,000 cycles; and its middle tongue opens the grid circuit of one of the tubes of the balanced modulator to unbalance the modulator so that the 11,000 cycle carrier current for call signaling is sent out on line CL; and its upper tongue connects a resistance 35 across the output circuit of the modulator to attenuate the carrier current to be transmitted to the line for call signaling. This carrier current to be transmitted to the line is interrupted or suppressed at the rate of 20 cycles per second, due to the operations of relay 11 which short circuits resistance 35 through conductors 36 and 37 at each closure of the relay contacts.

The manner in which the ringing signal is received at the distant terminal will be described in connection with the local terminal circuits shown in the drawing, since the circuits at the local and the distant terminals are identical except that, in the system as shown, the frequency band of the carrier channel for transmission west is different from the frequency band for transmission east. The transmitting oscillator at the distant terminal may normally generate say a 6000 cycle wave. A side band, say the upper one, resulting from modulation of this wave by speech may be used for transmitting messages westward. The transmitting arrangement at the distant terminal operates in the manner just described for the local terminal, in response to a 20 cycle ringing current transmitted west to the distant terminal, to shift the carrier frequency from the value of 6000 cycles to a value of say 7000 cycles and unbalance the modulator. Consequently a 7,000 cycle carrier frequency interrupted at the rate of 20 cycles per second is received from line CL at the local terminal as a call signal wave.

This wave is transmitted by filter RBF and combined in the demodulator and amplifier DA with a 6000 cycle carrier wave from the source RO to produce a 1,000 cycle wave interrupted at the 20 cycle rate. This interrupted 1,000 cycle wave passes through filter LPF to the bridge points or terminals 4 of the hybrid coil, so a 1,000 cycle current interrupted at 20 cycles per second is delivered from the network terminals 3 of the hybrid coil to the balancing network circuit NC. A portion of this current passes through the condenser and the resistance of the balancing network N, and a portion passes through condensers 30 and two resistances 40 to the tuned input circuit 45 of an electric space discharge amplifier A—50. This input circuit is tuned to the frequency of 1000 cycles per second. The output of this amplifier is used to operate a relay 55 which has its armature mechanically tuned to 1000 cycles per second and which when operated by the call signaling current, effectively opens and closes its normally closed contacts at a 20 cycle rate.

When the contacts are opened, charging current for a condenser 56 flows from battery through a resistance 57, condenser 56, and the winding of a polarized relay 60, which thereupon operates its armature in one direction, and which operates its armature in the other direction upon the closure of the contacts of relay 55, due to discharge of the condenser through the contacts of relay 55 and the windings of relay 60. The resistance 57 and a resistance 61 shunted across the contacts of relay 55 reduces the current and voltage received by the contacts of relay 55. The operations of relay 55 in response to call signaling current thus cause relay 60 to vibrate its

armature between its contacts at a 20 cycle rate.

During these vibrations of the armature of relay 60 a relay 65 attracts and holds its armature, due to flow of charging current for a condenser 66 from battery through the upper winding of relay 65, upper contact of relay 60, condenser 66 and a retardation coil 67, and flow of discharge current from the condenser 66 through lower contact of relay 60, the lower winding of relay 65, and coil 67. The windings of the relay 65 are so arranged that all of the magnetic pulses in the core are in the same direction. The relay 65 is made slightly slow releasing, for example, by a short circuited winding (not shown) to prevent chattering. The inductance of coil 67 renders the charge and discharge circuits resonant at 20 cycles, so relay 65 operates only on signaling current interrupted at the rate of approximately 20 cycles per second.

The opening of the back contact of the relay 65 introduces a condenser 70 and a low resistance 71 in series with battery, a high resistance 72 and the winding of relay 75 normally operated by current flowing from battery through resistance 72, winding of relay 75 and back contact of relay 65; and the closing of the front contact of relay 65 connects ground to the armature of relay 75 so that when the latter armature is released it will cause operation of a relay 80 by current from battery through the winding of relay 80, conductor 81 and armatures of relays 75 and 65. However, the relay 75 remains operated until the value of the current charging condenser 70 drops below that required to hold the relay operated. This provides a time delay which may be, for example, of the order of a half second. This delay assists in preventing false operation of the relay 80. The delay period is made of such length that if waves other than call signal waves, as for example voice waves, cause operation of relay 65, the relay 65 releases and restores the normal operating circuit of relay 75, before the condenser becomes substantially charged; whereas if the operating waves are call signal waves, which are maintained for a time relatively long compared to the duration of a voice wave component of a given frequency, the condenser will become substantially charged and the relay 75 will release its armature and allow its back contacts to close while the front contacts of relay 65 are closed. Thus the relay 75 responds to the action of call signal waves on relay 65, but not to the operation of relay 65 by other waves, such as waves due to voice waves. The resistance 72 is large to assist in making the delay period or condenser charging period long. The resistance 71 is large enough to protect the back contacts of relay 65 during discharge of the condenser 70 through resistance 71 and those

contacts, but is small enough to allow the condenser to substantially discharge very quickly upon the closure of those contacts, so that false operation of relay 80 can not occur due to cumulative charging of the condenser as a result of application of a rapid succession of waves of short duration to the winding of relay 65.

The operation of relay 80 disconnects line L from the relays 10 and 11 and the hybrid coil H, and connects a local source 85 of 20 cycle call signal current to the line.

False operation of relay 80 or of the call signal receiving means at the local terminal circuits shown in the drawing is prevented by having this call signal receiving means connected in the network circuit NC. This circuit is conjugate to line L and consequently receives practically no message or interference current from that line. Thus, assuming that half of the conversation over line L is transmission east, danger of false operation of the call signal receiving circuit is substantially eliminated for half of the conversation time, or in other words the call signal receiving circuit is subject to false operation substantially only half as many times as a call signal receiving circuit connected across the terminals 2 or 4 of the hybrid coil H, for example, would be. That is, the call signal receiving apparatus connected as shown in the drawing is subject, theoretically at least, to no near end false operation. Further, far end false operation, or operation due to message or interference currents approaching the local terminal over line CL is unlikely, because usually the voice frequency transmission equivalent of the portion of the system to the east of hybrid coil H is much greater than the voice frequency transmission equivalent of the portion of the system to the west of the hybrid coil. That is, transmission west is attenuated more than transmission east, before reaching the hybrid coil, or in other words, the only currents which reach the input of the call signal receiving circuit are usually weak since they have come over the carrier channel, which is usually operated at a transmission loss, and are consequently down in volume from their initial level by an amount corresponding to the voice frequency transmission equivalent of the circuit over which they have come, including the carrier channel to the hybrid coil. Thus, the difficulty is avoided of having to provide call signal receiving apparatus which is sufficiently sensitive to be operated by far end call signals yet which has a proper margin of safety against false operation by (near end) messages reaching the apparatus with relatively low attenuation.

A further advantage of the invention is that the call signal receiving equipment can have low impedance, if desired, because in its position on the balancing network side

of the hybrid coil its impedance does not upset nor affect the input impedance with which the hybrid coil faces the line L at terminals 2. Making the impedance of the call signal receiving apparatus low makes for low cost of the apparatus, for a given sensitivity. However, it is often important that the impedance facing the transmission circuit connected to terminals 2 of the hybrid coil be substantially equal to the impedance presented to those terminals by that circuit. This equality is especially important because at times the line L may be a line directly connected to a repeater (not shown) adjusted for such high gain that the impedance termination of line L at the end of the line remote from the repeater must maintain a close impedance balance between the line and its balancing network located at the repeater. Also, the impedance which faces the receiving channel RC at the hybrid coil is preferably substantially equal to the impedance with which that channel faces the hybrid coil, in order to secure maximum energy transfer from channel RC to the hybrid coil. Therefore the call signal receiving apparatus would have to be given a high impedance, if it were shunted across terminals 2 or terminals 4. In order that channels RC and TC may be conjugate, the impedance facing the hybrid coil at terminals 3 should have a value of the order of the impedance facing the hybrid coil at terminals 2. However, this adjustment is much less critical than the adjustment of the impedance with which the hybrid coil should face the low frequency transmission line. Therefore if the impedance of network N balances that of line L, the impedance with which the call signal responsive apparatus faces that network need not be extremely high at 1000 cycles compared to the impedance of that network. Two resistances 40 in circuit with the primary winding of the input transformer for amplifier A—50 increase the impedance presented to the network N by the call signal receiving apparatus. These resistances may have an aggregate value of the order of 40,000 ohms, for example.

The impedance of network N and the input impedance of the call signal receiving apparatus in parallel may be adjusted to equal the impedance of line L for voice frequencies, within the required limits of the impedance balance.

If desired, receiving ringing apparatus may be used which serves also as the network for balancing the impedance of line, the input impedance of the call signal receiving apparatus being made equal to the line impedance, within the required impedance limits. Doing this permits additional economies in that it increases substantially the gain of the call signal receiving circuit and hence makes it possible to dispense with equipment or else use cheaper elements in the apparatus. For

example, relay 55 may be made to serve as the network for balancing the impedance of the line, the network N and all of the apparatus which is shown connected between network N and relay 55 being then dispensed with. With that arrangement the winding of relay 55 would replace network N, and the relay would be made of the proper impedance to balance the line impedance, within the required limits.

It will be understood that as usual by the provision of suitable apparatus (not shown), a speech frequency channel may be operated over line CL simultaneously with the carrier channel. It is sometimes desirable to alter the transmission equivalent of the carrier channel to the hybrid coil H, as for example, by cutting in or out of circuit a padding network 90 in channel RC, so that the voice frequency transmission equivalent of the transmission channel which extends from the distant carrier terminal circuit to the hybrid coil H may bear a given relation to the speech frequency transmission equivalent of whatever line CL the carrier transmission channel may utilize, whether the line be long or short. This facilitates employing the carrier channel and the voice frequency channel over line CL interchangeably, for connecting low frequency lines terminating at the local carrier terminal circuit and the distant carrier terminal circuit. Switches 91, 92 and 93 indicate diagrammatically means for cutting network 90 in and out of circuit. By opening switch 91 and closing switches 92 and 93 the network is removed from circuit. In accordance with the invention a similar padding network 95 may then be switched into circuit NC by closing switch 96 and opening switches 97 and 98, to maintain the transmission equivalent of the system to the call signal receiving circuit unaltered, and the transmission level of the call signal current transmitted to the local terminal circuit from the distant terminal circuit may be maintained the same as before at the distant terminal circuit. Conversely, when the network 90 is reinserted in circuit the network 95 is removed from circuit NC again. By this arrangement the call signal energy level effective at the call signal receiving apparatus can be maintained the same when the voice frequency transmission equivalent of the carrier channel to the hybrid coil H is high as when it is low, without danger of the effective level being too high when the carrier channel equivalent is low, and without any necessity for changing the energy level of the call signals at the distant terminal circuits.

Although the invention has been shown and described in detail with especial reference to its application to carrier current transmission systems, it is applicable to other types

of systems also, as for example, voice frequency toll telephone systems.

What is claimed is:

1. A network comprising four circuits and means for connecting them in biconjugate relationship, means in one of said circuits for transmitting messages therethrough to said connecting means, and signal means, responsive to call signals, in the circuit conjugate to said one circuit.

2. In a transmission system, two circuits, a unidirectional path for transmitting waves to one of said circuits, a unidirectional path for transmitting waves from said one circuit, signal means in said other circuit responsive to call signals, and means connecting said paths to said circuits and connecting said circuits in conjugate relationship.

3. A transmission system comprising a circuit, a balancing circuit for balancing the impedance of said circuit, two unidirectionally transmitting paths for transmitting waves to and from said first circuit respectively, and signal means in said balancing circuit, responsive to call signals.

4. In combination, a two-way message transmission circuit, signal means responsive to call signals, and means for connecting said circuit and said means in conjugate relationship, the impedance presented to said second means by said signal means at the message frequencies being at least as small as of the order of the impedance presented to said second means by said circuit.

5. In a transmission system, a circuit, signal means responsive to call signals having impedance for balancing the impedance of said circuit, and means connecting said circuit and said means in conjugate relationship.

6. A transmission system comprising a circuit for transmitting message currents, a path for transmitting message currents from said circuit, a path for transmitting message currents to said circuit, a second circuit, means connecting said paths to said circuits and connecting said circuits in conjugate relationship, signal means in said second circuit, responsive to signal currents of frequency of the order of the message current frequency, means in said first path for modulating said message currents, and demodulating means connected to said second path.

7. The method of operating a message transmitting channel and a signal transmitting channel that are partly common, which comprises relatively varying the transmission equivalents of the channels so that when the message transmitting channel is operated at a shorter equivalent an individual portion of the signal transmitting channel is operated at a correspondingly longer equivalent.

8. In combination, a two-way message transmission circuit, signal means responsive

to call signals, a circuit for transmitting call signals to said call signal responsive means, means in said second circuit for varying its transmission equivalent and means connecting said circuits in conjugate relationship.

9. A transmission system comprising a circuit for transmitting message currents, a path for transmitting message currents from said circuit, a path for transmitting message currents to said circuit, a second circuit, means connecting said paths to said circuits and connecting said circuits in conjugate relationship, signal means in said second circuit, responsive to signal currents of frequency of the order of the message current frequency, means in said first path for modulating said message currents, demodulating means connected to said second path, and means for connection in said second circuit to vary the transmission equivalent of the system for the signal currents.

10. A transmission system comprising a circuit, a path for transmitting energy from said circuit, a path for transmitting energy to said circuit, a second circuit, means connecting said paths to said circuits and connecting said circuits in conjugate relationship, means in said second circuit operative in response to energy from said second path, means in said first path for modulating said message currents, and demodulating means connected to said second path.

11. A transmission system comprising a circuit, a path for transmitting energy of waves of a given frequency band from said circuit, a path for transmitting energy to said circuit, a second circuit, means connecting said paths to said circuits and connecting said circuits in conjugate relationship, means in said second circuit operative in response to energy from said second path, modulating means in said first path, demodulating means connected to said second path, and a relay included in said second means, mechanically tuned to a frequency of the order of a frequency at the middle of said band.

In witness whereof, I hereunto subscribe my name this 15th day of September, A. D., 1927.

HAROLD S. BLACK.