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RINGING CIRCUITS FOR MULTIPLEX SIGNALING

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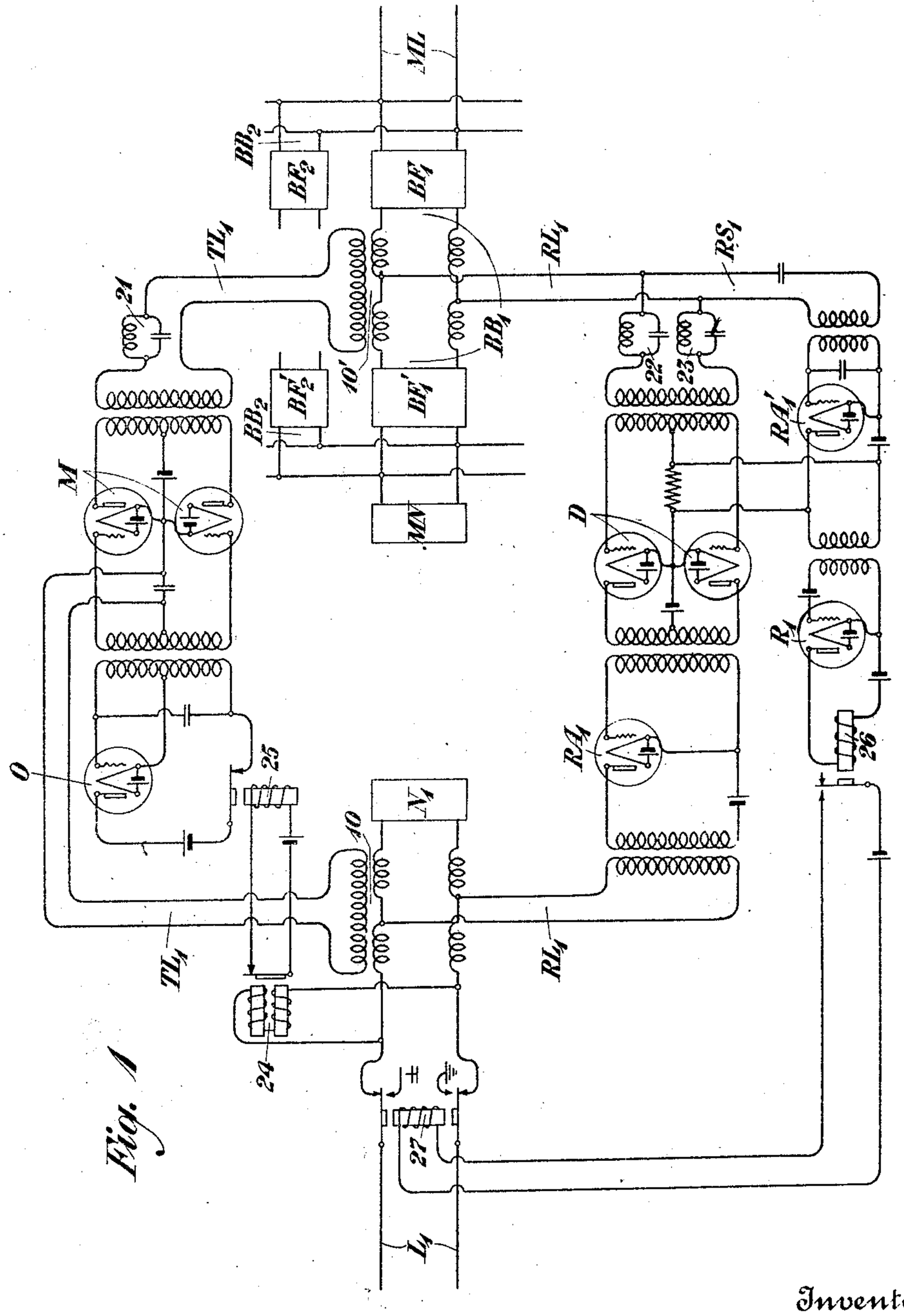

Fig. 1

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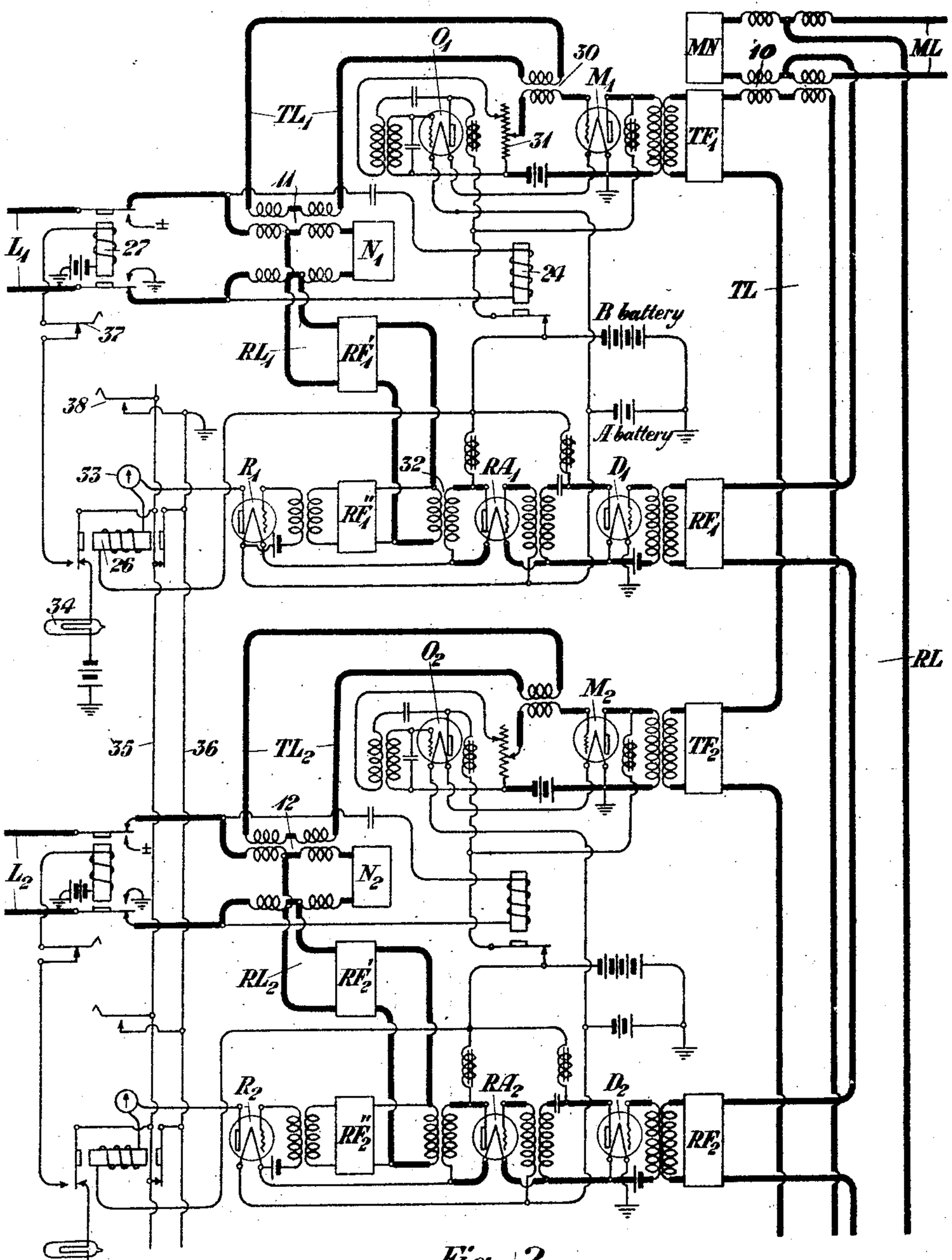

Fig. 2

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Patented Aug. 25, 1925. 1,550,657

UNITED STATES PATENT OFFICE.

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RINGING CIRCUITS FOR MULTIPLEX SIGNALING.

Application filed December 31, 1920. Serial No. 434,223.

To all whom it may concern:

Be it known that I, HERMAN A. AFFEL, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Ringing Circuits for Multiplex Signaling, of which the following is a specification.

This invention relates to the transmission of signals, and more particularly to the transmission of signals by means of so-called carrier currents.

One of the objects of the invention is to provide a multiplex transmission system in which the unmodulated component of the modulated carrier, instead of being suppressed at the transmitting station, is transmitted along with the side band to react with the side band in the detector at the distant receiving station to produce a difference frequency band corresponding to the low frequency signal.

Another object of the invention is to produce a multiplex signaling system in which the carrier frequencies employed for transmission in opposite directions in connection with any two-way communication channel will be separated in frequency in order to reduce the requirements as to balance between oppositely directed transmissions while at the same time conserving the frequency range.

Another object of the invention is to provide a simple and efficient arrangement for transmitting ringing or other supervisory signals over the channels of a multiplex system.

Another object of the invention is to provide a system of the character described in which the interruption of the carrier frequency is used for transmitting the ringing or other form of supervisory signal.

Still another object of the invention is to provide arrangements whereby in a ringing system depending upon the interruption of the carrier frequency a false ringing signal will be prevented when the carrier supply is unavoidably interrupted in the apparatus or line circuit.

A further object of the invention is to provide an indicating means for indicating the condition of carrier supply on the circuit, the indicating means being arranged to indicate either an absolute interruption of the carrier supply or a decrease in the amplitude of the carrier supply.

Other and further objects of the invention will be clear from a detailed description thereof when read in connection with the accompanying drawing, Figure 1 of which exemplifies one form of the invention, and Fig. 2 of which illustrates a preferred form of the invention.

Referring to Fig. 1, ML designates a main transmission line over which a plurality of signals may be simultaneously transmitted by means of carrier currents. L_1 designates one of a number of low frequency transmission lines, each of which may be associated with the main line ML by means of carrier apparatus for the purpose of multiplex transmission. The line L_1 is associated with a transmitting channel TL_1 and a receiving channel RL_1 through a balanced transformer arrangement 10 of well-known character, and said line is balanced by means of an artificial line or network N_1, whereby the transmitting channel TL_1 and the receiving channel RL_1 may be rendered substantially conjugate with respect to each other. The transmitting channel TL_1 and the receiving channel RL_1 are associated by means of a balanced transformer arrangement 10′ with a bridge connection BB_1 extending between the main line ML and a balancing network or artificial line MN. Band filters BF_1 and BF_1, are included in the bridge connection BB_1 on either side of the balanced transformer, in order to select through the corresponding transmitting and receiving channels the proper band of frequencies. It will be understood that other transmitting and receiving channels may be associated with the main line ML and the balancing network MN by means of parallel bridge connections, such as BB_2, etc., each parallel bridge connection being provided with an individual balanced transformer for associating the corresponding channels with the line.

The transmitting channel TL_1 is provided with a modulator M of the duplex balanced type, the general form of which is illustrated and described in the U. S. Patent No. 1,343,307, issued to John R. Carson June 15th, 1920. The particular form of modulator herein disclosed, however, differs from that disclosed in the Carson patent in that the circuits are arranged to normally suppress the signaling frequency instead of the carrier frequency. The carrier frequency is

supplied by means of an oscillator O of the well-known vacuum tube type, the circuits of the tube being so adjusted as to generate a frequency F_1, said frequency being applied to the grids of the two tubes of the modulator M in serial relationship. This arrangement permits the carrier frequency to be transmitted by the modulator as long as the oscillator is active. The voice signaling frequencies are transmitted in parallel to the two grids by means of a connection from the circuit TL_1 to the common conductor leading from the grids to the filaments.

The output portion of the transmitting channel TL_1, which is associated with the main line ML, includes an anti-resonant circuit 21, which offers practically an infinite impedance to the frequency F_2 employed as the carrier frequency for transmission to the receiving channel. The frequencies F_1 and F_2 are preferably so chosen as to be separated by an amount approximately equal to the width of the voice band or other low frequency signaling band involved, and the band filter BF_1 and balancing band filter BF_1, are so proportioned as to transmit a signaling band whose upper and lower cut-off points just include the frequencies F_1 and F_2. One of the side bands resulting from the modulation of the carrier frequency F_1 by the modulator M consequently corresponds to one of the side bands associated with the receiving carrier frequency F_2 and the band filter BF_1 functions to eliminate the transmitting and receiving side bands which do not overlap.

The receiving channel RL_1 includes a demodulator or detector D, preferably of the duplex balanced tube type described in U. S. Patent 1,343,308 issued to John R. Carson June 15th, 1920. Instead of supplying the carrier frequency to the detector D from a local source, the receiving carrier frequency F_2 is transmitted along with the side band and is selected in a branch circuit RS_1 associated with the receiving channel RL_1 and tuned to the receiving frequency. If desired, an amplifier RA_1 may be provided to amplify the carrier frequency to the amplitude adapted to give the best quality of signal and the amplified carrier is applied to the common branch of the duplex input circuit of the detector D. In order to prevent either the carrier frequency F_1 transmitted from the transmitting channel or the received carrier frequency F_2 received from the main line ML from entering the series circuit connecting the two grids of the duplex tube arrangement, anti-resonant circuits 22 and 23 may be provided in the input circuit of the detector, these circuits being anti-resonant at the frequencies F_1 and F_2 respectively. An amplifier RA_1 may be provided in the output circuit of the detector for amplifying the detected low frequency signal.

In order to provide for the transmission of ringing signals a ringing responsive relay 24 is bridged across the line L_1 and in response to a ringing signal the relay 24 controls an auxiliary relay 25 to open the circuit of the oscillator O, thereby interrupting the transmission of the carrier frequency F_1. Signaling apparatus responsive to the interruption of the carrier frequency is provided at the distant station. The nature of this apparatus may be understood from a description of the similar apparatus provided at the station illustrated for responding to the interruption of the carrier frequency F_2 in response to a ringing signal transmitted from the distant station. This apparatus comprises a rectifying tube R_1 associated with the branch circuit RS_1, preferably beyond the amplifying tube RA_1'. A relay 26 is included in the output circuit of the rectifier R_1, the relay being energized by the direct rectified current flowing in the output circuit as long as the carrier supply continues. When the frequency F_2 is interrupted, however, the relay 26 operates through an auxiliary relay 27 to apply ringing current to the line L_1.

Voice currents incoming from the line L_1 are transmitted over the circuit TL_1 to the modulator M, where they modulate the carrier frequency F_1 supplied by the oscillator O. The anti-resonant circuit 21 prevents the carrier frequency F_2 from flowing into the channel TL_1, and the modulated carrier frequency from the channel TL_1, as it passes through the band filter BF_1 to the main line ML, has eliminated therefrom one of the side bands as previously described, the carrier frequency F_1, however, being transmitted over the main line. The carrier frequency F_2 incoming from the main line, together with the overlapping side band which is transmitted, passes through the filter BF_1 to the receiving channel RL_1. The carrier frequency F_2 is selected into the branch circuit RS_1, while the modulated side band passes into the detector D through the series connection between the two grids. The selected carrier frequency F_2 is in turn amplified by the amplifier RA_1 and impressed upon the detector D through a common branch of the input circuit to beat with the side band. As a result the low frequency signaling band is detected, amplified by the amplifier RA_1, and transmitted to the line L_1.

The ringing signal incoming from the line L_1 actuates ringing responsive relay 24 to open the circuit of the relay 25, which in turn opens a circuit of the oscillator O to interrupt the carrier frequency F_1 normally transmitted over the main transmission line ML. The interruption of this carrier fre-

quency actuates the ringing apparatus at the distant central station. The transmission of a ringing signal from the distant station is manifested by an interruption of the carrier frequency F_2 normally incoming from the line ML, and upon the cessation of this frequency the rectifier R_1 causes the deenergization of the relay 26. Relay 26 closes the circuit of auxiliary relay 27, whereby the line L_1 is disconnected from the carrier channels and connected to a suitable source of ringing current.

A modified arrangement is illustrated in Fig. 2, this arrangement differing from that of Fig. 1 in that the ringing responsive relay 24 is arranged to interrupt the transmission of the carrier frequency by opening the connection from the B battery to the plate circuit of both the oscillator and the modulator. The modulator in this instance is not a balanced arrangement such as that illustrated in Fig. 1, but is a simple vacuum tube modulator so arranged that the carrier frequency from the oscillator and the voice currents from the line are impressed upon the modulator in series, the former through a potentiometer arrangement, and the latter through a transformer. The receiving portion of the circuit also differs from that illustrated in Fig. 1 in that the detector, instead of being a balanced form of detector, is a simple vacuum tube detector, upon which the carrier frequency and the frequencies comprised in the side band transmitted may be directly impressed. The rectifier for receiving a ringing signal is associated with the receiving channel on the output side of the detector beyond the receiving amplifier, instead of on the input side of the detector. For this purpose the output circuit of the receiving amplifier is provided with two branches, one leading through a low-pass filter such as the filter RF_1', in the case of the channel associated with the line L_1, and the other branch including a high-pass filter such as the filter RF_1''. The low-pass filter is designed to transmit the detected voice band, while the high-pass filter may have its lower cut-off point just above the voice range so that it will transmit any carrier frequency used in the system. As is well known, the unmodulated carrier frequency appears in the output circuit of the detector as well as the low frequency detected current, and the carrier frequency will therefore be passed through the filter RF_1'' to the rectifying tube. The filters of the type of the filter RF_1'' may be made standard and used in any channel of the system, regardless of the carrier frequency.

Another feature of the circuit arrangement illustrated in Fig. 2 is the provision of means to prevent a false ringing signal from occurring when the carrier frequency is unavoidably interrupted due to the temporary breakdown of some part of the circuit common to a complete system. In order to illustrate this feature two sets of transmitting and receiving channels are shown in the case of Fig. 2, instead of a single set as the case of Fig. 1, although it will be understood that in both instances as many sets of channels may be provided as desired. In order to prevent false ringing signals, the receiving relay associated with the rectifier of each receiving channel is provided with an extra contact for connecting the relay 27 to ground. Each relay of the type of the relay 26 is provided with one of these extra contacts, and therefore the ground connections will be completed as long as any one of the relays of the type of the relay 26 is energized. If the line should be interrupted, however, all of the relays of the type of the relay 26 associated with the various receiving channels will be deenergized and the ground connection will be opened, so that relays of the type of relay 27 cannot be energized to transmit ringing currents over the low frequency line. Each relay of the type of relay 26 may also be arranged to control as signal lamp which will glow at all times except when a particular relay is responding to a ringing signal. If the lamp ceases to glow for a long period, or if it is noted that all of the lamps cease to glow, it will indicate at once that there is a defect in the circuit. Milliameters may also be included in the output circuit of each rectifier. When the circuit is in normal condition the milliameters will indicate that a given amount of current is flowing, and if the transmission conditions should vary so as to decrease the amplitude of the carrier, this fact would be indicated by the decreased current flow through the milliameters, and the attendant noting this fact could proceed to make such adjustments as are necessary.

Further details of the apparatus will be clear from the description of the operation, which is as follows: Voice currents incoming from the line L_1 are transmitted through the transformer 11 into the circuit TL_1 and through the transformer 30 to the input circuit of the vacuum tube modulator M_1. The oscillator O_1 generates carrier oscillations which are also supplied to the input circuit of the modulator M_1 through a potentiometer 31. The carrier oscillations just supplied are modulated in accordance with the voice currents and one side band is transmitted through the filter TF_1, the other side band being suppressed. The transmitted side band passes into the common transmitting circuit TL and through the transformer 10 to the main transmission line ML. The modulated side band received from the main transmission line passes into the common receiving circuit RL and is selected by the cor-

responding band filter RF_1 into the receiving channel RL_1. As the carrier frequency is transmitted along with the side band, both the carrier frequency and the side band pass through the filter RF_1 to the input circuit of the detector D_1. The low frequency currents, in accordance with which the carrier was modulated at the distant station, are reproduced in the output circuit of the detector, and the unmodulated carrier frequency component also appears in said output circuit. These currents are amplified by the amplifier RA_1 and transmitted through the transformer 32. The detected voice currents pass into the branch including the low pass filter RF_1, and are then transmitted over the line L_1. The unmodulated carrier frequency component, however, passes into the branch including the high pass filter RF_1'', and, after being rectified by the rectifier R_1, appears in the output circuit of said rectifier as direct current which serves to maintain the relay 26 energized, and to give a definite indication of the milliameter 33.

The ringing current incoming from the line L_1 passes through the winding of relay 24, the circuit of which is tuned to the ringing frequency and actuates said relay to open the connection from the B battery to the plates of the oscillator O_1 and the modulating tube M_1. The opening of this connection disables both of these tubes so that the carrier frequency normally transmitted to the line ML from the oscillator O_1 is interrupted, thereby actuating the ringing apparatus at the distant station. Similarly, a ringing signal transmitted from the distant station will cause an interruption of the carrier frequency normally transmitted from the distant station over the line ML into the receiving channel RL_1. As soon as this carrier frequency (which, as previously stated, appears in the output circuit of the detector D_1 and is selected through the filter RF_1'' into the rectifier R_1 to energize the relay 26) is interrupted, the rectified current flowing through the relay 26 ceases to flow and said relay is deenergized. Normally a circuit for the signal lamp 34 is completed over the front left hand contact of relay 26 and over the front right hand contact of relay 26, and, similarly, contacts of other relays in parallel therewith to ground. The deenergization of the relay 26 opens the circuit of the signal lamp 34 at its left hand contact. The right hand contact of relay 26 is also opened but unless all of the other relays similar to relay 26 are at the same time deenergized the path to ground from bus bar 35 to bus bar 36 will be completed at the front right hand contact of the relay associated with some other receiving channel. Consequently, when the left hand contact of the relay 26 falls off a circuit from ground over said back right hand contact is completed through the winding of the relay 27 to battery. Relay 27 disconnects the line L_1 from the carrier apparatus and connects ringing current thereto. The lamp 34, of course, ceases to glow during the period that ringing current is being transmitted.

Should the line ML be interrupted, the carrier frequency normally transmitted in each of the receiving channels would cease and the relays corresponding to the relay 26 associated with each channel would be deenergized, thereby opening the connection between bus bars 35 and 36 and disconnecting ground from each of the lamps such as 34. The extinguishing of all of the lamps would indicate to an attendant that some trouble had occurred to which attention should be given. The relays such as relay 27 could not be operated under these circumstances, owing to the opening of the ground connection and thus a false ringing signal would be avoided. A key 37 is provided in the circuit of the relay 27, so that said circuit may be disabled at any time to permit the attendant to make tests without transmitting ringing current over the line L_1. A key 38 may also be provided for the purpose of connecting bus bars 35 and 36 together independently of the contacts of the relays such as relay 26, this key also being utilized for test purposes. As previously stated, any variation in the amplitude of the carrier supplied to a given channel will be indicated by the current flow through the milliameters such as milliameter 33 associated with the various rectifiers.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the following claims:—

What is claimed is:

1. In a carrier current signaling system, means for normally transmitting an unmodulated carrier frequency component, means for transmitting a modulated side band along with the unmodulated component when signaling, means for detecting a signal from the modulated side band, a special signal, separate means responsive to the unmodulated carrier component to prevent the operation of said special signal, and means responding to the interruption of the carrier to operate said special signal.

2. In a carrier current signaling system, means for normally transmitting an unmodulated carrier frequency component, means for transmitting a modulated side band along with the unmodulated component when signaling, means for detecting a signal from the modulated side band, a ringing signal, separate means responsive to the unmodulated carrier component to prevent

the actuation of said ringing signal, and means responding to the interruption of the carrier to actuate said ringing signal.

3. In a carrier current signaling system, means for normally transmitting an unmodulated carrier frequency component, means for transmitting a modulated side band along with the unmodulated component when signaling, means for detecting a signal from the modulated side band, a special signal, a branch circuit for selecting the unmodulated carrier component, and means in said circuit responsive to the transmission of said unmodulated carrier component to prevent the operation of said special signal, and means responding to the interruption of said component to operate said special signal.

4. In a carrier current signaling system, means for normally transmitting an unmodulated carrier frequency component, means for transmitting a modulated side band along with the unmodulated component when signaling, means for detecting a signal from the modulated side band, a ringing signal a branch circuit for selecting the unmodulated carrier component, and means in said circuit responsive to the transmission of said unmodulated carrier component to prevent the actuation of said ringing signal and means responding to the interruption of said component to actuate said ringing signal.

5. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, means for interconnecting said lines, means to normally transmit an unmodulated carrier component over said main transmission line, means for transmitting over the main transmission line a modulated side band along with the unmodulated component when signaling, a special signal for said low frequency line, means for detecting a signal from said modulated side band, separate means responsive to said unmodulated component to prevent the operation of said special signal, and means responsive to the interruption of said unmodulated component to operate said special signal for said low frequency line.

6. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, means for interconnecting said lines, means to normally transmit an unmodulated carrier component over said main transmission line, means for transmitting a modulated side band over the main transmission line along with the unmodulated component when signaling, a ringing signal for said low frequency line, means for detecting a signal from said modulated side band, separate means responsive to said unmodulated component to prevent the actuation of said ringing signal, and means responsive to the interruption of said unmodulated component to operate said ringing signal for said low frequency line.

7. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, means for interconnecting said lines, means to normally transmit an unmodulated carrier component over said main transmission line, means for transmitting over the main transmission line a modulated side band along with the unmodulated component when signaling, a special signal for said low frequency line, means for detecting a signal from said modulated side band, a branch circuit for selecting said unmodulated component, means in said branch circuit responsive to said unmodulated component to prevent the operation of said special signal, and means responsive to the interruption of said component to operate said special signal for said low frequency line.

8. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, means for interconnecting said lines, means to normally transmit an unmodulated carrier component over said main transmission line, means for transmitting a modulated side band over the main transmission line along with the unmodulated component when signaling, a ringing signal for said low frequency line, means for detecting a signal from said modulated side band, a branch circuit for selecting said unmodulated component, means in said branch circuit responsive to said unmodulated component to prevent the actuation of said ringing signal, and means responsive to the interruption of said component to operate said ringing signal over said low frequency line.

9. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, a receiving channel for interconnecting said lines, means to transmit the unmodulated carrier component along with the modulated side band over said main line, demodulating apparatus in said receiving channel for detecting a signal from said side band, branch circuits associated with the output side of the demodulating apparatus, one of said branches including means to transmit the detected signal current while suppressing the unmodulated carrier current, and the other branch including means to transmit the unmodulated carrier component while suppressing the detected signaling currents, means in the latter branch responsive to the interruption of the unmodulated carrier component for transmitting a special signal.

10. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, a receiving channel for interconnecting said lines, means to transmit the unmodulated carrier component along with the modulated side band over said main line, demodulating apparatus in said receiving channel for detecting a signal from said side band, branch circuits associated with the output side of the demodulating apparatus, one of said branches including means to transmit the detected signal current while suppressing the unmodulated carrier current, and the other branch including means to transmit the unmodulated carrier component while suppressing the detected signaling currents, means in the latter branch responsive to the interruption of the unmodulated carrier component for transmitting ringing current to said low frequency line.

11. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, a receiving channel for interconnecting said lines, means to transmit the unmodulated carrier component along with the modulated side band over said main line, demodulating apparatus in said receiving channel for detecting a signal from said side band, branch circuits associated with the output side of the demodulating apparatus, one of said branches including the low pass filter for transmitting detected signaling currents while suppressing the unmodulated carrier component appearing in the output side of said demodulating apparatus, the other branch including a high pass filter for transmitting the unmodulated carrier component while suppressing the detected signaling currents, means in said last mentioned branch responding to the interruption of said unmodulated component for transmitting a special signal.

12. In a carrier signaling system, a main transmission line over which carrier currents may be transmitted, a low frequency line, a receiving channel for interconnecting said lines, means to transmit the unmodulated carrier component along with the modulated side band over said main line, demodulating apparatus in said receiving channel for detecting a signal from said side band, branch circuits associated with the output side of the demodulating apparatus, one of said branches including means to transmit the detected signal current while suppressing the unmodulated carrier current, and the other branch including means to transmit the unmodulated carrier component while suppressing the detected signaling currents, means in the latter branch responsive to the interruption of the unmodulated carrier component for transmitting ringing current over said low frequency line.

13. In a carrier signaling system, a main transmission line over which carrier frequencies may be transmitted, a plurality of low frequency lines, a carrier channel for associating each low frequency line with said main transmission line, means for transmitting a carrier frequency for each receiving channel along with the corresponding modulated side band over said main transmission line, means associated with each receiving channel responsive to the interruption of the unmodulated carrier component for transmitting a special signal, and means to defeat said signal if the unmodulated carrier components for all of the receiving channels are interrupted simultaneously.

14. In a carrier signaling system, a main transmission line over which carrier frequencies may be transmitted, a plurality of low frequency lines, a carrier channel for associating each low frequency line with said main transmission line, means for normally transmitting an unmodulated carrier frequency component for each carrier channel, means for transmitting over the main line the corresponding modulated side band along with each unmodulated component when the low frequency lines are signaling, means associated with each carrier channel responsive to the interruption of the unmodulated carrier component corresponding to that channel for transmitting a special signal to the corresponding low frequency line, and means in addition to indicate the interruption of the unmodulated carrier component.

15. In a carrier signaling system, a main transmission line over which carrier frequencies may be transmitted, a plurality of low frequency lines, a carrier channel for associating each low frequency line with said main transmission line, means for normally transmitting an unmodulated carrier frequency component for each carrier channel, means for transmitting over the main transmission line the corresponding modulated side band along with each unmodulated component when the low frequency lines are signaling, means associated with each carrier channel responsive to the interruption of the unmodulated carrier component corresponding to that channel for transmitting a special signal to the corresponding low frequency line, and means to indicate a variation in the amplitude of the unmodulated carrier component.

16. In a carrier signaling system, a main transmission line over which carrier frequencies may be transmitted, a plurality of low frequency lines, a carrier channel for

associating each low frequency line with said main transmission line, means for transmitting a carrier frequency for each carrier channel along with the corresponding modulated side band over said main transmission line, means associated with each carrier channel responsive to the interruption of the unmodulated carrier component for transmitting a special signal, a circuit arrangement including said main transmission line which is common to the complete system and means to defeat said signal if part of the circuit arrangement common to the complete system fails.

17. A system adapted for signaling by modulated alternating carrier current comprising means to modulate said carrier current to produce a side band, means for continuous transmission of an unmodulated carrier wave component, a detector for combining the side band and unmodulated carrier wave component, a signal, means responsive to said unmodulated component only for normally preventing the actuation of the signal, and additional means associated therewith for preventing the actuation of the signal upon failure of said unmodulated component.

In testimony whereof, I have signed my name to this specification this 30th day of December, 1920.

HERMAN A. AFFEL.