

May 15, 1923.

H. A. AFFEL

1,454,840

MEANS FOR RINGING OVER MULTIPLEX TRANSMISSION CHANNELS

Filed July 29, 1919

2 Sheets-Sheet 1

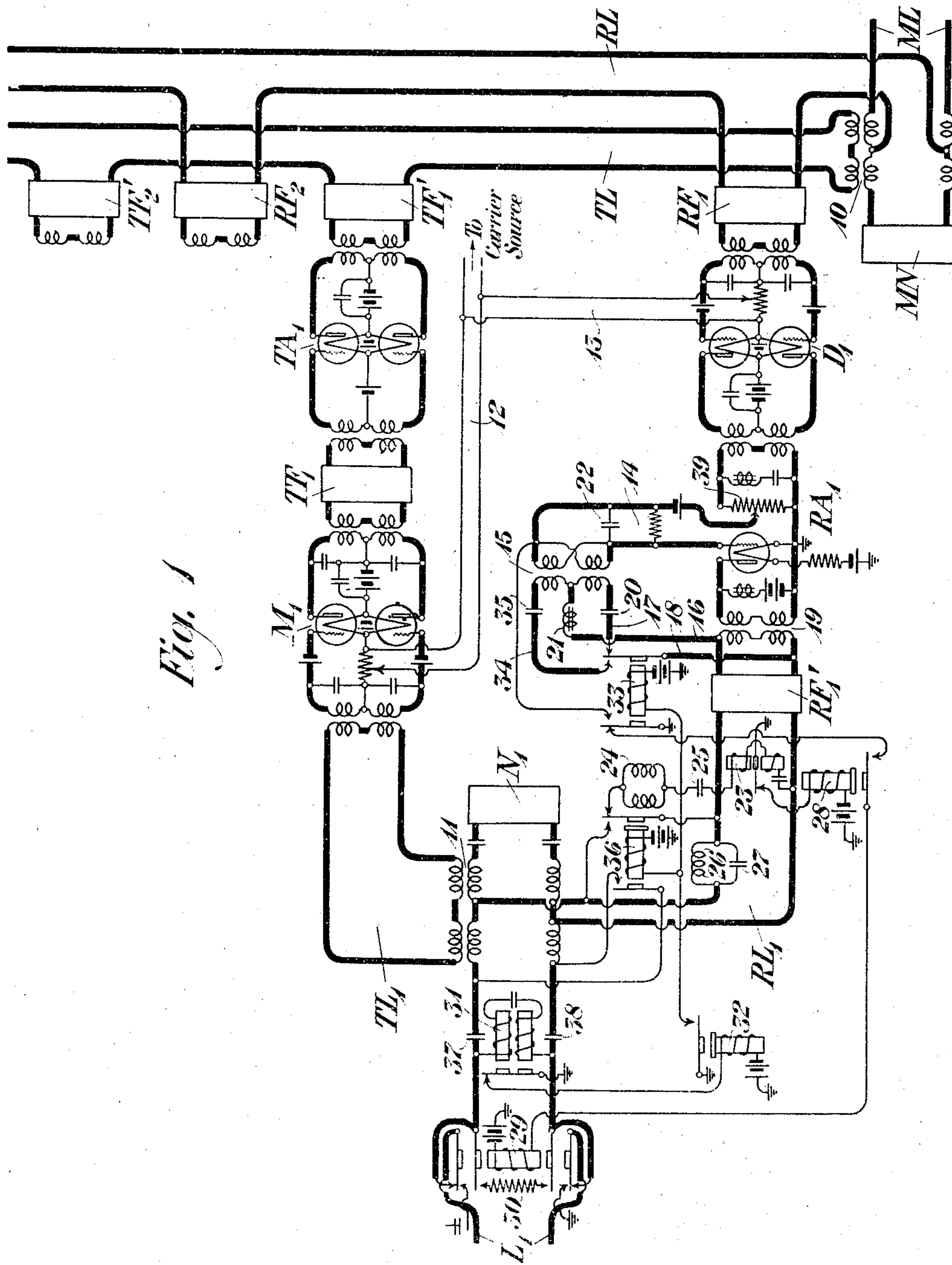


Fig. 1

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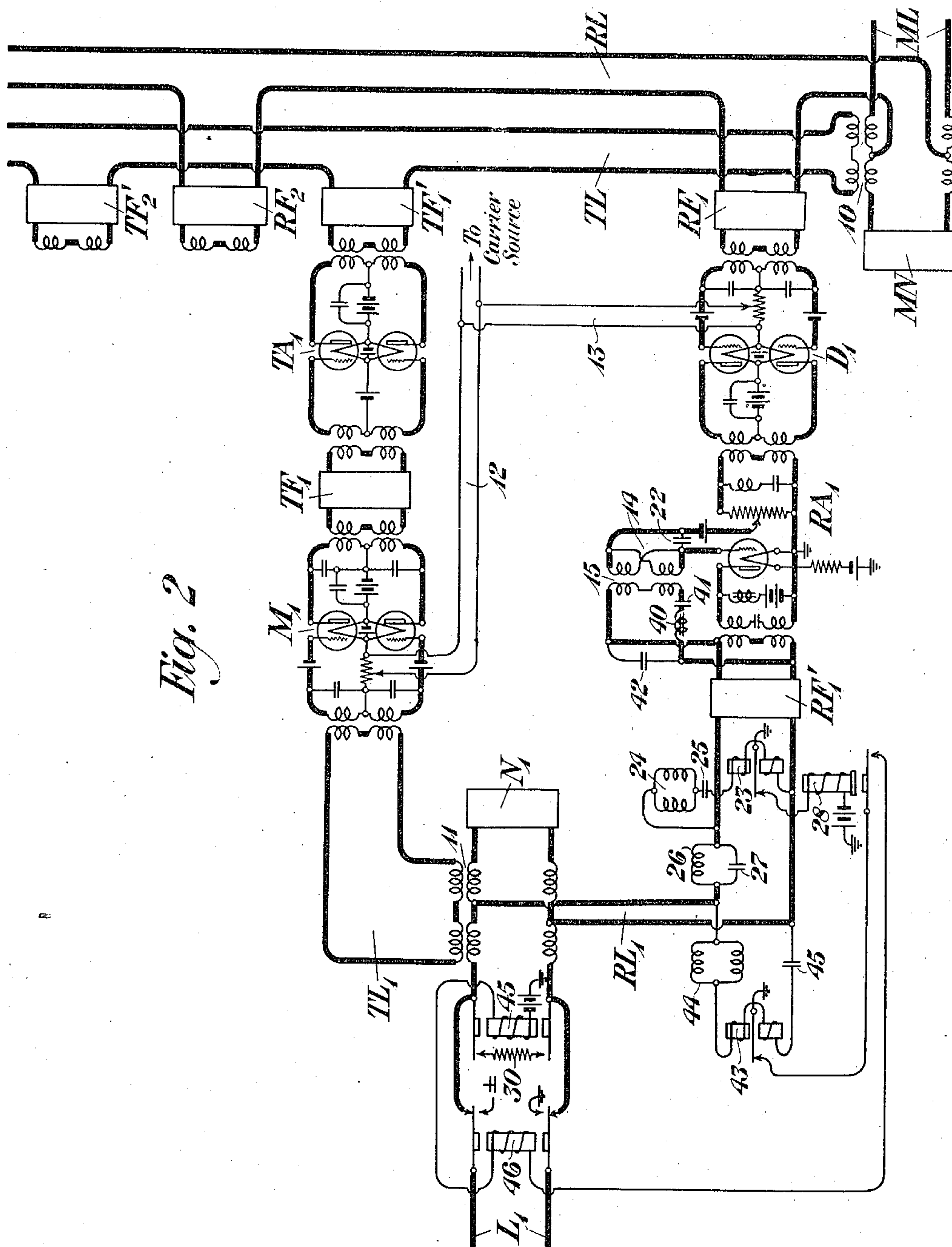
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2 Sheets-Sheet 2



INVENTOR.

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Patented May 15, 1923.

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UNITED STATES PATENT OFFICE.

HERMAN A. AFFEL, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR RINGING OVER MULTIPLEX TRANSMISSION CHANNELS.

Application filed July 29, 1919. Serial No. 314,071.

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 Means for Ringing Over Multiplex Transmission Channels, of which the following is a specification.

This invention relates to transmission systems and more particularly to multiplex systems employing carrier currents.

Where multiplex transmission is attained by the use of carrier currents a plurality of carrier frequencies are transmitted over a common transmission line, the carrier frequencies being separated sufficiently to prevent interference and each frequency being assigned for use as a separate channel of communication so that signals, such, for instance, as telephonic variations, may be transmitted by impressing them upon the carrier frequencies. Several channels may thus be superposed upon a common transmission line and each channel performs the functions of an ordinary telephone transmission line.

In ordinary telephone transmission it is customary to transmit over the line, in addition to the telephone currents ringing currents or other signaling currents for the purpose of signaling between operators in establishing connections. In order to obtain practical telephone service over each carrier communication channel, it is desirable that the channel be utilized for the transmission of such ringing or other signaling currents as well as for the transmission of the ordinary telephone currents.

A cardinal feature of this invention is the provision of means whereby ringing or other signaling currents may be transmitted over each channel of a multiplex system, in addition to the transmission of talking currents.

Another feature of the invention is the provision in a transmission circuit of an amplifier having a feed back connection so arranged that under certain conditions it will operate to reamplify a critical frequency, while under other conditions it will act as a generator of oscillations of that frequency.

Another feature of the present invention provides a two-way transmission circuit comprising two paths, one for transmission in one direction and one for transmission in the opposite direction, one of said paths in-

cluding an amplifier, which, under certain conditions, will operate to generate oscillations for transmission to the other path.

The invention likewise consists in a system in which a terminal low frequency line is associated with one channel of a high frequency multiplex system for the transmission of telephonic currents, of means whereby ringing current transmitted over the terminal line from a terminal station may be transmitted to a distant station over the high frequency channel.

The invention further, aims to provide, in a system in which a low frequency line is associated with one channel of a high frequency multiplex system for telephonic transmission, means whereby in response to ringing current transmitted from the terminal line, signal variations from a local source may be applied to the high frequency channel for transmission over said channel to a distant station.

The invention furthermore comprises means whereby in response to high frequency current modulated in accordance with a ringing signal and transmitted over a channel of a multiplex system, ringing current may be transmitted over a terminal line associated with such channel to a terminal station.

The invention also provides, in a multiplex system in which both talking and ringing currents are transmitted over the same channel, selective means to separate the talking and ringing currents so that the ringing currents may be utilized to selectively operate ringing apparatus.

The invention also provides, in a multiplex system in which terminal lines are balanced with respect to two-way high frequency channels associating them with a common high frequency line, and in which the transmission of a ringing signal over the high frequency line for a given low frequency line causes the disconnection of the low frequency line from the connecting channel for the purpose of transmitting locally generated ringing currents over the high frequency line, means to maintain the balance of the two-way channel while such low frequency line is disconnected.

Another feature of the invention provides, in a system in which two transmission lines are interconnected through a two-way circuit

having two paths which are balanced so as to be conjugate with respect to each other, means whereby the condition of balance between the two paths may be disturbed at will.

A still further feature of the invention provides, in a system of the character just described, means whereby the condition of balance between the two paths of the two-way circuit may be disturbed at will, for the purpose of transmitting from one path to the other.

The above features of the invention, as well as others more fully hereinafter appearing, may be realized by means of the arrangements set forth in the following description and illustrated in the accompanying drawing, Figures 1 and 2 of which constitute circuit diagrams of two embodiments disclosing such features of the apparatus as are necessary to a full understanding of the invention.

Referring to the drawing, ML designates a main line employed for the transmission of a plurality of carrier frequencies between two main stations at which terminal carrier equipment is provided for separating the frequencies into their respective channels and for associating them with low frequency transmission lines. A portion of the apparatus at one station only is illustrated, it being understood that similar apparatus will be provided at the other station. At the station illustrated in the drawing the main line ML is balanced by an artificial line MN and is associated through a balanced transformer arrangement 10 with a common transmitting circuit TL and a common receiving circuit RL, the arrangement being such that these two circuits are conjugate with respect to each other, so that electrical variations arising in the one circuit will be without effect upon the other.

The common transmitting and receiving circuits TL and RL are associated with a terminal low frequency line L_1 through a two-way circuit comprising a transmitting channel TL_1 and a receiving channel RL_1 , the former channel being inductively associated with the common circuit TL through a connection including a filter TF_1' , and the latter channel being inductively associated with the common receiving circuit RL through a connection including a filter RF_1 . The transmitting and receiving channels TL_1 and RL_1 are interconnected at their ends through a transformer arrangement 11 with the terminal line L_1 , the latter line being balanced by an artificial line or network N_1 so that the transmitting and receiving channels TL_1 and RL_1 will be conjugate with respect to each other. The common transmitting and receiving circuits TL and RL may be similarly associated with one or more other low frequency terminal lines through

transmitting and receiving channels similar to TL_1 and RL_1 , the manner in which additional channels are associated with the common circuits TL and RL, being indicated by the connections including the filters TF_2' and RF_2 .

The transmitting channel TL_1 includes, in addition to the filter TF_1' , a similar filter TF_1 . These filters are preferably broad band filters of the general type illustrated in U. S. patents issued to George A. Campbell, Nos. 1,227,113 and 1,227,114 dated May 22, 1917. These filters should be so designed as to transmit a band of frequencies equal in width to the band of frequencies employed in ordinary telephonic transmission, said band extending from the carrier frequency assigned to the channel to a limiting frequency either above or below said carrier frequency an amount equal to the width of the band.

In order to translate the low frequency signaling currents transmitted over the line L_1 into high frequency currents for transmission over the main line ML, the transmitting channel TL_1 is provided with a modulator M_1 . This modulator is preferably of the duplex vacuum tube type illustrated and described in the U. S. application of B. W. Kendall, Serial No. 125,349 filed October 13, 1916, or in the U. S. patent to John R. Carson, No. 1,343,307 issued June 15, 1920. The modulator M_1 is supplied with carrier oscillations of the frequency assigned to the channel over a circuit 12, but as these oscillations are impressed on the common conductor of the balanced circuit normally no oscillations are transmitted through the modulator.

The transmitting channel TL_1 is also provided with an amplifier TA_1 included in said circuit between the filters TF_1 and TF_1' . This amplifier may be of any well-known type, but, as illustrated, is a duplex vacuum tube amplifier of the so-called push and pull type.

The receiving channel RL_1 includes, in addition to the filter RF_1 , a filter RF_1' . These filters are likewise of the general type illustrated and described in the patents to Campbell above referred to, the filter RF_1 being similar in structure and transmitting a band of frequencies similar to that transmitted by the filters TF_1 and TF_1' . The filter RF_1' , however, is a low frequency filter designed to transmit a range of frequencies extending from zero up to the upper limiting frequency employed in ordinary telephonic transmission.

The receiving channel RL_1 also includes a demodulator or detector D_1 . This detector may be of any well-known type, but is illustrated as being of the duplex vacuum tube type illustrated and described in the U. S. patent to John R. Carson, No. 1,343,308

issued June 15, 1920. As set forth in the said patent to John R. Carson this demodulator operates in accordance with the so-called homodyne method of receiving and is therefore supplied with oscillations of the same frequency as the corresponding modulator. These oscillations are supplied over the circuit 13 to the common branch of the balanced input circuit of the demodulator so that normally no high frequency oscillations are transmitted through the demodulator.

The receiving channel RI_1 is also provided with an amplifier RA_1 , for the purpose of amplifying the detected low frequency currents. This amplifier may be of any well-known type, but, as illustrated, is a vacuum tube having its input circuit coupled with its output circuit through a connection including a circuit 14 inductively coupled through a transformer 15 with a circuit including conductors 16, 17 and 18, conductors 16 and 18 being connected to one winding of a transformer 19 in the output circuit of the amplifier. Conductor 17 is normally connected in series with conductor 18 and includes a condenser 20, while the conductor 16 includes an inductance 21. A condenser 22 is bridged across the primary windings of the transformer 15, thereby forming a circuit resonant at a critical frequency.

In the amplification of telephonic currents which may be considered to extend over a range from about 300 cycles to about 2,000 cycles, the feed back connection above described is without substantial effect and the amplifier operates to amplify telephonic frequencies in the ordinary manner. It is desirable, however, that the detected ringing currents which will be impressed upon the amplifier as hereinafter described shall be amplified to a greater degree than the talking currents. These ringing currents should be of some frequency outside the telephone range described, as, for instance, 133 cycles. By means of the condenser 22 the circuit 14 is therefore tuned to resonate at 133 cycles. The condenser 20 is of such a value, however, with respect to the inductance 21, that the portion of the feed back circuit in which these elements are included will not be resonant at a frequency of 133 cycles, but will be resonant at a frequency sufficiently remote therefrom so that the feed back circuit will cause reamplification at 133 cycles without causing the repeater circuit to sing.

In order to control the transmission of ringing current of suitable frequency to the terminal line L_1 in response to ringing signals received, detected and amplified by the apparatus in the receiving channel RL_1 , a relay 23 is bridged across the receiving channel RL_1 beyond the filter RF_1 by means of a circuit tuned to 133 cycles through the

agency of an inductance 24 and a condenser 25. This bridged circuit forms a path of low impedance to ringing currents of 133 cycles, but offers a high impedance to telephonic currents which may be in general above 300 cycles. In order to insure that the maximum amount of ringing current shall flow through the bridge including the relay 23, a circuit including an inductance 26 and condenser 27 is serially inserted in one side of the channel RL_1 beyond the bridge including the relay 23. The condenser 27 and the inductance 26 are so chosen as to form a circuit which is anti-resonant at 133 cycles, thereby preventing the flow of current of this frequency beyond the bridge including the relay 23. The relay 23, while being unresponsive to currents of voice frequency is readily responsive to ringing currents of 133 cycles and operates through relay 28 a relay 29, whereby the terminal line L_1 is disconnected from the channels TL_1 and RL_1 and ringing current from a local source of some suitable frequency such as 16 cycles or 133 cycles is applied to said line. In order to prevent the unbalance of the two-way circuit including the channels TL_1 and RL_1 during this operation the relay 29 also operates to connect an auxiliary network or resistance 30 across the terminals of the windings of the transformer 11, in order to balance the artificial line N_1 .

In order that ringing signals incoming from the line L_1 may be transmitted over the line ML to a distant station through the transmitting channel TL_1 , a relay 31 is bridged across the line L_1 , said relay being responsive to ringing current of any desirable frequency, as, for instance, 16 cycles or 133 cycles. This ringing responsive relay 31, upon being actuated operates through a slow-acting relay 32 to apply ringing current from a local source upon the input circuit of the modulator M_1 . While any local source of ringing current may be utilized for this purpose, it is convenient to utilize the amplifier RA_1 as a source of ringing current.

For this purpose the feed back circuit of the amplifier RA_1 is so arranged that by the operation of relay 33 under the control of relay 32, the conductor 18 is shifted from connection with the conductor 17 and is serially connected to a conductor 34 including a condenser 35. The condenser has a capacity sufficiently different from that of condenser 20 to change the period of the circuit so that it is now resonant at 133 cycles and consequently the feed back connection causes the amplifier RA_1 to oscillate at 133 cycles to generate ringing current.

In order that the ringing current generated by the amplifier RA_1 may be transmitted to the modulator M_1 a relay 36 is provided under the control of relay 32, said re-

lay being arranged to short circuit the line L_1 between the transformer 11 and the relay 31, thereby unbalancing the transformer connection between the transmitting channel TL_1 and the receiving channel RL_1 so that the channels are no longer conjugate. The oscillations supplied by the amplifier RA_1 may therefore be transmitted from the receiving channel RL_1 to the transmitting channel TL_1 and applied to the modulator M_1 . In order to prevent the oscillations thus transmitted from operating the relay 23 and in order to provide a transmission path of low impedance for the 133 cycle currents, the relay 36 is arranged to disconnect the bridge including the relay 23 and to short circuit the anti-resonant combination 26—27.

Further details of the apparatus will be clear from a description of the operation which is as follows:

Telephone currents incoming from the line L_1 are transmitted over the outer back contacts of relay 29 and through the transformer 11 to the transmitting channel TL_1 without actuating the relay 31, the circuit of which is so designed as to offer a large impedance to currents of telephonic frequency. The telephone currents upon being transmitted to the channel TL_1 are impressed upon the input circuit of the modulator M_1 . As already stated the circuit of the modulator M_1 is normally balanced so that carrier oscillations from the source 12 are not transmitted. The telephonic currents impressed upon the modulator, however, unbalance its circuit so that carrier oscillations are transmitted by the modulator whose amplitude is directly proportional to the amplitude of the modulating voice wave. These modulated oscillations are passed through the filter TF_1 , amplified by the amplifier TA_1 and then passed through the filter TF_1' to the common transmitting circuit TL . Simultaneously modulated carrier currents of other frequencies from other channels are impressed upon the circuit TL . The several modulated frequencies are transmitted through the transformer 10 and over the main line ML to the distant station.

Carrier currents having frequencies corresponding to the several channels at the station of Fig. 1 and modulated at the distant station in accordance with telephone signals, after being transmitted over the line ML , pass into the common receiving circuit RL , from which the different carrier frequencies are selected into the proper receiving channels through the agency of filters such as RF_1 , RF_2 , etc. The modulated carrier oscillations passed through the filter RF_1 are impressed upon the input circuit of the demodulator D_1 where they react with unmodulated oscillations from the source 13 to produce in the output circuit of the demodulator low frequency telephonic currents cor-

responding to the telephone currents, in accordance with which the high frequency oscillations were modulated at the distant station. The low frequency telephone currents thus supplied are impressed upon the amplifier RA_1 and are transmitted through the amplifier without substantially affecting the feed back circuit, which, as already stated, is so arranged as to cause the amplifier to reamplify oscillations having a frequency of 133 cycles which is below the lower limit of telephone currents. The telephone currents are therefore amplified by the amplifier RA_1 in the normal manner and are transmitted through the transformer 19, passing through the low frequency filter RF_1' to the midpoints of the transformer 11. The bridge including the relay 23 and the anti-resonant combination 26—27 do not materially decrease the transmission of the channel RL_1 , since they are designed to be affected with regard to currents in the neighborhood of 133 cycles only. The telephone currents upon arriving at the midpoints of the windings of the transformer 11 divide, part of the energy flowing to the artificial line N_1 and part of the energy flowing over the back contacts of the relay 29 to the line L_1 .

Ring current transmitted over the line L_1 from a distant terminal station passes over the back contacts of the relay 29 and through the windings of the ringing responsive relay 31. Condensers 37 and 38 having a high impedance to ringing currents, but readily permitting the passage of telephone currents, may be inserted between the relay 31 and the transformer 11 to insure that the greater proportion of the energy of the ringing current transmitted from the line L_1 shall be impressed upon the relay 31. Relay 31, in response to the ringing current opens a circuit of the slow acting relay 32 which completes circuits energizing relays 33 and 36. Relay 33 upon being energized, at its left hand contact disconnects ground from the normally opened circuit of the relay 29 to prevent any possibility of this relay being actuated to connect ringing current from a local source to the line L_1 . At its front lefthand contact relay 33 connects ground directly to the grid of the amplifier RA_1 through the primary winding of the transformer 15, thereby short circuiting the potentiometer 39. At its righthand front contact relay 36 disconnects conductor 18 from conductor 17 and connects it to conductor 34 which includes the condenser 35 so that the feed back circuit is so adjusted that the amplifier RA_1 oscillates at 133 cycles to generate ringing current. A distinct advantage arises from the short circuiting of the potentiometer 39 in the manner just described, due to the fact that the setting of the potentiometer is varied from time to time, under practical operating conditions,

to vary the amplification of the amplifier RA_1 in accordance with the transmission conditions of the circuit and by short circuiting the potentiometer, the amplifier when functioning as an oscillator will always be enabled to generate oscillations of the same amplitude.

The relay 36 upon being energized, at its right hand front contact opens the bridge including the relay 23, thereby preventing said relay from being actuated by the 133 cycle oscillations supplied by the amplifier RA_1 and at the same time it short circuits the anti-resonant combination 26—27, which, if it remained in the circuit would substantially prevent the transmission of the oscillations to the transformer 11. At its left hand front contact relay 36 connects a short circuit across the left hand terminals of the line windings of the transformer 11, thereby unbalancing the circuit so that transmission may take place from the receiving channel RL_1 , through the transformer 11 to the transmitting channel TL_1 . The 133 cycle oscillations are now transmitted from the amplifier RA_1 , through the filter RF_1' and through the transformer 11 to the input circuit of the modulator M_1 . The 133 cycle oscillations thus transmitted operate to modulate the carrier frequency through the agency of the modulator M_1 in the same manner as described in connection with telephone currents. High frequency oscillations modulated in accordance with the ringing currents supplied by the amplifier RA_1 are therefore transmitted from the modulator M_1 , through the filter TF_1 , amplifier TA_1 , filter TF_1' , common circuit TL , transformer 10 and over the main line ML to the distant station.

In case it is desired to ring over the line L_1 from the distant station the carrier apparatus at that station will be operated in a manner similar to that just described, so that carrier oscillations modulated in accordance with 133 cycle ringing current will be transmitted over the main line ML and into the common receiving circuit RL . The carrier oscillations are then selectively transmitted through the filter RF_1 to the input circuit of the demodulator D_1 . These modulated oscillations react in the demodulator D_1 with unmodulated oscillations from the circuit 13 to produce in the output circuit of the demodulator 133 cycle ringing currents, which are then impressed upon the amplifier RA_1 . This amplifier having its feed back circuit in its normal condition acts as a reamplifier at a frequency of 133 cycles and consequently the ringing currents are amplified to a much greater degree than in the case of telephone currents. The highly amplified ringing currents are then passed through the filter RF_1' and flow through the bridge, including the relay 23

to operate said relay, the anti-resonant combination 26—27 at the same time functioning to prevent any substantial amount of the ringing energy from being transmitted beyond the relay 23. Relay 23 upon being energized opens the circuit of the slow acting relay 28, thereby completing the circuit of relay 29, which at its outer front contacts disconnects the line L_1 from the transformer 11 and applies a local source of ringing current to said line. At its inner front contacts relay 29 at the same time substitutes an auxiliary line 30 for the line L_1 so that the balance of the transmitting and receiving channels TL_1 and RL_1 is maintained.

A somewhat different embodiment of the invention is illustrated in Fig. 2, this embodiment differing from that of Fig. 1, principally in the fact, that ringing current transmitted from a distant station over the terminal line L_1 is impressed directly upon the modulator instead of causing relayed current from a local source to be impressed upon the modulator. Since in this case there is no necessity for using the amplifier RA_1 as a source of ringing oscillations, the feed back circuit of the amplifier is not provided with any means for changing the capacity therein, but the portion of the feed back which is included on the secondary side of the transformer 15 is provided with inductance 40 and capacities 41 and 42 so proportioned that the amplifier will function to reamplify ringing currents of any desired frequency, as, for instance, 133 cycles, while for telephonic frequencies only the usual degree of amplification is provided. Furthermore, since ringing current is not generated by the amplifier RA_1 for transmission to the modulator M_1 , it is not necessary to short circuit the anti-resonant combination 26—27 and to open the bridge including the relay 23. By permitting the anti-resonant combination to remain in circuit, the relay 23 is, to a large extent, protected from being actuated by the ringing current which is transmitted from the distant station over the line L_1 , part of which instead of flowing to the transmission channel TL_1 , will flow to the receiving channel RL_1 .

In order to prevent the actuation of the relays controlled by the ringing responsive relay 23, in case sufficient current should pass the anti-resonant combination to actuate said relay, an additional ringing responsive relay 43 is bridged across the receiving channel RL_1 between the anti-resonant combination and the midpoints of the windings of the transformer 11, the bridged circuit including said relay 43 having inductance 44 and capacity 45 included therein to tune the bridge so as to be extremely sensitive to current of ringing frequency. Since a

greater amount of the ringing energy incoming into the receiving channel RL_1 from the line L_1 will be diverted into the bridge including the relay 43 than will be enabled to pass through the anti-resonant combination to the relay 23, the relay 43 will be operated to defeat the results which might flow from the false operation of the relay 23.

Further details of the apparatus will be apparent from the description of the operation.

The operation for telephone transmission between the line L_1 and the main line ML in both directions is substantially the same as in the case of Fig. 1 and need not be further considered. Ringing currents incoming from the line L_1 , however, will be transmitted over the back contacts of relay 46 and through the transformer 11 to the input circuit of the modulator M_1 . Part of the energy from the ringing current incoming from the line L_1 may also be transmitted into the receiving channel RL_1 . Due to the anti-resonant combination 26—27, such ringing energy as is transmitted into the channel RL_1 will be substantially prevented from passing to the bridge including the relay 23, and will flow for the most part through the bridge including the relay 43 which is tuned to be resonant at the frequency of the ringing current. Consequently, whether or not sufficient energy passes into the bridge including the relay 23 to operate said relay, a greater amount of energy will flow through the relay 43 so that if a false operation of the relay 23 should occur, the relay 43 will also be operated thereby opening the circuit of relays 46 and 45 which might otherwise be closed by the deenergization of relay 28. In response to the ringing currents, high frequency oscillations modulated in accordance with the ringing currents will be transmitted from the modulator M_1 through the filter TF_1 to the amplifier TA_1 . After being amplified the high frequency oscillations will be transmitted through the filter TF_1' into the common transmitting circuit TL , through the transformer 10 and over the line ML to the distant station.

High frequency oscillations modulated at the distant station in accordance with a ringing signal for transmission to the line L_1 will be transmitted over the line ML into the common receiving circuit RL and through the filter RF_1 to the demodulator D_1 . In response to the modulated high frequency currents, low frequency currents corresponding to the ringing currents in accordance with which the high frequency oscillations were modulated will appear in the output circuit of the demodulator D_1 , and upon being impressed upon the amplifier RA_1 will be reamplified by means of the feed back connection which is so arranged

as to cause the amplifier to reamplify at the ringing current frequency. The amplified ringing currents are then transmitted through the low frequency filter RF_1' and flow through the tuned bridge including the relay 23, the anti-resonant combination 26—27 substantially preventing the transmission of ringing currents to the portion of the receiving channel RL_1 beyond the bridge including the relay 23. Relay 23 upon being actuated opens a circuit of relay 28 and completes a circuit from ground over the normal contact of relay 43, back contact of relay 28 and through the windings of relays 46 and 45. Relays 46 and 45 are energized, the former disconnecting the line L_1 from the channels TL_1 and RL_1 and applying a local source of ringing current thereto for transmission to the distant terminal station. At the same time the relay 45 substitutes the artificial line or resistance 30 for the line L_1 to maintain the circuit balanced.

It will be seen that by means of this invention simple and yet efficient circuit arrangements have been provided whereby ringing current may be transmitted over the same channel of a multiplex circuit as the talking current, thereby avoiding the necessity of providing additional channels for the transmission of ringing or other auxiliary signals.

Furthermore, while the invention has been illustrated as embodied in certain arrangements which are considered desirable from a practical standpoint, 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 signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuits including modulating apparatus, and means whereby telephone currents and ringing currents may be transmitted over said low frequency circuit, said interconnecting means including modulating apparatus responding to either talking or ringing currents to supply to said high frequency circuit high frequency oscillations modulated in accordance with said talking or ringing currents.

2. In a signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuits including demodulating apparatus, and means whereby high frequency oscillations modulated in accordance with either telephone currents or ringing currents may be transmitted over said high frequency circuit to said demodulating apparatus, said interconnecting means including demodulating apparatus responding to said oscillations to transmit over said

low frequency circuit the telephone or ringing currents in accordance with which said oscillations were modulated.

3. In a signaling system, a high frequency circuit, a pair of low frequency circuits, means interconnecting one of said low frequency circuits with said high frequency circuit including modulating apparatus, means whereby telephone currents and ringing currents may be transmitted over said low frequency circuit, said interconnecting means including modulating apparatus responding to either talking or ringing currents to supply to said high frequency circuit high frequency oscillations modulated in accordance with said talking or ringing currents, means interconnecting the other low frequency circuit with said high frequency circuit including demodulating apparatus, means whereby high frequency oscillations modulated in accordance with either telephone currents or ringing currents may be transmitted over said high frequency circuit to said demodulating apparatus, said interconnecting means including demodulating apparatus responding to said oscillations to transmit over said low frequency circuit the telephone or ringing currents in accordance with which said oscillations were modulated.

4. In a signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuits including modulating apparatus, means whereby telephone currents transmitted over said low frequency circuit may be applied to said modulating apparatus, said interconnecting means including modulating apparatus responding thereto to transmit to the high frequency circuit high frequency oscillations modulated in accordance with said telephone currents, means responsive to ringing signals transmitted over said low frequency circuit to apply current variations from a local source to said modulating apparatus, said interconnecting means including modulating apparatus responding thereto to transmit to said high frequency circuit high frequency oscillations modulated in accordance with said current variations.

5. In a signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuits including modulating apparatus, means whereby telephone currents transmitted over said low frequency circuit may be applied to said modulating apparatus, said interconnecting means including modulating apparatus responding thereto to transmit to the high frequency circuit high frequency oscillations modulated in accordance with said telephone currents, a relay responsive to ringing signals transmitted over said low frequency circuit, means controlled by said relay to apply current variation from a local source to said modulating apparatus, said interconnecting

means including modulating apparatus responding thereto to transmit to said high frequency circuit high frequency oscillations modulated in accordance with said current variations.

6. In a signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuits including demodulating means, said interconnecting means including demodulating means being responsive to high frequency oscillations modulated in accordance with telephone currents and transmitted over said high frequency circuit to transmit telephone currents to said low frequency circuit, said interconnecting means including demodulating means being also responsive to high frequency oscillations modulated in accordance with current variations of a different character to supply the current variations in accordance with which the high frequency oscillations were modulated, and means responsive to said current variations to apply ringing current to said low frequency circuit.

7. In a signaling system, a high frequency circuit, a low frequency circuit, means interconnecting said circuit including demodulating means, said interconnecting means including demodulating means being responsive to high frequency oscillations modulated in accordance with telephone currents and transmitted over said high frequency line to transmit telephone currents to said low frequency circuit, said interconnecting means including demodulating means being also responsive to high frequency oscillations modulated in accordance with current variations of a different character to supply the current variations in accordance with which the high frequency oscillations were modulated, and a relay responsive to said current variations to apply ringing current to said low frequency circuit.

8. In a signaling system, a high frequency circuit, a low frequency circuit, a path interconnecting said circuits, a demodulator in said path, said path and demodulator responding to high frequency oscillations incoming from said high frequency circuit and modulated in accordance with voice currents or signaling currents of frequencies without the usual telephonic range to supply said voice currents or signaling currents of other frequencies, a circuit bridged across said path on the output side of said demodulator, said circuit tuned to the frequency of said signaling currents lying outside the usual telephonic range, means in said path beyond said bridge anti-resonant at said frequency, and means in said bridge responding to said frequency to apply ringing current to said low frequency circuit.

9. In a signaling system, a high frequency circuit, a low frequency circuit, a path in-

terconnecting said circuits, a demodulator in said path, said path and demodulator responding to high frequency oscillations incoming from said high frequency circuit and modulated in accordance with voice currents or signaling currents of frequencies without the usual telephonic range to supply said voice currents or signaling currents of other frequencies, a circuit bridged across said path on the output side of said demodulator, means in said bridged circuit to freely transmit currents of said other signaling frequency while substantially excluding telephonic currents from said bridge, means in said path beyond said bridge to freely transmit telephonic frequencies while substantially preventing the transmission of said signaling frequency, and means in said bridge responding to said frequency to apply ringing current to said low frequency circuit.

10. In a signaling system, a high frequency circuit, a low frequency circuit, a two-way circuit interconnecting said circuits and including two paths one for transmission in one direction and the other for transmission in the opposite direction, means to balance said low frequency circuit with respect to said paths, a demodulator in one of said paths, said demodulator responding to high frequency oscillations transmitted over said high frequency circuit to detect low frequency currents, means responsive to said low frequency currents to disconnect said low frequency circuit from said two-way circuit and apply ringing current to said low frequency circuit, and means to maintain the balance with respect to said two-way circuit during such disconnection.

11. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, said paths being so interconnected at their ends as to be substantially conjugate with respect to each other, and means whereby said conjugate relation may be unbalanced at will, said means being controllable from said line sections.

12. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, said paths being so interconnected at their ends as to be substantially conjugate with respect to each other, a source of oscillations associated with one path, and means whereby said conjugate relation may be unbalanced at will to permit oscillations from said source to be transmitted from one path to the other.

13. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, said paths being so

interconnected at their ends as to be substantially conjugate with respect to each other, a source of oscillations associated with one path, and means responsive to currents incoming from one of said line sections to unbalance said conjugate relation, whereby oscillations from said source may be transmitted from the path with which said source is associated and over the other path to the other line section.

14. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, said paths being so interconnected at their ends as to be substantially conjugate with respect to each other, a source of ringing current associated with one path, and means responsive to ringing currents incoming from one of said line sections to unbalance said conjugate relation, whereby ringing current from said source may be transmitted from the path with which said source is associated and over the other path to the other line section.

15. An amplifier having a feed back coupling between its input and output circuits whereby said amplifier may be enabled to reamplify certain frequencies, and means independent of said coupling for changing the constants of said coupled circuits so that said amplifier becomes a generator of oscillations at said frequencies.

16. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, an amplifier in one of said paths, means to convert said amplifier into a generator of oscillations at will, and means to transmit the oscillations so generated to the other of said paths.

17. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, an amplifier in one of said paths, and means responding to current transmitted from one of said line sections to convert said amplifier into a generator of oscillations and to transmit said oscillations to the other of said paths.

18. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, an amplifier in one of said paths, and means responding to ringing current transmitted from one of said line sections to convert said amplifier into a generator of ringing current, and to transmit the ringing current so generated to the other of said paths.

19. In a signaling system, two transmission line sections, a two-way circuit inter-

connecting said sections, said two-way circuit comprising two paths for transmission in opposite directions, an amplifier in one of said paths, means responding to ringing current transmitted from one of said line sections to so couple the input and output circuits of said amplifier as to cause the amplifier to generate oscillations, and means to transmit the oscillations so generated to the other of said paths.

20. In a signaling system, two transmission line sections, a two-way circuit interconnecting said sections, said two-way circuit comprising two paths for transmission

in opposite directions, and amplifiers in one of said paths, means responding to ringing current transmitted from one of said line sections to so couple the input and output circuits of said amplifiers as to cause said amplifiers to generate oscillations of ringing frequency and means to transmit the ringing oscillations so generated to the other of said paths.

In testimony whereof, I have signed my name to this specification this 23rd day of July, 1919.

HERMAN A. AFFEL.