Mar. 3, 1925. 1,528,010

C. S. DEMAREST ET AL

RADIO SIGNALING SYSTEM

Filed Dec. 31, 1923 2 Sheets-Sheet 1

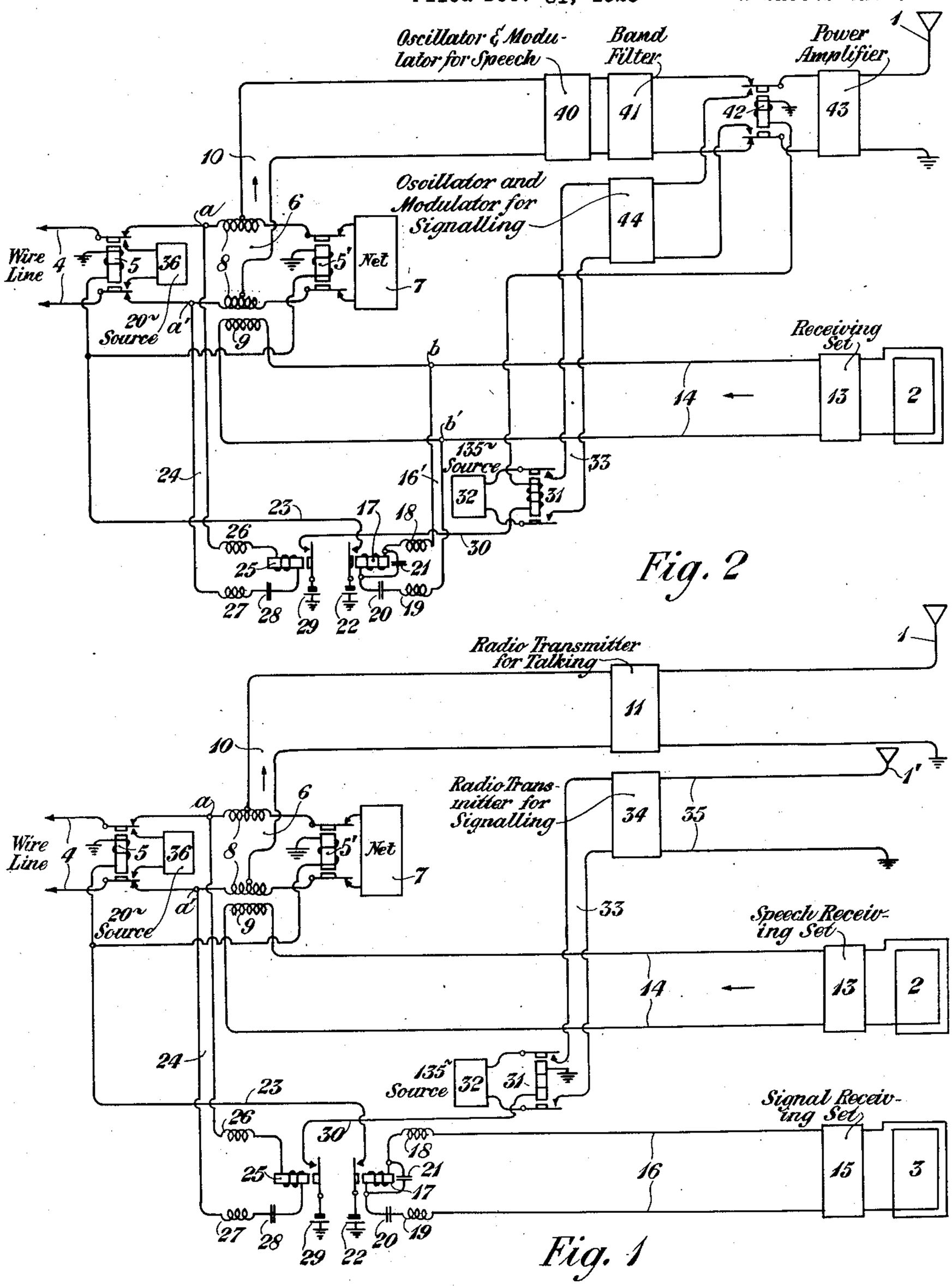

Fig. 2

Fig. 1

INVENTORS

C. S. Demarest and M. L. Almquist

BY

ATTORNEY

Mar. 3, 1925. 1,528,010

C. S. DEMAREST ET AL

RADIO SIGNALING SYSTEM

Filed Dec. 31, 1923 2 Sheets-Sheet 2

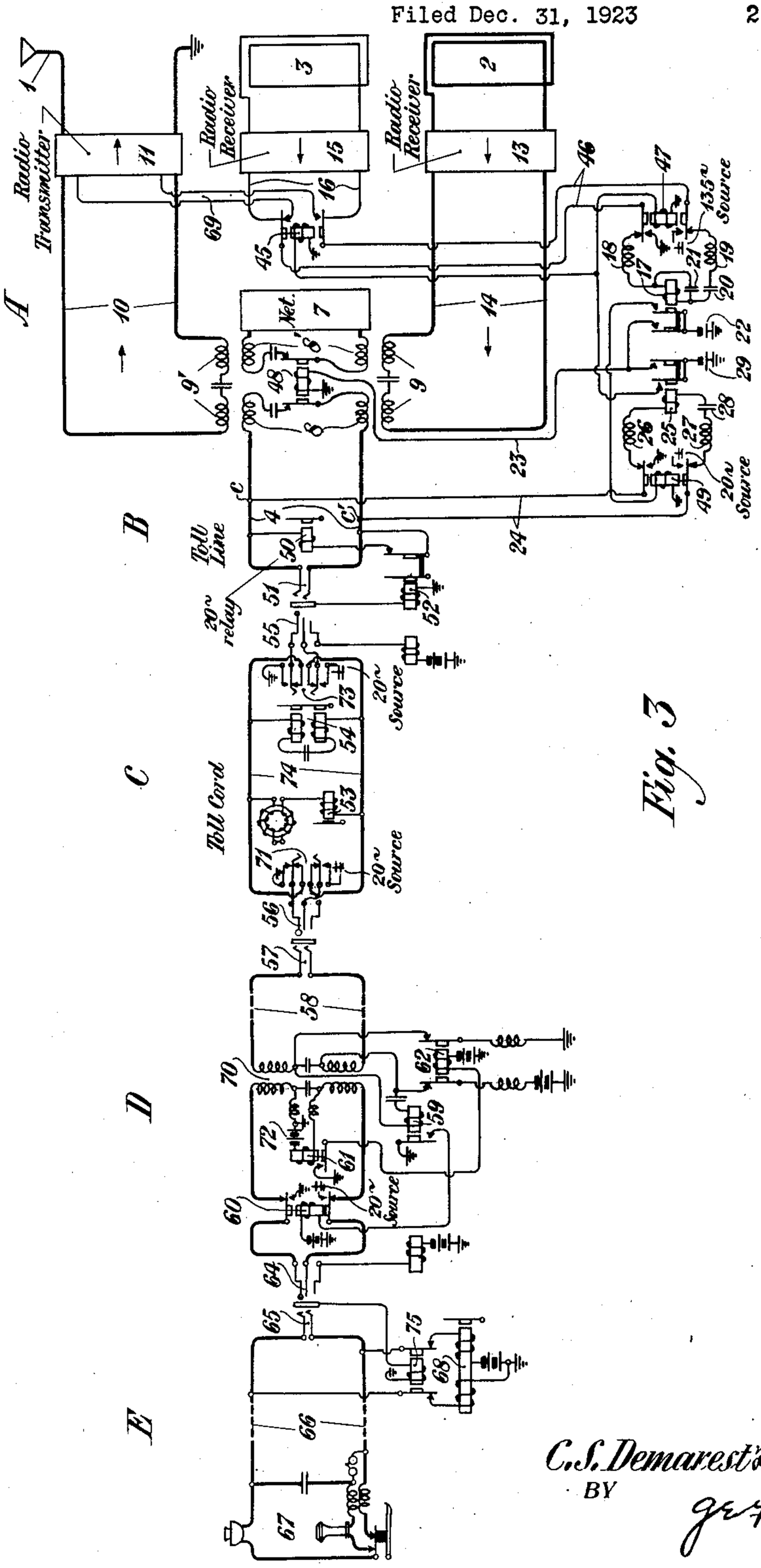

Fig. 3

INVENTORS
C. S. Demarest and M. L. Almquist
BY
ATTORNEY

Patented Mar. 3, 1925. 1,528,010

UNITED STATES PATENT OFFICE.

CHARLES S. DEMAREST, OF RIDGEWOOD, NEW JERSEY, AND MILTON L. ALMQUIST, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

RADIO SIGNALING SYSTEM.

Application filed December 31, 1923. Serial No. 683,746.

To all whom it may concern:

Be it known that we, CHARLES S. DEMAREST and MILTON L. ALMQUIST, residing at Ridgewood and Brooklyn, in the counties of Bergen and Kings and States of New Jersey and New York, respectively, have invented certain Improvements in Radio Signaling Systems, of which the following is a specification.

This invention relates to radio signaling systems, and particularly to improvements on the signaling methods employed in a communication system comprising a radio system combined with a wire system.

One of the objects of this invention is to provide separate receiving circuits for the reception of the speech modulated and the signal modulated carrier currents, which receiving circuits, by their special design and adjustment, produce greater amplification of the particular detected frequency or range of frequencies that each is intended to receive.

A further object of the invention is to provide for the signaling of a distant radio station by the modulation of the carrier current by a low frequency signaling current, for example, of the order of 135 cycles, the application of the 135 cycle current being controlled by a lower frequency current, of the order of 20 cycles, transmitted over the connecting wire line.

Another object of the invention consists of receiving carrier current, modulated, for example, by 135 cycle current, demodulating the modulated current, and allowing the 135 cycle component to control the application to the wire line of 20 cycle current.

Other objects of this invention will be apparent from the following description when read in connection with the attached drawing of which Fig. 1 shows schematically an arrangement having a transmitting and receiving circuit for the speech frequencies and a separate and distinct circuit for the signaling frequencies; Fig. 2 shows an arrangement employing separate modulators for talking and signaling, but using a common power amplifier and transmitting antenna; and Fig. 3 shows a radio signaling system having separate receiving sets for the speech frequency and the signaling frequency combined with a toll telephone system arranged for two-way operation.

In Fig. 1, the transmitting antenna 1 is intended for the transmission of a high frequency carrier current modulated by the speech frequency; and antenna 1′ for the transmission of a carrier modulated by the signaling frequency; 2 and 3 represent, respectively, the speech receiving antenna and the signal receiving antennæ here shown in the form of loops, but which may be of any form of antenna; 4 represents a wire line over which the speech frequency current and the signaling current (which preferably is below the lower limit of speech frequency) are transmitted to and from the radio signaling circuit. The line 4 is connected through the contacts of relay 5 with the hybrid coil 6 to which also is connected (by means of relay 5′) a network 7 adapted to balance the said line. The hybrid coil 6 connects the wire communication circuit with the radio communication circuit. A transmitting branch circuit 10 is connected across the midpoints of the series windings 8 by means of which currents of speech frequency impressed upon the line 4 by apparatus connected with the distant end thereof may be impressed upon the radio transmitter 11 and, in turn, upon antenna 1. This radio transmitter may be of any well-known type having a source of carrier current and means for modulating the said carrier current by the speech current; and also preferably having one or more stages of amplification.

The speech reception antenna 2 is connected with the receiving set 13, which may be of any well-known type but preferably should be designed and adjusted for the detection of the range of speech frequencies. The output side of this receiving set is connected by circuit 14 with the winding 9 of the hybrid coil 6 whereby the speech frequency currents resulting from detection are impressed upon the line 4 for transmission to the distant station. The signal receiving antenna 3 is connected with a receiving set 15 which is designed and adjusted for the maximum selectivity and amplification of the particular signaling frequency used as, for example, 135 cycles. The output side of this receiving set is connected by circuit 16 with one side of a composite ringer, which side is tuned, for example, for the particular signaling frequency which, as stated, will be assumed to be 135 cycles. This tun-

ing is effected by the inductances 18 and 19, the condensers 20 and 21 and also by the inductance of relay 17. This relay, when operated, connects the battery 22 with the conductor 23 connected with the winding of relays 5 and 5′. By the operation of relay 5, 20 cycle current from the source 36 will be applied to the line 4. Relay 5′ serves to disconnect the network 7 from the hybrid coil 6 whenever the line 4 is disconnected and thus maintains a state of balance. The other half of this composite ringer, which is connected across the line 4 at the points *a*—*a*′, contains the inductances 26 and 27, the condenser 28 and also the relay 25 by means of which it is tuned to a particular low frequency, for example, 20 cycles, which is the frequency used for signaling over the wire line 4. This relay, when operated, connects the battery 29 with conductor 30 thereby operating the relay 31. By the operation of relay 31, the source 32 of 135 cycle current is connected by the circuit 33 with the radio transmitter 34, which may be of any well-known type, whereby a high frequency carrier current will be modulated by the signaling current. The resultant signal modulated carrier current will be impressed upon the antenna 1′.

The manner in which this circuit operates to carry out the invention is as follows:

When a station connected with line 4 desires to signal a distant radio station, 20 cycle current will be applied to the line by or at the calling station, which will be transmitted over the line and will flow into the circuit 24 which, as stated, is tuned to the frequency of 20 cycles. The relay 25 will be operated, and the battery 29 will be connected by conductor 30 with relay 31, causing its operation. By the operation of the relay 31 the source 32 of 135 cycle current will be impressed by circuit 33 upon the radio transmitter 34 serving to modulate the carrier current. The resultant high frequency current modulated by 135 cycles will be impressed upon the antenna 1′ and will be radiated therefrom. As soon as the calling station connected with line 4 ceases to transmit 20 cycle current, relay 25 will be deenergized, and consequently the source 32 of 135 cycle current will be disconnected from the circuit 33, and the radiation of the calling signal will cease. Speech currents resulting from the talking of the subscriber connected with line 4 will be impressed on circuit 10 and will modulate the carrier frequency current in the radio transmitter 11.

When a distant radio station desires to call a station connected with the line 4, the antenna 3 will receive the carrier current modulated by the signaling current which has been assumed to be 135 cycles. This received current will be detected by the receiving set 15 which is designed to have maximum sensitivity and to produce maximum amplification for this particular frequency, namely, the low frequency signaling component, and the resultant current will be impressed upon the circuit 16 and will operate relay 17. This results in the operation of relays 5 and 5′ by current from the battery 22 connected with conductor 23 through the contact of relay 17. Accordingly there will be connected with the line 4 the source 36 of 20 cycle current, which will operate the signaling apparatus located at the station connected with line 4 responsive to 20 cycle current. As soon as the distant radio station ceases to send the calling signal, relay 17 will be deenergized, and upon the deenergization of relays 5 and 5′ the line 4 will be effectively connected with the speech branches of the radio circuit. Consequently, when the distant radio station begins to transmit speech modulated waves, they will be received by antenna 2 and detected by the receiving set 13, which is designed to have maximum sensitivity and to produce maximum amplification for the voice range of frequencies. The resultant speech frequencies will be impressed by circuit 14 upon the windings of the hybrid coil 6 and transmitted to the station upon line 4.

The arrangement shown in Fig. 2, in which the same numerals have been used to designate similar apparatus shown in Fig. 1, differs from that shown in Fig. 1 in that the same receiving set has been used for the reception of speech and signals. It is also characterized by the use of a single side band for the transmission of speech frequencies, the purpose of which will appear from the following description.

In the operation of this system, when a station connected with line 4 desires to call a distant radio station, 20 cycle current will be applied to the line which will flow through circuit 24 and operate relay 25. This serves to connect the battery 29 with conductor 30, thereby operating relays 31 and 42. By the operation of relay 31, 135 cycle current from the source 32 will be impressed upon the circuit 33 and, in turn, upon the radio transmitter 44 wherein it will serve to modulate the high frequency carrier current. Since relay 42 has also operated, the output side of the radio transmitter 44 will be connected over the inner contacts of relay 42 with the input side of the power amplifier 43 so that the signal modulated carrier will be brought up to the proper power level and impressed upon the antenna 1 for transmission to the distant station. As soon as the calling station on line 4 ceases to transmit its 20 cycle signaling current, relay 25 will be deenergized and consequently relays 31 and 42 will be released. Upon the deenergization of relay

42, the input side of the power amplifier 43 will be connected over the outer contacts of relay 42 with the output side of the speech transmitting channel. Accordingly, when the calling party begins to talk, the speech currents applied to line 4 will be impressed by the hybrid coil 6 upon the circuit 10 and will serve to modulate the high frequency currents set up in the radio transmitter 40.

As is well known, it is difficult to broadly tune an antenna, designed to operate on a long wave length. Assuming a carrier frequency of 50,000 cycles, the upper limit of one band of speech modulated carrier would be of the order of 52,000 cycles and of the other band 48,000 cycles. It is, therefore, desirable to suppress one of the bands, and, from the standpoint of the conservation of energy it is desirable to suppress the carrier also. The carrier may be suppressed by using for modulator 40 one of the types of modulators shown in the patent to J. R. Carson, No. 1,343,307, issued June 15, 1920. One of the side bands of speech modulation (say the lower one) resulting from 40 is suppressed by the band filter 41. Therefore, only the upper band is amplified by 43 and impressed upon the antenna 1. Assuming that this band ranges from 50,200 to 52,000 cycles, by tuning the antenna to give maximum radiation say at 51,000 cycles, good radiation is effected throughout the range of the band. In order to bring the signaling frequency within the range of frequencies for which the antenna 1 gives good radiation, the oscillator of 44 is adjusted for 51,000 cycles so that the modulated signaling wave ranges from 50,865 cycles to 51,135 cycles, which is within the limits of the antenna.

It will be seen, therefore, that by using separate modulators for speech and signals we are enabled to control the range of the modulated high frequency waves so that they will fall within the limits of the antenna for good radiation. The figures used above are purely illustrative and in no wise constitute a limitation upon the invention.

When the distant radio station calls the station connected with line 4, the received signal-modulated current will be impressed upon the receiving set 13, which may be of any type adapted to give good detection throughout the signal and the speech frequency range, for example, from 135 cycles up to the upper limit of the voice frequencies. The resultant low frequency current of the order of 135 cycles will be impressed upon the circuit 16′ connected with that side of the composite ringer tuned to 135 cycles. This will operate relay 17 which, in turn, will operate relays 5 and 5′, thereby connecting the source 36 of 20 cycle current to the line 4 and operating the signaling apparatus connected with the distant station. As soon as the distant radio station ceases to transmit the signal-modulated carrier current, relays 17, 5 and 5′ will be deenergized, and line 4 will be effectively connected with the speech channels of the radio station. Accordingly, when speech-modulated carrier currents are transmitted from the distant radio station, they will be received by antenna 2, detected by the reeciving set 13, impressed by circuit 14 upon the hybrid coil 6 and transmitted over line 4 to the distant station thereon. It is to be understood that the transmitting circuits of Fig. 2 may be combined with the receiving circuits of Fig. 1, thereby creating a radio station having separate modulators for speech and signals but having a common antenna; and also having separate receiving branches as in Fig. 1.

In Fig. 3, A represents a radio transmitting and receiving station; B represents a toll circuit; C represents a toll cord circuit; D represents a switching trunk; and E represents a subscriber's line. At the radio station A, the antenna 1 is designed for the transmission of the high frequency currents modulated by the speech and also by the signal frequencies; 2 and 3 represent the antennæ for the reception of the speech-modulated currents and the signal-modulated currents; 4 represents a line extending from the radio station to the toll switchboard. The line 4 is connected with the transmitting and receiving branches of the radio station by means of the connecting network 6 comprising a plurality of windings and condensers connected in the manner shown. A balancing network 7 is connected with the hybrid coil. The transmitting branch 10 connects the hybrid coil with the input side of the radio transmitting set 11. The speech reception antenna 2 is connected with the radio receiving set 13 which is designed to have uniform amplification for the particular frequencies within the speech range. The output side of the set 13 is connected by the circuit 14 with the windings 9 of the hybrid coil. The signal receiving antenna 3 is connected with the receiving set 15, which is designed to give high amplification for the particular frequency used in signaling. The output side of this set is connected by circuit 16 with the outer contacts of relay 45. Since the set must at all times be capable of receiving signals from distant radio stations, this output circuit is normally connected by circuit 46 with the side of the composite ringer tuned for the particular signaling frequency which will be assumed to be 135 cycles. This composite ringer is, in general, similar to that shown and described in connection with Figs. 1 and 2. Each of the relays 17 and 25 has an additional contact by means of which battery is applied to conductor 23 for con-

trolling the operation of the cut-off relay 48, which opens the connections of the line and the balancing network to the hybrid coil. Relay 47 is designed to apply 135 cycle current to the circuit 46 for the modulation of the carrier current in the radio transmitting set 11 for the signaling of a distant radio station. Relay 45, which operates whenever relay 47 operates, serves to effect the proper connection of the circuit 46 with circuit 69 leading to the transmitting set 11. Relay 49, which operates whenever relay 17 operates, serves to apply 20 cycle ringing current to the line 4, which terminates at the toll switchboard in the jack 51 and has bridged across it a relay 50 controlling a lamp or other device for signaling the operator. A cut-off relay 52 is connected with the sleeve contact of this jack and operates upon the insertion of the plug 55. The toll cord shown in its simplest form terminates in the plugs 55 and 56, 55 being adapted for insertion in the jack 51, and 56 for insertion in the jack 57 of the switching trunk. 53 and 54 represent, respectively, direct current and alternating current supervisory relays. An operator's telephone circuit is connected with the cord circuit in the usual manner. The switching trunk 58 terminates at the local exchange in a plug 64 intended to be inserted in the jack 65 of the subscriber's line 66 in order to complete the connection between the radio station A and the subscriber's set 67. Bridged across a condenser in the repeating coil 70 is a relay 69 which is responsive to 20 cycle ringing curent transmitted by the key 71 of the toll cord. Upon the operation of relay 59, relay 60 will be energized, which will apply 20 cycle current over the inner contacts of this relay to the subscriber's set 67. Relay 61, which is in series with the battery 72 supplying the current for the transmitter of station 67, will operate as soon as the subscriber answers his telephone, thereby energizing relay 62 which serves to extinguish the supervisory lamp (not shown) connected with 53. 68 represents the line relay and 75 the cut-off relay of a subscriber's line.

Let us assume that a party connected with a distant radio station desires to call the subscriber at 67. The high frequency currents modulated, say, by 135 cycle currents will be received by antenna 3 and detected by the receiving set 15. The resultant 135 cycle current will be impressed by the circuit 16 upon the circuit 46 and will cause the operation of relay 17. This will, in turn, cause the operation of relays 48 and 49 by current from the source 22. The operation of relay 48 prevents the 20 cycle current from flowing back through the hybrid coil 6 and circuit 10 and modulating the high frequency carrier current of the set 11. By the operation of relay 49, 20 cycle current will be impressed over its inner contacts and thence over circuit 24 and line 4, and will cause the operation of the signal controlled by relay 50. The toll operator at C will then insert plug 55 in jack 51, and will wait until the ringing ceases. As soon as the distant radio station ceases to ring, relay 17 will be released which, in turn, releases relays 48 and 49. As soon as the operator at C answers, the line 4 will be connected through the hybrid coil 6 to the transmitting set 11, thereby enabling her to talk over the transmitting path 10 with a distant operator. Having ascertained the number of the called party, the operator at C uses an order circuit to the local exchange at which the line E terminates, and directs the local operator to insert the plug 64 of the switching trunk D in the jack 65 of the subscriber's line. The toll operator then inserts plug 56 in jack 57 of the switching trunk, and operates key 71, causing the operation of relay 59 by the ringing current from the contacts of the key. Relay 60 will then operate, and the 20 cycle current from its inner contacts will flow over line 66 and will signal the subscriber at 67. When the operator or the subscriber at the distant radio station begins to talk, the speech modulated currents will be received by antenna 2 and will be detected by the receiving set 13. The resultant voice frequency currents will flow over circuit 14 and will be impressed by the windings 9 upon the hybrid coil 6. These currents will then be transmitted over the toll line 4 and the subsequent connecting lines to the subscriber at 67.

It is desired to point out that while we have shown a separate receiving antenna 3 for the reception of signal modulated currents, such arrangement is not essential for the carrying out of this invention inasmuch as the receiving set 13 may be made efficient for the reception of both speech and signal modulated currents. In such event, the output side of the receiving set 13 might be connected not only with the windings 9 of the hybrid coil, but also with the outer contacts of relay 45 in the same manner in which the circuit 16 is now connected. That is to say, the antenna 2 of the set 13 would receive both speech and signal modulated current, and the separate receiving apparatus represented by 3 and 15 would thereby be avoided. Furthermore, if it is desirable to have a separate radio transmitter for the signal frequencies, that is to say, an arrangement comprising an antenna and transmitter similar to 1 and 11, such an arrangement could be connected with circuit 69, and the connection of this circuit with transmitter 11 would be abandoned.

While this invention has been shown as embodied in a particular form and arrange-

ment of parts, it is not limited to this particular form but is capable of embodiment in other and different forms without departing from the spirit and scope of the appended claims.

What is claimed is:

1. In a communication system, the combination with a line circuit of a radio terminal circuit connected with the said line circuit, containing a transmitting branch including a radio transmitter arranged to modulate a carrier frequency by the speech frequency and also by the signaling frequency, a receiving branch arranged to receive the speech modulated carrier current, to detect the speech frequency and to impress it upon the said line circuit, a second receiving branch designed and arranged for the efficient detection of the signal-modulated carrier current, and frequency changing means responsive to the detected signal frequency to apply current of a different frequency to the said line.

2. In a communication system, the combination with a line having a source of low frequency signaling current connected therewith, a radio terminal circuit also connected therewith, having transmitting and receiving branches, and a frequency changing device responsive to low frequency current from the said line to control the application of a current of different frequency to the said transmitting branch, the said frequency changing device being also responsive to current of the said different frequency impressed thereon by the said receiving branch of the radio terminal circuit to control the application of current of the said low frequency to the said line.

3. In a radio communication system, the combination with a line having means for applying thereto for transmission thereover signaling current of a predetermined low frequency, and also having means connected therewith responsive to current of the same frequency, a radio terminal circuit having transmitting and receiving branches connected with the said line, the receiving branch being designed to receive high frequency current modulated by a low frequency current of a different order from that applied to the said line and to demodulate the same, the said terminal circuit having frequency changing means connected therewith responsive to the low frequency current transmitted over the said line to apply to the transmitting branch other low frequency current of a different order from that applied to the said line, the said frequency changing means being also responsive to the said low frequency current of the different order, resulting from demodulation of the high frequency current, to apply a low frequency current to the said line.

4. In a radio communication system, the combination with a line having connected therewith a source of 20-cycle current and also a signal device responsive to 20-cycle current, a radio terminal circuit having transmitting and receiving branches connected with the said line, the receiving branch being designed to receive high frequency currents modulated by 135-cycle current and to detect the 135-cycle component, the said terminal circuit having a frequency changing device arranged to apply 20-cycle current to the line whenever 135-cycle current is applied to the frequency changing means by the said receiving branch, and also arranged to apply 135-cycle current to the transmitting branch whenever 20-cycle current is applied to the frequency changing means by the said line.

5. In a radio communication system, the combination with a telephone toll line having a source of low frequency current connected therewith, of a subscriber's line having a signal responsive device connected therewith, and a radio terminal circuit having transmitting and receiving branches connected with the said toll line, the said terminal circuit having a composite ringer connected therewith responsive to the low frequency current received from the said source connected with the toll line and controlling the application of current of a different low frequency to the said transmitting branch, the said ringer being also responsive to the current of the said different frequency resulting from detection of the carrier frequency in the said receiving branch, and controlling the application of current of the said low frequency to the said line for operating the signal responsive device connected with the subscriber's line.

6. In a radio communication system, the combination with a telephone subscriber's line having a telephone substation connected therewith of a trunk line connected with the said subscriber's line, and a radio terminal circuit connected with the said trunk line and having means for the transmission and reception of calling signals, the said terminal circuit having means connected therewith responsive to a signaling impulse of fixed frequency transmitted over the said line to control the application of a signaling impulse of a different frequency to the said means for the transmission of calling signals connected with the said terminal circuit.

7. In a radio communication system, the combination with a telephone subscriber's line having a telephone substation connected therewith of a trunk line connected with the said subscriber's line, and a radio terminal circuit connected with the said trunk line and having means for the transmission and reception of calling signals, the said terminal circuit having translating means connected therewith responsive to the signaling

current of a fixed frequency received from the said line and also to the signaling component resulting from demodulation of a received high frequency signaling wave, and arranged to apply to the said means for transmission of the calling signals and to the said line respectively currents of the said different frequency and the said fixed frequency respectively.

8. In a radio communication system, the combination with a line of a terminal circuit comprising a transmitting and a receiving antenna, a source of carrier current, means to modulate the said carrier current by speech currents, a source of signaling current, means to modulate the said carrier by the said signaling current, and switching means controlled by signaling currents transmitted by the said line to control the application of the signal-modulated carrier to the said transmitting antenna.

In testimony whereof, we have signed our names to this specification this 29th day of December, 1923.

CHARLES S. DEMAREST.
MILTON L. ALMQUIST.