

Dec. 15, 1936.

L. D. WHITELOCK ET AL

2,064,639

COMMUNICATING SYSTEM

Filed June 9, 1934

3 Sheets-Sheet 1

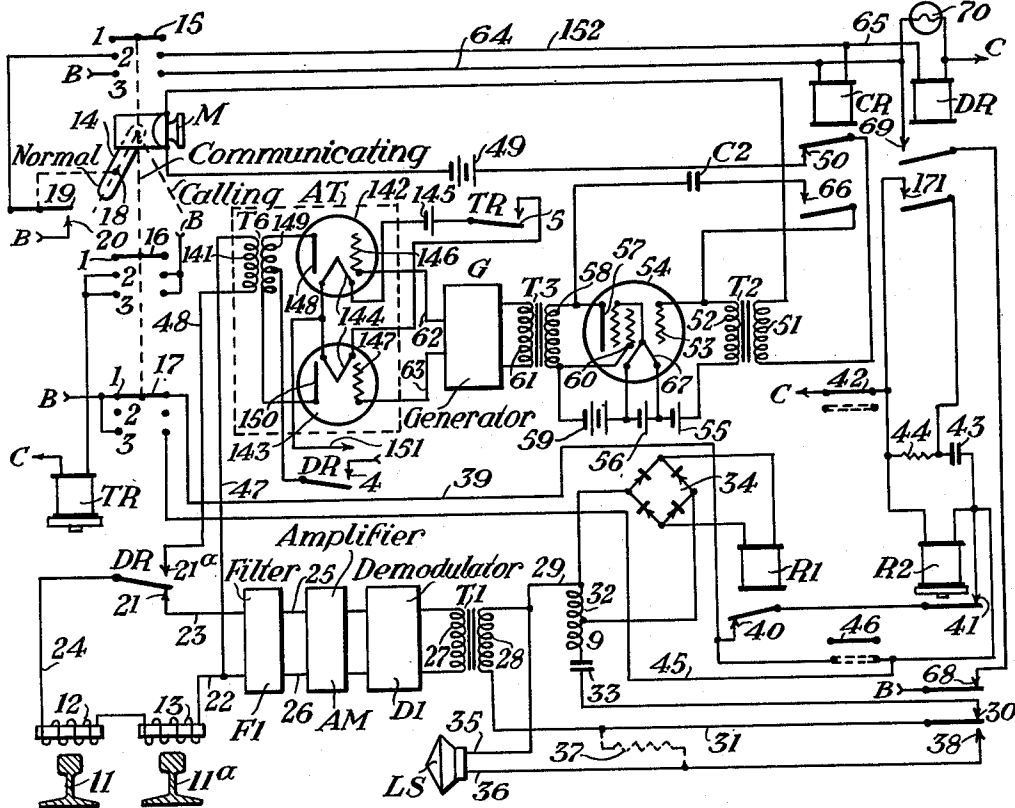


Fig. 1.

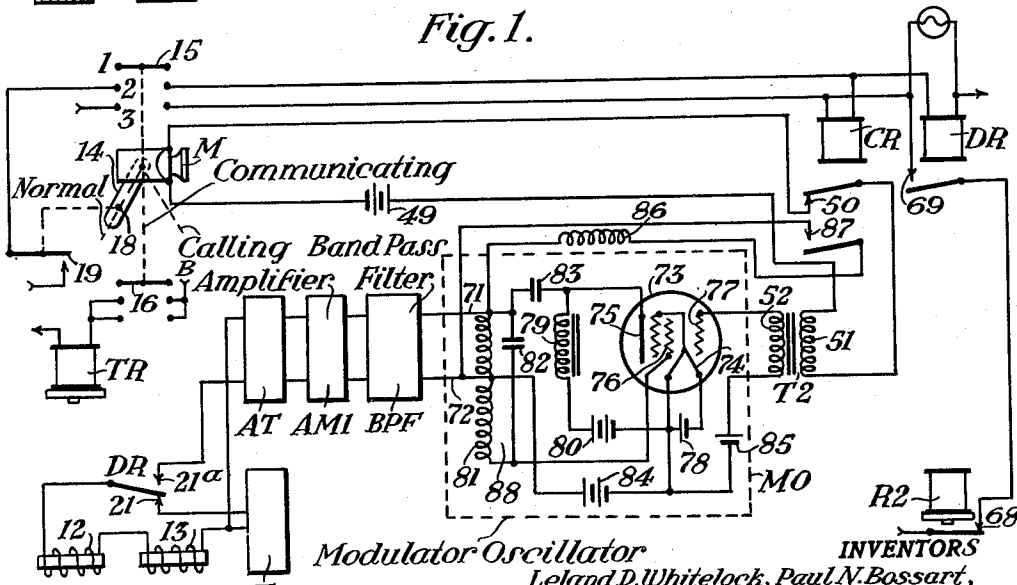


Fig. 2.

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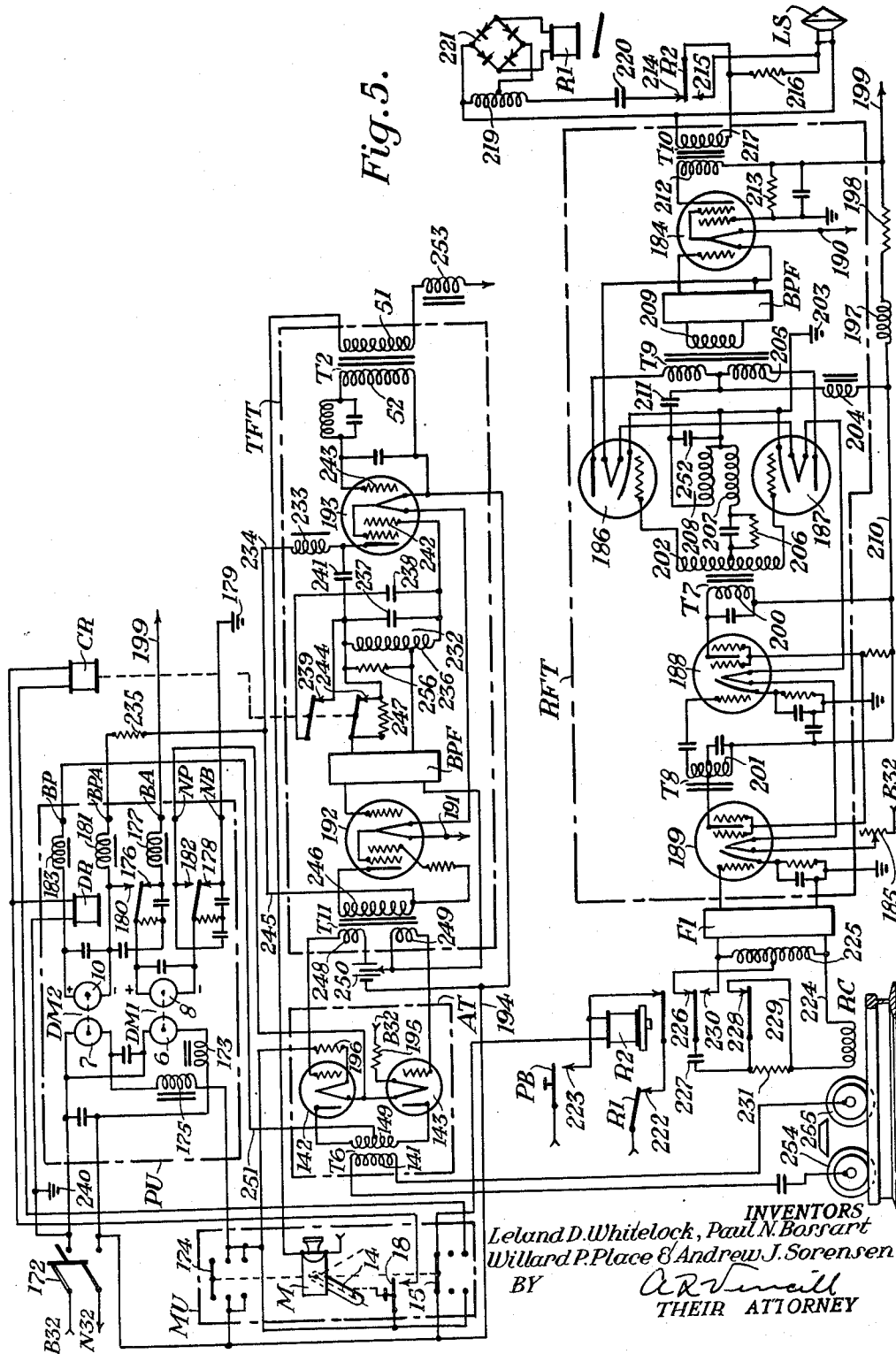
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3 Sheets-Sheet 3

Fig. 5.



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2,064,639

COMMUNICATING SYSTEM

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Application June 9, 1934, Serial No. 729,806

49 Claims. (Cl. 246—8)

Our invention relates to communicating sys-
tems, and particularly to communicating sys-
tems adaptable to telephone communication on
railway trains.

The present application is a continuation in
part of our copending application Serial No.
658,932, filed February 28, 1933, insofar as the
subject matter common to the two is concerned.

We will describe several forms of apparatus
embodying our invention, and will then point
out the novel features thereof in claims.

Communicating systems have been proposed
for telephoning between a wayside station and
a railway train, or between two trains, or be-
tween two spaced locations on the same train,
by transmitting from one location to the other
a carrier current modulated by voice frequen-
cies. The communicating circuit preferably in-
cludes the traffic rails in the manner disclosed
and claimed in the United States application for
Letters Patent, Serial No. 450,135, filed May 6,
1930, by L. O. Grondahl, for Electric train sig-
naling system. In systems of the type here in-
volved the receiving apparatus at each location
is normally active and in circuit in order that
either location can call the other at any time.
The transmitting apparatus is normally inactive
and is energized and in circuit only during the
transmission of a current. The receiving appa-
ratus preferably includes a loud-speaker and
since the receiving apparatus is normally in cir-
cuit, small earth currents and stray magnetic
fields picked up during the non-transmitting pe-
riod of the system produce a noise in the loud-
speaker that sometimes becomes very annoying,
especially since a high gain amplifier is em-
ployed. Furthermore, if two trains are close to-
gether, each train crew hears the conversation
of the other and this condition often results
in more or less confusion.

A feature of our invention is the provision of
new and novel apparatus for communicating
systems of the type here referred to, wherewith
the equipment at each location has a normal, a
calling and a communicating condition any one
of which may be readily established by the op-
erator at that location. Another feature of our
invention is the provision of new and novel ap-
paratus selectively responsive to a calling cur-
rent having a distinctive characteristic, where-
with the receiving apparatus will not respond
unless a call intended for that particular loca-
tion has first been received. A further feature
of our invention is the provision of simple and
effective means for reliably producing a calling

current having a distinctive characteristic to
which the receiving apparatus at the other loca-
tion will readily respond. Still another feature
of our invention is the provision of apparatus
by means of which the transmitting of a calling
current is semi-automatic; that is to say, if the
transmission of the calling current has been
started by an operator, it will be automatically
maintained for a predetermined interval, regard-
less of what action the operator takes in the
meantime, the interval of transmission being of
sufficient duration to insure full response of the
receiving equipment at the location being called.
Our invention also includes the provision of
apparatus for systems of the type involved
wherewith sources of current of different volt-
ages are made available as such voltages are
needed, together with apparatus which permits
the supplying of current to the communicating
circuit and the picking up current therefrom
through different electrical coupling as desired.
Other features of our invention will appear as
the specification progresses.

In the accompanying drawings, Fig. 1 is a
diagrammatic view of one form of apparatus em-
bodying our invention, wherein a sharply tuned-
circuit network is normally effective to receive
a selecting call, and the loud-speaker is discon-
nected, or is in a condition of low sensitivity.
The sending of the calling current is made semi-
automatic, and once started it will persist for a
given period regardless of what action the op-
erator takes in the meantime. An inductor is pro-
vided for both supplying current to and picking
up current from the traffic rails the inductor
being switched to the receiving apparatus or to
the transmitting apparatus as needed. Figs. 2
and 3 are each diagrammatic views of different
forms of the transmitting apparatus for gener-
ating a calling current of a predetermined fre-
quency, both of which forms of apparatus em-
body our invention. Fig. 4 is a diagrammatic
view of a second form of receiving apparatus
embodying our invention, and wherewith the
loud-speaker is normally in a condition of low
sensitivity by having a voice coil only in circuit;
and is switched to a condition of full sensitivity
in response to the calling current by the ener-
gizing of its field coil also. In this form of the
receiving apparatus the calling current is given
additional amplification. Fig. 5 is a diagram-
matic view of a modified form of the apparatus
of Fig. 1 which also embodies our invention. In
this modified form sources of current of different
voltages are provided and rendered available as

needed. Current is supplied to the traffic rails by a circuit directly coupled with the rails and is picked up by an inductively coupled circuit which is normally sharply tuned to resonance at the frequency of the calling current and more broadly tuned for telephoning. In each of the several views, like reference characters designate similar parts.

Referring to Fig. 1, the reference characters 12 and 13 designate inductor coils mounted on a railway train in inductive relation with the traffic rails 11 and 11', respectively. These inductor coils 12 and 13 are normally connected with a filter F1 of the receiving apparatus to be described later; and are adapted to be at times connected with a transmitter AT of the transmitting apparatus also to be described later. To provide two-way communication between two spaced locations both locations would be equipped with both the receiving and the transmitting apparatus of Fig. 1. To clarify the following description, we shall assume that telephone communication is to be provided between the locomotive and the caboose of a freight train, and, consequently, the complete apparatus of Fig. 1 would be installed both on the locomotive and in the caboose. Although a specific adaptation of our invention is here disclosed, it will be understood that we do not wish to limit ourselves to telephone systems for railway trains, but our invention is equally useful to other telephone systems of the type here involved.

In telephone systems for railway trains it has been proposed to attach to the microphone, indicated in Fig. 1 by the reference character M, an operating handle 14 which is adapted to be manually operated to any one of three positions indicated by dotted lines, and which positions we shall designate as normal, communicating, and calling, respectively. As will later appear, the normal position of the handle 14 places the transmitting apparatus in an inactive condition, and connects the receiving apparatus to the inductor coils 12 and 13. The communicating position of handle 14 places the transmitting apparatus in an active condition, and the equipment is rendered ready to either receive or transmit a telephone message. The calling position of handle 14 renders the transmitting apparatus active, and places the equipment in a condition for transmitting a calling current.

As shown schematically in Fig. 1, three circuit controlling contacts 15, 16 and 17 are operatively connected with the handle 14 and each of these contacts 15, 16 and 17 is moved to three respective positions identified in the drawings by the numerals 1, 2 and 3, in response to the normal, communicating and calling positions of the handle 14. Mounted on the handle 14 is a common spring return push button 18, which, as shown schematically, is operatively connected with a circuit controlling contact 19. Contact 19 is normally open and is forced down into engagement with a contact 20 by the depressing of the push button 18. The function of these several circuit controlling contacts associated with the microphone handle 14 will appear as the specification progresses.

It was stated above that the inductor coils 12 and 13 are normally connected with the receiving apparatus, and in Fig. 1 the circuit for connecting coils 12 and 13 to the receiving apparatus can be traced from the right-hand terminal of coil 13 along wire 22, filter F1, wire 23, back contact 21 of a directional relay DR to be

referred to later, and wire 24 to the left-hand terminal of the coil 12, the two coils 12 and 13 being connected in series. The back contact 21 and a front contact 21' of the directional relay DR are located in the drawings remote from the winding of that relay in order not to complicate the drawings. It will be understood that back contact 21 is closed when the relay is deenergized and front contact 21' is closed when the relay is energized. Energy picked up from the traffic rails by the coils 12 and 13 and passed by the filter F1 is applied to the input of an amplifier AM over the wires 25 and 26, and after amplification the energy is applied to a demodulator D1 the output of which includes the primary winding 27 of a transformer T1. The filter F1 is preferably a band-pass filter so proportioned and adjusted as to pass a band of frequencies having a width substantially equal to the voice frequency range used; that is, it passes a given carrier modulated with voice frequencies, or passes the side band frequencies of a carrier modulated with voice frequencies. Amplifier AM is any one of several types adapted to amplify a modulated carrier current, and the demodulator D1 is any one of several types adapted to demodulate a carrier modulated by voice frequencies and cause to appear in its output corresponding audiofrequencies only. The filter F1, amplifier AM and demodulator D1 may each be any one of several well-known types for such devices and are shown in Fig. 1 conventionally only in order to simplify the drawings as much as possible.

The secondary winding 28 of transformer T1 is normally connected to a cell selecting circuit and at other times is connected with an operating circuit. This cell selecting circuit extends from the upper terminal of the secondary winding 28 through wire 29, tuned circuit network 9, front contact 30 of a relay R2 to be described later, and wire 31 to the lower terminal of the secondary winding 28. The tuned circuit network 9 includes a reactor 32 and a condenser 33 in series, a portion of reactor 32 being connected to the input terminals of a rectifier 34, the output terminals of which are connected with the winding of a relay R1. The parts of this tuned circuit network are so proportioned and adjusted that it responds only to a definite frequency within the voice frequency range, say, for example, 700 cycles per second. It will be understood, of course, that other frequencies may be selected should it seem desirable to do so. It follows, that when a carrier current modulated with the frequency of 700 cycles per second is picked up from the traffic rails, the relay R1 is energized. At times the secondary winding 28 is connected to an operating circuit including a loud-speaker LS, and which can be traced from the upper terminal of secondary winding 28 along wire 35, winding of loud-speaker LS, wire 36, back contact 38 of the relay R2 and wire 31 to the lower terminal of secondary winding 28. It follows that at such time as relay R2 is deenergized, in a manner to be pointed out later, the output of the demodulator D1 is supplied through the transformer T1 directly to the operating circuit for the loud-speaker LS; and at such time as relay R2 is energized, the loud-speaker is energized and is inactive. As shown by dotted lines, a resistor 37 may be connected in shunt with the back contact 38 whereby the loud-speaker LS is normally in a condition of low sensitivity and is

then switched to a condition of full sensitivity by deenergizing the relay R2 to close the back contact 38 and form a shunt around the resistor 37. It is clear from the foregoing, that energy picked up under the normal condition is applied to the call selecting circuit and is ineffective to influence that circuit unless it is energy of the definite frequency to which the tuned circuit network 9 is adjusted. Deenergizing the relay R2 disconnects the call selecting circuit by opening the front contact 30, and connects the loud-speaker by closing the back contact 38. In the event the resistor 37 is provided, the loud-speaker LS is normally in a condition of low sensitivity and responds only feebly, and is switched to a condition of full sensitivity when the relay R2 is deenergized, and then responds at full volume.

The relay R2, which controls the call selecting circuit and the operating circuit for the loud-speaker LS, is normally energized over a stick circuit extending from the B terminal of a convenient source of current such as a battery not shown, through contact 17 in its No. 1 position, wire 39, back contact 40 of relay R1, its own front contact 41, winding of relay R2 and a manually operated contact 42 to the opposite terminal C of the current source. Thus a calling current of the predetermined frequency when picked up from the traffic rails and applied to the call selecting circuit energizes the relay R1 and that relay on picking up opens the back contact 40 in the stick circuit for relay R2 to release that relay. A suitable amount of slow release action is introduced in the operation of relay R2 by means of a condenser 43 and a resistor 44, the two being connected in series across the winding of the relay R2. It is clear, therefore, that a short time after relay R1 is picked up in response to the calling current, the relay R2 is released, disconnecting the call selecting circuit from the receiving apparatus and connecting the operating circuit of the loud-speaker thereto.

Operating the microphone handle 14 to the calling position to transmit a calling current in a manner to later appear will move the contact 17 to its No. 3 position and relay R2 will be retained energized by current from the B terminal of the current source over contact 17 in its No. 3 position, wire 45, winding of relay R2 and manually operated contact 42 to the terminal C of the current source. The function of this circuit just traced will be pointed out later. Relay R2 when once deenergized can be reenergized by placing the handle 14 in its normal position to bring contact 17 to its No. 1 position, and then depressing a manually operated contact 46. Current will now be supplied from the B terminal of the current source over contact 17, wire 39, contact 46, winding of relay R2 and contact 42 to the C terminal of the current source. Once energized by this pickup circuit just traced, the relay R2 will be retained energized by its stick circuit described above.

It is clear from the foregoing description of the receiving apparatus of Fig. 1 that any stray earth current that may be picked up by the inductor coils 12 and 13 during the normal condition of the apparatus will not be effective to create a noise in the loud-speaker. Furthermore, the conversation of other trains will not be strong enough to be heard with the loud-speaker in its low sensitive condition, and will be ineffective to influence the loud-speaker at all if it is normally disconnected. However, the receipt of a calling current of a predetermined frequency will

energize the tuned circuit network with the result that the loud-speaker will be shortly switched to full sensitivity ready to respond to any telephone message that may be delivered to that location. At the termination of a telephone conversation the operator can switch the loud-speaker back to its disconnected condition by operating the contact 46 to reenergize the relay R2.

We shall now describe the operation of the transmitting apparatus of Fig. 1. As stated hereinbefore, the operator will move the handle 14 to the communicating position when he desires to carry on a telephone conversation, and he will move the handle 14 to the calling position when he desires to transmit a calling current. Contact 16 when moved to either its No. 2 or No. 3 position completes a simple circuit for a transmitting relay TR and that relay is energized. Relay TR on picking up closes a front contact 5, which contact is located in Fig. 1 at a point remote from the winding of that relay in order to simplify the drawing as much as possible. It will be understood that contact 5 is normally open due to relay TR being normally deenergized, and is closed in the usual manner in response to the energizing of that relay. The transmitting relay TR is made slightly slow releasing in character to prevent the relay from releasing during the operation of the contact 16 between its No. 2 and No. 3 positions. The closing of the front contact 5 is adapted to render the transmitter AT active in a manner to shortly appear. At such time as the handle 14 is placed at the communicating position the depressing of the push button 18 to close the contact 19—20 supplies current from the B terminal of the current source over contact 19—20, contact 15 in its No. 2 position, wires 152 and 65, winding of the directional relay DR and to the C terminal of the current source, and the directional relay DR is energized. The inductor coils 12 and 13 are normally connected with the filter F1 of the receiving apparatus over the back contact 21 of the directional relay DR as described above. Energizing the directional relay DR in the manner just pointed out transfers the coils 12 and 13 to the transmitting apparatus, the circuit including the front contact 21^a of the directional relay DR. To be explicit, this last circuit can be traced from the right-hand terminal of the coil 13 over wires 22 and 47, secondary winding 141 of a transformer T6 of the transmitter AT, wire 48, front contact 21^a and wire 24 to the left-hand terminal of coil 12. It follows that at such time as the handle 14 is set at the communicating position, the operator can connect the coils 12 and 13 to either the receiving apparatus or to the transmitting apparatus by operating the push button 18 to energize or deenergize the directional relay DR. The directional relay DR also controls a front contact DR4 adapted to govern the operation of the transmitter AT as will later appear. Front contact DR4 is shown in Fig. 1 remote from the winding of that relay for clarity, and it will be understood that this front contact is closed in the usual manner when relay DR is energized.

The microphone M is provided with a circuit easily traced and which includes a battery 49, back contact 50 of a calling relay CR to be referred to later and the primary winding 51 of a transformer T2. Consequently, variations produced by speaking into the microphone M cause variations of the current flowing in the

primary winding 51 of transformer T2 which in turn induce corresponding frequencies in the secondary winding 52 of transformer T2. The voltages induced in the secondary winding 52 are applied to the control grid 53 of an amplifying tube 54, a suitable biasing battery 55 being inserted in the connection between the secondary winding 52 and the filament 57 of tube 54. The electron tube 54 may be any one of several types and is here shown as a pentode whose filament 57 is heated by a battery 56. The plate 57 of tube 54 is provided with a circuit that includes the primary winding 58 of a modulating transformer T3 and a battery 59, the screen grid 60 being connected directly to the positive terminal of battery 59. It follows that the voice frequencies induced in the secondary winding 52 of transformer T2 are repeated in the primary winding 58 of transformer T3 greatly increased in amplitude, and in turn induce an electromotive force of corresponding frequencies in the secondary winding 61 of that transformer.

The transmitting apparatus includes a generator G of carrier current of a frequency of, say, for example, 7,000 cycles per second, although it will be understood that other frequencies may be selected if found desirable. The carrier current generated by the generator G is modulated with the frequencies induced in the secondary 61 of transformer T3 in the usual manner, and the modulated carrier output of generator G is delivered to the input of the amplifier-transmitter AT over wires 62 and 63. The generator G shown conventionally in Fig. 1 may be any one of several well known types of generators of carrier current such for example as the vacuum tube type.

The amplifier-transmitter AT is preferably of the well-known push-pull amplifier type and includes two electron tubes 142 and 143. The filaments 144 of tubes 142 and 143 are heated by current supplied from a battery 145 over a simple circuit easily traced and which includes the front contact TR5 of the transmitting relay TR. The grid 146 of tube 142 is connected to one output terminal of the generator G over wire 62, and the grid 147 of tube 143 is connected to the opposite output terminal of the generator G over wire 63. The plate 148 of tube 142 is connected to the top terminal of the upper half of the primary winding 149 of the transformer T6, and the plate 150 of the tube 143 is connected to the low terminal of the lower half of the primary winding 149. The mid point of the primary winding 149 is connected to the positive terminal of a relatively high voltage current source, not shown, over the front contact DR4 of the directional relay DR. The negative terminal of this current source is connected to the filaments of tubes 142 and 143 over a wire 151. It follows that the transmitter AT is normally deenergized and becomes energized whenever either the communicating or calling condition is established and the relays DR and TR are picked up. The filament circuit for tubes 142 and 143 being completed at the front contact TR5 of the relay TR, and the plate circuits for these tubes being completed at the front contact DR4 of the relay DR. Thus the frequencies applied to the grids of the tubes 142 and 143 from the generator G are repeated in the plate circuits of these tubes greatly increased in amplitude, and corresponding frequencies are induced in the secondary winding 141 of the transformer T6 amplified to a relatively high energy level.

The energy induced in the secondary winding 141 is supplied to the inductor coils 12 and 13 whenever the directional relay DR is energized. It is clear, therefore, that with the handle 14 set at the communicating position and push button 18 is depressed, variations produced by speaking into the microphone M are converted into corresponding frequencies which are first amplified and then used to modulate a carrier current. The modulated carrier current is further amplified to a relatively high energy level and then applied to the communicating circuit.

A calling current is produced in the following manner. Moving the handle 14 to the calling position supplies current from the battery terminal B over contact 15 in its No. 3 position, wire 64, winding of the calling relay CR, wire 65, winding of the directional relay DR and to the C terminal of the battery; and the relays CR and DR are energized in series. Relay CR on picking up opens the microphone circuit at the back contact 50 and closes a front contact 66 to couple the plate circuit of tube 54 to its grid circuit through a coupling condenser C2. Opening the back contact 50 in the microphone circuit causes the impedance between the grid 53 and the filament 67 to greatly increase, since, with the shunting effect of the microphone circuit removed, the impedance between the grid 53 and the filament 67 is limited only to the transformer losses of transformer T2 and occurs at a frequency determined by the resonant frequency of the inductance of the transformer and its distributed capacity, plus the capacity of the tube 54 and other stray capacities in the circuit. This increase in the impedance of the grid circuit would normally be sufficient to cause the tube 54 to oscillate, but, in order to stabilize the oscillations the coupling condenser C2 is connected with the grid and the plate by means of the front contact 66 of relay CR. The condenser C2 augments the transfer of the energy of the plate circuit to the grid of the tube and insures that there is sufficient feed-back to overcome the dampened effect of any losses in the grid circuit. The capacity of condenser C2 and the parts of the circuit associated with the tube 54 are so proportioned and adjusted that a single frequency of say 700 cycles per second is generated when the relay CR is picked up. The carrier current generated by the generator G is now modulated by the single frequency of the calling current produced by the tube 54 and its related circuits. Hence, the calling current is a carrier having a frequency of 7000 modulated with the frequency of 700 cycles, and since the relay TR is also picked up and transmitter AT rendered active this calling current is delivered to the traffic rails amplified to a relatively high energy level by the transmitter AT.

The semi-automatic transmission of the calling current takes place as follows. Let us assume that the microphone handle 14 is in its normal position and that the operator desires to call the other location. The operator will first throw this handle 14 to the calling position and cause the relays TR, CR and DR to be energized. Relay TR on picking up renders the transmitter AT active, relay CR on picking up causes tube 54 to generate a calling frequency of 700 cycles, and as the coils 12 and 13 are now connected to the transmitter AT by the front contact 21^a of the relay DR, the traffic rails are supplied with the calling current. The

No. 3 position of contact 17 supplies current directly to the relay R2 and that relay is retained energized and relay DR being now picked up, current flows from the battery terminal B over front contact 68 of relay R2, front contact 69 of relay DR, winding of the calling relay CR, wire 65, winding of the relay DR and to the C terminal of the battery, an indicating lamp 70 being connected in parallel across the windings of relays CR and DR. It follows that whether the microphone handle 14 is kept in the calling position or restored to one of its other positions, the two relays CR and DR will both remain energized until the relay R2 is released. Moving the handle 14 away from the calling position opens the circuit to the relay R2 and that relay is deenergized; however, relay DR on picking up closes at its front contact 171 a shunt path around the resistor 44 and the condenser 43 is therefore directly across the winding of relay R2, causing the release period of that relay to be considerably longer than when the resistor 44 is in series with condenser 43. Hence, having once started the transmission of the calling current, the operator is free to move his handle 14 from the calling position to the communicating position and make ready to start conversation.

At the other location, the receipt of the calling current will be picked up from the traffic rails, filtered, amplified, demodulated and current of a frequency of 700 cycles per second will be supplied to the call selecting circuit. The tuned circuit network 9 will respond to this frequency of 700 cycles per second and the relay R1 will be energized to open the stick circuit of relay R2 and that relay will release at the end of the slow release period as determined by the associated condenser 43 and the resistor 44 in series. Hence, in a short time the relay R2 at the called location releases to disconnect the call selecting circuit and to connect the operating circuit of the loud-speaker with the result that the loud-speaker will now sound a note corresponding to the frequency of 700 cycles. It will be noted that the release of the relay R2 at the location which is being called is determined by the associated condenser 43 and resistor 44 in series, and will be materially shorter than the release period of the relay 42 at the calling location which is determined by the associated condenser 43 alone. Consequently, the calling current will be transmitted for a period sufficiently long to cause the receiving apparatus at the location which is being called to transfer its loudspeaker to a condition of full sensitivity and to sound a note calling the operator's attention that communication is desired, notwithstanding the calling operator is free to at once place his microphone handle 14 in the communication position immediately after initiating the calling current. At the calling location the release of its relay R2 terminates the transmitting of the calling current by opening the circuit to the CR relay, which in turn upon releasing disconnects the coupling condenser C2 and reestablishes the microphone circuit. The indication lamp 70 will be displayed during the time the calling current is being transmitted, and will be extinguished when the R2 relay releases, indicating to the operator at the calling location that the impulse of calling current has been terminated and that his apparatus is in a condition to start conversation. At the called location the 700 cycles of the calling current will cause the loud speaker to sound a note indicating to the operator at that location that a telephone mes-

sage is about to be delivered as stated above. The operator at the called location will respond by moving his microphone handle 14 to its communicating position and from this point on conversation can be had between the two locations by the operators manipulating their respective push buttons 18. At the end of the conversation each operator can restore his loud speaker and its associated call selecting circuit to their respective normal condition by depressing the switch 46 to reenergize the associated R2 relay. In the case it is desired to establish the loud-speaker in a condition of full sensitivity and still have the microphone handle 14 in the normal position, the operator can do so by either depressing the switch 42 long enough to bring about the release of the R2 relay or by moving handle 14 to the No. 2 position just long enough to release relay R2, and then restoring handle 14 back to the No. 1 position. At stated above, to cut the loud-speaker down to its low sensitivity at any time it is necessary only for the operator to depress the switch 46 to energize the R2 relay after which it will be retained energized over its stick circuit.

The calling current having a modulation frequency in the voice frequency range about where maximum energy is transmitted, namely, 700 cycles per second, the calling current has been found to be effective to strongly actuate the receiving apparatus at the remote location even under transmitting conditions so poor or at distances so great that the telephone current is so attenuated a telephone message is only feebly received. That is to say, a note of the loud-speaker corresponding to the frequency of the calling current may still be clear and distinct under conditions where the telephone message reproduced by the loud-speaker may be unintelligible. At such times the calling apparatus becomes valuable as a means for transmitting a code message from one location to the other. Assuming the operator at one location desires to communicate with the operator at the other location by a code message, the procedure is as follows: It will be understood, of course, that different codes of short and long impulses corresponding to different code messages are prearranged and are familiar to the operator at each location. Moving the handle 14 to the calling position causes the transmitting apparatus at that location to become active to supply calling current to the traffic rails in the manner described hereinbefore. The impulse of calling current is picked up at the remote location and the loud-speaker automatically connected to the output of the transformer T1 and a corresponding note sounded in the manner described previously. The sending operator terminates an impulse of calling current by moving the handle 14 back to the communicating position after which the calling current ceases as soon as the relay R2 releases. To start a second impulse of calling current the operator moves the handle 14 back to the calling position to again connect the coils 12 and 13 to the transmitting apparatus and to cause calling current to again be generated. It follows that the sending operator by operating his handle 14 between the No. 2 and No. 3 positions in accordance with long and short intervals causes impulses of calling current corresponding to a prearranged code to be delivered to the traffic rails, and the desired code message is reproduced by the loudspeaker at the other location by sounding corresponding long

and short notes. It is to be noted that the slow-release feature provided for maintaining the impulse of calling current for a period equal to the release period of the relay R2 after the handle 14 is moved from the No. 3 position does not hamper the sending of the code message. The sending operator by watching the indicating light 70 can tell each time an impulse has been terminated and, hence knows when he is free to start the next impulse. It is clear therefore that by operating the handle 14 in accordance with any prearranged code, a code message can be readily communicated from one location to the other by the apparatus of Fig. 1. Although it has been assumed above that code messages are transmitted under conditions in which telephone communication is not satisfactory, it is apparent that a code message can be transmitted in a manner just pointed out at any time. As a matter of fact the transmitting of a code message may at times be desirable to communicate an order quickly without the necessity of waiting for the receiving operator to indicate back to the sending operator that he is ready to receive a telephone message.

It has been proposed for carrier telephone systems to transmit but a single side band of the carrier modulated with voice frequencies, suppressing the carrier and the other side band. It has further been proposed to make use of a pentode type electron tube in the generating of the carrier current, applying to one grid the voice frequencies with which the carrier is to be modulated. Fig. 2 discloses a form of the transmitting apparatus of a side band telephone system embodying our invention, wherewith the desired single frequency for the calling current is obtained by shifting the frequency of the unmodulated carrier by an amount corresponding to the frequency desired. For example, with a carrier of 7000 cycles per second and a desired calling frequency of 700 cycles per second, the frequency of the carrier is shifted 700 cycles up or down depending upon which of the side bands is being used for the transmission of speech. Referring to Fig. 2, the inductor coils 12 and 13 are adapted to be connected to either the filter F1 of the receiving apparatus, or to be connected with the transmitter AT of the transmitting apparatus by virtue of the directional relay DR and the push button 18 associated with the microphone handle 14 the same as described in Fig. 1. The output of a modulator-oscillator indicated as a whole by the reference character MO is applied over wires 71 and 72 to a band-pass filter BPF adapted to substantially suppress the carrier and one side band passing only the remaining side band, preferably the upper side band, to the input of an amplifier AM1. Amplifier AM1 amplifies the upper side band and delivers the energy to the input of the transmitter AT which in turn supplies the upper side band frequencies to the coils 12 and 13 at a relatively high energy level. The filter BPF may be any one of several types of band-pass filters and in this instance is so proportioned and adjusted as to pass the upper side band frequencies having the width of the voice frequency range, of a carrier of 7000 cycles. The amplifier AM1 may be of any of the several standard types commonly used for amplifying a modulated carrier current and is here shown conventionally only in order to not unduly complicate the drawings. The transmitter AT shown conventionally in Fig. 2 is preferably similar to the transmitter

AT of Fig. 1 and is governed by the relays DR and TR the same as in Fig. 1.

The modulator-oscillator MO includes a pentode 73 having a filament 74, a plate 75 and two control grids 76 and 77, the filament 74 being heated by a battery 78. The plate circuit includes the usual inductor 79 and a plate battery 80 as will be readily understood by an inspection of Fig. 2. One terminal of an oscillating circuit 88 comprising an inductor 81 and a condenser 82 is connected with the plate circuit through a blocking condenser 83, and its other terminal is connected with the grid 76, a mid tap of inductor 81 being connected to the filament 74 through a suitable biasing battery 84. The parts of this oscillating circuit are so proportioned and adjusted that a carrier frequency of 7000 cycles per second is generated and applied to the wires 71 and 72 leading to the band-pass filter BPF. The microphone circuit includes the back contact 50 of the calling relay CR and the primary winding 51 of the transformer T2 the same as in Fig. 1. One terminal of the secondary winding 52 of transformer T2 is connected to the second control grid 77 of tube 73, and its other terminal is connected to the filament 74 through a battery 85. It is clear that voice frequencies developed in the microphone M induce corresponding frequencies in the secondary 52 which are applied to the grid 77 with the result that the carrier frequency is modulated with the voice frequencies.

Operating the microphone handle 14 of Fig. 2 to the calling position to bring contact 15 to its No. 3 position supplies current to the windings of relays CR and DR in series to energize those relays. Relay DR on picking up completes the circuit at its front contact 69 for retaining the two relays CR and DR energized until such time as the associated relay R2 is released irrespective of the position of the handle 14 the same as described in Fig. 1. With the calling relay CR picked up the opening of the back contact 50 renders the microphone circuit ineffective, and the closing of the front contact 87 connects an inductor 86 in parallel with a portion of the inductor 81 of the oscillating circuit 88. Connecting inductor 86 in parallel with inductor 81 varies the inductance of the oscillating circuit 88 to increase the frequency generated. The inductor 86 is so selected that the carrier frequency is shifted 700 cycles making the frequency now delivered to the band-pass filter BPF 7700 cycles per second. This single frequency of the calling current falls within the width of the band to which filter BPF is adjusted, and is passed to the amplifier AM1 and in turn to the transmitter AT. It follows that as long as the calling relay CR and the directional relay DR are picked up a calling current of 7700 cycles per second is supplied to the traffic rails. This calling current when picked up at the other location will influence the receiving apparatus at that location in the manner described in detail for Fig. 1. If it is desired to shift the frequency of the carrier down, the inductor 86 would be replaced by a suitable condenser. It is to be noted that by changing the frequency in the manner disclosed in Fig. 2, it is possible to avoid having relay contacts in the oscillating circuit during such periods as conversation is to be transmitted. Otherwise, a change in the resistance of a relay contact may alter the frequency of the oscillating circuit enough

to cause poor transmission of a telephone message.

It has been proposed for single side band transmission in telephone systems to accomplish the elimination of the carrier which has been modulated with voice frequencies by a push-pull circuit arrangement. In Fig. 3 is disclosed a form of the transmitting apparatus of a system embodying our invention wherewith the carrier frequency of a balanced modulator is shifted a definite amount to establish a calling current, and by changing the connection of the 2-tube balanced modulator so that the carrier frequency instead of being balanced out adds its effect in the output circuit. Referring to Fig. 3, the inductor coils 12 and 13 are adapted to be connected to the filter F1 of the receiving apparatus or to the transmitter AT of the transmitting apparatus by virtue of the directional relay DR and the push button 18 associated with the microphone handle 14 the same as described hereinbefore. The microphone circuit includes the primary winding 51 of the transformer T2 with the result that variations produced in the microphone induce corresponding voice frequencies in the secondary 52 of transformer T2 the same as in Figs. 1 and 2. In this instance the voice frequencies induced in the secondary winding 52 are applied to the grid 89 of an amplifying tube 90, a suitable biasing battery 91 being inserted in the connection between the secondary winding 52 and the filament 92 of tube 90. The plate 140 of tube 90 is connected with a circuit that includes the two portions 93 and 94 of the primary winding of a modulating transformer T4, the secondary windings 95 and 96 of which supply the amplified voice frequencies to the grids 97 and 98 of the two tubes 99 and 100 of a balanced modulator-oscillator designated as a whole by the reference character BMO. The secondary windings 95 and 96 of transformer T4 form one continuous winding arranged in two equal parts with a mid tap to be shortly referred to.

The balanced modulator-oscillator BMO comprises two electron tubes 99 and 100 of the standard 3-element type and a conventional oscillating circuit 106. The grid circuits of tubes 99 and 100 and also their plate circuits are arranged in the conventional push-pull manner; and the oscillating circuit 106 is adapted to have its generated carrier frequency shifted as will shortly appear. The plates 103 and 104 of tubes 99 and 100, respectively, are connected to the outside terminals of the primary windings 101 and 102 of an output transformer T5, the outside terminal of primary winding 102 being connected directly to the plate 104 of tube 100 and the outside terminal of the primary winding 101 being connected with the plate 103 of tube 99 over a back contact 105 of the calling relay CR. The common center terminal of windings 101 and 102 is connected with the positive terminal of a plate battery 111 through an inductor 112, the opposite terminal of battery 111 being connected to the filaments of these tubes. The oscillating circuit 106 comprises a portion of an inductor 107 and two condensers 108 and 109 in parallel, the connection for the condenser 109 including a back contact 110 of the calling relay CR. One terminal of this oscillating circuit is connected through a blocking condenser 113 to the plate circuits for tubes 99 and 100 at the mid point of the primary windings 101 and 102; and its other terminal is connected through the lower portion of inductor 107 and a suitable biasing element

114 to the grid circuits at the mid point of the secondary windings 95 and 96 of transformer T4; a mid tap 115 of inductor 107 being connected to the filaments of the two tubes. It is clear that the tubes 99 and 100 are operated in parallel with the grid terminal of the oscillating circuit 106 connected to the two grids of the tubes through the secondary windings of transformer T4, and the plate terminal of the oscillating circuit connected to the two plates of the tubes through the blocking condenser 113 and the primary windings of transformer T5. The result of this arrangement is that there will be no carrier transmitted to the secondary winding 116 of the output transformer T5, since the primary windings 101 and 102 are arranged in the push-pull manner and the oscillations supplied to the plate circuits are balanced out. The addition and subtraction of the voltages corresponding to the voice frequencies with the voltages of the carrier frequencies when applied to the two grids 97 and 98 cause the grids to be opposite in polarity with the result that the variations produced in the plate circuits of these tubes corresponding to the side bands are additive in effect in the transformer T5. The two side band frequencies corresponding to the carrier modulated with voice frequencies are hence supplied by the transformer T5 to the band-pass filter BPF which in this instance is so proportioned and adjusted as to select one side band and suppress the other, preferably the upper side band being passed. The upper side band is then applied to the input of the amplifier transmitter AT, and hence is delivered to the inductor coils 12 and 13 at relatively high energy level. An amplifier similar to the amplifier AM1 of Fig. 2 may be inserted between the band-pass filter BPF and the transmitter AT should it seem desirable to do so.

To provide a calling current the carrier frequency generated by the modulator-oscillator BMO, instead of being balanced out in the secondary windings of the output transformer T5 is made to add, and at the same time its frequency is shifted by an amount corresponding to the desired modulation frequency, the change in the frequency being either up or down depending upon whether the upper or lower side band is the one being utilized for conveying the telephone message. We shall assume that the oscillating circuit 106 is so proportioned and adjusted as to generate a carrier frequency of 7000 cycles per second, and that the upper side band is selected by the band-pass filter BPF; and that a modulation frequency of 700 cycles per second is desired for calling. That is to say, the carrier frequency of 7000 cycles is to be shifted to 7700 cycles for calling. Operating the microphone handle 14 to the calling position supplies current to the two relays CR and DR in series the same as in Fig. 1, and these relays then remain energized until such time as the associated relay R2 is released, notwithstanding the fact that the handle 14 may be moved to position No. 2 in the meantime. Opening the back contact 105 and the closing of the front contact 117 transfers the plate 103 of tube 99 from the upper terminal of primary winding 101 to the lower terminal of the primary winding 102 to which the plate 104 of tube 100 is also connected. The result is that the plate circuits of tubes 99 and 100 instead of having a push-pull arrangement are now in parallel each including the primary winding 102. Relay CR on picking up also opens the back contact 110

and the condenser 109 is removed from the oscillating circuit causing the frequency of this circuit to be increased. The condenser 109 is so selected that when it is removed from the oscillating circuit, the frequency of the carrier is increased from 7000 cycles to 7700 cycles. It follows that as long as the calling relay CR is energized, a carrier frequency of 7700 cycles is passed to the output transformer T5 at full intensity of the two tubes operating in parallel, instead of being balanced out by the push-pull arrangement in effect when a telephone conversation is to be transmitted. Since the frequency of the calling current, namely 7700 cycles per second, lies within the voice frequency range of the band-pass filter BPF, the calling frequency is passed to the transmitter AT and hence is delivered to the inductor coils 12 and 13. This calling current of the single frequency of 7700 cycles per second when picked up at the other location and applied to its receiving apparatus will cause that apparatus to function in the same manner as described for Fig. 1. In case it is desired to have the calling current corresponding to a frequency of the lower side band, the condenser 109 would be normally disconnected from the oscillating circuit 106 and then connected into the circuit when the calling relay CR is energized.

The modified form of the receiving apparatus disclosed in Fig. 4 provides an additional amplification for the calling current. In this form of apparatus embodying our invention the output transformer T1 has its primary winding 27 connected with the demodulator D1 the same as in Fig. 1. Transformer T1, however, is provided with two secondary windings 118 and 120, the secondary winding 118 being connected directly with a voice coil 119 of the loud-speaker LS, and the secondary winding 120 being connected with the control grid 121 of a pentode and to the opposite terminal C of the current which includes a suitable biasing battery 123. The plate 124 of tube 122 is connected to a battery 126 through a reactor 127 to form the usual plate circuit, and the screen grid 125 is connected directly to the positive terminal of the battery 126. Two condensers 128 and 129 are connected in series between the plate and the filament of tube 122 and these condensers are preferably made of substantially the same size and have a comparatively large capacity so that any high frequency current which may flow in the plate circuit will be by-passed to the filament. A reactor 130 is connected across the condenser 129, and it will be noted that due to condenser 128 acting as a blocking condenser, no unidirectional current will flow in reactor 130. A portion of reactor 130 is connected to the sharply tuned circuit network 9 which includes the condenser 33 and reactor 32 in series the same as described hereinbefore. A portion of reactor 32 is connected to the input terminals of the rectifier 34, the output terminals of which are connected to the top winding of a relay R4. The alternating current corresponding to the modulation frequency supplied by the secondary 120 causes corresponding variations in the plate circuit of tube 122, and similar variations of current in the reactor 130. When the frequency of this current corresponds to the resonant frequency of the tuned circuit network 9, current is supplied through the rectifier 34 to the relay R4 and that relay is energized. Hence, when the current passed by the filter F1 of the re-

ceiving apparatus is modulated at a predetermined frequency, a portion of the output of the demodulator D1 is applied across the grid and filament of the tube 122 where it is amplified and caused to flow in the circuit network 9 to energize relay R4. By selecting the frequency of the calling current at which the tuned circuit network 9 responds about where the greatest voice energy is transmitted, that is, at about 700 cycles per second, it is possible to operate relay R4 by the voice at the transmitting location.

A field coil 131 of the loud speaker LS is adapted to be energized by either one of two circuits. The first circuit can be traced from the terminal B of the current source over coil 131, wire 132, front contact 133 of relay R4 and to the opposite terminal B of the current source. The second circuit extends from the battery terminal B through coil 131, wires 132 and 134, contact 17 in its No. 2 position and thence to the C terminal of the current source.

Relay R4 is provided with a holding winding which is arranged to be energized by a local circuit. This circuit extends from the battery terminal B through the lower or holding winding of relay R4, its own front contact 135, wire 136, contact 17 in its No. 1 position and thence to the battery terminal C. Hence, relay R4 once picked up by current supplied over the selecting network 9, will be retained energized by current supplied from the local source until such time as the microphone handle 14 is moved out of its normal position. The energizing of relay R4 in the manner just described causes the field winding 131 of the loud-speaker to be excited and the loud-speaker operated in a condition of full sensitivity. The operator in moving the microphone handle 14 from its normal position to the communicating position opens the circuit to the holding winding of relay R4 and that relay is released, but the circuit to the field winding 131 is retained closed by the circuit that includes the contact 17 in its No. 2 position, and hence the loud-speaker LS is retained in the condition of full sensitivity during a telephone conversation. A rectifier 137 may be connected across the field winding 131 as shown to suppress any spark or arc at the front contact 133 or at the contact 17.

If the operator desires to place the loud-speaker LS at full sensitivity when no calling current has been received, he can do so by depressing a spring return switch 138 to energize the holding winding of relay R4 by a circuit easily traced and which includes the contact 17 in its No. 1 position. Relay R4 once picked up will then be retained energized by the circuit that includes its own front contact 135 and the loud-speaker LS will be held in a condition of full sensitivity. To cut the loud-speaker down to a condition of low sensitivity it is necessary only for the operator to move the handle 14 away from the normal position for a short interval of time and then put it back to its normal position. In case it is not necessary to answer a received telephone message and the microphone handle 14 is not moved out of its normal position, the loud-speaker LS is left at full sensitivity at the termination of the telephone message but it can be restored to the condition of low sensitivity by the operator moving the handle 14 away from the normal position for a short interval of time. In Fig. 4, the field coil 131 being normally deenergized, the resultant

reduction in sensitiveness of the loud-speaker will be ample to remove any noise due to static conditions, and yet a calling signal may still be heard faintly even if the call selecting circuit fails, the voice coil 119 being in circuit at all times.

In the form of our invention disclosed in Fig. 5, a power unit for supplying the proper plate voltages to the various electron tubes is provided, the arrangement being such that the power unit is rendered active as needed and the generated voltages switched to the plate circuits of the sending and receiving tubes according to whether current is to be transmitted or is to be received. In this form of our invention, current is supplied to the traffic rails over a circuit directly coupled therewith and is picked up through the medium of a receiving coil tuned sharply for calling and the tuning of which is broadened for telephoning either automatically or manually.

Referring to Fig. 5, the microphone M and the associated circuit controlling contacts and push button are shown as a unit designated by the reference character MU, the circuit controlling contacts being operatively connected with the microphone handle and the push button mounted thereon the same as in Fig. 1. The microphone circuit is easily traced and includes the microphone M, the primary winding 51 of the transformer T2, a reactor 253 and a current source as will readily be understood by an inspection of the drawings. It follows that an electromotive force having frequencies corresponding to the voice impulses produced in the microphone M is induced in the secondary winding 52 of the transformer T2.

The power unit designated by the reference character PU consists of two dynamotors or motor generators DM1 and DM2 together with filter devices to be referred to later. Energy is obtained for energizing the motor elements 6 and 7 of the two dynamotors from any convenient source such as a headlight generator not shown, the opposite terminals of which are designated by the reference characters B32 and N32. A common double-pole cut-out switch 172 is preferably interposed between the source of power and the power unit, and the B32 wire is preferably connected with a ground electrode 240. With the cut-out switch 172 closed, current is constantly supplied to the motor element 6 over a simple circuit which includes a choke coil 173. With the switch 172 closed and the microphone handle 14 of the unit MU operated to either its communicating or calling position and the contact 174 moved to its No. 2 or No. 3 position, current is supplied to the motor element 7 of the dynamotor DM2 by a simple circuit easily traced and which includes the contact 174 and a choke coil 175. It follows that as long as the cut-out switch 172 remains closed, the dynamotor DM1 is operated to develop a voltage across its generator element 8, and when the microphone handle 14 is set at either its communicating or calling position, the dynamotor DM2 is also operated to develop a voltage across its generator element 10. To fix the ideas, we shall assume that the source of energy B32-N32 is of 32 volts direct current, and that each of the dynamotors develop 500 volts direct current, the polarity of the brushes of the generator elements 8 and 10 being as indicated by the plus and minus signs placed on the drawings.

In this form of the invention, the directional relay DR is made a part of the power unit, the

relay DR and the calling relay CR being controlled, however, in a manner similar to that of Fig. 1. It is thought unnecessary to repeat the description of the control of these relays except to point out that under the normal position of the handle 14 both relays are deenergized, under the calling position of the handle 14 both relays DR and CR are energized over a circuit including the No. 3 position of the contacts 15 and 174, respectively, while the communicating position of the handle 14 permits the directional relay DR to be picked up or released by depressing or releasing the push button 18, the circuit including the push button depressed and the contact 174 in its No. 2 position. The deenergized condition of the directional relay DR connects over its back contact 176 the positive brush of the generator element 8 with the BA terminal of the power unit, a choke coil 177 being interposed in the connection; and connects over the back contact 178 the negative brush of the generator 8 with the terminal NB of the power unit, this terminal NB being in turn connected with a ground electrode 179. The energized condition of the directional relay DR connects over its front contact 180 the positive brush of the generator 8 with the terminal BPA of the power unit and also with the negative brush of the generator element 10, a choke coil 181 being interposed between the contact 180 and the terminal BPA. The negative brush of the generator 8 is now connected over the front contact 182 with the terminal NP of the power unit. The positive brush of the generator element 10 is connected over a choke coil 183 with a terminal BP of the power unit. Consequently, under the normal position of the microphone handle 14 and with the directional relay DR deenergized, the dynamotor DM1 only is operated and a potential difference of 500 volts is established between the terminals BA and NB. With the handle 14 moved to either the communicating or calling position, the second dynamotor DM2 is started up and if the directional relay DR is energized, as it will be in the calling position and as it may be during the communicating position by the depressing of the push button 18, a difference of potential of 500 volts exists between the terminals BPA and NP and a difference of potential of 1000 volts exists between the terminals BP and NP. To suppress sparking and to avoid potential surges, condensers and leak resistors may be connected around the contacts 178-182 and 176-180 of the relay DR as will be understood by an inspection of Fig. 5. The several choke coils of the power unit are effective to filter out the ripples produced at the commutators of the dynamotors and of source B32-N32. The manner of utilizing the voltage delivered by the power unit will appear as the description of the apparatus of Fig. 5 progresses.

The transmitting apparatus of Fig. 5 includes, in addition to the microphone M, a transmitter AT, a frequency translating unit designated as a whole by the reference character TFT, and a circuit for supplying the outgoing current to the traffic rails. The receiving apparatus includes, in addition to the loud-speaker LS, a frequency translating unit indicated as a whole by the reference character RFT, and a receiving coil RC for picking up current from the communicating channel. As stated hereinbefore, in practicing our invention, the receiving apparatus is made normally active ready to receive at any time an incoming current, while the transmitting

apparatus is normally inactive and is rendered active only when it is desired to send a current. It will be understood, of course, that each location will be provided with the full equipment of Fig. 5 so that two-way communication may be accomplished. To the end that the receiving apparatus may be normally active, the electron tubes provided for the frequency translating unit RFT have their filaments constantly heated and have a voltage applied to their plate elements with the result that whenever current is picked up by the receiving coil and applied to the grids of the several tubes, the apparatus functions as intended. The electron tubes provided for the frequency translating unit TFT of the transmitting apparatus preferably have their filaments heated also under the normal condition in order that there may be no delay in the transmitting apparatus assuming a condition for transmitting a current. However, the source of plate voltage for these sending tubes is normally disconnected from the plate elements and hence the transmitting apparatus is normally inactive. The power tubes of the transmitter AT of Fig. 5 normally have no current applied to either the filaments or to the plates the same as in Fig. 1. To heat the filaments of the tubes of the two frequency translating units, a circuit is provided for serially connecting the filaments of the several tubes across the source B32—N32, this circuit being traced from the B32 terminal over resistor 185, filaments of tubes 189, 188, 187, 186 and 184 to the terminal 190 of the unit RFT, and thence to the terminal 191 of the unit TFT as indicated by the arrows, (the connection between these terminals being omitted for simplicity), filaments of the tubes 192 and 193, and wire 194 to the terminal N32 of the source of power. It will be noted that the filaments of the power tubes 142 and 143 of the transmitter AT are heated by a circuit extending from the B32 terminal over resistor 195, filaments of the two tubes 143 and 142, resistor 196, and thence over the contact 174 in either its No. 2 or No. 3 position to the N32 terminal of the source of power. It is to be seen, therefore, that the tubes of both the frequency translating units RFT and TFT are constantly heated as long as the cut-out switch 172 is closed, but that the power tubes of the transmitter AT are heated only when the microphone handle is moved to either the communicating or calling position.

The frequency translating unit RFT of the receiving apparatus may take any one of several forms for such devices and as here shown includes two stages of high frequency amplification, a demodulating stage, a filter, and one stage of low frequency amplification. The specific structure of this device forms no part of our invention, and it will be described only sufficiently for an understanding of our invention, it being understood that volume control, stabilizing capacitances and biasing voltages may be added as desired. The tubes 189 and 188 of the two high frequency stages of amplification are each of the screen grid type having an indirectly heated cathode, the cathode in each case being connected with ground through a suitable biasing element. The plates of these tubes 189 and 188 are each connected with the BA terminal of the power unit PU over wire 210, reactor 197, resistor 198 and wire 199, the connection between the two portions of the wire 199 being indicated by arrows in order to simplify the drawings as much as possible. The primary

winding 200 of a coupling transformer T7 is interposed in the connection of the plate of the tube 188 with the wire 210, and a portion of the winding 201 of a coupling transformer T8 is interposed in the connection between the plate of the tube 189 and the wire 210. The grid of the first stage tube 189 is connected with the receiving coil RC in a manner to be more fully described later, and the winding 201 of the coupling transformer T8 is included in the grid circuit of the second stage tube 188, and, consequently, current picked up by the receiving coil RC will be repeated in the primary winding 200 of the transformer T7 greatly increased in amplitude and will induce an electromotive force of corresponding frequency in the secondary winding 202 of that transformer.

In this form of our invention single side band transmission is contemplated, a carrier of 7000 cycles per second being modulated with voice frequencies or with the calling frequency, the carrier and one side band suppressed and the upper side band passed. Hence, during a telephone conversation frequencies corresponding to the upper side band of the carrier modulated at voice frequencies are induced in the secondary winding 202 of the transformer T7, and during a calling condition a single frequency equal to an upper side band frequency of the carrier modulated at a predetermined voice frequency is induced in the secondary winding 202. For demodulating such upper side band frequencies the tubes 186 and 187 of the demodulating stage are associated with an oscillating circuit so proportioned as to generate a local carrier of 7000 cycles, and are provided with push-pull balanced circuits for mixing the frequencies induced in the secondary winding 202 with the local carrier. As here shown these tubes are triodes having indirectly heated cathodes, the cathodes of the tubes being connected with a ground electrode 203. The plates of the tubes 186 and 187 are connected with the BA terminal of the power unit over a reactor 204, wire 210 and thence over the same plate circuit traced for the tubes 188 and 189, the upper portion of the primary winding 205 of a transformer T9 being interposed in the connection between the reactor 204 and the plate of tube 186, and the lower portion of the primary winding 205 being interposed between the reactor 204 and the plate of the tube 187. The grids of the tubes 186 and 187 are connected with the outside terminals of the secondary winding 202 of the transformer T7, a center terminal of which is connected with the cathodes over a biasing element 206 and a portion of a reactor 207. An oscillating circuit 208 is formed to include a portion of the reactor 207 and a condenser 252, and this circuit has one terminal connected with the center terminal of the secondary winding 202 over the biasing element 206 and its other terminal connected with a center terminal of the primary winding 205 of the transformer T9 over a blocking condenser 211. In other words, the oscillating circuit 208 is connected with the two grids through the two portions of the secondary winding 202 of the transformer T7 and is connected with the two plates through the two portions of the primary winding 205 of the transformer T9. It is clear that frequencies induced in the secondary winding 202 are applied to the grids of the two tubes 186 and 187 opposite in phase, and the local carrier is applied to the two grids in phase.

The addition and subtraction of the carrier voltage and the upper side band frequency voltages when thus applied to the grids of the tubes 186 and 187 demodulate the side band and produce in the plate circuits audio frequencies and other products of demodulation. That is, the upper side band frequencies are translated down the frequency scale to audio frequencies. The audio frequencies and other products of demodulation produced in the plate circuits induce electromotive forces of corresponding frequencies in the secondary winding 209 of the transformer T9, the electromotive forces induced in the secondary winding 209 by the two portions of the primary winding 205 being additive. The secondary winding 209 is in turn connected to the input of a band-pass filter BPF.

The band-pass filter BPF of the unit RFT shown conventionally may be any one of several well known types of filters and is so proportioned and adjusted as to pass the audio frequencies induced in the secondary winding 209 and to suppress the other products of demodulation. The output side of the filter BPF is connected with the grid circuit of the low frequency amplifier tube 184, the plate of which is connected with the BA terminal of the power unit over the wire 199, the primary winding 212 of a transformer T10 being interposed between the plate and the connection with the wire 199. The tube 184 is here shown as a pentode one control grid of which is connected with the output of the band-pass filter BPF as stated above, and the other control grid of which is connected with the terminal of the primary winding 212 remote from the plate over a resistor 213. It follows that audio frequencies applied to the band-pass filter BPF are passed to the grid circuit of the tube 184 where they are amplified and reproduced in the primary winding 212 of the transformer T10 and in turn induce an electromotive force of corresponding frequencies in the secondary winding 217 of that transformer.

The secondary winding 217 supplies current to a call selecting circuit and also to the loud-speaker. The call selecting circuit includes a reactor 219, a condenser 220 and a front contact 214R2 of the relay R2, the front contact 214 being shown in Fig. 5 remote from the winding of the relay for the sake of simplicity. A portion of the reactor 219 is connected to the input terminals of a rectifier 221, the output terminals of which are connected with the relay R1, the arrangement being such that this call selecting circuit is tuned to respond to the calling frequency of 700 cycles per second. The loud-speaker LS of Fig. 5 is normally connected with the secondary winding 217 over a circuit including a resistor 216, and hence is normally in a condition of low sensitivity. In the event the relay R2 is released and its back contact 215R2 is closed, which back contact is also shown remote from the winding of the relay, the resistor 216 is short-circuited and the loud-speaker LS is connected with the secondary winding 217 in the condition of full sensitivity. The relay R2 is provided with a stick circuit which includes the back contact 222R1 of relay R1, which back contact is shown remote from the winding of that relay for the sake of simplicity, and the No. 1 position of the circuit controlling contact 15 of the unit MU. A pickup circuit for the relay R2 is provided which includes the contact 223 of a push button PB. It is clear that with relay R2

once picked up by push button PB being depressed, it is then retained energized over its stick circuit, and this relay in turn closes the call selecting circuit and switches the loud-speaker to a condition of low sensitivity. A calling current supplied to the receiving apparatus will be amplified, demodulated, filtered, applied to the call selecting circuit, and the relay R1 will be energized, with the result that the relay R2 will be released to disconnect the call selecting circuit and to switch the loud-speaker to a condition of full sensitivity. In addition to controlling the call selecting circuit and the loud-speaker, the relay R2 governs the tuning of the receiving coil RC as will now be described.

The receiving coil RC may be mounted at any convenient place on the caboose or locomotive as the case may be, in inductive relation with the traffic rails. We have found that a line wire paralleling the traffic rails such as a line wire commonly employed in telegraph work and strung on a pole paralleling the railway, also serves as a path for the communicating current. Consequently, the receiving coil RC may be mounted in inductive relation with a line wire if found desirable to do so, or it may consist of different portions which are mounted in inductive relation with the traffic rails and line wire, respectively. That is to say, the receiving coil RC is responsive to the communicating current flowing in the traffic rails or in the line wire or in both. The receiving coil RC is preferably of the air core type and constructed to have a relatively low power factor.

The coil RC is normally included in a circuit sharply tuned to resonance at the frequency of the calling current and the tuning is broadened for receiving a telephone current. As here shown, a normal receiving circuit can be traced from the right-hand terminal of the coil RC over wire 224, the lower portion of a reactor 225, front contact 226 of the relay R2, condenser 227, a second front contact 228 of the relay R2 and wire 229 to the left-hand terminal of the coil RC. This circuit is so proportioned as to be tuned sharply to resonance at the frequency of the calling current and hence noise currents having frequencies a few cycles to each side of the calling current only will be picked up during non-transmitting periods. Upon reception of a calling current and the energizing of the relay R1, the relay R2 will be deenergized and that relay upon releasing disconnects the above traced receiving circuit and completes a second receiving circuit which extends from the right-hand terminal of the receiving coil RC over wire 224, a larger portion of the reactor 225, back contact 230 of relay R2, condenser 227, resistor 231, and to the left-hand terminal of the coil RC. The resistor 231 and the other parts of this last traced circuit are so proportioned that the tuning of the receiving circuit is relatively broad and responds to the upper side band frequencies of the carrier having a width equal to the voice frequency range. The reactor 225 is included in the input side of the band-pass filter F1 which filter is so proportioned and adjusted as to pass the upper side band frequencies of the voice frequency range. Consequently, the upper side band telephone current transmitted from the remote location subsequent to the sending of a calling current will be picked up by the receiving coil RC and passed by the filter F1 to the input of the frequency translating unit RFT where it will be amplified, translated down the frequency scale

by demodulation, filtered and then further amplified and applied to the loud-speaker. After a telephone conversation, the receiving coil RC may be switched to its sharply tuned circuit by the operator depressing the push button PB and re-energizing the relay R2.

The frequency translating unit TFT of the transmitting apparatus may take any one of several forms and here consists of a modulator-oscillator, a filter and one stage of amplification. The modulator-oscillator includes the pentode 193 and a conventional oscillating circuit 232. The plate of the tube 193 is connected with the BPA terminal of the power unit over reactor 233, wire 234, and a resistor 235. The oscillating circuit includes reactor 236 and the two condensers 237 and 238 in parallel, the condenser 238 being included in the circuit over a back contact 239 of the calling relay CR. This oscillating circuit has one terminal connected with the plate circuit of the tube 193 over a blocking condenser 241 and its other terminal connected with the control grid 242. The parts of this oscillating circuit are so proportioned that when the two condensers 237 and 238 are included in the circuit a carrier of 7000 cycles per second is generated. The control grid 243 of the tube 193 is provided with a circuit that includes the secondary winding 52 of the transformer T2 and in which secondary winding voice frequencies are induced as pointed out hereinbefore. It is apparent that the carrier frequency will be modulated by the voice frequencies produced in the microphone M. The modulated carrier is applied to a band-pass filter shown conventionally over a back contact 244 of the calling relay CR, and around which back contact a resistor 247 is connected. A resistor 256 may be connected across the connection of the oscillating circuit with the filter if desired. The associated band-pass filter BPF is so proportioned that the carrier and one side band are suppressed and the other side band, in this instance the upper side band, is passed. The output side of the band-pass filter is connected with the grid circuit of the amplifying tube 192, the plate of which tube is connected with the BPA terminal of the power unit over the primary winding 246 of a transformer T11, wires 245 and 234, and the resistor 235. It follows from the foregoing description of the unit TFT that with the calling relay CR deenergized and voltage applied to the plates of the tubes 193 and 192, a carrier of 7000 cycles per second is generated which may be modulated at voice frequencies, the carrier and the lower side band suppressed, and the upper side band increased in magnitude by the full amplification of the tube 192. In the event the calling relay CR is picked up and its back contacts 239 and 244 are open, the condenser 238 is disconnected from the oscillating circuit 232, and the resistor 247 is interposed in the connection between that circuit and the filter. The disconnecting of the condenser 238 shifts the frequency of the carrier generated from 7000 to 7700 cycles which is now applied to the filter, its amplitude being attenuated by the resistor 247. The frequency of 7700 cycles falling within the voice frequency range of the modulated carrier, it is passed by the filter and in turn is amplified by the tube 192. In other words, the voice frequencies applied to the frequency translating unit of the transmitting apparatus are translated up the frequency scale to upper side band frequencies of the carrier, and in the event the

calling relay is picked up, the carrier is shifted by an amount equal to a given voice frequency to produce a calling current. It will be noted that inasmuch as no potential is normally supplied at the terminal BPA of the power unit, the frequency translating unit of the transmitting apparatus is normally inactive.

The two tubes 142 and 143 of the transmitter AT are connected in a push-pull arrangement the same as described for Fig. 1. In Fig. 5, the grid of the tube 142 is connected with the secondary winding 248 of the transformer T11, and the grid of the tube 143 is connected with the secondary winding 249 of the same transformer, a biasing battery 250 being interposed between a common connection of these two secondary windings and the filaments of the tubes. The plates of the power tubes 142 and 143 are connected with the BP terminal of the power unit over a wire 251, the upper and lower portions of the primary winding 149 of the transformer T6 being interposed in the plate circuits of the tubes 142 and 143, respectively. The secondary winding 141 of the transformer T6 of the transmitter AT is connected with the wheels 254 and 255 of the vehicle with the result that the transmitter AT when rendered active will supply the upper side band frequencies delivered to its input circuit from the unit TFT to the traffic rails amplified to a relatively high energy level.

In describing the operation of the apparatus of Fig. 5, we shall assume that the cut-out switch 172 is closed and the equipment occupies the normal position, that is, the position shown in the drawings. Under these circumstances, the dynamotor DM1 is operated to supply 500 volts direct current to the terminals BA and NB of the power unit. The filaments of the tubes of the two translating units are heated but only the plates of the tubes of the receiving apparatus are supplied with voltage, since the directional relay DR is deenergized. The relay R2 being picked up, the call selecting circuit and the loud-speaker are connected with the output of the receiving apparatus, the loud-speaker being in a condition of low sensitivity, and the receiving coil RC is connected to the input of the receiving apparatus sharply tuned to the calling frequency. Although the receiving apparatus is thus in a condition for receiving, noise currents of a frequency close to the frequency of the calling current only will be picked up during the non-transmitting period and these frequencies will be applied to the loud-speaker in the low sensitivity condition with the result that noise will be reduced to a low level. A calling current of the proper frequency when picked up by the receiving coil RC will be passed to the frequency translating unit RFT little attenuated and will be amplified, demodulated and filtered and impressed upon the call selecting circuit for energizing the relay R1. Picking up the relay R1 releases the relay R2 to transfer the loud-speaker to a condition of full sensitivity, and to broaden the tuning of the receiving coil RC sufficiently to pass a band of frequencies having the voice frequency range. Reception of a telephone current subsequent to the receiving of a calling current will be picked up by the coil RC and passed to the frequency translating unit RFT where it will be amplified, demodulated, filtered, further amplified and supplied to the loud-speaker. The operator will respond to a calling current by shifting the microphone handle 14 to the communicating position with the

result that the second dynamotor DM2 will be started up and the filaments of the power tubes of the transmitter AT will be supplied with current. To now transmit a telephone message, the operator will first depress the push button 18 to energize the directional relay DR. Relay DR, on picking up, will disconnect the plate circuits of the receiving tubes from the power unit, and will supply 500 volts to the tubes of the frequency translating unit TFT and 1000 volts to the power tubes of the transmitter AT. Speaking into the microphone will now cause the carrier to be modulated at the voice frequencies, the upper side band selected, this upper side band amplified to a relatively high energy level and supplied to the traffic rails. From this point on, the operator will shift the equipment to the condition for sending or to the condition for receiving by operating the push button to release or pick up the directional relay DR. When the relay is released, plate voltage is applied to the tubes of the receiving apparatus and when it is picked up plate voltage is applied to the tubes of the transmitting apparatus. It is to be noted, therefore, that when current is supplied to the traffic rails, this current will be ineffective to actuate the receiving apparatus at the same location since the tubes of the receiving apparatus at that location are now without plate voltage.

Should the operator desire to send a calling current, he will shift the handle 14 to the calling position which will start the second dynamotor DM2, pick up both the directional relay DR and the calling relay CR, and also supply current to the filaments of the power tubes. The energizing of the directional relay DR will transfer the power unit from the plates of the receiving tubes to the plates of the transmitting tubes the same as described above, and the energizing of the calling relay CR will cause the frequency of the carrier to be shifted from 7000 cycles to 7700 cycles which will now be amplified to a relatively high energy and supplied to the traffic rails. Again it will be noted that the outgoing current will be ineffective to actuate the receiving apparatus due to the fact that no voltage will be applied to the plates of the tubes of that apparatus.

While direct and inductive couplings are provided in Fig. 5, it will be understood that electrostatic coupling for either transmitting or receiving may be employed if found desirable. Furthermore, it is apparent that a single inductor coupled with traffic rails may be provided and that inductor connected with the transmitting apparatus or with the receiving apparatus through the medium of contacts operated by the directional relay the same as in Fig. 1. It will be noted that the receiving apparatus of Fig. 5 may be transferred from the normal calling condition to the telephone condition by the operator holding the handle 14 out of its normal position to move the contact 15 away from its No. 1 position long enough to cause the release of the relay R2.

As stated earlier in the specification, we do not wish to limit ourselves to communicating systems for railway trains, but our invention is equally useful for other communicating systems of the modulated carrier current type and the application here disclosed will serve to illustrate the many places our invention may be employed.

Although we have herein shown and described only certain forms of apparatus embodying our

invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of our invention.

Having thus described our invention, what we claim is:

1. A communicating system including; telephone equipment at each of two locations and each comprising a sending apparatus for transmitting a carrier telephone current or a carrier calling current, and a receiving apparatus for receiving such carrier current, said receiving apparatus having a selective calling condition and a telephoning condition; a circuit extending between said locations; a controller at each location having a first, a second and a third position; means effective in the first position of the controller to render the sending apparatus inactive and to connect the receiving apparatus to said circuit in its selective calling condition, means effective in the second position of said controller for rendering the sending apparatus active to transmit a telephone current and to selectively connect either the sending or the receiving apparatus with the circuit, means effective in the third position of the controller to connect the sending apparatus with the circuit in an active condition to supply the calling current, and manually operated means to govern said controller.

2. A communicating system including, transmitting apparatus at each of two spaced locations adapted to transmit a carrier frequency modulated with a signaling frequency but normally inactive, receiving apparatus at each of said two locations adapted to receive and demodulate a modulated carrier frequency and normally active, a communicating circuit extending between said two locations, normal circuit means at each location to connect the receiving apparatus with said communicating circuit, calling circuit means at each location to disconnect the receiving apparatus from said circuit and to render active and to connect the transmitting apparatus with said circuit, a circuit controller having a first and a second position, communicating circuit means at each location to render the transmitting apparatus active and to render said circuit controller effective for selectively including the transmitting or the receiving apparatus in the communicating circuit; a first manually controlled means at each location to selectively govern the normal, calling and communicating circuit means; and a second manually controlled means at each location to govern the circuit controller.

3. A communicating system for railway trains including, communicating equipment comprising a transmitting apparatus and a receiving apparatus, said equipment having a normal call receiving condition, a telephone condition and a call sending condition, a communicating circuit including the traffic rails; a first controller having a first, a second and a third position; a second controller having a first and a second position, means effective in the first position of the first controller to establish the normal call receiving condition and to couple the receiving apparatus to the traffic rails, means effective in the second position of the first controller to establish the telephone condition and to render effective said second controller to selectively couple either the transmitting apparatus or the receiving apparatus to the traffic rails, means

effective in the third position of the first controller to establish the call sending condition and to couple the transmitting apparatus to the traffic rails, a first manually operated means to govern the first controller, and a second manually operated means to govern said second controller.

4. A communicating system for railway trains including, transmitting apparatus at each of two spaced locations on a train and adapted to supply a carrier calling current or a carrier telephone current but normally inactive, receiving apparatus at each of said locations adapted to receive such carrier current and normally active, a circuit extending between said two locations, a normal means at each location to couple the receiving apparatus to said circuit, calling means at each location to render active the transmitting apparatus to supply the carrier calling current and to couple said transmitting apparatus with the circuit, a circuit controller having a first and a second position, telephone means at each location to render active the transmitting apparatus to supply the carrier telephone current and to render said circuit controller effective to selectively connect either the transmitting apparatus or the receiving apparatus with the circuit for exchanging telephone messages between the two locations; a first manually operated means to selectively govern the normal, calling and telephone means; and a second manually operated means to govern said circuit controller.

5. A communicating system including, a source of carrier current of a predetermined frequency, telephone means for modulating said carrier current with voice frequencies, manually controlled means for at times causing said source to produce a calling current having a frequency corresponding to said carrier modulated with a predetermined single voice frequency, a receiving means adapted to receive said carrier modulated with voice frequencies, a telephone receiver, operating means governed by said receiving means for operating said telephone receiver but normally ineffective, a call selecting circuit governed by said receiving means and responsive only to said predetermined frequency of the calling current, means controlled by said call selecting circuit for rendering said operating means effective to operate said telephone receiver in response to an impulse of calling current, and means for retaining said operating means effective after the termination of said impulse.

6. A communicating system including, a source of calling current adapted to supply a frequency corresponding to a predetermined carrier frequency modulated with a predetermined single voice frequency but normally inactive, a manually controlled means for at times rendering said source active, a loud-speaker, a receiving means adapted to be influenced by said calling current, a call selecting circuit normally connected with said receiving means and responsive only to said frequency of the calling current, an operating circuit governed by said receiving means for operating the loud-speaker but normally disconnected, means controlled by said call selecting circuit for connecting said operating circuit with said receiving means in response to an impulse of calling current, and means for retaining said operating circuit connected with the receiving means after the termination of said impulse.

7. A communicating system including, a source of carrier current of a predetermined frequency, signaling means for modulating said carrier frequency with signaling frequencies of a given range, manually controlled means for at times causing said source to produce a calling current having a frequency corresponding to said carrier modulated with a predetermined single frequency within said given range, a receiving means adapted to receive said modulated carrier current, a signaling device responsive to all frequencies within said given range, operating means governed by said receiving means for operating said signaling device but normally ineffective, a call selecting circuit governed by said receiving means and responsive only to said predetermined frequency of the calling current, means controlled by said call selecting circuit for rendering said operating means effective in response to an impulse of calling current, and means for retaining said operating means effective after the termination of said impulse.

8. A communicating system including, a source of carrier current of a given frequency, telephone means for modulating said carrier current with voice frequencies, manually controlled means for at times rendering said telephone means ineffective and for causing said source to supply a calling current having a frequency corresponding to the carrier modulated with a predetermined frequency within the voice frequency range, a loud-speaker, a receiving means adapted to be influenced by said modulated carrier current, a call selecting circuit normally connected with said receiving means and responsive only to the predetermined frequency of the calling current, an operating circuit governed by the receiving means for operating the loud-speaker but normally disconnected, means controlled by the call selecting circuit effective to connect said operating circuit with the receiving means and to disconnect the call selecting circuit in response to an impulse of the calling current, means for retaining the operating circuit connected with the receiving means at the termination of said impulse, and means for restoring the operating circuit and the call selecting circuit to their normal condition.

9. A communicating system including, a source of carrier current of a given frequency, telephone means for modulating said carrier current with voice frequencies, semi-automatic means for at times rendering said telephone means ineffective and for causing said source to supply for a predetermined interval a calling current having a frequency corresponding to the carrier modulated with a predetermined frequency within the voice frequency range, a loud-speaker, a receiving means adapted to be influenced by said modulated carrier current, a call selecting circuit normally connected with said receiving means and responsive only to the predetermined frequency of the calling current, an operating circuit governed by the receiving means for operating the loud-speaker but normally disconnected, means controlled by the call selecting circuit effective in response to an impulse of the calling current to disconnect the call selecting circuit and to connect the operating circuit to the receiving means whereby the loud-speaker sounds a calling note, means for retaining the operating circuit connected with the receiving means to reproduce a telephone message at the loud-speaker, and means for restoring the oper-

ating circuit and the call selecting circuit to their normal condition.

10. A communicating system including, a communicating circuit, a source adapted to supply a carrier current to said circuit, an electron tube amplifier having a plate and a grid, a transformer having one winding connected with the plate of said tube and a second winding connected with said source, a microphone, means to apply voice frequencies produced by speaking into the microphone to the grid of said tube for modulating the carrier by the corresponding amplified voice frequencies, coupling means including a reactance device for at times coupling the plate to the grid of the tube for causing the electron tube to generate a given frequency for modulating the carrier with said single frequency, and manually controlled means to render either the microphone or the coupling means active whereby either a telephone message or a calling signal corresponding to said given frequency is delivered to said communicating circuit.

11. A communicating system including, a communicating circuit, an electron tube having a plate and two control grids; an oscillating circuit including an inductor and a condenser in parallel, and connected with said plate and one of said grids for generating a carrier current of a given frequency; telephone means including a microphone connected with the other grid of said tube for modulating the carrier with voice frequencies of a telephone message, calling means adapted when active to connect a second inductor in parallel with the inductor of said oscillating circuit to increase the carrier frequency by an amount equal to a given voice frequency, filtering means influenced by the oscillating circuit and adapted to pass to the communicating circuit only side band frequencies of said carrier of a width equal to voice frequencies, and manually controlled means to render either the telephone means or the calling means effective.

12. A communicating system including, a communicating circuit, an oscillating circuit including an inductor and a condenser in parallel, means connected with said oscillating circuit to cause it to supply a carrier current of a given frequency, telephone means including a microphone and connected with said oscillating circuit in such a manner as to modulate the carrier with voice frequencies of a telephone message, a second inductor, calling means for connecting said second inductor in parallel with the inductor of the oscillating circuit to increase the carrier frequency by an amount equal to a given voice frequency, means to transmit the current supplied by the oscillating circuit to the communicating circuit, and manually controlled means to render either the telephone means or the calling means effective.

13. A communicating system including, a communicating circuit, two electron tubes each having a plate and a grid, an output transformer having its primary winding normally connected with said plates in a push-pull arrangement, an input transformer having its secondary winding connected with said grids in a push-pull arrangement, a telephone circuit connected with the primary winding of the input transformer, an oscillating circuit including an inductor and a condenser in parallel, said oscillating circuit having one terminal connected with said plates and the opposite terminal con-

nected with said grids and arranged in such a manner that a carrier current of a given frequency is generated and modulated with the voice frequencies produced in the telephone circuit and then is balanced out leaving only the side band frequencies in the secondary winding of the output transformer; calling means to vary the oscillating circuit to shift the frequency of the carrier from said given frequency by an amount corresponding to a predetermined voice frequency, means governed by the calling means to transfer the plates of said tubes to a parallel arrangement to deliver to the output transformer the shifted carrier, means to couple the secondary of the output transformer to the communicating circuit, and manually controlled means to render either the telephone circuit or the calling means active.

14. A communicating system including, a communicating circuit, two electron tubes each having a plate and a grid, an output transformer having its primary winding normally connected with said plates in a push-pull arrangement, an input transformer having its secondary winding connected with said grids in a push-pull arrangement, a telephone circuit connected with the primary winding of the input transformer, an oscillating circuit including an inductor and a condenser in parallel, said oscillating circuit having one terminal connected with said plates and the opposite terminal connected with said grids and arranged in such a manner that a carrier current of a given frequency is generated and modulated with the voice frequencies produced in the telephone circuit and then is balanced out leaving only the side band frequencies in the secondary winding of the output transformer; calling means to decrease the capacity of the condenser of said oscillating circuit to increase the carrier frequency by an amount corresponding to a predetermined voice frequency, means governed by the calling means to transfer the plates of said tubes to a parallel arrangement to deliver to the output transformer the shifted carrier corresponding to a predetermined upper side band frequency, means to couple the secondary of the output transformer to the communicating circuit, and manually controlled means to render effective either the telephone circuit or the calling means.

15. A communicating system including, a communicating circuit, telephone means adapted to supply frequencies corresponding to a given carrier frequency modulated with the voice frequencies of a telephone message to said communicating circuit, calling means adapted to supply a single frequency corresponding to said carrier frequency modulated with a predetermined voice frequency to said communicating circuit, a manually operated means having a communicating position for rendering the telephone means active and a calling position for rendering the calling means active, and automatic means effective in response to the calling position of said manually operated means for maintaining the calling means active for a given time interval regardless of the subsequent position of said manually operated means.

16. In combination, a receiving circuit adapted to receive current having a frequency range corresponding to the voice frequencies, a loud-speaker, means controlled by the receiving circuit for operating the loud-speaker, a control device for establishing the loud-speaker in a condition of low sensitivity or in a condition

of full sensitivity and normally at the condition of low sensitivity, a call selecting means governed by the receiving circuit and including a tuned circuit network responsive to a given single frequency only within the voice frequency range, means controlled by the call selecting means for causing the control device to establish the loud-speaker in a condition of full sensitivity in response to an impulse of current of said given frequency, and holding means for retaining the loud-speaker in the condition of full sensitivity.

17. In combination, a receiving circuit adapted to receive frequencies corresponding to a given carrier frequency modulated with voice frequencies, a demodulator having its input influenced by the receiving circuit, a loud-speaker, operating means controlled by the output of the demodulator for operating the loud-speaker, a relay for governing the operating means and normally deenergized to establish the loud-speaker in a condition of low sensitivity, an amplifier governed by the demodulator, a control circuit governed by the amplifier and selectively responsive to a given frequency only within the voice frequency range, means controlled by said control circuit to energize said relay in response to an impulse of current of said given frequency to establish the loud-speaker in a condition of full sensitivity, a holding circuit including a local source of current for retaining said relay energized, and manually controlled means for governing said holding circuit.

18. In combination, a receiving circuit adapted to receive side band frequencies of a carrier frequency modulated with voice frequencies, a demodulator influenced by the receiving circuit, a loud-speaker governed by the demodulator and having a low sensitive condition and a full sensitive condition, means for normally establishing the low sensitive condition of the loud-speaker, a call selecting circuit governed by the demodulator and including a device tuned to a given voice frequency, means controlled by said device for establishing the full sensitive condition of the loud-speaker in response to an impulse of current of said given frequency, holding means for retaining the loud-speaker in the full sensitive condition, and manually controlled means for governing the holding means.

19. In combination, a receiving circuit adapted to receive frequencies corresponding to a given carrier frequency modulated with voice frequencies, a demodulator influenced by the receiving circuit, a loud-speaker, an operating circuit for connecting the loud-speaker with the demodulator but normally disconnected, a tuned device responsive to a given voice frequency only, a call selecting circuit for connecting said device with the demodulator and normally connected, means controlled by said device in response to an impulse of current of said given frequency to disconnect said call selecting circuit and to connect the operating circuit with the demodulator, and manually controlled means to restore said operating circuit and said call selecting circuit to their normal condition.

20. A communicating system for railway trains including a communicating circuit comprising the traffic rails, a train-carried receiving circuit inductively coupled with the traffic rails and adapted to be influenced by a carrier current modulated with voice frequencies, a demodulating means having its input influenced by said receiving circuit, a call selecting circuit controlled by the output of said demodulating

means and selectively responsive to a given frequency within the voice frequency range, a loud-speaker, an operating means controlled by the output of said demodulating means for operating the loud-speaker but normally inactive, and means controlled by the call selecting circuit for automatically rendering said operating means active in response to an impulse of carrier current modulated at said given frequency picked up from the traffic rails.

21. A communicating system including, a communicating circuit, a source of calling current adapted to supply a frequency corresponding to a side band frequency of a given carrier modulated with a predetermined voice frequency to the communicating circuit but normally inactive, manually controlled means for at times rendering said source active, receiving means coupled to the communicating circuit and adapted to receive and demodulate said calling current, a loud-speaker, an operating circuit governed by the receiving means for operating the loud-speaker but normally disconnected, control means selectively responsive to said predetermined voice frequency, a call selecting circuit governed by the receiving means for energizing the control means and normally connected, means effective when said control means is energized to disconnect the call selecting circuit and to connect the operating circuit to the receiving means whereby the loud-speaker is switched to the receiving means and a call note sounded in response to the calling current.

22. A communicating system including, a communicating circuit, a current generating means adapted to supply to said circuit a frequency corresponding to a given carrier frequency modulated with a predetermined voice frequency but normally inactive, receiving means coupled to the communicating circuit and adapted to receive and demodulate the current from said source, a loud-speaker governed by said receiving means but normally disconnected, a selecting circuit normally connected with said receiving means and selectively responsive to said predetermined frequency only, means controlled by said selecting circuit to connect said loud-speaker with the receiving means in response to an impulse of current of the predetermined frequency, and manually operated means for rendering said current generating means active in accordance with a prearranged code to establish a corresponding code of current impulses whereby said loud-speaker is automatically rendered active and notes corresponding to said code are sounded.

23. A communicating system for railway trains including, a communicating circuit comprising the traffic rails, a transmitting circuit at one location on a train and inductively coupled with the traffic rails, a transmitting means for supplying to the transmitting circuit a frequency corresponding to a given carrier modulated with a predetermined voice frequency but normally inactive, a receiving circuit located at a second point on the train and inductively coupled with the traffic rails, receiving means controlled by said receiving circuit and adapted to demodulate the current from said transmitting means, a loud-speaker governed by said receiving means, and manually operated means for rendering the signaling means active in accordance with a prearranged code to establish a corresponding code of current impulses whereby said loud-speaker is rendered active to sound notes corresponding to said code.

24. A communicating system including; telephone equipment at each of two locations each of which comprises a sending apparatus capable of supplying either a carrier telephone current or a carrier calling current but normally inactive, and a receiving apparatus capable of receiving and demodulating such carrier currents and normally active; a calling, a transmitting and a directional relay at each location; a communicating circuit extending between said two locations, means controlled jointly by said transmitting and directional relays for rendering the sending apparatus active, means controlled by said calling relay for rendering the sending apparatus effective to supply a calling current, means controlled by said directional relay for selectively coupling either the sending or the receiving apparatus with said circuit, and manually operated means for selectively governing said relays.

25. A communicating system including, a communicating circuit, an electron tube provided with a plate and two control grids, an oscillating circuit including an inductance and a capacitance connected with said plate and one of said grids for generating a carrier current of a predetermined frequency, telephone means including a microphone connected with the other of said grids for modulating the carrier with voice frequencies, transmitting means coupled with said oscillating circuit for supplying current to the communicating circuit and including a filter operative to pass a given side band of said carrier of a width equal to the voice frequencies, calling means connected with said oscillating circuit including a reactance device and a circuit controlling contact and operative to vary the frequency of the carrier current by an amount equal to a given voice frequency, and manually controlled means for operating said circuit controlling contact.

26. In combination, a receiving circuit including a filter operative to pass a carrier current modulated with voice frequencies, a demodulator having its input influenced by the receiving circuit, a loud-speaker, a control relay, an operating circuit controlled by the output of the demodulator for operating the loud-speaker and including a back contact of said relay, a call selecting circuit governed by the output of the demodulator including a tuned device responsive to a given voice frequency only, a pickup circuit for said control relay including a normally open manually operated contact, and a stick circuit for said control relay including a contact operated by the tuned device and a normally closed manually operated contact, whereby the loud-speaker is retained normally inactive and is established in an active condition either automatically upon reception of a calling current of said given frequency or manually by operation of said normally closed contact.

27. A communicating system comprising, a communicating circuit extending from a location, transmitting means at the location including an electron amplifying tube and a microphone connected with the grid of the tube, receiving means at the location including an electron amplifying tube and a loud-speaker connected with the plate of the tube, a current source, a directional relay, means for connecting said current source with the plate of the receiving amplifying tube including a back contact of said relay, means for connecting said current source with the plate of the transmitting amplifying tube including a front contact of said relay, control means for

governing said relay including a manually operated circuit controller, and means for coupling the output of the transmitting means and the input of the receiving means with said communicating circuit.

28. A communicating system comprising; transmitting means including a microphone, an electron tube oscillator, a filter and an electron tube amplifier; receiving means including an electron tube amplifier, an electron tube demodulator, a filter and a loud-speaker; a circuit source, a directional relay, means for connecting said current source with the plates of the tubes of the receiving means including a back contact of the directional relay, means for connecting said current source with the plates of the tubes of said transmitting means including a front contact of the directional relay, and circuit means for controlling the directional relay including a manually operated circuit controlling contact.

29. A communicating system comprising; transmitting means including a microphone, an electron tube oscillator, a filter, an electron tube amplifier and a sending circuit; receiving means including a receiving coil, an electron tube amplifier, an electron tube demodulator, a filter and a loud-speaker; a current source, a directional relay, means for connecting the source with the plates of the tubes of the receiving means for reproducing the telephone message of a carrier side band telephone current picked up by the receiving coil and said means including a back contact of said relay, means for connecting the source with the plates of the tubes of the transmitting means for supplying to the sending circuit a carrier side band telephone current and said means including a front contact of said relay, and circuit means for controlling said relay including a manually operated circuit controlling contact.

30. A communicating system comprising; transmitting means including a microphone, an electron tube oscillator, means for modulating the output of said oscillator with voice frequencies produced in the microphone and a sending circuit; receiving means including a receiving coil, an electron tube demodulator and a loud-speaker; a current source, means for connecting the current source with the plate of said demodulating tube for reproducing the telephone message of a carrier telephone current picked up by the receiving coil and including a first circuit controlling contact, means for connecting the current source with the plate of said oscillating tube for transmitting over the sending circuit a carrier telephone current and including a second circuit controlling contact, and manually operated means for selectively operating said contacts.

31. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, train-carried receiving means including an electron tube demodulator, a loud-speaker and a conductor electrically coupled with the traffic rails; transmitting means including a microphone, an electron tube oscillator and a conductor electrically coupled with the traffic rails; a current source, means for connecting the current source with the plate of the demodulating tube for reproducing at the loudspeaker a carrier telephone current picked up by the conductor of the receiving means and said means including a circuit controlling contact, other means for connecting the current source with the plate of the

oscillator tube for supplying to the traffic track a carrier telephone current and said other means including another circuit controlling contact, and manually operated means for selectively closing one or the other of said contacts.

32. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, train-carried receiving means including an electron tube demodulator, a loud-speaker and a conductor electrically coupled with the traffic rails; transmitting means including a microphone, an electron tube oscillator, an electron power amplifying tube and a conductor electrically coupled with the traffic rails; a power unit including a first and a second generator, means for connecting the first generator with the plate of the demodulating tube including a first circuit controlling contact, means for connecting the first generator with the plate of the oscillator tube and for connecting the generators serially with the plate of the power tube, and said means including a second circuit controlling contact, and manually operated means for selectively closing one or the other of said contacts.

33. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, train-carried receiving means including an electron tube demodulator, a loud-speaker and a conductor electrically coupled with the traffic rails; transmitting means including a microphone, an electron tube oscillator, an electron power amplifying tube and a conductor electrically coupled with the traffic rails; a power unit including a first and a second generator the first of which is normally active and the second of which is normally inactive, means for connecting the first generator with the plate of the demodulating tube including a first circuit controlling contact, means for connecting the first generator with the plate of the oscillator tube and for connecting the generators serially with the plate of the power tubes and said means including a second circuit controlling contact, and manually operated means effective to selectively close one or the other of said contacts and to render said second generator active.

34. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, a first electron tube, a telephone receiver electrically coupled with the plate circuit of said tube, a grid circuit for said tube including a conductor electrically coupled with the traffic rails, a second electron tube, a microphone electrically coupled with the grid circuit of said second tube, a plate circuit for said second tube including a conductor electrically coupled with the traffic rails, a source of plate voltage, means for connecting the source with the plate circuit of the first tube for reproducing in the telephone receiver the telephone message corresponding to a telephone current picked up by said first mentioned conductor, said means including a normally closed contact, other means for connecting the source with the plate circuit of said second tube for supplying a telephone current to the traffic rails corresponding to voice impulses produced in said microphone, said other means including a normally open contact, and manually controlled means operative to open said normally closed contact and to close said normally open contact.

35. A communicating system for railway trains comprising, train-carried transmitting

means including a generator of a given carrier frequency current and a transmitting circuit, telephone means including a microphone coupled with the transmitting means for producing a carrier telephone current, calling means coupled with the transmitting means for producing a calling current corresponding to the carrier modulated at a given voice frequency, train-carried receiving means including a receiving circuit and a demodulator, means including a loud-speaker coupled with said demodulator for reproducing such carrier telephone current or such calling current picked up by the receiving circuit; control means including a push button and a manually operated circuit controller having a first, a second and a third position; means governed by the control means for rendering the receiving means active and the transmitting means inactive and said means operative in the first position of said controller and also in the second position of the controller with the push button released, means governed by the control means for rendering the transmitting means active and the receiving means inactive and said means operative in the second position of the controller with the push button depressed and in the third position of the controller, and means governed by the control means for rendering the calling means active and said means operative in the third position of the controller only.

36. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, a directional relay, a calling relay, train-carried transmitting means including a generator of a carrier current of a given frequency and a sending circuit coupled with the traffic track, means including a microphone coupled with said generator for supplying a carrier telephone current to the traffic track, calling means including a reactance device coupled with said generator for supplying to the traffic track a calling current corresponding to said carrier modulated at a given voice frequency, train-carried receiving means including a demodulator and a receiving circuit coupled with the traffic track, means including a loud-speaker coupled with the demodulator for reproducing the telephone message of such telephone current and to sound a tone corresponding to the calling current when such currents are picked up by the receiving circuit, control means operative to render the receiving means active including a back contact of the directional relay, other control means operative to render the transmitting means active including a front contact of the directional relay, means for at times rendering the calling means active including a contact operated by said calling relay, and manually controlled means for governing said relays.

37. A communicating system including, a communicating circuit, an output transformer having a secondary winding connected with said circuit, an input transformer, telephone circuit means including a microphone connected with the primary winding of the input transformer; two electron tubes each having a plate, a grid and a cathode; a relay, means including a first back contact of said relay to connect the plates of said tubes with the primary winding of the output transformer in a push-pull arrangement, other means including a front contact of said relay to connect the plates of said tubes with the primary winding of the output transformer in a parallel arrangement, means to connect the

secondary winding of the input transformer with the grids of said tube in a push-pull arrangement, a source of carrier frequency current, means to connect the carrier source between a center tap of the secondary winding of the input transformer and the cathode of said tubes, calling means including a second back contact of said relay and a reactance device operative to shift the frequency of said carrier from the given frequency to produce a calling frequency, and manually operated means to govern said relay whereby said communicating circuit is selectively supplied with either a side band carrier telephone current or with an amplified calling current.

38. A communicating system comprising, a communicating circuit extending from a location; receiving means at said location including an electron tube amplifier, a signal receiving device and a conductor electrically coupled with the circuit; transmitting means at said location including a signal sending device, a low power electron tube amplifier, a high power electron tube amplifier and a conductor electrically coupled with said circuit; a power unit including a first and a second generator, a relay, means for connecting the first generator with the plate of the receiving amplifier tube and including a back contact of said relay, means for connecting the first generator with the plate of the low power amplifier tube and for connecting the generators serially with the plate of the high power amplifier tube, and said means including a front contact of said relay, and manually operated means for governing said relay.

39. A communicating system comprising a communicating circuit extending from a location; receiving means at said location including an electron tube amplifier, a signal receiving device and a conductor electrically coupled with the circuit; transmitting means at said location including a signal sending device, a low power amplifier tube, a high power amplifier tube and a conductor electrically coupled with said circuit; a power unit including a first and a second generator the first of which is normally active and the second of which is normally inactive, a relay, means for connecting the first generator with the plate of the receiving amplifier tube and including a back contact of said relay, means for connecting the first generator with the plate of the low power amplifier tube and for connecting the generators serially with the plate of the high power amplifier tube, and said means including a front contact of said relay, and manually operated means including a first contact effective to control said relay and a second contact effective to control said second generator.

40. A communicating system comprising, a communicating circuit extending from a location, transmitting apparatus at the location including a generator of carrier current and an output circuit coupled with said communicating circuit, means including a microphone coupled with said generator for supplying a carrier telephone current to the communicating circuit, call sending means including a reactance device coupled with said generator for supplying a calling current corresponding to said carrier modulated at a given frequency to the communicating circuit, receiving apparatus at the location including a demodulator and an input circuit coupled with said communicating circuit, a telephone receiver coupled with said demodulator for reproducing the telephone message of such carrier telephone

current picked up from the communicating circuit, a call signaling device coupled with said demodulator and tuned to said given frequency for establishing a signal in response to such calling current picked up from the communicating circuit; a control means having a first, a second, a third and a fourth position; a first circuit means including a contact closed only in the first position of said control means operative to render the receiving apparatus only active and to couple the signaling device with the demodulator, a second circuit means including a contact closed only in the second position of said control means operative to render the receiving apparatus only active and to couple the telephone receiver with the demodulator, a third circuit means including a contact closed only in the third position of said control means operative to render the transmitting apparatus only active and effective to send the telephone current, a fourth circuit means including a contact closed only in the fourth position of the control means operative to render the transmitting apparatus only active and effective to send the calling current, and manually operated means for selectively governing the positions of the control means.

41. A communicating system comprising, transmitting apparatus at a location including a generator of carrier current and a transmitting circuit, telephone means including a microphone coupled with the transmitting apparatus for sending a carrier telephone current, calling means coupled with the transmitting apparatus for sending a calling current corresponding to the carrier modulated at a given frequency, receiving apparatus at said location including a receiving circuit and a demodulator, means including a telephone receiver coupled with said demodulator for reproducing the message of such carrier telephone current, other means including a sharply tuned device coupled with said demodulator to establish a signal in response to such calling current; control means having a normal, a communicating and a calling position and including a directional controller having a sending and a receiving position; first circuit means including a contact closed only in the normal position of the control means and operative to render the receiving apparatus only active and to couple said other means with the demodulator, second circuit means including a contact closed only in the communicating position of the control means and the receiving position of the directional controller and operative to render the receiving apparatus only active and to couple the telephone receiver with the demodulator, a third circuit means including a contact closed only in the communicating position of the control means and the sending position of the directional controller and operative to render the transmitting apparatus only active and with the microphone effective, a fourth circuit means including a contact closed only in the calling position of the control means and operative to render the transmitting apparatus only active and with the calling means effective, and manually operable means for governing the control means.

42. A communicating system for railway trains comprising in combination with the traffic rails of a stretch of railway track and a train adapted to travel thereon, transmitting apparatus mounted on a vehicle of the train and

including a source of communicating current and circuit means for connecting the opposite terminals of the source with the rails at two spaced points adjacent said vehicle, receiving apparatus on said vehicle and including a signaling device responsive to such communicating current and a conductor in direct inductive relation with the traffic rails, and means to selectively render active either the transmitting or the receiving apparatus.

43. A communicating system for railway trains comprising in combination with the traffic rails of a stretch of railway track and a train adapted to travel thereon, transmitting apparatus mounted on a vehicle of the train and including a source of communicating current and means for connecting the opposite terminals of the source with two wheels of the vehicle, receiving apparatus on said vehicle and including a signaling device responsive to such communicating current and a conductor in direct inductive relation with the traffic rails, and means to selectively render active either the transmitting or the receiving apparatus.

44. A communicating system for railway trains comprising in combination with the traffic rails of a stretch of railway track and a train adapted to travel thereon, two independent apparatuses mounted on a vehicle of the train one of which is capable of supplying a communicating current and the other of which is effectively responsive to a communicating current, means to directly connect one of said apparatuses with the traffic rails, and other means to connect the other of said apparatuses with a conductor mounted on said vehicle in direct inductive relation with the traffic rails.

45. A communicating system for railway trains comprising in combination with the traffic rails of a stretch of railway track and a train adapted to travel thereon, two independent apparatuses mounted on a vehicle of the train one of which is capable of supplying a communicating current and the other of which is effectively responsive to a communicating current, means to directly connect one of said apparatuses with the traffic rails, other means to connect the other of said apparatuses with a conductor mounted on said vehicle in direct inductive relation with the traffic rails, and manually operable means for rendering active only one of said apparatuses at a time.

46. A communicating system for railway trains comprising, a communicating circuit including the traffic rails; train-carried receiving apparatus including an electron tube demodulator, a conductor coupled with the traffic rails effectively connected to the input of the demodulator and a loud-speaker effectively coupled with the output of the demodulator; train-carried transmitting apparatus including an electron tube modulator, a microphone associated with the modulator to modulate the carrier at voice frequencies and a sending circuit coupled with the track rails and effectively connected with the output of the modulator; a source of plate current, a first control circuit means effective to connect the plate current source to the electron tube demodulator, a second control circuit means effective to connect the plate current source to the electron tube modulator, and means for selectively governing said first and second control circuit means, whereby telephone communication

to and from the train is accomplished through the traffic rails.

47. A communicating system for railway trains comprising, a communicating circuit including the traffic rails; a train-carried receiving circuit means inductively coupled with the traffic rails and adapted to be influenced by a carrier current modulated with voice frequencies, demodulating means having its input influenced by said receiving circuit means, signalling circuit means connected with the output of the demodulating means, said signaling circuit means having a first condition in which it is effectively responsive to a predetermined single voice frequency only and a second condition in which it is effectively responsive to the range of voice frequencies, a relay having contacts interposed in said signaling circuit means for selectively establishing either the first or the second condition thereof, and a control circuit for said relay including a manually operated contact.

48. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, train-carried receiving apparatus including an electron tube demodulator, a loud-speaker and a conductor electrically coupled with the traffic rails; train-carried transmitting apparatus including a microphone, a source of carrier current, an electron tube modulator, an electron tube power amplifier and a conductor electrically coupled with the traffic rails; a power unit effective to supply a low plate voltage and a high plate voltage, a first means to connect the power unit to the plate of the demodulator tube to supply the low plate voltage thereto and including a first contact, a second means to connect the power unit to the plate of the modulator tube to supply the low plate voltage thereto and including a second contact, a third means to effectively connect the power unit to the power amplifier tube to supply the high plate voltage thereto and including a third contact; and means for governing said first, second and third contacts whereby either a first condition is established in which the receiving apparatus only is active and is effectively influenced by communication current flowing in the rails, or a second condition is established in which the transmitting apparatus only is active and is effective to supply communication current to the rails.

49. A communicating system for railway trains comprising, a communicating circuit including the traffic rails, train-carried transmitting means including an oscillating circuit consisting of an inductor and two condensers in parallel to supply a carrier current of a predetermined frequency and a sending circuit coupled with the traffic rails, telephone means including a microphone associated with the oscillating circuit to modulate the carrier with voice frequencies to supply to the rails a carrier telephone current, calling means including a relay operative to disconnect one of said condensers to increase the carrier frequency by an amount equal to a predetermined voice frequency to supply to the rails a calling current, and manually controlled means for governing said relay.

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CERTIFICATE OF CORRECTION.

Patent No. 2,064,639.

December 15, 1936.

LELAND D. WHITELOCK, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 17, second column, line 11, claim 28, for the word "circuit" read current; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of February, A. D. 1937.

Henry Van Arsdale
Acting Commissioner of Patents.

(Seal)