

Aug. 23, 1932.

J. D. SARROS

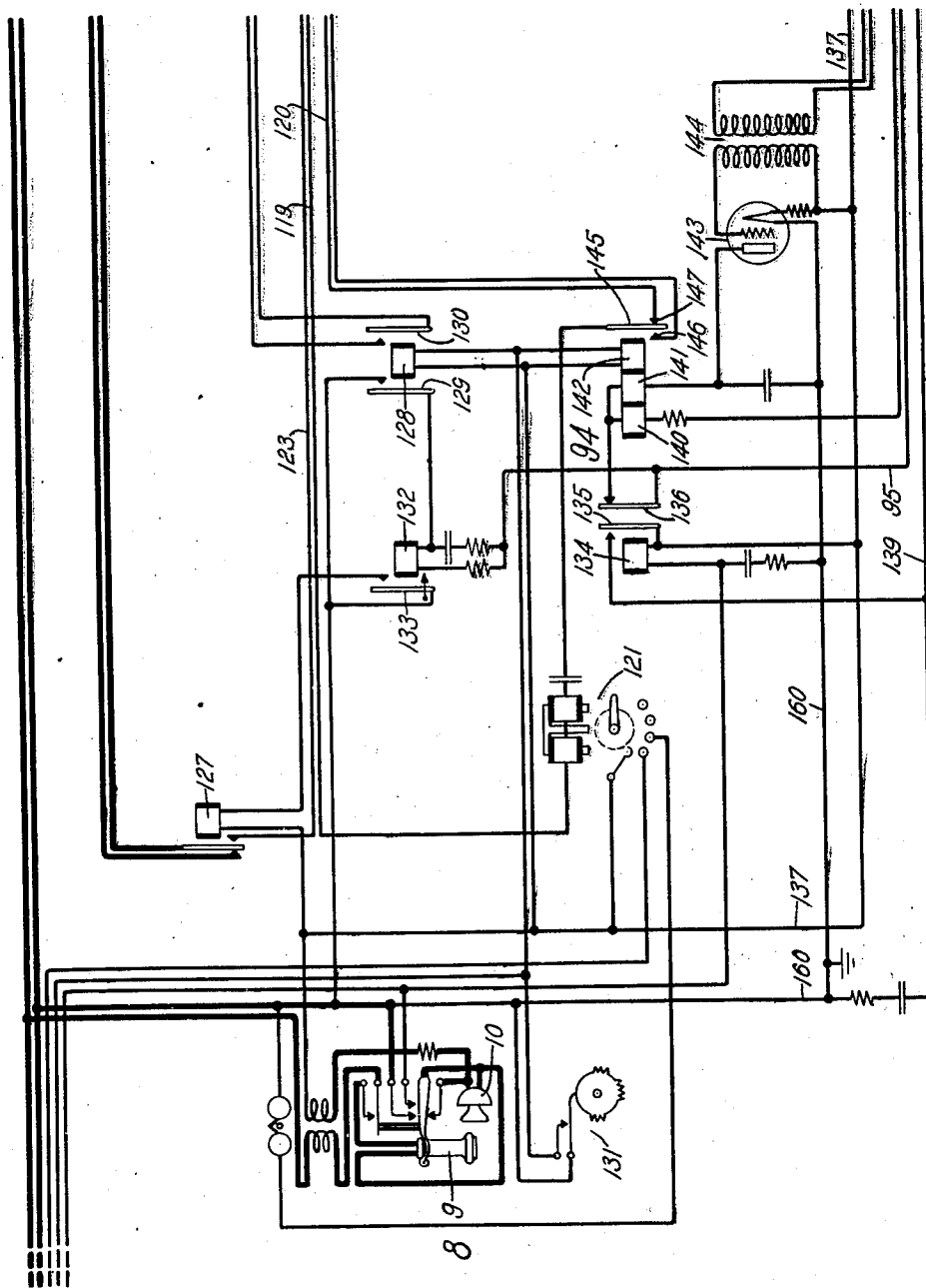
1,873,334

POWER LINE CARRIER TELEPHONE SYSTEM

Filed Aug. 10, 1929

3 Sheets-Sheet 1

FIG. 1



INVENTOR
J. D. SARROS
BY
Wayne B. Wells
ATTORNEY

Aug. 23, 1932.

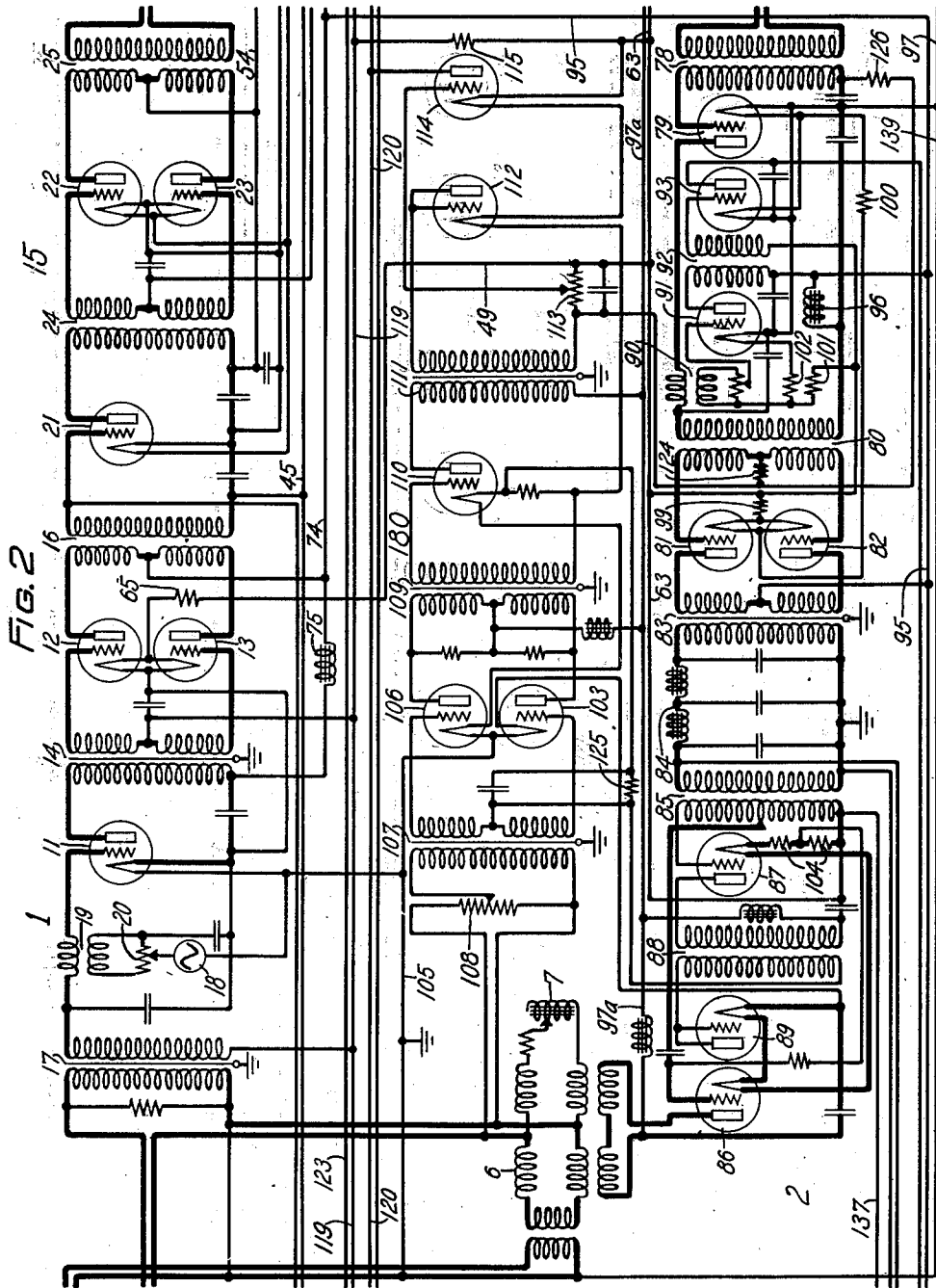
J. D. SARROS

1,873,334

POWER LINE CARRIER TELEPHONE SYSTEM

Filed Aug. 10, 1929

3 Sheets-Sheet 2



INVENTOR
J. D. SARROS

BY

Wayne B Wells
ATTORNEY

Aug. 23, 1932.

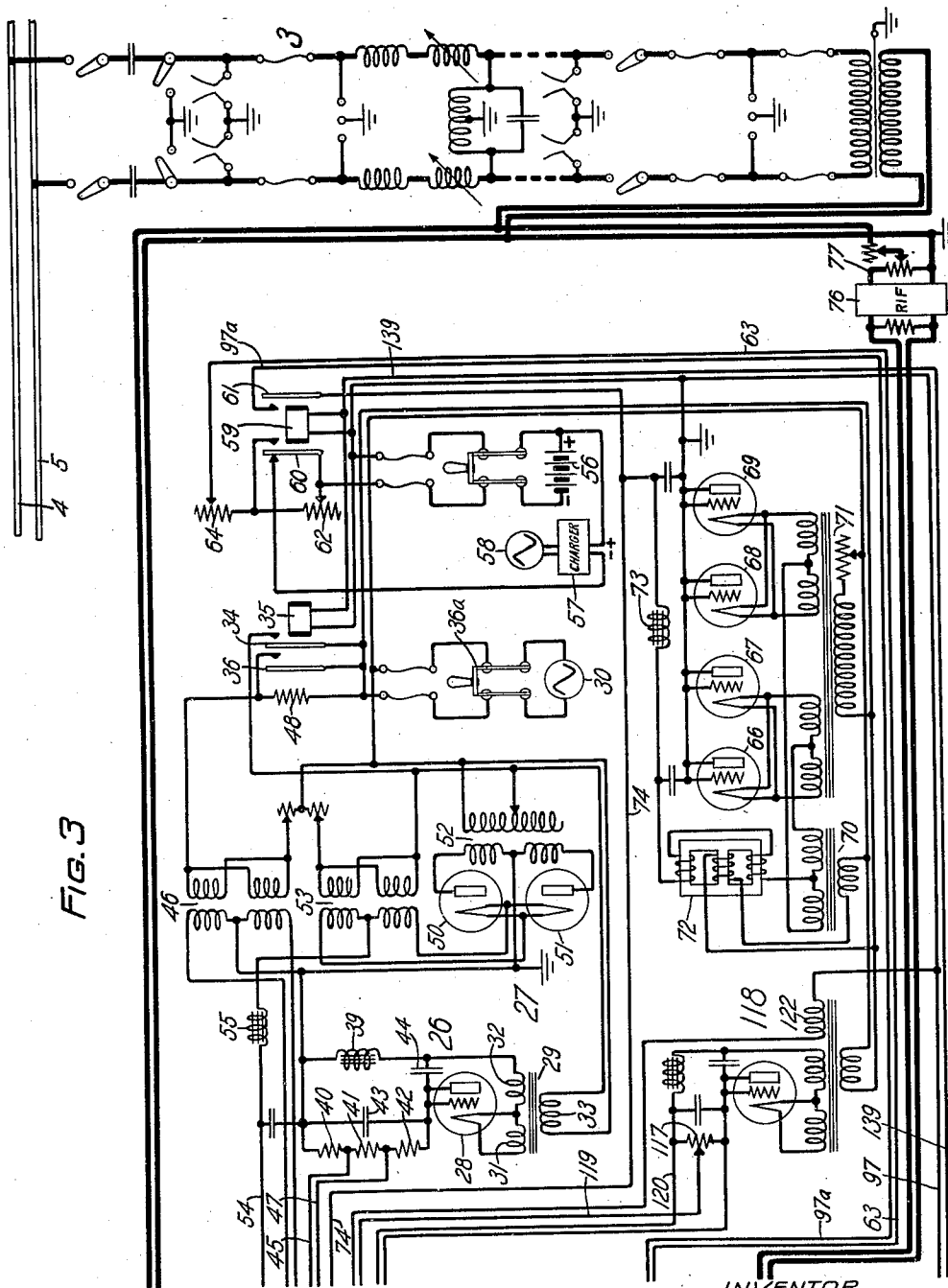
J. D. SARROS

1,873,334

POWER LINE CARRIER TELEPHONE SYSTEM

Filed Aug. 10, 1929

3 Sheets-Sheet 3



INVENTOR
J. D. SARROS
BY

Wayne B Wells
ATTORNEY

UNITED STATES PATENT OFFICE

JAMES D. SARROS, OF LONG ISLAND CITY, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

POWER LINE CARRIER TELEPHONE SYSTEM

Application filed August 10, 1929. Serial No. 384,876.

This invention relates to carrier current communication systems and particularly to power line carrier current communication systems.

5 One object of the invention is to provide an improved carrier current transmission system employing the same carrier wave for communication in opposite directions, transmitting a code signal of carrier waves for
10 selectively calling a station and transmitting the carrier wave and both side bands during communication between stations.

Another object of the invention is to provide a power line carrier current communication system having a signal station with a
15 transmitting and a receiving channel connected to the power line that shall block the transmitting channel when the station is idle and when the receiving channel is in use
20 and that shall block the receiving channel when the transmitting channel is in use while communicating with or calling another station.

A further object of the invention is to
25 provide a power line carrier current communication system of the above indicated type that shall block the transmitting channel at a station by impressing negative blocking potential on a tube in the transmitting
30 channel when the station is idle or the receiving channel is in service and that shall block the receiving channel by impressing negative blocking potential on the grid of a tube
35 in the receiving channel when the transmitting channel is in service while communicating with or calling another station.

The present invention is particularly adapted for use on high-tension power transmission systems which transmit low-frequency
40 high-voltage alternating current for power purposes. The signal currents are of relatively high frequency in order to facilitate communication between signal stations and separation of the power current from the signal
45 currents.

In the patent to C. N. Nebel, No. 1,733,553 dated October 29, 1929, is disclosed a power line carrier current system wherein communication between signal stations on a power line is effected in both directions by means
50 of the same carrier wave and only one side band is transmitted during communication. In the disclosed system one carrier wave is used to effect communication in opposite directions between stations and the carrier
55 wave and both side bands are transmitted over the power line during communication between stations. Selective calling of a station is effected by transmitting a code signal of the carrier wave.

In the system used to disclose the invention a plurality of signal stations are connected to a high tension power line. The stations are coupled to the power line by suitable coupling filters and preferably in the
65 manner disclosed in the patent to W. V. Wolfe, No. 1,678,133, dated July 24, 1928.

In the disclosed system a plurality of carrier current signal stations are connected to a high tension power line. Each signal station
70 comprises a transmitting channel, a receiving channel and duplex control circuits for preventing simultaneous operation of the two channels. The duplex control circuits are in many respects similar to the duplex
75 control circuits disclosed in the patent to Charles N. Nebel, No. 1,733,553. The transmitting and receiving channels are connected to an operator's telephone set or to an extension circuit by means of a suitable hybrid
80 coil.

The transmitting channel comprises a three-element modulating tube having the input circuit thereof supplied with voice
85 frequency currents from the operator's telephone set or from the extension circuit and with carrier waves from a suitable oscillator. The oscillator circuit is connected to the input circuit of the modulator tube by a transformer having a potentiometer connected
90

across the primary winding thereof to control the percentage of modulation and prevent overloading amplifiers in the system. The output circuit of the modulator is connected to two thermionic amplifier tubes which are connected in push-pull relationship. The two amplifier tubes are connected through a power amplifier to the power line. The power amplifier is similar in construction and operation to the power amplifier disclosed in the above mentioned patent to Charles N. Nebel.

The receiving channel comprises a band pass filter which selects the carrier wave and the two side bands used in this system and excludes signal waves which may be used by other signal systems connected to the power line. The receiving band pass filter is connected to a detector tube. The output circuit of the detector tube supplies voice frequency currents to amplifier tubes in push-pull relationship and filters to the operator's telephone set. The detector output circuit also supplies carrier waves to a circuit for operating a selector. The grids of the detector tube and the two amplifier tubes in push-pull relationship adjacent thereto are controlled by duplex control circuits for blocking the receiving channel when the transmitting channel is in service. The duplex control circuits also govern the negative potential impressed on the grids of the modulator tube and the two amplifier tubes adjacent the modulator tube in the transmitting channel to block the transmitting channel when the station is idle and when the receiving channel is in service.

The selective calling of a distant station is effected by transmitting a code signal of the carrier wave over the power line to the distant station. The operation of the selector key at the sending station operates the duplex control circuit so as to block the receiving channel and prevent blocking of the transmitting channel and transmits a code signal of carrier waves from the oscillator to the distant station being called.

The code signal of carrier waves received at the distant called station operates a suitable selector for indicating to the operator that the station is being called. Means are provided whereby the selector will only be operated when carrier current free from modulating currents is received. In the disclosed system a differential relay is provided for insuring against operation of the selector during communication or talking between two stations. The differential relay has one winding energized by the detected voice frequency currents from the receiving channel and a second winding energized by rectified carrier waves from the receiving channel. If carrier waves alone are received the relay will be operated to effect operation of the selector. However, if carrier waves

and modulated waves are received operation of the differential relay is prevented. The calling circuits shown in this application are disclosed and claimed in the application of H. B. Arnold, Serial No. 384,928, filed August 10, 1929.

In the accompanying drawings Figures 1, 2 and 3 disclose a power line carrier current signal station constructed in accordance with the invention.

Referring to the drawings, a signal station comprising a transmitting channel 1 and a receiving channel 2 is connected by coupling means 3 to a power line comprising conductors 4 and 5. The coupling means between the signal station and the power lines may be of any suitable character and as before set forth is preferably of the type disclosed in the patent to W. V. Wolfe, No. 1,678,133, dated July 24, 1928. A hybrid coil 6 provided with balancing impedance 7 connects the transmitting channel 1 and the receiving channel 2 to an operator's telephone set 8 comprising a receiver 9 and a transmitter 10.

The transmitting channel 1 comprises a three-element thermionic modulator tube 11, which is connected to two thermionic amplifier tubes 12 and 13 by means of a transformer 14. The amplifier tubes 12 and 13 are connected together in push-pull relationship and have their output circuits connected to a power amplifier 15 by means of a transformer 16. A transformer 17 connects the input circuit of the modulator tube 11 to the hybrid coil 6. An oscillation generator 18, which is preferably of the thermionic type, is connected to the input circuit of the modulator tube 11 by means of transformer 19. A potentiometer 20 is connected across the primary winding of the transformer 19 for adjusting the percentage of modulation to such value that efficient transmission of the carrier wave and the two side bands can be obtained.

The power amplifier 15 included in the transmitting channel 1 comprises a thermionic amplifier tube 21 and two thermionic amplifier tubes 22 and 23 in push-pull relationship with respect to each other. The output circuit of the amplifier tube 21 is connected to the input circuits of tubes 22 and 23 by means of transformer 24 and the output circuits of the tubes 22 and 23 are connected to the coupling means 3 by means of a transformer 25.

Rectifying means 26 is provided for supplying grid biasing potential to the tubes 21, 22 and 23 of the power amplifier and rectifying means 27 is provided for supplying plate potential to the thermionic tubes 21, 22 and 23 of the power amplifier.

The rectifying means 26, which supplies grid biasing potential to the tubes of the power amplifier, comprises a thermionic tube 28 which is connected by a transformer 29

to a source of alternating current 30. The transformer 29 comprises a secondary winding 31 which is included in the filament circuit of the tube 28, a secondary winding 32 which is included in the plate circuit, and a primary winding 33 which is connected through an armature 34 of a relay 35 and a double pole switch 36a to the source of alternating current 30.

The relay 35 is controlled from the operator's telephone set 8 in a manner to be hereinafter disclosed for operating the armature 34 and a second armature 36 to control the rectifying means 26 and 27. The relay 35 controls the grid biasing potential and the plate potential supplied to the tubes of the power amplifier 15. The circuit of the rectifier tube 28 may be traced from the tube through the secondary winding 32 of transformer 29, retard coil 39 and potentiometer sections 40, 41 and 42 to the plate of the tube 28. Condensers 43 and 44 are provided for smoothing out ripples in the rectified current.

The grid biasing circuit for the power amplifier tube 21 extends from the grid of the tube 21 through the secondary winding of transformer 16, conductor 45, section 40 of the potentiometer and the secondary windings of a transformer 46 to the filament of the tube 21. The grid biasing circuit for the two amplifier tubes 22 and 23 in push-pull relationship extends from the grids of the two tubes 22 and 23 through the secondary windings of the transformer 24, conductor 47, sections 40 and 41 of the potentiometer and the secondary windings of the transformer 46 to the filaments of the tubes 22 and 23.

The filaments of the power amplifier tubes 21, 22 and 23 are heated by alternating current from the source 30 supplied to the transformer 46. When the signal station is idle and relay 35 is released, the primary winding of transformer 46 is connected to the source of alternating current 30 through a resistance element 48. The resistance element 48 serves to limit the current supplied to the filaments of the tubes 21, 22 and 23 in the power amplifier when the signal station is not in use. Upon operation of relay 35 the armature 36 short-circuits the resistance element 48 to insure heating the filaments of the power amplifier tubes to normal value.

The means 27 for supplying plate potential to the tubes 21, 22 and 23 of the power amplifier comprises two two-element thermionic rectifier tubes 50 and 51 which are connected to the source of alternating current 30 by means of a transformer 52. The transformer 52 is connected to the source 30 through the armature 34 of the relay 35 to insure against supplying plate potential to the tubes of the power amplifier except when the station is

in use. A transformer 53 is provided for supplying heating current from the source 30 to the filaments of the tubes 50 and 51. Transformer 53 is connected to the source 30 through the armature 34 of the relay 35 in order to insure against heating the filaments of the rectifier tubes when the station is not in service.

The plate circuit for the thermionic tube 21 may be traced from the plate of the tube 21 through the primary winding of the transformer 24, conductor 54, retard coil 55, secondary windings of the transformer 53, rectifier tubes 50 and 51 in parallel, secondary windings of the transformer 52 and secondary windings of the transformer 46 to the filament of the tube 21. The circuit for supplying plate potential to the tubes 22 and 23 may be traced in a like manner.

A battery 56 is provided for supplying grid biasing potential and filament current to the tubes 11, 12 and 13 in the transmitting channel 1. This battery also supplies grid biasing potential and filament current to many other thermionic tubes in the system. A suitable charger or rectifier 57, which is connected to a source of alternating current 58, is controlled by a relay 59 for charging the battery 56. The relay 59 which is provided with two armatures 60 and 61 is operated in parallel with the relay 35 in a manner to be more clearly set forth hereinafter. When the relay 59 is released and the signal station is idle the battery 56 is charged by a circuit including the armature 60. Grid biasing potential and filament current is supplied to a conductor 63 at this time through a resistance element 62 and resistance element 64.

Upon operation of the relay 59, the armature 60 disconnects the charging means connected to the battery 56 and excludes the resistance element 62 from the battery circuit. The filament heating circuit for the thermionic tubes 11, 12 and 13 may be traced from the negative terminal of the battery 56 through armature 60, resistance element 64, conductor 63, conductor 49, resistance element 65, filaments of the tubes 12 and 13 in parallel, filament of the thermionic tube 11 and ground return to the positive terminal of the battery 56. A grid biasing circuit for the thermionic tubes 11, 12, and 13 in the transmitting channel will be described when reference is made to the circuits for effecting duplexing operation.

Plate potential for the tubes 11, 12 and 13 in the transmitting channel and for many other tubes in the signal station is provided by the rectifying means comprising thermionic tubes 66, 67, 68 and 69 connected in parallel relationship. Transformers 70 and 71 are provided for connecting the rectifying tubes 66 to 69, inclusive, to the source of alternating current 30. The secondary windings of the transformer 71 supply heating

current to the filaments of the tubes 66 to 69, inclusive, and the secondary windings of the transformer 70 supply plate potential to the rectifying tubes 66 to 69, inclusive. Voltage compensating means 72 of the type shown and described in the above mentioned patent to C. N. Nebel, No. 1,733,553 is provided in circuit with the rectifying tubes 66 to 69, inclusive.

The plate circuit for the modulator tube 11 in the transmitting channel may be traced from the filaments of the rectifier tubes 66 to 69, inclusive, through the secondary windings of the transformers 70 and 71, voltage compensating device 72, retard coil 73, conductor 74, retard coil 75, primary winding of transformer 14, plate and filament of the modulator tube 11 and ground return to the rectifier tubes 66 to 69, inclusive. In a like manner the plate circuit for the amplifier tubes 12 and 13 may be traced.

The receiving channel 2 comprises a band pass filter 76 which is connected to the coupling means 3 through a potentiometer 77. The band pass filter 76 selects the carrier wave and the side bands which are characteristic to the system under consideration. It is to be understood that other carrier current systems employing different carrier waves may be connected to the same power lines 4 and 5. The band pass filter 76 is connected through a transformer 78 to a three-element thermionic detector tube 79. The output circuit of the detector tube 79 is connected by a transformer 80 to two amplifier tubes 81 and 82 which are connected in push-pull relationship. The amplifier tubes 81 and 82 are connected by a transformer 83, a low pass filter 84 and a transformer 85 to a voice frequency amplifier tube 86. The voice frequency amplifier tube 86 is connected by the hybrid coil 6 to the operator's set 8. The transformer 85 is also connected to an amplifier tube 87 which in turn is connected by a transformer 88 to a thermionic rectifier tube 89. The thermionic rectifier tube 89 governs the duplex control circuits 180 when the receiving channel is in use for insuring the blocking of the modulator 11 and amplifier tubes 12 and 13 in the transmitting channel.

The output circuit of the detector tube 79 is not only connected to the amplifier tubes 81 and 82 by the transformer 80 but is connected by a transformer 90 to a thermionic amplifier tube 91. The thermionic amplifier tube 91 is connected by transformer 92 to a rectifier tube 93. The transformer 90 in the output circuit of detector 79 supplies high frequency carrier current which may pass through the detector tube to the amplifier tube 91 and rectifier tube 93. The carrier current amplified by the tube 91 and rectified by the tube 93 is used to control the operation of a differential relay 94.

Plate current for the thermionic tubes in the receiving channel is supplied by the rectifying tubes 66 to 69 inclusive. Filament current and grid biasing potential for the tubes in the receiving channel is supplied by battery 56. The grid biasing circuits for the tubes in the receiving channel utilized in blocking said channel when the transmitting channel is in use will be described when reference is made to the duplex control circuits.

The circuit from the rectifier to the plate of the detector tube 79 may be traced from the filaments of the rectifier tubes 66 to 69, inclusive, through secondary windings of the transformer 70, voltage compensator 72, impedance coil 73, conductor 74, conductor 95, retard coil 96, primary winding of transformer 80, primary winding of transformer 90, plate and filament of the detector tube 79 and a ground return conductor 97 to the rectifying tubes 66 to 69 inclusive. In a like manner potential for the plates of the tubes 81 and 82 and 91 is supplied from the conductor 95 connected to the rectifying tubes 66 to 69, inclusive. Plate potential for the thermionic tubes 86 and 87 is supplied from a conductor 97a connected to the rectifying tubes 66 to 69, inclusive, through the armature 61 of relay 59. The plate circuit for the rectifying tube 93 will be traced when reference is made to the selective calling circuits for the signal station.

The filament circuit for the tubes 81, 82, 93 and 79 may be traced from the conductor 63, which is connected to the negative terminal of the battery 56, through a resistance element 99, filaments of tubes 81 and 82 in parallel, resistance element 100, the filaments of the tubes 93 and 79 in parallel and a ground conductor 97 to the positive terminal of the battery 56. The filament circuit for the tube 91 extends from the conductor 63 through resistance elements 101 and 102. The filament circuit of the tubes 86, 87, 89 and a tube 103 in the duplex control circuits extends from the conductor 63 through resistance element 104, and filaments of the tubes 87, 86, 89 and 103 to a ground conductor 105 which is connected to the positive terminal of the battery 56.

The duplex control circuits which govern the blocking of tubes in the transmitting channel when the receiving channel is in service and the blocking of tubes in the receiving channel when the transmitting channel is in service comprise two tubes 103 and 106 connected in push-pull relationship and a transformer 107, which connects the input circuits of the tubes 103 and 106 through potentiometer 108 to the input conductors of the transmitting channel 1. A transformer 109 is provided for connecting the output circuits of the amplifier tubes 106 and 103 to a thermionic amplifier tube 110. The output circuit of the amplifier tube 110 is connected by

a transformer 111 to a rectifier tube 112. The circuit of the rectifier tube 112 includes a resistance element 113 which governs the negative biasing potential impressed on the detector tube 79 and the two amplifier tubes 81 and 82. A three-element thermionic tube 114 is provided having a resistance element 115 in the output circuit thereof for governing the negative biasing potential impressed on the grid of the modulator tube 11 and the amplifier tubes 12 and 13 in the transmitting channel. The potential impressed on the grid of the tube 114 is controlled by the potential across the resistance element 113.

Plate potential for the tube 114 is obtained from a potentiometer 117 in the output circuit of a rectifier tube 118. The output circuit for the tube 114 may be traced from the filament of the tube through the resistance element 115, conductor 119, a portion of the potentiometer 117 and conductor 120 to the plate of the tube 114.

The rectifier tube 118 which supplies plate potential to the tube 114 also supplies current for operating a selector 121. A transformer 122 is provided for connecting the rectifier tube to the source of alternating current 30. One secondary winding of the transformer 122 supplies filament current to the rectifier tube and another secondary winding is connected in the plate circuit of the rectifier tube. A third secondary winding of the transformer 122 is connected to a conductor 123 for supplying a 60 cycle signal tone to the duplex control circuits during transmission of a calling signal. Suitable filtering means is provided between the rectifier tube 118 and the potentiometer 117.

A resistance element 125 in the output circuit of the rectifier tube 89 controls the negative grid bias on the tubes 103 and 106 in the duplex control circuits. The rectifier tube 89 impresses potential across the resistance element 125 when the receiving channel is in service. The potential produced across the resistance element 125 impresses a strong negative potential on the grids of the two tubes 103 and 106. Accordingly, when the tubes 103 and 106 are blocked no power is amplified by the tube 110 for supplying current to the rectifier tube 112. Consequently substantially no potential is impressed across the resistance element 113 and substantially no negative biasing potential is impressed on the grid of the tube 114. When no negative biasing potential is impressed on the grid of the tube 114, a relatively strong flow of current through the tube 114 and the resistance element 115 is produced. It may be noted that when the station is idle no potential is impressed across resistance element 113 and a flow of current is effected through tube 114 and resistance 115. Negative potential on the grids of the modulator tube 11 and the amplifier tubes 12 and 13 in the transmitting

channel varies according to the potential impressed across the resistance element 115. Accordingly the transmitting channel is blocked not only when the receiving channel is in use, but also when the station is idle.

The grid biasing circuit for the modulator tube 11 may be traced from the grid of the modulator tube 11 through the primary winding of the transformer 19, secondary winding of the transformer 17, conductor 119, resistance element 115, and filaments of the tubes 13 and 12 and ground to the filament of the modulator tube 11. In like manner, the grid circuit for the amplifier tubes 12 and 13 may be traced.

The negative grid potential for the detector tube 79 and the amplifier tubes 81 and 82 in the receiving channel 2 is obtained from the resistance element 113 in circuit with the rectifier tube 112 of the duplex control circuits 180. The grid circuit for tubes 81 and 82 may be traced from one terminal of the resistance element 113 through a resistance element 124, and secondary windings of transformer 80 to the grids of the tubes 81 and 82. The filaments of the tubes 81 and 82 are connected to the other terminal of resistance element 113 by conductor 63. The grid circuit for the detector tube 79 extends from one terminal of the resistance element 113 through a resistance element 126, secondary winding of the transformer 78 to the grid of the detector tube 79, filament of the detector tube 79, resistance element 100, filament of the tube 81, resistance element 99, and the conductor 63 to the other terminal of the resistance element 113.

A relay 127 is provided for impressing a 60 cycle signal tone on the duplex control circuits 180 from the transformer 122 when selective calling of the distant station is being effected. The signal tone is impressed upon the duplex control circuits at this time in order to insure blocking of the receiving channel. A signal pulsing relay 128 provided with armatures 129 and 130 is under the control of a selector key 131 when selectively calling a distant station. The armature 129 controls a slow releasing relay 132 and the armature 130 controls a shunt circuit across the transmitting channel to govern the impulses of unmodulated carrier current transmitted to the power line. The slow releasing relay 132 is provided with an armature 133 for completing a circuit through the energizing coil of the relay 127. The relay 132 being slow releasing serves to maintain the relay 127 operated and a signal tone on the duplex control circuits whenever the relay 128 is being intermittently operated by the selector key 131.

A relay 134 is controlled by the receiver switchhook and is provided with an armature 135 for completing a circuit to energize the relays 35 and 59. The relay 134 is pro-

vided with a second armature 136 for preventing operation of the differential relay 94 except by the selector key when the receiver 9 is removed from the switchhook. The circuit for energizing the relays 35 and 59 may be traced from the battery supply conductor 63 through a battery supply conductor 137, armature 135, conductor 139, and coils of the relays 59 and 35 in parallel to the positive terminal of the battery 56.

The differential relay 94 which operates the selector 121 comprises three windings 140, 141 and 142. The winding 140 is energized in accordance with the operation of the rectifier tube 93 in the receiving circuit. The rectifier tube 93 energizes the winding 140 whenever carrier current either modulated or unmodulated is received over the power line. The winding 141 of the differential relay is controlled by a thermionic tube 143. The input circuit for the tube 143 is connected by a transformer 144 across the terminals of the low pass filter 84. The winding 141 is energized by voice frequency currents passing through the filter 84 and is only energized when carrier current modulated with voice frequency current is transmitted over the power line. The third winding 142 of the differential relay is operated by the selector key 131 and the selector key (not shown) at the extension station. The armature 145 of the differential relay operates between contact members 146 and 147. The contact members 146 and 147 are connected to opposite terminals of the potentiometer 117 and the armature 145 is connected through the operating coil of the selector to a mid-point of the potentiometer 117. The windings 140 and 141 oppose each other so that when both windings are energized no operation of the selector can be effected. If unmodulated carrier current impulses are received the winding 140 is energized for effecting operation of the selector. If modulated carrier current impulses are received, it is apparent both windings 140 and 141 are energized to prevent operation of the selector. Preferably the differential relay 94 is polarized.

Communication with a distant station

In order to communicate with a distant station the receiver is removed from the switchhook and a circuit completed from the battery conductor 137 for operating the relay 134. The relay 134 effects operation of the relays 35 and 59. The relay 35 effects operation of the power supply means for the power amplifier tubes 21, 22 and 23 in the transmitting channel. The relay 59 disconnects the charger from the battery 56 and supplies plate potential to the thermionic tubes 110, 103 and 106 in the duplex control circuits and to the thermionic tubes 86 and 87 in the receiver channel. When the transmitting channel is in service, voice frequency currents

from the transmitter 10 are transmitted through the hybrid coil 6 and the transformer 17 to the input circuit of the modulator tube 11 to be modulated with carrier current from the oscillator 18. The modulated currents are amplified by the tubes 12 and 13 and the power amplifier 15 before being transmitted over the power line.

At this time the duplex control circuits which are connected to the transmitting channel by the transformer 107 apply a relatively large potential across the resistance element 113 in the circuit of the rectifier 112. The potential across the resistance element 113 impresses a relatively large negative bias on the grid of the tube 114 to prevent impressing potential across the resistance element 115. Accordingly no negative blocking potential at this time can be impressed on the grids of the modulator tube 11 and the amplifier tubes 12 and 13. The resistance element also impresses a blocking negative potential on the grids of the detector tube 79 and the amplifier tubes 81 and 82 in the receiving channel 2.

When the receiving channel is in service, detector tube 79 is operated for demodulating the carrier current received over the power line. The voice frequency currents in the output circuit of the detector 79 are amplified by the tubes 81 and 82 and passed through the filter 84. The voice frequency currents then pass through the amplifier 86 and the hybrid coil 6 to the operator's telephone receiver 9. The circuits for operating the telephone set receive power from the battery conductor 137 and such circuits are completed through the ground conductor 160. The voice frequency currents in the receiving channel operate the amplifier tube 87 and the rectifier tube 89 for impressing a potential across the resistance element 125. The potential across the resistance element 125 impresses a strong negative bias on the grids of the tubes 103 and 106 in the duplex control circuits. Consequently no potential can be impressed across the resistance element 113 and no negative bias can be impressed on the grid of the tube 114. The potential impressed across the resistance element 115 from the potentiometer 117 impresses a strong negative bias on the modulator tube 11 and amplifier tubes 12 and 13 to block the transmitting channel.

Selectively calling a distant station

When selectively calling a distant station the key 131 is operated to pulse the relay 128. The circuit for operating the relay 128 extends from battery conductor 137 through the coil of the relay and the key 131 to the ground conductor 160. The pulsing of the relay 128 holds the slow releasing relay 132 in operated position. The circuit for energizing the relay 132 extends from supply con-

ductor 95 through the coil of the relay, and armature 129 to the ground conductor 160. The relay 127, which is operated by the relay 132, maintains a 60 cycle signal tone on the duplex control circuits when a calling signal is being transmitted. The signal tone impressed on the duplex control circuits 180 insures the locking of the receiving channel and the removal of the blocking from the transmitting channel. The relay 128 operates an armature 130 in accordance with the signal code for intermittently establishing a shunt circuit across the input circuit of the power amplifier and thus controls the carrier current impulses transmitted over the power line.

Call received from a distant station

If a selective calling signal is received from a distant station, the coil 140 on the differential relay 94 is operated by the amplifier tube 91 and the rectifier tube 93 in accordance with the impulses of unmodulated carrier current in the output circuit of the detector tube 79. Inasmuch as no modulated impulses of carrier current are being received at this time the winding 141 of the differential relay is deenergized and operation of the selector 121 is effected by the differential relay in accordance with the code of received signals.

It is to be understood that if so desired, an extension station of the type disclosed in the patent to H. B. Arnold, No. 1,717,083 dated June 11, 1929, may be connected to the selector 121, the relays 128 and 134 and the hybrid coil 6. The conductors for connection to the extension circuit have been indicated in Figs. 1 and 2 of the drawings.

Modifications of the system and in the arrangement and location of parts may be made within the spirit and scope of the invention, and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a power line carrier current communication system, employing the same carrier wave for transmission in both directions and transmitting the carrier wave and both side bands during communication between stations, a power line, a signal station having a transmitting and a receiving channel connected to the power line, a thermionic modulator tube and two thermionic amplifier tubes in push-pull relationship in said transmitting circuit, a detector tube and two thermionic amplifier tubes in push-pull relationship in said receiving channel, means at said station including said tubes in the transmitting and receiving channels to send and receive over the power lines the side bands and the unmodulated carrier component for communication purposes, means for applying negative blocking potential to the grids of the modulator tube and the two amplifier tubes in the transmitting circuit when the station is idle and when the receiving

channel is in use, and means for applying negative blocking potential to the grids of the detector tube and two amplifier tubes in the receiving channel when the transmitting channel is in use.

2. In a power line carrier current communication system employing the same carrier wave for transmission in both directions and transmitting the carrier wave and both side bands during communication between stations, a power line, a signal station having a transmitting channel and a receiving channel connected to the power line, an operator's telephone set, a hybrid coil for connecting said telephone set to the transmitting and receiving channels, a three-element thermionic modulator tube and two three-element amplifier tubes in push-pull relation in said transmitting channel, an oscillator connected to the input circuit of said modulator tube, a three-element thermionic detector tube and two three-element thermionic amplifier tubes in push-pull relation in said receiving channel, means at said station including said tubes in the transmitting and receiving channels to send and receive over the power lines the side bands and the unmodulated carrier component for communication purposes, means for impressing a negative blocking potential on the grids of said modulator and amplifier tubes in the transmitting channel when the receiving channel is in use and for impressing a negative blocking potential on the grids of said tubes in the receiving channel when the transmitting channel is in use and means to transmit a code signal of unmodulated carrier current over the power line for calling purposes.

3. In a power line carrier current communication system, a power line, a signal station having a transmitting channel and a receiving channel connected to the power line, a three-element thermionic modulator tube and two three-element thermionic amplifier tubes in push-pull relation in said transmitting circuit, a three-element thermionic detector tube and two three-element thermionic amplifier tubes in push-pull relation in said receiving channel, an operator's telephone set, a hybrid coil for connecting said telephone set to said transmitting channel and said receiving channel, means for impressing a negative blocking potential on the grids of said tubes in the transmitting channel when the receiving channel is in use and for impressing a negative blocking potential on the grids of said tubes in the receiving channel when the transmitting channel is in use to call and to communicate with a distant station, and means to transmit a code signal of unmodulated carrier current over the power line for calling purposes.

4. In a carrier current communication system, a transmission line, a signal station connected to said line, a transmitting channel at

said station comprising a three-element modulator tube, a high frequency oscillator and two three-element amplifier tubes in push-pull relationship, a receiving channel at said station comprising a three-element detector tube and two three-element amplifier tubes in push-pull relationship, means for impressing a negative blocking potential on the grids of the modulator and amplifier tubes in said transmitting channel when the station is idle or the receiving channel is in service and for impressing a negative blocking potential on the grids of the tubes in said receiving channel when the transmitting channel is in service, and means to transmit a code signal of unmodulated carrier current for calling purposes.

In witness whereof, I hereunto subscribe my name this 6th day of August, 1929.

JAMES D. SARROS.