

May 23, 1933.

C. N. NEBEL

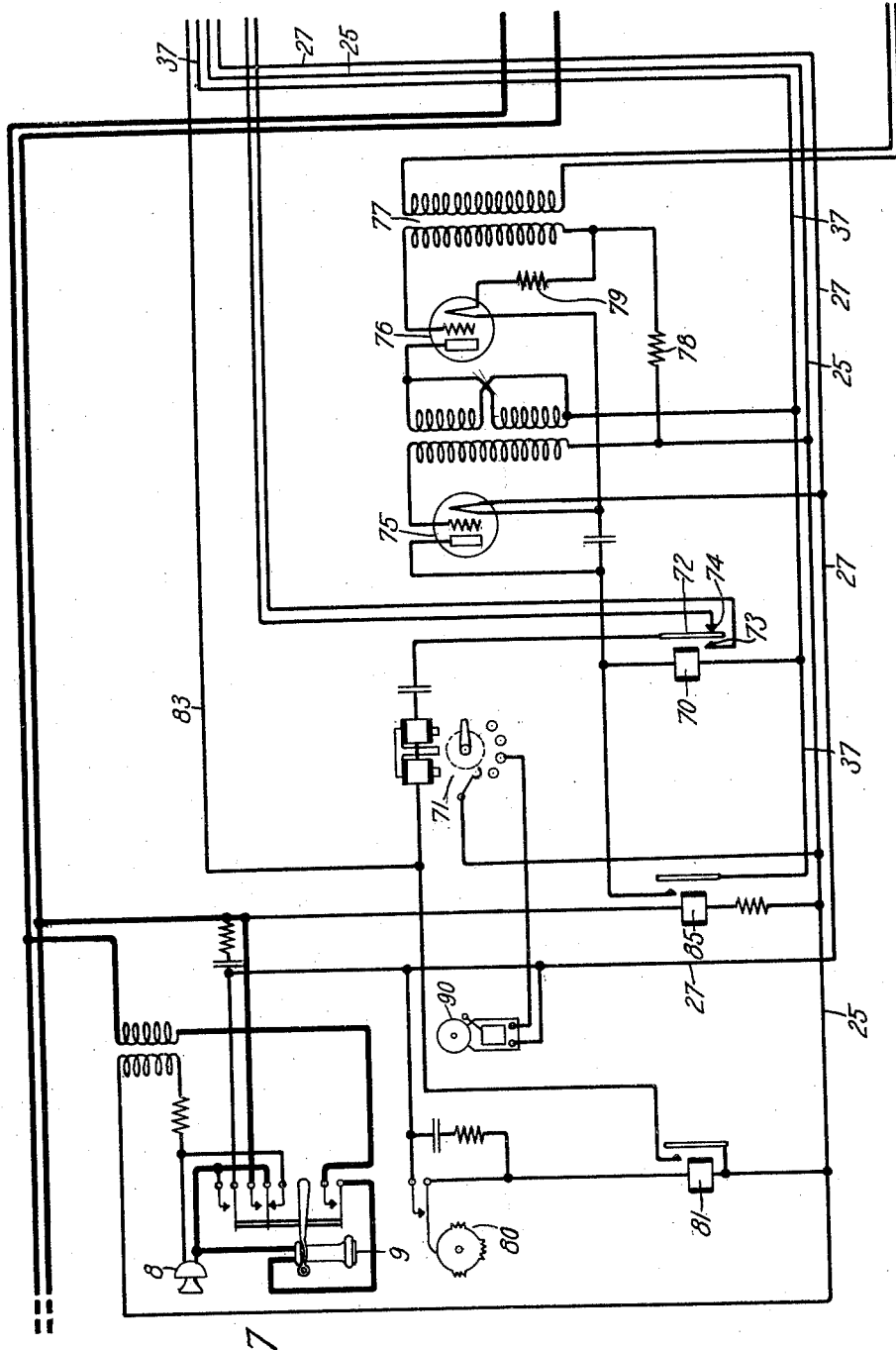
1,910,960

POWER LINE CARRIER CURRENT SYSTEM

Filed Aug. 10, 1929

3 Sheets-Sheet 1

FIG. 1



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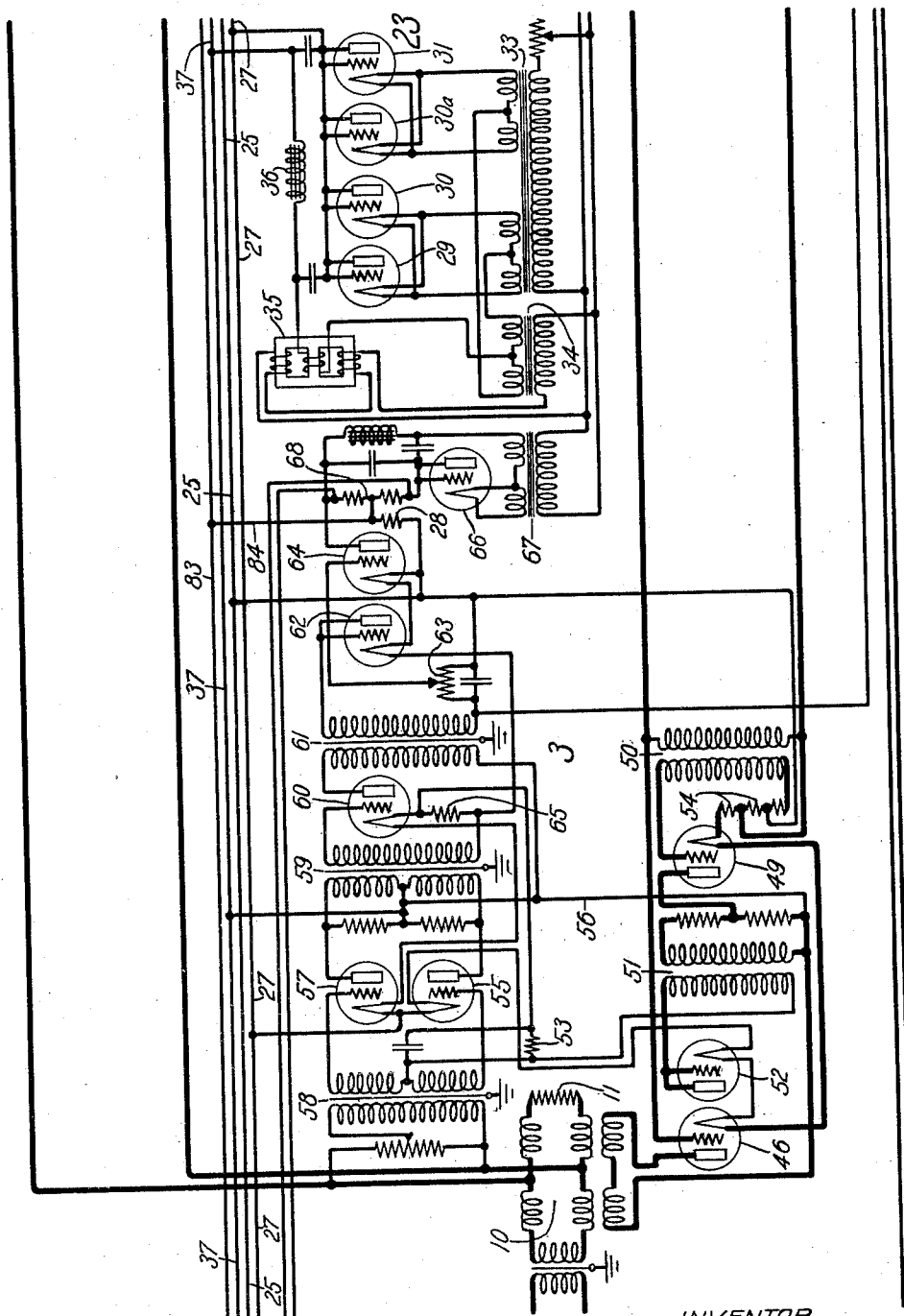
1,910,960

POWER LINE CARRIER CURRENT SYSTEM

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3 Sheets-Sheet 2

FIG. 2



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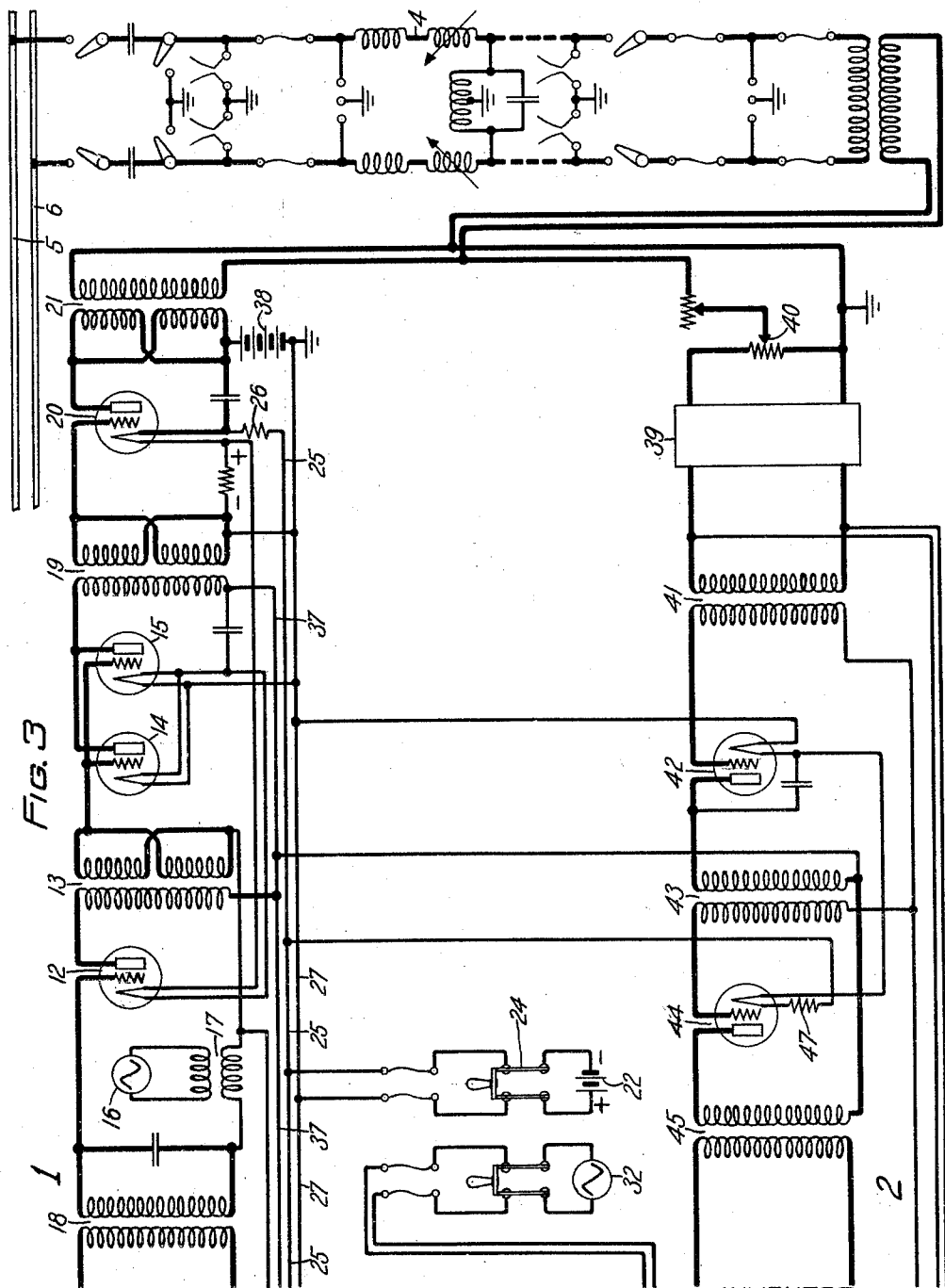
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POWER LINE CARRIER CURRENT SYSTEM

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3 Sheets-Sheet 3



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POWER LINE CARRIER CURRENT SYSTEM

Application filed August 10, 1929. Serial No. 384,877.

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

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

Another object of the invention is to provide a power-line carrier-current system having a plurality of signal stations connected thereto, that shall effect selective calling between stations by transmitting code signals of the carrier wave and that shall effect communication between stations by transmitting the carrier wave and side bands.

A further object of the invention is to provide a power-line carrier-current communication system of the above indicated type that shall maintain the transmitting channel of each idle signal station blocked and that shall effect selective calling between stations by controlling the blocking means to transmit code signals of the carrier wave.

When communicating by carrier-current waves over high tension power-lines it is desirable to limit the number of carrier waves used on account of the transmission characteristic of the power-line and to provide a more efficient communication system. The transmission characteristic of the power-line is controlled by many different features such as the length of the power-line, the number and location of branch lines, the power apparatus connected to the power-line and the amount of the so-called Corona.

In the present invention a single carrier wave is employed for transmission in both directions and the carrier wave and the side bands are transmitted during communication between stations. Selective calling between stations is effected by transmitting

code signals of the carrier wave unmodulated with any voice frequency current.

A signal station constructed in accordance with the invention comprises a transmitting channel and a receiving channel which are connected to a power-line by coupling means preferably of the type disclosed in the C. N. Nebel Patent No. 1,733,553, dated October 29, 1929. An operator's telephone set is connected to the transmitting and receiving channels by a hybrid coil having the usual balancing network connected thereto.

The transmitting channel is provided with a three-element thermionic modulator tube, two three-element thermionic amplifier tubes connected in parallel relationship, and a third thermionic power amplifier tube which is joined to the coupling means between the station and the power lines. A thermionic oscillator is connected to the input circuit of the modulator in order to supply a carrier current for modulation with the voice frequency currents received from the operator's telephone set.

The receiving channel is provided with a filter for selecting the carrier wave and side bands characteristic to the system, and an amplifier and a detector tube of the thermionic type. The detector tube supplies voice frequency currents to the operator's telephone set through the hybrid coil.

Suitable duplex control circuits, preferably of the type disclosed in the patent to C. N. Nebel, No. 1,733,553, are provided for supplying negative blocking potential to the grids of certain of the tubes in the transmitting channel when the station is idle and when the receiving circuit is in use. The duplex control circuits further impress a negative blocking potential on the grids of the tubes in the receiving channel when the transmitting channel is in use. A selector key is provided for transmitting a code signal of carrier impulses to selectively call a distant station. The selector key controls means for removing the negative blocking potential from the grids of the tubes in the transmitting channel in accordance with the code signal being transmitted. The nega-

tive blocking potential impressed upon the grids of the tubes in the transmitting channel is so controlled as to impress a code signal of carrier current on the line circuit. The calling impulses of unmodulated carrier current received at a called station operate a relay for controlling the operation of a selector. Suitable extension circuits, as for example the extension circuits shown in the patent to H. B. Arnold, No. 1,717,083, dated June 11, 1929, may be provided if so desired.

Figures 1, 2 and 3 in the accompanying drawings are diagrammatic views of a power line carrier current telephone system constructed in accordance with the invention.

Referring to the drawings, a power line signal station comprising a transmitting channel 1, a receiving channel 2 and duplex control circuits 3 is connected by coupling means 4 to a power line comprising conductors 5 and 6. An operator's telephone set 7 comprising a transmitter 8 and a receiver 9 is connected to the transmitting channel 1 and the receiving channel 2 by means of a hybrid coil 10 having the usual balancing impedance 11. The coupling means 4 between the power line conductors 5 and 6 and the transmitting and receiving channels is preferably of the type disclosed in the above mentioned patent to C. N. Nebel, No. 1,733,553.

The transmitting channel 1 comprises a three-element thermionic modulator tube 12 which is connected by a transformer 13 to two parallelly connected thermionic amplifier tubes 14 and 15. An oscillation generator 16 which is preferably of the thermionic type is connected to the input circuit of the modulator tube 12 by means of a transformer 17. A transformer 18 is provided for connecting the hybrid coil 10 to the input circuit of the modulator tube for supplying voice frequency currents to be modulated with the carrier wave supplied by the oscillation generator 16. The output circuits of the two amplifier tubes 14 and 15 are connected by a transformer 19 to a power amplifier tube 20. The power amplifier tube is connected by transformer 21 to the coupling means 4.

Filament heating current for the tubes 12, 14, 15 and 20 is supplied by a battery 22 and plate potential for tubes 12, 14 and 15 is supplied by a rectifier 23. The positive terminal of the battery 22 is grounded and the negative terminal of the rectifying means is grounded. The heating circuit for the filaments of the tubes 12, 14, 15 and 20 may be traced from the negative terminal of the battery 22 through a switch 24, battery conductor 25, resistance element 26, filament of the tube 20, filament of the tube 12, filaments of the tubes 14 and 15 in parallel, and ground return conductor

27 to the positive terminal of the battery 22. Grid biasing potential for the tubes 12, 14 and 15 is obtained from across a resistance element 28 in the duplex control circuits in a manner which will be hereinafter disclosed when reference is made to the duplex control circuits. The potential drop across the resistance element 28 is so controlled as to impress a negative potential on the grids of the tubes 12, 14 and 15 for blocking the transmitting channel when the signal station is not in use and when the receiving station is in use. Grid biasing potential for the tube 20 is obtained from the filament heating circuit.

The rectifying means 23, which supplies plate potential to the tubes 12, 14 and 15, comprises four rectifier tubes 29, 30, 30a and 31. The tubes 29, 30, 30a and 31 are supplied with alternating current from a source 32. The filaments of the rectifier tubes 29 to 31, inclusive, are heated by alternating current supplied by a transformer 33 which is connected to the source 32. A transformer 34 which is connected to the source 32 supplies power to the rectifier tubes 29 to 31, inclusive. A voltage compensating device 35 of the type shown and described in the patent to C. N. Nebel, No. 1,733,553 is connected to the rectifying means 23. The circuit for supplying plate potential to the tube 12 may be traced from the filaments of the rectifier tubes 29 to 31 inclusive, through the secondary windings of the transformers 33 and 34, voltage compensating device 35, retard coil 36, supply conductor 37, primary winding of the transformer 13, plate and filament of the modulator tube 12, filaments of the tubes 14 and 15 and ground return conductor 27 to the rectifier tubes 29 to 31 inclusive. The circuit for applying plate potential to the tubes 14 and 15 may be traced in like manner. Plate potential for the power amplifier tube 20 is obtained from a battery 38.

The receiving channel 2 comprises a band pass filter 39 which is connected through the coupling means 4, to power lines 5 and 6 by means of a potentiometer 40. A transformer 41 connects the filter 39 to the input circuit of a detector tube 42. The output circuit of the detector tube 42 is connected by a transformer 43 to an amplifier tube 44. The output circuit of the amplifier tube 44 is connected by a transformer 45 and an amplifier tube 46 to the hybrid coil 10. The circuit for heating the filaments of the detector tube 42 and the amplifier tube 44 may be traced from the negative terminal of the battery 22, through the battery supply conductor 25, resistance element 47, filament for the amplifier tube 44 and filament for the detector tube 42 to the ground return conductor 27. Plate potential for the tubes 42 and 44 is obtained from

the rectifying means 23 through the supply conductor 37. The plate circuit for the tube 44 may be traced from the supply conductor 37, through the primary winding of the transformer winding 45, plate and filament of the tube 44 and filament of the tube 42 to the ground return conductor 27. The plate circuit for the tube 42 may be traced in a like manner.

A thermionic amplifier tube 49 is connected to the output circuit of the amplifier tube 44 in the receiving channel by means of a transformer 50 and the transformer 45. The output circuit of the amplifier tube 49 is connected by transformer 51 to a rectifier tube 52. The rectifier tube 52 governs the potential across a resistance element 53 for controlling the grid biasing potential impressed on certain of the tubes in the duplex control circuits. The filament heating circuit for the amplifier tubes 46 and 49 and the rectifier tube 52 may be traced from battery supply conductor 25, through a resistance element 54, filament of the tube 49, filaments of the tubes 46 and 52 and filament of a tube 55 in the duplex control circuits to the ground return conductor 27. Plate potential for the amplifier tubes 46 and 49 is obtained from the supply conductor 37 through a conductor 56.

The duplex control circuits comprise an amplifier tube 57 and the amplifier tube 55 which are connected in push-pull relationship. The input circuits of the amplifier tubes 55 and 57 are connected by a transformer 58 to the primary winding of the transformer 18 in the transmitting channel. The output circuits of the amplifier tubes 55 and 57 are connected by a transformer 59 to an amplifier tube 60. The amplifier tube 60 is connected by a transformer 61 to a rectifier tube 62. A resistance element 63 in circuit with the rectifier tube 62 controls a thermionic tube 64 for governing the negative biasing potential impressed on the tubes 12, 14 and 15 in the transmitting channel. The resistance element 63 also controls the negative biasing potential impressed on the detector tube 42 and the amplifier tube 44. The heating circuit for the tubes 57, 60, 62 and 64 may be traced from the battery supply conductor 25, through the filaments of tubes 64 and 62, resistance element 65, filament of tube 60 and filament of tube 57 to the ground return conductor 27. Plate potential for the tubes 55, 57 and 60 is supplied from the supply conductor 37, through the conductor 56.

The grid biasing potential for the tubes 55 and 57 in the duplex control circuits is controlled by the potential drop across the resistance element 53. The potential drop across the resistance 53 as before set forth is controlled by the rectifier tube 52 and the amplifier tube 49 which are connected

to the receiving channel 2. If the receiving channel is in use a potential is placed across the resistance element 53 which impresses a blocking negative potential on the grids of the tubes 55 and 57. If the tubes 55 and 57 are blocked from the receiving channel 2 no potential is impressed across the resistance element 63 in the circuit of the rectifier 62. Consequently, no blocking potential can be impressed on the grids of tubes 42 and 44 in the receiving circuit. When no potential is impressed across the resistance element 63 the grid of the thermionic tube 64 has no blocking negative potential impressed upon it. Consequently, the tube 64 which is in circuit with the resistance element 28 permits a free flow of current therethrough.

A rectifier comprising a thermionic tube 66 and a transformer 67 which is connected to the source 32 provides plate potential for the thermionic tube 64. The transformer 67 which is connected to source 32 has one secondary winding for heating the filament of the rectifier tube and another secondary winding for supplying power to the rectifier. A potentiometer 68 is connected to the rectifier tube 66 by a suitable filtering means. The plate of the tube 64 is connected to one terminal of the potentiometer 68 and the filament of the tube 64 is connected through the resistance element 28 to a point intermediate to the terminals of the potentiometer 68. The resistance 28 controls the negative grid bias on the modulator tube 12 and the amplifier tubes 14 and 15. The resistance element 28 applies a negative blocking potential to the grids of the tubes 12, 14 and 15 when the tube 64 is inactive. Consequently the tubes 12, 14 and 15 are blocked when the station is idle and when the receiving channel is in use.

A relay 70 is provided for controlling a selector 71. The relay comprises an armature 72 operating between contact members 73 and 74. The armature of the relay is connected through the coil of the selector 71 to a point on the potentiometer 68 intermediate the ends thereof. The contact members 73 and 74 are connected to opposite terminals of the potentiometer 68. Thus vibratory movement of the armature 72 insures operation of the selector 71 from the potentiometer 68. The relay 70 is controlled by a rectifier tube 75 and an amplifier tube 76. The amplifier tube 76 is connected by transformer 77 to the output circuit of the band pass filter 39 in the receiving channel. The filament heating circuit for the rectifier tube 75 extends from the battery supply conductor 25, through resistance elements 78 and 79 and the filament of the tubes 76 and 75 to the ground return conductor 27. A grid biasing potential for the tubes 75 and 76 is obtained from the

filament circuit. The plate circuit for the rectifier tube 75 extends from the supply circuit 25 to the coil of the relay 70 and plate and filament of the tube 75 to the ground return conductor 27.

A selector key 80 is provided for operating a pulsing relay 81 to transmit impulses of unmodulated carrier current over the power line for selective signaling purposes. The circuit completed by the selector key through the relay 81 extends from the battery supply conductor 25 through the coil of the relay 81, selector key 80 and the ground return conductor 27 to battery 22. Relay 81 completes a circuit for shunting the resistance element 28 in the duplex control circuits. The resistance element 28 controls the blocking of the transmitting channel. The shunt circuit completed by the armature of the relay 81 may be traced from the armature of the relay, through conductors 83 and 84, resistance element 28 and the supply conductor 25 to the armature of the relay 81. The pulsing relay 81 also effects the operation of the selector 71 to indicate the signal that is being transmitted.

Communication with a distant station

When communicating with a distant station the receiver 9 is taken off the switchhook and relay 85 energizes from a circuit extending from the supply conductor 25 through the coil of the relay 85, and a switch operated by the telephone switchhook to the ground return conductor 27. Relay 85 connects a shunt circuit around the energizing coil of the relay 70 in order to insure against any operation of the selector 71 while communication between stations is taking place. The voice frequency current supply from the transmitter 8 through hybrid coil 10 to the modulator tube 12 is modulated with the carrier wave supplied by the oscillation generator 16. The modulated carrier current in the output circuit of the modulator 12 is amplified by the tubes 14, 15 and 20 and transmitted over the power line to the distant station. Voice frequency currents are also supplied to the duplex control circuits 3. At this time it is assumed the receiving channel is not in use and consequently, no potential is impressed across the resistance element 53. The amplifier tubes 55, 57 and 60 supply power to the rectifier tube 62. The resistance element 63 in the circuit of the rectifier tube 62 impresses a negative blocking potential on the grids of the detector tube 42 and the amplifier tube 44 in the receiving channel. The resistance element 63 also impresses a negative blocking potential on the grid of the tube 64. Consequently, no potential is impressed across the resistance element 28 and no blocking potential can be impressed on the grids of the modulator

tube 12 and the amplifier tubes 14 and 15 in the transmitting channels. During communication between stations the carrier wave and both sidebands are transmitted.

The carrier current and sidebands received from a distant station pass through the band pass filter 39. The detector tube 42 which is connected to the band pass filter 39 by the transformer 41 detects the voice frequency currents which are amplified by the tubes 44 and 46 and transmitted through the hybrid coil 10 to the operator's telephone set 7. When the receiving channel is in use the amplifier tube 49 and the rectifier tube 52 impress potential across the resistance element 53. The resistance element 53 as before set forth impresses negative blocking potential on the grids for the tubes 55 and 57. Consequently, no potential is impressed across the resistance element 63 to insure against applying any blocking potential to the grids of the detector tube 42 and the amplifier tube 44 in the receiving channel. The resistance element 28, however, at this time impresses negative blocking potential on the grids of the modulator tube 12 and the amplifier tubes 14 and 15.

Selective calling of a distant station

When calling a distant station, the selector key 80, which may be of the type disclosed in the patent to J. C. Field 1,354,814 dated October 5, 1920, is operated in accordance with the code signal of the distant station. Relay 81 is pulsed in accordance with the code signal being transmitted. Relay 81 intermittently shunts the resistance element 28 in the duplex control circuits 3 to intermittently remove the blocking negative potential normally applied to the grids of the modulator tube 12 and the amplifier tubes 14 and 15 in the transmitting channel. When the negative blocking potential is removed from the tubes 12, 14 and 15, an impulse of carrier current from the oscillator 16 is transmitted over the power line. The impulses of unmodulated carrier current which are received from over the power line are amplified and rectified by the tubes 76 and 75 for operating the relay 70. The relay 70 effects direct control of the selector 71. Selector 71 completes a circuit from the battery conductor 25 through a call bell 90 to the ground return conductor 27.

Modifications in 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 transmission system employing the same carrier wave for transmission in both directions, a

power line, a signal station connected to said power line, means at said station for selectively calling a distant station by transmitting a code signal of said carrier wave, means at said station for modulating speech currents with said carrier wave to communicate with a distant station, and means at said station during communication between stations for blocking the receiving channel when the transmitting channel is in use and for blocking the transmitting channel when the receiving channel is in use.

2. In a power-line carrier-current transmission system employing the same carrier wave for transmission in both directions and transmitting the carrier wave and side bands, a power line, a station having a transmitting channel and a receiving channel connected to said power line, means at said station to send and receive over the power line a side band and the unmodulated carrier component for communication purposes, and means for blocking the transmitting channel when the station is idle, for maintaining the transmitting channel in blocked condition while insuring against blocking the receiving channel when a signal is being received and for holding the receiving channel open when the station is idle.

3. In a power-line carrier-current transmission system employing the same carrier wave for transmission in both directions and transmitting the carrier wave and both side bands, a power line, a signal station having a transmitting channel and a receiving channel connected to said power line, means at said station to send and receive over the power line the side bands and the unmodulated carrier component for communication purposes, and means controlled from the receiving channel for blocking the transmitting channel when the receiving channel is in use and controlled from the transmitting channel for blocking the receiving channel when the transmitting channel is in use, said means holding the transmitting channel blocked and the receiving channel opened when the station is idle.

4. In a power-line carrier-current signal system, a power line having a plurality of signal stations connected thereto and using the same carrier wave for transmission in both directions, each of said stations having a receiving and a transmitting channel, means in each transmitting channel for modulating the carrier wave with voice frequency currents and transmitting the carrier wave with side bands, means in each receiving channel for detecting the voice currents modulated with the carrier wave and transmitted from a distant station, means for selectively calling a distant station by transmitting a code signal of said carrier wave, and means at each station when communicating with another station for block-

ing the receiving channel while the transmitting channel is in use and for blocking the transmitting channel while the receiving channel is in use, and when idle for blocking the transmitting channel while holding the receiving channel open.

5. In a carrier-current communication system employing the same carrier wave for transmission in opposite directions and transmitting the carrier wave during communication between stations, a transmission line, a signal station connected thereto and having a transmitting and a receiving channel, a three-element thermionic modulator tube in said transmitting channel, a three-element thermionic detector tube in said receiving channel, means at said station to send and receive over the line a side band and the unmodulated carrier component for communication purposes, means for selectively calling a distant station by transmitting a code signal of said carrier wave, and means for impressing a negative blocking potential on said modulator tube when the station is idle or the receiving channel is in use and for impressing a negative blocking potential on the grid of said detector tube when the transmitting channel is in service.

6. In a power-line carrier-current transmission system using the same carrier wave for transmission in both directions and transmitting the carrier wave and side bands, a power line, a signal station having a transmitting channel and a receiving channel connected to said power line, a three-element thermionic modulator tube in said transmitting channel, a three-element detector tube in said receiving channel, means at said station to send and receive over the power line the side bands and the unmodulated carrier component for communication purposes, and means for impressing a negative blocking potential on the grid of said modulator tube when the receiving channel is in use and for impressing a negative blocking potential on the grid of said detector tube when the transmitting channel is in use.

7. In a power-line carrier-current transmission system using the same carrier wave for transmission in both directions, a power line, a signal station having a transmitting channel and a receiving channel connected to said power line, a three-element thermionic modulator tube in said transmitting channel, a three-element thermionic detector tube in said receiving channel, means at said station to send and receive over the power line the side bands and the unmodulated carrier component for communication purposes, and means controlled from the transmitting channel for impressing a negative blocking potential on the grid of said detector tube when the transmitting channel is

in use and controlled from the receiving channel for impressing a negative blocking potential on the grid of said modulator tube when the receiving channel is in use.

5 8. In a carrier-current transmission system using the same carrier wave for transmission in both directions, a transmission line, a signal station having a transmitting channel and a receiving channel connected
10 to said transmission line, means in the transmission channel for modulating speech current with said carrier wave and for transmitting the carrier wave and the two side bands, means for selectively calling a distant station by transmitting a code signal
15 of said carrier wave, detecting means in the receiving channel, and means for blocking the receiving channel when the transmitting channel is in use, for blocking the transmitting channel when the receiving channel is in use, and for blocking the transmitting
20 channel while holding the receiving channel open when the station is idle.

9. In a power-line carrier-current communication system using the same carrier wave for transmission in both directions and transmitting the carrier wave and both side bands, a power line, a signal station
25 having a transmitting channel and a receiving channel connected to said power line, a three-element thermionic modulator tube and two three-element thermionic amplifiers in parallel relation in said transmitting channel, a three-element detector tube and a
30 three-element amplifier tube in said receiving channel, means at said station to send and receive over the power line the side bands and the unmodulated carrier component for communication purposes, and
35 means when the receiving channel is in use for impressing a negative blocking potential on the grids of said tubes in the transmitting channel and when the transmitting channel is in use for impressing a negative
40 blocking potential on the grids of said tubes in the receiving channel.

10. In a power-line carrier-current communication system employing the same carrier wave for transmission in opposite directions, a power line, a signal station having a transmitting and a receiving channel
45 connected to said power line, modulating means in said transmitting channel, a thermionic oscillator connected to said modulating means, detecting means in said receiving channel, means for blocking said transmitting channel when the station is idle and
50 when the receiving channel is in use and for blocking said receiving channel when the transmitting channel is in use, and means for removing the blocking of said transmitting channel according to a code signal to transmit impulses of unmodulated carrier
55 current and selectively call a distant station.

65 11. In a power-line carrier-current com-

munication system employing the same carrier wave for transmission in opposite directions and transmitting the carrier wave and both side bands during communication between stations, a power line, a signal station
70 having a transmitting and a receiving channel connected to said power line, a three-element thermionic modulator tube and two three-element thermionic amplifier tubes in said transmitting channel, a thermionic oscillator connected to the input circuit of
75 said modulator, a three-element thermionic detector tube and a three-element thermionic amplifier tube in said receiving channel, means at said station when communicating with another station over said power line for blocking said tubes in the receiving
80 channel while the transmitting channel is in use and for blocking said modulator and amplifier tubes in the transmitting channel while the receiving channel is in use and during an idle period of the station, and means for removing the blocking of the tubes
85 in the transmitting channel according to a code signal to transmit impulses of unmodulated carrier current and selectively call a distant station.

12. In a carrier current transmission system, a transmission line, a signaling station having transmitting and receiving channels
90 connected to said transmission line, means for blocking the transmitting channel when the station is idle and when the receiving channel is in use, and for blocking said receiving channel when the transmitting channel is in use, means for communicating with the distant station by modulated current, and means for removing the blocking of said
95 transmitting channel according to a code signal to transmit impulses of unmodulated carrier current and selectively call a distant station.

13. In a power line carrier current communicating system, a power line, a signal station having a transmitting and receiving channel connected to said power line,
100 means at said station to send and receive over the power line a side band and the unmodulated carrier component for communication purposes, means for blocking said transmitting channel when the station is idle and when the receiving channel is in use, and for blocking said receiving channel when the transmitting channel is in use, and means for removing the blocking of said
105 transmitting channel according to a code signal to transmit impulses of unmodulated carrier current and selectively call a distant station.

In witness whereof, I hereunto subscribe my name this 9th day of August, 1929.

CHARLES N. NEBEL.