Aug. 23, 1932. H. B. ARNOLD 1,873,255

POWER LINE CARRIER TELEPHONE SYSTEM

Filed Aug. 10, 1929 2 Sheets-Sheet 1

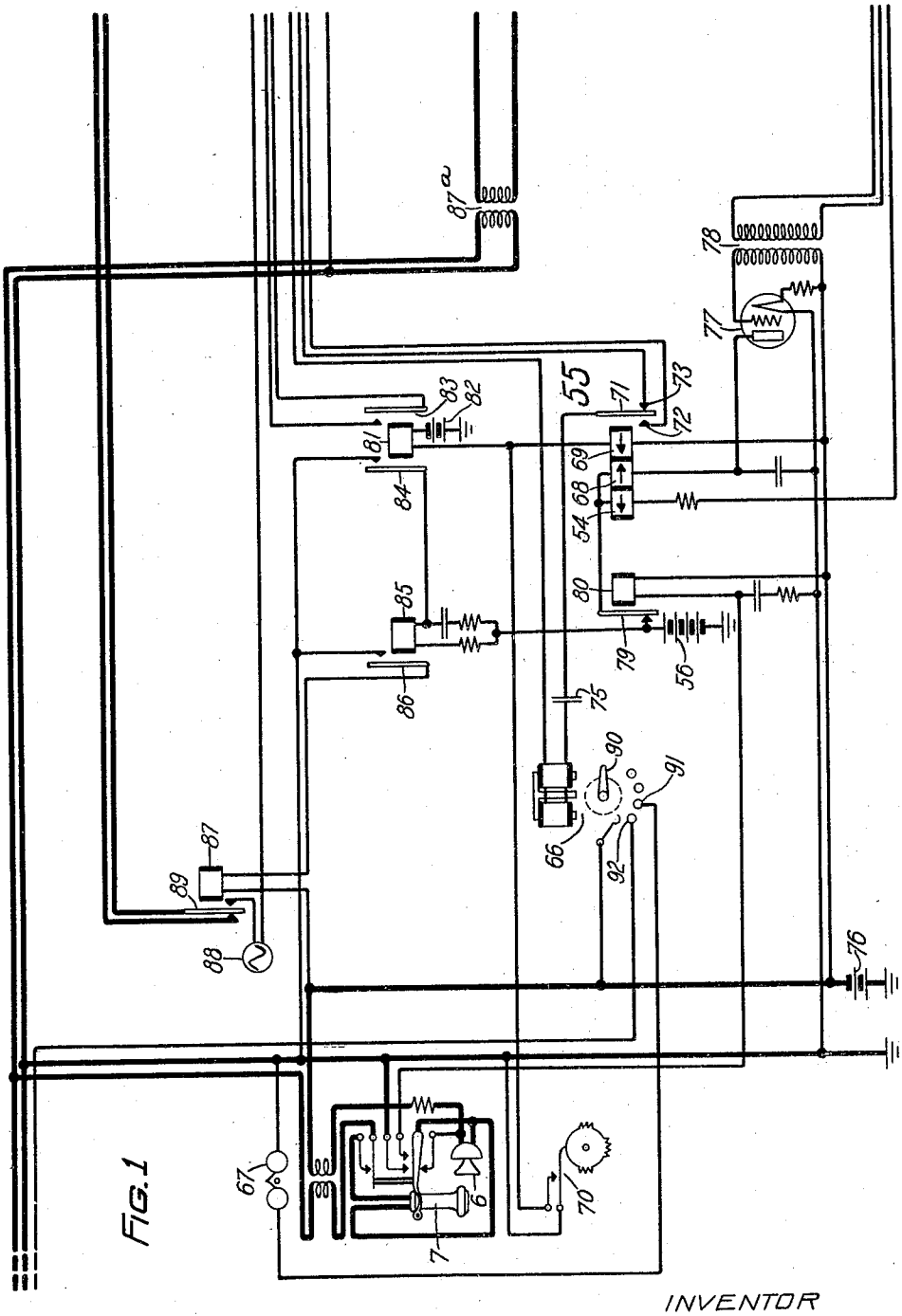

FIG. 1

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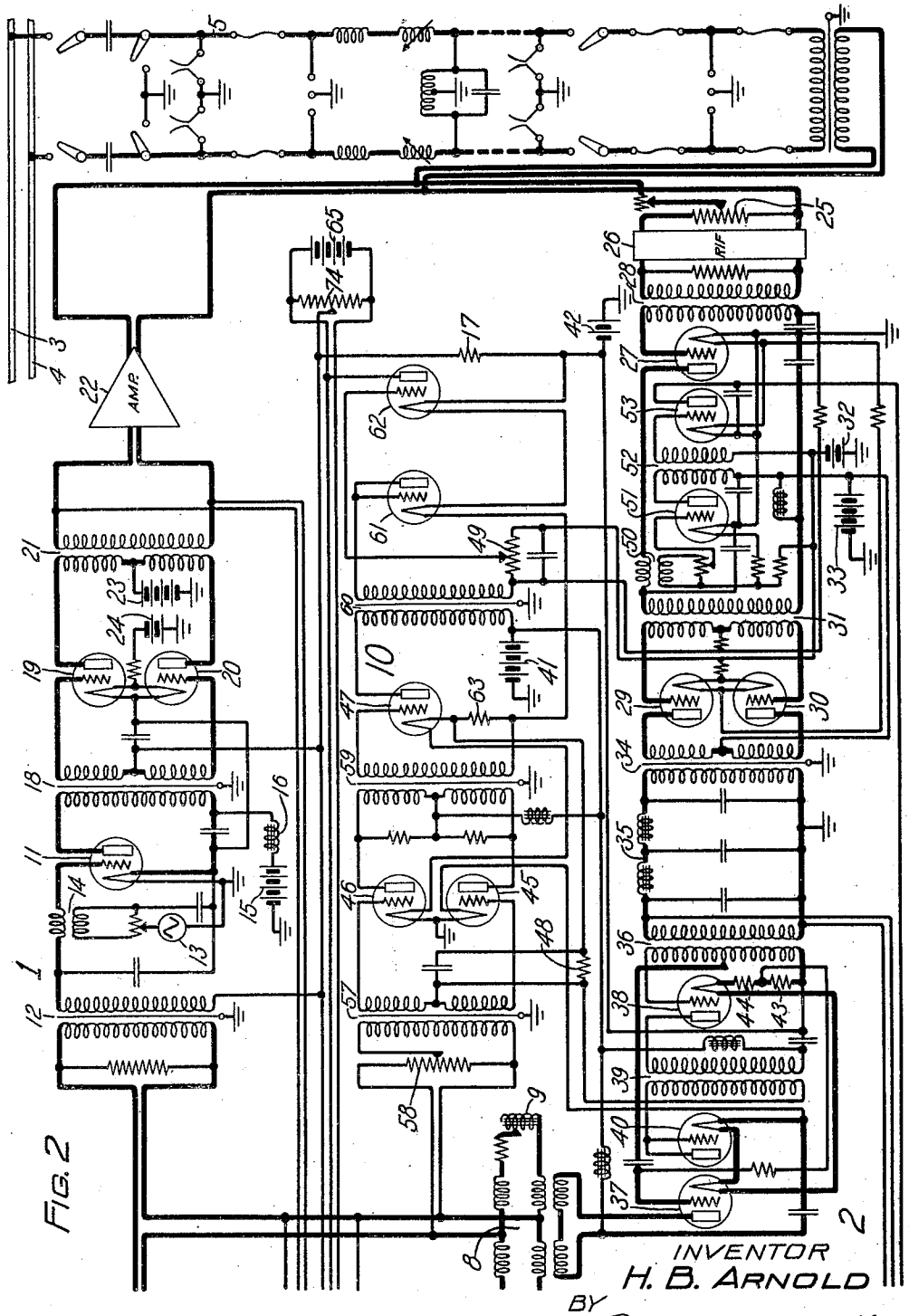

FIG. 2

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Patented Aug. 23, 1932 1,873,255

UNITED STATES PATENT OFFICE

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POWER LINE CARRIER TELEPHONE SYSTEM

Application filed August 10, 1929. Serial No. 384,928.

This invention relates to carrier current signal systems and particularly to selective calling circuits for power line carrier current signal systems.

One object of the invention is to provide a carrier current signal system effecting communication between stations by modulated carrier current and selective calling by code signals of unmodulated carrier current that shall have electromagnetic call means at each station responsive only to a code signal of carrier current free from modulation with voice frequency currents.

Another object of the invention is to provide a power line carrier current signal system that shall effect communication between stations by modulated carrier current and selective calling by code signals of carrier current free from any modulation with voice frequency currents and that shall employ a differential relay at each station to insure operation of the call selector only when a code signal of unmodulated current free from modulation with voice frequency currents is received.

In certain types of power line carrier current signal systems communication between signal stations is effected by voice frequency currents modulated with carrier current and selective calling of any station is effected by transmitting a code signal of impulses of one wave within the voice frequency range modulated with carrier current. The patent to C. N. Nebel No. 1,733,553 dated October 29, 1929, discloses a power line carrier current signal system wherein the same carrier wave is employed for communication in opposite directions between signal stations. In such system only one side band is transmitted over the power line during communication between signal stations. Selective calling of any station is effected by transmitting a predetermined number of impulses of one wave within the voice frequency range modulated with a carrier wave. The number of impulses of modulated carrier current required to operate a selector at any station is made sufficiently high and the timing adjustment is arranged to prevent operation of a selector during communication between stations.

The application of J. D. Sarros Serial No. 384,876 filed August 10, 1929, discloses a power line carrier current system employing the same carrier wave for transmission in opposite directions and wherein the carrier wave and both side bands are transmitted during communication between any two signal stations. The present invention is particularly adapted for use in the system disclosed in the above mentioned application of J. D. Sarros. The power line carrier current signal system employed to disclose this invention is substantially the same as the system disclosed in the above mentioned application of J. D. Sarros and the selective calling circuits shown in the application of J. D. Sarros, Serial No. 384,876 are similar to the calling circuits disclosed hereinafter.

In the system employed to disclose the present invention a plurality of carrier current signal stations are connected to a power line in any suitable manner as for example, by condensers in the manner disclosed in the above mentioned patent to C. N. Nebel, No. 1,733,553. Each signal station is provided with a transmitting and receiving channel. The transmitting channel comprises a three-element thermionic modulator tube which is supplied with carrier current from a suitable oscillator and with voice frequency currents from the operator's telephone set, or from the telephone set of an operator at an extension station. The output circuit from the modulator tube is connected through suitable amplifying means to the coupling means between the power line and the signal station.

The receiving circuit comprises a thermionic detector tube for separating the voice frequency currents from the carrier waves during communication between two stations. The detector tube is connected through suitable amplifying means to the receiver of the operator's telephone set. Suitable duplex control circuits are provided for impressing a negative blocking potential on the grid of the modulator tube when the station is idle, or the receiving circuit is in use and for impressing a negative blocking potential on the grid of the detector tube when the transmitting circuit is in use.

Selective calling circuits are provided for selectively calling any distant station. Means operated by the selector key is provided for operating the duplex control circuits when calling a distant station so as to impress a negative blocking potential on the grid of the detector tube and remove the negative blocking potential from the grid of the modulating tube in the transmitting channel. When transmitting a code signal from any station, unmodulated carrier current free from any modulations with voice frequency current is transmitted over the line to the distant station.

A differentially wound relay is provided for governing the operation of the selector at each signal station. The differential relay is preferably polarized. One coil of the differential relay is energized from the output circuit of the detector tube to prevent any operation of the differential relay and the selector when carrier current modulated with voice frequency current is received over the power line. A second coil is provided on the differential relay which is energized whenever carrier current is received over the power line. The differential relay is only operated to effect operation of the selector when a code signal of unmodulated current free from any modulated carrier current is received. If voice frequency currents and modulated currents are simultaneously received over the power line, the two coils of the differential relay neutralize each other and insure against any operation of the selector. By such means it is possible to prevent any operation of the selector during communication between any two stations.

In the application of Charles N. Nebel, Serial No. 384,878 filed August 10, 1929, is disclosed carrier current signal systems wherein thermionic vacuum tube calling circuits are provided in a system similar to that disclosed in the above mentioned patent to C. N. Nebel, No. 1,733,553.

Figures 1 and 2 of the accompanying drawings disclose a signal station for a power line carrier current telephone system constructed in accordance with the invention.

Referring to the drawings a signal station having a transmitting channel 1 and a receiving channel 2 is connected to a power line comprising conductors 3 and 4 by means of a coupling circuit 5. The coupling circuit 5 is preferably of the type disclosed in the above mentioned patent to C. N. Nebel, No. 1,733,553. An operator's telephone set comprising a transmitter 6 and a receiver 7, is connected to the transmitting channel 1 and the receiving channel 2 by means of a transformer 87*a* and a hybrid coil 8. The hybrid coil 8 is provided with the customary balancing impedance 9. Duplex control circuits 10 are provided for blocking the transmitting channel when the station is idle and when the receiving channel is in use and for blocking the receiving channel when the transmitting channel is in use.

The transmitting channel 1 comprises a three element thermionic modulator tube 11, which is connected to the hybrid coil 8 by means of a transformer 12. An oscillation generator 13 which is preferably of the thermionic type is connected to the input circuit of the modulator tube 11 by means of a transformer 14. The carrier wave developed by the oscillation generator 13 is modulated with the voice frequency currents received from the operator's telephone set. Plate potential for the modulator tube 11 is supplied from a battery 15 through a retard coil 16. Grid biasing potential for blocking the tube 11 is obtained from the drop across a resistance element 17 in the duplex control circuits 10. An explanation of the operation of the resistance element 17 in controlling the modulating tube 11 will be given when reference is made to the duplex control circuits.

The output circuit of the modulator tube 11 is connected by a transformer 18 to two thermionic amplifier tubes 19 and 20. The two tubes 19 and 20 are connected together in push-pull relationship. A transformer 21 is provided for connecting the output circuits of the tubes 19 and 20 to a power amplifier 22 which in turn is connected through the coupling circuits 5 to the power line conductors 3 and 4. The grids of the tubes 19 and 20 are supplied with negative blocking potential from the resistance element 17 in the same manner as the grid for the modulator tube 11. Plate potential for the tubes 19 and 20 is provided by a battery 23. A battery 24 supplies filament heating current for the modulator tube 11 and the two amplifier tubes 19 and 20.

The receiving channel 2 comprises a potentiometer 25 and a band pass filter 26 which are connected to the power line conductors 3 and 4 through the coupling circuits 5. The band pass filter 26 which selects the carrier wave and side bands characteristic to the system is connected to a detector tube 27 by means of the transformer 28. The detector tube 27 is coupled to two amplifier tubes 29 and 30 in push-pull relationship by means of a transformer 31. Grid biasing potential for blocking the detector tube 27 and the two amplifier tubes 29 and 30 is supplied by the potential drop across a resistance element 49 in the duplex control circuits 10. Filament heating current for the detector tube 27 and the amplifier tubes 29 and 30 is supplied from a battery 32. Plate potential for the detector tube 27 and the two amplifier tubes 29 and 30 is supplied by a battery 33.

The output circuits of the amplifier tubes 29 and 30 are connected by a transformer 34, a low pass filter 35, and a transformer 36 to a

thermionic amplifier tube 37. The low pass filter 35 permits the voice frequency currents detected by the tube 27 to freely pass therethrough. The amplifier tube 37 is directly connected to the hybrid coil 8. The secondary winding of the transformer 36 is not only connected to the input circuit of the amplifier tube 37, but is also connected to an amplifier tube 38. The amplifier tube 38 is connected by a transformer 39 to a rectifier tube 40 which governs the duplex control circuits when the receiving channel is in use. Plate potential for the thermionic tubes 37 and 38 is received from a battery 41. Filament heating current for the tubes 37, 38 and 40 is obtained from a battery 42. The heating current circuit may be traced from the battery 42 through resistance element 43 and 44, filament of the tube 38, filaments of the tubes 37 and 40, filament of a thermionic tube 45 in the duplex control circuits 10 and ground return to the battery 42. Grid bias for the tube 38 is obtained from the drop across the resistance element 43 and 44. Grid bias for the tube 37 in a like manner is obtained from the filament heating circuit.

The plate circuit for the rectifier tube 40 may be traced from the grounded filament of a thermionic tube 46 in the duplex control circuit through the filament of a tube 47 in the duplex control circuits, resistance element 48, secondary winding of the transformer 39, and plate and filament of the rectifier tube 40 to ground. The resistance element 48 controls the biasing potential impressed on the grids of the tubes 46 and 45 in the duplex control circuits for blocking the transmitting channel when the receiving channel is in use.

The output circuit of the detector tube 27 is connected by a transformer 50 to an amplifier 51. The amplifier tube 51 is connected by transformer 52 to a thermionic tube 53 which in turn is connected to a winding 54 of a polarized differential relay 55. The transformer 50 in the output circuit of the detector tube 27 collects the high frequency carrier wave whch may pass through the detector tube. Plate potential for the tube 51 is supplied by battery 33 and plate potential for the tube 53 is supplied by battery 56. Grid biasing potential and filament heating current for the tubes 51 and 53 are supplied by the battery 32. A more complete description of the operation of the differential relay 55 and the thermionic tubes 51 and 53 will be given when reference is made to the selective calling circuits.

The duplex control circuits 10 comprise the thermionic tubes 45 and 46 in push-pull relationship which are connected by a transformer 57 and potentiometer 58 to the transmitting channel 1. The output circuits of the tubes 45 and 46 are connected by transformer 59 to the amplifier tube 47. The amplifier tube 47 is connected by a transformer 60 to a rectifier tube 61. Plate potential for the tubes 45, 46 and 47 is obtained from the battery 41. Grid biasing potential for the tubes 45 and 46 as heretofore set forth is obtained by the drop across the resistance element 48. The filament heating circuit for the tubes 46, 47, 61 and a thermionic tube 62 extends from a battery 42, through the filaments of the tubes 62 and 61, a resistance element 63, filament of the tube 47, filament of the tube 46 and ground return to the battery 42. Grid biasing potential for the thermionic tube 47 is obtained from the filament heating circuit. The plate circuit through the rectifier tube 61 may be traced from the filament of the rectifier tube through the filament of the tube 47, filament of the tube 46, ground return conductor, battery 32, resistance element 49, and the secondary of the transformer 60 to the plate of the tube 61.

The three element thermionic tube 62 controls the potential impressed on the resistance element 17 from a battery 65. The potential impressed on the grid of the tube 62 is controlled by the resistance element 49. When the transmitting channel is in service, the potential drop across the resistance element 49 places a high negative potential on the grid of the tube 62. The blocking of tube 62 prevents impressing of a blocking negative potential on the grids of the modulator tube 11 and the two amplifier tubes 19 and 20 from the resistance element 17. When the station is idle and when the receiving channel is in use no potential is impressed on the grid of the tube 62 from the resistance element 49. Accordingly when the station is idle and when the receiving channel is in use, negative blocking potential is impressed upon the modulator tube 11 and the amplifier tubes 19 and 20. The grid circuit for the modulator tube 11 may be traced from the grid of the modulator tube 11 through the secondary winding of the transformer 14, secondary winding of the transformer 12, resistance element 17, battery 42, and ground return to the filament of the modulator tube 11. A like grid circuit is provided for the amplifier tubes 19 and 20.

The differential relay 55, which is of the polarized type, controls a selector 66 for operating a call bell 67 at the operator's station or a call bell (not shown) on an extension station. The differential relay comprises the coil 54 which is energized by rectified carrier current impulses, a winding 68, which is energized by rectified voice frequency currents and a winding 69 which is energized according to the operation of a selector key 70. The selector key 70 may be of any suitable type such as the master impulse transmitting device disclosed in U. S. patent to J. C. Field, #1,354,814, dated October 5, 1920. The differential relay 55

is provided with an armature 71 operating between contact members 72 and 73, for controlling the selector 66 from the battery 65. A potentiometer 74, which is connected across the battery 65, has two opposite terminals thereof connected to the contact elements 72 and 73. The armature 71 of the differential relay is connected through a condenser 75 and a coil of the selector 66 to a mid-tap of the potentiometer 74. The circuit for energizing the winding 69 of the differential relay extends from a grounded battery 76 through the coil 69, impulse transmitting key 70, and ground return to the battery 76. Pulsing of the differential relay by the selector key 70 serves to vibrate the armature 71 for impressing impulses from the battery 65 on the selector coil to effect operation of the selector 66 in accordance with the code signal being transmitted.

A rectifier tube 77 has the input circuit thereof connected by transformer 78 to the output circuit of the low pass filter 35. The output circuit of the rectifier tube 77 is connected to the coil 68 of the differential relay 55. The energizing circuit for the coil 68 of the differential relay may be traced from the grounded battery 56 through the armature 79 of a relay 80, coil 68, plate and filament of the tube 77 and ground return to the battery 56. The coil 68 of the differential relay opposes the coil 54 and when both coils are energized, no operation of the differential relay can take place. If unmodulated carrier current impulses are received, the winding 54 alone is energized to effect operation of the differential relay and the selector 66. If impulses of carrier wave modulated with voice frequency currents are received over the power line, the winding 68 as well as the winding 54 is energized to insure against any operation of the differential relay and the selector. No operation of the selector can take place during communication between stations.

Upon operation of the impulse transmitting key 70 for transmitting a code calling signal over the power line, a pulsing relay 81 is energized by a circuit extending from battery 82. The pulsing relay 81 is provided with an armature 83 for placing a shunt circuit across the transmitting channel and an armature 84 for completing a circuit from the battery 56 through a slow releasing relay 85. The armature 83 of the relay 81 intermittently places a shunt circuit across the transmitting channel in accordance with the code signal to transmit impulses of carrier current over the power line. The relay 85, which is slow releasing, is held in an operated position during pulsing of the relay 81. The relay 85 is provided with an armature 86 for completing a circuit from the battery 76 through a signal tone relay 87.

The signal tone relay 87 serves, when transmitting a selective call to a distant station, for impressing low frequency current from an oscillator 88 upon the duplex control circuits 10. The oscillator 88, which preferably supplies a current of sixty cycles, is connected by the armature 89 of the relay 87 to the primary winding of the transformer 57. When the oscillator 88 is connected to the duplex control circuits, it is apparent that potential will be produced across the resistance element 49 for impressing negative blocking potential on the grids of the detector tube 27 and the amplifier tubes 29 and 30 in the receiving channel. Furthermore it is apparent that the negative grid potential impressed upon the tube 62 from the resistance element 49 will insure against any blocking of the modulator tube 11 and the amplifier tubes 19 and 20 in the transmitting channel.

Communicating with a distant station

When communicating with a distant station, voice frequency currents from the operator's telephone set are modulated with carrier current from the oscillator 13 in the modulator tube 11. The carrier wave and both side bands are amplified by the tubes 19 and 20 and the power amplifier 22 for transmission over the power line to a distant office. Voice frequency currents are also supplied to the transformer 57 in the duplex control circuits 10. The amplifier tubes 45 and 46 in push-pull relationship and the amplifier tube 47 are operated for supplying current to the rectifier tube 61. The current rectified by the tube 61 impresses potential across the resistance element 49. The potential across the resistance element 49 impresses a negative blocking potential on the grid of the tube 62 to insure against any blocking of the modulator tube 11 and the two amplifier tubes 19 and 20 in the transmitting channel. Moreover, the potential across the resistance element 49 impresses negative blocking potential on the grids of the detector tube 27 and the amplifier tubes 29 and 30 to insure blocking of the receiving channel 2. At this time the receiving channel is not in use and accordingly sufficient potential is not impressed across the resistance element 48 for blocking the tubes 45 and 46 in the duplex control circuits.

During communication with a distant station carrier current modulated with voice frequency currents is received over the power line for energizing the receiving channel 2. The received modulated current passes through the band pass filter 26 to the detector tube 27. The detector tube 27 separates the voice frequency currents from the carrier current and supplies voice frequency currents through the amplifier tubes 30 and 29, transformer 34, low pass filter 35, transformer 36, and the tube 37 to the hybrid coil 8. The hybrid coil 8 is connected by a trans-

former 87*a* to the receiver of the operator's telephone set.

The amplifier tube 38 and the rectifier tube 40 are operated by the voice frequency currents received from the low pass filter 35 for impressing potential across the resistance element 48. The potential across the resistance element 48 impresses negative blocking potential on the grids of the tubes 45 and 46 in the duplex control circuits. The blocking of the tubes 45 and 46 insures against impressing potential across the resistance element 49. Inasmuch as there is no potential across the resistance element 49, the tube 62 is not blocked and the potential across the resistance element 17 impresses negative blocking potential on the grids of the modulator tube 11, and the amplifier tube 19 and tube 20 in the transmitting channel. No negative blocking potential can be impressed on the grids of the detector tube 27 and the amplifier tubes 29 and 30 from the resistance element 49 at this time by reason of the blocking of the amplifier tubes 45 and 46.

The winding 54 of the differential relay is energized by the current supplied from the tubes 51 and 53 and the winding 68 of the differential relay is energized by the voice frequency currents received from the output circuit of the tube 77 which is connected to the output circuit of the low pass filter 35. Consequently at this time no operation of the differential relay can take place.

Selective calling circuits

In transmitting a selective calling signal to a distant station, the key 70 is operated for pulsing the relay 81 in accordance with the code signal to be transmitted. The relay 81 operates the armature 83 for intermittently placing a shunt across the transmitting channel to intermittently transmit impulses of carrier current from the oscillator 13. At the same time the armature 84 of the relay 81 effects operation of the slow releasing relay 85. The slow releasing relay 85 operates relay 87 for impressing a signal tone of low frequency current on the duplex control circuits 10. The low frequency current impressed on the duplex control circuits serves to produce a potential drop across the resistance element 49. Such potential drop across resistance element 49 blocks the tube 62 and insures against any blocking of the tubes in the transmitting channel and insures the blocking of the tubes in the receiving channel. The winding 69 of the differential relay 55 is energized in accordance with the pulsing of the relay 81 for operating the selector 66 according to the selected calling signal being transmitted.

If a selective calling signal is received from a distant station, the winding 54 of the differential relay 55 is intermittently energized for operating the selector 66 according to the received signal. Inasmuch as the selective calling signal comprises impulses of unmodulated carrier current, the winding 68 of the differential relay will not be energized. Differential relay 55 is preferably a polarized relay in order to prevent operation of the relay in case the voice frequency supplied to the winding 68 are weak compared with the high frequency impulses supplied to the winding 54. The selector 66, when operated by the differential relay 55, completes a circuit from the grounded battery circuit 76 through the switch arm 90, contact member 91, call bell 67 and ground return to the battery 76. A contact member 92 on the selector 66 may be connected to the call bell at an extension station (not shown).

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 carrier current signal system, a signal station, means at said station for effecting communication over the system by modulated carrier current and for effecting selective calling by a code signal of carrier current, a selector at said station, and means comprising a differential relay having one winding energized in response to the receipt of a code signal of carrier current impulses for operating said selector and a second winding energized in response to the receipt of modulated current for preventing operation of the selector.

2. In a carrier current signal system, a signal station, means at said station for effecting communication over the system by modulated carrier current and for effecting selective calling by a code signal of carrier current, a selector at said station, and means comprising a polarized differential relay for operating said selector in response to the receipt of a code signal of carrier current impulses and for preventing operation of the selector in response to the receipt of separated impulses of modulated carrier current.

3. In a carrier current signal system, a signal station having a receiver and a switchhook therefor, means at said station for communicating over the system by modulated carrier current and for effecting selective calling by transmitting a code signal of unmodulated carrier current, a selector at said station, and means comprising an electro-magnetic relay responsive before the receiver is removed from the switchhook to unmodulated carrier current impulses received over the system and unresponsive before the receiver is removed from the switchhook to separated impulses of modulated carrier current received over the system for governing the operation of said selector.

4. In a power line carrier current signal system, a power line, a signal station having a transmitting and a receiving channel connected to said line, means in said transmitting channel for transmitting a carrier wave modulated with voice frequency current to effect communication over the power line and for transmitting a code signal of unmodulated carrier current impulses to effect selective calling, a selector at said station, and means in said receiving channel comprising a polarized differential relay for operating said selector in response to the receipt of a code signal of unmodulated carrier current impulses and for preventing operation of the selector in response to the receipt of separated impulses of modulated carrier current.

5. In a power line carrier current signal system employing modulated carrier current for communicating between stations and unmodulated current to selectively call a station, a power line, a signal station connected to the power line, a receiver at said station having a switchhook therefor, a selector at said station, and means comprising an electro-magnetic relay for operating the selector in response to the receipt of a code signal of unmodulated carrier current before the receiver is removed from the switchhook and for preventing operation of the selector in response to the receipt of carrier current modulated with voice frequency current before the receiver is removed from the switchhook.

6. In a power line carrier current signal system, a power line, a signal station having a transmitting and a receiving channel connected to said line, means in said transmitting channel for transmitting a carrier wave modulated with voice frequency current to effect communication over the power line and for transmitting a code signal of unmodulated carrier current to effect selective calling, a selector at said station, and means in said receiving channel comprising a differential relay for operating said selector in response to the receipt of a code signal of carrier current and for preventing operation of the selector in response to the receipt of modulated carrier current.

7. In a power line carrier current signal system, a power line, a signal station connected to said power line, a selector at said station, and means comprising a differential relay for operating the selector in response to the receipt of a code signal of unmodulated carrier current and for preventing operation of the selector in response to the receipt of carrier current modulated with voice frequency current.

8. In a power line carrier current signal system, a power line, a signal station connected to said power line, a selector at said station, a three element thermionic detector tube for obtaining voice frequency currents from received modulated current, and means comprising a differentially wound relay for operating said selector said relay having one winding energized by received carrier current to operate the selector, and a second winding energized by voice frequency currents from the detector to prevent operation of the selector by the relay when modulated currents are received.

9. In a carrier current signal system, a signal station having a transmitting channel and a receiving channel, means at said station for communicating with a distant station by modulated carrier current and for selectively calling another station by transmitting a code signal of unmodulated carrier current, means at said station 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, a selector at said station, and means comprising an electro-magnetic relay responsive to unmodulated carrier current for governing the operation of said selector.

10. In a power line carrier current signal system, a power line, a signal station having a transmitting channel and a receiving channel connected to said power line, means at said station for communicating with a distant station by modulated carrier current and for selectively calling another station by transmitting a code signal of unmodulated carrier current, means at said station for blocking the transmitting channel when the receiving channel is in use and for blocking the receiving channel when the transmitting channel is in use, a selector at said station, and means comprising a differentially wound relay responsive to unmodulated carrier current and unresponsive to modulated carrier current for governing the operation of said selector.

11. In a carrier current signal system, a signal station having a transmitting and a receiving channel, a three element thermionic modulator tube and a source of carrier waves in said transmitting channel, means for supplying voice frequency to said tube for modulation with said carrier current to communicate with a distant station, means for transmitting a code signal of said carrier wave for selectively calling a distant station, a detector in said receiving channel for obtaining voice frequency currents from the received modulated currents, a selector, a relay having two differential windings for operating said selector, means for energizing one of said windings by voice frequency currents in the detector output circuit and for energizing the other winding when carrier wave impulses are received to effect operation of the selector only when carrier current free from modulation with voice frequency current is received.

12. In a carrier current signal system, a signal station having a transmitting and a re-

ceiving channel, a source of carrier waves, a three element thermionic tube in said transmitting channel for modulating voice frequency currents with said carrier waves to communicate with a distant station, a three element thermionic detectir tube in said receiving channel for obtaining voice frequency currents from the received modulated currents, means comprising duplex control circuits at said station for applying negative blocking potential to the grid of said modulator tube when the station is idle or the receiving channel is in service and for applying a negative blocking potential to the grid of the detector tube when the transmitting circuit is in service, means comprising a selector key for operating the duplex control circuits to remove the blocking potential from the modulator grid and for transmitting a code signal of carrier current to selectively call a distant station, a selector, and means comprising a differential relay having one winding energized by the voice frequency currents in the detector output circuit and another winding energized when carrier waves are received to operate the selector only when carrier current free from modulation with voice frequency current is received.

In witness whereof, I hereunto subscribe my name this 8th day of August, 1929.

HENRY B. ARNOLD.