

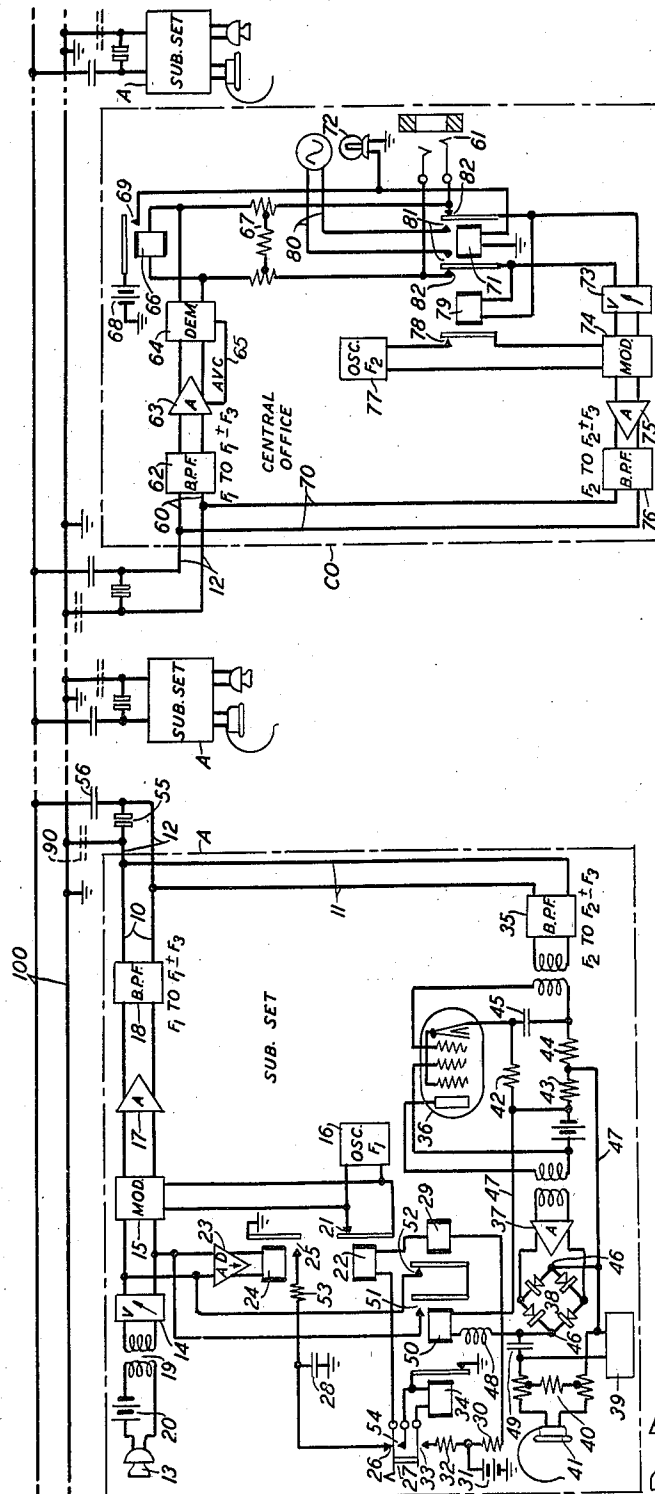
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POWER LINE CARRIER FREQUENCY TELEPHONE SYSTEM

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POWER LINE CARRIER FREQUENCY
TELEPHONE SYSTEM

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This invention relates to electric wave transmission systems, and, more particularly, to a power line carrier frequency telephone system.

Carrier frequency telephony on transmission lines primarily intended for the transmission and distribution of low frequency high voltage electric power has, of course, been known for some time although never very extensively applied. It has, however, become of increasing interest in view of the somewhat extensive electrification of rural areas and the possibility provided by the rural power lines of providing telephone service thereover to the scattered inhabitants of the sparsely settled regions through which the power line extends.

An object of this invention is to provide an improved arrangement for transmitting and receiving telephonic communication on high frequency waves over a transmission path, such as a high voltage power line.

In accordance with the invention, a plurality of telephone stations and a central office for the stations are coupled to a power line. Transmitting from each station is on a common high frequency carrier wave and receiving at each station is on a second common high frequency carrier wave. The central office acts not only as a means for connecting parties on the power line telephone system with an outside or general telephone system, but constitutes a relay or frequency change-over station for the telephone stations of the power line system, that is, the outgoing transmission from a telephone station on the one high frequency carrier wave is received at the central office, and, after suitable demodulation, the modulation products are remodulated onto the second high frequency carrier wave for transmission to the called or listening telephone station. No voice-operated devices are necessary at the central office although voice-operated devices are employed at the telephone station to enable the transmitting circuit thereat. When voice-operated devices for enabling the transmitting circuit are provided at the telephone stations and the latter are arranged for transmitting on the same carrier wave, intentional or inadvertent operation of the voice-operated devices at a called station while the party at the calling station is talking may produce an unpleasant or undesirable interruption or interference with the transmission from the calling station.

A feature of this invention is the provision at the telephone station of means in the receiving circuit to disable the transmitting circuit en-

abling means while transmission is incoming to the receiving circuit.

A more complete understanding of the invention and the various features thereof will be obtained from the detailed description which follows taken in conjunction with the appended drawing, the single figure of which illustrates an embodiment of the invention.

The single figure of the drawing shows a power line carrier frequency telephone system comprising a power line 100 and a plurality of telephone stations A, one of which is shown in detail, and a central office CO for the stations coupled to the power line. The system is arranged so that the stations communicate with one another, or with a general telephone system through the central office. Transmitting, or transmission outgoing from each station, is on a common high frequency or carrier wave F_1 , and receiving, or transmission incoming to each station, is on a second common high frequency or carrier wave F_2 , the central office constituting a relay or frequency change-over station for receiving the transmission of the calling or talking party on the one frequency and for converting it to the frequency on which the called or listening party is able to receive it.

The power line has one wire grounded and is adapted to transmit low frequency, high voltage electric power simultaneously with its use as a transmission line for carrier frequency telephonic communication. The power line, of course, could be an insulated single phase line, or comprise a pair of phase wires of a multiphase line, or other type of power line.

Each telephone station A comprises a transmitting circuit 10, a receiving circuit 11 and a coupling line 12. The transmitting circuit comprises a transmitter 13, a volume control amplifier 14, a modulator 15, a high frequency or carrier wave generator or oscillator 16, an output amplifier 17 and a band-pass filter 18. The transmitter 13, for example, of the carbon granule type, is connected to the volume control amplifier through a transformer 19, and is connected in series with one transformer winding and a source 20 of talking current. The volume control amplifier may be of the voice-operated gain adjusting or volume limiter type, or may be provided with a manual control to provide for talkers of different transmission levels so that the voice current level into the modulator will be the same at all times, or to insure that there will be a high ratio between the communication current and the noises in the transmission line. The

modulator may be of any suitable type, as may the oscillator 16. The oscillator generates a high frequency F_1 which, during transmitting, is supplied to the modulator and is modulated by the voice frequency currents impressed on the modulator from the amplifier 14. The modulation products are amplified in the amplifier 17 and either the upper or the lower side-band, or both side-bands of the modulated high frequency wave are passed by the filter 18 to the line. The filter is adapted to transmit a band of frequencies comprising the upper or the lower side-band or both side-bands of the modulated high frequency wave for outgoing transmission from the station, i. e. it transmits the band F_1 to $F_1 + F_3$, F_1 to $F_1 - F_3$ or F_1 to $F_1 \pm F_3$, where F_3 is the upper limit of the audio frequency band being transmitted in the system. Normally, however, no high frequency wave is delivered to the modulator since the oscillator is short-circuited by the normally closed contact 21 of relay 22. The normal condition of the station would be that in which the subscriber is not talking. An amplifier-detector 23 is connected across the output of the amplifier 14, and is adapted, when sound waves are impressed on the transmitter 13, to amplify and detect a portion of the voice frequency currents being delivered to the modulator and to deliver such detected currents to the relay 24 to cause it to close its normally open contact 25.

One end of the winding of relay 22 is connected through the normally closed contact 26 of the signaling key 27 to the junction of a resistance 53 associated with the contact 25 and a condenser 28, one terminal of which is connected to ground. The other end of the winding of relay 22 is connected to ground through a relay 29, a resistance 30 and a source 31 of current. Another resistance 32 is connected between the positive terminal of source 31 and the normally open contact 33 of key 27. An interrupter 34, to vibrate, for example, at 20 cycles per second, is connected for operation on closure of normally open contacts 33 and 54 of the key 27.

The receiving circuit comprises a band-pass filter 35, an amplifier 36, a second amplifier 37 for additional amplification if desired, a demodulator 38, station signaling or ringing means 39, an attenuator network 40 and a telephone receiver 41. The filter is adapted to transmit a band of frequencies comprising the upper or lower side-band, or both side-bands, of the modulated high frequency wave employed in the system for transmission incoming to the station, that is, the filter passes the band F_2 to $F_2 + F_3$, F_2 to $F_2 - F_3$ or F_2 to $F_2 \pm F_3$, where F_2 is the carrier wave frequency for receiving and F_3 is the upper limit of the audio frequency band being transmitted in the system. The amplifier 36 may comprise an electron discharge device whose input control grid biasing potential is determined by the potential drop in the cathode resistor 42, and in the resistor 43, which is supplied with the direct current component of the output of the demodulator 38. Variation in the output level of the demodulator from a preassigned level varies the value of the current fed back to the resistor 43 through the connections 47, to vary the bias on the control grid of the discharge device to change the gain of the control amplifier and to restore the demodulator output to its preassigned level. The variation in the modulator output may result from change in the level of the transmission incoming to the station because of different

distances between any one station and the other stations coupled to the power line. The resistance 44 and condenser 45 act with retard coil 48 and the winding of relay 50 to suppress alternating current feedback in the controlled amplifier. The demodulator is shown as comprising a plurality of variable resistance devices such as copper-copper oxide rectifier units in bridge configuration. As already indicated, the gain control resistor 43 is connected across the terminals 46 of the demodulator through connections 47, a retard coil 48 being provided in one connection. Condenser 49 is a blocking condenser. The station signaling means 39 may comprise a ring adapted to be operated, for example, on a 20-cycle ringing current. The network 40 compensates for the lower volume level required for listening as compared with that required for operation of the signaling means 39. A relay 50 is included in the feedback connection from the demodulator, and has a normally open contact 51 associated therewith closure of which, while normally closed contact 52 of relay 29 remains closed, short-circuits the input to the amplifier-detector 23. Relay 50, however, will be energized only when transmission is incoming to the station. The object of this arrangement will be pointed out in more detail hereinafter.

The station is connected to the power line by the coupling line 12, one conductor of the latter being connected directly to the grounded wire and the other to the non-grounded wire through a coupling condenser 56. With an insulated single phase line, or in case of connection to a pair of phase wires of a multiphase system, a coupling condenser would be provided in each conductor of the coupling line. Coupling might also be accomplished by use of a power distribution transformer, for example in the manner described and claimed in L. K. Swart application, Serial No. 359,879 filed October 5, 1940. In any case a suitable protector 55 is provided to safeguard the subscriber and the station equipment against the hazard of the high voltage on the power line.

The central office will now be described. It comprises an incoming or receiving circuit 60 and an outgoing or transmitting circuit 70 between the coupling line 12 and the operator's line jack 61. The incoming circuit 60 comprises a filter 62 similar to filter 18 of the telephone station, an amplifier 63, a demodulator 64 with a suitable automatic volume control feedback connection 65 from the demodulator to the amplifier, a relay 66 adapted to respond to the low frequency signaling current, for example, 20 cycles per second originating at a telephone station, and an attenuator network 67 to equalize for the different levels required for the signaling current and for the voice frequency currents. The armature associated with the relay 66 is connected to ground through a current source 68, and its normally open contact 69 is connected to ground through the winding of relay 71 and through the operator's signal lamp 72. The outgoing circuit 70 comprises an amplifier 73 similar to the amplifier 14, a modulator 74, an output amplifier 75 and a band-pass filter 76 similar to filter 35. An oscillator 77 generating the high frequency carrier wave F_2 is coupled to the modulator, the connections including the normally closed contact 78 of an interrupter or buzzer 79 adapted to respond to a low frequency current, for example, 20 cycles per second, to be supplied over the connection 80 through the normally open contacts 81 of relay 71 when the latter is energized

or to be sent over the connection 61 by the operator when she rings.

The operation of the system will now be described. Let it be assumed that the party at one station wishes to call a party at a second station on the power line. Although not shown, the receiver 41 would be supported on a switchhook which, as will be evident to those skilled in the art, could have associated therewith normally open contacts controlling the talking current circuit of the transmitter 13 and the power supply circuit for the oscillator and the transmitting circuit amplifiers. As shown in the drawing, the receiver has been removed from its hook and the talking current circuit for the transmitter 13 is closed and the oscillator and the amplifiers of the transmitting circuit are understood to be connected to their power supply circuits. The receiving circuit amplifiers are continuously energized so that the receiving circuit is at all times in condition to receive incoming transmission. By listening for a moment, the calling party ascertains if the power line is already in use. If it is idle, he depresses the key 27, the number of times and for a period specified for the called station by the signaling code of the power line telephone system. Each time the key is depressed, energizing current is supplied from source 31 to the interrupter through contact 33, and energizing currents for relays 22 and 29 are supplied from the same source, the current circuit for the relays being completed by closure of contact 54. Operation of relay 34 causes the contact 21 of relay 22 to break-and-make at the interrupter frequency, for example, 20 cycles per second. This modulates, at a corresponding frequency, the carrier wave F_1 supplied to the modulator from the oscillator 16, and the modulated carrier wave is transmitted through amplifier 17 and filter 18 to the line and over the latter to the central office and through the central office to all of the stations. The modulated carrier wave is transmitted by the filter 62 to the amplifier 63 and is demodulated by the demodulator 64, the demodulated signal energizing the relay 66. Closure of the normally open contact 69 energizes relay 71 and the signal lamp 72. Operation of relay 71 closes the normally open contacts 81 and low frequency signaling current is supplied over connections 80 to the transmitting circuit. The interrupter 79 is operated thereby and modulates the carrier wave F_2 by the corresponding break-and-make of contact 78. The modulated carrier wave is amplified in amplifier 75, and transmitted through the filter 76 to the power line. The modulated carrier wave F_2 is received at all of the stations, being passed by filter 35 to the amplifiers 36 and 37 and demodulator 38. The demodulated signal is delivered to and operates the signaling means 39. When the called party answers, the calling party talks into the transmitter 13, and the voice frequency currents developed in the transformer are amplified in amplifier 14 and impressed on the modulator. Simultaneously the voice currents are impressed on the amplifier-detector 23. The rectified voice currents output of the amplifier detector energizes the relay 24, and normally open contact 25 closes. The condenser 28, normally under charge from source 31, discharges through resistance 53, and relays 22 and 29 energize to open the normally closed contacts 21 and 52 for as long as the calling party continues to talk. The carrier wave F_1 supplied to the modulator is modulated by the voice frequency currents, and the

speech modulated carrier wave is amplified in amplifier 17 and transmitted to the line through the filter 18. The modulated carrier wave enters the central office and is transmitted through the filter 62 through the amplifier 63 and demodulator 64. A preassigned output level from the demodulator is maintained through the automatic volume control connection 65. The demodulation voice frequency products pass through the network 67 and the normally closed contacts 82 of relay 71 to the outgoing circuit 70. The voice frequency currents are amplified in amplifier 73, modulated onto the carrier wave F_2 , and are transmitted through the output amplifier 75 and filter 76 to the power line. The modulated carrier wave travels over the power line to the called station and enters the receiving circuit 11 thereat. The modulated wave is transmitted by the filter 35 to the amplifiers 36, 37, and demodulated by the demodulator 38. The demodulated voice frequency currents are delivered to the receiver 41 through network 40. The direct current component of the demodulation products is fed back through the connections 47 to the gain control resistor 43 to maintain the demodulator output level at a preassigned value. At the same time, the feedback current energizes the relay 50 and causes closure of the normally open contact 51. Since at the called station, relay 29 would not be energized, contact 52 is closed and the amplifier detector circuit at the receiving station is short-circuited or disabled. The called or the listening party cannot intentionally or accidentally take control of his transmitting circuit by talking, or perhaps coughing, into his transmitter while transmission is incoming through the station. If the called or listening party were free to use his transmitting circuit, it is apparent that interference with transmission from the other station would result because of the presence on the power line of outgoing transmission from two stations on the same carrier wave. Since the receiving circuits of all of the stations in the system are normally energized when any two stations, or any one station and the central office have established a connection, the transmitting circuits in each of the other stations will be disabled during the talking period of such connections.

If the calling party had desired to call the operator at the central office instead of any telephone station on the line, the procedure would have been the same as described above; the operator responds to the central office signal by plugging her telephone set (not shown) into the jack 61. The operator, therefore, receives on carrier wave F_1 and transmits and signals on carrier wave F_2 . The operator may connect a power line telephone station and a party on an outside or general telephone system through conventional switchboard facilities.

The system described with reference to a power line transmission path is applicable also to a transmission path provided by a pair of telephone wires. If the line 100 comprised two conductors balanced with respect to ground instead of having one grounded as shown in the drawing, and a condenser 99 were inserted as indicated, such an arrangement would be realized. This would permit private or semiprivate service to be provided over an ordinary rural telephone line.

What is claimed is:

1. A carrier frequency telephone system comprising a telephone station coupled to a line, said station comprising a transmitting circuit for

transmitting on a high frequency electric wave, and a receiving circuit for receiving on another high frequency electric wave, said transmitting circuit being normally disabled and including voice energy operated means for enabling it, said receiving circuit being normally enabled and including an amplifier for an incoming modulated high frequency wave, a demodulator for demodulating the amplified modulated high frequency wave, a feedback connection from said demodulator to said amplifier, and means in said feedback connection for disabling the transmitting circuit enabling means during receiving by said receiving means.

2. A carrier frequency telephone system comprising a telephone station coupled to a line, said station comprising a transmitting circuit for transmitting on a high frequency electric wave, and a receiving circuit for receiving on another high frequency electric wave, said transmitting circuit being normally disabled and including voice energy operated means for enabling it, said receiving circuit being normally enabled and including an amplifier for an incoming modulated high frequency wave, a demodulator for demodulating the amplified modulated high frequency wave, means for disabling the transmitting circuit enabling means during receiving by said receiving circuit, and means for feeding back an output component of said demodulator to regulate the gain of said amplifier and to operate said disabling means.

3. A carrier frequency telephone system comprising a telephone station coupled to a line, said station comprising a transmitting circuit for transmitting on a high frequency electric wave, said transmitting circuit being normally disabled and including means to enable it for transmission to the line, and a receiving circuit for receiving on another high frequency electric wave, said receiving circuit being continuously enabled and including an amplifier for modulated high frequency electric waves incoming to the station from the line, a feedback connection from the output circuit of said amplifier to its input circuit, and means in said feedback connection for disabling the transmitting circuit enabling means during receiving by said receiving circuit.

4. A carrier frequency telephone system comprising a telephone station coupled to a line, said station comprising a transmitting circuit for transmitting on a high frequency electric wave, said transmitting circuit being normally disabled and including means to enable it for transmission to the line, and a receiving circuit for receiving on another high frequency electric wave, said receiving circuit being continuously enabled and including an amplifier for modulated high frequency electric waves incoming from the line, an amplifier gain control feedback connection from the output circuit of said amplifier to its input circuit, and means in said feedback connection for disabling the transmitting circuit enabling means during receiving by said receiving circuit.

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