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ELECTRIC WAVE TRANSMISSION SYSTEM

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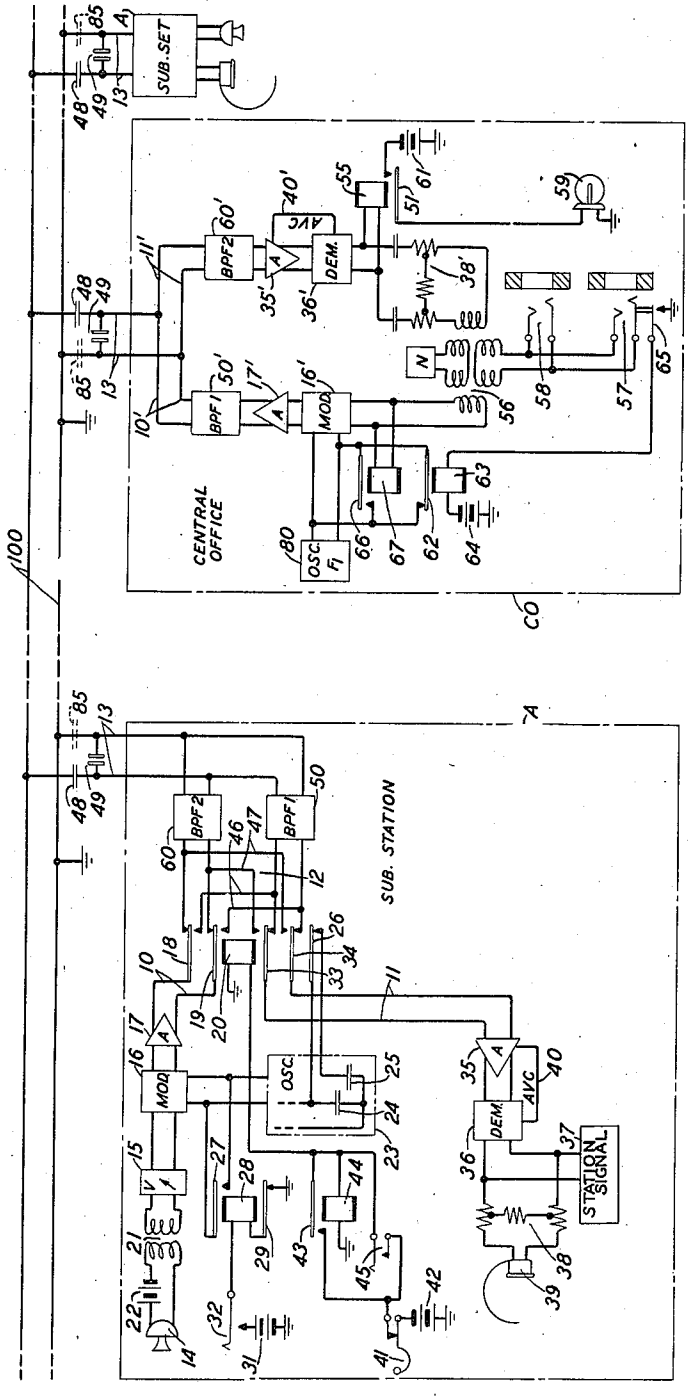

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ELECTRIC WAVE TRANSMISSION SYSTEM

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4 Claims. (Cl. 179—36)

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

An object of the invention is to improve and to simplify telephone communication over a transmission line, and, more specifically, over a power line.

In accordance with the invention, a plurality of telephone stations and a central office or operator's station for the telephone stations are coupled to a transmission line primarily intended for transmission and distribution of low frequency, high voltage electric power. Telephone communication, that is, signaling and conversation, takes place on two high frequency electric waves which, for convenience of description, will be denominated hereinafter as carrier waves of high frequency, F_1 and F_2. The system is arranged so that the telephone stations coupled to the line may call one another and carry on conversation without calling or going through the central office. Such calls may be referred to as local calls. The system is arranged, also, so that each power line telephone system subscriber may call, or be called by, a party on another or a general telephone system through the central office for the power line telephone system. Such calls may be referred to as toll calls.

In making local calls, the calling party signals the called party, in accordance with the preassigned signaling code for the system, on one of the high frequency waves, for example, on carrier wave F_1. Each station normally is in condition to receive such signals. After the called party has answered, the calling party transmits on the high frequency F_1 used for signaling, and receives on the other frequency, that is, on carrier wave F_2; the called party receives on carrier wave F_1, and transmits on the other high frequency wave. Each station, of course, is provided with a transmitting circuit and a receiving circuit, for modulating the signaling and the voice frequency current on the high frequency wave used for transmitting, and for demodulating the incoming modulated high frequency waves.

In making toll calls, the operator at the central station is signaled by the calling party on the carrier wave F_2, and conversation between the calling station and the central office takes place with the calling party transmitting on the carrier wave F_2 and receiving on the carrier wave F_1, and the operator transmitting on the carrier wave F_1 and receiving on the carrier wave F_2. When it is necessary for the operator to signal one of the stations in the power line telephone system, she does so on the high frequency wave F_1.

A more complete understanding of the invention will be obtained from the detailed description which follows read in connection with the appended drawing wherein the single figure shows a power line telephone system embodying the invention.

The single figure shows a power line carrier frequency telephone system comprising a line 100 primarily adapted for the transmission and distribution of low frequency, high voltage electric power and simultaneously used for high frequency or carrier wave telephony. A plurality of telephone stations A, two of which are shown and only one in detail, and a central office CO for the telephone station, are coupled to the power line. The latter is shown as a single phase line, one of whose wires is grounded; but it may be, of course, an insulated single phase line, or comprise a pair of phase wires of a multiphase system or other power line. Although only one telephone station is shown in detail, it will be understood that each of the telephone stations is the same, and operates in a manner similar to that now to be described.

The telephone station A comprises a high frequency transmitting circuit 10, a high frequency receiving circuit 11, a switching and filter circuit 12, and a coupling line 13. The transmitting circuit comprises a transmitter or microphone 14, a volume limiter or gain adjusting device 15, a modulator 16 and an output amplifier 17, and terminates at the armatures 18, 19 of the circuit switching relay 20. The transmitter may be of the granular carbon type, is coupled to the device 15 by a transformer 21, and is connected in series with the transformer primary winding and a source 22 of talking current. The modulator 16 may be of any suitable type employing either electron discharge devices or variable resistance devices, such as copper-copper oxide rectifier units. An oscillator 23 is associated with the modulator, and is adapted to generate the high frequencies or carrier waves F_1 and F_2 for signaling and transmitting purposes. The oscillator may comprise an electron discharge device circuit whose oscillation frequency determining circuit includes a pair of condensers 24, 25 connected, for example, in parallel. Condenser 25 is adapted to be removed from the circuit by the opening of the lower contact of the armature 26 of relay 20. With condenser 24 only in the oscillator's frequency determining circuit, the

oscillation generated would be, for example, the high frequency F_1. With both condensers in the circuit, the wave generated would be the high frequency F_2. The armature 27 and associated normally open lower contact of the relay or interrupter 26 are connected across the oscillator output. The interrupter 28 is adapted to vibrate at a suitable low frequency, for example, 20 cycles per second, and is provided with a lower armature 29 and associated normally closed lower contact connected to ground. Current to operate the interrupter is provided by source 31 through the normally open contact of the signaling key or push-button 32.

The receiving circuit is connected to the lower armatures 33, 34 of the relay 20 and comprises an amplifier 35, a demodulator 36, station signaling means 37, an attenuator network 38 and a telephone receiver 39. If desired, an automatic volume control connection 40 between the demodulator and amplifier may be provided to maintain the demodulator output at a preassigned level during receiving. The switchhook 41 is connected to a source 42 of current, and its normally open (shown closed) contact is connected to the normally open contact of the armature 43 associated with the relay 44 and to the normally open contact of the key or push-button 45. When the receiver 39 is removed from the hook 41, and the push-buttom 45 is closed, operating current for relays 20 and 44 is provided by the source 42. Relay 44 locks up through its armature 43 and associated contact, and provides an energizing circuit for relay 20 from source 42 until the receiver 39 is replaced on the hook 41.

The circuit 12 is a part of the transmitting and receiving circuit and comprises a pair of band-pass filters 50, 60. The filter 50 is adapted selectively to transmit either or both sidebands of the modulated high frequency or carrier wave F_1, and the filter 60 is adapted selectively to transmit either or both sidebands of the modulated high frequency or carrier wave F_2. Each filter is connected between the coupling line 13 and a pair of normally closed contacts associated with the relay 20, those of the filter 50 being the lower contacts associated with the armatures 33, 34, and those of the filter 60 being the upper contacts associated with the armatures 18, 19. Cross-connections 46 connect the filter 50 to the normally open lower contacts of armatures 18, 19, and cross-connections 47 connect the filter 60 to the normally open upper contacts of armatures 33, 34.

The coupling circuit 13 comprises a pair of conductors, one of which is coupled directly to the grounded wire of the power line and the other of which is connected through a condenser 48 to the non-grounded wire. If an insulated single phase power line or a pair of phase wires of a multiphase line are involved, a condenser should be connected in each coupling conductor. Instead of connecting the telephone station to the power line through a coupling condenser or condensers, the power distribution transformer located at the subscriber's premises could be employed for coupling purposes, for example, in the manner described and claimed in L. K. Swart, application Serial No. 359,879, filed October 5, 1940. In any event, a suitable protector 49 should be included in the coupling circuit to protect the subscriber and the station equipment against the hazards of high voltage arising on the power line.

The operation of the system in the making of a local call, that is, a call between two telephone stations on the power line, will now be described. Prior to the initiation of the call, the receiver 39 will be on the hook 41. Although not shown, it will be evident to the skilled in the art that additional switch contacts could be associated with the switchhook 41 and circuit connections provided so that, when the receiver is on the switchhook, the talking current circuit for transmitter 14 and the power supply circuits for the amplifiers 15 and 17 and the oscillator 23 would be interrupted and so that, when the receiver is removed from the switchhook, the talking current circuit for the transmitter 14 would be closed and also the circuits for the supply of power to the amplifiers 15 and 17 and the oscillator 23. The receiving circuit amplifier 35, however, would be energized at all times so that the station would be in condition to receive incoming signaling pulses for operation of the station signaling means 37; and so that a party on the line could ascertain if the system was in use by placing his receiver to his ear, while holding the switchhook down so as to avoid introducing a carrier wave onto the power line that might interfere with a conversation already taking place between other stations. As shown in the drawing, the telephone station is in condition for receiving on carrier wave F_1, and for transmitting on carrier wave F_2.

Let it be assumed that the power line is not being used for telephonic transmission by another party or parties on the line, and that the calling party is ready to initiate his call. The key or button 45 is depressed to cause relays 20 and 44 to operate on current from source 42, and to be held operated as a result of the closure of armature 43 and its associated contact. The filter 50 is connected through connections 46 to the armatures 18, 19 and, hence, to the transmitting circuit, and the filter 60 is connected through connection 47 to the armatures 33, 34 and, hence, to the receiving circuit. The armature 26 is disengaged from its associated contact to remove condenser 25 from the oscillator frequency determining circuit. The oscillator delivers a high frequency wave F_1 to the modulator and through the filter 50 to the line. The calling party then depresses or pushes key 32 the number of times and in accordance with the code prescribed for the system, to signal the desired station, to operate the interrupter 28. This causes armature 27 to vibrate in association with its normally open contact to modulate the carrier wave supplied to the modulator. The carrier wave is modulated at the signaling rate, and is transmitted through the filter 50 to the line, and passes over the line to all of the stations. At each telephone station the incoming modulater carrier wave F_1 is transmitted by the filter 50 to the receiving circuit, is amplified in amplifier 35, demodulated by demodulator 36 and operates the station signaling means 37. In answering, the called party removes his receiver from its switchhook and the called station circuit is the same as was that of the calling station before key 45 was depressed, that is, the called station is arranged to transmit on the carrier wave F_2 and to receive on the carrier wave F_1. When the called party answers, the calling party talks into the transmitter 14, the audio frequency current corresponding to the sound waves that are developed in the transformer 21 are suitably amplified in the device 15 and transmitted to the modulator to modulate the carrier wave F_1 in accordance therewith.

The modulated carrier wave passes through the output amplifier 17 and the filter 50 to the power line and over the latter to the called station. Since the called station transmits on the carrier wave F_2, transmission incoming to the calling station will comprise a modulated carrier wave F_2 which is transmitted through the filter 60 to the receiving circuit. The incoming wave is amplified in the amplifier 35, demodulated by the demodulator 36 and the demodulation components will be transmitted through the network 38 to the telephone receiver 39. The network 33 is provided to equalize for the lower transmission level required for listening compared to that required for operation of the station signaling means 37. When the conversation has terminated, replacement of the receiver on the switchhook 41 results in the deenergization of the relays 29 and 44 and the restoration of the station circuit to its original condition in which it is adapted to receive on the carrier wave F_1.

Before describing the manner in which a toll call may be made by a telephone station of the system, the circuit arrangement and equipment at the central office will be described. The central office is provided with a transmitting circuit 16' and a receiving circuit 11' coupled to the power line through a coupling line 13. The receiving circuit comprises a band-pass filter 60' for selectively transmitting a modulated carrier wave F_2, an amplifier 35', a demodulator 36', a signaling current relay 55 and an attenuator network 38', the receiving circuit terminating in one winding of a hybrid coil and balancing network 56. The operator's cord (not shown) may be connected with the hybrid coil through the operator's line jack 57. A monitoring jack 58 is also provided to enable the operator to listen preparatory to signaling a telephone station to ascertain that the power line is not already in use by parties on the power line. An operator's signal lamp 59 is connected to the armature 51 associated with the normally open contact of relay 55, the contact being connected to a source of current 61. In the transmitting circuit between the hybrid coil 56 and the coupling line 13 are a modulator 16', a band-pass filter 50' for transmitting modulated carrier wave F_1 and an output amplifier 17'. An oscillator 30 is connected to the modulator and is adapted to generate the high frequency wave F_1. Normally, the oscillator is prevented from delivering its output to the modulator because of the short circuit provided by the armature 62 of relay 63 and its associated normally closed contact. The relay 63 is connected to current source 64 and to one spring 65 of the operator's line jack which has an associated normally open contact connected to ground. When the operator inserts the plug of her set in the line jack, ground is connected to the spring 65 and relay 63 operates to remove the short circuit on the high frequency supply to the modulator. The armature 66 and associated normally open contact of relay 67 are connected across the input to the modulator. The relay 67 is supplied with low frequency, for example, 20 cycles per second, signaling current through the operator's line jack. Operation of the relay 67 in accordance with the low frequency signaling current supplied by the operator, in accordance with the signaling code for the power line telephone system, results in the modulation of the carrier wave.

When the operator at the central office wishes to call a particular telephone station coupled to the power line 100, she ascertains that the line is not in use by listening through the monitoring jack. If the line is available, she plugs her set into the line jack thereby operating relay 63 and enabling the oscillator to furnish the carrier wave F_1 to the modulator 16'. Ringing current is supplied to the relay 67 and the carrier wave is modulated thereby. The signal modulated wave is transmitted by the amplifier 17' and the filter 50' through the coupling line to the power line. This modulated wave will be received at all of the telephone stations which, as already indicated, are arranged normally to receive on the carrier wave F_1. At the telephone station the modulated wave is transmitted by the filter 50 to the receiving circuit 11, and, after amplification and demodulation, operates the signaling means 37. The called subscribed removes the receiver 39 from its hook and transmits to the operator on carrier wave F_2 supplied by oscillator 23, the button 45 remaining unoperated. Conversation may be carried on between the called subscriber and the operator, or through a cord circuit at the central office with a party on another telephone system as in the case with two stations coupled to the power line, except that transmitting from the station is on frequency F_2 and receiving thereat is on frequency F_1. When a power line telephone system subscriber wishes to call the operator, he removes his receiver from its hook and signals the operator by use of the key or button 32. Operation of interrupter 28 modulates carrier wave F_2 and the modulated carrier wave is transmitted through filter 60 to the power line and received at the central office through its receiving circuit 11'. The output of the modulator 36' is supplied to the relay 55 resulting in the operation of the signal lamp 59 to provide a visual indication to the operator.

The system described is not limited to use with a power line. It could be employed, for example, in conjunction with an ordinary rural telephone line to give private line or semiprivate line service. In such a case, the line 100 would be balanced with respect to ground, and a condenser 85 would be inserted in the connection between the telephone stations and what in the power line system described would be the grounded conductor.

What is claimed is:

1. A carrier frequency telephone system comprising a line and a plurality of telephone stations coupled to said line, and a central office for said stations coupled to the line, each of said stations comprising a transmitting circuit for transmitting on a high frequency carrier wave, and a receiving circuit for receiving on a high frequency carrier wave, and normally being arranged to transmit on a common carrier wave and to receive on a second common carrier wave, means to alter the normal arrangement of the station to enable it to transmit on said second common carrier wave and to receive on said first carrier wave, and means to signal another station on said second carrier wave and to signal said central office on said first carrier wave, and said central office comprising a transmitting circuit for transmitting only on said second carrier wave and a receiving circuit for receiving only on said first carrier wave, and means to signal a telephone station only on said second carrier wave.

2. A carrier frequency telephone system comprising a line and a plurality of telephone subscriber's stations coupled to said line, each sta-

tion comprising a transmitting circuit for transmitting on a high frequency carrier wave and a receiving circuit for receiving on a high frequency carrier wave, and normally being arranged to transmit on a common carrier wave and to receive on a second common carrier wave, said transmitting circuit including a filter for selectively passing said first carrier wave and said receiving circuit including a filter for selectively passing said second carrier wave, a source of said high frequency carrier waves, means for supplying the first carrier wave to the transmitting circuit, means for interchanging said filters in said circuit and simultaneously supplying the second carrier wave to said transmitting circuit, and means for signaling out of the station on either carrier wave.

3. A carrier frequency telephone system comprising a line, a plurality of telephone stations and a central office for said stations coupled to said line, each of said stations and said central office comprising a transmitting circuit for transmitting on a high frequency carrier wave, and a receiving circuit for receiving on a high frequency carrier wave, each of said stations normally being arranged to transmit on a common carrier wave and to receive on a second common carrier wave, said central office being arranged to transmit on said second common carrier wave and to receive on said first common carrier wave, means at each station to enable transmitting therefrom on said second common carrier wave and to enable receiving thereat on said first common carrier wave, means at each station for signaling the other stations on said second carrier wave and for signaling the central office on said first carrier wave, and means at said central office for signaling said stations on said second carrier wave.

4. A carrier frequency telephone system comprising a line, a plurality of telephone stations and a central office for said stations coupled to said line, each of said stations and said central office comprising a transmitting circuit for transmitting on a high frequency carrier wave and a receiving circuit for receiving on a high frequency carrier wave, each of said stations normally being arranged to transmit on a common carrier wave and to receive on a second common carrier wave, said transmitting circuit including a filter for selectively passing said first carrier wave and said receiving circuit including a filter for selectively passing said second carrier wave, a source of the carrier waves at each station, means for supplying the first carrier wave to said transmitting circuit, and means for interchanging said filters in said circuit and simultaneously supplying the second carrier wave to said transmitting circuit, said central office being arranged to receive only on said first carrier wave and to transmit only on said second carrier wave, a source of said second carrier wave at said central office, means at each station for signaling the other stations on said second carrier wave and for signaling the central office on said first carrier wave, and means at said central office for signaling said stations on said second carrier wave.

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