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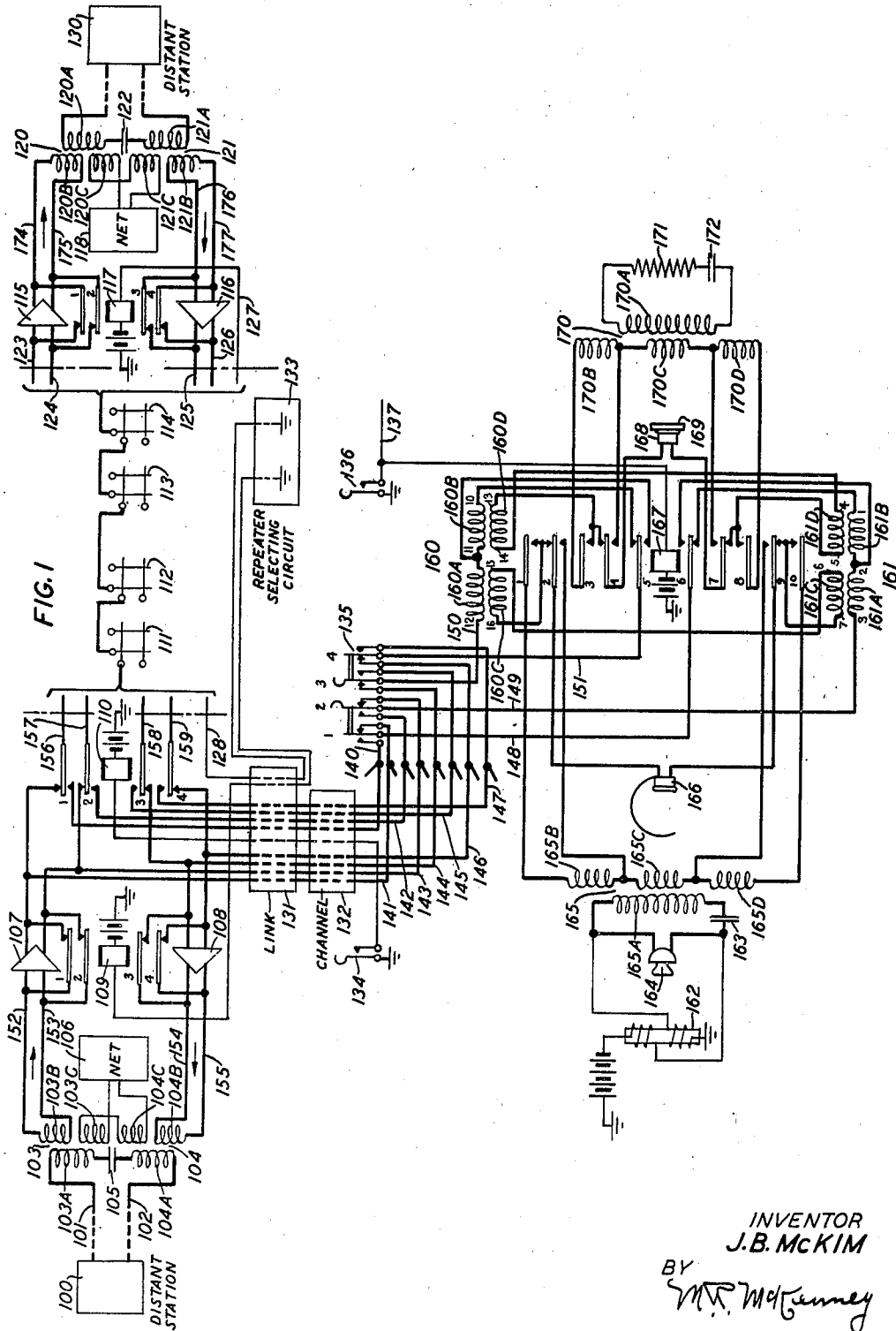
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2,294,237

TELEPHONE CIRCUIT

Filed June 5, 1940

2 Sheets-Sheet 1



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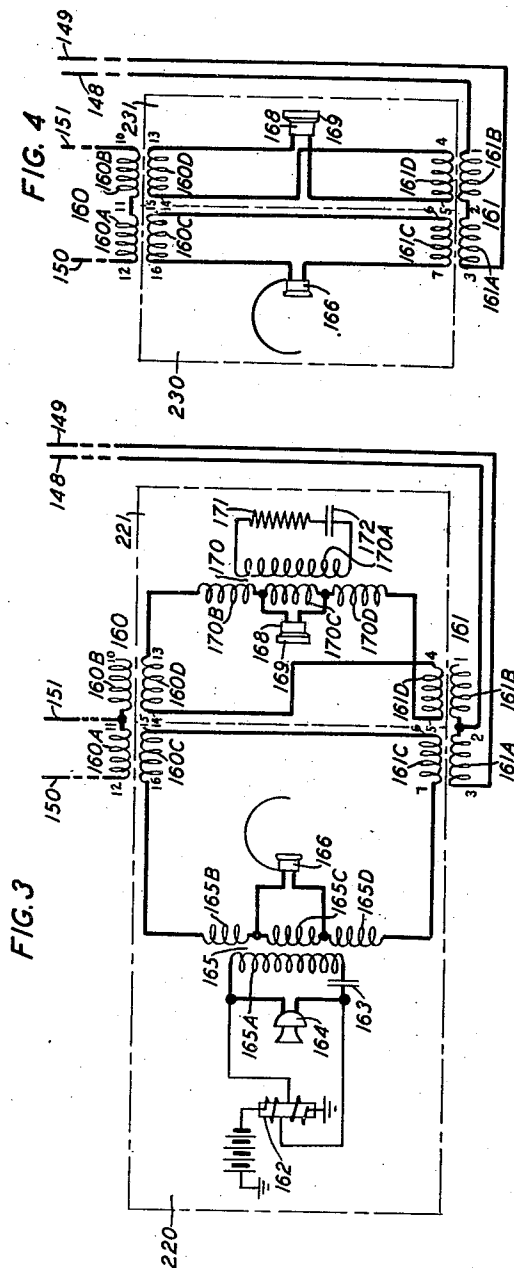
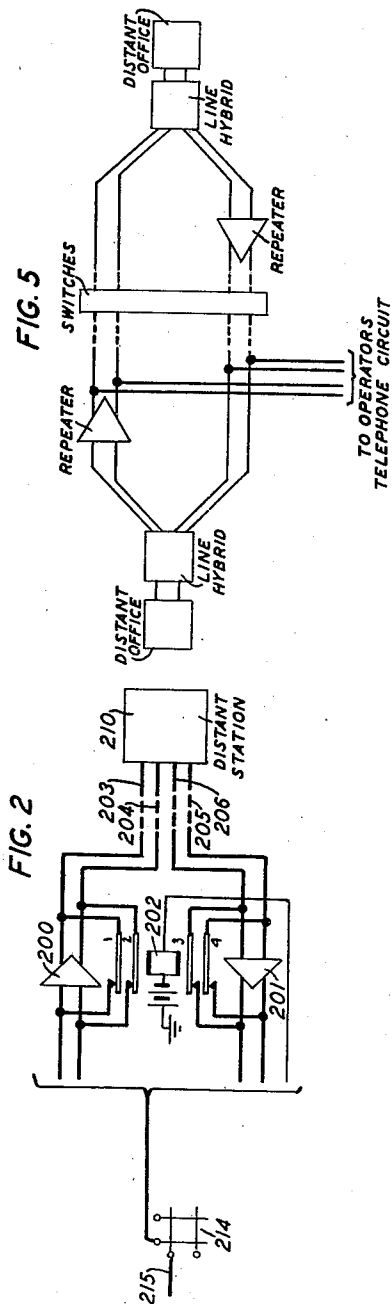
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TELEPHONE CIRCUIT

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Application June 5, 1940, Serial No. 338,888

11 Claims. (Cl. 179—27)

This invention relates to telephone circuits and particularly to operators' circuits for use in four-wire telephone systems.

In a four-wire telephone system the trunks from other offices or stations may enter a telephone office on a four-wire basis or may enter the office on a two-wire basis and terminate in the windings of hybrid coils. These coil windings serve to connect a balancing network with the two-wire trunks and connect the two-wire lines with the two channels of a four-wire trunk extending through the office trunk equipment, repeaters, switches and other equipment of the office. The latter trunk connection having hybrid coils for connecting two-wire trunks with four-wire lines may be of the character shown in Patent 2,024,592 to J. B. McKim of December 17, 1935. Voice frequency current amplifying repeaters are usually available for each two-wire channel through automatic selecting equipment associated with both the incoming trunk circuit and the outgoing trunk circuit. Repeater may be selected for the channels of both incoming and outgoing trunks when these trunks are of sufficient length to warrant their use. For some connections the incoming trunk is of sufficient length to warrant the use of repeaters therewith but the outgoing trunk is not of sufficient length to warrant the insertion of repeaters. For other connections repeaters are only selected for the outgoing trunk and for other connections they are not selected for either the incoming or the outgoing trunk. It is well known that the voice amplifying repeater used for such lines permits voice frequency current transmission in one direction only and therefore repeaters in both channels of a four-wire system are arranged for transmission in one direction over one two-wire channel and in the other direction over the other two-wire channel. The trunk hybrid coils which connect two-wire trunks to four-wire trunks are arranged for the latter type of transmission and for transmission through the hybrid coil windings associated with both channels when repeaters are not inserted in these channels. The transmission in opposite directions over line channels having repeater therein is through different windings or sets of windings in the trunk hybrid coils.

The object of the present invention is to arrange an operator's telephone circuit for connection with the four wires of this system to function for talking and listening to either or both of two connected parties in a manner to prevent voice frequency current interferences.

The operator's telephone circuit for this system is arranged for connection with both two-wire channels through hybrid coil windings bridged across each of the two-wire channels between the points where repeaters are inserted when required. Other hybrid coil windings are associated with the telephone circuit transmitter and receiver equipment and the telephone circuit balancing networks.

A feature of the invention is in devising a telephone circuit for a four-wire telephone system arranged to connect an operator's telephone set and balancing network with the two-wire channels of a four-wire system through the windings of a hybrid coil combination so arranged that the telephone circuit may be used for monitoring or conversing including listening over either two-wire channel having repeaters in one or both channels of both the incoming and outgoing trunks, or repeaters in one or both channels of either the incoming or the outgoing trunks with no repeaters in the channels of the alternate trunk, or lines having no repeaters in the channels of either the incoming or the outgoing trunks.

Another and related feature is in connecting an operator's telephone circuit to both two-wire channels of a four-wire telephone system and in so arranging the hybrid coil windings of the telephone circuit that voice current power from conversation by a telephone party over one two-wire trunk having a repeater therein creates a current flow in the operator's headset circuit and the balancing network in a direction to nullify current flow from this circuit to the second two-wire channel of the four-wire trunk system to prevent voice frequency interference in the alternate two-wire channel.

Another and related feature resides in adjusting the telephone circuit operator's equipment and the telephone circuit balancing networks for monitoring, or for conversing with a telephone party including listening, over either or both two-wire channels with or without repeaters therein and in having the windings of the hybrid coils so related that power from one two-wire channel is not transmitted in the form of electrical currents over the alternate two-wire channel.

Another and related feature resides in a balancing network for an operator's telephone circuit for monitoring or listening during conversation having a telephone receiver equivalent to the operator's receiver damped by a pad which is equivalent to the human ear.

These and other features will be discussed more fully in the following description.

To illustrate the features of the invention reference may be had to the accompanying drawings in which:

Fig. 1 illustrates a distant calling office or station and a distant called office or station associated through two-wire lines and hybrid coils with the equipment of a four-wire toll telephone office. This equipment includes an incoming trunk and an outgoing trunk with associated connecting switches, an operator's position having a telephone circuit therein and link equipment for associating the telephone position equipment with the incoming trunk;

Fig. 2 illustrates a distant office connected directly over a four-wire trunk line with the equipment of a telephone office as illustrated in Fig. 1;

Fig. 3 is a diagrammatic illustration of the telephone circuit adjusted for talking and listening while talking;

Fig. 4 is a diagrammatic illustration of the same telephone circuit adjusted for monitoring; and

Fig. 5 illustrates a four-wire system arranged for introducing a repeater in one channel only in the incoming and outgoing trunk circuits.

Line connections

The upper portion of Fig. 1 illustrates two distant offices or stations interconnected by an incoming trunk at the left, an outgoing trunk at the right and cross-bar switches 111, 112, 113 and 114 within the automatically operable telephone office. It may be assumed that the call is initiated by a toll operator in a distant toll office 100 who energized the usual incoming trunk signaling equipment for obtaining the services of the cordless toll operator in the automatically operable telephone office shown. This automatically operable office may be the same as fully disclosed in patent application to G. V. King, J. B. McKim and O. Myers Serial No. 295,010, filed September 15, 1939 issued as Patent 2,236,246, March 25, 1941. As fully disclosed in the aforementioned patent, after appropriate signals have been transmitted in both directions the calling operator in station 100 gives the cordless toll operator the designation of the distant party that is wanted. In toll service this wanted party may be connected to the equipment in another distant toll office.

The cordless toll operator thus energizes the sender and marker associated with her position for selecting an idle outgoing trunk to the designated office shown as office 130 connected to the telephone exchange over a two-wire trunk line circuit. This office may, however, be connected to the selected outgoing trunk over a four-wire trunk line as shown in Fig. 2. After the trunk to this office is selected by the marker the equipment in the marker is adjusted to operate switches such as switches 111, 112, 113 and 114 for connecting the outgoing trunk equipment with the calling incoming trunk equipment.

Unidirectional voice amplifying repeaters are diagrammatically shown in the incoming trunk and the outgoing trunk. Repeaters 107 and 108 are in the incoming trunk circuit and repeaters 115 and 116 are in the outgoing trunk circuit. The use of amplifying repeaters in either the line incoming from a distant office or outgoing to a distant office depends upon the character of the line. The character of the line is indicated to the control apparatus which automatically selects repeaters for each channel of the four-wire

system when repeaters are required. The automatic selecting apparatus for repeaters may be as fully disclosed in the patent application to A. J. Busch and F. J. Scudder, Serial No. 295,012,

filed September 15, 1939. It will be found by referring to the above patent application that a link such as diagrammatically disclosed at 131 is energized for automatically selecting repeaters. After the selection of the repeaters a relay such as 109 in the incoming trunk or 117 in the outgoing trunk is operated by the action of the repeater selecting equipment. The energization of either of these relays opens the contacts which normally exclude repeater circuit paths from the channels of the trunk circuit. In some instances connections will be established which do not have repeaters in either the incoming trunk or the outgoing trunk, in which case the four-wire channels are used in the same manner as a two-wire channel would be used. For example, the voice frequency currents from distant office 100 would pass through the trunk hybrid coils and energy would be transmitted through hybrid coil windings 103A and 104A which would create equal current in windings 103B and 104B and in both channels of the four-wire circuit, thence over contacts 1 and 2, 3 and 4 of relay 109, contacts 1 and 2, 3 and 4 of relay 110, contacts of switches 111, 112, 113 and 114, contacts 1 and 2, 3 and 4 of relay 117, windings 120B, 121B, 120A and 121A, over the two-wire trunk to distant office 130.

Other connections may have unidirectional repeaters in the incoming trunk line but not in the outgoing trunk line. This is done when the incoming line is long and the outgoing line is short, for example, where the outgoing line is extended to an office within the area of the toll center. Under this circumstance the voice frequency currents created by a subscriber or telephone operator would extend to the equipment in office 100 over trunk conductors 101 and 102 through the hybrid coil windings 103A and 104A, thence through hybrid coil winding 103B, repeater 107, contacts 1 and 2 of relay 110, over the upper channel switch contacts, conductors 123 and 124, contacts 1 and 2 of relay 117, hybrid coil winding 120B, hybrid coil windings 120A and 121A to an operator or a subscriber connected with office 130. The incoming voice frequencies through hybrid coil winding 104A extend through hybrid coil winding 104B but are blocked by repeater 108 and are thus not transmitted over this lower channel. The voice frequency currents created by a subscriber or operator connected with office 130 travel over the alternate channel. This current is transmitted over the two conductors of the trunk through hybrid coil windings 120A and 121A, thence through hybrid coil winding 121B over contacts 3 and 4 of relay 117, conductors 125 and 126, lower channel switch contacts, conductors 158 and 159, contacts 3 and 4 of relay 110, repeating coil 108, winding 104B, windings 103A and 104A, trunk conductors 101 and 102 to the distant subscriber or operator connected with the equipment in office 100. The voice frequency currents from the subscriber associated with office 130 are also transmitted through hybrid coil windings 120A and 120B, thence over conductors 174 and 175, contacts 1 and 2 of relay 117, conductors 123 and 124, 156 and 157, contacts 1 and 2 of relay 110 to repeater 107. At this point the voice frequency currents are blocked and are transmitted no further in the direction of office 100. The relation of these current paths with the telephone circuit which

is connected to the four wires of the two telephone channels will be discussed later. The above conditions may also apply to a connection when repeaters are inserted in the outgoing trunk line and not in the incoming trunk line. It is apparent that in this case the voice frequency current flow with relation to the telephone circuit equipment is quite different, which will also be discussed later.

Other telephone connections have repeaters inserted both in the incoming trunk line and in the outgoing trunk line. As previously described, in this case both relays 109 and 117 are operated for inserting the repeaters in both channels of the incoming trunk and the outgoing trunk circuits. For a gain of this character the voice frequency currents are transmitted from office 100 through hybrid coil windings 103A, 104A and 103B, repeating coil 107, repeating coil 115, hybrid coil windings 120B, 120A and 121A to the distant office 130. The voice frequency currents in this direction also extend through hybrid coil winding 104B but are blocked by repeater 108 in the alternate channel. The voice frequency currents transmitted from office 130 are transmitted through hybrid coil windings 120A, 121A and 121B, repeating coil 116 and repeating coil 108, hybrid windings 104B, 104A and 103A to the operator or subscriber associated with office 100. These voice frequency currents are also transmitted through hybrid coil winding 120B but are blocked by the voice frequency repeater 115 in the alternate channel.

Operator's telephone circuit

All of the above connections are automatically established as previously stated when the cordless toll operator sets control apparatus for completing a telephone connection. As set forth in the aforementioned application to King et al., the initiation of a call from an operator in the distant office 100 energizes the equipment in an incoming trunk circuit which automatically energizes a link diagrammatically shown as 131 for associating the incoming trunk circuit through a channel such as 132 with an idle cordless toll operator's position. The equipment of the incoming trunk circuit also actuates a signal in this cordless toll operator's position to indicate to the operator the type of call entering a channel in the position. A tone is transmitted to this cordless operator to indicate that the equipment in the position and the incoming trunk circuit has been operated and is in readiness for transmission between the operator at the calling station and the cordless position operator. Relay 167 is either automatically operated over lead 137 in response to the operation of other cordless position apparatus or is operated manually from key 136 for adjusting the operator's telephone circuit from the monitoring condition shown diagrammatically in Fig. 4 to the talking and listening condition shown diagrammatically in Fig. 3. The cordless position operator then requests the designation of the wanted party and sets a group of keys for operating a control device. During the conversation between the cordless operator and the operator in office 100 no repeaters have been inserted in the channels regardless of whether a long or short trunk is associated therewith and consequently the trunk circuit paths are as shown through the contacts 1, 2, 3 and 4 of relay 109. The voice frequency currents are thus transmitted from office 100 through the hybrid including coils 103 and 104 over both four-wire channels of the

trunk circuit, leads 141, 143, 144 and 146 to the operator's telephone circuit and from the operator's telephone circuit over the same channels to the operator in the distant office 100. After the cordless operator has received instructions from the operator in office 100 and has operated her key-set the equipment of this incoming trunk circuit automatically transmits what are known as "class signals" to the control circuit which indicates to the control circuit the character of the incoming trunk line and associated equipment. At this time a control circuit may operate relay 109 for inserting repeaters in the channels of the four-wire system. This immediately alters the direction of flow of the voice frequency currents. Thereafter with relay 167 operated the voice frequency currents from the distant station 100 flow through the hybrid coil winding 103B, repeater 107 to the operator's telephone circuit over conductors 141 and 143, contacts 1 and 2 of key 135, conductors 148 and 149 and through hybrid coil winding 161A of the telephone circuit hybrid. The voice frequency currents from station 100 are blocked in the lower channel by repeater 108. The voice frequency currents created by the cordless position operator flow through transmitter 164, windings 165A, B and D of transformer 165 and windings 160C and 161C of the telephone circuit hybrid. The transmitter circuit includes a local battery supply extending through windings of retardation coil 162. The voice frequency power generated in the hybrid coil winding 161A is transmitted over conductors 148 and 149, through contacts 1 and 2 of key 135, conductors 141 and 143 to repeater 107 where it is blocked. The voice frequency power generated in the hybrid coil winding 160A extends over conductors 150 and 151 through contacts 3 and 4 of key 135, conductors 144 and 146, repeater 108, thence over conductors 154 and 155, trunk hybrid coil winding 104B, windings 103A and 104A, over trunk conductors 101 and 102 to the operator's telephone circuit in distant office 100. This gives the directions of voice frequency current transmission between the telephone office 100 and the cordless telephone operator's position circuit with and without repeaters inserted in the two channels of the incoming trunk circuit.

The outgoing trunk in the right portion of Fig. 1 is selected and connected to the incoming trunk by switches 111, 112, 113 and 114 and also connected to the apparatus of the distant office or station 130 before any voice frequency currents pass over the channels of this trunk. If repeaters are required in the outgoing trunk, these are also inserted before voice frequency current passes over the channels. The voice frequency current flow between an operator at station 130 and an operator at station 100 has already been discussed. Conversation between the cordless toll operator and the operator at station 130 is required when difficulty is encountered, when an incorrect connection has been made or sometimes to give the distant operator the designation of a wanted party. Therefore the operator's telephone set, Fig. 1, may be associated with the operator's equipment in station 130, for talking and listening to the operator in station 100 and for monitoring after a telephone connection is completed over the channels of the four-wire system either having no repeaters in the channels or with repeaters in these channels.

The operator's telephone circuit for this four-wire system may be divided into the following parts as diagrammatically shown in Figs. 3 and 4.

1. Monitoring headset including the operator's receiver and hybrid coil windings.

2. Monitoring balancing network including a receiver like the operator's receiver damped by a pad to simulate the human ear and hybrid coil windings.

3. Talking and listening headset including the operator's receiver, transmitter, the telephone set induction coil for coupling the receiver circuit and transmitter circuit and hybrid coil windings.

4. Talking and listening balancing network including the receiver like the operator's receiver damped by a pad to simulate the human ear, a resistance and capacity element to simulate the transmitter and associated equipment, an induction coil for coupling the receiver network to the transmitter network and hybrid coil windings.

5. A relay 167 for adjusting the telephone circuit from the monitoring condition 1 and 2 to the talking and listening condition 3 and 4 or the reverse, depending upon the wiring connections of this relay. The relay may be wired so that in its normal position the talking and listening headset and balancing network are connected to the four wires of the channels and when operated it associates the monitoring set and network with the four wires of the channels. This relay also adjusts the hybrid coil windings of the telephone circuit which are bridged across the two-wire channels so that two windings are bridged across each channel for monitoring and one winding is bridged across each channel for talking and listening. The second winding is added during monitoring to prevent a noticeable change in the transmission of the parties talking over the telephone lines.

Current flow in telephone circuit and networks

The current flow in the operator's telephone set during monitoring of the various types of line connections will first be considered. It will be assumed that the telephone set has been associated with the two channels of a line comprising an incoming trunk and an outgoing trunk both of which have voice frequency repeaters therein. That is, both relays 109 and 117 have been operated to include the repeaters in each channel of the incoming trunk and the outgoing trunk. It will also be assumed that voice frequency current is being transmitted from station 100 to station 130. The voice frequency current flow will pass through hybrid coil windings 103A and 104A which create a current flow through hybrid coil winding 103B, repeater 107, repeater 115, hybrid coil winding 120B, hybrid coil windings 120A and 121A to the equipment in station 130. This current also flows to the cordless operator's telephone circuit over conductors 141 and 143 through key 135, conductors 143 and 149 through the telephone circuit hybrid coil windings 161A and 161B. The voice frequency current flow from station 100 through hybrid coil winding 104B does not reach the telephone circuit since it is blocked by the unidirectional repeater 108 which only transmits voice frequency current in the opposite direction. It will be remembered that during monitoring, relay 167 is not operated and therefore the current flow in the hybrid coil windings 161A and 161B is transmitted to the operator's receiver 166 in the telephone set 230 and through the network 231 as shown diagrammatically in Fig. 4. Since this current is an alternating current no polarity can be given in describing the current flow but a current flow in a given direction may be assumed

to give the effect upon the operator's telephone circuit network, the telephone set and the alternate channel. It may therefore be assumed that the current flow is from terminal 1 of hybrid coil winding 161B to terminal 2 and continuing through hybrid coil winding 161A to terminal 3. This creates a current flow in the network in the direction from terminal 5 to terminal 4 of hybrid coil winding 161D, thence from terminal 14 to terminal 13 of hybrid coil winding 160D through the network balancing receiver 168 to terminal 5 of hybrid coil winding 161D. The current flow in the operator's monitoring set is created in a direction from terminal 7 of hybrid coil winding 161C to terminal 6, terminal 15 of hybrid coil winding 160C to terminal 16, through the operator's receiver 166 to terminal 7 of hybrid coil winding 161C. It will be noted that the current flow in the network hybrid coil winding 160D is in the opposite direction to the current flow in monitoring winding 160C. Equal and opposing fluxes are created in windings 160C and 160D so that no current flows through the windings 160A and 160B which are bridged across the channel having repeater 108 therein. If voice frequency current were permitted to flow through windings 160A and 160B of the hybrid, this voice frequency current from conversation over the upper channel through repeater 107 would return over conductors 150 and 151 through contacts 3 and 4 of key 135, conductors 144 and 146, through repeater 108 and be transmitted in the opposite direction from whence it came, thus causing a noticeable disturbance in the line hybrid which is sometimes known as a voice frequency echo.

The same monitoring condition would prevail when voice frequency current is transmitted from a distant office or station 130 with repeaters 115 and 116 in the outgoing trunk channels. In this condition voice frequency current is transmitted through hybrid coil winding 121B, over the lower channel, repeater 116 and thence to the telephone circuit over conductors 144 and 146 through contacts 3 and 4 of key 135, conductors 150 and 151, through hybrid coil windings 160A and 160B. This is the opposite condition in the telephone circuit from the one previously described. Assuming now a current flow from terminal 12 of hybrid coil winding 160A to terminal 11 and through hybrid coil winding 160B to terminal 10, a current is created in the network hybrid coil windings 160D and 161D and the telephone set hybrid coil winding 160C and 161C. This current may be assumed to flow from terminal 15 to terminal 16 in hybrid coil winding 160C and from terminal 13 to terminal 14 in hybrid coil winding 160D. The hybrid coil windings of the network are so related that the current path through the network winding 161D is from terminal 4 to terminal 5 and in the operator's set hybrid coil winding 161C the path is from terminal 7 to terminal 6. This creates an equal and opposite flux and consequently no current flows through the hybrid coil windings 161A and 161B connected with the alternate channel of the four-wire line over conductors 148 and 149 through contacts 1 and 2 of key 135, conductors 141 and 143 to the upper channel as shown. Voice frequency current if permitted to flow through hybrid coil windings 161A and 161B would, of course, be blocked by repeater 107 but would be transmitted through the repeater 115 and hybrid coil winding 120B to create a voice frequency disturbance in the associated channel.

The monitoring condition may now be assumed

on a line connection having repeaters inserted in each channel of the incoming trunk circuit by the operation of relay 109 and an outgoing trunk circuit having no repeaters, in which relay 117 is normal as shown. In this case voice frequency current created by conversation over the trunk from office 100 would be transmitted through repeater 107 and over the upper channel to station 130 as described. When monitoring on this conversation the voice frequency current will flow to the operator's telephone circuit over conductors 141 and 143 which would create a circuit condition in the monitoring headset and network as previously described so that current will not flow from the telephone circuit hybrid coil combination through repeater 108 to the telephone office. The condition is different when voice frequency current is created by conversation in office 130. This voice frequency current flows through trunk hybrid coils over the lower channel through repeater 108, hybrid coil winding 164B to the distant office 100 and would be blocked in the upper channel by repeater 107. Current flow to the telephone circuit hybrid would, however, be transmitted through trunk hybrid coil windings 120B and 121B, thence over contacts 1, 2, 3 and 4 of relay 117, conductors 123, 124, 125 and 126, conductors 141, 143, 144 and 146, contacts 1, 2, 3 and 4 of key 135, conductors 148, 149, 150 and 151 through the telephone circuit hybrid coil windings 160A, 160B, 161A and 161B which are bridged across these channels. Voice frequency current is thus created in the telephone circuit which for this example may be assumed to flow through hybrid coil windings 160A and 160B from terminal 12 to terminal 10 and in windings 161A and 161B from terminal 1 to terminal 3. This current flow is thus in the same direction through the headset circuit from terminal 15 through hybrid coil winding 160C to terminal 16, through the operator's receiver 166, terminal 7 of hybrid coil winding 161C to terminal 6, since in this case the current flow through the hybrid coil windings bridged across the two channels enters the telephone circuit hybrid coil windings in opposite directions. The two voltages in the channel circuits associated with the network are equal and since the network coil windings are equal and opposing in direction with relation to the current flow no current flow is created in the network. Under this condition the network balances the line condition equally as well as under other conditions where voltage is generated therein.

After a telephone connection has been completed the cordless position operator may converse with either an operator or subscriber in office area 100 or an operator or subscriber in office area 130 by operating relay 167. Relay 167 associates the operator's transmitter 164, the operator's receiver 166 and the network with both channels of the four-wire system. In Fig. 3 the arrangement is shown diagrammatically with the operator's headset equipment for talking and listening in the rectangle 220, and the network for talking and listening in the rectangle 221. The cordless operator may talk to both parties when the two parties are connected together or may talk to one party or the other by separating the two parties. The parties are separated by the operation of key 134 which associates ground through the winding of relay 110 to battery. The operation of relays 110 and 167 associates the operator's telephone set with the incoming opera-

tor or party associated with office 100. With key 135 energized office 100 is cut off and the telephone circuit is associated through the inner contacts of relay 110, switches 111, 112, 113 and 114 with the office 130. Voice frequency current from the operator's telephone set is transmitted through both hybrid coil windings 160C and 161C. This produces a current flow in windings 160A and 161A which is transmitted to both channels of the four-wire system. When the cordless toll operator is talking in the direction of station 100, these voice frequency currents are transmitted through repeater 108 and thence over trunk conductors 101 and 102, but the voice frequency currents through the hybrid coil winding bridged across the alternate two-wire channel are blocked by repeater 107. If both offices 100 and 130 are connected together with relay 110 not operated the latter voice frequency currents would be transmitted through repeater 115 to the equipment in office 130. With key 135 energized and relay 110 energized, the voice frequency current flow is also transmitted through the telephone circuit hybrid coil windings, through repeater 115 to the distant office 130, but the voice frequency currents are blocked in the alternate channel by repeater 116. Under the same condition if no repeaters have been inserted in the channels the voice frequency current from the hybrid coil windings bridged across the alternate channels is transmitted over both the upper and lower channels through trunk hybrid coil windings 120B and 121B, trunk hybrid coil windings 120A and 121A to the distant office. This is also true in talking to the party at station 100 if repeaters 107 and 108 have not been inserted in the two channels of the four-wire system.

When the cordless operator talks to a party in office 100 or 130 the network shown in the rectangle 221 is arranged to perfectly balance the operator's headset circuit. This perfect balance is made possible by the feature of using a receiver 168 which is identical with receiver 166 and a pad 169 which is identical with the pad produced by the human ear against receiver 166.

The current flow conditions in the network 221 are similar to those described for the monitoring network 231. For example, voice frequency current from station 100 when repeaters have been inserted in the channels, flows through repeater 107 and is blocked by the repeater 108 in the alternate channel. The current flow therefore enters the telephone circuit over conductors 148 and 149 which creates a current flow in the operator's headset circuit in a single direction through hybrid coil windings 161C and 160C. The current flow in the network hybrid coil windings 161D and 160D is, however, in opposite directions which creates an equal and opposite current flow in the hybrid windings 160C and 160D. No power is created in the hybrid coil winding 160A and thus there is no current flow over the alternate two-wire channel associated with the conductors 150 and 151. If this current were permitted to flow over these conductors voice frequency current would pass through repeater 108, causing a disturbance in the trunk channel which would be apparent to the party talking from station 100. If no repeaters are in the upper and lower channels when a person is talking from station 100, the voice frequency current flows over both the channels through hybrid coil windings 160A and 161A bridged across these channels. The current flow through receiver 166 is in the same direction as before, thus creating

opposite and equal current flow in the network hybrid coil windings 160D and 161D. In this case no current flows in the balancing network. Assuming now that relays 167 and 110 are operated and key 135 is operated, a person talking from station 130 would create voice frequency current over the lower channel and through repeater 116, assuming that repeaters have been inserted in the outgoing trunk channels. This current is blocked by repeater 115. Thus the voice frequency current flows over conductors 125 and 126 through contacts 3 and 4 of relay 110, conductors 145 and 147, contacts 3 and 4 of key 135, conductors 150 and 151 through hybrid winding 160A. Assuming that the current flow is from terminal 12 to terminal 11 in the hybrid coil winding 160A, this current flow then would be in a direction from terminal 15 to terminal 16 in hybrid coil winding 160C, through the receiver 166 and associated windings of transformer 165, terminal 7 to terminal 6 of hybrid coil winding 161C. In this case a current is created in the network hybrid coil winding 160D from terminal 13 to terminal 14, terminal 4 to terminal 5 of hybrid coil winding 161D, windings of transformer coil 170 and receiver 168. The current created in hybrid coil windings 161C and 161D is thus equal but in opposite directions and does not create any power for current flow in hybrid coil winding 161A associated with the alternate channel. If no repeaters have been inserted in the outgoing trunk channels the voice frequency current flowing from station 130 would pass over both channels through contacts 1, 2 and 3, 4 of relay 117 and thus enter hybrid coil windings 160A and 161A of the telephone circuit. As previously stated, this creates a current flow through hybrid coil windings 160C and 161C for the operator's receiver 166, but creates an equal and opposite power in hybrid coil windings 160D and 161D and therefore creates no current flow in the network during this flow of voice frequency current from the station 130.

Fig. 2 illustrates a distant office 210 connected to the toll telephone office over a four-wire system. The trunk conductors 203, 204, 205 and 206 are thus directly connected between the two telephone offices. In this case no hybrid coil is required in the telephone office for associating an incoming trunk or an outgoing trunk with the telephone equipment of the office. The trunk in Fig. 2 has been shown as an outgoing trunk having relay 202 for automatically inserting repeaters in both channels the same as described for relay 117. This trunk is associated with an incoming trunk by the energization of switches the same as switches 111 to 114. A single switch 214 has been shown and conductor 215 would connect to a switch the same as switch 113. Voice frequency current from station 210 would enter the office in the same manner as described when a hybrid is used. The voice frequency currents from station 210 would be transmitted through voice frequency repeater 201 if repeaters are inserted in both channels. The voice frequency current from an office such as 100 or from a cordless position operator would be transmitted through voice frequency repeater 200. The two channels of this four-wire system are associated with the cordless operator's telephone circuit in the same manner as previously described where hybrid coils are used for connecting a two-wire line with the four-wire system in the telephone office and the effect of voice frequency currents is the same in the operator's telephone circuit

and reacts in the same manner as described for the aforementioned four-wire system using line hybrids.

The four-wire system diagrammatically shown in Fig. 5 may be assumed to be the same as shown in Fig. 1 with the exception that for the sake of economy repeaters are available for only one channel of the incoming and the outgoing trunk circuit. It is clear that the operator's telephone circuit herein disclosed functions in the manner described for this character of line.

What is claimed is:

1. In a telephone system, a telephone office, a trunk incoming to said office having two two-wire transmission channels, trunks outgoing from said office, means for establishing a conversational connection between said incoming trunk and one of said outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in said two-wire channels if required, an operator's telephone circuit for listening to said conversation, coils forming part of said telephone circuit independent of said channels having windings arranged for separately bridging the two wires of each of said channels, means for connecting said bridging windings to the wires of both of said channels, and means in the telephone circuit for preventing voice transmission from either channel to the alternate channel through said telephone circuit coils with or without repeaters in said channels.

2. In a telephone system, a telephone office, a trunk incoming to said office having two-wire transmission channels, trunks outgoing from said office, means for establishing a conversational connection between said incoming trunk and one of said outgoing trunks, voice repeaters normally disconnected from said trunks, means for connecting said repeaters in said two-wire channels if required, an operator's telephone circuit for listening to said conversation, coils forming part of said telephone circuit independent of said channels having windings arranged for separately bridging the two wires of each of said channels, means for connecting said bridging winding to the wires of both of said channels, and means in the telephone circuit including a balancing network cooperating with the bridged winding connected to both channels of said four-wire trunk to prevent voice transmission from either channel to the alternate channel through said telephone circuit with or without repeaters in said channels.

3. In a telephone system, a telephone office, a trunk incoming to said office having two two-wire transmission channels, trunks outgoing from said office, means for establishing a conversational connection between said incoming trunks and one of said outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in said two-wire channels if required, an operator's telephone circuit having an operator's headset circuit and a balancing network, and means to connect said telephone circuit to both said channels including hybrid coil windings in said headset circuit and network and windings bridged across the wires of each channel cooperating with the channels of said four-wire trunk to prevent voice transmission from either channel to the alternate channel through the telephone circuit.

4. In a telephone system, a telephone office, trunks incoming to said office having two-wire transmission channels, trunks outgoing from said

office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in any two-wire channels of the connected trunks if required, an operator's telephone circuit common to said trunk circuits and independent thereof, means for connecting said telephone circuit to the two wires of both channels of said trunks, and means in said telephone circuit for preventing voice transmission from either channel to the alternate channel through said telephone circuit with or without repeaters in the channels as required.

5. In a telephone system, a telephone office, trunks incoming to said office having two two-wire transmission channels, trunks outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, voice current amplifying repeaters for unidirectional transmission over said channels normally disconnected from said trunks, means for connecting said repeaters in any two-wire channels of the connected trunks if required, an operator's telephone circuit common to said trunk circuits and independent thereof having an operator's headset circuit and a balancing network, and means to connect said telephone circuit to both said channels between the points where the repeaters are inserted in the incoming and outgoing channels, including hybrid coil windings in said headset circuit and network cooperating with associated hybrid coil windings of said telephone circuit bridged across the wires of each channel to prevent voice transmission from either channel to the alternate channel through said hybrid coil windings, either with or without repeaters in said channels.

6. In a telephone system, a telephone office, trunks incoming to and outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming and outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in any two-wire channel of the connected trunks if required, an operator's telephone circuit common to said trunk circuits and independent thereof including a hybrid coil combination formed into the operator's headset circuit, a line balancing network and channel bridging circuits, means for connecting said channel bridging circuits to the wires of both channels, means for altering the connections of said headset circuit and network for talking and listening and for monitoring on a conversation over said four-wire trunk connection, the hybrid coil combination in said telephone circuit being so arranged as to prevent voice transmission from either channel to the alternate channel through said telephone circuit when connected for talking and listening or monitoring and with or without repeaters in said channels.

7. In a telephone system, a telephone office, trunks incoming to and outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, unidirectional voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in any two-wire channel of the connected trunks if required, a telephone circuit common to said trunk cir-

uits and independent thereof including a hybrid coil combination formed into the operator's headset circuit, a line balancing network and channel bridging circuits, means for connecting said headset and network through said hybrid coil windings with both channels of said connected trunks for listening to conversations in both directions, and means for connecting said telephone circuit through hybrid coil windings with both channels of either the incoming trunk or the outgoing trunk independent of the other for separately listening to conversations from either direction, said conversations over one channel creating voice currents in the telephone circuit hybrid coil windings in a direction to prevent voice current disturbances in the alternate channel.

8. In a telephone system, a telephone office, trunks incoming to and outgoing from said office, means for establishing a conversational connection between an incoming trunk and an outgoing trunk, an operator's telephone circuit having an operator's telephone headset circuit including a receiver and a balancing network having an identical receiver and a pad for said receiver simulating the pad produced by the human ear pressed against said receiver, and means for connecting said operator's telephone circuit with said trunks.

9. In a telephone system, a telephone office, trunks incoming to and outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, voice current amplifying repeaters for unidirectional transmission over said channels normally disconnected from said trunks, means for connecting said repeaters in any two-wire channels of the connected trunks, an operator's telephone circuit having an operator's telephone headset circuit and a balancing network, means including a hybrid coil combination for connecting said telephone circuit to the two wires of both channels through windings separately bridged to alternate channels, windings in said headset circuit and windings in said balancing network equal to the windings in said headset circuit for the transmission of voice currents through one bridged winding from its associated channel to the headset circuit and the balancing network, which creates current in the same direction through the hybrid coil windings of the headset and network associated with the channel over which the voice currents were transmitted but in opposite directions through the hybrid coil windings of the headset and network cooperatively associated with the hybrid coil winding bridged to the alternate channel which prevents the creation of electrical power in said latter bridged winding and prevents current flow in said alternate channel.

10. In a telephone system, a telephone office, trunks incoming to and outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in said two-wire channels as required, an operator's telephone circuit for listening to conversations over said channels and for talking over said channels comprising a hybrid coil combination formed into a headset circuit, a network arranged to balance the lines for either listening or talking over said lines and separate bridging windings for connection to the two wires of each channel, so-arranged that current from

one channel passing through one bridged winding creates current in the headset and network in such a direction that no current passes to the alternate bridged winding and that current from both channels passing through both bridged windings is neutralized in the network and thus creates no current flowing in said network.

11. In a telephone system, a telephone office, trunks incoming to and outgoing from said office having two two-wire transmission channels, means for establishing conversational connections between said incoming trunks and said outgoing trunks, voice current repeaters normally disconnected from said trunks, means for connecting said repeaters in the two-wire channels of said trunks as required, said trunks being so arranged that voice currents incoming from a station flow equally over both channels of a first trunk to the other connected trunk with the repeaters normally disconnected and flow over a single channel of the first trunk to the other connected trunk with repeaters connected in the two-wire channels of said first trunk, an operator's telephone circuit for listening to conversations over said channels and for talking over said channels, comprising a hybrid coil combination formed into said telephone circuit having windings bridging the two

wires of each channel between connected trunks so that voice currents flowing over both channels from a first trunk will flow equally through both said bridged windings and voice currents flowing over one channel will flow through only one bridge winding, said hybrid coil combination also being formed into a headset circuit and network of the operator's telephone circuit electrically coupled to said bridged windings, so arranged that voice currents from one channel passing through one bridged winding creates current in the headset circuit windings and network windings which is aiding in the windings coupled to said one bridged winding and opposed in the windings coupled to the bridged winding connected to the alternate channel to prevent voice transmission through said telephone circuit to said alternate bridged winding and said alternate channel and so arranged that voice currents from both channels passing through both bridged windings creates aiding current in the headset circuit windings coupled to both bridged windings and equal and opposite voltages in the network windings so that no current flows in the network thus preventing voice transmission through said telephone circuit to either channel.

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