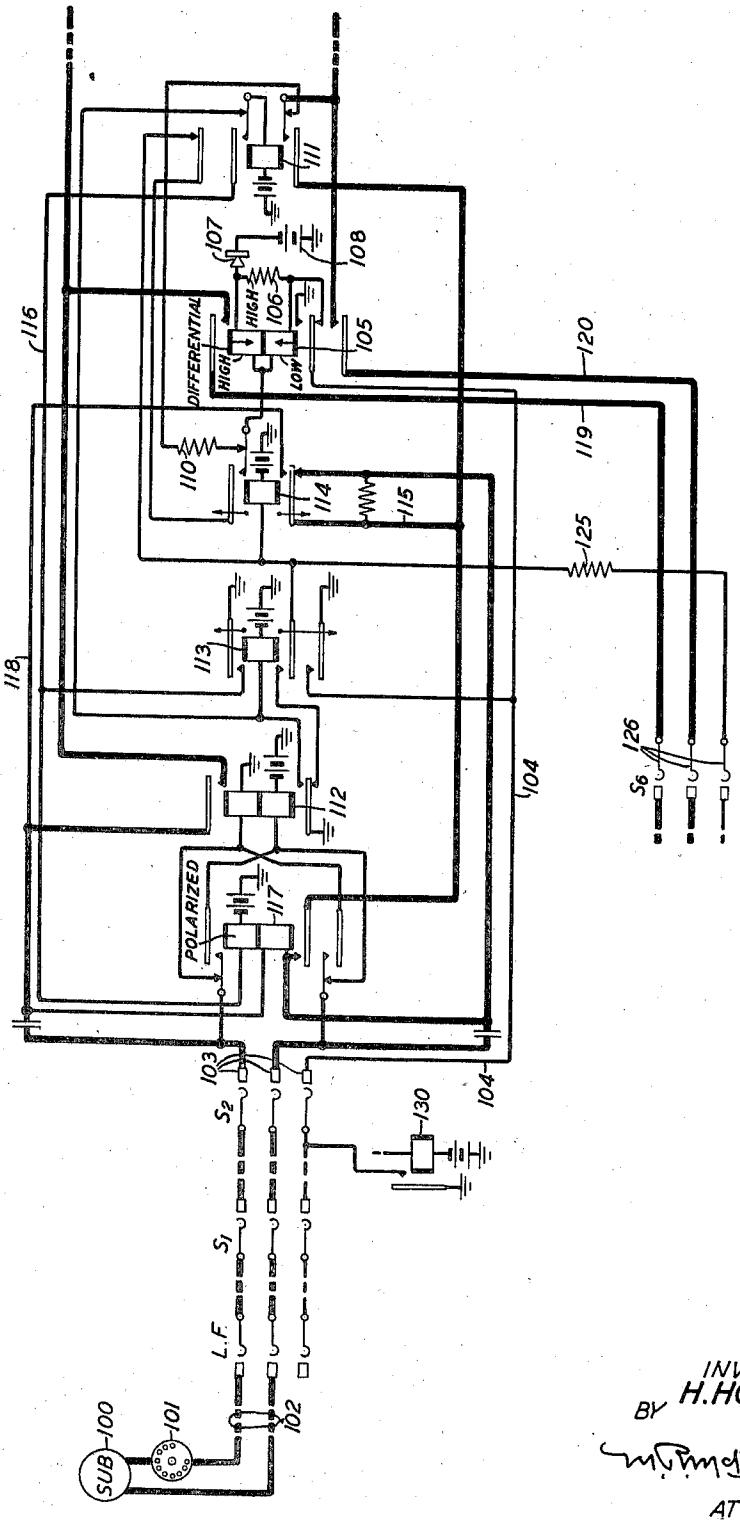
Dec. 14, 1937. H. HOVLAND 2,102,155

TELEPHONE SYSTEM

Filed June 25, 1936 2 Sheets-Sheet 1

FIG. 1



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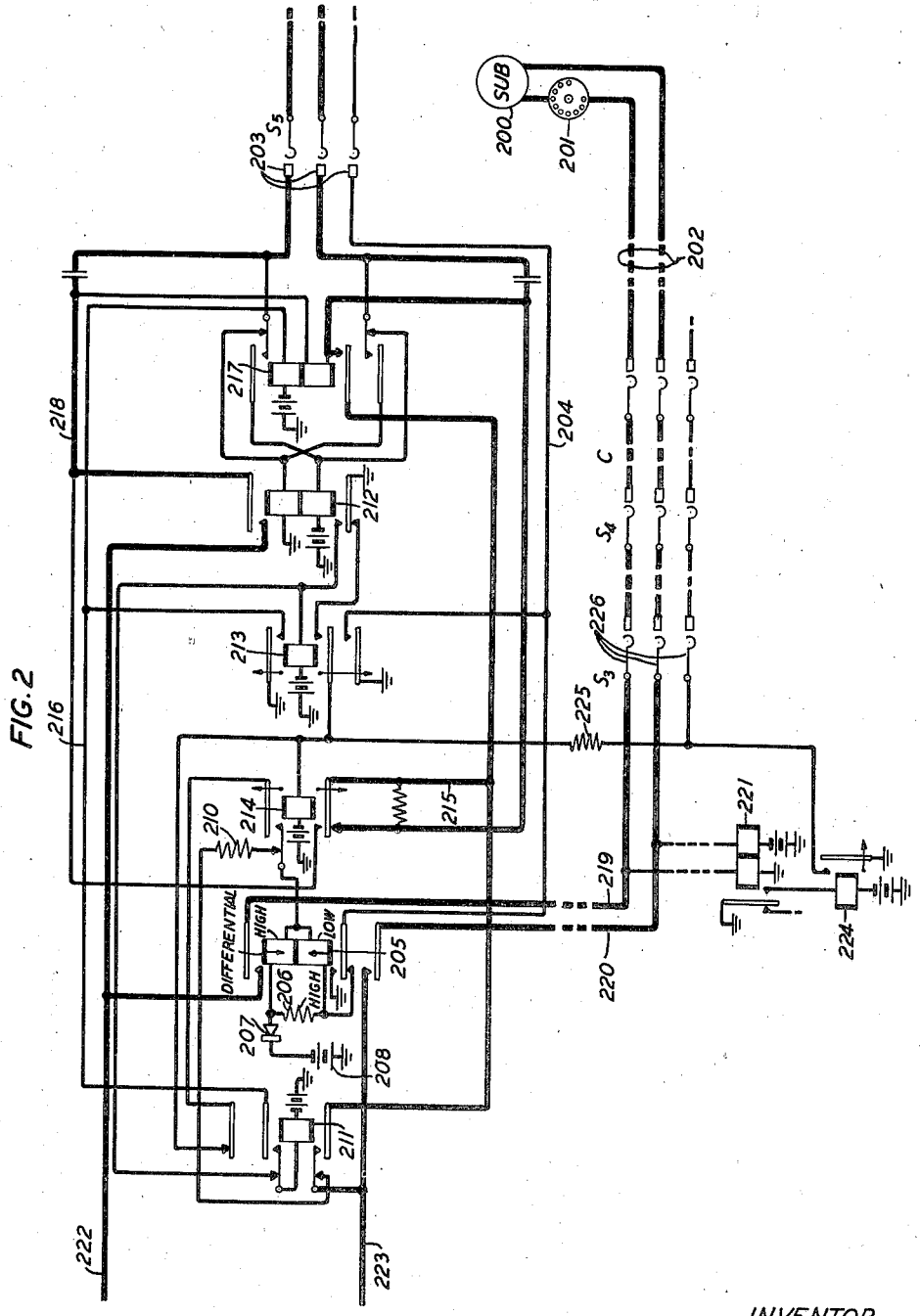

FIG. 2

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TELEPHONE SYSTEM

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7 Claims. (Cl. 179—16)

This invention relates to telephone systems and particularly to those employing automatic switches for establishing connections.

The object of the invention is to improve the efficiency of telephone equipments by reducing unguarded intervals and by minimizing the liability of double connections.

Where trunk circuits interconnecting two offices in a dial system are utilized for traffic in both directions, it is necessary to provide some form of busying or guarding means at each end so that when the trunk is seized at one end it will be become busy to the switches or other seizing means at the opposite end. Between the time the trunk is seized at one end and the time it is guarded at the opposite end it is liable to double seizure. Various ways have been proposed heretofore to reduce this unguarded interval.

According to a feature of the present invention, the unguarded interval of a two-way trunk is greatly reduced by an arrangement in which a circuit is closed directly from the switch that seizes the outgoing end of the trunk over a conductor of the trunk to the distant end, which circuit energizes the winding of a guard relay at the distant end of the trunk. This relay operates immediately and places a guarding condition on said trunk at the distant office. Also, it prepares the pulse receiving relay at the distant office, which relay operates and causes the guard relay to be held in a local circuit in order that it may be disconnected from the trunk to free the latter for the transmission of the impulses that follow immediately.

Another feature is a two-way trunk equipped at each end with a differential guard relay and having a guard circuit including both of said relays and one of the talking conductors of the trunk which is closed by the switch seizing the trunk at either end, the current flow through said relays being such that only the relay at the distant end of the trunk operates and in operating immediately renders the distant end of the trunk busy.

The foregoing and other features of the invention will be more fully described in the following detailed specification and will also be set forth in the accompanying claims.

Fig. 1 of the accompanying drawings show one end of a two-way trunk circuit arranged according to this invention and associated with conventional circuit representations of a calling subscriber's line and the usual line finder and selectors.

Fig. 2 shows the other end of the aforesaid two-way trunk circuit identical with the trunk of Fig. 1 and associated with conventional circuit representations of a called subscriber's line and the usual selectors and connector.

The invention will now be described in detail. Let it be assumed that the subscriber of station **100** desires to establish a telephonic connection with the station **200**. Stations **100** and **200** with the associated dials **101** and **201**, respectively, are not shown in detail but are represented conventionally. When the receiver at station **100** is removed from its switch-hook, a line finder LF establishes connection with the terminals of line **102** of station **100**. When the first two digits of the directory number of the subscriber of station **200** have been dialed with the dial **101**, the connection is thereby extended through step-by-step selectors S_1 and S_2 to the terminals **103** of the two-way trunk circuit of Fig. 1. Line finder LF and selectors S_1 and S_2 are of the well-known type found in step-by-step dial offices and are represented in an abbreviated conventional form. When selector S_2 seizes the terminals **103**, ground is connected to the sleeve conductor **104** by means of a relay in the selector, such as relay **130**. Current now flows from said ground through the lower back contacts and the differentially connected series windings of relay **105** through a rectifier **107** to battery **108**. The windings of relay **105** are shunted by the resistance **106**. The rectifier **107** is preferably of the well-known copper-oxide type, but any other rectifier of suitable characteristics may be used. It passes current in the direction of the arrowhead and blocks current in the opposite direction. Current also now flows from the positive ground of battery **208** of Fig. 2, through the intervening earth between the offices of Fig. 1 and Fig. 2 to the aforesaid ground on sleeve conductor **104**. From here the current continues through the lower back contacts and winding of relay **105**, upper back contacts of relay **114**, through compensating resistance **110**, lower back contacts of relay **111**, over the interoffice ring conductor **223**, through lower back contacts of relay **211**, compensating resistance **210**, upper back contacts of relay **214**, upper and lower windings of relay **205** in multiple, through resistance **206** and rectifier **207** to the battery **208**. Since current flows through the lower winding of relay **105** in one direction with respect to the upper winding and in the opposite direction through the lower winding of relay **205**, relay **105** remains inert, and relay **205** attracts its armatures. Due to the current from battery **208** flowing through the lower winding of relay **105**,

which current is added to that from battery 108, it is necessary to compensate for varying trunk conductor resistances between the two offices by so selecting the value of compensating resistance 116 as to obtain suitable non-operating margins for relay 105. It should also be pointed out here that the use of the rectifiers 107 and 207 as shown prevents a possible flow of current over the ring conductor between the two offices, when the trunk circuit is not in use, due to a difference of battery voltage or to earth potential effects. Relay 205 in operating connects ground with its lower inner front contacts to sleeve conductor 204, thereby causing, in accordance with a particular feature of this invention, the terminals 203 to test busy immediately to selectors hunting for an idle outgoing trunk. It is designed to operate quickly so as to reduce the unguarded interval. Relay 205 also connects with its upper and lower outer make contacts the tip and ring conductors 222 and 223 to conductors 219 and 220, which are connected to the corresponding tip and ring brushes 226 of the selector S_3. This prepares an initial circuit for relay 221 traceable from battery through the right-hand winding of said relay 221, conductor 220, lower contact of relay 205, conductor 223, thence as above traced through the lower winding of relay 105 to grounded conductor 104. Relay 221 operates in this circuit and operates relay 224, which in turn operates relay 214. The purpose of operating relay 214 is to provide a circuit for holding the relay 205 locally since its original operating circuit over the trunk will soon be opened by relay 111 to prepare for pulsing. The holding circuit for relay 205 may be traced from ground on the armature of relay 224, resistance 225, upper contact of relay 211, upper front contact of relay 214, windings of relay 205, rectifier 207 to battery. Thus relay 214 at its upper armature severs the original operating circuit and at the same time closes a local holding circuit for relay 205. By this arrangement the seizure of the trunk by selector S_2 results immediately in the operation of relay 205 to guard the trunk at the distant end and in the operation of impulse relay 221 and relay 214 to hold the guard relay 205 locally so the trunk can be free from the relay 205 when it is prepared a moment later for pulsing. Should for any reason the relay 111 operate before relay 214 operates, the relay 205 is held in a circuit traceable from ground through the left winding of relay 221, conductor 219, upper contact of relay 205, thence over the trunk conductor 222, through the bridge at the originating office, back over conductor 223, normal contacts of relay 211, resistance 210, contact of relay 214, windings of relay 205 to battery.

Immediately after selector S_2 of Fig. 1 seizes the terminals 103 as above explained, relay 112 operates over the circuit established by line finder LF and selectors S_1 and S_2 through the circuit of station 100 and dial 101. Relay 112 in operating, closes through, with its upper contacts, the trunk tip conductor and operates relays 111 and 113 in multiple through a circuit that is traceable from ground on the lower operated front contacts of relay 112, through the winding of relay 113 to battery and the upper inner normally closed break contacts and winding of relay 111 to battery. Relay 113 is designed to operate quickly so as to connect ground with its upper contacts to conductor 116, enabling relay 111 to lock up through its upper front contacts before its operating circuit before traced is opened by the break of its upper continuity contacts. Ground is also connected by the lower outer contacts of relay 113 to the sleeve terminal of selector S_2, thereby holding operated the preceding switches and guarding the terminals 103 against seizure by another selector. Relay 113 with its upper contacts also closes a circuit from ground through the upper winding of relay 117 to battery. The current flow through this winding, alone, however, is insufficient to operate relay 117. Through the lower winding of relay 117 another circuit is also closed at this time over the trunk line conductors between the offices of Figs. 1 and 2. This circuit is traced from battery through the right-hand winding of relay 221, over conductor 220, through the lower operated outer contacts of relay 205, over the ring trunk conductor 223, lower operated make contacts of relay 111, lower back contacts of relay 114, lower winding of relay 117, upper operated contacts of relay 112, over the tip line conductor 222, through upper operated contacts of relay 205, over conductor 219 and through the left-hand winding of relay 221 to ground. Relay 117, however, does not operate at this time since the currents through its upper and lower windings are magnetically in opposition to each other. Relay 221 is now held in the loop circuit just traced, and its initial operating circuit is opened at the contacts of relay 111.

The subscriber of station 100 will now dial the third digit of the called number. On the first break of the contacts of dial 101, relay 112 releases and opens with its upper make contacts the circuit hereinbefore traced through the lower winding of relay 117 and the windings of the pulse relay 221 of the selector S_3 of Fig. 2. Relay 112 in releasing also closes a circuit for operating relay 114, which is traced from ground on the lower back contacts of relay 112, lower inner operated contacts of relay 113 and winding of relay 114 to battery. Relay 114 in operating connects with its lower front contacts conductor 115 to tip conductor 118, thereby removing the lower winding of relay 117 from the pulsing circuit. Relays 113 and 114 are slow to release and during pulsing remain operated. Relay 221 follows the pulses of relay 112 and in well-known manner causes selector S_3 to establish connection with the terminals of selector S_4. After the third digit is dialed, relay 114 releases. When selector S_4 is seized by the brushes 223, relays 221 and 224 are released in well-known manner by the functioning of apparatus in selector S_4, and relay 214 is now held by sleeve ground from selector S_4. When the fourth, fifth and sixth digits are dialed, the apparatus of Fig. 1 functions in a similar manner to cause selector S_4 and connector C to extend the connection to the line of station 200.

When the subscriber of station 200 removes the receiver thereat, a relay in connector C operates and, in accordance with usual practice, reverses the direction of current flow over the tip and ring conductors. Since relay 114 releases after dialing the last digit of the called number, the circuit through the lower winding of relay 117 is re-established, and relay 117 now operates as the current through each winding is now magnetically aiding. Relay 117 in operating reverses the relation of the windings of relay 112 with respect to the line conductors extending through to the station 100 in order to establish in well-known manner a charge condition against station 100 or to give supervision to an operator when this is required. Relay 117 in operating short-

circuits with its lower inner make contacts the lower back contacts of relay 114, thereby assuring a more reliable conversational circuit path than would be obtained through the lower back contacts of relay 114 alone. The connection between stations 100 and 200 is now completed.

When the subscriber of station 100 hangs up the receiver thereat, when the conversation has been completed, relay 112 releases, releasing in turn relays 113 and 111. The release of relay 113 removes ground from conductor 104, thereby causing the release of the preceding switches, and opens the circuit through the upper winding of relay 117. The release of relay 112 also opens the circuit through the lower winding of relay 117 and the windings of the pulsing relay, not shown, in the connector C. This relay releases, releasing the associated preceding selectors, in accordance with the usual well-known arrangement. Ground is thereby removed from the winding of relay 214 which releases, releasing relay 205. All apparatus is now restored to normal.

The operation of the system will now be discussed for a call originating in the office of Fig. 2 and terminating in the office of Fig. 1. Let it be assumed that a calling subscriber, such as the subscriber of station 200, desires to call the subscriber of station 100. The line of station 200 is connected to a line finder and associated selectors, as shown in the case of the line of station 100, but not shown for the line of station 200. When the terminals 203 are seized by the brushes of selector S_5, ground from the selector is connected to sleeve conductor 204 and current flows from this ground, through the lower inner back contacts of relay 205, lower and upper windings of relay 205 in series, in multiple with resistance 206, through rectifier 207 to battery 208. Current also now flows from the positive ground of battery 108 through the intervening earth between the offices of Fig. 1 and Fig. 2 to the ground on conductor 204, thence through the lower inner back contacts and lower winding of relay 205, upper back contacts of relay 214, compensating resistance 210, lower back contacts of relay 211, thence over the ring conductor to the office of Fig. 1 and through the lower back contacts of relay 111, resistance 110, upper back contacts of relay 114, the upper and lower windings of relay 105, through resistance 106, and rectifier 107 to battery 108. As hereinbefore described in the case of the call from station 100 to station 200, relay 205 corresponding to relay 105 of the previous description does not operate due to the differential connection of its windings. Relay 105, however, operates due to the magnetically aiding action of the current in its windings, immediately connects a guarding ground to the sleeve terminal of selector S_2, and connects the tip and ring conductors to conductors 119 and 120, respectively. Connection is now established with the line of station 100 through incoming selectors, including selector S_6, and a connector, not shown, in the same manner as connection was established with the line of station 200.

The foregoing description is for a completed call. If, in the case of a call originating at station 100, it is found that the call to station 200 cannot be completed due to an all-trunks-busy or line-busy condition, the associated connecting switches transmit to station 100 a busy tone indication in the regular manner. When the receiver at station 100 is hung up, the circuit releases as before described. The system functions in a similar manner in the case of a call originating at station 200.

Although the switches illustrated herein are spoken of as switches of the usual step-by-step type, it is to be understood that the invention is not limited to systems using switches of this kind. Any suitable kind of switch may be used. Also the invention may be applied to trunks employed in systems where operators take part in the establishment of connections.

What is claimed is:

1. In a telephone system, a trunk circuit, means for seizing said circuit at either end, a guard circuit including one of the conductors of said trunk closed by said seizing means upon the seizure of one end of said trunk, and a relay in said guard circuit at the other end of said trunk having a contact for placing a busy condition upon said trunk at said other end.

2. In a telephone system, a trunk circuit, automatic switches for seizing said trunk at either end, a guard circuit including one of the conductors of said trunk, means in one of said automatic switches for closing said guard circuit upon the seizure of one end of said trunk, a relay in said guard circuit at the distant end of the trunk operable in response to the closure of said guard circuit, and a circuit closed by the contacts of said relay for applying a busy potential to said distant end of the trunk circuit.

3. In a telephone system, a two-conductor trunk circuit having an outgoing end and an incoming end, a switch for seizing said trunk at the outgoing end thereof, a second switch for seizing said trunk at the incoming end thereof, a guard relay at said incoming end of the trunk, a circuit including one of the conductors of said trunk closed by said first-mentioned switch upon the seizure of the outgoing end of said trunk for operating said guard relay, said relay having contacts for applying a busy potential to the incoming end of said trunk to prevent its seizure by said second-mentioned switch, and circuit means local to the incoming end of said trunk for maintaining said guard relay energized.

4. In a telephone system, a trunk circuit having an outgoing end and an incoming end, a switch for seizing the outgoing end of said trunk to extend a call over the trunk, an incoming switch at the incoming end of said trunk for further extending said call, switching means at said incoming end for seizing said trunk, a guard relay, a circuit closed by said first-mentioned switch in the act of seizing the outgoing end of said trunk, said circuit including one of the talking conductors of the trunk and also the winding of said guard relay, a pulse receiving relay for said incoming switch, said guard relay having contacts for extending the talking conductors to said pulse receiving relay and a contact for placing a busy condition on the incoming end of said trunk, and means for disconnecting said guard relay from the trunk and for holding it energized under the control of said pulse relay.

5. In a telephone system, a two-way trunk circuit, switches for seizing said trunk at either end, a guard circuit including one of the conductors of said trunk, relays in said guard circuit, one at either end thereof, and means in the switch seizing the trunk circuit at either end thereof for closing said guard circuit to operate the relay at the distant end to render the trunk busy at said distant end.

6. In a telephone system, a two-way trunk circuit, a first switch for seizing one end of said

trunk, a second switch for seizing the other end of said trunk, relays, one at either end of said trunk having contacts for placing a busy potential on the test conductor of the trunk to prevent its seizure by the associated switch, and a guard circuit closed by one of said switches in seizing the trunk, said circuit including the windings of both relays, and a source for supplying current to said guard circuit in such a direction as to cause the operation of the relay at the end distant from the seized end.

7. In a telephone system, a two-way trunk circuit, a first switch for seizing one end of said trunk, a second switch for seizing the other end of said trunk, said trunk having test terminals in said switches, differential guard relays, one at each end of said trunk, a circuit closed by either of said switches in the act of seizing said trunk which extends from the seizing switch over the associated test terminal, over a talking conductor of the trunk to the distant end thereof, said circuit including the windings of both of said relays, a source for supplying current to said circuit in such a direction as to cause the operation only of the relay at the end distant from the seized end, and contacts on the operated relay for applying a busy potential to the test terminal of the trunk at the associated end.

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