Sept. 10, 1935. J. BAUMFALK 2,014,221

TELEPHONE SYSTEM

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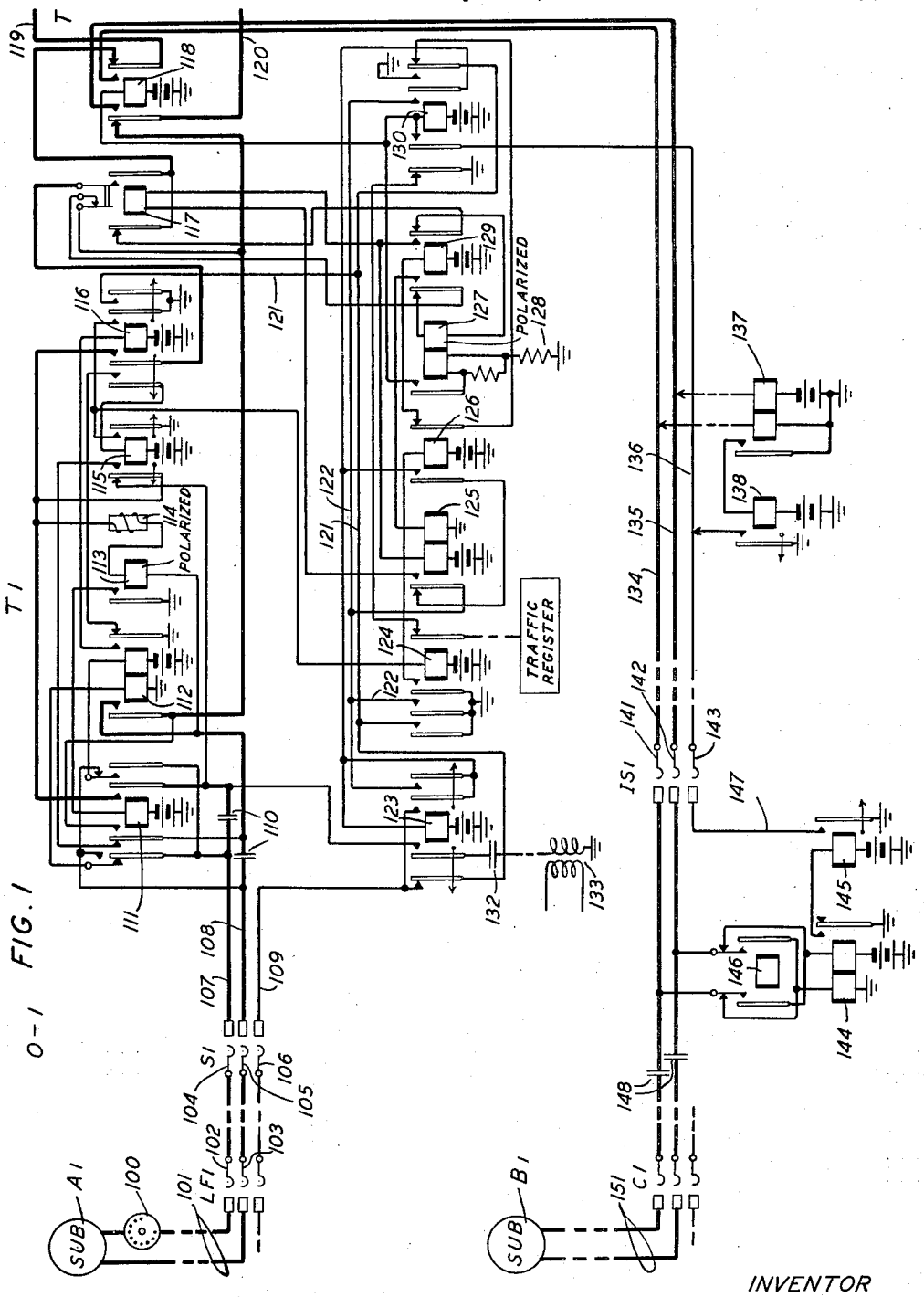

FIG. 1

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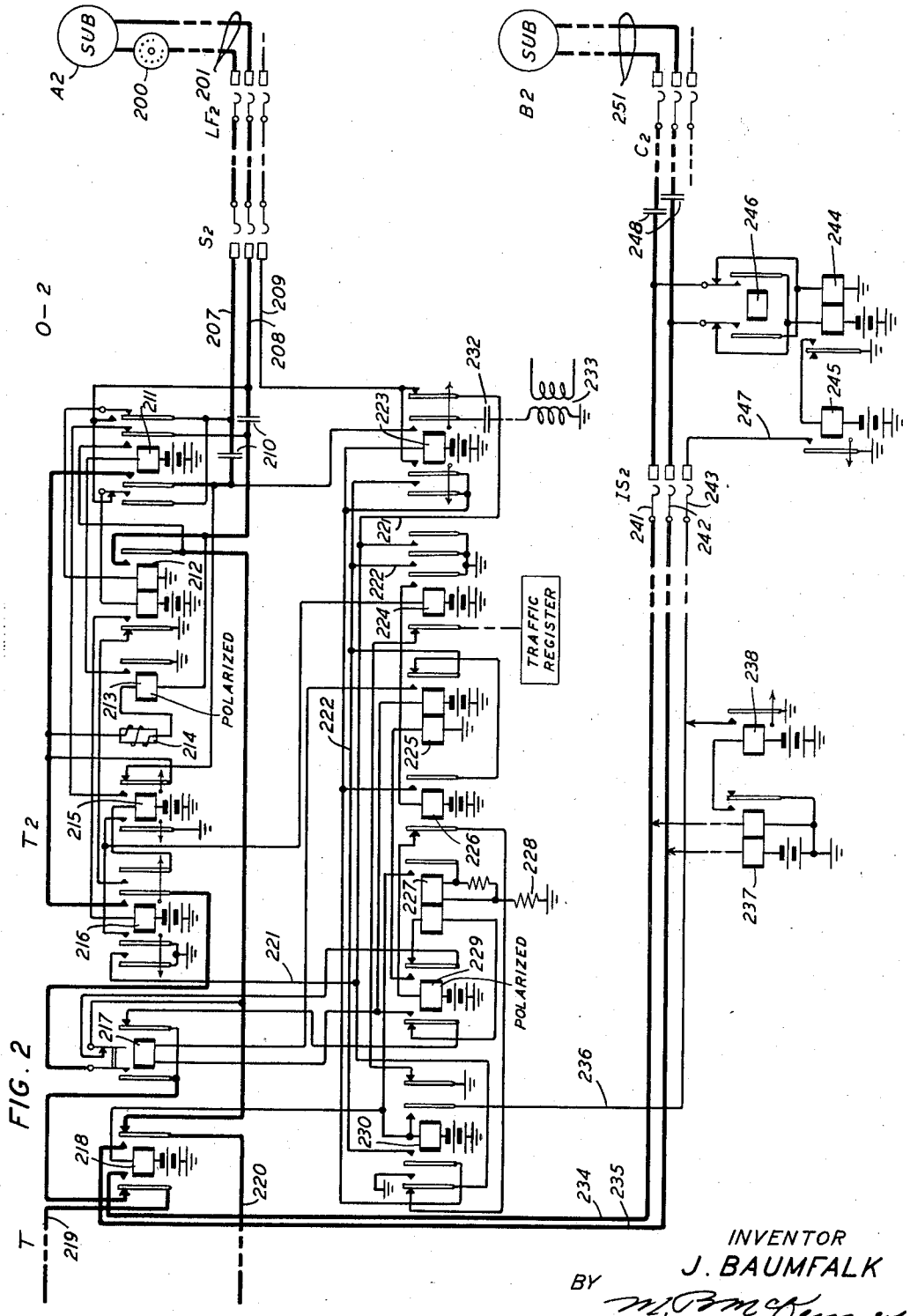

FIG. 2

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2,014,221

TELEPHONE SYSTEM

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18 Claims. (Cl. 179—16)

The invention relates to telephone systems and more particularly to systems employing automatic switches for establishing talking connections between calling and called subscribers' stations.

The object of the invention is to provide an improved two-way trunk circuit for use in automatic telephone systems, to eliminate the difficulties encountered in the use of two-way trunks between offices due to differences in ground potential, and to increase the efficiency of two-way trunks by eliminating the possibility of trouble or delay due to the simultaneous seizure of such a trunk at both ends.

One feature of the invention is control apparatus associated with a two-way trunk, which apparatus comprises a relay, the winding of which is normally bridged across the conductors of the trunk for response to seizure of the trunk at the distant end, means effective upon seizure of the trunk for use on an outgoing call for disconnecting the winding of the relay from the trunk and for repeating selective impulses over the trunk, and means effective upon operation of the bridging relay for disconnecting the winding of the relay from the trunk and operatively connecting the trunk to an incoming selector which is individual to the trunk.

Another feature of the invention is a two-way trunk between automatic telephone offices arranged to transmit a busy signal to the calling station in the office in which the trunk is last seized, in case the trunk is seized at both ends, and to complete the call incoming from the office in which the trunk is first seized.

A further feature of the invention is an arrangement for giving each of the calling subscribers a busy signal in case the trunk is simultaneously seized at both ends, and for completing the next succeeding call incoming from the office at which the trunk is first released.

These and other features of the invention will be more readily understood by considering a telephone system in which the invention is embodied. One such system is illustrated in the drawings which form a part of this specification. The invention is, of course, not limited in its application to the system shown in the drawings but may be applied generally to systems employing automatic switches in the completion of interoffice connections.

Referring to the drawings:

Fig. 1 represents schematically a central office O—1 in which A1 is a subscriber's station connected by line 101 to terminals in the back of a line finder switch LF1; S1 is a first selector switch permanently connected to the line finder LF1, T1 is trunk apparatus associated with the conductors 119 and 120 of a two-way interoffice trunk T, IS1 is an incoming selector switch individual to the trunk T, C1 is a connector switch, and B1 is a subscriber's station connected by line 151 to terminals in the bank of switch C1; and

Fig. 2 represents schematically a central office O—2 to which the two-way interoffice trunk T extends; A2 is a subscriber's station connected by line 201 to terminals in the bank of line finder switch LF2, S2 is a first selector switch permanently connected to the line finder LF2, T2 is trunk apparatus associated with the conductors 219 and 220 of trunk T, IS2 is an incoming selector switch individual to trunk T, C2 is a connector switch, and B2 is a subscriber's station connected by line 251 to terminals in the bank of switch C2.

The system represented by the drawings is one in which the subscribers' stations include dial impulse senders for use in controlling the selective operation of automatic switches to establish desired connections. The line finder, selector and connector switches are all of the well known two motion step-by-step type. For a detailed description of the structure of such switches and the operation of such switches when used as selectors or connectors, reference may be had to pages 53 to 65, inclusive, of the 2nd edition of "Automatic Telephony" by Smith and Campbell published in 1921. For a description of the operation of such switches when used as line finders, reference may be had to the patent to H. Hovland No. 1,711,682 granted May 7, 1929. Each of the line finders, first selector and connector switches is represented by a set of brushes and a single set of terminals, all associated apparatus not necessary to a full and clear description of this invention being omitted. While not shown in the drawings, incoming trunk impulse repeaters might, if necessary, be inserted between the trunk equipments T1 and T2 and the incoming selectors IS1 and IS2 respectively.

Assume a call to have been originated at station A1, line 101 to have been found by line finder LF1, selector S1 to have been operated in response to the impulses, created by the dialing of the first digit of the number of the station being called, to select the level which gives access to a group of trunks including the trunk T, and the selector S1 to have hunted, found and seized an idle set of terminals, all in well known manner. Assuming the seized terminals to be represented by the set shown in the

drawings as connected to conductors 107, 108, 109 and individual to the trunk T, the line relay 112 of trunk equipment T1 is operated by the current in a circuit traced from battery through the right winding of this relay, right back contact of relay 111, conductor 108, terminal and brush 105 of selector S1, brush 103 and terminal of line finder LF1, over line 101 and through the instrument at station A1, terminal and brush 102 of line finder LF1, brush 104 and terminal of selector S1, conductor 107, outer left back contact of relay 111, through the left winding of relay 112 to ground. At the same time that relay 112 is being operated, relay 129 is being operated by current in a circuit from battery through the winding of relay 129, back contact of relay 126, right back contact of relay 130, conductor 121, left back contact of relay 123, to the incoming sleeve conductor 109 and thence through the terminal and brush 106 of selector S1 to ground at the release relay (not shown) of the selector switch. Relay 112 closes a circuit for operating relay 116. Relay 116 closes a circuit for operating relay 124 and connects ground to conductor 121, thence through the back contact of relay 123 over conductor sleeve 109 to the terminal and brush of selector S1 to serve as a guarding potential for the trunk T and a holding potential for the selector S1 and line finder LF1 after the temporary ground connection is opened by the deenergization of the release relay of the selector, in well known manner. Relay 124 also connects ground to conductor 121 and closes a circuit for operating relay 126. The operation of relay 126 causes the release of relay 129.

Normally, the right winding of relay 127 of equipment T1 is bridged across conductors 119 and 120 of trunk T and the left winding of relay 227 of equipment T2 is bridged across conductors 119 and 120 of trunk T. When relay 129 operates, as above described, the right winding of relay 127 is disconnected from the conductors of trunk T and a circuit is closed from battery through the left winding of relay 125, right front contact of relay 129, left back contact of relay 117, right back contact of relay 118, over conductor 119 of trunk T, conductor 219, left back contact of relay 218, right back contact of relay 217, left back contact of relay 229, left winding of relay 227, right back contact of relay 229, left back contact of relay 217, right back contact of relay 218 over conductor 220 of trunk T, conductor 120, left back contact of relay 118, right back contact of relay 117, left front contact of relay 129, through the right winding of relay 125 to ground; relay 125 at one end of trunk T and relay 227 at the other end of trunk T are both operated by the current in this circuit.

In operating, relay 125 closes a circuit from battery through its left winding, winding of relay 117, front contact of relay 125, conductor 122, to ground at the middle front contact of relay 124; relay 125 is locked and relay 117 is operated by the current in this circuit. Relay 117 disconnects the windings of relay 125 from conductors 119 and 120 and closes a bridge across these conductors which may be traced from conductor 119 through the right back contact of relay 118, right front contact of relay 117, inner left front contact of relay 116, impedance 114, winding of relay 113, left front contact of relay 112, left back contact of relay 118 to conductor 120. At the other end of trunk T, relay 227 closes a locking circuit from battery through the windings of relays 218 and 230 in parallel, through the front contact and right winding of relay 227, and through resistance 228 to ground. In operating, relay 230 disconnects the winding of relay 229 from conductor 221 and connects ground over conductor 221 through the back contact of relay 223, over conductor 209, to the sleeve terminal of trunk T in the banks of all selectors such as S2 having access to this trunk, thereby guarding against seizure by any selector in office O—2. In operating, relay 218 disconnects conductors 219 and 220 of trunk T from the left winding of relay 227 and extends trunk T over conductors 234 and 235 to the incoming selector IS2 and through the windings of the line relay 237 of this selector to ground and battery respectively. There is therefore a closed metallic circuit over the conductors of trunk T which circuit includes the windings of the line relay 237 of the incoming selector at one end of the trunk and the winding of the polarized relay 113 at the other end of the trunk; the current in this circuit is effective to operate the line relay 237 but is not effective to operate relay 113. The operation of the line relay 237 of the selector IS2 is followed by the operation of the release relay 238, thereby connecting ground over sleeve conductor 236 through the right front contact of relay 239 to hold relays 230 and 218 operated and to short-circuit the right winding and thereby cause the release of relay 227.

When the calling subscriber at station A1 dials the next digit of the number of the station being called, the line relay 112 of trunk equipment T1 is alternately released and reoperated in response to the interruptions of the line circuit by the dial 100. The first release of relay 112 closes a circuit for operating the slow-to-release relay 115. Each time relay 112 releases and reoperates the bridge across conductors 119 and 120 is opened and closed at the left contacts of relay 112, thereby causing a corresponding release and reoperation of the line relay 237 of selector IS2 in office O—2. Relay 115 remains operated while impulses are being received as does also the release relay 116. With relay 115 operated, the winding of relay 113 and impedance 114 are short-circuited by the left front contact of relay 115 to improve the transmission of impulses over trunk T. The response of relay 237 to the impulses received over trunk T causes the operation of selector IS2 to select the level of the terminal bank corresponding to the digit dialed. The selector IS2 then automatically selects and seizes an idle set of terminals leading to a connector switch such as C2, the conductors 234 and 235 being extended through brushes 241 and 242 to the windings of the line relay 244 of this connector. Line relay 244 operates, closing the circuit for operating release relay 245. Relay 245 connects a holding ground to the sleeve conductor 247 thence through the terminal and brush 243 of switch IS2 to conductor 236. Upon extension of the connection through the brushes of selector IS2 the line relay 237 of this selector is disconnected, relays 237 and 238 being thereby released.

When the last two digits of the number of the station being called are dialed by the subscriber at station A1, relay 112 of trunk equipment T1 responds, the impulses being repeated over trunk T to cause the alternate release and reoperation of line relay 244 of connector switch C2. The brushes of the connector are thereby selectively positioned to engage the terminals of the called

line which is represented by line 251 leading to station B2. The line 251 having been tested and found idle, ringing current is transmitted over the line from the connector switch to signal the subscriber at station B2 in well known manner. When the subscriber at station B2 answers the call, relay 246 operates to interchange the connections between the conductors of trunk T and the windings of relay 244, the polarized supervisory relay 113 of trunk equipment T1 being operated by the resulting reversal of the current through its winding. Relay 113 closes a circuit for operating relay 111 and relay 111 interchanges the connections between the windings of relay 112 and conductors 107 and 108, the resulting reversal of current over these conductors being used to control meter operation or any other desired supervisory function. The inner left front contacts of relay 111 prevent the opening of the bridge across the conductors of trunk T due to a temporary release of relay 112. The talking circuit includes condensers 110 of trunk equipment T1 and condensers 248 of connector switch C2.

When the connection is released by the calling subscriber, relay 112 of trunk equipment T1 releases causing the temporary reoperation of relay 115 and the release of relay 116. If relay 113 is not operated, the release of relay 112 also causes the immediate release of relay 244 of the connector switch C2; but if relay 113 is operated at the time relay 112 releases, the opening of the bridge across the conductors of trunk T awaits the release of relay 116 at which time relays 113 and 111 in office O—1 and relay 244 of connector C2 are released. In any case the release of relay 116 is followed by the release of relays 115, 124 and 126. The release of relay 124 causes the release of relays 125 and 117, the trunk equipment T1 being thereby restored to normal ready for use on a call in either direction over trunk T.

The release of relay 244 of connector C2 causes the release of relay 245. The release of relay 245 disconnects the holding ground from conductors 247, thereby causing the return of selector IS2 to normal and causing the release of relays 218 and 230 of trunk equipment T2. The release of relay 230 disconnects the busy ground from conductors 221 and 209 so that trunk equipment T2 is now ready for another call in either direction. With relay 245 released the connector C2 is restored to normal in usual manner as soon as the subscriber at station B2 replaces the receiver.

Assuming now that the subscriber at station A2 originates a call, that the line 201 is thereupon extended by the operation of line finder LF2 to the selector S2, and that in response to the dialing of the first digit of the number of the station being called the selector S2 selects the terminals which are individual to trunk T. If trunk T is not at the same time being seized in office O—1, relays 212, 216 and 224 are operated in succession; and relays 229 and 225 of trunk equipment T2 and relays 127, 118 and 130 of trunk equipment T1 are operated in succession in the manner that the correspondingly numbered relays of trunk equipments T1 and T2 were operated as described above on the call from station A1 to station B1. Upon dialing the remainder of the number of the station being called, the impulses will be repeated by relay 212 over trunk T to control the selective operation of selector IS1 and a connector C1 to complete the connection with the called line which is represented by line 151 of the station B1.

It may be, however, that trunk T is being seized by a selector in office O—1 at the same time that it is being seized by a selector in office O—2. If, in such a case, relay 129 at one end of the trunk is operated at the same time that relay 229 is operated at the other end of the trunk, relay 125 is connected to conductors 119 and 120 and relay 225 is connected to conductors 219 and 220. Neither relay 125 nor relay 225 operates, and when in office O—1 relay 126 operates as above described, a circuit for operating relay 123 is closed from battery through the winding of relay 123, front contact of relay 126, back contact of relay 125, to ground at the middle front contact of relay 124; and when in office O—2 relay 226 operates in similar manner, a circuit for operating relay 223 is closed from battery through the winding of relay 223, front contact of relay 226, back contact of relay 225 to ground at the middle front contact of relay 224. When relay 129 releases, the right winding of relay 127 is again bridged across conductors 119 and 120 in office O—1; and when relay 229 releases the left winding of relay 227 is again bridged across conductors 219 and 220 in office O—2. The operation of relay 123 in office O—1 connects ground from the middle front contact of relay 124, over conductor 122, through both right front contacts of relay 123 to sleeve conductor 109 to hold selector S1 and line finder LF1 and connects one winding of the tone transformer 133 through condenser 132 and the left front contact of relay 123 to one of the talking condensers 110 thereby transmitting a busy tone to the calling subscriber in office O—1. The operation of relay 223 in office O—2 in like manner connects ground from the middle front contact of relay 224, over conductor 222, through both left front contacts of relay 223 to sleeve conductor 209 to hold selector S2 and line finder LF2 and connects one winding of tone transformer 233 through condenser 232 and the right front contact of relay 223 to one of talking condensers 210 thereby transmitting a busy tone to the calling subscriber in office O—2. There is no talking circuit between the two calling subscribers since neither of relays 117 or 217 have been operated. When each one of the calling subscribers releases the connection, the corresponding trunk equipment, T1 or T2, is restored to normal rendering that end of the trunk again selectable for a new call. Thus the release of the connection by the subscriber at station A1 causes the release of relays 112, 116, 124, 126 and 123; and the release of the connection by the subscriber at station A2 causes the release of relays 212, 216, 224, 226 and 223. With the connection released at both ends the trunk may be seized at either end. If the trunk is released at one end and again seized at that end before being released at the other end, the battery feed relay (125 or 225) at the seized end of the trunk operates in series with the bridge relay (227 or 127) at the opposite end of the trunk; and the connection thus originated at the released end of the trunk may be completed without awaiting the release of the connection at the other end.

If, in a case when the trunk T is seized at both ends, the bridge relay 127 operates and locks before seizure of the trunk in office O—1 effects the operation of relay 129, then the trunk T will be extended by the operation of relays 118 and 130 to the incoming selector IS1 for use in completing the call incoming from office O—2; in this case the failure of relay 125 to operate causes

the operation of relay 123 to connect a busy tone over conductor 107 to the line of the calling subscriber in office O—1 as above described. But if the bridge relay 227 operates and locks before seizure of the trunk in office O—2 effects the operation of relay 229, then the trunk T will be extended by the operation of relays 218 and 239 to the incoming selector IS2 for use in completing the call incoming from office O—1; and in this case the failure of relay 225 to operate results in the operation of relay 223 to connect a busy tone over conductor 207 to the line of the calling subscriber in office O—2.

What is claimed is:

1. In a telephone system, two offices, a trunk between said offices, automatic switches in each of said offices for seizing said trunk, a bridge free from both battery and ground potential normally connected across each end of said trunk for responding to seizure of the trunk at the distant end, means at one end of the trunk for opening the bridge across that end of the trunk in response to seizure of the trunk at the other end, and means at said other end of the trunk for opening the bridge across said other end of the trunk in response to seizure of the trunk at said one end.

2. In a multi-office telephone system, a trunk for completing calls between two of the offices, automatic means in each of said offices for seizing said trunk, and means in each of said offices responsive to the simultaneous seizure of said trunk in both of said offices for connecting a busy tone to one of the talking conductors of each of the switches by which said trunk is seized.

3. In a telephone system, subscribers' lines, a two-way trunk for use in completing telephone calls, an automatic switch at each end of said trunk for use in extending connections from calling lines to said trunk, and means at one end of said trunk effective upon seizure of the trunk at said one end after seizure of the trunk at the other end for connecting a busy tone to one of the talking conductors of the switch by which the trunk is last seized.

4. In a telephone system, subscribers' lines, a two-way trunk for use in completing telephone calls, an automatic switch at each end of said trunk for use in extending connections from calling lines to said trunk, and means at each end of said trunk for connecting a busy tone to one of the talking conductors of the switch by which said trunk is seized, each of said means being operatively effective in response to the seizure of said trunk at the end with which the means is associated after seizure of the trunk at the other end.

5. In a telephone system, a trunk, an automatic switch at each end of said trunk for seizing said trunk, a bridge normally connected across each end of said trunk for responding to seizure of the trunk at the opposite end, each of said bridges being free from battery and ground and each comprising a relay for responding to seizure of the trunk at the opposite end, a switch individual to each end of said trunk for use in completing calls incoming over said trunk, and means at each end of said trunk rendered effective by the operation of the relay in the bridge at that end for extending said trunk to the one of said switches which is individual to that end of the trunk.

6. In a telephone system, a trunk, an automatic switch at each end of said trunk for seizing said trunk, a bridge normally connected across each end of said trunk for responding to seizure of the trunk at the opposite end, each of said bridges being free from battery and ground and each comprising a relay for responding to seizure of the trunk at the opposite end, means responsive to seizure of said trunk at one end for disconnecting the bridge normally connected across that end, means responsive to seizure of the trunk at the other end for disconnecting the bridge normally connected across said other end, a switch individual to each end of said trunk for use in completing calls incoming over said trunk, and means at each end of said trunk rendered effective by the operation of the relay in the bridge at that end for extending said trunk to the one of said switches which is individual to that end of the trunk.

7. In a telephone system, subscribers' lines in each of two offices, a trunk for completing calls between said offices, an automatic switch in each of said offices for seizing said trunk, a relay winding bridged across one end of said trunk for operation in response to seizure of said trunk at the distant end, a switch at said one end of the trunk and individual thereto, means responsive to the operation of said relay for extending the conductors of said trunk to said individual switch, and means responsive to the seizure of said trunk at said one end after seizure of the trunk at said distant end for connecting a busy tone to one of the talking conductors of the switch by which said trunk is last seized without interfering with the incoming call extended to said individual switch.

8. In a multi-office telephone system, a trunk between two offices, subscribers' lines in each office, automatic switches in each of said offices for seizing said trunk and for extending calling lines to said trunk, a switch in one of the offices individual to said trunk for use in completing calls incoming over said trunk, a relay winding bridged across said trunk in said one of the offices for responding to seizure of said trunk in the other of said offices, means responsive to the operation of said relay for extending the conductors of said trunk to said individual switch, means responsive to the seizure of said trunk and the extension of a calling line to said trunk by one of the automatic switches in said one of the offices subsequent to the operation of said relay for transmitting a busy tone to the calling subscriber, and means responsive to the opening of the line of said calling subscriber for disconnecting the switch by which said trunk was last seized without interfering with the completion of the incoming connection through said individual switch.

9. In a telephone system, subscribers' lines, a two-way trunk, an automatic switch at each end of said trunk for seizing and appropriating said trunk for use in completing calls over said trunk, means at each end of said trunk responsive to seizure for closing a talking connection between the talking conductors of the seizing switch and the conductors of said trunk, and means responsive to the simultaneous seizure of said trunk by both of said switches for preventing the closure of said talking connections.

10. In a telephone system, a first office, a second office, a two-way trunk between said offices, automatic switches in each of said offices for seizing said trunk, a relay normally bridged across the trunk in the first office, a relay normally bridged across the trunk in the second office, means responsive to seizure of the trunk in the

second office for disconnecting the bridging relay in that office and for causing the operation of the bridging relay in the first office, and means responsive to said operation of the bridging relay in said first office for disconnecting said bridging relay from said trunk.

11. In a telephone system, a first office, a second office, a two-way trunk between said offices, automatic switches in each of said offices for seizing said trunk, a relay normally bridged across the trunk in the first office, a relay normally bridged across the trunk in the second office, means responsive to seizure of the trunk in either office for disconnecting the bridging relay in that office and for causing the operation of the bridging relay in the other office, and means in each office responsive to the operation of the bridging relay in the same office due to seizure of the trunk in the other office for disconnecting the operated bridging relay from the trunk.

12. In a telephone system, a trunk, means comprising an automatic switch at each end of said trunk for seizing said trunk, a relay at each end of said trunk, the winding of each of the relays being normally bridged across the conductors of the trunk, a selector individual to each end of the trunk for use in completing calls incoming over the trunk, and means at each end of said trunk rendered effective by the operation of the relay at the same end for extending the trunk to the associated individual selector.

13. In a telephone system, a two-way trunk, switching means at one end of the trunk for seizing said trunk for use in completing an outgoing call, a selector at the other end of the trunk for use in completing incoming calls, a relay at said other end of the trunk, the winding of said relay being bridged across the trunk for energization in response to the seizure of said trunk at said one end, and means rendered effective by the operation of said relay for extending the conductors of said trunk to said selector.

14. In a telephone system, a two-way trunk, switching means at one end of the trunk for seizing said trunk for use in completing an outgoing call, a selector at the other end of the trunk for use in completing incoming calls, a relay at said other end of the trunk, the winding of said relay being bridged across the trunk for energization in response to the seizure of said trunk at said one end, and means rendered effective by the operation of said relay for disconnecting the conductors of the trunk from the winding of said relay and for connecting the conductors of the trunk to said selector.

15. In a telephone system, a two-way trunk, means at each end of the trunk for seizing said trunk for use on an outgoing call, a selector individual to each end of the trunk for use in completing incoming calls, a relay at each end of the trunk, the winding of each of the relays being normally bridged across said trunk, means responsive to seizure of the trunk at one end for disconnecting the bridging relay at that end and for causing the operation of the bridging relay at the other end, and means responsive to the operation of the bridging relay at one end of the trunk for operatively connecting the trunk to the selector individual to that end of the trunk.

16. In a telephone system, a two-way trunk, means at one end of the trunk for seizing said trunk for use in completing an outgoing call, a switch at the other end of the trunk for use in completing incoming calls, a relay at said other end of the trunk, the winding of said relay being bridged across the trunk for energization in response to the seizure of the trunk at said one end, an impulse receiving relay for said switch, and means operatively responsive to the energization of said bridging relay for connecting the conductors of said trunk to the windings of said impulse receiving relay.

17. In a multi-office telephone system, subscribers' lines in each of two offices, an impulse sending device for each line, a trunk between said offices, a bridge comprising the winding of a relay normally connected across each end of the trunk, means in each office for connecting a calling line to the trunk, a selector individual to the trunk in each of the offices for use in completing incoming calls, means effective upon seizure of the trunk in one office for causing the operation of the bridging relay in the other office, means operatively responsive to the operation of the bridging relay in one office for extending the conductors of the trunk to the selector which is individual to the trunk in that office, and means associated with the trunk in each office for repeating impulses received from a calling line over the trunk to selectively operate the individual selector in the other office.

18. In a telephone system, subscribers' lines, an impulse sending device for each line, a two-way trunk, switching means at one end of the trunk for connecting a calling line to said trunk, a selector at the other end of said trunk for use in completing incoming calls, a relay at said other end of the trunk, the winding of said relay being bridged across the trunk for energization in response to the connection of a calling line to said one end of the trunk, means rendered effective by the operation of said relay for connecting the conductors of said trunk to said selector, and means at said one end of the trunk for receiving impulses from a calling line and for repeating the impulses over the trunk to selectively operate said selector.

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