Aug. 18, 1942. G. L. CAIN ET AL 2,293,588

TELEPHONE SYSTEM

Filed April 18, 1941 2 Sheets-Sheet 1

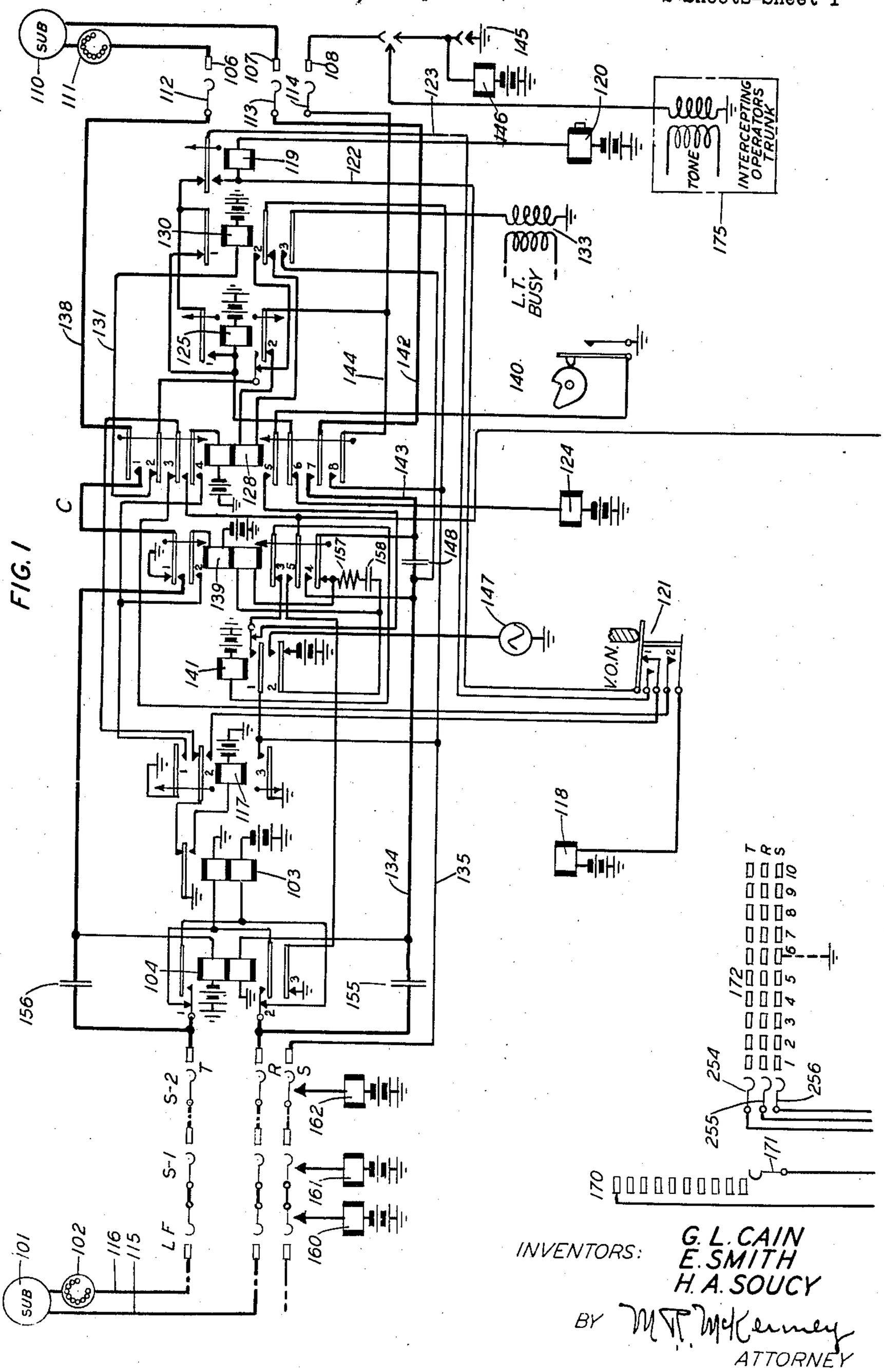


FIG. 1

INVENTORS: G. L. CAIN
E. SMITH
H. A. SOUCY

BY M. T. McKenney
ATTORNEY

Aug. 18, 1942.

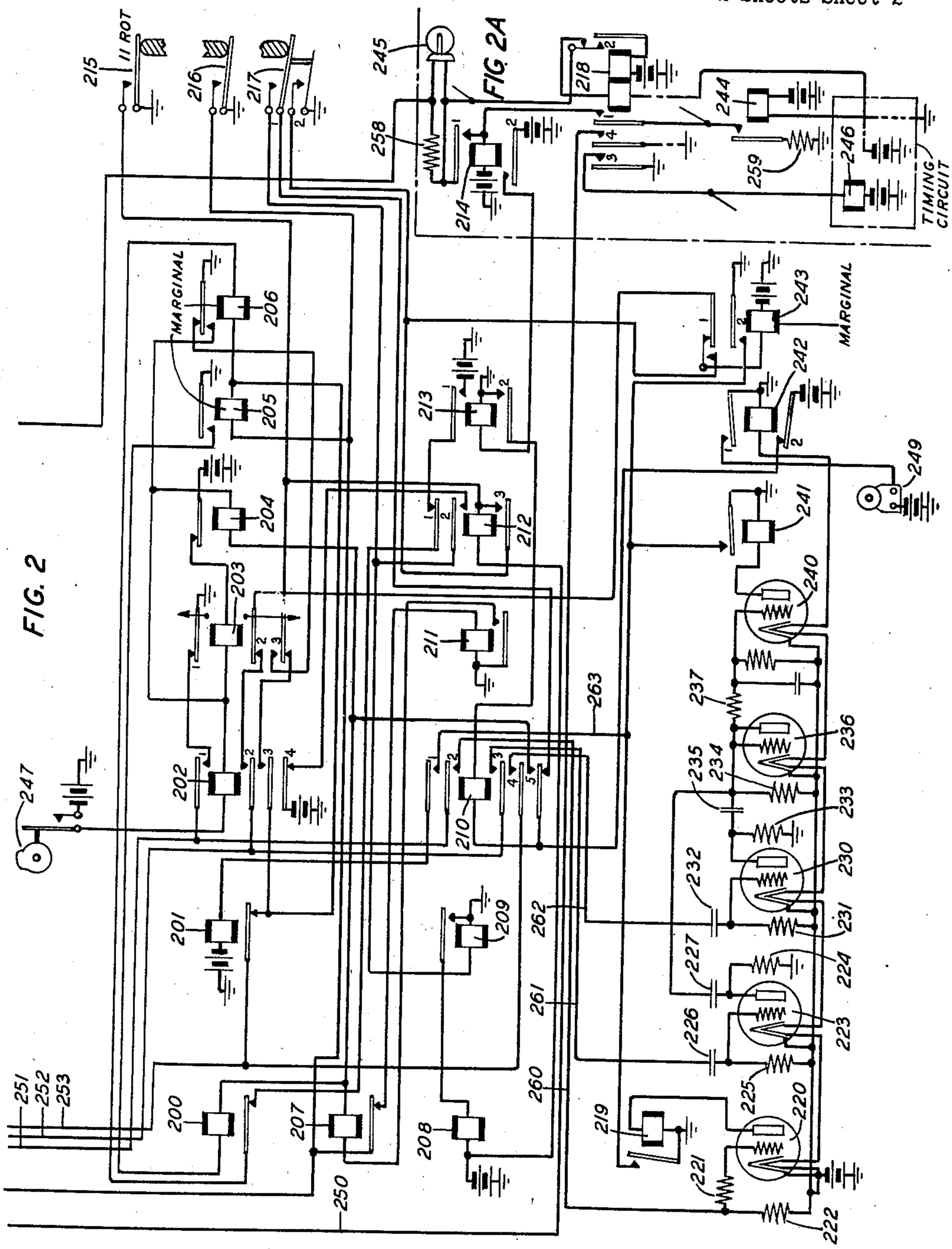
G. L. CAIN ET AL

2,293,588

TELEPHONE SYSTEM

Filed April 18, 1941

2 Sheets-Sheet 2



INVENTORS: G. L. CAIN
E. SMITH
H. A. SOUCY

BY M. T. McTierney

ATTORNEY

Patented Aug. 18, 1942 2,293,588

UNITED STATES PATENT OFFICE

2,293,588

TELEPHONE SYSTEM

George Leland Cain, Elton Smith, and Harold Arthur Soucy, Fort Worth, Tex., assignors to American Telephone and Telegraph Company, a corporation of New York

Application April 18, 1941, Serial No. 389,138

10 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly those in which conversational connections are established by automatic switches.

The objects are to improve the releasing operations of partly established connections, test the condition of connectors from which a trouble signal has been given and other connectors serving telephone connections without interfering with established connections and otherwise improve such systems.

Systems have been devised heretofore in which the immediate release of all switches of the connection takes place when the calling subscriber replaces his receiver and in which release of the final or connector switch is effected at the end of a measured interval following the replacement of the called subscriber's receiver providing the calling party is slow in hanging up his receiver. Moreover it is common practice to employ the relay of the connector that responds to the called subscriber's switchhook not only for the purpose of controlling the release circuits but also to effect a reversal in the direction of current flow in the established connection for supervision.

A feature of the present invention is an improvement in these prior systems which consists in testing the condition of a switching connection and in causing a responsive action in a testing circuit to a plurality of different switching connection circuit conditions for either releasing said switching connection or for stepping off of said switching connection when the circuit condition encountered does not warrant the release of the connection.

Another and related feature consists in repeating the test of the switching connection until a trouble is cleared.

Another and related feature consists in the use of a vacuum tube circuit responsive to current sources associated with the line conductors for controlling the testing circuit responsive to different conditions enccuntered in a connector switching circuit.

The foregoing and other features of the invention will be described more fully in the following specification which should be taken in conjunction with the accompanying drawings and also the appended claims:

Referring to the drawings, Fig. 1 illustrates a calling subscriber 101 connected to a called subscriber 110 by a line finder switch, a first selector, a second selector and a connector. The line finder and selectors are diagrammatically shown and may be of any suitable type such as the Strowger switch, the operation and release of which are well known. Figure 1 also illustrates the commutator and a horizontal level of a connector switch testing circuit and the brushes associated therewith. Fig. 2 illustrates a connector switch testing circuit and Fig. 2A illustrates the essential apparatus of a trouble indicating circuit cooperatively associated with the testing circuit, Fig. 2 and the connector circuit, Fig. 1.

In general the telephone system to which the invention applies is known as the step-by-step telephone switching system wherein after a telephone connection has been completed from a calling to a called subscriber through a line finder, first selector, second selector and connector, the calling subscriber controls the release of these switches after the conversation has ceased. The failure of the calling subscriber to replace the receiver on the switchhook therefore holds this train of switches in an operated position and prevents the called subscriber from making further calls until such time as the connector is released. When a connector is held by the calling subscriber and the called subscriber has replaced the receiver on the switchhook or is held in an operated position by a fault in the connector, a circuit is established in the connector for actuating what is known as a permanent signal shelf alarm circuit. The actuation of the alarm circuit lights a lamp to indicate that a connector is being held by a calling subscriber or by a fault in the connector or the associated circuits and normally after an interval of time an alarm is sounded.

According to the present invention the energization of the permanent alarm circuit actuates a testing circuit and causes the testing circuit to associate itself with the connector in trouble by the operation of a step-by-step switch. The vertical movement of the testing circuit step-by-step switch is arrested by a ground on a segment of the switch commutator which ground is connected therewith by an alarm circuit actuated by a connector switch in the corresponding horizontal level. The rotary movement of the brushes is under the control of the testing circuit in which any of a plurality of circuit conditions may be established depending upon the circuit condition found to prevail in the connector tested. Assuming that the connector giving the alarm is connected to a set of terminals in the middle of the horizontal level it is then necessary for the testing circuit brushes to pass over other terminals to reach the connector in trouble. The testing circuit may therefore encounter other connectors which are in different normal operating conditions, either having completed a telephone con-

nection from a calling subscriber to a called subscriber or are in the process of completing such a connection. The testing circuit is arranged to respond to the different conditions found in connectors. As the testing circuit brushes advance around the terminal bank, the conditions to be encountered on the various sets of terminals in the horizontal row may be as follows:

1. A normal release connector, i. e., not in use for a service connection and not associated with a trouble condition.

2. A connector being used for a conversational connection.

3. A connector associated with a called subscriber with ringing current actuating the called subscriber's ringer.

4. A connector associated with a busy line and transmitting a busy tone to the calling subscriber.

5. A connector associated with an intercepting operator.

Any of the above conditions are recognized by the devices of the testing circuit which cause the testing circuit to advance its associated switch brushes without disturbing the normal functioning of the connector encountered.

If the testing circuit is associated with a connector which is being held by a calling subscriber and the called subscriber has replaced the receiver on the switchhook, the testing circuit actuates the connector release mechanism which restores the connector mechanism to normal and restores the preceding switches to normal which were actuated for making the telephone call. Other conditions are caused by the varied actions of the calling and called subscribers which if not taken into consideration might create dissatisfaction and annoyance to some subscribers even though these conditions may be unusual in normal telephone usage or telephone practice. For example, a circuit in a connector may be established for actuating the testing circuit and when the testing circuit switch brushes are associated with this connector a telephone connection may have been established between a calling and a called subscriber or the connection may be in the process of being established. Under this condition the testing circuit switch brushes are stepped off of the terminals of the connector which gave the alarm. If the trouble condition persists repeated tests may be made until the conversation is terminated and the trouble is found.

A detailed description will first be given of the connector circuit, Fig. 1, followed by a description of the testing circuit Fig. 2, the trouble circuit Fig. 2A and the relation of the circuit conditions found in the connector to the responsive action in the testing circuit.

Let it be assumed that the subscriber of line 101 desires to establish a connection with the station 110 and that the connection has been extended in the usual manner through line finder LF and selectors S1 and S2 to the tip, ring and sleeve terminals of connector C. When this circuit is seized by the selector S2 a circuit is closed through the windings of relay 103 which may be traced from battery through the lower winding of relay 103, normally closed contacts 2 of relay 104, ring terminals and brushes of selectors S1, S2, and the line finder LF, thence over line conductor 115 and through subscriber's telephone 101 and dial 102, over conductor 116 and through tip terminals and brushes of line finder LF, and selectors S1 and S2, normally closed contacts 1 of relay 104 and upper winding of relay 103 to ground. Relay 103 operates which operates relay 117 through a circuit traceable from battery through the winding of relay 117 to ground on the contact of relay 103. Relay 117 in operating connects ground on its contact 3 to the sleeve conductor 135 and the sleeve terminals and brushes of selectors S1, S2 and line finder LF, thereby holding in the operated position the selectors and line finder and guarding connector C from other hunting selector circuits.

On the first break of the contacts of dial 102 for the purpose of dialing the tens digits of the called number, relay 103 releases and closes a circuit from battery through the windings of vertical magnet 120 and relay 119, lead 122, contact 1 of the vertical off-normal contact assembly 121, contact 2 of relay 117 to ground on the contact of relay 103. Relay 117 is slow to release and does not release during the momentary open periods of the front contact of relay 103, while responding to the pulses of dial 102. Relay 119 and vertical magnet 120 are operated through the circuit hereinbefore retraced. As soon as the shaft of the connector switch is moved from its normal position on its first vertical step, the vertical off-normal springs 121 operate and transfer the operating circuit for relay 119 and vertical magnet 120 from conductor 122, to conductor 123, thereby placing the windings of relay 119 and vertical magnet 120 in series through the make contact of relay 119, and contact 2 of the vertical off-normal spring combination 121. This transfer from conductor 122 to 123 is made without interrupting the circuit, since the three upper springs of combination 121 are of the make-before-break type. When the contacts of dial 102 are closed again after the first break, relay 103 reoperates and again closes the circuit through the winding of relay 117, before this relay has had time to release, as hereinbefore explained. On the next open period of dial 102, relay 103 again releases and transmits a second ground pulse, through the circuit of relay 119 and vertical magnet 120. Relay 119 is slow to release and remains locked up over the open periods of the back contacts of relay 103. The second ground pulse aforesaid causes the shaft of the switch to take another step upward. This action continues until all required pulses for the tens digits are transmitted by dial 102 and the connector brushes 112, 113 and 114 have reached the level containing the terminals of the line being called.

After the tens digit has been dialed and dial 102 is restored to normal, relay 103 remains operated, relay 119 releases, and the winding of vertical magnet 120 is deenergized. When relay 119 releases, a circuit is closed through rotary magnet 124 for rotary stepping and a circuit is closed for relay 125. These circuits may be traced from battery through the winding of rotary magnet 124, contact 6 of relay 123 to junction point 129, and from battery through the winding of relay 125 to said junction point 129, thence through the upper contact 1 of relay 130, back contact of relay 119, over conductor 123, contact of combination 121 to contact 2 of relay 117. On the first break of dial 102 for dialing the units digits of the called number, i. e., for rotary stepping, relay 103 releases and connects a ground impulse to contact 2 of relay 117 and over the rotary stepping circuit just traced. Relay 117 remains operated during dial pulses, as in the case of vertical stepping. In response to said first ground impulse rotary magnet 124 will operate and cause the switch brushes 112, 113 and 114 to rotate one

step in a horizontal direction. Relay 125 operates to short-circuit the upper contacts of relay 130 to maintain the above circuit closed if relay 130 momentarily operates. Subsequent dial pulses cause rotary magnet 124 to step the switch around until the line 110 of the called subscriber is reached.

When dial 102 has restored to normal the circuit for relay 125 and the rotary magnet 124 is opened since relay 103 remains operated. Slow relay 125 does not release at once. Before connecting ringing current to this line a test is made to determine whether the line is busy or idle. If the called subscriber line is busy, ground 145 will be found on the sleeve terminal connected to conductor 108, and will cause the operation of test relay 130 from battery through its winding, contact 2 of relay 128, contact 2 of slow-release relay 125, conductor 144, to ground 145 on sleeve conductor 108 through brush 114. Relay 130 in operating opens the original circuit for rotary magnet 124 and when slow-release relay 125 finally releases the second circuit established for rotary magnet 124 is opened and a holding circuit is established for relay 130. Relay 130 in operating connects the secondary winding of busy tone transformer 133 through its contacts 3, ring conductor 134, condenser 155, ring conductor of selectors 2 and 1 and the line finder to the calling subscriber's station, which indicates to the calling subscriber that the called line is busy. Relay 130 is locked up through a circuit traced from battery through the winding of relay 130, contact 2 of relay 128, contact 2 of relay 125 released, contact 2 of relay 130 to ground on sleeve conductor 135. Under this condition the calling subscriber will disconnect, causing the release of relays 103 and 117, thereby closing a circuit from battery through the winding of release magnet 118, contact 2 of VON combination 121, contact 3 of relay 128, contact 2 of relay 117 and contact of relay 103 to ground. Release magnet 118 is energized and causes the restoration of the connector switch to normal, including VON springs 121. Relay 130, which was locked to ground on sleeve conductor 135, releases since ground was removed by the opening of contact 3 of relay 117 when this relay released. The removal of ground from conductor 135 causes in the well-known manner the energization of release magnets 160, 161 and 162 of the preceding switches and the consequent release of these switches.

Let it be assumed now that the line 110 of the called subscriber is found idle. Under this condition battery will be found by sleeve brush 114 on the terminal connected to sleeve conductor 108 through the winding of cut-off relay 146. Under this condition relay 130 will not operate as hereinbefore described when the line 110 was found busy. After relay 125 has released upon the completion of rotary stepping, a circuit is closed for the operation of relay 128, which may be traced from aforesaid battery connection on brush 114, through contact 2 of relay 125, lower winding of relay 128, contact 2 of relay 130, to ground on sleeve conductor 135. Relay 128 in operating locks through its upper winding and its contact 4 to ground on contact 1 of relay 117. In operating relay 128 also connects tip conductor 138, through its contact 1 to ground on contacts 1 of relay 139; opens the circuit of the winding of relay 130, by opening its contact 2; connects ground from pick-up interrupter 140 through its contact 5, contact 1 of relay 141, contact 3 of relay 139 to battery through the winding of relay 141. Relay 141 operates and locks through its contact 1 to ground on contact 3 of relay 117. Relay 128 in operating also opens the lead to the rotary magnet 124 through its contacts 6; connects ring conductor 142 to ring conductor 143 through its contact 7, and joins sleeve conductor 135 to sleeve conductor 144, thereby grounding said conductor 144 for operating cut-off relay 146, and guarding the terminals of the line of subscriber 110 from seizure by another connector.

When relay 141 operates it closes a circuit for ringing the station 110. This circuit is traced from source of ringing current 147, which may comprise an interrupter connected with an alternating-current generator and with battery on different segments, through contact 2 of relay 141, lower winding of relay 139, contact 4 of relay 139, over conductor 143, contact 7 of relay 128, conductor 142, through connector brush 113 and associated contact, over the line of subscriber 110, connector brush 112 and associated contact, conductor 138, contact 1 of relay 128, to ground on contact 1 of relay 139. The ringer (not shown) of station 110 is now actuated, but relay 139 does not operate until subscriber 110 answers by removing the receiver from the switchhook, thereby removing the ringer winding from the circuit and connecting a low impedance bridge across the line. Ringing tone is sent back to the calling subscriber over conductor 134 during the periods when ringing current is connected with station 110. The contacts of relay 139 are adjusted so that in operating a locking circuit is closed from battery through its upper winding and contact 2 to ground on contact 1 of relay 117 before the circuit through its lower winding is broken at either of its contacts 1 or 4. The operation of relay 139 disconnects ringing current from subscriber's station 110. The locking circuit for relay 141 is also opened causing the release of the latter relay to disconnect the ringing source 147. In some instances the called subscriber such as the subscriber at station 110 may remove his receiver to make a call after a connector has been connected to his line, but before relay 141 has been operated by pick-up interrupter 140. To guard this condition a circuit is provided to operate relay 139 before ringing current is applied to this called station. This circuit may be traced from battery through contact 2 of relay 141, lower winding of relay 139 and thence over the line conductors as traced through station 110 to ground on contact 1 of relay 139. Under this condition the locking circuit for relay 139 is established through its upper winding in the same manner as previously described.

The conversational circuit between the calling and called subscribers is completed by relay 139 by closing through the tip conductors on its contact 1, and the ring conductors on its contact 4. Relay 139 in operating also completes the operating circuit for relay 104, which may be traced from battery through the upper winding of relay 104, contact 1 of relay 139, contact 1 of relay 128, over the tip conductor 135 and the line of station 110, through station 110 including dial 111, ring conductors of the line, conductor 142, contact 7 of relay 128, contact 4 of relay 139 to ground through the lower winding of relay 104. Relay 104 in operating reverses the direction of current over the line of calling station 101, thereby causing the operation of an associated line message register (not shown) in the well-known manner.

After the aforesaid reversal, battery through the lower winding of relay 103 is connected by contact 1 of relay 104 to the tip conductor, and ground through the upper winding of relay 103 is connected by contact 2 of relay 104 to the ring conductor.

At the end of the conversation, when the calling subscriber disconnects, relays 103 and 117 release, removing ground from the upper locking windings of relays 139 and 128, which release. The release of relay 128 closes a circuit for operating release magnet 118, which may be traced from battery through the winding of magnet 118, contact 2 of VON combination 121, contact 3 of relay 128, contact 2 of relay 117, and the contact of relay 103 to ground. The operation of release magnet 118 restores the connector switch to normal in the well-known manner. The removal of ground from conductor 135 causes the operation of release magnets 160, 161 and 162 and the immediate release of the preceding switches LF, S1 and S2.

The connector switch operates satisfactorily in the manner outlined above unless equipment becomes out of adjustment through carelessness of a maintenance man or when a calling subscriber fails to replace the receiver on the switchhook when a telephone conversation is terminated and the called subscriber has replaced the receiver or when an attempt has been made to connect a calling subscriber with a called subscriber and the called subscriber does not answer or the line has been found busy. As outlined above, the release of the connector and the preceding switches LF, S1 and S2 is under the control of the calling subscriber 101 since relays 103 and 117 must release in order to establish a circuit for release magnet 118. When a connector is not released by the calling subscriber, the called subscriber's line is maintained busy and this subscriber cannot obtain connection with other telephone lines until this connector has been released. Assuming that this condition prevails, certain apparatus in the connector circuit will be in the following operated or released positions. Relay 104 is released since this relay is under the control of the called subscriber who has replaced the receiver on the switchhook. Relay 103 would remain operated since the subscriber at station 101 has not replaced the receiver on the switchhook and consequently a circuit is established for this relay through switches S1, S2 and LF over the subscriber's loop. Relay 103 holds relay 117 operated and a holding circuit is maintained for relays 139 and 128 through the upper windings of these relays to ground on contact 1 of relay 117. Under this condition, a supervisory circuit is established to energize a permanent signal timing circuit shown in Fig. 2A. This circuit may be traced from ground through contact 3 of relay 104, contact 5 of relay 139, filament of lamp 245 in parallel with resistance 258, contact 2 of relay 218, left winding of relay 218, tuning circuit pick-up interrupter (not shown), to battery in the timing circuit. The high resistance of the left winding of relay 218 prevents the illumination of lamp 245 at this time. The energization of relay 218 causes the closure of a timing circuit which actuates different equipment after different time intervals have elapsed and will ultimately energize an audible alarm after a comparatively long time interval to indicate that the connector and preceding switches are held in an operated position. This timing circuit is diagrammatically shown and may be any timing circuit well known in the art.

The testing circuit Fig. 2 is shown arranged for association with a plurality of connectors C which are connected by multiple wiring to the T, R and S terminals of the horizontal levels, such as 172 of the testing switch and the connectors which are so wired to a terminal level would ordinarily be mounted on the same shelf of an equipment frame. The testing circuit is thus associated with a plurality of shelves of connectors and may be energized by any of these connectors over a circuit extending from a connector to the electrical equipment shown in Fig. 2A. One lamp 245 is provided for each connector. Relays 214 and 218 are provided for each shelf of connectors. The commutator 170 of the testing switch has one segment for each shelf of connectors. Relay 244 may be common to a complete frame of connectors and the timing circuit may be common to a plurality of frames of connectors.

In accordance with the present invention this timing circuit is employed to energize the connector test circuit after a short time interval by first energizing relay 244. This relay associates ground through resistance 259 and its contact 1, contact 1 of relay 218, winding of relay 214 to battery energizing relay 214 in the shelf alarm circuit. The energization of relay 214 associates battery through the winding of the test circuit start relay 213 to ground. Relay 214, in operating, establishes a locking circuit for itself to ground on contact 3 of connector relay 104 through lamp 245 and resistance 258. The winding of relay 214 is of low resistance and causes the illumination of lamp 245. The locking circuit for relay 214 is established in this manner so that if at any time when the test circuit is functioning, the connector ground is removed from the test circuit, the testing circuit will restore to normal. With test circuit start relay 213 energized, a circuit is established for relay 210 from ground through contact 2 of relay 213, winding of relay 210, contact 2 of normally operated relay 242 to battery. Relay 213 also establishes a circuit from battery through its contact 1, contact 1 of relay 212, contact of rotary magnet 200, winding of relay 206, winding of relay 205, contact of vertical magnet 207, winding of relay 211 to ground. Relays 205 and 206 are marginal and do not operate in the circuit traced. Relay 211 operates for energizing the vertical magnet 207 a circuit for which may be traced from ground through the contact of relay 211, winding of vertical magnet 207, contact 5 of relay 210 to battery on contact 2 of the normally operated relay 242. Relay 210 connects leads 260, 261, 262 and 263 from the tube circuit to the testing relays and to the testing circuit switch brushes 254, 255 and 256 for indicating different conditions encountered in connector circuits as described later. The energization of vertical magnet 207 causes the elevation of commutator brush 171 and the tip, ring and sleeve brushes 254, 255, and 256. The brush 171 seeks a terminal on a level 1 to 10 which has been associated with ground by the connector shelf alarm signal circuit. This ground may be traced from contact of relay 218 to the commutator segment associated with the tenth horizontal level. When the vertical magnet 207 attracts its armature, the circuit for relay 211 is opened causing its release. The release of relay 211 opens the circuit for vertical magnet 207

causing its release and relay 211 thereupon reoperates to reenergize the vertical magnet 207. The alternate operation and releases of the vertical magnet and relay 211 continues until ground is encountered on one of the commutator terminals. A circuit is shown from ground through the tenth segment of commutator 170 and brush 171 to a point between the winding of relay 211 and the windings of relay 205. This ground shunts relay 211 causing its release which opens the circuit for the vertical magnet 207. This ground also increases the current flow through relays 205 and 206 to cause the operation of the marginal relay 205. In the above example, this ground was encountered on commutator segment 10 which shunted relay 211 and arrested the further operation of the vertical magnet 207. This ground may be encountered on any one of the segments 1 to 10 which would arrest the operation of the vertical magnet when brush 171 reaches this commutator segment and brushes 254, 255 and 256 reach the corresponding horizontal level of the connector switch terminals such as 172. The operation of relay 205 establishes a circuit for the rotary magnet 200 which may be traced from ground on the contact of relay 205, winding of rotary magnet 200, contact 5 of relay 210 to battery on contact 2 of relay 242. The energization of the rotary magnet causes the progression of the brushes 254, 255 and 256 over the tip, ring and sleeve terminals of connectors which are wired to these terminals.

Let it be assumed that connectors of the type shown in Fig. 1 are wired to the sets of terminals of the tenth level 172 and that the connector wired to one set of these terminals has given an alarm signal. Any of these connectors may be in use and as previously shown the removal of the switchhook in the calling station causes relays 103 and 117 to be energized and consequently ground is associated through contact 3 of relay 117 with sleeve conductor 135 and with the sleeve terminal of the connector. The operation of rotary magnet 200 in making its first step dissociates its armature from its contact which opens a circuit for relay 205 causing its release. The release of relay 205 releases the rotary magnet 200 which reestablishes the operating circuit for relay 205 unless ground is connected to the sleeve terminal of contact set No. 1 by the connector wired to this set of terminals. If ground is encountered on the sleeve terminal a circuit is established from this ground through brush 256, contact of relay 201 to a point between the winding of relay 205 and the winding of relay 206 which releases relay 205 arresting the action of the rotary magnet and causes the operation of marginal relay 206. If the connector wired to a set of terminals is idle and no ground is encountered on the sleeve terminal, relay 205 is reoperated which reenergizes the rotary magnet for moving the brushes another step. When relay 206 is operated it establishes a circuit from ground through its contact, winding of relay 204, contact 5 of relay 210, to battery through contact 2 of relay 242 which operates relay 204.

Calling party permanent

The testing circuit is arranged to function in different manners responsive to different conditions which may be found in each connector switching circuit encountered by the testing switch brushes. As previously stated, the permanent signal shelf alarm circuit may be actuated when a calling subscriber has not replaced the receiver on the switchhook whereas the called subscriber has replaced the receiver and the testing circuit responds to this condition to cause the release of this connector. A time interval is usually provided before the testing circuit acts to release the connector. For this purpose the releasing circuit is established through an interrupter such as interrupter 247 for operating relay 202 after the operation of relay 206. The circuit for relay 202 may be traced from battery, through the contact of interrupter 247, winding of relay 202 to ground through the contact of relay 206. The energization of relay 202 connects ground to the tip conductor and battery to the ring conductor of the calling line loop which shunts relay 103 and causes its release. This circuit may be traced from ground through the upper winding of relay 103, contact 1 of relay 104, brush 254, lead 251, contact 1 of relay 202, contact 1 of relay 203 to ground. The circuit from battery through the lower winding of relay 103 may be traced through contact 2 of relay 104, ring brush 255, conductor 252, contact 2 of relay 202, contact 2 of relay 203, contact 1 of relay 243, winding of relay 243 to battery. Relay 243 is a low resistance marginal relay for use with either comparatively short subscribers' loops or long subscribers' loops. The operation of relay 202 also establishes a circuit for relay 212 traced from ground through contact 3 of relay 117, lead 135, brush 256, conductor 253, contact of relay 201, contact 3 of relay 202, contact 3 of relay 203, winding of relay 212 to battery. Relay 212 establishes a locking circuit for itself through its contact 3 to ground on contact 2 of the vertical off-normal springs 217.

When relay 103 is caused to be released by shunt, the circuit for relay 117 is opened causing the release of this relay and the release of relays 139 and 128 since the holding circuits through their upper windings has been opened by the release of relay 117. The release magnet 118 is thus energized for releasing the connector over a circuit from battery through the winding of release magnet 118, contact 2 of vertical off-normal springs 121, contact 3 of relay 128, contact 2 of relay 117 to ground on the contact of relay 103. The removal of ground from conductor 135 causes the energization of release magnets 160, 161 and 162 for the release of the line finder, selector 1 and selector 2, respectively, in the manner well known in the art. The release of the connector removes ground from sleeve brush 256 which removes the shunt ground from the junction point between the windings of relays 205 and 206 causing the reoperation of relay 205 and the release of the marginal relay 206. Relay 205 is operated over a circuit from battery through contact 1 of relay 213, contact 1 of relay 212, contact of the rotary magnet 200, winding of relay 206, winding of relay 205 to ground on the rotary off-normal contact and to ground through brush 171. The operation of relay 205 extends ground through the winding of the rotary magnet 200, contact 5 of relay 210, contact 2 of relay 242 to battery. The operation of rotary magnet 200 causes the release of relay 205 which releases the rotary magnet causing relay 205 to again operate which continues until the brushes 254, 255 and 256 reach the 11th rotary step. The release of relay 206 opens the circuit for relay 202 which releases. When the testing circuit switch brushes reach the 11th rotary step ground is connected through

springs 215, winding of relay 212 to battery operating relay 212 which locks through its contact 3 to ground on the vertical off-normal contact 217. The operation of relay 212 establishes an energizing circuit for relay 209 from ground through its winding, contact 2 of relay 212, contact 4 of relay 202 to battery. The operation of relay 209 connects ground through its contact, winding of release magnet 208 to battery causing the release of the testing circuit switch.

Called subscriber answers

In the above circuit traced for shunting the winding of connector relay 103 to cause its release and the release of the connector switch, battery was connected through the lower winding of relay 103 and the contact of relays 104 and 202, thence through the winding of relay 243 to battery. Relay 243 does not operate in this circuit, but if the subscriber at station 110 should remove the receiver from the switchhook before or approximately at the same time that relay 202 is operated the condition is altered by the operation of relay 104 in response to the removal of the receiver in station 110. This is the same condition found by the testing circuit when it is associated with a connector in normal use for a conversational connection between a calling subscriber and a called subscriber but since the circumstances are different a different circuit combination is formed in the testing circuit as later described. The operation of relay 104 reverses the current from the windings of relay 103 through the contacts of relay 104 over the calling subscriber's loop and to the tip and ring test brushes 254 and 255 in the testing circuit, causing the operation of relay 243 which locks to ground on the vertical off-normal springs 207. The operation of relay 243 opens the battery circuit extending through its winding to the ring conductor of the connector circuit and operates relay 201. Under this condition the connector relay 103 does not release and the testing circuit rotary stepping magnet 200 is energized to move the testing circuit brushes off of the connector terminals. The operation of relay 201 disassociates the connector sleeve ground from the junction point between relays 206 and 205. The removal of this ground causes relay 206 to release and relay 205 to again operate over a circuit from battery through contact 1 of relay 213, contact 1 of relay 212, contact of the rotary magnet 200, winding of relay 206, winding of relay 205 to ground on the rotary off-normal contact and to ground through brush 171 and commutator 10 which is placed thereon by contact 1 of relay 218. The operation of relay 205 extends ground through the winding of the rotary magnet 200, contact 5 of relay 210, contact 2 of relay 242 to battery. The operation of the rotary magnet 200 causes the release of relay 205 which releases the rotary magnet causing relay 205 to again operate which continues until the brushes 254, 255 and 256 reach the eleventh rotary step if another connector in an off-normal condition is not encountered on terminals between the released connector and the eleventh rotary step. The release of relay 206 opened the circuit for relay 202 which released. When the brushes reach the eleventh rotary step, ground is connected through spring 215, winding of relay 212 to battery operating relay 212 which locks through its contact 3 to ground on the vertical off-normal contact 217. The operation of relay 212 establishes an energizing circuit for relay 209 from ground, through its winding, contact 2 of relay 212, contact 4 of relay 202 to battery. The operation of relay 209 connects ground through its contact, winding of release magnet 208 to battery causing the release of the testing circuit switch.

Repeated test

The foregoing restoration of the testing circuit switch took place so as to cause no interference between subscribers who may want to continue conversation. The circumstances may, however, be such that the alarm signal circuit is again actuated by the time the testing circuit has restored to normal. For example, the subscriber at 101 may have the receiver off the switchhook and the subscriber at 110 may have attempted to make another call to a different subscriber. After failing to obtain service the subscriber at 110 may have replaced the receiver on the switchhook which would again restore relay 104. Under this condition relays 103, 117, 139 and 128 would remain operated and ground would be associated through contact 3 of relay 104, contact 5 of relay 139 to either maintain relays 218 and 214 operated or reoperate relay 218 which would reoperate relay 214. Under this circumstance, relay 213 is operated which actuates the testing circuit to repeat the test of this connector switch. The circuit previously traced for the vertical and rotary magnets is again established from battery through contact 1 of relay 213, contact 1 of relay 212 which has restored to normal, contact of rotary magnet 200, winding of relay 206, winding of relay 205, contact of vertical magnet 207, winding of relay 211 to ground which energizes relay 211 as previously described. Since relays 205 and 206 are marginal they do not operate in the circuit traced and the vertical magnet is energized through the contact of relay 211. The circuit operations proceed as previously explained to elevate brushes 254, 255 and 256 to the terminals of the connector giving the alarm signal. On this repeated test, if the subscriber 110 has replaced the receiver on the switchhook and subscriber 101 has not, relay 103 is released by shunt as previously described. The connector is released causing the release of the associated line finder, selector 1 and selector 2 which causes the release of the testing circuit.

Conversational connection

Under some circumstances the shelf alarm signal circuit is actuated and the testing circuit switch brushes are elevated to the terminal level containing the connector giving the alarm but upon reaching this level connectors are encountered over which conversation is taking place between two subscribers. This condition is different from the one previously described under the subheading of (Calling party permanent) since sufficient time does not elapse for relay 202 to operate. It will be remembered that relay 206 is energized when ground is encountered on the sleeve of the connector, which under this condition is connected thereto through contact 3 of relay 117, and that the circuit for relay 202 is established from battery through the interrupter 247, winding of relay 202 to ground on relay 206 for releasing relay 103. But with conversation taking place between subscribers over the connector, the following circuits are established which causes the testing circuit switch to step its brushes 254, 255 and 256 off of the terminals associated with this connector before the circuit of relay 202 is connected through the contact of

interrupter 247. This circuit involves tube 220 and it should be noted that this tube circuit is arranged for normally creating a plate current to energize relay 219, which maintains relay 201 normally released. A connector in use for telephone conversation has both relays 104 and 103 operated and consequently battery through the lower winding of relay 103 is extended to the tip terminal of the connector over the calling subscriber's line loop to ground through the upper winding of relay 103. A circuit is established from this battery through switch brush 254, contact 2 of relay 210, lead 260 to a junction point between resistances 221 and 222 in the circuit wiring of tube 220. Since the battery connected to relay 103 and the battery connected to tube 220 are of the same voltage this creates a negative bias on the grid circuit of tube 220 which sufficiently reduces the plate current through the winding of relay 219 to cause the release of the latter relay. The operation and release adjustments of relay 219 are so arranged that this relay may be released by a certain percentage reduction in the plate current. It is recognized that the potential impressed upon the sleeve terminal of the connector through the lower winding of relay 103 will vary to some extent depending upon the length of the line loop. The release of relay 219 establishes a circuit from ground, through its contact, contact 1 of relay 210, winding of relay 201 to battery which operates relay 201. The operation of relay 201 opens the ground circuit which had been established from the sleeve of the connector placed thereon through contact 3 of relay 117 which extends through brush 256 to a junction point between relays 205 and 206. The operation of relay 201 thus causes the release of relay 206 and the energization of relay 205. As previously described, this establishes a circuit for the rotary magnet from ground on the contact of relay 205, through the winding of rotary magnet 200, contact 5 of relay 210 to battery on contact 2 of relay 242. The brushes 254, 255 and 256 may be rotated to the eleventh rotary step if another off-normal connector is not encountered and a circuit is established for relay 212 from ground on springs 215, winding of relay 212 to battery. The operation of relay 212 energizes relay 209 and the energization of relay 209 establishes a circuit for the release magnet 208 in the manner previously described.

It is possible that a fault may be present in the connector giving the alarm and that this fault continues to be present after the conversation has ceased between subscribers using the connector when the first test was made. A fault of this character may occur through carelessness of a repair man who may have dropped solder causing a cross between contacts which does not prevent the use of the connector but which may create a condition to give a permanent alarm signal. Under this circumstance, the testing circuit repeatedly establishes connection with the connnector and when conversation over this connector has ceased it may seize the connection and give an alarm after a timed interval.

Busy called lines or no answer

Other conditions may be encountered in connectors which have been directed by a calling party to a busy line or to a called party such as 110 who has not answered by removing the receiver from the switchhook. Under these circumstances, either an audible ringing tone is found on the ring conductor of the calling line or a busy tone is found on the ring conductor of the calling line when the testing switch brushes reach the terminals wired to the connector. Under this circumstance, the testing circuit may have been energized in the manner previously described and associates the tip, ring and sleeve brushes 254, 255 and 256 with the connectors in a switch bank. The foregoing conditions are automatically recognized by the testing circuit. The tone circuit may be traced from the ring conductor of the connector over testing circuit brush 255, conductor 252, contact 3 of relay 210, conductor 261, condenser 226 to the grid of tube 223. This busy tone or audible ringing tone is fed from a current source in the form of alternating or pulsating current which is amplified and placed across tube 236. Tube 236 rectifies this current and applies direct current voltage to tube 240 for diminishing the plate current flow through the winding of relay 241 causing the release of the latter normally operated relay. This connects ground through the contact of relay 241, contact 1 of relay 210, winding of relay 201 to battery which operates the latter relay to open the ground circuit extending from the sleeve conductor of the connector switch circuit to the junction point between relays 205 and 206. This causes the release of relay 206 and the reoperation of relay 205 for reactuating the stepping circuit of the testing switch in the manner previously described for stepping the test brushes to the next set of terminals. Any off-normal connectors encountered actuate the testing circuit as described herein and the testing circuit is restored to normal when the test switch brushes reach the eleventh rotary step.

Relay 242 is normally operated from battery supplying current to the tubes. The release of this relay indicates a battery failure by establishing a circuit for the alarm bell 249.

Intercepting operator's trunk

The testing circuit may encounter a connector which is associated with an intercepting operator's trunk circuit having been routed thereto from a calling subscriber who called for a telephone line which no longer existed. The intercepting operator's circuits are arranged for conversational connections with a calling subscriber through the equipment of a connector without operating connector relay 104 in order to prevent the operation of the message registered in the calling subscriber's line. This connection, therefore, presents the same circuit conditions to the testing circuit as a connector which is held by a calling subscriber after the called subscriber has replaced the receiver on the switchhook. The intercepting operator's trunk is, however, arranged to transmit a tone over the sleeve conductor, as shown, in place of the usual sleeve ground. This tone is transmitted to the testing circuit over a circuit which may be traced through the secondary winding of transformer 175, sleeve terminal 103, brush 114, contact 8 of relay 128, conductor 135, sleeve terminal associated with test brush 256, contact 4 of relay 210, conductor 262, condenser 232 to the grid of tube 230. Tube 236 is arranged to rectify this current and apply the rectifying current to tube 240 causing the release of relay 241. The release of relay 241 connects ground through contact 1 of relay 210, winding of relay 210 to battery for operating the latter relay. The operation of relay 201 immediately opens the circuit extending

from the sleeve of the connector switch to the junction point between relays 205 and 206 the same as previously described. This causes the release of relay 206 and the reoperation of relay 205 for reactuating the stepping circuit of the testing switch, stepping the test brushes to the next set of terminals in this horizontal level.

False ground

If a false ground is present on the sleeve conductor of a connector the testing circuit remains associated with the connector for a sufficient time to cause the operation of relay 202 from ground, through the contact of relay 206, winding of relay 202 to battery to interrupter 247. Under this condition relay 212 is energized from ground on the sleeve, conductor 135, brush 256, conductor 253, contact of relay 201, contact 2 of relay 202, contact 3 of relay 203 normal, winding of relay 212 to battery. Since relay 202 is operated, a circuit is not established at this time for relay 209 or the release magnet 208. After an interval of time a release alarm is sounded in the alarm circuit. Relay 104 is operated when a connector is removed from service so that the testing circuit will not receive a false indication during a test of this connector.

What is claimed is:

1. In an automatically operable telephone office, automatic switches including connectors, a connector testing circuit, means in a connector for operating a signal circuit for initiating the operation of said testing circuit and for indicating the location of said connector to said testing circuit, means in said testing circuit responsive to the operation of said signal circuit for connecting said testing circuit with said connector, means in said testing circuit for disconnecting from a connector in use for normal telephone service and means in said testing circuit for releasing a connector held operated but not in use for normal telephone service.

2. In an automatically operable telephone office, automatic switches including connectors, a connector testing circuit, means in a connector for operating a signal circuit for initiating the operation of said testing circuit and for indicating the location of said connector to said testing circuit, means in said testing circuit responsive to the operation of said signal circuit for connecting said testing circuit with said connector, means in said testing circuit for disconnecting from said connector when found in use for normal telephone service and means for repeating said test under the control of said signal circuit.

3. In an automatically operable telephone office, automatic switches including connectors, a connector testing circuit, a trouble indicating circuit, means in a connector for operating said trouble indicating circuit, means in said trouble indicating circut for initiating the operation of said testing circuit and for indicating the location of said connector to said testing circuit, means in said testing circuit responsive to the operation of said trouble indicating circuit for connecting said testing circuit with said connector, means in said testing circuit responsive to voltage polarity of current connected to the calling subscriber's line upon the release of the called subscriber for restoring said connector to normal and means in said testing circuit responsive to the voltage polarity of current connected to the calling subscriber's line with the receivers of two connected subscribers off their respective switchhooks for disengaging the testing circuit from said connectors.

4. In an automatically operable telephone office, automatic switches including connectors, a connector testing circuit having a step-by-step switch therein, a trouble indicating circuit, means in a connector for operating said trouble indicating circuit, means in said trouble indicating circuit for initiating the operation of said connector testing circuit and for indicating the location of the connector having a trouble condition to said testing circuit, means for connecting said testing circuit switch with said connector, means in said testing circuit responsive to a current from a tone source in a connector for actuating said testing circuit to disengage the testing circuit switch brushes from said connector, and means to repeatedly test said connector responsive to the continued actuation of said troubled indicating circuit.

5. In an automatically operable telephone office, automatic switches including banks of connector switches, a connector testing circuit having a step-by-step switch therein, a trouble indicating circuit, means in a connector for operating said trouble indicating circuit, means in said trouble indicating circuit for initiating the operation of said testing crcuit and for indicating the bank location of the connector having a trouble condition to said testing circuit, means for connecting said testing circuit switch with said connectors, means in said testing circuit responsive to current from a source in a connector circuit for disengaging the testing circuit switch brushes from said connector and means in said testing circuit responsive to current from another source in a connector for arresting the advance of said testing circuit switch brushes.

6. In an automatically operable telephone office, automatic switches including banks of connector switches, a connector testing circuit having a step-by-step switch therein, a trouble indicating circuit, means in a connector for operating said trouble indicating circuit, means in said trouble indicating circuit for initiating the operation of said testing circuit and for indicating the bank location of the connector having a trouble condition to said testing circuit, means for connecting said testing circuit switch with said connectors, a vacuum tube circuit in said testing circuit responsive to current from a source in a connector circuit for actuating said testing circuit to disengage the testing circuit switch brushes from said connector and means in said testing circuit responsive to current from another source in a connector for arresting the advance of said testing circuit switch brushes.

7. In an automatically operable telephone office, automatic switches including connectors, a connector testing circuit having a step-by-step switch therein, a trouble indicating circuit, means for operating said trouble indicating circuit, means in said trouble indicating circuit for initiating the operation of said connector testing circuit and for indicating the location of the connector having a trouble condition to said testing circuit, means for connecting said testing circuit switch with said connector, an alternating current source in said connector for indicating a service connection, an amplifying circuit and a rectifying circuit in said testing circuit responsive to said alternating current source for developing a direct current source to actuate said testing circuit for disengaging the testing circuit switch brushes from said connector terminals

and for restoring said testing circuit to normal.

8. In an automatically operable telephone office, automatic switches including connectors, an automatic connector testing circuit having a switch, means for directing said testing circuit switch to the location of particular connectors, means in said testing circuit variably responsive to variable connector circuit conditions, in a connector in use for conversational service between two subscribers, in a connector associated with a subscriber's station being actuated by ringing current, in a connector associated with a busy line and in a connector for use for conversational service between a calling subscriber and an intercepting operator, for disassociating said testing circuit from a connector in any one of said circuit conditions, and means responsive to a connector circuit condition in a connector held operated by a calling subscriber after the called subscriber has replaced the receiver for restoring said connector to normal.

9. In an automatically operable telephone office, automatic switches including connectors, a connector switch testing circuit, a switch in said testing circuit having a plurality of sets of terminals in groups, each set being wired to a connector, a signal circuit, means in the connectors of a group for operating said signal circuit, means in said signal circuit responsive to its operation for marking a group of connectors for test, means in said signal circuit for actuating said testing circuit to cause its switch to hunt for said marked group, means in said testing circuit to cause its association with the connectors of said group, means in said testing circuit responsive to varied circuit conditions in a connector in any phase of completing a service connection or which has completed a service connection for disassociating the testing circuit from said connector and causing the test switch to step to the next succeeding connector of the group and means in said testing circuit responsive to a non-service circuit condition in a connector for restoring said connector to normal.

10. In an automatically operable telephone office, automatic switches including connectors, a connector switch testing circuit, a switch in said testing circuit having a plurality of sets of terminals in groups, each set being wired to a connector, a signal circuit, means in the connectors of a group for operating said signal circuit, means in said signal circuit responsive to its operation for marking a group of connectors for test, means in said signal circuit for actuating said testing circuit to cause its switch to hunt for said marked group, means in said testing circuit to cause said switch to step from one connector to the next connector throughout said group responsive to variable connector circuit conditions, in a connector in use for conversational service between two subscribers, in a connector associated with a subscriber's station being actuated by ringing current, in a connector associated with a busy line and in a connector for use for conversational service between a calling subscriber and an intercepting operator, for disassociating said testing circuit from connectors in any of said circuit conditions and means in said testing circuit responsive to a circuit in a connector held operated by a calling subscriber after the called subscriber has replaced the receiver for restoring said connector to normal.

GEORGE LELAND CAIN.
ELTON SMITH.
HAROLD ARTHUR SOUCY.