

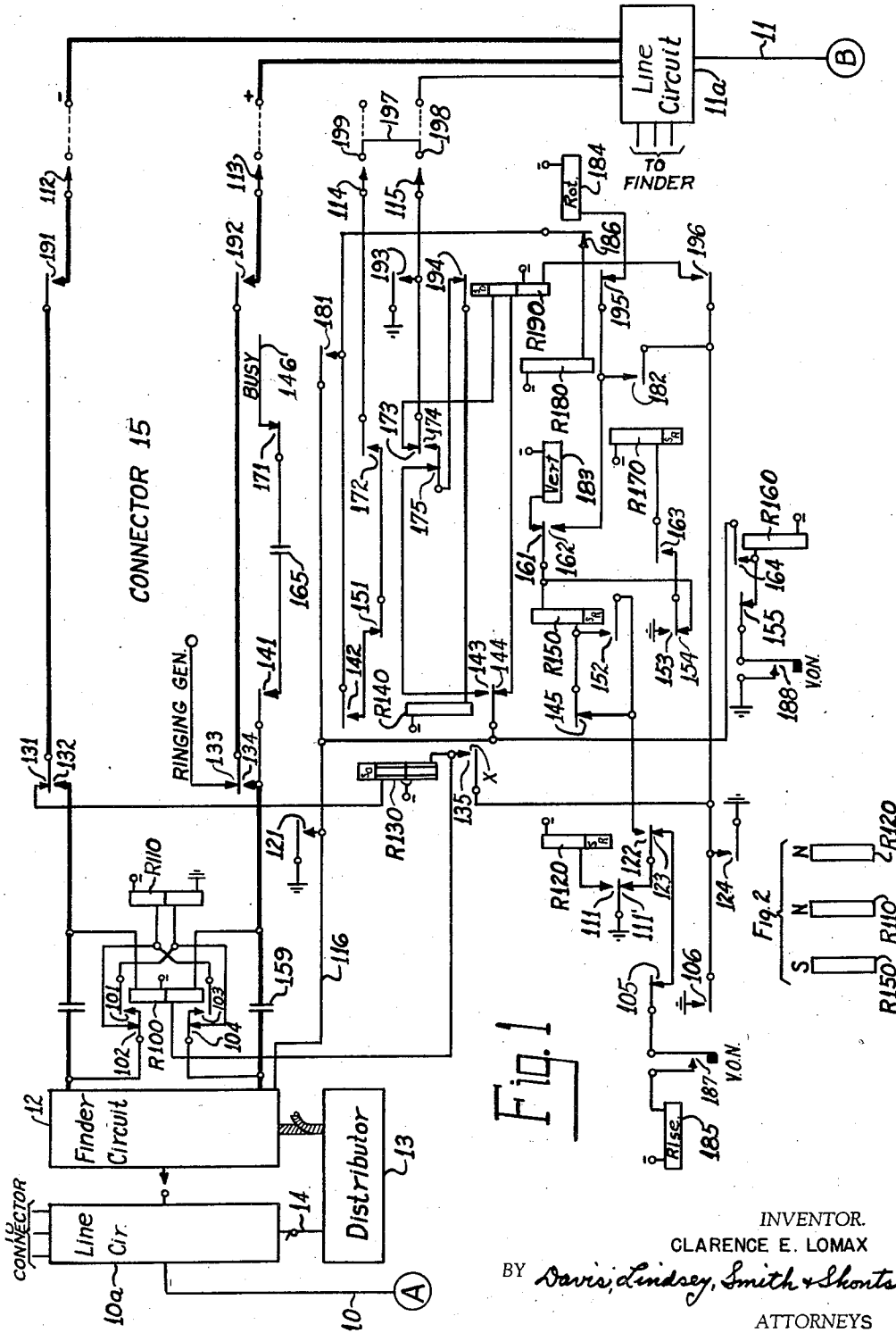
March 2, 1943.

C. E. LOMAX

2,312,427

AUTOMATIC SWITCHING APPARATUS

Filed Jan. 11, 1941



UNITED STATES PATENT OFFICE

2,312,427

AUTOMATIC SWITCHING APPARATUS

Clarence E. Lomax, Oak Park, Ill., assignor to
Associated Electric Laboratories, Inc., Chicago,
Ill., a corporation of Delaware

Application January 11, 1941, Serial No. 374,073

15 Claims. (Cl. 179—18)

The present invention relates to automatic switching systems and, more particularly, to improvements in the impulse controlled equipment of the switchgear conventionally used in automatic systems of telephonic communication.

It is an object of the present invention to provide for use in a system of the character described a plural digit impulse-controlled automatic switch which is entirely accurate and reliable in its response to impulses transmitted thereto over lines having inferior impulsing characteristics.

It is a further object of the invention to provide an automatic switch of the character described which includes a line or pulsing relay which is so arranged relative to the other relays of the switch that it is subjected to an electromagnetic priming action during each of the digits transmitted to the switch.

It is another object of the invention to provide an automatic switch of the character described which is so arranged that the operation of the line relay is influenced and improved by the electromagnetic coupling provided between this relay and the change-over or digit transfer relay of the switching during each digit transmitted to the switch.

It is still another object of the invention to provide an automatic switch of the character described which is so arranged that the operation of the line relay is influenced and improved by the electromagnetic coupling provided between this relay, the hold or release relay and the change-over or digit transfer relay, during each series of impulses transmitted to the switch.

The invention is illustrated in its embodiment in a connector switch forming a part of a small automatic telephone system. More specifically, the connector switch is of the two-motion, two-digit type utilizing vertical and rotary magnets for effecting the primary and secondary movements of the movable switch wipers. The first digit transmitted to the switch is utilized for line group selection and the second digit is utilized for the selection of a particular line in a selected group. The impulse controlled equipment of the switch includes the usual line relay, a slow-acting hold or release relay, and a slow-to-release change-over or digit transfer relay of the series type, which is utilized to effect a transfer of the pulsing circuit local to the switch from the vertical or group select magnet to the rotary or units select magnet of the switch. In accordance with the present invention provisions are made for energizing this change-over relay

during each of the two digits transmitted to the switch in setting up a connection, and this relay, the line relay and the hold relay are so positioned and poled with respect to each other that the operation of the line relay accurately to follow the impulses transmitted thereto, is substantially improved. More specifically, the magnetic circuit of the line relay is disposed within the magnetic fields resulting from energization of the release and change-over relays, and the magnetic circuits of these three relays are so related that the flux linking with the magnetic circuit of the line relay and occasioned by the energization of the change-over relay, assists or enhances the energization of the line relay, while the flux linking the magnetic circuit of the line relay and resulting from energization of the release relay, assists in the deenergization of the line relay.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention, both as to its organization and method of operation, together with further objects and advantages thereof will best be understood by reference to the specification taken in connection with the accompanying drawing in which Fig. 1 illustrates the invention as embodied in a connector switch forming a part of a small automatic telephone system, and Fig. 2 illustrates the physical arrangement of the line, release and change-over relays embodied in the connector switch shown in Fig. 1.

Referring now more particularly to Fig. 1 in the drawing, the system there illustrated has an ultimate capacity of 100 lines and may be utilized to serve a small community which forms a part of a larger central exchange area, suitable ring-down trunks being provided for routing connections from the exchange equipment of the community exchange to a central office, not shown, of the manual type. Briefly described, the illustrated system comprises a plurality of subscriber lines 10, 11, etc. which individually terminate in the community exchange in line circuits 10a, 11a, etc. The two lines 10 and 11 extend to the substations A and B, respectively, each of which conventionally includes substation equipment of the common battery type. More specifically, each substation comprises the usual transmitter and receiver, a hybrid system, a dial-controlled impulsing device, a hook switch and a bell or ringer.

For the purpose of setting up connections between the lines 10, 11, etc., the exchange is

equipped with a plurality of finder-connector links, one of which is illustrated as including the finder 12 and the connector 15, which are automatically allotted for use by a link distributor 13. Although the distributor 13 may be of any desired commercial form, it is preferably of the preselective rotary type, such that an idle link is selected for use immediately a previously selected link is seized over a calling line. The line finders of the system may similarly be of any desired type, although preferably are of the well-known Strowger type utilizing two-motion Strowger switches for line selecting purposes.

The connectors of the exchange are also of the Strowger type. These switches are identical in construction and arrangement and, accordingly, the physical structure and circuit wiring thereof will be understood from a consideration of the connector 15. Briefly described, this connector comprises a Strowger switching mechanism which includes a stationary contact field divided into levels, a set of movable wipers 112 to 115, inclusive, the usual vertical, rotary and release magnets 183, 184 and 185, respectively, and vertical off-normal springs 187 and 188. The enumerated magnets are arranged to be controlled by a set of relays which includes a battery reversing relay R100, a line or pulsing relay R110, a slow-to-release hold or release relay R120, a slow-acting ring cut-off relay R130, a busy test relay R140, a series change-over or digit transfer relay R150, a transfer relay R160, a slow-to-release control relay R170, a trunk-hunting relay R180, and a slow-to-operate line switching relay R190. These relays are interconnected to control the vertical, rotary and release magnets of the switch, and also the line switching required incident to the completion of a connection, by circuits which are described with particularity hereinafter.

In considering the operation of the system it may be assumed that a call intended for the substation B is initiated at the substation A. To initiate the call the calling party removes the telephone instrument provided at the substation A from its supporting hook or cradle, in the usual manner, whereby the associated hook or cradle switch is operated to complete a calling circuit which includes the conductors of the line 10 and extends to the line circuit 10a. When this circuit is completed the line relay conventionally embodied in the line circuit 10a operates to mark the calling line 10 in the bank contacts of the finders provided in the exchange and to impress ground or start potential upon the distributor start lead 14. Assuming that the distributor 13 has previously operated to select the illustrated finder-connector link for use, the application of ground potential to the distributor start lead 14 results in the operation of the finder 12 to seize the calling line 10 through the line circuit 10a. More specifically, the relay equipment of the distributor 13, operating first in conjunction with the vertical magnet of the finder 12, causes the wipers of this finder to move vertically to a position opposite the level of bank contacts in which the conductors of the line 10 are terminated. After this level is located a transfer operation occurs whereby the relay equipment of the distributor 13 cooperates with the rotary magnet of the finder 12 to rotate the wipers of this finder until they engage the contacts of the contact set at which the conductors of the line 10 terminate. When the line 10 is thus seized by the finder 12, rotary movement of the finder wipers is arrested and the usual circuit is completed for energizing

the cut-off relay of the line circuit 10a. Incident to these operations the calling loop circuit is extended to the connector 15, the line 10 is marked as busy, and a guard potential is impressed upon the guard lead individual to the finder 12 to mark the illustrated link as busy in the test contacts of the distributor switch forming a part of the distributor 13. When the cut-off relay of the line circuit 10a operates, the distributor start lead 14 is disconnected from ground, and operation of the distributor switch is initiated to select another idle link for the use of the next incoming call. The manner in which all of these operations are effected is well understood in the art and will be readily understood from the above brief explanation.

As indicated above, when the finder 12 operates to seize the calling line 10, it extends the calling loop circuit through the contacts 102 and 104 of the battery reversing relay R100 to the terminals of the line relay R110 so that the line relay is energized thereover. In operating, the line relay R110 closes its contacts 111 to complete an obvious circuit for energizing the release relay R120. The relay R120, upon operating, closes its contacts 121 to complete an obvious path for impressing ground potential upon the release conductor 116, thereby to complete locking circuits for the operated cut-through relay of the finder 12 and the operator cut-off relay of the line circuit 10a. At its contacts 122, the relay R120 prepares a circuit for energizing the change-over relay R150 in series with the vertical magnet 183 during the first series of impulses transmitted to the connector 15. At its contacts 123, the relay R120 opens a point in the circuit for energizing the release magnet 185. At its contacts 124, the relay R120 prepares certain operating and locking circuits referred to more specifically hereinafter. Following the operation of the two relays R110 and R120 the connector 15 is conditioned to respond to the impulses of the first digit of the directory number designating the desired substation B. During the impulses of this digit, as transmitted through operation of the calling device provided at the substation A, the line relay R110 alternately operates and restores one or more times, depending upon the numerical value of the digit. Assuming that the directory number designating the called substation B is 44, the line relay R110 restores and reoperates four times during each of the first and second digits. Each time the relay R110 restores, it opens its contacts 111 to interrupt the operating circuit for the release relay R120. When the line relay R110 first restores at the beginning of the open-circuit period of the first impulse the above-mentioned circuit is completed for energizing the relay R150 in series with the vertical magnet 183, this circuit extending from ground by way of the contacts 111', 122 and 145, the winding of R150, the contacts 161 and the winding of the magnet 183 to battery. When energized over this circuit the relay R150 operates and closes its contacts 152 to complete an obvious path in shunt with the break contacts 145 controlled by the busy test relay R140. At its contacts 151, the relay R150 opens a point in the operating circuit for the trunk-hunting relay R180. At its contacts 153, the relay R150 prepares one of the operating circuits for the slow-to-release control relay R170. At its contacts 154, the relay R150 opens a point in the other operating circuit for the relay R170. The vertical magnet 183, upon operating in response to the completion of the circuit traced above, co-

operates with its associated ratchet and pawl mechanism to elevate the wipers 112 to 115, inclusive, one step so that these wipers are positioned opposite the first level of bank contacts in the associated contact field. In response to the vertical movement of the wipers, the vertical off-normal springs 187 are moved into engagement to prepare the operating circuit for the release magnet 185 and the vertical off-normal springs 188 are closed to prepare the operating circuit for the transfer relay R160. It will be understood that at the end of the open-circuit period of the first impulse when the line relay R110 reoperates the vertical magnet 183 is deenergized. It will also be understood that three additional current pulses are transmitted to this magnet through the winding of the change-over relay R150 by the line relay R110 during the first digit. Each time the vertical magnet 183 is energized it operates to lift the associated wipers 112 to 115, inclusive, an additional step. Accordingly, these wipers are left standing opposite the fourth level of bank contacts in which the conductors of the called line 11 are terminated at the end of the first digit. Due to the slow-to-release characteristics thereof, the release relay R120 and the change-over relay R150 remain operated during impulsing.

Shortly following the end of the first digit and during the inter-digit pause between the first and second digits the change-over relay R150 restores to complete the prepared operating circuit for the transfer relay R160, this circuit extending from ground by way of the off-normal springs 188, the contacts 155 and the winding of R160 to battery. When thus energized the relay R160 operates and locks to ground over a path including the contacts 164 and 121. At its contacts 163, the relay R160 prepares the operating circuits for the relay R170. At its contacts 161, the relay R160 opens the above-traced circuit over which current pulses were delivered to the vertical magnet during the dialing of the first digit. At its contacts 162, the relay R160 prepares a circuit for energizing the rotary magnet 184 in series with the change-over relay R150 during the dialing of the second digit. This circuit is completed at the beginning of the open-circuit period of the first impulse of the second digit and extends from ground by way of the contacts 111', 122 and 145, the winding of R150, the contacts 162 and 195 and the winding of the magnet 184 to battery. In re-operating, the relay R150 closes its contacts 153 to complete the prepared operating circuit for the relay R170 and opens its contacts 155 to interrupt the operating circuit for the transfer relay R160. At its contacts 151, the relay R150 opens a point in the operating circuit for the trunk-hunting relay R180. The rotary magnet 184, in operating, rotates the wipers 112 to 115, inclusive, into engagement with the contacts forming the first contact set in the selected fourth level. At its contacts 186, the magnet 184 opens another point in the operating circuit for the trunk-hunting relay R180. It will be understood that the rotary magnet 184 is deenergized when the line relay R110 reoperates to terminate the open-circuit period of the first impulse in the second digit. It will also be understood that during each succeeding impulse of this digit a current pulse is delivered to the rotary magnet 184 through the winding of the relay R150, so that at the end of the second digit the wipers 112 to 115, inclusive, are left standing in engagement with the contacts terminating

the conductors of the line 11. During this rotary movement of the switch wipers, the busy test relay R140 is energized each time the test wiper 115 engages a contact terminating the private conductor of a busy line. Thus the relay R170, upon operating at the beginning of the second digit, closes its contacts 174 to connect the busy test relay R140 to the test wiper 115, whereby this relay is energized each time the test wiper engages a test contact marked with ground potential indicating that the associated line is busy. In operating, the relay R170 also opens its contacts 171 to prevent busy tone current from being projected over the calling loop circuit during the rotary movement of the switch wipers, and closes its contacts 172 to prepare the operating circuit for the trunk-hunting relay R180. At its contacts 175, the relay R170 opens a point in the locking circuit for the busy test relay R140. At its contacts 173, the relay R170 opens a point in the operating circuit for the idle test or switch-through relay R190.

As indicated above, immediately the called line 11 is selected it is tested to determine the idle or busy condition thereof. In the event the line is busy the private conductor thereof is marked with ground potential in the line circuit 11a so that the busy test relay R140 is energized over the above-mentioned test circuit. This circuit extends by way of the grounded test contact individual to the line 11, the test wiper 115, the contacts 174 and 194, and the winding of R140 to battery. In operating, the relay R140 closes its contacts 143 to prepare a locking circuit for itself; opens its contacts 145 to interrupt the initially completed pulsing circuit extending through the winding of the change-over relay R150 to the rotary magnet 184; and closes its contacts 142 further to prepare the operating circuit for the trunk-hunting relay R180. At its contacts 141, the relay R140 prepares the above-mentioned circuit for transmitting busy tone current over the calling end of the connection. At its contacts 144, the relay R140 opens a point in the operating circuit for the switch-through relay R190.

Shortly following the selection of the called line 11 in the manner pointed out above, the two relays R150 and R170 sequentially restore, in the order named and in an obvious manner. In releasing, the relay R150 closes its contacts 151 further to prepare the operating circuit for the trunk-hunting relay R180 and opens its contacts 152 to interrupt the pulsing circuits to the vertical and rotary magnets, thus preventing any further response on the part of the connector to additional impulses transmitted thereto. The relay R170, upon restoring, closes its contacts 175 to complete the above-mentioned locking circuit for the busy test relay R140, this circuit extending from ground by way of the contacts 121, 143, 175 and 194, and the winding of R140 to battery. After this circuit is completed the relay R170 opens its contacts 174 to interrupt the operating circuit for the busy test relay. At its contacts 171, the relay R170 completes the above-mentioned circuit for transmitting a busy tone signal over the calling end of the connection, this circuit extending from the ungrounded terminal of the busy tone current source, not shown, by way of the conductor 146, the contacts 171, the condenser 165, the contacts 141 and the condenser 159 to one side of the loop circuit extending to the calling substation. From this point the current is transmitted through the

receiver provided at the substation A and over the opposite side of the line 10 to the opposite terminal of the busy tone signal source. The reproduction of this current by the receiver provided at the calling substation serves to inform the calling party that the desired connection cannot be obtained. Following the operations just described no further operation of the apparatus included in the switch train occurs until the call is abandoned at the calling substation. The manner in which the link is released when the calling party restores the telephone instrument at the calling substation to its supporting hook or cradle will be clearly apparent from the following explanation.

In the event the called line 11 is idle at the time it is selected, the test or private conductor thereof is marked with negative battery potential so that the busy test relay R140 is short-circuited over the above-traced test circuit and fails to operate. Accordingly, when the relays R150 and R170 restore shortly following the end of the second digit the operating circuit for the slow-to-operate switch-through relay is completed, this circuit extending from ground by way of the contacts 121 and 144, the upper winding of R190, the contacts 173, the test wiper 115 and engaged test contact, the private conductor of the line 11 and the winding of the cut-off relay embodied in the line circuit 11a to battery. When thus energized the relay R190 operates and closes its contacts 196 to complete a holding circuit for itself, this holding circuit extending from ground by way of the contacts 124 and 196, and the lower winding of R190 to battery. At its contacts 193, the relay R190 completes a circuit for impressing ground potential directly upon the test wiper 115, thereby to increase the energization of the cut-off relay embodied in the line circuit 11a and to mark the line 11 as busy in the bank contacts of the other connector switches. At its contacts 194, the relay R190 opens another point in the operating and locking circuits for the busy test relay R140. At its contacts 195, the relay R190 opens another point in the operating circuit for the rotary magnet 184. At its contacts 191 and 192, the relay R190 completes a circuit over which ringing current is transmitted to energize the ringer provided at the called substation B. The cut-off relay of the line circuit 11a, in operating, disconnects the windings of its associated line relay from the talking conductors of the line 11 to clear this line of the shunt impedance represented by the line relay windings.

The circuit traversed by the ringing current following operation of the switch-through relay R190 may be traced as extending from the ungrounded terminal of the ringing current generator, not shown, by way of the contacts 133 and 192, the wiper 113, the positive side of the line 11, the bridged ringer and condenser connected across the conductors of the line 11 at the substation B, the negative side of the line 11, the wiper 112, the contacts 191 and 131, the upper winding of R130 and the exchange battery to the grounded terminal of the ringing current generator. A portion of the current traversing this circuit is by induction repeated to the lower winding of the ring cut-off relay R130 and is transmitted over the calling end of the connection to signal the calling subscriber that the called substation is being rung. The ringer provided at the substation B similarly responds to the ringing current by operating to signal the called subscriber

that a call is present on the line 11 which should be answered.

The desired talking circuit between the calling and called substations is completed when the call is answered at the called substation. More specifically, when the telephone instrument at the called substation B is removed from its supporting hook or cradle, a direct current circuit is completed for energizing the ring cut-off relay R130. This circuit extends from ground by way of the ringing current generator, the contacts 133 and 192, the wiper 113, the positive line side of the line 11, the direct current bridge across the conductors of this line at the called substation, the negative side of the line 11, the wiper 112, the contacts 191 and 131 and the upper winding of R130 to battery. When thus energized, the relay R130 closes its preliminary make contacts 135 to complete a locking circuit for itself which extends from ground by way of the contacts 124 and 135, and the lower winding of R130 to battery. After this locking circuit is completed the relay R130 opens its contacts 131 and 133 to interrupt the circuit traversed by the ringing current and two points in its operating circuit as traced above. At its contacts 132 and 134, the relay R130 completes the desired talking circuit between the calling and called substations, and in so doing closes a circuit for energizing the battery reversing relay R100. The latter circuit may be traced as extending from ground by way of the contacts 124 and 135, the lower winding of R100, the contacts 134 and 192, the wiper 113, the positive side of the line 11, the direct current bridge across the conductors of this line at the called substation, the negative side of the line, the wiper 112, the contacts 191 and 132, and the upper winding of R100 to battery. It will be understood that current for energizing the transmitter provided at the called substation is delivered over this circuit. Similarly, current for energizing the transmitter provided at the calling substation is transmitted through the windings of the line relay R110. When energized over the circuit just traced the relay R100 operates and closes its contacts 106 to complete obvious multiple locking circuits for itself and for the relays R130 and R190. At its contacts 105, the relay R100 opens another point in the operating circuit for the release magnet 185. At its contacts 101 to 104, inclusive, the relay R100 reverses the direction of current flow over the calling loop circuit, this current reversal being without effect in handling a call of the character under consideration. It is noted, however, that this current reversal may be utilized for supervisory purposes in handling calls routed to the link from an operator's position in the distant central office. Following the operation of the battery reversing relay R100 no further operation of the apparatus occurs until the connection is released.

The connector 15 is of the last-party-release type, i. e., it is only restored to normal after a connection routed therethrough has been released at both the calling and called ends thereof. Thus it will be apparent that if the called subscriber restores the instrument provided at the called substation to its supporting hook or cradle the only relay operation resulting therefrom is the deenergization and release of the battery reversing relay R100. In restoring, this relay opens its contacts 106 to interrupt the multiple locking circuits for the relays R130 and R190, closes its contacts 105 to reprepare the operating circuit for the release magnet 185, and reverses

the direction of current flow over the calling loop circuit. If the connection is subsequently released at the calling end thereof the line and release relays R110 and R120 are caused sequentially to restore, in an obvious manner. The relay R120, in restoring, opens its contacts 124 to interrupt the locking circuits for the relays R130 and R190. At its contacts 121, the relay R120 opens one of the paths over which ground potential is impressed upon the release conductor 116. It will be noted, however, that ground potential is maintained upon this conductor over a path which includes the contacts 164 and 155 and the off-normal springs 188. At the contacts 121, the locking circuit for the transfer relay R160 is also interrupted but this relay remains in its operated position due to the continued energization thereof over its operating circuit as traced above. The relay R190, upon restoring, opens its contacts 193 to disconnect the private conductor of the line 11 from ground and thus cause the deenergization and release of the cut-off relay embodied in the line circuit 10a. When this cut-off relay restores the line circuit 11a is fully released and the line 11 is marked as idle in the contacts of the connector switches to which it is accessible.

In restoring, the release relay R120 completes the prepared operating circuit for the release magnet 185, this circuit extending from ground by way of the contacts 111', 123 and 105, the off-normal springs 187 and the winding of the magnet 185 to battery. When thus energized the magnet 185 attracts the holding pawl of the Strowger switching mechanism, whereby the wipers 112 to 115, inclusive, are restored to rotary and vertical normal in the usual manner. When these wipers are returned to normal the off-normal springs 187 and 188 are respectively disengaged to cause the deenergization and release of the magnet 185 and the relay R160, respectively. Following the operations just described the connector 15 is fully restored to normal. When the off-normal springs 188 are opened, the release conductor 116 is disconnected from ground to cause the release of the finder 12 and the line circuit 10a in a manner well understood in the art. Incident to the release of the finder 12 the link busying potential is removed from the guard conductor individual to the link illustrated, whereby this link is rendered available for selection by the distributor 13. Incident to the release of the line circuit 10a, and more specifically the release of the cut-off relay embodied therein, guarding ground potential is removed from the private conductor of the line 10 and negative battery potential is impressed upon this conductor to mark the line 10 as idle. From the above explanation it will be apparent that in the event the called line is busy at the time it is selected the release of the switch train proceeds in substantially the manner described above. In this regard it will be apparent that the busy test relay R140 is deenergized and restores when the release conductor 116 is disconnected from ground.

In the event the connection is cleared out at the calling end thereof before it is released at the called substation the line relay R110 and the hold relay R120 are deenergized and restored, in the order named. In such case the battery reversing relay R100 is operated at the time the relay R120 restores. Accordingly, the two relays R130 and R190 are prevented from releasing and the circuit for energizing the re-

lease magnet 185 is held open at the contacts 195. Moreover, ground potential is maintained on the release conductor 116 over a path including the off-normal springs 188 and the contacts 155 and 164, thus preventing the release of the finder 12 and the line circuit 10a. When the connection is subsequently released at the called substation, the relay R100 restores to open the locking circuits for the relays R130 and R190 and to complete the prepared operating circuit for the release magnet 185. From this point on the release of the connection proceeds in the manner explained above.

In the event the above described call originating at the calling substation A and routed to the connector 15 is of the character requiring the assistance of a central office operator for completion, the calling subscriber dials the central office directory number which comprises two digits. The first of these digits designates the contact level in which the ring-down trunks extending to the central office are terminated, and the second digit designates the first trunk of the group. Automatic trunk hunting facilities are provided in the connector 15 so that if the first trunk of the group is busy the remaining trunks are tested in succession until an idle trunk is found or until all of the trunks have been tested. To this end, the private and extra control contacts individual to each central office trunk, with the exception of the contacts individual to the last trunk of the group, are strapped together in the manner indicated by the strap 197 extending between the private contact 198 and the extra control contact 199. With this wiring arrangement, if the wipers 112 to 115, inclusive, are operated in the manner explained above to engage the contacts terminating the first trunk of the group at a time when this trunk is busy, a circuit is prepared for energizing the trunk-hunting relay R180 and the previously traced circuit is completed for energizing the busy test relay R140. Shortly following the selection of this trunk the relay R150 restores and closes its contacts 151 to complete the operating circuit for the trunk-hunting relay R180. This circuit extends by way of the grounded extra control wiper 114, the contacts 172, 151, 142 and 186, and the winding of R180 to battery. It will be noted that if the private and extra control contacts individual to the first trunk of the group are marked with negative battery potential indicating that the trunk is idle, the relay R140 and the relay R180 are short-circuited and fail to operate during the test period. Accordingly, the call is permitted to proceed over the first trunk to the distant exchange in the manner explained above with reference to the call routed to the substation B.

Assuming that the first trunk of the group is busy, the relay R180 is energized and operates to complete a locking circuit for itself which extends from ground by way of the contacts 121, 181 and 186 and the winding of R180 to battery. At its contacts 182, the relay R180 completes an alternative circuit for energizing the rotary magnet 184 in parallel with the slow-to-release control relay R170. This circuit extends from ground by way of the contacts 124 to the contacts 182 where it divides, one branch extending through the contacts 195 and the winding of the magnet 184 to battery and the other branch extending by way of the contacts 162, 154 and 163 and the winding of R170 to battery. When thus energized the rotary magnet 184 operates to step the wipers 112 to 115, inclusive, into en-

gagement with the contacts terminating the conductors of the second trunk in the selected group. At its contacts 186, the magnet 184 opens the operating and locking circuits for the trunk-hunting relay R180. The relay R180 now restores and opens its contacts 182 to deenergize the relay R170 and the rotary magnet 184. At its contacts 181, the relay R180 further interrupts its own locking circuit. The rotary magnet 184, upon restoring, re completes the test circuit over which the trunk-hunting relay R180 is energized. In this regard it will be noted that if the second trunk of the group is also busy, ground potential is retained upon the private and extra control wipers 115 and 114, thus preventing the release of the busy test relay R140 and causing the reenergization of the trunk-hunting relay R180 when the rotary magnet 184 releases. The inter-related operation of the relay R180 and the rotary magnet 184 continues until an idle trunk in the group is found or until all of the trunks have been tested and found to be in a busy condition. Due to the slow-to-release characteristic thereof, the relay R170 remains operated during the trunk hunting operation just described.

Assuming that an all-busy condition of the trunks exists, the wipers 112 to 115, inclusive, are rotated to engage the contacts terminating the last trunk of the group. In the termination of this trunk the strap between the private and extra control contacts individual thereto is omitted. Accordingly, no further circuit is available for energizing the trunk-hunting relay R180 but a circuit is available for maintaining the energization of the busy test relay R140. In this case the relay R180, upon restoring, deenergizes the relay R170, permitting the latter relay to restore after an interval. In releasing the relay R170 completes the locking circuit for the busy test relay R140 and closes the circuit for transmitting a busy tone signal to the calling subscriber. The manner in which the connection is released under the control of the calling subscriber following the receipt of the busy signal is exactly the same as described above.

Assuming that one of the trunks in the selected group is idle, the trunk-hunting operation on the part of the connector 15 is arrested when this trunk is selected. More specifically, when a trunk having its private and extra control contacts marked with negative battery potential is selected by the connector 15, the busy test relay R140 is deenergized and restores and no further circuit is available for energizing the trunk-hunting relay R180. Accordingly, the relay R170 restores after an interval to complete the prepared operating circuit for the switch-through relay R190. From this point on the manner in which the call proceeds to the central exchange operator's position and the connection is released is exactly the same as set forth above.

Referring now more particularly to the arrangement of the connector 15, whereby the response of the line relay R110 to impulses transmitted thereto over high resistance or leaky lines is improved, an explanation regarding certain details of this relay and the two relays R120 and R150 is in order. These relays are of the horizontal type and are mounted close together on a suitable base above the Strowger switching mechanism, the relative positions thereof being substantially as shown in Fig. 2 of the drawing. Although each relay has a separate heelpiece, the magnetic circuits thereof are in such close

proximity to each other that a certain amount of leakage flux from the core or magnetic circuit of one relay links the core or magnetic circuit of each adjacent relay. Since the line relay R110 is in the center, disposed between the other two relays, it is in a position to influence and to be influenced to the greatest extent by the leakage flux produced by energization of each of the other two relays. This influence is greatly enhanced if the line relay R110 is provided with a brass heelpiece which substantially increases the leakage flux. The three enumerated relays are wound in such direction that if the armature end of the line relay R110 is a north magnetic pole, for example, the armature end of the release relay R120 will also be a north pole while the armature end of the change-over relay R150 will be a south pole, as indicated in Fig. 2 of the drawing.

Considering the operation of the switch in order to explain how the operation of the line relay R110 is improved, it will be noted that when the line relay is energized it closes a circuit for the release relay R120 and the leakage flux produced by the energization of the latter relay will oppose the flux traversing the core or magnetic circuit of the line relay. Accordingly, when the circuit of the line relay is broken it will be deenergized more quickly than it would in the absence of the leakage flux linking therewith. On the other hand, when the circuit of the line relay R110 is again closed after the first interruption, the energization of the release relay R120 is at a minimum but the change-over relay R150 is fully energized and the polarity of the latter relay is such that the leakage flux produced thereby and linking with the magnetic circuit of the line relay assists in the magnetization of the magnetic circuit of the line relay. Thus an electromagnetic priming action of the line relay R110 occurs at the end of the open-circuit period of each impulse transmitted to the switch. It will be apparent that this priming action of the change-over relay R150 is obtained during each of the two digits transmitted to the connector 15 in setting up a connection. Thus the arrangement of the circuit wiring is such that the relay R150 is energized both during the vertical and rotary movement of the connector switch wipers. Accordingly, the advantages achieved by arranging the three relays R110, R120 and R150 in the manner explained above are retained throughout both impulsing periods.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is contemplated to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. In a telephone system, a two-motion impulse responsive connector switch comprising movable contacts, a pair of operating magnets for respectively imparting the two motions to said movable contacts, a line relay, a change-over relay, said line relay being disposed in the magnetic field of said change-over relay and being so arranged that the leakage flux resulting from energization of said change-over relay assists in the energization of said line relay, circuits interconnecting said magnets, said change-over relay and the contacts of said line relay, and means for controlling said circuits so that

said change-over relay is energized in series with one of said magnets during the transmission of one series of impulses to said switch and is energized in series with the other of said magnets during the transmission of a succeeding series of impulses to said switch.

2. In a telephone system, a two-motion impulse responsive connector switch comprising movable contacts, a pair of operating magnets for respectively imparting the two motions to said movable contacts, a line relay, a release relay energized in response to operation of said line relay, a change-over relay, said line relay being disposed in the magnetic fields of said release and change-over relays and the three of said relays being so arranged that the leakage flux resulting from energization of said release relay assists in the deenergization of said line relay and the leakage flux resulting from energization of said change-over relay assists in the energization of said line relay, circuits interconnecting said magnets, said change-over relay and the contacts of said line relay, and means for controlling said circuits so that said change-over relay is energized in series with one of said magnets during the transmission of one series of impulses to said switch and is energized in series with the other of said magnets during the transmission of a succeeding series of impulses to said switch.

3. In a telephone system, a two-motion impulse responsive connector switch comprising movable contacts, a pair of operating magnets for respectively imparting the two motions to said movable contacts, a line relay, a change-over relay, said line relay being disposed in the magnetic field of said change-over relay and being so arranged that the leakage flux resulting from energization of said change-over relay assists in the energization of said line relay, and means comprising said line relay for controlling said change-over relay and said magnets so that said change-over relay is energized concurrently with one of said magnets during the transmission of one series of impulses to said switch and is energized concurrently with the other of said magnets during the transmission of another series of impulses to said switch.

4. In a telephone system, a two-motion impulse responsive connector switch comprising movable contacts, a pair of operating magnets for respectively imparting the two motions to said movable contacts, a line relay, a release relay energized in response to operation of said line relay, a change-over relay, said line relay being disposed in the magnetic fields of said release and change-over relays and the three of said relays being so arranged that the leakage flux resulting from energization of said release relay assists in the deenergization of said line relay and the leakage flux resulting from energization of said change-over relay assists in the energization of said line relay, and means comprising said line relay for controlling said change-over relay and said magnets so that said change-over relay is energized concurrently with one of said magnets during the transmission of one series of impulses to said switch and is energized concurrently with the other of said magnets during the transmission of another series of impulses to said switch.

5. In a plural digit automatic switch, a line relay, a second relay, said line relay being so disposed within the magnetic field of said second relay that the leakage flux resulting from energization of said second relay affects the operation of said line relay, and means for energizing said

second relay during at least two digits transmitted to said switch.

6. In a plural digit automatic switch, a line relay, a second relay, said line relay being so disposed within the magnetic field of said second relay that the leakage flux resulting from energization of said second relay assists the energization of said line relay, and means for energizing said second relay during each of at least two digits transmitted to said switch.

7. In a plural digit impulse controlled automatic switch, a line relay, a change-over relay, said line relay being so disposed within the magnetic field of said change-over relay that the leakage flux resulting from energization of said change-over relay affects the operation of said line relay, means for energizing said change-over relay during each of at least two series of impulses transmitted to said switch, and pulsing circuits controlled by said change-over relay.

8. In a plural digit impulse controlled automatic switch, a line relay, a change-over relay, said line relay being so disposed within the magnetic field of said change-over relay that the leakage flux resulting from energization of said change-over relay assists the energization of said line relay, means for energizing said change-over relay during each of at least two series of impulses transmitted to said switch, and pulsing circuits controlled by said change-over relay.

9. In a plural digit automatic switch, a line relay, and means electromagnetically coupled to said relay for magnetically priming said relay during each of a plurality of digits transmitted to said switch.

10. In a plural digit automatic switch, a line relay including a magnetic circuit, a second relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay, and means for energizing said second relay during each of a plurality of digits transmitted to said switch.

11. In a plural digit automatic switch, a line relay including a magnetic circuit, a second slow-acting relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay and so poled that the flux linking the magnetic circuit of said line relay when said second relay is energized assists the energization of said line relay, and means including said line relay for energizing said second relay at the beginning of each of a plurality of digits transmitted to said switch.

12. In a plural digit automatic switch, a line relay, means including a second relay electromagnetically coupled to said line relay for decreasing the energization of said line relay during each of a plurality of digits transmitted to said switch, and means including a third relay electromagnetically coupled to said line relay for magnetically priming said line relay during each of a plurality of digits transmitted to said switch.

13. In a plural digit automatic switch, a line relay including a magnetic circuit, a second relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay and so poled that the flux linking the magnetic circuit of the line relay when said second relay is energized effectively changes the energization of said line relay in one sense, a third relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay and so poled that the flux linking the magnetic circuit of the line relay when said third relay is energized effectively changes the energization of said line

relay in the opposite sense, and means for energizing said second and third relays during each of a plurality of digits transmitted to said switch.

14. In a plural digit automatic switch, a line relay including a magnetic circuit, a slow-to-release hold relay energized in response to operation of said line relay and including a magnetic circuit coupled to the magnetic circuit of said line relay, the magnetic circuit of said hold relay being so poled that the flux linking the magnetic circuit of said line relay and resulting from energization of said hold relay effectively decreases the energization of said line relay, a slow-to-release change-over relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay and so poled that the flux linking the magnetic circuit of said line relay and resulting from energization of said change-over relay effectively increases the energization of said line relay, and means including said line relay for energizing said change-over relay at the beginning of each of a plurality of digits transmitted to said switch.

15. In a plural digit impulse controlled automatic switch, a line relay including a magnetic circuit, a slow-to-release hold relay energized in

response to operation of said line relay and including a magnetic circuit coupled to the magnetic circuit of said line relay, the magnetic circuit of said hold relay being so poled that the flux linking the magnetic circuit of said line relay and resulting from energization of said hold relay effectively decreases the energization of said line relay, a slow-to-release change-over relay including a magnetic circuit electromagnetically coupled to the magnetic circuit of said line relay and so poled that the flux linking the magnetic circuit of said line relay and resulting from energization of said change-over relay effectively increases the energization of said line relay, means including said line relay for energizing said change-over relay at the beginning of each of a plurality of digits transmitted to said switch, a pulsing circuit controlled by said line relay and having two branches, and means comprising a transfer relay controlled by said change-over relay for opening one of the two branches of said circuit and for completing the other branch of said circuit during the inter-digit pause between two digits transmitted to said switch.

CLARENCE E. LOMAX,