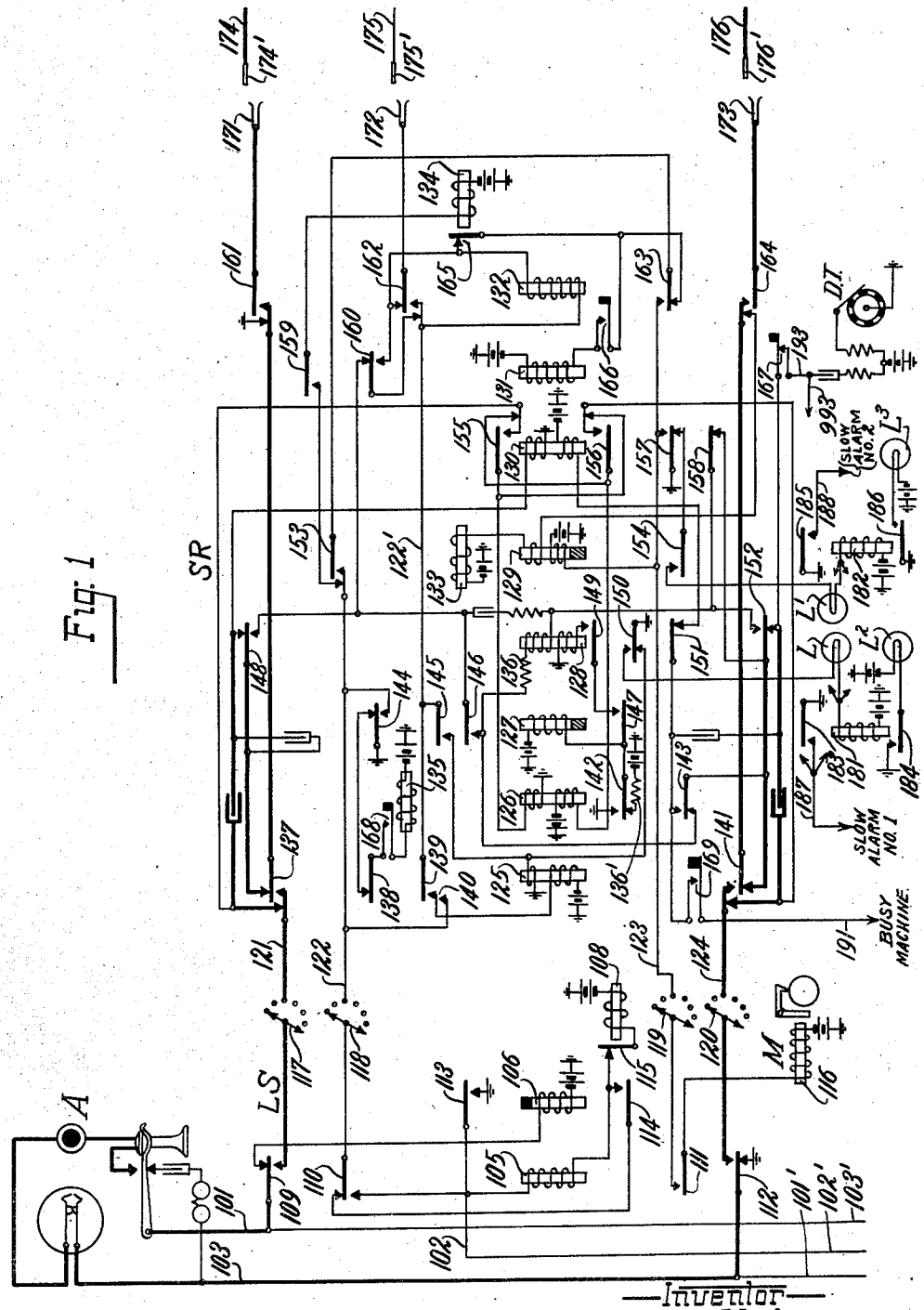
Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 1

Fig. 1



Inventor
John Wicks

R. B. Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 2

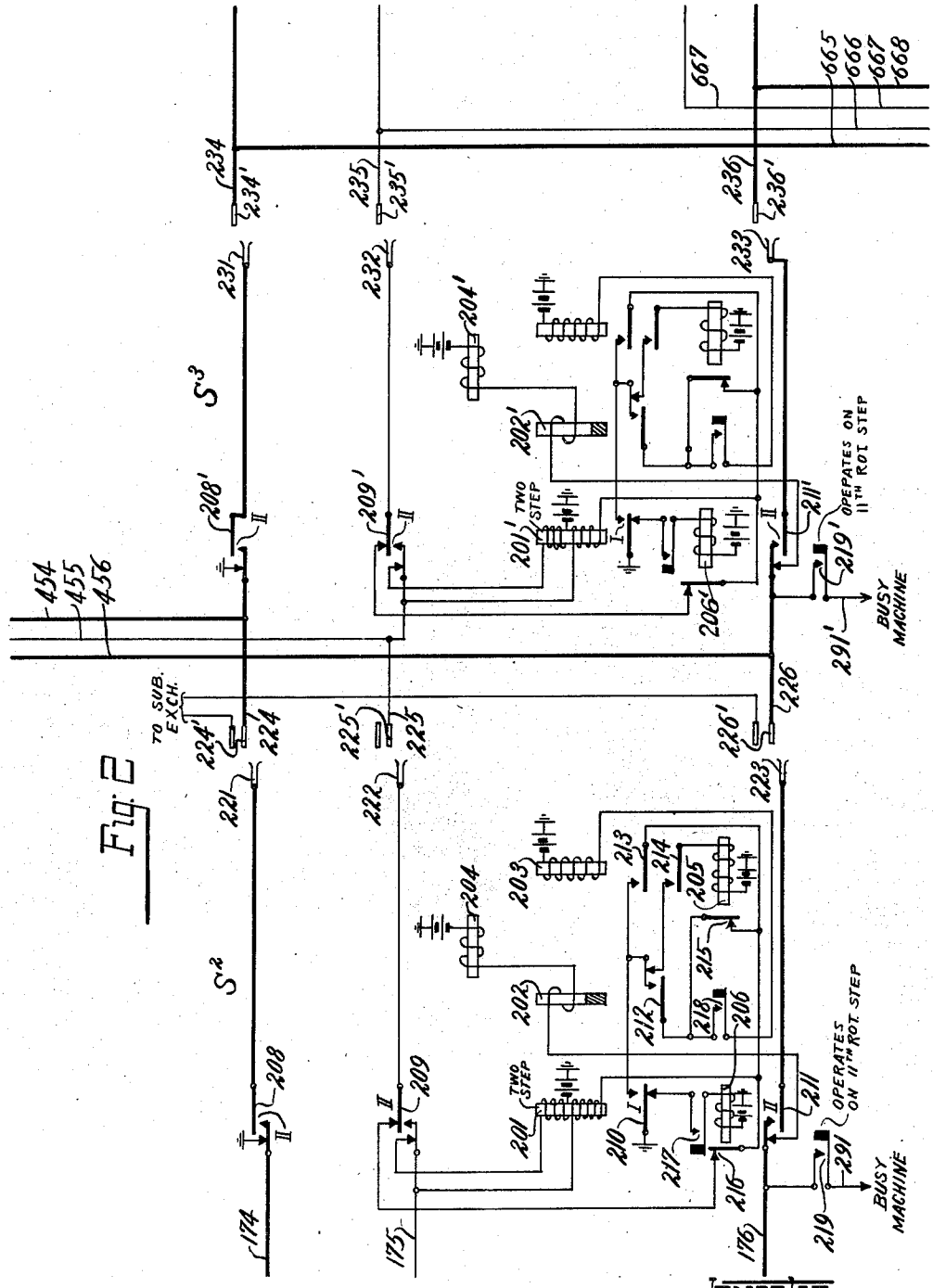


Fig. 2

Inventor
John Wicks

R. B. Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 3

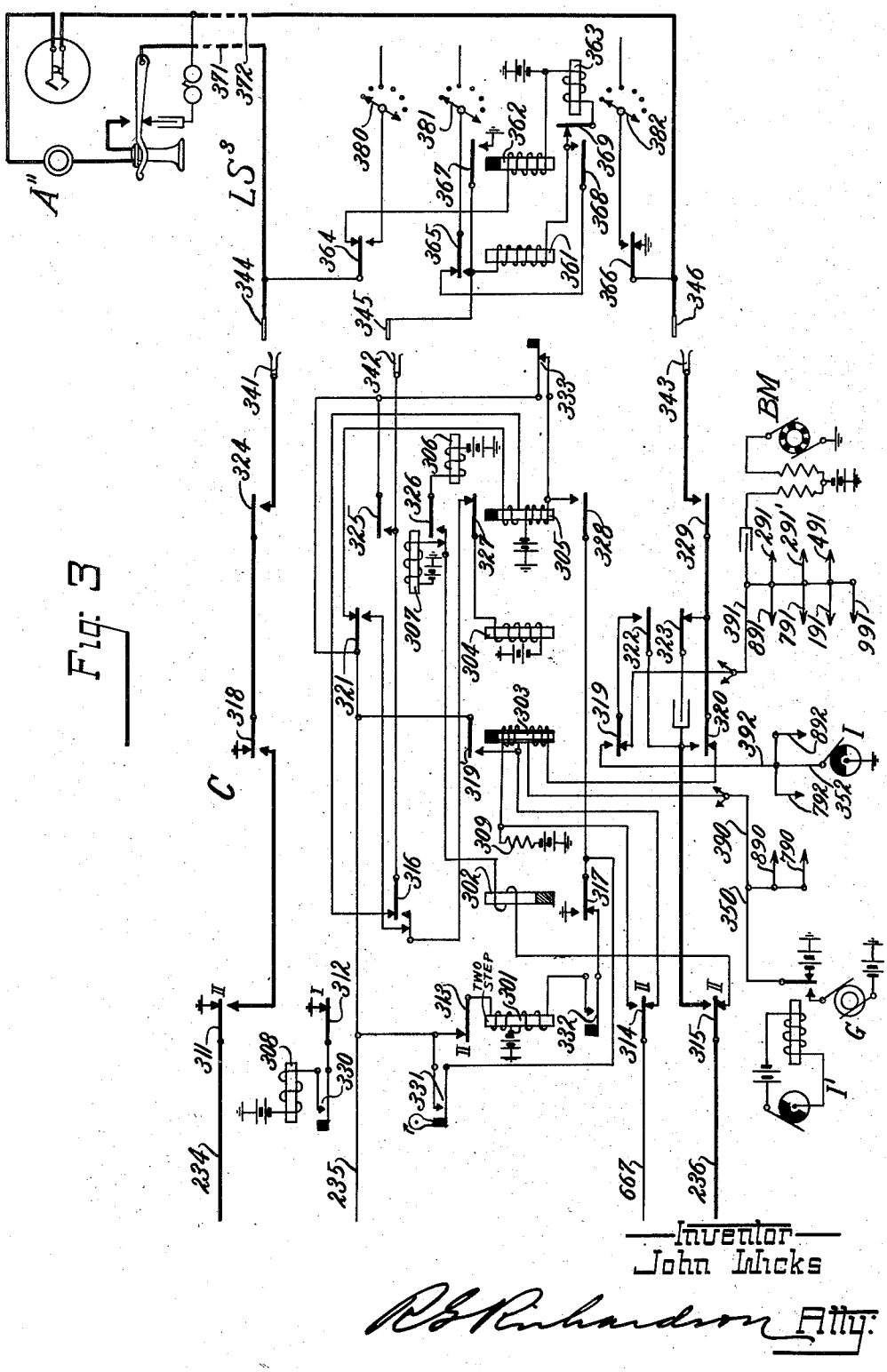
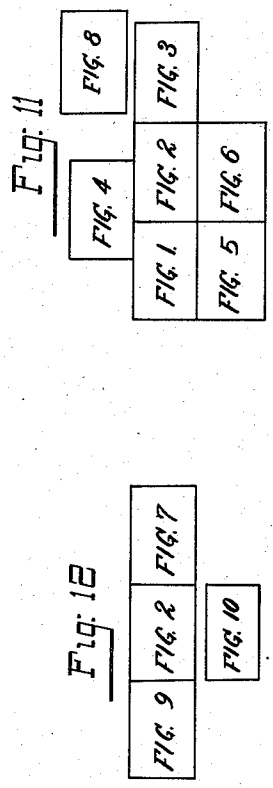


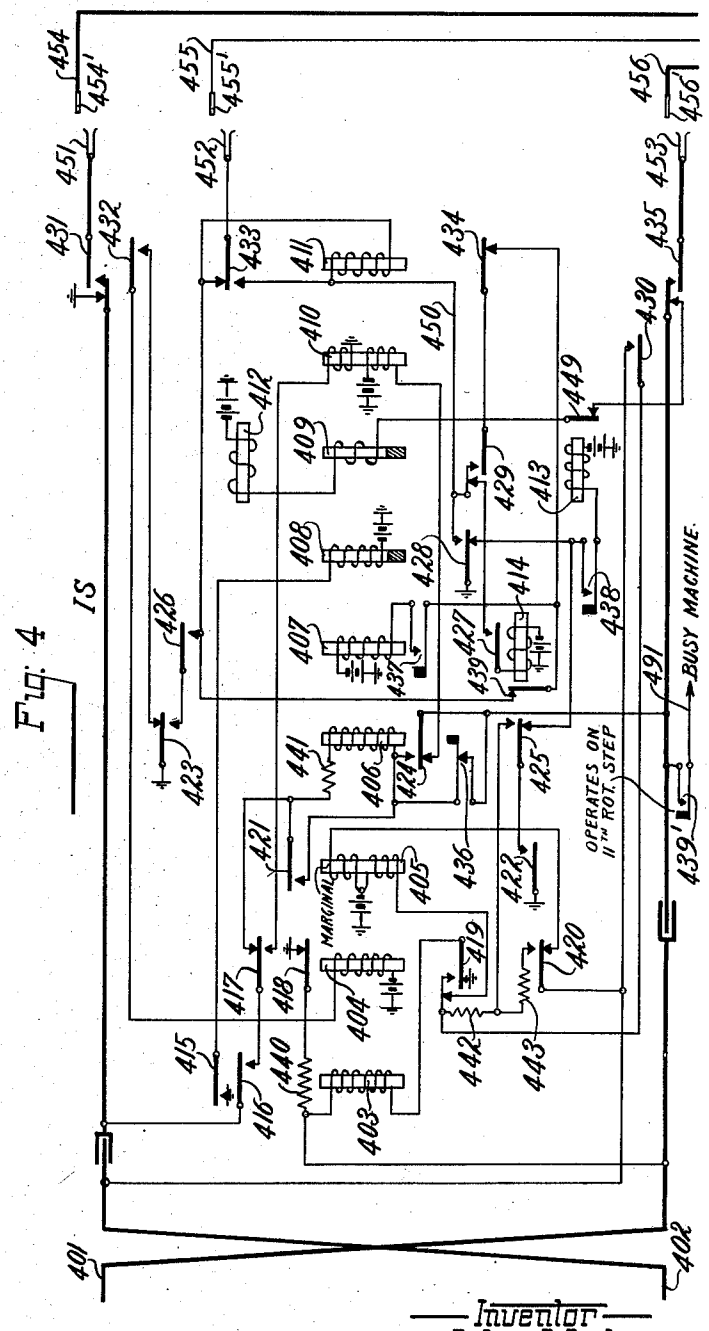
Fig. 3

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 4





Inventor
John Wicks

Atty:

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 5

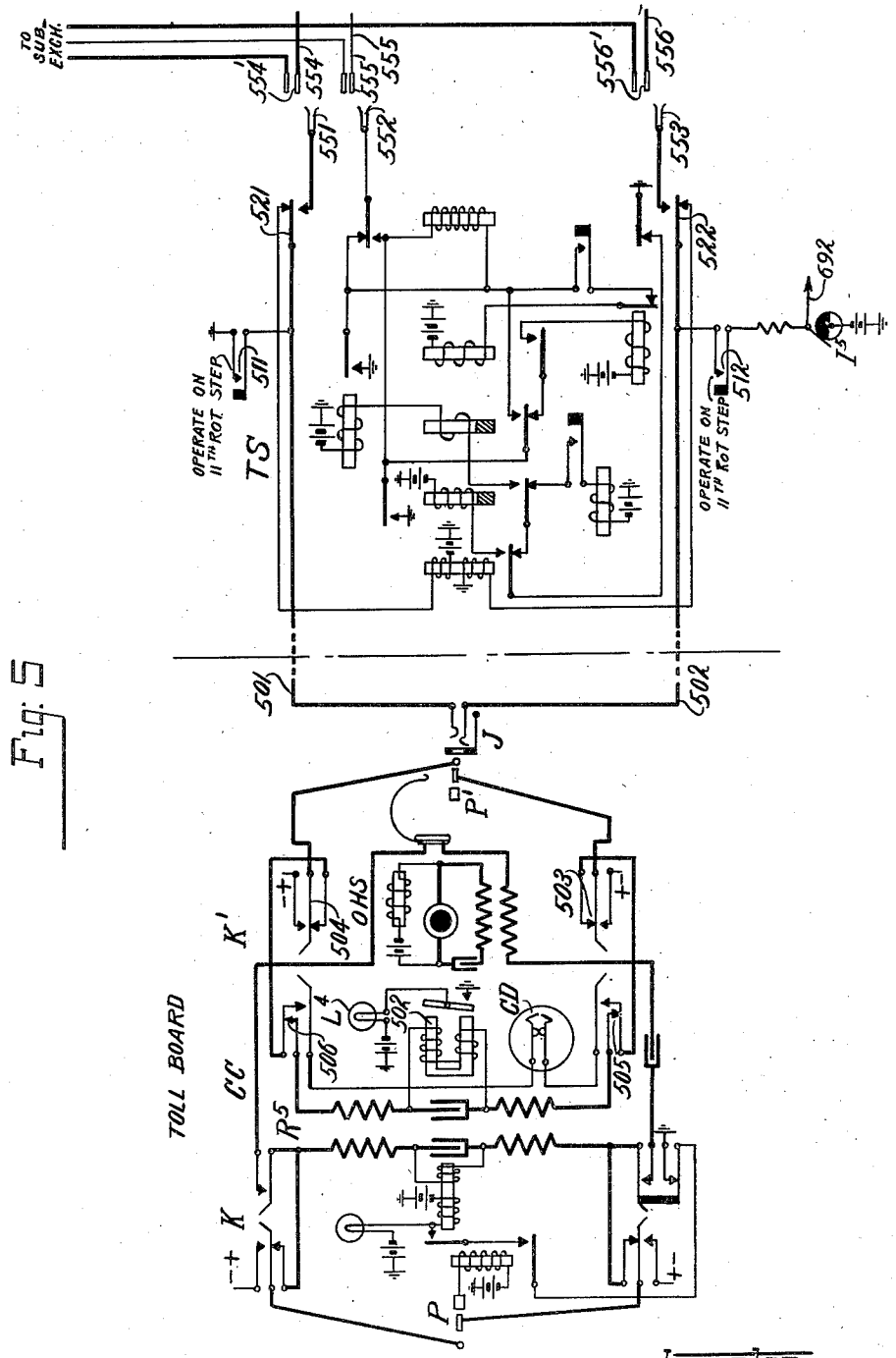


Fig. 5

Inventor
John Wicks

R. B. Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 6

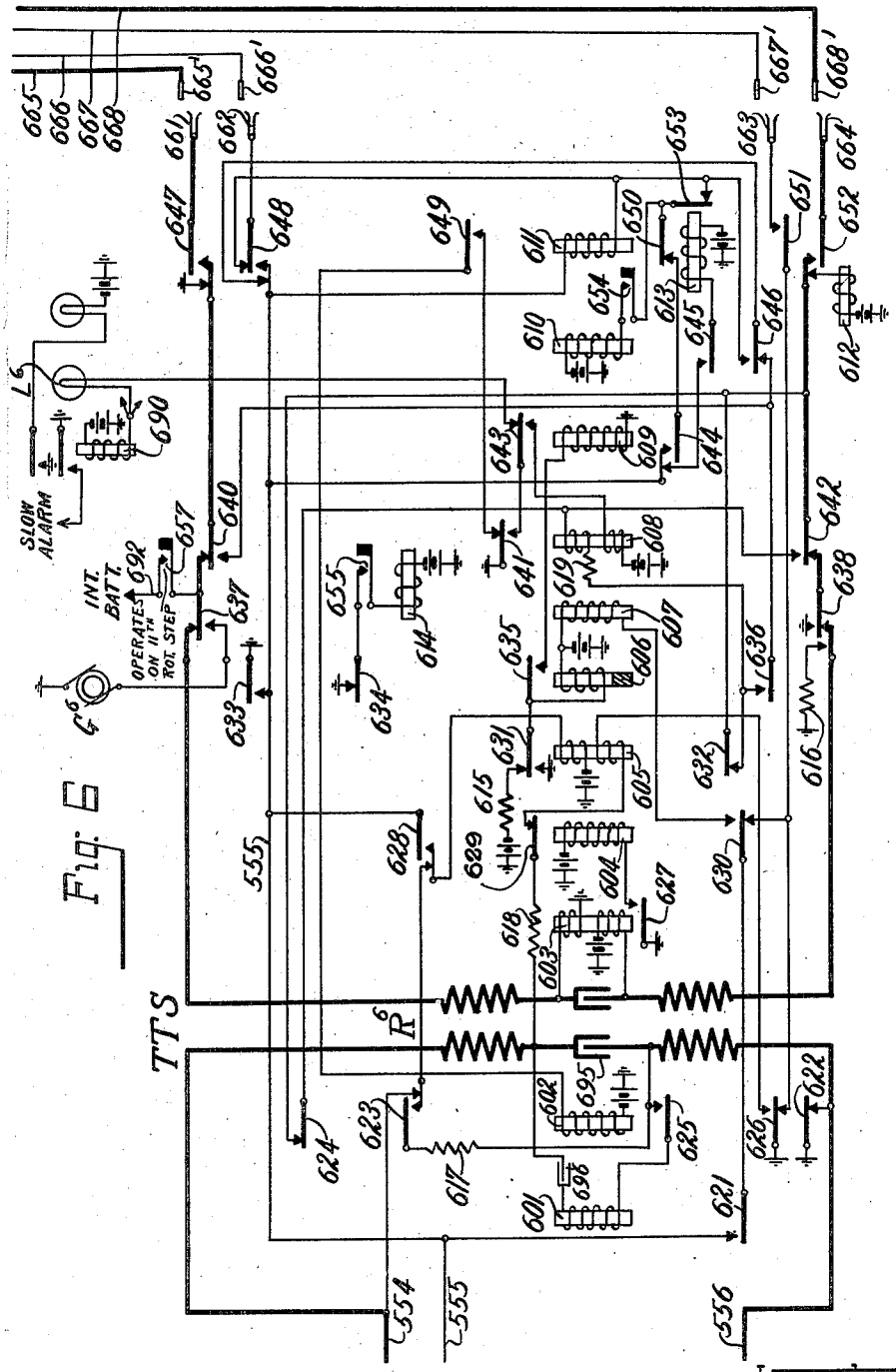


Fig. 6

Inventor
John Wicks

Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 7

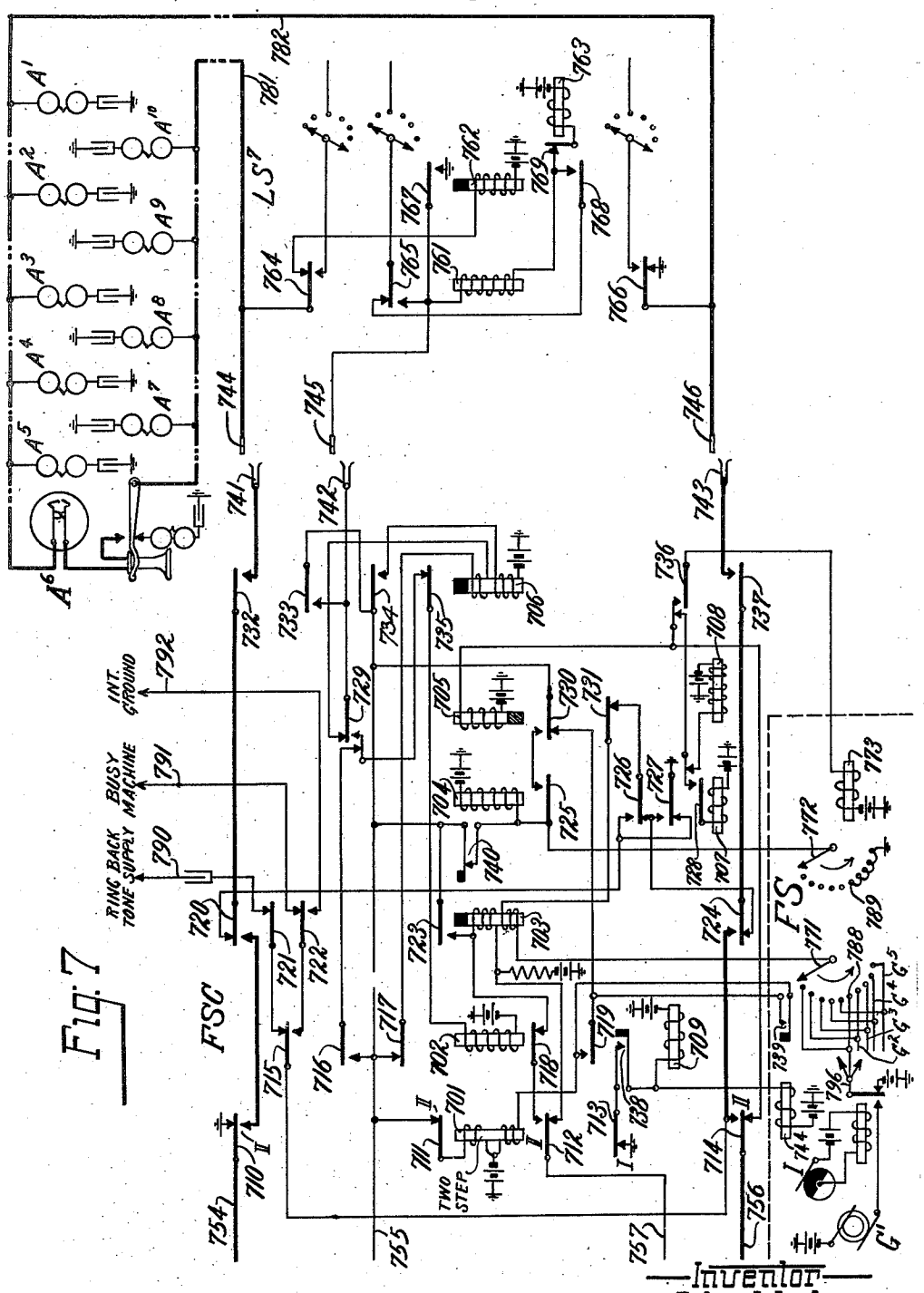


Fig. 7

Inventor
John Wicks

R. B. Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 8

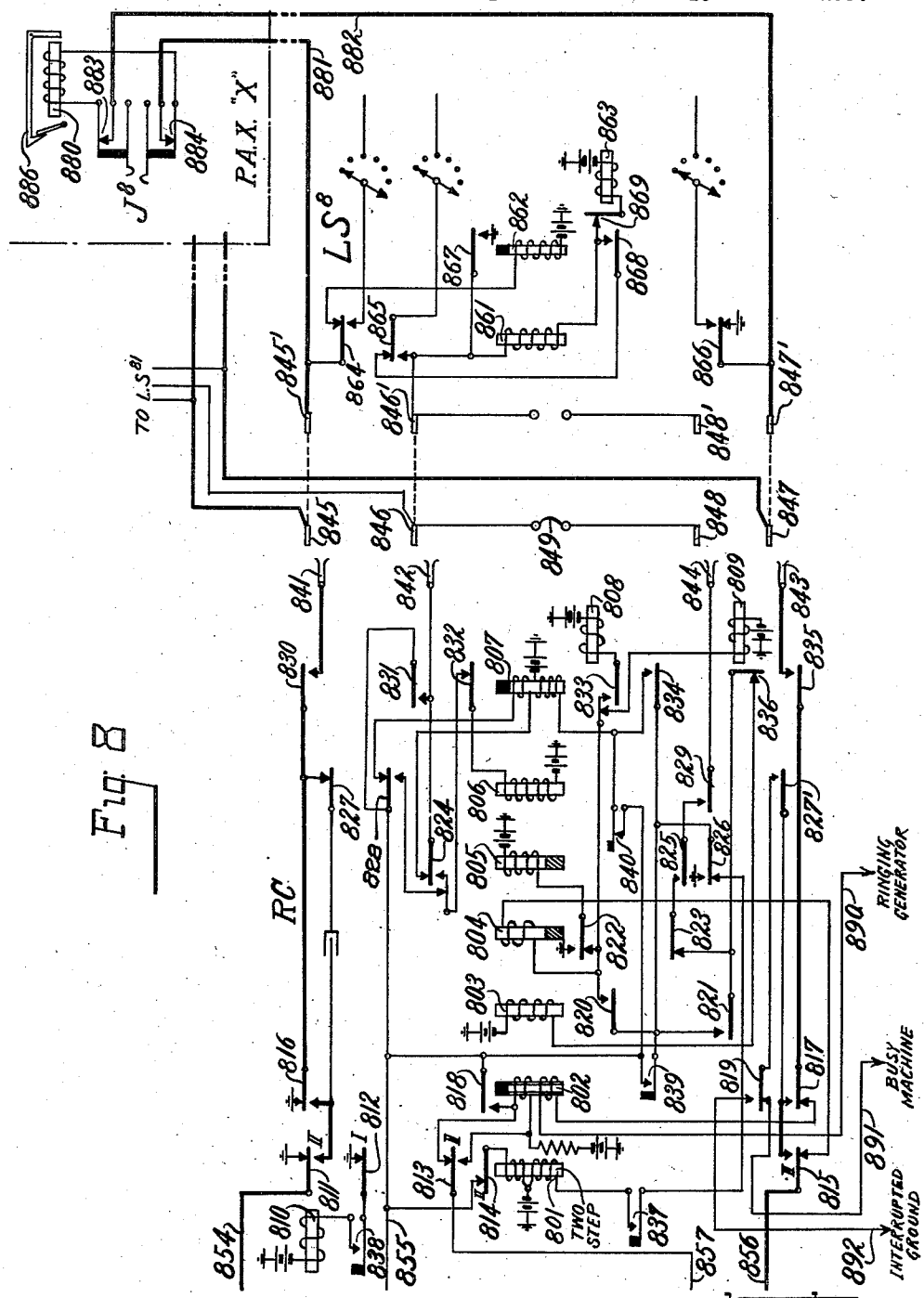


Fig. 8

Inventor
John Wicks

Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 9

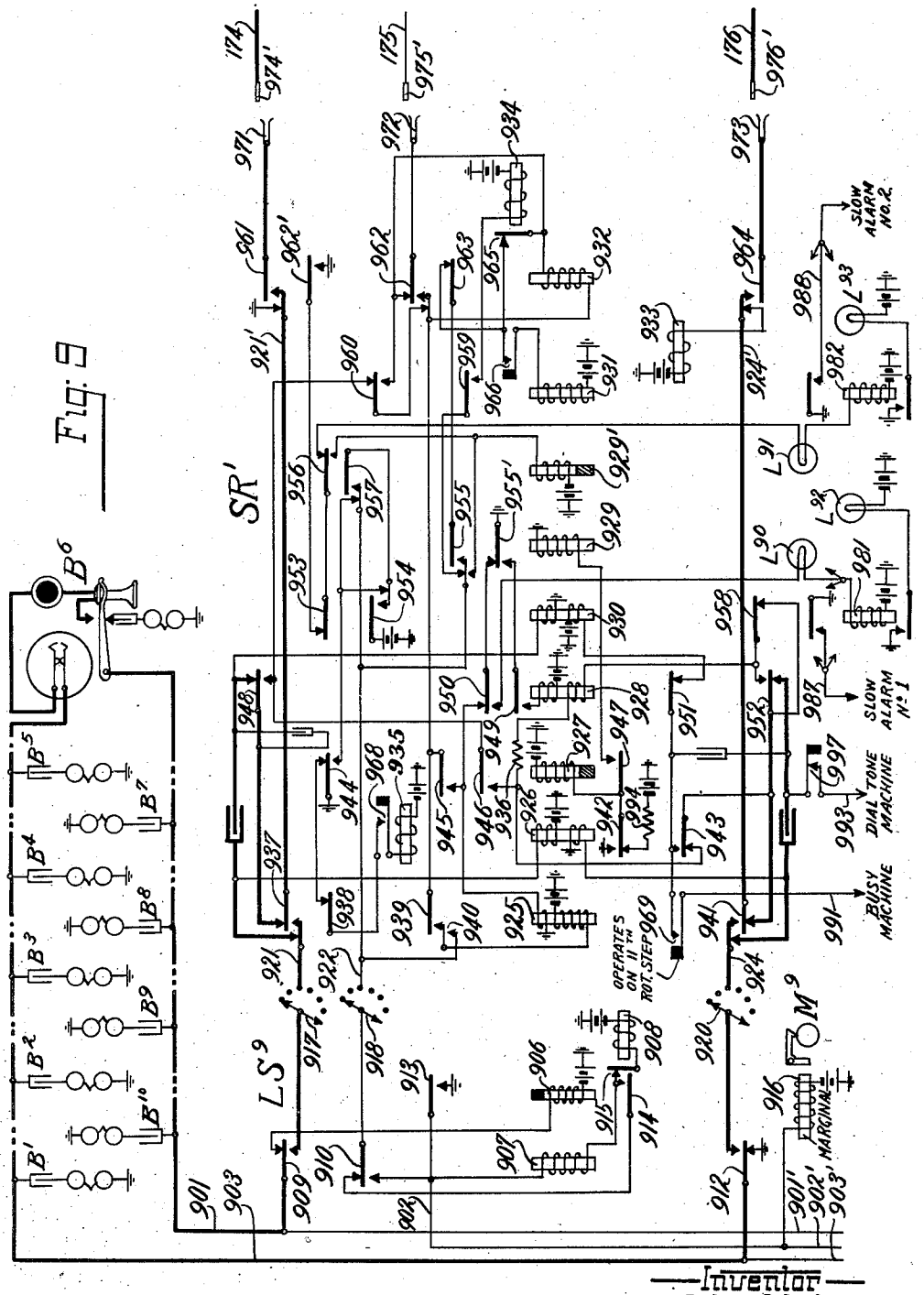


Fig. 9

Inventor
John Wicks

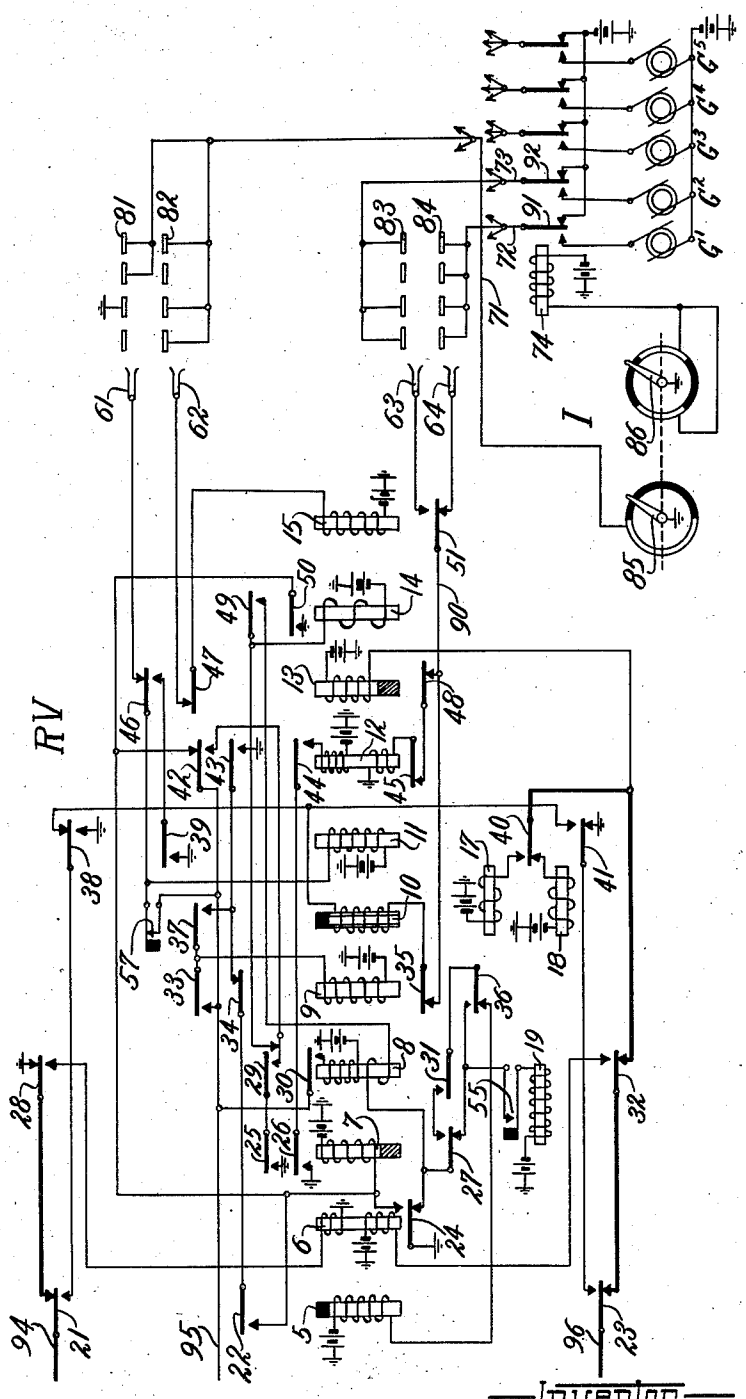
Richardson Atty.

Aug. 12, 1930. J. WICKS 1,772,472

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 26, 1926 10 Sheets-Sheet 10

Fig. 10



Inventor
John Wicks

R. B. Richardson Atty.

Patented Aug. 12, 1930 1,772,472

UNITED STATES PATENT OFFICE

JOHN WICKS, OF OAK PARK, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE

AUTOMATIC TELEPHONE SYSTEM

Application filed August 26, 1926, Serial No. 131,575. Renewed December 19, 1929.

This invention relates to telephone systems in general, but is more particularly concerned with automatic telephone systems in which connections are established through the medium of subscriber controlled automatic switches. In such a system, automatic switches such as a first selector, one or more intermediate selectors, and a connector are successively operated under the control of a dial at the calling station. This invention further pertains especially to that kind of automatic telephone system in which the motor magnets of the automatic switches are directly operated by current impulses produced by the line relay of the first selector, the line relay of the first selector being operated by impulses produced by the dial of the calling station.

An automatic telephone system of this kind, known as a direct pulsing system, is disclosed in the inventor's copending application Serial No. 8,343, filed Feb. 11, 1925. In the system disclosed in the above application, the current impulses for operating the motor magnets of the automatic switches are produced by the line relay of the first selector (better termed, the first selector repeater) and are transmitted to the magnets of the first selector repeater and to the magnets of the succeeding switches over one of the talking conductors of the extended trunk line. While this method of control is entirely satisfactory for switch operation in a single exchange, loop control (control over the two conductors of the trunk line in series) is recognized as being most preferable for controlling switch operations, especially when connections between exchanges are extended. In the former case the difference in ground potential between any two exchanges, which may vary between wide limits from time to time, constantly threatens proper switch operation when such operation is controlled over a single conductor. In the present invention, the possibility of this condition causing trouble is entirely eliminated, for the reason that the control of the magnets of the switches is affected over the two trunk conductors in series.

The main object of this invention, therefore, is the provision of new and improved automatic switches for use in a direct pulsing automatic telephone system. The main feature resides in the circuit arrangement whereby the current impulses for operating the magnets of the switches produced by the line relay of the first selector repeater, are transmitted to the magnets of the switches over the two sides of the extended trunk line in series.

Other objects are accomplished and various features are contained in the invention which will be fully described in the body of this specification with the aid of the accompanying drawings.

Referring now to the accompanying drawings comprising Figs. 1–12, Figs. 1–10 show by means of the usual schematic circuit diagrams a sufficient amount of the apparatus in a multi-office telephone system embodying the principles of this invention to enable the invention to be clearly described and understood.

Fig. 11 is a diagram showing how the drawings upon which Figs. 1–8 appear are to be arranged, (Fig. 8 to be substituted for Fig. 3 as directed hereinafter) to be most intelligently understood in connection with the descriptions of the establishment of certain connections to be given. Fig. 12 likewise is a diagram showing how the drawings upon which Figs. 2, 8–10 appear may be arranged (Fig. 10 to be substituted for Figs. 2 and 7 as directed hereinafter) to be best understood in connection with the descriptions of the establishment of certain other connections to be given also. The following paragraphs give a brief description of each of the above figures.

Fig. 1 shows the subscriber substation A whose line terminates at the exchange in the individual lineswitch LS, and is accessible to a group of connectors by way of conductors 101′—103′. The lineswitch LS, with other similar lineswitches has access to a group of first selector repeaters of which the selector repeater SR is one. In the banks of the selector repeaters access is had to the outgoing trunks to the other offices in the system, a group of trunks to each office being accessi-

ble in a separate level; in one certain level access is had to a group of reverting call switches, and in another level access is had to a group of local second selectors. The dial tone machine DT, for producing a dial tone current supply, the supervisory equipment, comprising relays 181 and 182 and lamps L—L³, and the subscriber's meter M, are also shown in Fig. 1. The substation A is of the usual automatic type. The lineswitch LS is of the well known rotary type having no normal position and moving in one direction only, being advanced upon the back stroke of the associated stepping magnet. The selector repeater SR mechanically is of the usual Strowger vertical and rotary type. The circuits of selector repeater SR form a particular part of this invention and will be described in detail in later paragraphs.

Fig. 2 shows the local second selector S^2, and the local third selector S^3. The selector S^2 is one of the group of local second selectors accessible in a certain level in the banks of the first selector repeaters. In the banks of this group of second selectors, access is had to the various groups of local third selectors, the selector S^3 being one of a certain group. In the banks of third selectors access is had to the various groups of connectors. It is also assumed that the exchange in question has a sub-office. Trunks to the sub-office are accessible in a certain level in the local second selector terminating thereat in incoming third selectors, similar to incoming selector IS, Fig. 4.

The selectors S^2 and S^3 are identical in mechanical and circuit details and are of the well known Strowger vertical and rotary type. The circuits of these intermediate selectors are modified to meet the requirements of the invention and will be described in detail hereinafter.

Fig. 3 shows the connector C which is one of a certain group of regular connectors accessible in the banks of the group of third selectors containing selector S^3 (and also in the banks of the group of toll transmission selectors containing toll transmission selector TTS, Fig. 6). In the banks of the connector C access is had to a group of lines extending to substations, the line to substation A'' being one of these. This line also terminates in the individual lineswitch LS^3. Below the connector C the ringing equipment, comprising the generator G and interrupter T, the ground interrupter I, and the busy machine BM are shown.

Mechanically the connector C is of the well known Strowger vertical and rotary type. The circuits of the connector also form a part of the invention and will be described in detail in following paragraphs. The substation A'' and the lineswitch LS^3 are in all respects like the substation A and lineswitch LS, shown in Fig. 1, except that in lineswitch LS^3 the fourth conductor for metering purposes has been omitted.

Fig. 4 shows the incoming second selector IS. This selector terminates one of the incoming trunks from one of the other offices in the system. The incoming trunks from the other offices likewise terminate in similar incoming second selectors. The banks of the incoming second selectors are directly multipled with the banks of the local second selectors, and the incoming second selectors are thereby given common access to the various groups of local third selectors.

The incoming selector IS mechanically is also of the Strowger vertical and rotary type. The circuit arrangement, forming a particular part of this invention, will be described in detail hereinafter.

The right-hand half of Fig. 5 shows the incoming toll selector TS. This toll selector terminates one of the toll trunks incoming from the office in which the main toll board is located. As many incoming toll trunks, terminating in similar incoming toll selectors, are provided as are necessary to carry the traffic to the office in question. In the banks of the incoming toll selectors, access is had to groups of toll transmission selectors, and also to a group of trunks extending to the sub-office of the office in question these trunks also terminating at the sub-office in similar toll transmission selectors.

The toll selector switch TS is of the ordinary Strowger vertical and rotary type and is operated according to the well known two wire system of control. Special off-normal springs are provided however, to adapt it for use in the system being described.

The left-hand half of Fig. 5 shows the toll operator's cord CC by means of which toll connections are established over trunks extending to the various offices in the system, each trunk terminating at the toll board in a jack such as jack J. This cord is of standard type and forms no particular part of the invention itself. The circuit thereof will be described only in so far as is necessary to fully describe other apparatus controlled by means within the cord.

Fig. 6 shows the toll transmission selector TTS, which is one of a certain group of toll transmission selectors accessible in the banks of the incoming toll selectors. The banks of the toll transmission selectors are directly multipled with the banks of the local third selectors, and the toll transmission selectors and local third selectors are thereby given common access to the connectors.

Mechanically, the toll transmission selector TTS is also of the Strowger vertical and rotary type. The circuit arrangements, however, have been modified to meet the requirements of the invention and will likewise be described in detail hereinafter.

Fig. 7 shows the frequency selecting con-

nector FSC which is in all respects like connector C, Fig. 3, mechanically and in the method of operation, except that it is provided with an individual frequency selecting mechanism FS which is operated responsive to a digit to select the frequency of ringing current to be applied to the called line. In its banks access is had to party lines. The frequency selecting connector FSC is one of a group of frequency selecting connectors accessible in the banks of a certain group of local third selectors multipled with the banks of a certain group of toll transmission selectors, which in this case will also be assumed to be the same group having access to the group of regular connectors containing connector C. One party line, accessible to connector FSC, serving substations A'—A^{10}, and terminating at the exchange in the lineswitch LS^7 is shown. The substation A^6 shown in full, and also the other substations, only the bells of which are shown, are in all respects like the substation A, Fig. 1, except that the ringers are normally connected from one or the other side of the line to earth instead of being normally bridged across the line conductors. Lineswitch LS^7 is in all respects like lineswitch LS^8, Fig. 3. A description of the operation of connector FSC will be given in so far as it differs from the operation of connector C.

Fig. 8 shows the rotary connector RC, which is also like the connector C, Fig. 3, except that it performs an automatic rotary hunting movement after completing its rotary directive movement. In its banks, access is had to groups of lines extending to private branch exchanges with the number of the first line assigned as the call number of the entire group. The rotary connector RC is one of a group of rotary connectors accessible in the banks of a certain group of local third selectors multipled with the banks of a certain group of toll transmission selectors, which in this case will be assumed to be the same group having access to the group of connectors containing connector C. The first and last trunk of a group extending to the private branch exchange X, accessible to connector RC, are shown. Each trunk terminates in an individual lineswitch such as LS^8 at the main exchange, and in a jack such as jack J^8 at the branch exchange. The lineswitch LS^8 is in all respect like lineswitch LS^3 shown in Fig. 3. A description of the operation of connector RC in so far as it differs from the operation of connector C, Fig. 3, will also be given.

Fig. 9 shows the first selector repeater SR' which is very similar to the first selector repeater SR, Fig. 1, the difference in the two cases residing in the manner in which the operation of the subscriber's meter is controlled. The first selector repeater SR is adapted to control the operation of the subscriber's meter over a fourth conductor, while the first selector repeater SR' is adapted to control the operation of the subscriber's meter by the momentary application of booster battery to the regular release trunk to which, in this latter case, the subscriber's meter is connected when a connection is established. The party line serving substations B'—B^{10}, and terminating in the lineswitch LS', and the substation meter M^9 are also shown.

The substations B'—B^{10}, are identical to substations A'—A^{10}. The lineswitch LS^9 and the subscriber's meter M^9 are like the lineswitch LS and meter M, except that the fourth wiper is omitted in lineswitch LS^9, and the meter M^9 is connected to the private normal conductor 902' and is marginally adjusted.

Fig. 10 shows the reverting call switch RV, which, with other similar reverting call switches, is accessible in a certain level in the banks of the first selector repeaters. The reverting call switch RV is also of the Strowger vertical and rotary type, its circuits being modified, however, to meet the requirements of the invention, as will be described in detail in later paragraphs.

In the lower right-hand corner of Fig. 10 the special ringing equipment is shown, comprising the five ringing generators (which may be the same generators indicated in Fig. 7), the interrupting relay 74 and interrupter I. The interrupter I comprises two commutators with conducting and insulating segments as shown, and wipers for each rotating on the same shaft.

With this general description of the objects of the invention, the features, and the apparatus used, in mind, a further understanding and appreciation of the invention may be gained from a detailed description of the operations performed in the establishment of various connections between subscribers. For this purpose it will first be assumed that the suscriber at substation A wishes to establish a connection with the subscriber at substation A'', (drawings to be arranged as shown in Fig. 11).

Call from substation A to substation A''

To initiate a call, the subscriber at substation A first removes his receiver. Removing the receiver at the substation A places a bridge across the line conductors 101 and 103, thereby closing a circuit for the line relay 106 of the lineswitch LS. Line relay 106 energizes over this circuit and places ground potential on the private normal conductor 102 at armature 113 thereby marking the line to substation A busy to connectors having access thereto, at the same time preparing an energizing circuit for the switching relay 105. At armature 114, relay 106 also connects the test wiper 118 to the junction of relay 105 and stepping magnet 108. If the

trunk upon which the switch wipers are positioned at this time is busy, an energizing circuit for the stepping magnet 108 is completed from ground on the test contact engaged by the test wiper 118, armature 110 and the resting contact, armature 114 and the working contact, interrupting contacts 115 through the winding of the stepping magnet 108 to battery. Accordingly stepping magnet 108 operates in a buzzer like manner to advance the switch wipers 117—120 in search of an idle trunk line. During this operation switching relay 105 is prevented from operating by reason of the ground potential on both ends of its winding.

When an idle trunk line is reached, stepping magnet 108 ceases to operate, and relay 105, being no longer short circuited, energizes in series with the stepping magnet 108. Stepping magnet 108 does not operate over this circuit due to the relatively high resistance of the winding of relay 105. In operating, relay 105 prepares a circuit for the subscriber's meter M at armature 111, prepares a holding circuit for itself at armature 110 and the working contact, and at armatures 109 and 112 disconnects the line conductors from the line relay 106 and ground, and extends the talking connection by way of these armatures and their working contacts, wipers 117 and 120, conductors 121 and 124, normally closed contacts controlled by armatures 137 and 141, normally closed contacts controlled by armatures 155 and 156, through the lower and upper windings of the line relay 126 to battery and ground, respectively. Line relay 126 operates and closes a circuit for the release relay 127 at armature 142 and the working contact. Release relay 127 operates and performs the following circuit changes: At armature 144 ground potential is placed on the release conductor 122, thereby marking the trunk to first selector repeater SR busy and also completing a holding circuit for line relay 106 of the lineswitch LS, this taking place before the slow acting line relay 106 has had time to release its armatures. At armature 147 a circuit for the lower winding of holding relay 128 is prepared. At armatures 145 and 146 an initial energizing circuit for holding relay 128 is closed, which may be traced from ground by way of armature 150 and the resting contact, working contact and armature 145, normally closed springs controlled by armature 162, armature 160 and the resting contact, armature 146 and the working contact, resistance 136, through the upper winding of relay 128, armature 158 and the resting contact, resting contact and armature 141, normally closed springs controlled by armature 164, through the upper winding of series relay 129, through the winding of vertical magnet 133 to battery. Relay 128 operates over this circuit and by the actuation of armatures 148 and 152 establishes a new energizing circuit for itself. This circuit extends from ground at normally closed contacts controlled by armature 161, armature 137 and the resting contact, armature 148 and the working contact, armature 146 and the working contact, resistance 136, through the upper winding of relay 128, working contact and armature 152, resting contact and armature 141, normally closed springs controlled by armature 164, through the upper winding of series relay 129, through the winding of vertical magnet 133 to battery. At armature 150 a circuit is closed for the lamp L in series with relay 181. Lamp L lights and relay 181 operates. The purpose of the lamp L and relay 181 will be described later. By the operation of armature 150, direct ground is removed from release conductor 122', ground now being supplied thereto through the upper winding of relay 125.

The first selector repeater SR is now in condition to receive the first series of impulses to be dialed by the calling subscriber, all the above operations having taken place responsive to the removal of the receiver at the calling substation. Furthermore, as soon as the wipers of the lineswitch LS are rotated into engagement with the trunk extending to the then idle first selector repeater SR, a dial tone is transmitted to the calling subscriber from the dial tone machine DT to which conductor 193 is connected. Hearing this tone indicates to the calling subscriber that he may commence dialing the number of the desired subscriber.

In response to the dialing of the first digit of the called number, the loop across the line conductors 101 and 103 is opened a corresponding number of times, thereby opening the circuit and causing a corresponding number of deenergizations and reenergizations of the line relay 126. Each time that relay 126 releases its armature 143, the resistance 136 and the upper winding of relay 128 are short circuited. The resistance of the upper winding of relay 128 is relatively high compared to the resistance of the upper winding of relay 129 and the resistance of the winding of vertical magnet 133. The short circuiting of resistance 136 and the upper winding of relay 128 therefore permits an increase in the current flow through the vertical magnet 133 sufficient to cause the operation of the magnet each time the said resistance and winding is short circuited. Thus vertical magnet 133 operates to step the switch wipers opposite the level of bank contacts corresponding to the digit dialed. Release relay 127 remains operated during the sending of impulses by reason of its usual slow acting characteristic. Relay 128 is also maintained operated continuously over its lower winding even though its upper winding be short circuited intermittently, the locking circuit thereof extend-

ing from ground through said lower winding, working contact and armature 149, working contact and armature 147, through the winding of relay 127 to battery and also to battery over a parallel circuit including armature 142 and the resting contact and resistance 136'.

Series relay 129 is also energized in series with vertical magnet 133, and by reason of its slow acting characteristic is maintained operated during the operation of vertical magnet 133. In operating, relay 129 closes an initial energizing circuit for stepping relay 131 which extends from ground on release conductor 122, working contact and armature 153, armature 163 and the resting contact, off-normal springs 166 which are closed upon the first vertical step of the switch wipers, through the winding of the stepping relay 131 to battery. Relay 131 operates and closes a holding circuit for itself at armature 160 which may be traced from ground through the upper winding of relay 125, working contact and armature 145, normally closed springs controlled by armature 162, armature 160 and the working contact, interrupting springs 165, off-normal springs 166, through the winding of relay 131 to battery. The circuit of the stepping magnet 134 is also prepared at armature 159.

At the termination of the impulses of the first digit, relay 129 deenergizes and opens the initial energizing circuit of relay 131 at armature 153. This armature, in releasing, allows the springs controlled thereby to close and complete the circuit for stepping magnet 134. Magnet 134 operates and rotates the switch-wipers 171—173 into engagement with the first set of bank contacts in the selected level and also opens the holding circuit for stepping relay 131 at interrupting springs 165. Relay 131 deenergizes and in turn opens the circuit of stepping magnet 134 at armature 159, also opening its own locking circuit at armature 160. Magnet 134 deenergizes and again closes interrupting springs 165. If the trunk terminating in this set of bank contacts is busy at this time, ground potential will be present on the test contact upon which the wiper 172 is positioned. A circuit will again be closed for stepping relay 131 from ground on this test contact, wiper 172, armature 162 and the resting contact, interrupting springs 165, off-normal springs 166 through the winding of relay 131 to battery. Relay 131 will again operate to close the circuit of stepping magnet 134, which thereupon energizes and rotates the switch wipers into engagement with the next set of bank contacts as previously described. This stepping operation is repeated until an idle trunk is found, which is indicated by the absence of ground potential on the associated test contact.

It will be assumed that the first idle trunk in the selected level at this time is the trunk comprising conductors 174—176. When the switch wipers 171—172 are rotated into engagement with the set of bank contacts 174'—176' terminating this trunk, no circuit is closed for the stepping relay 131. Consequently the switch wipers are arrested in this position. Furthermore, since no ground potential is applied to the upper terminal of the switching relay 132, the following circuit becomes effective to cause the energization of the switching relay 132; ground through the upper winding of relay 125, working contact and armature 145, through the winding of relay 132, interrupting contacts 165, off-normal springs 166, through the winding of relay 131 to battery. The current flow in this circuit, limited by the comparatively high resistance of relay 132, is insufficient to cause the energization of relay 131. Relay 132 operates, however, and performs the following circuit changes: Ground potential is supplied to the release conductor 175 of the selected trunk by way of upper winding of relay 125, working contact and armature 145, working contact and armature 162, and wiper 172, and the test contact 175' to which the conductor 175 is connected. A point in the circuit for operating the subscriber's meter M is closed at armature 163. At armatures 161 and 164 the control circuit is extended by way of wipers 171 and 173, bank contacts 174' and 176', conductors 174 and 176 to the local second selector S^2. The normal ground and battery connections to the upper and lower talking conductors are disconnected at the springs controlled by armatures 161 and 164. The control circuit now extends from ground at normally closed springs controlled by armature 208 of second selector S^2, conductor 174, bank contact 174', wiper 171, armature 161 and the working contact, armature 137 and the resting contact, armature 148 and the working contact, armature 146 and the working contact, resistance 131, upper winding of relay 128, working contact and armature 152, resting contact and armature 141, working contact and armature 164, wiper 173, bank contact 176', conductor 176, normally closed springs controlled by armature 211, winding of relay 202, through the winding of vertical magnet 204 to battery. The application of ground potential to release conductor 175 closes a circuit extending by way of the normally closed contacts controlled by armature 209 through the upper winding of the two-step relay 201 to battery. The energization of the upper winding of relay 201 causes the operation of armature 210 only. This operation merely opens a point in the circuit of release magnet 206 and prepares other circuits to be described later.

In response to the next digit dialed by the subscriber at substation A, resistance 136 and the upper winding of relay 128 are again

short circuited a corresponding number of times. This causes the operation of the vertical magnet 204 in a manner similar to the way in which vertical magnet 133 of the first selector repeater SR was operated. In operating, magnet 204 steps the wipers 221—223 opposite the level of bank contacts corresponding to the digit dialed. Relay 202, which operates in series with the vertical magnet 204 and due to its slow-acting characteristics remains operated during the transmission of this series of impulses, closes a circuit which may be traced from ground by way of armature 210 and the working contact, working contact and armature 212, off-normal springs 218 which are closed upon the first vertical step of the switch wipers, through the winding of stepping relay 203 to battery. Stepping relay 203 operates and closes a holding circuit for itself at armature 213 and prepares a circuit for stepping magnet 205 at armature 214. At the termination of this series of impulses series relay 202 deenergizes and, by permitting the closure of the springs controlled by armature 212, closes a circuit for stepping magnet 205. Magnet 205 operates and rotates the switch wipers 221—223 into engagement with the first set of bank contacts in the selected level, and also opens the holding circuit of stepping relay 203 at interrupting springs 215. Stepping relay 203 deenergizes and opens a circuit of the stepping magnet 205. In releasing, stepping magnet 205 again closes interrupting contacts 215. If the trunk terminating in this set of bank contacts is busy, ground potential will be present on the test contact engaged by test wiper 222, and a circuit will again be closed for relay 203 from ground on said test contact, wiper 222, armature 209 and the resting contact, interrupting contacts 216, interrupting contacts 215, off-normal springs 218, through the winding of relay 203 to battery. The alternate operation of the stepping relay 203 and magnet 205 now takes place in a manner identical to the way in which stepping relay 131 and stepping magnet 134 of the first selector repeater SR operated, thereby causing the selector S^2 to position its wipers on the first set of bank contacts terminating an idle trunk line, an idle trunk line again being indicated by the absence of ground potential on the test contact. During this time, relay 201 is prevented from operating in its second step by reason of the ground potential on both terminals of its lower winding.

It may be assumed that the trunk line selected is the one comprising conductors 224—226. Since wiper 222 encounters no ground potential, the circuit which may be traced from ground on the release conductor 175, through the lower winding of relay 201, interrupting contacts 215, off-normal springs 218, through the winding of the stepping relay 203 to battery, becomes effective to cause relay 201 to operate in its second step. Due to the high resistance of the lower winding of relay 201, the current flow in the circuit is insufficient to cause the operation of relay 203. Relay 201, in operating to its second step, causes the full operation of all its armatures with the following results: At armature 209 ground potential is supplied to the release conductor 225 of the local third selector S^3 by way of ground on release conductor 175, working contact and armature 209, wiper 222, and the test contact 225′ to which conductor 225 is connected. The circuit for the upper winding of relay 201 is at the same time opened by the separation of contacts controlled by armature 209. At armatures 208 and 211 the control circuit is extended to the selector S^3, ground now being supplied to the upper talking conductor at springs controlled by armature 208′, and battery to the lower talking conductor through vertical magnet 204′ in series with relay 202′ at springs controlled by armature 211′.

The selector S^3 is identical in all details to the selector S^2 and operates responsive to the next series of impulses dialed by the calling subscriber in a manner identical to the way in which selector S^2 operates, positioning its wipers opposite the level of bank contacts corresponding to the digit dialled and then selecting an idle trunk in this level.

It may be assumed that the trunk selected is the one comprising conductor 234—236 terminating at the connector C. Thus, when this trunk is seized a circuit is closed for the upper winding of the two-step relay 301 from ground supplied to release conductor 235, resting contact and armature 313, through the upper winding of 301 to battery. Relay 301 operates in its first stage operating armature 312 only, opening a point in the circuit of release magnet 308. A circuit is also closed for switching relay 305 from ground on conductor 235 through the normally closed vertical off-normal springs 333, through the lower winding of relay 305 to battery. Relay 305 operates and prepares a holding circuit for itself at armature 328, and at armature 326 connects the vertical magnet 306 in series with the series relay 302 at the same time disconnecting the rotary magnet 307. Relay 305 at this time functions as a change-over relay as will be further described later. Seizure of the trunk also causes the control circuit to be extended to the connector C, ground now being supplied to the upper talking conductor at springs controlled by armature 311, and battery to the lower talking conductor through vertical magnet 306 in series with relay 302 at springs controlled by armature 315.

Responsive to the dialing of the next digit by the calling subscriber, resistance 136 and the upper winding of relay 128 are again

short circuited a corresponding number of times thereby causing the operation of the vertical magnet 306 to position the switch wipers 341—343 opposite the corresponding level of bank contacts. Series relay 302 operates in series with the vertical magnet 306 and due to its slow-acting characteristic remains operated during the transmission of the series of impulses. At armature 317 and the working contact, the holding circuit for relay 305 is completed to maintain this relay operated during the vertical movement of the switch wipers, the initial energizing circuit for the lower winding of relay 305 being opened on the first vertical step of the switch wipers at vertical off-normal spring 333. The operation of armature 316 at this time is without effect. At the end of this series of impulses, relay 302 deenergizes and opens the holding circuit of the lower winding of relay 305 at armature 317. Relay 305 deenergizes and reconnects the rotary magnet 307 in series with the relay 302 at armature 326 at the same time disconnecting the vertical magnet 306.

Responsive to the next series of impulses dialed by the calling subscriber the rotary magnet 307 is operated to rotate the switch wipers into engagement with the set of bank contacts corresponding to the digit dialed, this set being the one terminating the line of the called substation A″, namely bank contacts 344—346. Relay 302 again operates during the transmission of this series of impulses, this time in series with the rotary magnet 307, and prepares the testing circuit for the test relay 304 at armature 316 and the working contact. The remaining operations of the connector C now depend upon whether the called line is busy or idle at this time.

If the line to substation A″ is busy at this time, ground potential will be present on the back contact 345, and the engagement of wiper 342 with contact 345 completes a circuit for the test relay 304 from ground on contact 345 by way of wiper 342, armature 316 and the working contact, resting contact and armature 327, through the winding of test relay 304 to battery. Relay 304 operates and opens a point in the ring back tone circuit at armature 323, closes a point in the busy tone circuit at armature 322, and prepares a locking circuit for itself at armature 321. Shortly after the termination of this series of impulses, relay 302 deenergizes, this time closing a locking circuit for test relay 304 by permitting springs controlled by armature 316 to close. A circuit for the lower winding of two-step relay 301 is also closed by the release of armature 317 which may be traced from ground on release conductor 235, rotary off-normal springs 331 closed upon the first rotary step of the switch wipers, armature 317 and the resting contact, vertical off-normal springs 332 closed upon the first vertical step of the switch wipers, through the lower winding of relay 301 to battery. The energization of the lower winding of this relay causes this relay to operate in the second step, causing the full operation of all the armatures of this relay with the following results: At armature 313 the circuit for its upper winding is opened, and at armatures 311 and 315 the ground and battery supplied to conductors 234 and 236 are disconnected. The disconnection of ground and battery from the conductors 234 and 236 causes the deenergization of the holding relay 128 in the first selector repeater SR. In deenergizing, relay 128 opens the circuit of the supervisory relay 181 at armature 150, at the same time placing ground potential on the release trunk directly. By the release of armature 151, the lower winding of battery feed relay 130 is connected to the lower talking conductor. By the release of armatures 148 and 152 a talking circuit is completed from the substation A to the connector C, so that the calling subscriber may hear the busy tone from the busy machine BM, a busy tone potential being supplied to the lower talking conductor from the common busy tone conductor 391, resting contact and armature 319, armature 322 and the working contact, to conductor 236 from where it is transmitted to the calling substation. Hearing this tone notifies the calling subscriber that the desired line is busy at this time, whereupon he will replace his receiver with the intention of calling some later time. Replacing his receiver initiates the release of all the operated switches, this operation being fully described in later paragraphs.

Returning now to the point where further operations of the connector were determined by the busy or idle condition of the calling line, it may now be assumed that the line to substation A″ is idle at the time connection therewith is attempted. In this event the test relay 304 is not operated, no ground potential being present on the bank contact 345. In this case, when relay 302 falls back at the termination of the impulses, a circuit is closed which may be traced from ground on release conductor 235, armature 321 and the resting contact, through the upper winding of relay 305, resting contact and armature 316, wiper 342, bank contact 345 through the winding of the switching relay 361 of the line-switch LS^3, interrupting contacts 369, through the winding of the magnet 363 to battery. Relays 305 and 361 operate in this circuit, but due to the high resistance of the switching relay 361, the current flow is insufficient to cause the operation of magnet 363. Relay 305, in operating, closes a locking circuit for itself at armature 328, places ground potential on the bank contact 345 at armature 325 by way of wiper 342, thereby marking the line of substation A″ busy, and

at armatures 324 and 329 closes the signalling circuit to signal the subscriber at substation A''. The signaling circuit may be traced from ground by way of the resting contact and armature 318, armature 324 and the working contact, wiper 341, bank contact 344, line conductor 371 through the bells of the substation A'', line conductor 372, bank contact 346, wiper 343, working contact and armature 329, armature 320 and the resting contact, through the lower winding of ring cut-off relay 303, common signalling conductor 390 to which battery superimposed ringing current from generator G and direct battery are intermittently connected. Relay 361 in energizing, disconnects the normal ground and battery connections from the line conductors without connecting up the switch wipers 380—382, this being due to the usual mechanical interlocking mechanism between relays 361 and 362. The bells at the substation A'' now operate responsive to the ringing current until the subscriber at substation A'' answers. Obviously, relay 301 is again operated in its second step at the end of the last series of impulses, the circuit for its lower winding being closed by the release of armature 317, after which relay 128 in the selector repeater SR is deenergized, preparing the talking circuit by releasing armatures 148 and 152 as previously described.

When the subscriber at substation A'' removes his receiver to answer the call, a direct current bridge is placed across the line conductors 371—372 which closes a direct current circuit for the ring cut-off relay 303. Ring cut-off relay 303 operates and closes a locking circuit for its upper winding at armature 319' which may be traced from ground on release conductor 235, armature 319' and the working contact, through the upper winding of relay 303, resistance 309 to battery. At armatures 318 and 320 the ringing circuit is disconnected and the talking circuit between the subscribers at substation A and substation A'' is finally completed. The release of armatures 148 and 152 bridges battery feed relay 130 directly across the called line. Relay 130 operates and disconnects one terminal of relay 128 from the lower talking conductor at armature 158; reverses the ground and battery connections to the calling line at armatures 155 and 156; and at armature 157 closes a circuit for the magnet 116 of the subscriber's meter M in parallel with the lower winding of relay 129. The meter M operates to register the call. Relay 129 operates and locks to the release trunk at armature 153, and functions to maintain the circuit of magnet 116 closed until the connection is released. In this way the meter M is prevented from being falsely operated by the jiggling of the receiver switchhook at the called station. The reversing of the battery and ground connections to the calling line performs no function in the present connection. This operation may be used to cause the collection of a coin when a call is initiated from a pay station, and is therefore shown here for the purpose of illustration. The calling and called subscribers may now hold conversation, relays 125 and 130 being the only bridges across the line, talking battery being furnished through the windings of relay 125 for the calling subscriber and through the windings of relay 130 for the called subscriber.

At the end of the conversation both subscribers will replace their receivers. When the called subscriber replaces his receiver, the direct current bridge across the line conductors is opened thereby causing the deenergization of the battery feed relay 130. Relay 130 deenergizes and restores its armatures to normal. The direction of current flow to the calling substation is restored to normal by the release of armatures 155 and 156, and a circuit for the supervisory lamp L' and relay 182 is closed at armature 157. When the calling subscriber replaces his receiver, the direct current bridge across the line conductors 101 and 103 is interrupted thereby opening the circuit for the line relay 126. Relay 126 deenergizes and opens the circuit of release relay 127 at armature 142. Relay 127 deenergizes and releases its armatures with the following results: At armature 144 ground potential is removed from the release conductor 122, and a circuit, which includes the off-normal springs 168 closed upon the first vertical step of the switch wipers and armature 138, is closed for the release magnet 135. In operating, magnet 135 restores the switch wipers 171—173 to normal. The removal of ground from release conductor 122 also opens the holding circuit for the lower winding of relay 129, and removes ground potential from the meter conductor 123. Relays 129 and 105 thereupon deenergize and restore their armatures to normal; magnet 116 of the subscriber's meter M restores to normal.

By the release of armature 145, ground potential is removed from the release conductors 122, 225, and 235, which are serially connected, extending through the first selector repeater SR, second selector S^2, third selector S^3, and connector C. The removal of ground from these respective conductors causes the deenergization of switching relay 132 in the selector repeater SR, switching relay 201 in the second selector S^2, switching relay 201' in the third selector S^3, and switching relay 301 in the connector C. The deenergization of the above mentioned switching relays effect the closure of the following release circuits: A circuit for release magnet 206 is closed from ground by way of armature 210 and the resting contact, vertical off-normal springs 217 closed upon the first vertical step of the wipers 221—223 of selector

S^2, through the winding of release magnet 206 to battery. Release magnet 206 operates and causes the restoration of the wipers 221—223 of the selector S^2. Similarly, a circuit is closed for release magnet 206' of the third selector S^3, which magnet operates to release wipers 231—233 of the selector S^3 to normal. A circuit is also closed for release magnet 308 which may be traced from ground by way of the resting contact and armature 312, vertical off-normal springs 330 closed upon the first vertical step of the connector C, through the winding of the release magnet 308 to battery. Magnet 308 operates and causes the restoration of the wipers 341—343 of the connector C to normal. The removal of ground potential from the release conductor 235 also opens the holding circuits for the ring cut-off relay 303, and switching relay 305. These relays thereupon deenergize and restore their armatures to normal. All apparatus used in establishing the above described connection has now been restored to normal and is ready to be used again to establish other connections.

Call from distant office to substation A''

In any multi-office system provisions are made for extending calls from one subscriber in one exchange to another subscriber in another exchange. In the ordinary or more common telephone system, an outgoing repeater is required for each outgoing trunk extending to another exchange, for the purpose of repeating impulses to the other exchange. In the present system however, the use of outgoing repeaters is entirely obviated, the trunks extending from one exchange to another being accessible directly in the banks of first selector repeaters of the type shown in Fig. 1 (or Fig. 9, to be described later) and terminating directly in incoming selector repeaters such as shown in Fig. 4. To describe the operations performed in establishing a connection from a subscriber in one office to a subscriber in another office, it will be assumed that a certain subscriber in some distant office desires connection with the subscriber at substation A^{11}, (drawings to be arranged as shown in Fig. 11).

To establish this connection, the subscriber in the distant office removes his receiver and dials the directory number of the substation A''. In response to the removal of the receiver at the calling substation the individual lineswitch of the said substation operates to select a trunk to an idle first selector repeater, which may be identical to the first selector repeater shown in Fig. 1. Responsive to the dialing of the first digit of the called number, the first selector repeater operates as described above and positions its wipers opposite the level of the bank contact in which trunks to the office serving the subscriber at substation A'' are accessible, and then automatically select an idle one of these trunks. It may be assumed that the trunk selected is the one comprising conductors 401 and 402 terminating in the incoming second selector IS, Fig. 4. When this trunk is seized, a circuit is closed which may be traced from ground by way of the resting contact and armature 419 in the incoming selector IS, through the winding of line relay 403, trunk conductor 401, over a loop including a resistance and the holding relay of the selected first selector repeater similar to resistance 136 and relay 128 of selector repeater SR, over trunk conductor 402, armature 420 and the resting contact, through the upper winding of the marginally adjusted impulse relay 405 of the incoming selector IS to battery. The resistance of the above traced circuit is sufficiently high to prevent the operation of relay 405 at this time. Relay 403 is partially shunted by the ground connection by way of resting contact and armature 418 and resistance 440 but nevertheless operates over the above traced circuit and performs the following circuit changes: At armature 415 an obvious circuit is closed for release relay 408. Relay 408 operates and at armature 428 opens a point in the circuit of release magnet 413 and connects ground potential to release conductor 450. Relay 403 in operating also closes a circuit which may be traced from ground by way of the normally closed springs controlled by armature 431, armature 416 and the working contact, armature 417 and the resting contact, resistance 441, through the winding of the holding relay 406, normally closed vertical off-normal springs 436, normally closed springs controlled by armature 435, resting contact and armature 449, through the winding of series relay 409, through the winding of vertical magnet 412 to battery. The current flow in this circuit is insufficient to cause the operation of magnet 412 and series relay 409 at this time, but holding relay 406 energizes and at armature 424 shunts the off-normal springs 436 which are opened upon the first vertical step of the switch wipers, prepares the holding circuit for stepping relay 407 at armature 423, and at armature 425 prepares a deenergizing circuit for impulse relay 405.

Responsive to the next series of impulses dialed by the calling subscriber, the resistance and relay in the selected first selector repeater at this office similar to resistance 136 and relay 128 of selector SR, Fig. 1, are short circuited by contacts on the line relay a number of times corresponding to the digit dialled, as previously described. Each time that this resistance and relay are short circuited, the current flow in the above traced circuit including the two trunk conductors in series is sufficiently increased to cause the operation of the marginal relay 405. Marginal relay 405, in operating, closes a circuit

for the lower winding of relay 405 at armature 422 which may be traced from ground by way of armature 422 and the working contact, armature 425 and the working contact, resistance 442, normally closed springs controlled by armature 419, through the lower winding of relay 405 to battery. Marginal relay 405 is differentially wound with the windings so proportioned that the magneto motive force produced by the current in the upper winding when the resistance and winding of the impulsing relay in the first selected repeater are short circuited, is greater than that produced by the lower winding. For this reason relay 405 remains operated during the time the resistance and the impulsing relay of the first selected repeater are short circuited. But when the short circuit is removed from the said relay and resistance, the current flow in the upper winding of relay 405 is reduced so that the magneto motive force produced by the current in the lower winding is greater than that produced by the current in the upper winding. Relay 405 therefore immediately deenergizes and in so doing opens the circuit of its own lower winding at armature 422. In this manner, the impulse relay 405 operates in positive synchronism with the line relay of the first selector repeater. Each time relay 405 operates, resistance 441 and relay 406 are short circuited. This causes impulses of increased current in the circuit of magnet 412 and series relay 409. As a result magnet 412 is operated to raise the wipers 451—453 of the incoming selector IS opposite the level of bank contacts corresponding to the digit dialed. Series relay 409 operates in series with the magnet 412, remaining operated continuously during the transmission of the series of impulses by reason of its slow acting characteristic, and closing a circuit for the stepping relay 407. This circuit may be traced from ground by way of armature 428 and the working contact, working contact and armature 429, armature 434 and the resting contact, off-normal springs 437 closed upon the first vertical step of the switch wipers, through the winding of stepping relay 407 to battery. Stepping relay 407 operates and closes a holding circuit for itself at armature 426 which may be traced from ground by way of armature 423 and the working contact, armature 426 and the working contact, interrupting springs 439, off-normal springs 437, through the winding of relay 407 to battery. At armature 427 a circuit is prepared for the rotary magnet 414.

At the termination of this series of impulses, series relay 409 de-actuates and closes a circuit for magnet 414 which may be traced from ground by way of armature 428 and the working contact, normally closed springs controlled by armature 429, working contact and armature 427 through the winding of rotary magnet 414 to battery. By the release of armature 429 the initial energizing circuit for stepping relay 407 is also opened. In operating, magnet 414 rotates the switch wipers 451—453 into engagement with the first set of contacts in the selected level and also opens the holding circuit for relay 407 at interrupting springs 439. Stepping relay 407 thereupon de-actuates and opens the circuit of the rotary magnet 414 at armature 427. Magnet 414 restores and closes interrupting springs 439. If the trunk accessible at this set of contacts is busy, ground potential will be present on the test contact engaged by wiper 452, and relay 407 will again be energized. Thus stepping relay 407 and magnet 414 operate alternately and cause the switch wipers to be moved into engagement with a set of bank contacts terminating an idle trunk, in the well known manner.

When the contacts terminating at the idle trunk are reached, which may be assumed to be the trunk comprising conductors 454—456, no ground potential will be encountered by wiper 452, and the circuit which may be traced from ground by way of armature 428 and the working contact, through the winding of relay 411, interrupting contacts 439, off-normal springs 437, through the winding of stepping relay 407 to battery, becomes effective to energize switching relay 411. Due to the resistance of switching relay 411, the current flow in this circuit is insufficient to cause the operation of stepping relay 407. Switching relay 411 operates, however, and performs circuit changes as follows: At armature 433 ground potential is supplied to release conductor 455 by way of armature 428 and the working contact; a circuit is prepared for switchover relay 404 at armature 432; the initial energizing circuit of relay 407 is opened at armature 434; and at armature 431 and 435 ground and battery via magnet 412 is disconnected from the heavy talking conductors by the separation of the normally closed springs controlled by these armatures and the control circuit is extended by way of wipers 451 and 453, bank contacts 454′ and 456′, conductors 454 and 456 to the third selector S^3 where ground and battery through magnet 204′ is normally supplied to conductors 454 and 456, respectively, thereby maintaining a circuit for holding relay 406 of the incoming selector IS intact. Ground potential supplied to the release conductor 455, marks the selector S^3 engaged and causes the energizing of two-step relay 201′ in its first step, thereby preparing the selector for operation.

Responsive to the next series of impulses dialed by the calling subscriber, relay 405 is again operated a corresponding number of times, short circuiting relay 406 and resistance 441 the same number of times, which causes the operation of the vertical magnet

204′ of the third selector S^3 which steps the switch wipers opposite the level of bank contacts corresponding to the digit dialed. At the completion of this operation, the selector S^3 performs the automatic rotary operation and selects a trunk to an idle connector as previously described, which may be assumed to be the trunk to connector C.

In response to the next two digits dialed by the calling subscriber, the connector C is caused to position its wipers on the contacts terminating the line to the desired substation. After the rotary operation of the connector C, switching relay 301 operates as previously described and at armatures 311 and 315 disconnects the normal ground at battery connection from the line conductors 234 and 236. This causes a deenergization of relay 406 in the incoming selector IS. As a result, a circuit for switchover relay 404 is closed at armature 423, and at armature 424 the lower winding of battery feed relay 410 is reconnected to the lower talking conductor. Relay 404 in operating performs the following circuit changes: At armature 418 the partial shunt around relay 403 is interrupted; by the actuation of armatures 419 and 420, ground and battery are disconnected from the incoming trunk conductors and a high resistance bridge including relay 403, resistance 442, and resistance 443 is substituted therefor; at armature 417 the upper winding of battery feed relay 410 is connected to the upper talking conductor via armature 416. Disconnecting ground and battery from the incoming trunk conductors causes the deenergization of the holding relay in the first selector repeater in the distance office similar to relay 128 in selector repeater SR. The deenergization of this holding relay bridges the battery feed relay in the first selector repeater similar to relay 130 of the first selector repeater SR across the outgoing trunk conductors. Relay 403 in the incoming selector IS is now energized from battery supplied to the trunk conductor by said battery feed relay. Relay 403 will momentarily deenergize during the time that the holding relay similar to 128 in selector SR is deenergizing and connecting the battery feed relay across the trunk conductors, but will have no effect. Release relay 408 is slow acting and therefore will not deenergize even though its circuit is momentarily opened. The battery feed relay in the first selector repeater in the distant office does not operate in series with relay 403 and resistances 442 and 443 because of an insufficient current flow.

After the wipers of the connector have been rotated into engagement with the bank contacts terminating the line to the desired substation, the line of this substation is tested for the busy or idle condition, in the manner described above. If the line is busy at this time, a busy tone will again be transmitted to the calling station in response to which the calling subscriber is expected to replace his receiver and thereby initiate the release of the connection in the manner to be described later. If the desired line is idle, signaling current will be applied to the line conductors to signal the subscriber at the called substation A″.

Assuming that the line to substation A″ is idle, when the called subscriber removes his receiver to answer the call, a direct current bridge is placed across the line conductors which causes the operation of the battery feed relay 410 in the incoming selector IS. Relay 410 operates and short circuits the resistances 442 and 443 at armature 430. The short circuiting of these resistances sufficiently increases the current flow in the circuit including the battery feed relay of the first selector repeater in the distant office and the trunk conductors in series to cause the operation of the said battery feed relay. The results effected by the operation of the battery feed relay in the first selector repeater in the distant office are the same as those performed by the relay 130 in the selector repeater SR explained in the previously described connection between the subscriber at substation A and the subscriber at substation A″. The talking connection is thus established and the two subscribers may hold conversation.

At the termination of the conversation both subscribers replace their receivers. Replacing the receiver at the called substation interrupts the direct current bridge across the line conductors thereby opening the circuit of the battery relay 410 in the incoming selector IS. Relay 410 in deenergizing removes the short circuit from resistances 442 and 443. The reinsertion of resistances 442 and 443 in the circuit including the battery feed relay in the first selector repeater in the distant office corresponding to relay 130 in selector repeater SR causes the said battery feed relay to deenergize and release its armatures. Replacing the receiver in the calling substation opens the circuit of the line relay of the first selector repeater at the distant office which deenergizes and interrupts the circuit including the battery feed relay similar to relay 130 the two trunk conductors 411 and 402, and relay 403 in series and also initiates the release of the first selector repeater in the manner previously described. Relay 403 deenergizes and opens the circuit of the release relay 408 at armature 415. Release relay 408 deenergizes and by the release of armature 428 ground potential is removed from the release conductors 450, 455, and 235 serially connected extending through the incoming selector IS, the third selector S^3 and connnector C. At the same time a circuit for the release magnet 413 is

closed which may be traced from ground by way of armature 428 and the resting contact, off-normal springs 438 closed upon the first vertical step of the switch wipers, through the winding of the release magnet 413 to battery. Magnet 413 operates to restore the switch wipers to normal. The removal of ground potential from the release conductor 450 opens the circuit of the switching relay 411, which in restoring its armatures to normal opens the circuit of the switch over relay 404 at armature 432. Relay 404 thereupon deenergizes and restores its armatures to normal. The removal of ground potential from the release conductors 455 and 235 causes the restoration of the third selector S^3 and connector C to normal as previously described.

Toll call from toll board to substation A''

To establish toll connections from the main toll board to a local subscribers, a new type of toll transmission selector, designed especially to meet the requirements of this invention, has been provided. To describe the operation of this new type of toll transmission selector and to describe the operation of the new connector herein provided when utilized in a toll connection, it will be assumed that a toll connection is desired with the subscriber at substation A'', (drawings to be arranged as shown in Fig. 11). In this telephone system it is assumed that the main toll board is located at one exchange, from which toll trunks extend to the other exchanges in the system. It may now be assumed that the toll operator at the main toll board position answers the incoming toll call by means of the cord circuit CC, Fig. 5, and, having learned the name or number of the called subscriber inserts the calling plug P' of the cord CC into the jack of an idle toll trunk extending to the exchange serving the called subscriber. It may further be assumed that the trunk selected is the one comprising conductors 501 and 502, terminating at the exchange under consideration in the selector TS. As previously stated, the selector TS is of the well known Strowger vertical and rotary type, the operation of which is well understood by those skilled in the art, and therefore a detailed description of its operation is thought unnecessary. When the toll operator inserts the plug P' into the jack J she dials the directory number of the called subscriber. Responsive to the dialing of the first digit of the called number, the selector S operates to position its wipers opposite the level of bank contacts, corresponding to the digit dialed, and then automatically rotates to position its wipers 551—553 on a set of bank contacts terminating an idle trunk. It may be assumed that the idle trunk selected is the one comprising conductors 554—556 accessible at bank contacts 554'—556'. It may be mentioned that the first digit of the called number as concerns the toll operator is the second digit in the directory number of the desired station, since the operator in completing the call manually selects the office to which the call is to be extended.

When the trunk line comprising conductors 554—556 terminating in the toll transmission selector TTS is seized, ground potential is placed on the test contact 555 to mark the trunk busy, and a circuit is closed for the line relay 605 of the toll transmission selector TTS, which circuit may be traced from ground by way of armature 622 and the resting contact, conductor 556, bank contact 556', wiper 553, working contact and armature 522, trunk conductor 502, ring of jack J, sleeve of plug P', contacts 503, contacts 505, lower right-hand winding of repeating coil R^5, winding of polarized relay 502, upper right-hand winding of repeating coil R^5, contacts 506, contacts 504, tip of plug P', and tip of jack J, conductor 501, armature 521 and the working contact, wiper 551, bank contact 554', conductor 554, normally closed springs controlled by armature 623, normally closed springs controlled by armature 628, through the upper winding of line relay 605 to battery. Line relay 605 operates and opens the short circuit around resistance 619 and the upper winding of holding relay 608 at armature 632, and closes a circuit for release relay 606 at armature 631. Relay 606 operates and performs the following circuit changes: Ground potential is placed on release conductor 555 to mark the trunk engaged and to provide a holding circuit for selector TS at armature 633, this taking place before the release relay in the selector TS has had time to fall back. A point in the circuit of release magnet 613 is opened at armature 634. The circuit of the series relay 609 is prepared at armature 635, relay 609 being maintained deenergized at this time by reason of ground potential on its upper terminal by way of the working contact and armature 631. At armature 636 a circuit is closed which may be traced from ground on the release conductor 555 supplied thereto by way of armature 633 and the working contact, normally closed springs controlled by armature 648, armature 646 and the resting contact armature 636 and the working contact, resistance 619, through the upper winding of relay 608, armature 624 and the resting contact, springs controlled by armature 652, through the winding of vertical magnet 612 to battery. Due to the resistance of the upper winding of relay 608 and resistance 619, the current flow of this circuit is insufficient to cause the operation of magnet 612. Relay 608 operates however, and performs the following circuit changes: At armature 641 and the working contact, a circuit is closed for the supervisory relay 690

and lamp L^6 in series, at the same time preparing the circuit for the lower winding of relay 608. At armatures 642 and 640 a new circuit is closed for the upper winding of relay 608 which may be traced from ground by way of the normally closed springs controlled by armature 647, armature 640 and the working contact, armature 636 and the working contact, resistance 619, upper winding of relay 608, working contact and armature 642, normally closed springs controlled by armature 652, through the winding of vertical magnet 612 to battery.

Responsive to the next digit dialed by the toll operator, line relay 605 deenergizes and reenergizes a corresponding number of times. As a result, resistance 619 and the upper winding of relay 608 are short circuited, at armature 632 and the resting contact, a like number of times which causes corresponding impulses of increased current flow in the circuit of the vertical magnet 612. Responsive thereto, vertical magnet 612 operates to position the wipers 661—664 opposite the level of bank contacts corresponding to the digit dialed. Furthermore, each time that relay 605 deenergizes, ground potential is disconnected from the upper terminal of the series relay 609 and battery through the resistance 615 is substituted therefore by way of armature 631 and the resting contact. Relay 609 therefore energizes over the circuit from ground through its own winding, working contact and armature 635 to battery by way of armature 631 and the resting contact and resistance 615, and also to battery through the winding of relay 606. Each time that relay 605 reenergizes during impulses, relay 609 is short circuited, and by reason of its being short circuited, assumes slow acting characteristics and therefore does not deenergize during the transmission of a series of impulses. Relay 609, in operating, closes an initial energizing circuit for stepping relay 610 at armature 644 which circuit may be traced from ground on release conductor 555, working contact and armature 644, resting contact and armature 650, off-normal springs 654 which are closed upon the first vertical step of the switch wipers, through the winding of stepping relay 610 to battery. Relay 610 operates and prepares a circuit for the rotary magnet 613 at armature 645. In operating, relay 609 also closes the circuit for the lower locking winding of relay 608 at armature 643. The closure of this holding circuit positively assures the continuous operation of relay 608 during the transmission of impulses, that is, during the time its upper winding is short circuited. Relay 610 also closes a temporary locking circuit for itself at armature 646 which may be traced from ground on release conductor 555, normally closed springs controlled by armature 648, armature 646 and the working contact, interrupting springs 653, off-normal springs 654, through the winding of relay 610 to battery.

At the end of this series of impulses, line relay 605 is no longer deenergized and remains energized continuously. Relay 609 is again continuously short circuited at armature 631 and the working contact and deenergizes. In releasing its armature 644, permitting the contacts controlled thereby to close, a circuit is closed for the rotary magnet 613 which may be traced from ground on release conductor 555, springs controlled by armature 644, working contact and armature 645, through the winding of rotary magnet 613 to battery. Armature 643 in releasing again closes the circuit for the supervisory relay 690. Rotary magnet 613 operates over the above traced circuit and rotates the switch wipers 661—664 into engagement with the first set of bank contacts in the selected level and also opens the holding circuit for the stepping relay 610 at the interrupting contacts 653. Stepping relay 610 deenergizes and opens its own locking circuit at armature 646, and opens the circuit of the rotary magnet 613 at armature 645. Magnet 613 releases and again closes interrupting springs 653. If the trunk line terminating in this first set of bank contacts is busy, ground potential will be present on the test contact encountered by test wiper 662. A circuit is then again closed for stepping magnet 610 traceable from ground on test contact, test wiper 662, armature 648 and the resting contact, interrupting springs 653, off-normal springs 654, through the winding of relay 610 to battery. Relay 610 again operates, closing the circuit of the rotary magnet 613 which again operates and steps the switch wipers into engagement with another set of bank contacts. In this manner stepping relay 610 and magnet 613 operate alternatively, until the switch wipers are rotated into engagement with a set of bank contacts terminating an idle trunk. When an idle trunk line is found, which may be the trunk line comprising conductors 665—668 terminating in bank contacts 665′—668′, no ground potential will be present on the bank contact 666′. Consequently no circuit will again be closed through the stepping relay 610. Therefore the wipers will be arrested in engagement with this set of bank contacts. Furthermore, the ground potential will be removed from the lower terminal of the switching relay 611, thus permitting this relay to energize over a circuit traceable from ground on release conductor 555, through the winding of relay 611, interrupting contacts 653, off-normal springs 654, through the winding of the stepping relay 610 to battery. Due to the high resistance of the switching relay 611, the current flow in this circuit is insufficient to cause the operation of stepping relay 610.

Switching relay 611 operates, however, and performs the following circuit changes: Ground potential is supplied to the test contact 666′ and release conductor 666 by way of wiper 662 and armature 648 and the working contact which is connected to the release conductor 555. The trunk line is thus marked engaged and an obvious circuit is closed for the upper winding of switching relay 301 of connector C which terminates the selected trunk line. Switching relay 301 of connector C operates in its first step to prepare the connector C to receive the first set of impulses as has been previously described. In operating, relay 611 also prepares the circuit of reversing relay 602 at armature 649. At armature 650 a point in the initial circuit of stepping relay 610 is opened to prevent this relay from operating responsive to the dialing of the next digit. At armatures 647 and 652 the connection is extended to the connector C, ground and battery through magnet 612 being disconnected from the heavy talking conductors, and ground and battery through vertical magnet 306 of connector C being substituted therefor. At armature 651 a circuit is closed which may be traced from ground by way of armature 626 and the resting contact, armature 651 and the working contact, wiper 663, bank contacts 667′ ring-control conductor 667, armature 314 and the resting contact, through the upper winding of ring-cut-off relay 303, resistance 309 to battery. Relay 303 operates, closes a locking circuit for itself at armature 319′, closes a point in the busy-tone circuit at armature 319, and at armatures 318 and 320 interrupts the ringing circuit, at the same time closing points in the talking circuit.

Responsive to the next two digits dialed by the toll operator, connector C operates in a manner described previously to position its wipers on the set of bank contacts terminating the line to substation A″, namely, bank contacts 344—346, after which the line to substation A″ is tested for the busy or idle condition. Immediately following the rotary motion operation, switching relay 301 energizes in its second step, effecting the following results: The ground and battery connections are disconnected from the talking conductors by the operation of armatures 311 and 315, thereby interrupting the circuit of the impulsing relay 608 in the toll transmission selector TTS. At armature 314, the ring-control conductor 667 is disconnected from the lower terminal of ring cut-off relay 303 and connected to the upper terminal of this winding.

Relay 608, in deenergizing, closes points in the talking circuit by permitting armatures 640 and 642 to engage their resting contacts. By the release of armatures 641, the circuit of relay 670 and lamp L′ is opened and a circuit for reversing relay 602 is closed which may be traced from ground by way of armature 641 and the resting contact, working contact and armature 649, through the winding of relay 602 to battery. Relay 602 operates and performs the following circuit changes: At armature 625, ringing relay 601 is bridged across condenser 695 in series with the condenser 696. A point in the initial energizing circuit of relay 608 is opened at armature 624. Ground is disconnected from conductor 556 at armature 622. By the operation of armature 623 battery through the upper winding of relay 605 is disconnected from conductor 554 and is connected through resistance 617 and the lower left-hand winding of repeating coil R^6 to conductor 556. At armature 626 ground is removed from the ring control conductor 667, this taking place before relay 303 is deenergized—armature 314 being operated. At the same point ground is connected to conductor 554 through the lower winding of relay 605, resting contact and armature 629, resistance 618, and the upper left-hand winding of repeating coil R^6. Thus the direction of current flow over the incoming toll trunk is reversed. Polarized relay 502 now operates and closes the circuit of lamp L^4. The lighting of lamp L^4 indicated to the toll operator that connection has been extended to the desired line.

If the line to substation A″ is busy when the connector wipers are rotated into engagement with the contacts terminating this line, the busy relay 304 is operated as described previously, closing a locking circuit for itself, and by the operation of armature 322 interrupted ground potential is extended by way of the common interrupter I, working contact and armature 319, armature 322 and the working contact, working contact and armature 315, conductor 236, conductor 668, bank contact 668′, wiper 664, armature 652 and the working contact, armature 642 and the resting contact, armature 638 and the resting contact, lower right-hand winding of repeating coil R^6, through the lower winding of battery feed relay 603 to battery. As a result, relay 603 energizes and deenergizes, alternately opening and closing the circuit of relay 604. Relay 604 operates its armatures 628 and 629 to intermittently open and close the circuit of the polarized relay 502 in the cord circuit CC. This causes the polarized relay 502 to intermittently open and close the circuit of the lamp L^4 which causes the lamp to flash. The flashing of the lamp L^4 notifies the operator that the called line is busy, whereupon she will remove the plug P′ from the jack J to release the connection.

It may be assumed, however, that the line to substation A″ is not busy when the connector C positions its wipers on the bank contacts terminating this line. In this case busy relay 304 is not operated and the interrupted

ground supply is not connected to the lower talking conductor, and the relay 603 in the toll transmission selector TTS is not operated at this time. Consequently the lamp L^4 in the operator's cord CC remains lighted continuously. This notifies the operator that the line to substation A'' to which the connection has been extended is idle at this time.

After being notified that the connection has been extended to the desired substation, and that the line to substation is idle at this time, the toll operator when ready throws the key K' to the ringing position thereby connecting alternating current across the trunk conductors. In response to this alternating current, ringing relay 601 operates and extends ground by way of grounded release conductor 555, working contact and armature 621, armature 630 and the resting contact, armature 651 and the working contact, wiper 663, bank contact 667', conductor 667, armature 314 and the working contact, to the upper terminal of ring cut-off relay 303. Relay 303 is thereby short circuited, releases its armatures, and completes the ringing circuit for operating the bells at substation A''. The bells of the substation A'' will now ring intermittently until the subscriber answers the call.

When the subscriber at substation A'' removes his receiver to answer the call, a direct current bridge is placed across the line conductors 371—372, which causes the operation of ring cut-off relay 303 as previously described. By the operation of armatures 318 and 320, the ringing circuit is opened and a circuit for the battery feed relay 603 is closed, this circuit including the upper and lower talking conductors and the line conductors of the called substation in series. Relay 603 operates and closes a circuit for relay 604. Relay 604 operates and disconnects battery and ground connections from the conductors 554 and 556 thereby opening the circuit of polarized relay 502 in the toll operator's cord circuit CC. Polarized relay 502 therefore releases its armatures and interrupts circuit of the lamp L^4. The extinguishing of lamp L^4 notifies the toll operator that the called subscriber has answered the call.

The toll operator at the main toll board now notifies the distant toll operator that connection has been completed with the called subscriber. The distant toll operator then makes the final connection after which the calling subscriber who initiated the toll call and the called subscriber may engage in conversation.

At the end of the conversation both the calling subscriber and the called subscriber will replace their receivers. When the subscriber at substation A'' replaces his receiver, the bridge across the line conductors 371 and 372 is opened, interrupting the circuit of the battery feed relay 603. Relay 603 deenergizes and opens the circuit of relay 604. Relay 604 deenergizes and again connects battery and ground to conductors 556 and 554 which again causes the operation of the polarized relay 502 of the toll operator's cord circuit CD. In operating, polarized relay 502 closes the circuit of lamp L^4. The lighting of lamp L^4 at this time notified the toll operator that the subscriber at substation A'' has replaced his receiver. She thereupon removes the plug P' from the jack J and gives the disconnect signal to the distant toll operator by any convenient means such as by operating the key K to the signaling position, connecting alternating current across the conductors of the incoming trunk (not shown).

Removing the plug P' from the jack J, opens the circuits of the line relay 605 in the toll transmission selector TTS by opening the bridge across the trunk conductors 501 and 502. Relay 605 deenergizes and restores its armatures to normal. The engagement of armature 631 with its resting contact places a shunt around the winding of the release relay 606, thereby causing it to deenergize, shortly after which its armatures are restored to normal. Relay 609 is momentarily energized during the time that armature 631 is back and relay 606 is actuated, but its operation at this time has no utility. As a result of the restoration of relay 606, ground potential is removed from release conductor 555 at armature 633. The removal of ground potential from the release conductor 555 causes the release of the selector S and also of the connector C. The release of the connector C has previously been described and the release operation of the selector S is well known, and therefore a detailed description of the release of these switches is thought unnecessary. The removal of ground potential from the release conductor 555 also opens the circuit of the switching relay 611 in the toll transmission selector TTS. This relay thereupon deenergizes and restores its armatures to normal. The restoration of armature 649 also opens the circuit of the reversing relay 603 which thereupon deenergizes and restores its armatures to normal. A further result of the restoration of relay 606 is the closure of the circuit for the release magnet 614 which may be traced from ground by way of the resting contact and armature 634, off-normal springs 655 closed upon the first vertical step of the switch wipers, through the winding of release magnet 614 to battery. Release magnet 614 energizes and restores the switch wipers to normal in the usual manner. All the apparatus used in setting up the toll connection from the toll board to the subscriber at substation A'' has now been

restored to normal and is ready to be used in the establishment of another connection.

Call from substation A to private branch exchange X.

In the telephone system described, calls may also be extended to a private branch exchange over any one of a group of trunks by dialing the number assigned to the desired branch exchange. Trunks extending to the private branch exchanges are accessible in the banks of rotary connectors, such as the rotary connector RC shown in Fig. 8, which in turn are accessible to local third selectors and toll transmission selectors. This rotary connector is of the new type designed to operate in accordance with the general objects of this invention. In order to explain the operations performed thereby in establishing a connection to a private branch exchange, it may be assumed that the subscriber at substation A desires connection with the private branch exchange X, (drawings to be arranged as shown in Fig. 11).

To establish a connection with the private branch exchange X, the subscriber at substation A again removes his receiver and dials the directory number assigned to the branch exchange X. Responsive to the removal of the receiver and the dialing of the first three digits of the called number, the lineswitch LS operates to select and connect with an idle first selector repeater, such as the first selector repeater SR, the first selector repeater operates to select and connect with an idle local second selector, such as selector S^2, the selected second selector operates to select and connect with an idle local third selector, such as selector S^3, and the local third selector operates to select and connect with an idle rotary connector (the rotary connectors being accessible in a certain level in the banks thereof). It may be assumed that the connector selected is connector RC. When the trunk comprising conductors 854—856 is seized ground potential placed on the release conductor 855 causes two-step relay 801 to operate in its first step to open a point in the circuit of release magnet 810. A circuit is also closed from ground on the release conductor 855, off-normal springs 840 opened upon the first vertical step of the switch wipers, through the lower winding of switching relay 807 to battery. Relay 807, which now functions as a change-over relay, operates and prepares a locking circuit for itself at armature 834, and at armature 833 disconnects the rotary magnet 809 and connects the vertical magnet 808 in series with the series relay 804 to the lower talking conductor by way of armature 815 and the resting contact. The actuation of the other armatures of relay 807 has no effect at this time.

Responsive to the dialing of the next digit, vertical magnet 808 operates to raise the switch wipers 841—843 opposite the level of bank contacts corresponding to the digit dialed. Relay 804 energizes in series with magnet 808 and due to its slow-acting characteristic is maintained operated continuously during the transmission of the impulses. The actuation of armature 822 closes the circuit of slow-acting relay 805. Relay 805 operates and maintains the locking circuit of relay 807 at armature 826, this circuit including armature 834. The circuit over which this relay is initially energized is opened at vertical off-normal springs 840 upon the first vertical step of the switch wipers. At the end of this series of impulses relays 804 and 805 release, and the locking circuit of relay 807 is interrupted. Relay 807 deenergizes and, by releasing armature 833, reconnects the rotary magnet 809 in series with relay 804.

Responsive to the last series of impulses, rotary magnet 809 operates to rotate the switch wipers 841—844 into engagement with the set of bank contacts terminating the first trunk of the group of trunks extending to the private branch exchange X. During the transmission of this series of impulses relays 804 and 805 again operate, relay 805 preparing a circuit for the busy test relay 806 at armature 824 and the working contact.

The operation of the connector RC following the positioning of the switch wipers 841—844 upon the bank contacts terminating the first trunk of the group extending to the private branch exchange X depends on whether this trunk is busy or idle at this time. It will be assumed that the first trunk of the group is the one terminating in bank contacts 845—848, and that the last trunk of the group is the one terminating in bank contacts 845′—848′. If the first trunk is busy at this time, ground potential will be present on the bank contact 846, and bank contact 848 connected to bank contact 846 by way of the jumper 849. It may be mentioned that the test contacts similar to contacts 846 and 848 for all the other trunks of the group except the last trunk are connected together by means of jumpers such as jumper 849. As soon as wiper 842 engages test contact 846 a circuit is closed from ground potential on contact 846, wiper 842, armature 824 and the working contact, resting contact and armature 832, through the winding of test relay 806 to battery. Relay 806 operates and opens a point in the ring-back tone circuit at armature 827, prepares a locking circuit for itself at armature 828, prepares a circuit for the stepping relay 803 at armature 829, and prepares the busy-tone circuit at armature 827′. At the termination of this last train of impulses, relay 804 deenergizes and by releasing armature 822 prepares a holding circuit for the auxiliary series relay 805 and

closes a circuit for the stepping relay 803 at armature 823 which circuit may be traced from ground on test contact 848, wiper 844, armature 829 and the working contact, armature 825 and the working contact, armature 823 and the resting contact, interrupting springs 836, through the winding of the stepping relay 803 to battery. Relay 803 operates and closes a locking circuit for itself at armature 821 which extends from ground on the release conductor 855, rotary off-normal springs 839 closed upon the first rotary step of the switch wipers, working contact and armature 821, interrupting contacts 836, through the winding of relay 803 to battery. At armature 820 the energizing circuit for the rotary magnet 809 and the holding circuit for relay 805 are closed. These circuits may be traced from ground and release conductor 855, off-normal springs 839, armature 820 and the working contact, then by way of resting contact and armature 822, through the winding of relay 805 to battery, and also by way of the normally closed springs controlled by armature 833 through the winding of rotary magnet 809 to battery. Consequently relay 804 remains energized and magnet 809 operates rotating the switch wipers into engagement with the next set of bank contacts and also opening the circuit of stepping relay 803 at interrupting springs 836. Relay 803 deenergizes, opening its own holding circuit at armature 821, and opening the circuit for relay 805 and magnet 809 at armature 820. Magnet 809 releases and again closes interrupting springs 836.

If the trunk lines accessible in this next set of bank contacts is also busy, ground potential will again be present on both bank contacts corresponding to contacts 846 and 848. Again relay 803 will energize and close a circuit for magnet 809, which results in the movement of the switch wipers into engagement with another set of bank contacts. In this manner the switch wipers will be rotated step by step until an idle trunk is found or until the wipers are moved into engagement with the bank contacts 845′—848′ terminating the last trunk of the group of trunks extending to the desired private branch exchange.

Assuming that wipers 841—844 are rotated into engagement with the bank contacts terminating the last trunk of the group, all the other trunks having tested busy, regardless of whether this last trunk is busy or idle, no circuit will be again closed for stepping relay 803, since bank contact 808′ is not connected with bank contact 846′. Consequently the wipers will be arrested in this position. If this trunk is also busy, test relay 806 remains operated. Relay 805, which is maintained energized during the hunting movement of the switch by reason of the fact that a circuit is closed each time armature 820 operates, being no longer energized, releases. In releasing its armature 824, a locking circuit is closed for test relay 806 from ground on release conductor 855, armature 828 and the working contact, normally closed springs controlled by armature 824, resting contact and armature 832 through the winding of test relay 806 to battery. By the release of armature 826 a circuit is closed which may be traced from ground on release conductor 855, off-normal springs 839, armature 826 and the resting contact, off-normal springs 837 closed upon the first vertical step of the switch wipers, through the lower winding of two-step relay 801 to battery. Relay 801 operates in its second step, disconnecting the normal connections of ground and battery through relay 804 and magnet 809 from the upper and lower talking conductor at armatures 811 and 815, and opening the circuit of its initial energizing winding at armature 814. The operation of armature 813 has no function at this time. These operations cause certain operations in the first selector repeater described in connection with the establishment of a previous connection, resulting in the closure of a talking circuit from the calling substation to the connector RC. The engagement of armature 815 of relay 801 of the connector RC with its working contact, also closes the busy tone circuit from the busy machine which may be traced from the conductor 891, armature 819 and the resting contact, working contact and armature 827′, working contact and armature 815 to the lower talking conductor. The busy tone is then transmitted to the calling subscriber to apprise him of the busy condition of all the trunk lines to the desired branch exchange.

It may now be assumed that the last trunk of the group of trunks extending to the called private branch exchange is found idle when the rotary connector RC rotates its wipers 841—844 into engagement with the bank contacts 845′—848′ terminating this trunk. No ground potential will be present on the bank contact 846′, consequently test relay 806 will deenergize immediately upon the engagement of wiper 842 with bank contact 846′. In this case when relay 805 releases its armatures relay 801 energizes as described previously, and a circuit is closed which may be traced from ground on release conductor 855, armature 828 and the resting contact, through the upper winding of the switching relay 807, resting contact and armature 824, wiper 842, bank contact 846′, through the winding of switching relay 861 of the line switch LS, individual to the selected trunk, interrupting contacts 869 through the winding of the rotary magnet 863 to battery. Relays 807 and 861 operate in this circuit, but due to the comparatively high resistance of relay 861 the current in this circuit is in-

sufficient to cause the operation of magnet 863. Due to the usual mechanical interlocking arrangement between relays 861 and 862, relay 861 is permitted to operate just sufficiently to disconnect the normal connections of ground and battery through relay 862 from the line conductors. Relay 807, in operating, performs the following circuit changes: Ground potential is supplied to bank contact 846′ at armature 831 and the working contact and wiper 842 to mark this trunk line busy. At armature 834, a holding circuit is closed for relay 807 which may be traced from ground on the release conductor 855, off-normal springs 839, armature 834 and the working contact, through the lower winding of relay 807 to battery. At armatures 830 and 835 the signaling circuit is closed which extends from ground by way of the resting contact and armature 816, armature 830 and the working contact, wiper 841, bank contact 845′, trunk conductor 881, contacts 884, through the winding of drop signal magnet 880, contact 883, trunk conductor 882, bank contact 847′, wiper 843, working contact and armature 835, armature 817 and the resting contact, through the lower winding of the ring cut-off relay 802, to conductor 890 connected to the common ringing conductor 350. Ringing current flowing in this circuit causes the actuation of the ring-down drop 886. The actuation of this drop signal apprises the operator at the private branch exchange of the incoming calls, whereupon she will answer the call by inserting the answering plug of an idle cord into the pack J^8. Inserting the answering plug of a cord in the jack J^8 opens the signaling circuit by separating the contacts 883 and 884 and also places a direct current bridge across the line conductors 881 and 882. (This bridge is present in the operator's cord, not shown.) This direct current bridge placed across the line conductor causes the energization of ring cut-off relay 802 in the usual manner. Relay 802 in operating closes a locking circuit for itself at armature 818, and finally completes a talking circuit at armatures 816 and 817 and their working contacts. The other operations performed by the operator at the private branch exchange necessary to extend the call to the called subscriber are well known and do not pertain to this invention and are therefore omitted from this description.

After the connection between the calling and called subscriber is completed, the two subscribers may engage in conversation at the termination of which both subscribers will replace their receivers. The operations performed by the first selector repeater, the second selector, and the third selector in releasing have been previously described, and since the release operations of the connector RC are identical to the release operations of the connector C, no further description of these operations will be given.

In any telephone system, provisions are usually made for giving service to party line subscribers. In the present system, lines which serve a plurality of subscribers terminate at the exchange in individual lineswitches which are identical to the lineswitches in which individual subscribers' lines terminate, and are accessible in the banks of a group of frequency selecting connectors, such as the connector FSC, Fig. 7. The frequency selecting connector FSC is of a new type designed to operate according to the main object of this invention. The operation performed by a frequency selecting connector in establishing a connection to a party line subscriber will be described presently.

In a previous description, the operation of the first selector repeater SR, Fig. 1, was given. This first selector repeater is designated for use for establishing connections from substations, the subscribers' meters of which are operated over a fourth conductor, extending from the first selector repeater through the individual lineswitch and then connected to the subscribers' meter. Another common method of controlling the operation of a subscriber's meter is by the momentary application of booster battery to the release conductor, the subscriber's meter in this case being connected directly to the release conductor or private normal conductor. Accordingly the first selector repeater SR′, Fig. 9, the major circuits and operation of which are similar to the first selector repeater SR shown in Fig. 1, is adapted for use for the establishment of connections from subscribers' station whose meters are to be operated by the momentary application of booster battery to the release conductor.

Call from substation B^6 to substation A^6

In order to describe the operations performed by a first selector repeater of the alternative design, such as selector repeater SR′, Fig. 9, and at the same time describe the operations performed by a frequency selecting connector, such as the connector FSC shown in Fig. 7, it will be assumed that the subscriber at substation B^6 wishes to establish a connection with a subscriber at substation A^6, (drawings to be arranged as shown in Fig. 12).

To establish this connection, the subscriber at substation B^6 removes his receiver and dials the directory number of the desired subscriber. Responsive to the removal of the receiver at the substation A^6, the lineswitch LS^9 individual to the line comprising conductors 901 and 903, operates to select and connect with an idle first selector repeater accessible in the banks thereof. It

may be assumed that the first selector repeater SR′ is the one selected. When the connection is extended thereto, a circuit is closed for line relay 926, the circuit including the two line conductors 901 and 903, and trunk conductors 921 and 924 in series. Line relay 926 operates and prepares a circuit for the back bridge battery feed relay 930 at armature 943, and closes a circuit for the release relay 927 at armature 942. Release relay 927 operates and performs the following circuit changes: At armature 944 ground potential is placed on the release conductor 922, thereby marking the trunk to this first selector repeater SR′ busy and also completing the holding circuit for the line relay 907 of the lineswitch LS^9. This operation of course takes place before the slow acting line relay 906 has had time to release its armatures. At armature 947 a circuit for the series relay 929 is prepared. At armatures 945 and 946 an initial energizing circuit for the holding relay 928 is closed which may be traced from ground by way of armature 955′ and the resting contact, armature 950 and the resting contact, working contact and armature 945, normally closed springs controlled by armature 962, armature 960 and the resting contacts, armature 946 and the working contact, resistance 936, lower winding of relay 928, armature 958 and the resting contact, resting contact and armature 941, normally closed springs controlled by armature 964, through the winding of vertical magnet 933 to battery. Relay 928 operates and closes a new circuit for its lower winding at armatures 948 and 952 which may be traced from ground by way of the normally closed springs controlled by armature 961, armature 937 and the resting contact, armature 948 and the working contact, armature 946 and the working contact, resistance 936, lower winding of relay 928, working contact and armature 952, resting contacts and armature 941, normally closed springs controlled by armature 964 through the winding of vertical magnet 933 to battery. At armature 950 a circuit is closed for the supervisory relay 981. The utility of this relay will be described in later paragraphs. At armature 949 a holding circuit for the upper winding of relay 928 is prepared.

The first selector repeater SR′ is now in condition to receive the first series of impulses to be dialed by the calling subscriber, all the above operations having taken place responsive to the removal of the receiver at the calling substation. Furthermore, as soon as the wipers of the lineswitch LS^9 are rotated into engagement with the bank contacts terminating in the trunk extending to the first selector repeater SR′, a dial tone circuit is closed extending from the conductor 993, connected to the dial tone machine, normally closed vertical off-normal springs 997 to the lower talking conductor from where the dial tone is transmitted to the calling subscriber. Hearing this tone indicates to the calling subscriber that he may commence dialing the number of the desired subscriber.

Responsive to the dialing of the first digit of the called number, relay 928 and resistance 936 are short circuited a like number of times by the engagement of armature 943 with its resting contact each time relay 926 deenergizes. The short circuiting of resistance 936 and the lower winding of relay 928 causes vertical magnet 933 to operate and step the switch wipers opposite the level of bank contacts corresponding to the digit dialled. Furthermore, each time that relay 926 deenergizes a circuit is established for series relay 929 which may be traced from ground through the winding of relay 929, working contact and armature 947, through the winding of release relay 927 to battery, and also by way of armature 942 and the resting contact, resistance 994 to battery. Each time that relay 926 again reenergizes during the transmission of impulses relay 929 of course is again short circuited, and for this reason assumes a slow-acting characteristic and therefore operates and remains operated during the transmission of the series of impulses. In operating, relay 929 closes a holding circuit for the upper winding of relay 928, thereby positively assuring the continuous operation of this relay during the time that it is short circuited. At armature 955 the initial circuit for the stepping relay 931 is closed which may be traced from ground on release conductor 922, working contact and armature 955, armature 963 and the resting contact, off-normal springs 966 closed upon the first vertical step of the switch wipers, through the winding of the stepping relay 931 to battery. Relay 931 operates and prepares a temporary locking circuit for itself at armature 960 which may be traced from ground by way of the upper winding of relay 925, working contact and armature 945, normally closed springs controlled by armature 962, armature 960 and the working contact, interrupting springs 965, off-normal springs 966, through the winding of relay 931 to battery. At armature 959 a circuit is prepared for the rotary magnet 934. By the actuation of armature 955 of relay 929, a circuit is also closed for relay 929′. Relay 929′ operates and prepares a locking circuit for itself at armature 956, and by actuating armature 957 includes this armature and the springs controlled by armature 954 in the circuit for supplying ground potential to release conductor 922. The purpose of this operation will become obvious in later descriptions.

At the termination of the transmission of

this series of impulses, series relay 929 deenergizes, now being continuously short circuited at armature 942 until the transmission of the next series of impulses.

Armature 955′, in releasing, opens the temporary holding circuit of relay 928, and armature 955, in releasing, causes the closure of the circuit of rotary magnet 934 traceable from ground on the release conductor 922, normally closed springs controlled by armature 955, armature 959 and the working contact, through the winding of rotary magnet 934 to battery. Magnet 934 operates, rotates the switch wipers into engagement with the first set of bank contacts in the selected level, and opens the circuit of relay 931, at interrupting springs 965. Relay 931 deenergizes and opens the circuit of the rotary magnet 934. Magnet 934 deenergizes and again closes interrupting springs 965. If the trunk terminating this set of bank contacts is busy, ground potential will be present on the bank contacts engaged by wiper 972, thus closing another circuit for stepping relay 931. Relay 931 again operates to close the circuit of rotary magnet 934. Magnet 934 again operates and rotates the switch wipers in engagement with another set of bank contacts. In this manner, described more in detail in connection with the operation of the first selector repeater SR, the switch wipers 971—973 are moved into engagement with the first set of bank contacts terminating an idle trunk line, after which a switching relay 932 operates to extend the connection to the second selector terminating the trunk line selected and performing other operations identical to those performed by switching relay 132 of the first selector repeater SR described in a previous connection. In addition a locking circuit for relay 929′ is closed at armature 962′.

It may be assumed that the second selector S^2 accessible at bank contacts 974′—976′ is the one selected (it being further assumed in this case that the trunk line comprising conductors 174—176 terminates in bank contacts 974′—976′, respectively).

Responsive to the dialing of the next digit second selector S^2 operates and selects a trunk extending to an idle third selector accessible in the level of bank contacts corresponding to the digit dialed, and extends the connection thereto. It may be assumed that the third selector S^2 is the selector selected. Selector S^3 therefore operates responsive to the third digit dialed, raising its wipers opposite the level of bank contacts terminating the proper group of frequency selecting connectors, and then rotating them to hunt a trunk terminating an idle frequency selecting connector, extending the connection thereto. It may be assumed that the connector taken for use is the frequency selecting connector FSC. When this connector is seized, ground potential is supplied to the release conductor 755 which closes a circuit for the upper winding of two-step relay 701 over an obvious circuit and also closes a circuit which may be traced from ground on this conductor, vertical off-normal springs 740 opened upon the first vertical step of the switch wipers, through the winding of the combination change-over and reversing relay 704 to battery. Two-step relay 701 operates in its first stage, operating armature 713 only which opens a point in the circuit of the release magnets 709 and 744. Relay 704 operates over the above traced circuit, its useful operation at this time being the connection of vertical magnet 707 by way of armature 728 and the working contact, normally closed contacts controlled by armature 736, resting contact and armature 714, to the lower talking conductor 756.

Responsive to the next digit dialed by the calling subscriber, vertical magnet 707 operates to position the switch wipers opposite the level of bank contacts corresponding to the digit dialed. Series relay 705, being connected in multiple with the magnet 707 and being slow-acting, operates during the transmission of impulses to the vertical magnet 707. The useful function performed by relay 705 at this time is the closure of the locking circuit for relay 704 which may be traced from ground by way of conductor 755, armature 730 and the working contact, working contact and armature 725, through the winding of relay 704 to battery. Relay 704 is maintained operated during the transmission of vertical impulses over this circuit, its initial circuit being opened by the separation of off-normal contacts 740 upon the first vertical step of the switch wipers.

At the end of this series of impulses, series relay 705 deenergizes and opens the circuit of relay 704 at armature 730. Relay 704 deenergizes and by the release of armature 728, magnet 707 is disconnected and rotary magnet 708 is substituted therefor.

Responsive to the next series of impulses dialed by the calling subscriber, rotary magnet 708 is operated to position the switch wipers 741—743 upon the set of bank contacts corresponding to the digit dialed, this being the bank contacts 744—746 terminating the line to substation A^6. Relay 705 again operates this time in multiple with the rotary magnet 708, its useful function now being the preparation of the circuit for test relay 702 at armature 729 and the working contact. The further operation of the connector FSC now depends upon whether the line of substation A^6 is busy or idle at this time. Assuming first that the line to substation A^6 is busy at the time wipers 741—743 engage the bank contacts 744—746, ground potential will be present on the bank contact 745, thereby closing a circuit which may

be traced from ground on this bank contact, wiper 742, armature 729 and the working contact, resting contact and armature 735, through the winding of test relay 702 to battery. Test relay 702 operates and performs the following circuit changes: At armature 715, a point in the circuit of the ring-back tone circuit is opened and a point in the busy tone circuit is closed. A locking circuit is prepared for this relay at armature 716 and the working contact. A point in the initial energizing circuit of relay 706 is opened at armature 717. At armature 719 a point in the circuit of the lower winding of two-step relay 701 is closed. Shortly after the termination of the impulses for the rotary operation of the connector, relay 705 again deenergizes and closes a locking circuit for test relay 702, this circuit being traceable from ground on the release conductor 755, working contact and armature 716, normally closed springs controlled by armature 729, resting contact and armature 735, through the winding of relay 702 to battery. Armature 730, in releasing, closes a circuit traceable from ground on release conductor 755, armature 730 and the resting contact, armature 719 and the working contact, through the lower winding of two-step relay 701 to battery. Relay 701 energizes in its second stage and performs circuit changes identical to those performed by similar relays in the other two connectors previously described in this specification, the final result being the transmission of the busy tone to the calling subscriber to apprise him of the busy condition of the called line.

It may now be assumed that the line extending to substation A^6 is idle when the switch wipers 741—743 are rotated into engagement with contacts 744—746 terminating this line. In this case relay 702 is not operated. Now when relay 705 releases its armatures, shortly after the termination of the last set of impulses dialed by the calling subscriber, a circuit is closed which may be traced from ground on release conductor 755, resting contact and armature 717, through the upper winding of relay 706, resting contact and armature 729, wiper 742, bank contact 745, through the winding of the switching relay 761 of the lineswitch LS^7 interrupting springs 769, through the winding of rotary magnet 763 to battery. Relays 706 and 761 operate in this circuit, but due to the relatively high resistance of relay 761, the current flow in this circuit is insufficient to cause the operation of magnet 763. Due to the usual interlocking mechanism between relay 761 and relay 762 of the lineswitch LS^7, the armatures of relay 761 are permitted to operate just sufficient to disconnect the line conductors 782 and 781 from their normal ground and battery connection. In operating, relay 706 performs the following circuit changes: Ground potential is connected to the test contact 745, by way of armature 733 and the working contact, wiper 742, thereby marking the line to substation A^6 busy. At armature 734, a locking circuit is closed for relay 706 traceable from ground on the release conductor 755, armature 734 and the working contact, through the lower winding of relay 706 to battery. A point in the circuit of the busy test relay 702 is opened at armature 735. At armature 732 and 737, normally open points in the talking and signalling circuit are closed. By the actuation of armature 736, rotary magnet 708 is disconnected from the lower talking conductor 756 and the frequency selecting magnet 773 is substituted therefor.

The last digit in the called number is the digit which determines the frequency of the signalling current to be used, and the line which it is to be applied, and therefore determines which of the subscribers connected to the called line is to be signalled. The final digit to be dialed in this case is the digit 6, the substations on the line having been numbered by exponents corresponding to the digit to be dialed in order to signal each substation. Responsive to the dialing of this digit magnet 773 operates by reason of the short circuiting of resistance 936 and lower winding of relay 928 in the first selector repeater SR′, and rotates the frequency selecting wipers 771—772 into engagement with the sixth set of contacts in their respective banks. The last six contacts in the banks of wiper 772 are multiply connected to ground. When wiper 772 is positioned on the sixth contact in its bank an obvious circuit is closed for relay 704. At this stage of the operation of the connector FSC relay 704 functions to predetermine to which side of the selected line the selected ringing current is to be applied.

Shortly after the termination of this series of impulses, relay 705 again deenergizes, this time functioning to close the circuit for the lower winding of relay 701 which may be traced from ground on release conductor 755, armature 730 and the resting contact, off-normal springs 739 closed as soon as the frequency selecting wipers 771 and 772 are moved off-normal, through the lower winding of the two-step relay 701 to battery. Relay 701 operates in its second step as previously described, the final result being the preparation of the circuit in the first selector repeater SR′ for talking, and the transmission of the ring back tone to the calling subscriber, the ring back tone extending from conductor 790 connected to one of the generator leads, resting contact and armature 721, resting contact and armature 715, working contact and armature 714 to conductor 756, from where it is transmitted to the calling subscriber. A further result of this last deenergization of relay 705 is the closure of the

ringing circuit, which may be traced from the conductor 796, to which direct battery and battery superimposed generator of the proper frequency is alternately connected, contact 788, wiper 771, through the lower winding of the cut-off relay 703, armature 731 and the resting contact, armature 726 and the working contact and armature 720, armature 732 and the working contact, wiper 741, bank contact 744, line conductor 781, through the ringer at substation A^6 to ground. This signaling current also passes through the ringers at substations A^7—A^{10}, but these ringers are tuned to respond to signaling current of a frequency other than the frequency of a current supplied to conductor 796. Signaling current from the conductor 796 operates the ringer at substation A^6 to signal the subscriber, which will continue to operate until the subscriber at substation A^6 answers the call, or until the call is abandoned by the calling subscriber .

When the subscriber at substation A^6 removes his receiver to answer the call, a direct current bridge is placed across the line conductors 781—782 thereby closing a direct current circuit for the lower winding of ring cut-off relay 703. This circuit extends from battery supplied to common ring conductor 796 through the lower winding of relay 703 to conductor 781 over the path traced above, the bridge at substation A^6, line conductor 782, bank contact 746, wiper 743, working contact and armature 737, armature 724 and the resting contact, working contact and armature 727 to ground. Ring cut-off relay 703 operates, disconnects the ring back tone circuit at armature 721, closes a locking circuit for itself at armature 723, and at armature 720 and 724 interrupts the ringing circuit and finally completes a talking connection between the calling and called subscribers. In so doing, the circuit is closed for the battery feed relay 930, this circuit including the bridge across the line conductors at the called substation A^6, the two talking conductors extending through the operated switches in series, conductors 921′ and 924′, armatures 937 and 941 and their resting contacts, armatures 948 and 952 and their resting contacts, through the upper winding to ground and through the lower winding of relay 930 to battery by way of armature 943 and the working contact, and armature 951 and the resting contact. Relay 930 operates and disconnects the lower terminal of the lower winding of relay 928 from the lower talking conductor at armature 958, opens a circuit of meter control relay 929′ at armature 953, and connects booster battery to the release conductor 922 at armatures 954 and the working contact. Relay 929′ is slow acting and therefore does not deenergize until a short time after its circuit is opened. Thus booster battery is momentarily supplied to release conductor 922 by way of armature 954 and the working contact, armature 957 and the working contact, from where the circuit extends by way of release conductor 922, wiper 918, armature 910 and the working contact, through the winding of the marginally adjusted meter magnet 916 to exchange battery, this circuit being complete during the time that both relays 930 and 929′ are operated. Magnet 916 operates the meter M′ which registers the call. Shortly after a circuit of relay 929′ is opened, this relay restores its armatures and again connects direct ground to release conductor 922, which causes the release of the marginally adjusted magnet 916.

The calling and called subscribers may now engage in conversation. After the termination of a conversation, both subscribers replace their receivers initiating the release of the entire connection. The operations performed in releasing the first selector repeater SR′ are identical to those described in connection with the description of the release of the first selector repeater SR previously given. The release operations for the connector FSC are also the same as those performed by the connector C the description of which is given in previous paragraphs, except that in this case the engagement of armature 713 with its resting contact closes a circuit for the release magnet 744 in addition to closing the circuit for the release magnet 709. Release magnet 709 operates to restore the switch wipers 741—743 to normal, and release magnet 744 operates to restore the frequency selecting wipers 771 and 772 to normal.

Call from substation B^6 to substation B^2

In any telephone system having party lines, provisions are made for making it possible for one subscriber to signal another subscriber on the same line, and this preferably without apprising the other subscribers on that line. In this system described, reverting call switches, such as the reverting call switch RV shown in Fig. 10, are provided for this purpose. The reverting call switch RV is of a new type in so far as it is designed to operate in accordance with the general object of this invention. The operation of this reverting call switch and also the operation of a first selector repeater when connection is made with a reverting call switch in so far as these operations differ from the operations performed in extending a call to a subscriber not on the same line with the calling subscriber will be described. For this purpose it will be assumed that the subscriber at substation B^6 wishes to have conversation with the subscriber at substation B^2. (In this description, Figs. 9 and 10 only need be considered, Fig. 10 being placed to the right of Fig. 9.)

In order for the subscriber at substation B^2 to be called to his telephone and for the subscriber at substation B^6 to be suitably informed when the subscriber at substation B^2 removes his receiver, the subscriber at substation B^6 must remove his receiver and dial a special number which will result in a connection to a reverting call switch and then to a special ring-back set which will ring the bells of the two subscribers alternately after the subscriber at substation B^6 again replaces the receiver, the ringing of the bells at the substation B^6 ceasing as soon as the subscriber at substation B^2 removes the receiver. The subscriber at substation B^6 may then also remove his receiver and converse with the subscriber at substation B^2.

The operations performed are as follows: Responsive to the removal of the receiver at substation B^6, the lineswitch LS operates to select and connect with an idle first selector repeater, which may be the first selector repeater SR'. Responsive to the first digit dialed by the calling subscriber the selector repeater SR' operates to position its wipers opposite the level of bank contacts in which access is had to the reverting call switches, and then performs the automatic hunting movement, selects an idle one of these reverting call switches, and extends the connection thereto. All these operations take place in a manner identical to the way in which an idle local second selector was selected and the connection extended thereto. It may be assumed that the reverting call switch RV is the one selected. When the reverting call switch is seized, ground potential is applied to the release conductor 95, thereby closing the circuit for the combination change-over relay and reversing relay 11 from ground by way of release conductor 95, off-normal springs 57, through the winding of relay 11 to battery. Relay 11 operates and prepares a holding circuit for itself at armature 39, and connects the vertical magnet 17 to the lower heavy control conductor by way of the working contact and armature 40, resting contact and armature 32, resting contact and armature 23. A circuit is also closed from ground on release conductor 95, armature 42 and the resting contact, through the winding of release relay 7 to battery. Relay 7 operates, opens a point in the release magnet circuit at armature 27, and prepares circuits to be described later.

Responsive to the second digit dialed by the calling subscriber, vertical magnet 17 operates to position the switch wipers 61—64 opposite the level of bank contacts corresponding to the digits dialed. Slow acting relay 13 operates in parallel with magnet 17, and by reason of its slow acting characteristic maintains its armatures actuated continuously during the transmission of impulses to magnet 17. Relay 13, in operating at this time closes the holding circuit for relay 11 at armature 46, the initial energizing circuit for relay 11 being opened by the separation of off-normal springs 57 upon the first vertical step of the switch wipers.

At the end of this series of impulses, relay 13 deenergizes, and in releasing its armatures opens the holding circuit for relay 11 at armature 46. Relay 11 thereupon deenergizes and at armature 40 disconnects vertical magnet 17 from the lower heavy control conductor and substitutes rotary magnet 18 therefor by permitting armature 40 to engage its resting contact.

Responsive to the third digit dialed by the calling subscriber, rotary magnet 18 operates and rotates the switch wipers 61—64 into engagement with the set of bank contacts corresponding to the digit dialed, this being, in this case, bank contacts 81—84. Again relay 13 operates, this time in parallel with magnet 18 and maintains its armatures actuated during the time of transmission of impulses to magnet 18. In operating this time, relay 13 maintains the energizing circuit for relay 12 open at armature 48 and also maintains points in the circuits of relays 11 and 15 open at armatures 46 and 47 during the rotary motion of the switch, thereby preventing these latter two relays from operating uselessly while wipers 61 and 62 pass over contacts.

At the termination of the impulses transmitted to magnet 18, relay 13 deenergizes and prepares the circuits for relays 11 and 15 at armatures 46 and 47, respectively, and closes the energizing circuit for relay 12 which may be traced from ground through the lower winding of relay 12, armature 45 and the resting contact, armature 48 and the resting contact, to conductor 90 to which battery superimposed ringing potential or direct battery is alternately connected as will be described later. Relay 12 operates and closes a locking circuit for its upper winding which may be traced from ground by way of working contact and armature 26, armature 44 and the working contact, through the upper winding of relay 12 to battery. At armature 45 its initial energizing circuit is opened. At armature 43 an auxiliary circuit is prepared for release relay 7. By the disengagement of armature 42 and its resting contact, the initial circuit for release relay 7 is opened, and by the engagement of this armature with its working contact, a circuit is closed for relay 14 which may be traced from ground on release conductor 95, armature 42 and the working contact, normally closed springs controlled by armature 29, through the winding of relay 14 to battery, ground potential being supplied to conductor 95 through the upper winding of relay 925. The upper winding of relay 925 is of sufficiently low resistance so that this relay is not operated when connected in series with switching re-

lay 932, and the switching relays of succeeding switches, which are multiply connected to the release conductor and energized through relay 925 in the case of a connection between substations not on the same line. The resistance of relay 14 of the reverting call switch RV, however, is also comparatively low and permits sufficient current flow in the above traced circuit including the upper winding of relay 925 and the winding of relay 14 in series to cause the operation of both relay 14 and relay 925. Relay 14, in operating, prepares the circuit for the lower winding of switching relay 8 at armature 49; and closes an auxiliary circuit for relay 7 at armature 50, this taking place before relay 7 has had time to release its armatures (its initial energizing circuit having previously been opened at armature 42). The lower winding of relay 8 is not appreciably energized at this time since it is shunted by ground supplied to the release conductor through the upper winding of relay 925. When relay 925 operates, however, it performs the following circuit changes: The talking conductors 921 and 924 are connected directly to conductors 921′ and 924′, disconnecting the condensers and the windings of relay 926 from in bridge of these conductors by the separation of the normally closed springs controlled by armatures 927 and 941. A point in the circuit of release magnet 925 is opened at armature 938. At armature 939 a locking circuit for the lower winding of relay 935 is prepared and by the closure of springs 940 a connection is made over which ground is later to be furnished to release conductor 922 from release conductor 95. Relay 926 now being disconnected, deenergizes and releases its armatures. The engagement of armature 942 with its resting contact connects battery through the resistance 994 to the lower terminal of release relay 927 thereby shunting this relay and causing its deenergization. By the release of armature 945, ground supplied to the release conductor 95 through the upper winding of relay 925 is disconnected. This operation removes the short circuit on the lower winding of relay 8 thereby permitting this relay to energize over the circuit from ground by way of armature 24 and the resting contact, through the lower winding of relay 8, working contact and armature 49, through the winding of relay 14 to battery. At this instance ground is supplied to release conductor 95 for holding relays 925 and 932 in the selector repeater SR′, and relay 917 in the lineswitch LS^9 operated by way of armature 24 and the resting contact, through the lower winding of relay 8, working contact and armature 49, normally closed springs controlled by armature 29, and working contact and armature 42. As soon as relay 8 operates, however, direct ground is supplied to release conductor 95 by way of working contact and armature 25, armature 29 and the working contact, and working contact and armature 42. In operating, relay 8 also closes a locking circuit for itself to release conductor 95 at armature 30, and at armatures 28 and 32 bridges the upper and lower windings of the battery feed relay 6 across the conductors 94 and 96.

Since the foregoing operations following the dialing of the last digit all take place in a comparatively short time, the subscriber at substation B^6 has not had time to replace his receiver, and a direct current bridge is still maintained across the line conductors 901 and 903. Therefore as soon as relay 6 is bridged across the conductors 94 and 96, it energizes over the calling loop including line conductors 901 and 903 in series and closes an auxiliary circuit for release relay 7 at armature 24 and the working contact. The disengagement of armature 24 with its resting contact opens the circuit including the lower winding of relay 8 and relay 14 in series, causing the deenergization of relay 14. In deenergizing, relay 14 opens a point in an auxiliary circuit of relay 7 at armature 50, but relay 7 is now maintained energized over the auxiliary circuit which includes armature 24 and the working contact. It may be mentioned that during the short time existing after relay 8 operates and before relay 6 operates, a circuit for relay 5 is closed but relay 5 has a slow-to-pull-up characteristic, as indicated by the solid black portion on the upper end of the core, and does not operate at this time.

After finishing the dialing of the three digits, the subscriber at substation B^6 replaces his receiver. Replacing the receiver at the substation B^6 opens the bridge across the line conductors 901 and 903, thereby interrupting the circuit of the battery feed relay 6. Relay 6, in deenergizing, closes the circuit of relay 5 extending from ground by way of armature 24 and the resting contact, armature 27 and the working contact, working contact and armature 31, armature 36 and the resting contact, through the winding of relay 5 to battery. Relay 5 operates and completes another circuit for switching release relay 7 at armature 22 and the resting circuit traceable from ground by way of the working contact and armature 43, resting contact and armature 34, armature 22 and the working contact, through the winding of relay 7 to battery. At armatures 21 and 23, the circuits are prepared for signaling the two subscribers.

At this point it may be well to describe generally the method to be used to selectively signal the calling and called subscribers. The substations B′—B^5 may be signaled by the application of ringing potential from the generators G^1—G^5, respectively, to the line conductor 903. Likewise, the substations B^6—B^{10} may be signaled by the application of ringing potential from the generator G^1—G^5,

respectively, to line conductor 901. Therefore, to operate the ringer at substation B^2 and also substation B^6, ringing potential from generator G^2 must be applied to line conductor 903, and from generator G^1 to line conductor 901. To cause the reverting call switch RB to perform this operation, the switch wipers 61—64 were rotated into engagement with the set of bank contacts 81—84. Both contacts 81 and 82 are connected to the common conductor 71 to which ground is periodically applied by the constantly rotating arm 85 of the interrupter I. Therefore at each application of ground potential to the common conductor 71, a circuit is closed for relay 11 by way of bank contact 81, wiper 61, resting contact and armature 46, through the winding of relay 11 to battery, and a circuit is also closed for relay 15 by way of bank contact 82, wiper 62, resting contact and armature 47, through the winding of relay 15 to battery. The wiper 86 of the interrupter I is fastened on the same shaft as wiper 85, and closes a circuit for the interrupting relay 74, for a certain length of time when no ground potential is supplied to conductor 71, and again for a certain time during the time when ground is supplied to conductor 71. Thus, relay 74 connects the battery superimposed generators to the common ringing conductors 72, 73, etc., for a certain time during the time when relays 11 and 15 are operated, and again for a certain time during the time when relays 15 and 11 are deactuated. Therefore, when relays 11 and 15 are deactuated and relay 74 is operated, a circuit may be traced from battery superimposed generator G^1, working contact and armature 91, common ringing conductor 72, bank contact 84, wiper 64, resting contact and armature 51, conductor 90, resting contact and armature 35, through the cut-off control relay 10, resting contact and armature 38, working contact and armature 21, conductor 94, bank contact 974′, wiper 971, armature 961 and the working contact, armature 937 and the working contact, conductor 921, wiper 917, working contact and armature 909, line conductor 901, through the ringer at substation B^6 to ground. During the time interval when interrupting relay 74 is operated and relays 11 and 15 are also operated, a circuit may be traced from battery superimposed generator G^2 working contact and armature 92, common ringing conductor 73, bank contact 83, wiper 63, working contact and armature 51, conductor 90, resting contact and armature 35 through the cut-off control relay 10, working contact and armature 41, working contact and armature 23, conductor 96, working contact 976′, wiper 973, armature 964 and the working contact, armature 941 and the working contact, conductor 924, wiper 920, working contact and armature 912, line conductor 903, through the ringer at substation B^2 to ground. It is understood of course that ringing current also flows through the other ringers to ground at other substations, but that the other ringers in each case are tuned so as not to respond to the particular frequency of ringing current supplied to the line conductors at this time. The bells of the substation B^2 and substation B^6 will now ring alternately until the subscriber at substation B^2 removes his receiver to answer the call (or until the subscriber at B^6 momentarily removes his receiver to abandon the call as will be mentioned later).

When the subscriber at substation B^2 removes his receiver, a direct current bridge is placed across the line conductors 901 and 903 which closes a direct current circuit for the cut-off control relay 10, this circuit including two line conductors and the bridge at the substation B^2 in series traceable from direct battery or battery superimposed generator as applied to either conductors 72 or 73 over either one or the other of the ringing circuits traced, depending on the particular time when the receiver at the substation B^2 is removed, back over the other ringing circuit to ground by way of the armature 38 and the working contact or armature 41 and the resting contact as the case may be. Relay 10 operates immediately and closes a circuit for the ring cut-off relay 9 at armature 37 from ground by way of the working contact and armature 43, working contact and armature 37, through the winding of relay 9 to battery. Relay 9 operates and closes a locking circuit for itself to release conductor 75 at armature 33 and the working contact, opens the circuit of release relay 7 at armature 34, interrupts the ringing circuit at armature 35, and at armature 36 closes the circuit for release magnet 19. This last circuit may be traced from ground by way of armature 24 and the resting contact, armature 27 and the working contact, working contact and armature 31, armature 36 and the working contact, off-normal springs 55 closed upon the first vertical step of the switch wipers, through the winding of the release magnet 19 to battery. Release magnet 19 operates and restores the switch wipers 51—54 to normal. The disengagement of armature 36 with its resting contact, also opens the circuit of slow acting relay 5. Shortly after its circuit is opened, relay 5 deenergizes and again bridges the battery feed relay 6 across conductors 94 and 96 at armatures 21 and 23 and the resting contacts. Relay 6 operates and again closes the circuit for relay 7 at armature 24 and the working contact, this taking place before relay 7 by reason of its slow acting characteristic has had time to release its armatures, the circuit over which it was being energized having been opened by the disengagement of armature 34 and its resting contact.

The interruption of the ringing at the sub-

station B^6 notifies the subscriber thereat that the subscriber at substation B^2 has removed his receiver, whereupon the subscriber at substation B^6 also removes his receiver and commences conversation. The two subscribers may then engage in conversation, talking battery being furnished through the winding of battery feed relay 6.

At the termination of the conversation both subscribers will replace their receiver thereby opening the bridge across the line conductors. This interrupts the circuit of relay 6 which thereupon deenergizes and opens the circuit of relay 7. Relay 7 deenergizes and opens a holding circuit for relay 12 at armature 26, and removes ground potential from the release conductor 95 at armature 25. The removal of ground from the release conductor 95 opens the holding circuits for relays 8 and 9. Relays 8 and 9 thereupon deenergize and restore their armatures to normal. The removal of ground from release conductor 95 also causes relay 11 to deenergize and restore its armatures to normal, this relay having operated due to the off-normal springs 57 closing when the switch wipers were restored to normal by the operation of release magnet 19.

The removal of ground from release conductor 95 also opens the holding circuit for relays 932 and 925 in the first selector repeater SR', and for switching relay 907 of the line-switch LS^9. Relay 932 deenergizes and restores its armatures to normal. By the engagement of armature 938 and its resting contact, a circuit is closed for release magnet 935. This magnet then operates and restores the switch wipers 971—973 to normal. All the apparatus has now been restored to normal and is ready to be taken into use in another connection.

Had the subscriber at substation B^2 not answered the call, the subscriber at substation B^6 would have stopped the signaling and initiated the release of the operated switches by momentarily removing his receiver. Obviously removing the receiver at substation B^6 would cause the same operations in the reverting call switch RV as those initiated by the removal of the receiver at the substation B^2, and the replacement of the receiver again would initiate the release operations described immediately above.

Toll connections to a party line or P. A. X.

In the above descriptions of the establishment of various connections, the establishment of a toll connection from the main toll board to the substation A'' through the toll transmission selector TTS, Fig. 6, and the regular connector C, Fig. 3, only was considered. Obviously toll connections may also be established to party line substations such as the substation A^6 by way of a frequency selecting connector such as connector FSC, Fig. 7, and also to private branch exchanges by way of a rotary connector such as rotary connector RC, Fig. 8. The operation of these connectors when used in the establishment of toll connections are practically the same as when used in the establishment of local connections. In each case however, as described in detail in connection with the establishment of a toll connection to subscriber at substation A'', the ring cut-off relay such as relay 802 in connector RC, and relay 703 in connector FSC, is operated immediately upon seizure of the switch, thereby preventing the application of signaling current to the connected line until the ringing relay is again unlocked by the reapplication of ground potential to the ring control conductor such as conductor 857 of connector RC, and conductor 757 of connector FSC at the will of the operator.

In the establishment of a toll connection to a private branch exchange, means are ordinarily provided for recalling the operator at the private branch exchange after she has answered the first signal by inserting the answering plug of an idle cord in the jack of a trunk over which the call has been extended. In the present system, the operator at a private branch exchange is signaled by the connection of the regular interrupted signaling current supply at the connector in the establishment of a toll connection the same as in the establishment of a local connection, this being disconnected from the lines when the call is answered. Means have been provided in the toll transmission selector, however, whereby the toll operator may re-signal the operator at the private branch exchange any time she wishes to do so.

A description of this feature in the toll transmission selector will now be given. For this purpose it may be assumed that the toll operator at the main toll board has established a connection by means of the cord circuit CC over the trunk line comprising conductors 501—502, through the selector TS, the toll transmission selector TTS, and the rotary connector RC over the trunk line comprising conductors 881—882, to the private branch exchange X; and it may further be assumed that the operator at the private branch exchange X has answered the call by the insertion of the answering plug of an idle cord into the jack J^8.

With the connection so established, the following conditions prevail in the toll transmission selector TTS: Ringing relay 601 is bridged across the condenser 695, relay 602 being operated over the circuit including armature 641 and armature 649. Battery feed relay 603 is operated over a circuit including the two heavy talking conductors in series and the bridge across the line conductors in the private branch exchange operator's cord, the plug of which is now in jack J^8. Relay

604 is operated from ground by way of armature 627 and the working contact. Relay 605 is operated over the circuit from ground on the release conductor 555, supplied thereto by way of armature 633 and the working contact, armature 628 and the working contact to relay 605. Release relay 606 is operated over the circuit including armature 631 and its working contact and switching relay 611 is operated over a circuit from ground on release conductor 555 through its winding, interrupting contact 653, off-normal springs 654 through the winding of relay 610 to battery. The operator at the main toll board may now re-signal the operator at the private branch exchange any time by again throwing the key K' to the ringing position, thereby supplying alternating current to the outgoing trunk conductors. Ringing relay 601 in the toll transmission selector TTS operates responsive to this alternating current and closes a circuit for the auxiliary signaling relay 607 which may be traced from ground supplied to the release conductor 555, working contact and armature 621, armature 630 and the working contact, through the winding of relay 607 to battery. Relay 607 operates and closes the re-signaling circuit which extends from ground by way of the working contact and armature 638, over the lower heavy talking conductor through the signalling relay of the operator's cord at the private branch exchange, over the upper heavy talking conductor, armature 637 and the working contact, to generator G^6. Alternating current supplied by the generator G^6 causes the operation of the usual signaling means in the operator's cord circuit at the private branch exchange in the well known manner. The operation of armature 638 permits the closure of normally open springs controlled by this armature and in so doing establishes a holding circuit for relay 603 which may be traced from ground through resistance 616, springs controlled by armature 638, lower right-hand winding of repeating coil R^6, through the lower winding of relay 603 to battery. Relay 603 therefore remains energized during the re-signaling time even though its normal circuit is opened by the disengagement of armatures 637 and 638 from their resting contact.

Relay 601 releases its armature 621 and opens the circuit of relay 607 as soon as the alternating current supplied to conductors 501 and 502 is disconnected by the release of the key K' in the toll operator's cord circuit CC. Opening the circuit of relay 607 causes this relay to deenergize and again place the circuits in the talking condition.

All trunks busy supervision

In the above descriptions of the establishment of various connections, in every case it was assumed that the selectors in performing their rotary hunting movement always found an idle trunk over which to extend the connection to a succeeding switch. Under extreme traffic conditions, however, there is a possibility of all the trunks accessible in a selected level of bank contacts being busy at the particular time that the selecting operation is performed. In such a case the particular selector rotates its wipers past the last set of bank contacts to the eleventh rotary step in which position of course the rotary motion automatically stops, since the test wiper engages no contact. With the switch shaft in this position, rotary off-normal springs are closed to complete a busy tone circuit over the calling line. The calling subscriber on hearing the busy tone is informed that the attempted connection is not being completed and that he must hang up his receiver and try again. For example, should the first selector repeater SR, Fig. 1, be rotated to the eleventh rotary step, finding all the trunks in a particular level busy, cam springs 169 are closed thereby connecting conductor 191 connected to the busy tone machine shown in Fig. 3, to the lower talking conductor by way of the working contact and armature 143, over which the busy tone is transmitted to the calling subscriber. The cam springs 969 perform the same function for the first selector repeater SR', Fig. 9.

The same may be said of cam springs 219 and 219' of selectors S^2 and S^3, Fig. 2. When either selector S^2 or S^3 rotates its wiper to the eleventh rotary step, a circuit is opened for the holding relay of the selector repeater, such as relay 128 which relay, in deenergizing, places the selector repeater in talking condition. The connection of the conductor 291 or 291' to the lower talking conductor then results in the transmission of the busy tone to the calling subscriber.

Should the incoming selector IS, Fig. 4, having been selected to extend a connection, be rotated to the eleventh position, finding all the trunks in the selected level busy, ground potential will be removed from the lower terminal of the switching relay 411 which permits this relay to operate. Since wipers 451 and 453 are not now connected to ground and battery through the vertical magnet of a succeeding switch as they would be if an idle trunk had been found, holding relay 406 deenergizes. With relay 406 deenergized and relay 411 energized, a circuit is closed from ground by way of armature 423 and the resting contact, working contact and armature 432, through the winding of relay 404 to battery. Relay 404 operates and, as described previously, disconnects ground and battery from the incoming conductors 401 and 402 and substitutes therefor the bridge including the winding of relay 403 and resistances 442 and 443. Disconnecting ground and battery from the incoming trunk conductor causes

the release of the holding relay in the selector repeater such as relays 128 of selector repeater SR, which results in placing the preceding selector repeater in talking condition. The rotation of the switch wipers to the eleventh rotary step causes the closure of off-normal springs 439′, connecting conductor 491 connected to the busy machine to one of the incoming trunk conductors. Since the talking connection now extends from the calling substation to the incoming selector IS, the busy tone is transmitted to the calling subscriber thereby apprising him of the busy condition, whereupon he is expected to replace his receiver and try to establish a connection at some later time.

Slightly different methods are employed to signal the toll operator at the main toll board when the toll selector, or the toll transmission selector, finds all the trunks busy in a selected level. The toll first selectors are provided with additional sets of rotary off-normal springs, which when operated connect the ground and interrupted battery supply to the incoming conductors producing an interrupted current flow over the trunk conductors in such a direction as to intermittently cause the operation of the polarized relay in the cord circuit and cause the flashing of the supervisory lamp. For example should the selector TS, Fig. 5, rotate its wipers to the eleventh rotary step, finding all the trunks in the selected level busy, cam springs 511 and 512 are closed, thereby connecting ground and interrupted battery from the interrupter I^5 to trunk conductors 501 and 502, respectively. The resulting current flow through the polarizer relay 502 of the cord circuit CC is such as to cause the operation of relay 502 which will intermittently close the circuit of the lamp L^4. The flashing of the lamp L^4 notifies the toll operator of the all trunks busy condition encountered. The speed of the interrupter I^5 differs from that of interrupter I so that the flashing of the lamp L^4 caused by each will differ. The operator is therefore able to distinguish whether she has encountered an all trunks busy condition or has connected with a busy line.

In the toll transmission selector a different method is employed for causing the flashing of the supervisory lamp in the toll operator's cord circuit. Should the toll transmission selector TTS, Fig. 6, rotate its wipers to the eleventh rotary step, finding all the trunks in the selected level busy, cam springs 657 are closed, thereby connecting conductor 692, connected to the battery interrupter I^5, Fig. 5, to the upper talking conductor. A circuit for relay 603 which includes the upper right hand winding of the repeating coil R^6 is alternately opened and closed. In addition to this, the rotation of the switch wipers 661—664 of the bank contacts removes ground potential from the lower terminal of the winding of switching relay 611, thereby permitting this relay to energize. Since, wipers 661 and 664 are not now connected to ground and battery through the vertical magnet of the succeeding switch as they ordinarily would be if an idle trunk had been found, the circuit of holding relay 608 is opened and this relay deenergizes. Relay 608 in deenergizing closes a circuit from ground by way of armature 641 and the resting contact, working contact and armature 649, relay 611 now being energized, through the winding of relay 602 to battery. Relay 602 operates and reverses the ground and battery connections over the incoming conductors, which reverses the current flow through the winding of the polarized relay 502 in the operator's cord circuit CC and causes its operation. The intermittent energization and deenergization of relay 603 intermittently closes and opens the circuit of relay 604. Relay 604 energizes and deenergizes correspondingly and at armature 628 intermittently disconnects the battery connection to conductor 556 by intermittently permitting the springs controlled by armature 628 to open and close. These interruptions in the circuit of the polarized relay 502 will cause it to intermittently release its armature thereby causing the flashing of the lamp L^4, which again indicates to the operator that an all-trunks busy condition has been encountered, whereupon she must release the connection and try again.

Alarm circuits

In the previous descriptions of the operations of selector repeater SR, Fig. 1, and of selector repeater SR′, Fig. 9, the utility of the various alarm relays such as relays 181 and 182, Fig. 1, and relays 981 and 982 in Fig. 9, was deferred for later paragraphs. These descriptions will now be given in this and the following paragraphs. Referring first to Fig. 1, when the selector repeater SR is first seized in setting up a connection, relay 128 operates and closes a circuit for lamp L and supervisory relay 181 in series at armature 150. Lamp L lights and relay 181 operates. A circuit is then closed for lamp L^2 at armature 184 and ground is applied to slow alarm conductor 187 at armature 183. As described, relay 128 remains operated until the last digit of the called number has been dialed. Then circuit changes take place in the connector to cause relay 128 to deenergize. The circuit including lamp L and relay 181 in series, is then interrupted whereupon relay 181 deenergizes and disconnects ground from the slow alarm conductor 187 and opens the circuit of lamp L^2. The slow alarm No. 1 (not shown) is so adjusted that it will not sound the bell until ground has been maintained on the alarm conductor 187 longer than the time ordinarily required to

establish a connection. If, however, relay 128 is maintained operated for a much longer time than this interval for which the slow alarm No. 1 is adjusted, caused by a short circuit across a pair of line conductors, or by reason of a calling subscriber having established a partial connection or merely having removed his receiver and having neglected to replace it, the slow alarm No. 1 is sounded. This calls the attention of the attendant at the exchange who by means of the lamp L^2 determines the group of selectors and by means of the lamp L determines the particular selector which is being maintained partially operated. The attendant then may take the necessary step to correct the trouble.

The slow alarm No. 2, controlled by the supervisory relay 182, is mainly for the purpose for preventing one subscriber from tying up another subscriber's line. Should the subscriber at substation A, for instance, establish a connection with another subscriber through the first selector repeater SR, the relay 129 operates and locks operated on the release trunk when the called subscriber answers. The back bridge battery feed relay 130 also operates when a called subscriber answers. Now when the called subscriber replaces his receiver, relay 130 deenergizes and closes a circuit which may be traced from ground by way of armature 157 and the resting contact, armature 154 and the working contact, lamp L', through the winding of relay 182 to battery. Relay 182 operates and places ground potential on the common alarm conductor 188 at armature 185 and also closes a circuit for the lamp L^3 at armature 186. If now the calling subscriber at substation A does not also replace his receiver after a reasonable length of time and thus permit the operated switches to release in a manner described previously, the slow alarm No. 2 is sounded, calling attention of the attendant at the exchange who finds the selector repeater so held operated, by means of lamp L^3 and the lamp L' which determines the particular selector and take the necessary steps to correct the condition.

Referring now to Fig. 9, the supervisory relays 981 and 982 serve the same corresponding purposes as described in the preceding paragraphs. The circuits of these relays however are controlled in a slightly different manner. For instance when the selector repeater SR' is seized, relay 928 operates and closes a circuit for the lamp L^{90} and relay 981 in series, this circuit including armature 955' and the resting contact and armature 950 and the working contact. This circuit is opened, however, each time the subscriber dials, because the relay 929 operates during the time of transmission of each series of impulses. Each time its circuit is opened, relay 981 deenergizes and disconnects ground from the slow alarm conductor 987. For this reason the slow adjustment on the slow alarm signal No. 1 in this case need not be as long as in the previous case, since no time need be allowed for the establishment of a complete connection.

During the establishment of a connection, relays 929' and 932 of the selector repeater SR' operate. After the connection has been established the called subscriber answers the call, the back-bridge battery-feed relay 930 operates, causing relay 929' to deenergize. Now when the called subscriber replaces his receiver after the conversation is ended, a circuit for the supervisory relay 982 and lamp L^{91} is completed from ground by way of the working contact and armature 962', resting contact and armature 953, armature 956 and the resting contact, through lamp L^{91}, through the winding of relay 982 to battery. Lamp L^{91} lights and relay 982 operates placing ground on the slow alarm conductor 988 and closing a circuit for lamp L^{93}. Again the alarm will be sounded if the connection is not released after a reasonable length of time.

This completes the description of the operation of the various switches used in the establishment of the various kinds of conditions. What is thought new and desired to have protected by Letters Patent will be pointed out in the appended claims.

What is claimed is:

1. In a telephone system, a trunk line, an automatic switch terminating said trunk line, a relay bridged across said trunk line, a magnet for controlling the movement of said switch bridged across said trunk line in series with a source of current, and a line relay controlled over said trunk line for short circuiting said first relay to cause the operation of said magnet.

2. In a telephone system, a trunk line comprising two inductively coupled sections, a relay bridged across the outer section of said trunk line, an automatic switch, a stepping magnet for controlling the movement of said switch bridged across the outer section of said trunk line in series with a source of current, and means responsive to impulses sent over the inner section for intermittently short circuiting said relay to cause said magnet to operate said switch.

3. In a telephone system, a trunk line comprising two inductively coupled sections, a relay bridged across the outer section of said trunk line, an automatic switch, a stepping magnet for controlling the movement of said switch bridged across the outer section of said trunk line in series with a source of current, means responsive to impulses sent over the inner section for intermittently short circuiting said relay to cause said magnet to operate said switch, a second trunk line which is connected to said first trunk line by the operation of said switch, and

means for disconnecting said magnet when the connection is established.

4. In a telephone system, a first switch and a second switch connected by a trunk line, a motor magnet in said second switch bridged across the talking conductors of said trunk line, and means in said first switch for controlling the operation of said magnet over the two conductors of said trunk line in series to operate said second switch.

5. In a telephone system, a first and a second switch connected by a trunk line, a motor magnet in said second switch for controlling the movement of said second switch, a closed circuit for said magnet including a source of current and the two talking conductors of said trunk line in series, and means in said first switch for altering the current flow in said circuit to control the operation of said magnet.

6. In a telephone system, a first and a second switch connected by a trunk line, a motor magnet in said second switch for controlling the movement of said second switch, and means in said first switch for sending impulses to said magnet over the two talking conductors of said trunk line in series.

7. In a telephone system, means for establishing a talking connection including in succession a selector repeater, a selector, and a connector, and means in said selector repeater for repeating digits of a called number to the magnets of the succeeding switches over a circuit including the two talking conductors in series.

8. In a telephone system, a train of serially related automatic step by step switches, a stepping magnet in each switch, a trunk line connecting the first and second switches, and a line relay in the first switch for operating said magnets over the two talking conductors of said trunk line in series.

9. In a telephone system, a selector switch accessible to a calling line via a trunk line, other serially related switches accessible to said selector, a line relay in said selector controlled over said calling line, vertical and rotary magnets in each of said other switches, and circuits for all of said vertical magnets and one of said rotary magnets over which control thereof is affected, said circuits including the two talking conductors of said trunk line in series.

10. In a telephone system, a train of automatic switches including a selector repeater, intermediate selectors, and a connector, a trunk line associated with each switch, means in each switch including a magnet for operating the switch to extend the connection to the succeeding switch via the associated trunk line, a relay in said selector repeater, operating circuits for said magnets successively established including said relay and the two talking conductors of the preceding serially connected trunk lines in series, said relay being maintained operated during the establishment of the connection, and means in said connector operative upon the completion of its operation for deactuating said relay to close normally open points in the trunk line associated with said selector repeater.

11. In a telephone system, a trunk line, a selector repeater and a connector connected by a second trunk line, a motor magnet in said connector for operating said connector, a relay in said selector repeater, an operating circuit for said magnet including said relay and the two talking conductors of said trunk line in series, said relay being maintained energized over said circuit, means controlled over said first trunk line for sending impluses of current over said operating circuit to operate said magnet, and means responsive to the completion of the operation of said connector for opening said control circuit to deenergize said relay to connect said first and said second trunk lines.

12. In a telephone system, a trunk line, a selector repeater and a connector connected by a second trunk line, a motor magnet in said connector for operating said connector, a relay in said selector repeater, an operating circuit for said magnet including said relay and the two talking conductors of said trunk line in series, said relay being maintained energized over said circuit, means controlled over said first trunk line for sending impulses of current over said operating circuit to operate said magnet, means responsive to the completion of the operation of said connector for opening said control circuit to deenergize said relay to connect said first and said second trunk lines, and separate means for maintaining said relay energized while said current impulses are being sent.

13. In combination, a first relay, a second relay, a third relay, a magnet, means for actuating and deactuating said first relay, contacts on said first relay closed upon the actuation thereof for closing a circuit for said second relay and for shunting said third relay, contacts on said second relay for closing a self-locking circuit in series with said third relay, contacts on the first and second relays for jointly closing an operating circuit for said magnet, and other contacts on said first relay closed upon the deactuation thereof for closing a circuit for said third relay and for shunting said second relay.

14. In a telephone system, an automatic switch for extending connections to called lines, a relay operated during the operation of said switch, a trunk line terminating in said switch, a battery feed relay in said switch for feeding talking current to the called line, contacts on said battery feed relay for connecting a characteristic potential to the release conductor of said trunk line via contacts on said first relay, and contacts on said battery feed relay for opening the cir-

cuit of said first relay to cause said first relay to restore and disconnect said characteristic potential from said release conductor.

15. In a telephone system, a trunk line, an automatic switch terminating said trunk line, a circuit including a relay, a magnet for controlling the movement of said switch, and the two talking conductors of said trunk line in series, said relay being actuated in said circuit, a line relay controlled over said trunk line for short-circuiting said first relay to cause the operation of said magnet, and separate means controlled by said line relay for maintaining said first relay actuated while it is short circuited.

16. In a telephone system, an automatic switch, a trunk line comprising two inductively coupled sections, a circuit including a relay, a magnet for operating said switch, and the two talking conductors of the outer section of said trunk line in series, said relay being operated in said circuit, means responsive to impulses sent over the inner section for intermittently short circuiting said relay to cause said magnet to operate said switch, and separate means controlled by said impulse responsive means for maintaining said relay actuated while it is being short circuited.

17. In a telephone system, a trunk comprising a first section and a second section inductively coupled, an automatic switch terminating said trunk line, a first and a second relay bridged across said first section, means for establishing a current flow over the first section of said trunk line to operate said first relay, a bridge including a third relay closed across said second section by the operation of said first relay, means for producing impulses of increased current flow over the first section of said trunk line to intermittently operate said second relay, and means controlled by said second relay for intermittently short circuiting said third relay to repeat said impulses over said second section.

18. In a telephone system, an automatic switch, a trunk line terminating in said switch, means for establishing a normal current flow in a circuit including the talking conductors of said trunk line, means for producing impulses of increased current in said circuit, a controlling relay in said circuit responsive only to said impulses for operating said switch, and a holding relay responsive both to normal current and to said impulses for maintaining said switch operated.

19. In a telephone system, a trunk line, an automatic switch terminating said trunk line, a controlling relay for said switch bridged across said trunk line, means for establishing a current flow over said trunk line, said current flow being of insufficient value to cause the operation of said relay, means for sending impulses of increased current over said trunk line to cause the operation of said relay, a second winding on said relay differentially wound with respect to the operating winding, a circuit for said second winding closed each time said relay operates to cause said relay to restore each time said current flow is restored to its initial value.

20. In a telephone system, a trunk line, an incoming selector terminating said trunk line, an impulse responsive relay and a source of current bridged across said trunk line in series, means for sending impulses over said trunk to operate said impulse responsive relay, means controlled by said impulse responsive relay for operating said selector and other switches to connect with a called line, and means responsive to the completion of said connection for substituting a resistance for said impulse responsive relay and said source of current.

21. In a telephone system, a trunk line, an incoming selector terminating said trunk line, an impulse responsive relay and a source of current bridged across said trunk line in series, means for sending impulses over said trunk to operate said impulse responsive relay, means controlled by said impulse responsive relay for operating said selector and other switches to connect with a called line, means responsive to the completion of said connection for substituting a resistance for said impulse responsive relay and said source of current, and means responsive to the removal of the receiver by the called party for short circuiting said resistance.

22. In a telephone system, a trunk line, an incoming selector terminating said trunk line, an impulse responsive relay and a source of current bridged across said trunk line in series, means for sending impulses over said trunk to operate said impulse responsive relay, means controlled by said impulse responsive relay for operating said selector and other switches to connect with a called line, means responsive to the completion of said connection for substituting a resistance for said impulse responsive relay and said source of current, a battery feed relay for supplying current to said trunk line, and means responsive to said substitution for disabling said impulse sending means and for connecting said battery feed relay to said trunk line.

23. In a telephone system, a trunk line, an incoming selector terminating said trunk line, an impulse responsive relay and a source of current bridged across said trunk line in series, means for sending impulses over said trunk to operate said impulse responsive relay, means controlled by said impulse responsive relay for operating said selector and other switches to connect with a called line, means responsive to the completion of said connection for substituting a resistance for said impulse responsive relay and said source of current, a battery feed relay for supplying cur-

rent to said trunk line, and means responsive to the removal of the receiver at the called station for short circuiting said resistance to cause the operation of said battery feed relay.

24. In a telephone system, a trunk line, a repeater terminating said trunk line, a holding relay and an impulse responding relay bridged across said trunk line in series, means for sending impulses corresponding to the digits of a called number over said trunk line to operate said impulse responding relay, a shunt around said holding relay, and means operative after the last digit is sent for removing said shunt around said holding relay.

25. In a telephone system, an impulse repeater, an automatic switch controlled by said repeater, and means responsive to the completion of the positioning of said switch for cutting out said repeater.

26. In a telephone system, a trunk line comprising two inductively coupled sections, an automatic switch, a relay responsive to impulses received over the first section, means for controlling the operation of said switch over said second section, and means responsive to the completion of the operation of said switch for conductively connecting said sections.

27. In a telephone system, a trunk line comprising two inductively coupled sections, a second trunk line, an automatic switch terminating said second trunk line, means for connecting the outer section of said first trunk line with said second trunk line, operating magnets for said switch, means for operating said magnets over the two conductors of said second trunk line in series, and means operative after the operation of said switch for conductively connecting the two sections of said first trunk line.

28. In a telephone system, a trunk line, a connector switch having a vertical and a rotary movement, a vertical magnet and a rotary magnet in said switch, means for successively bridging said magnets across the talking conductors of said trunk line, and means for sending impulses corresponding to the last two digits of a called number over the two talking conductors of said trunk line in series for causing said magnets to successively operate said switch in its vertical and rotary movement to connect with the called line.

29. In a telephone system, a party line connector switch having a vertical and a rotary movement, a trunk line terminating in said switch, a signalling current selecting mechanism, a vertical magnet, a rotary magnet, a signalling current selecting magnet, means for successively bridging said magnets across the talking conductors of said trunk line, means for sending impulses corresponding to the last three digits of a called number over the talking conductors of said trunk line in series for causing said magnets to successively operate said switch in its vertical and its rotary movement and said signalling current selecting mechanism to connect with the called line and signal the called subscriber.

30. In a telephone system, an automatic switch, means for seizing said switch, a resistance, a magnet for operating said switch, means responsive to the seizure of said switch for closing a circuit including said resistance and said magnet in series, and means for intermittently short-circuiting said resistance to operate said magnet.

31. In a telephone system, a trunk line, an automatic switch terminating said trunk line, means for seizing said trunk line, a resistance, a magnet for operating said switch, means operative when said trunk line is seized for closing a circuit including said resistance, the talking conductors of said trunk line, and said magnet in series, and means for intermittently short-circuiting said resistance to operate said magnet.

32. In a telephone system, a trunk line comprising a first and a second section, means for seizing said trunk line and for producing a normal current flow in said first section, means responsive to said normal current flow in said first section for producing a normal current flow in said second section, means for producing impulses of increased current flow in said first section, and means responsive to said impulses of increased current for producing corresponding impulses of increased current in said second section.

33. In a telephone system, an automatic switch, means for seizing said switch, a relay for controlling the operation of said switch, means operable when said switch is seized for impressing a normal magneto-motive force on the core of said relay, means for intermittently impressing an increased magneto motive force on the core of said relay to cause the same to energize intermittently, and means responsive to each energization of said relay for impressing a magneto motive force on the core of said relay opposing the normal magneto motive force and slightly greater in value to force the deenergization of said relay after each cessation of increased magneto motive force.

34. In a telephone system, an automatic switch, means for seizing said switch, a relay having two windings, a magnet for operating said switch, means operative when said switch is seized for closing a circuit including one winding of said relay and said magnet in series, means for intermittently short-circuiting said one winding to cause the operation of said magnet, and means including said other winding for maintaining said relay operated while said one winding is short-circuited.

35. In a telephone system, automatic switches, a trunk line associated with each

switch, means in each switch including a magnet for operating the switch to extend a connection to the succeeding switch via the associated trunk line, a relay in the first switch, means for successively establishing operating circuits for said magnets including said relay and the two talking conductors of the preceding serially connected trunk lines in series, said relay being maintained operated over said circuits, and means responsive to the deactuation of said relay occasioned by the failure of any switch to extend the connection to the succeeding one for placing the trunk line associated with the first switch in talking condition.

36. In a telephone system, a trunk line, an automatic switch terminating said trunk line and having a directive movement and a hunting movement, a magnet for controlling the directive movement, a slow-acting relay, means for sending impulses to said magnet over a circuit including said magnet, the two conductors of said trunk line, and said relay in series, said relay being maintained energized continuously during the sending of impulses, and means controlled by the deenergization of said relay upon the cessation of impulses for starting the hunting movement of said switch.

37. In a telephone system, an automatic switch, a resistance, magnets for operating the switch, means for connecting said resistance with said magnets successively, and means for operating each magnet while it is connected with said resistance by intermittently short-circuiting said resistance.

38. A switch controlling device including a relay non-responsive when under the influence of a normal magneto motive force, and responsive when under the influence of an increased magneto motive force, and means responsive to the operation of the relay for placing the relay under the influence of a magneto motive force opposing the normal magneto motive force and slightly greater in value to force the release of the relay when the increased magneto motive force is removed.

39. In a telephone system, an impulse repeater, a train of automatic switches controlled by said repeater, and means responsive to the completion of the positioning of the last switch of the train for cutting out said repeater.

40. The method of operating a train of automatic switches over interconnecting trunk lines by establishing an initial control circuit including two conductors of the trunk line and the motor magnet of the first switch of the train in series and progressively expanding the control circuit to include the motor magnets of succeeding switches of the train.

41. In a telephone system, a trunk line, a switch terminating said trunk line, a motor magnet for the switch bridged across the talking conductors of the trunk line, and means for controlling said magnet over the two talking conductors of the trunk line in series.

In witness whereof, I hereunto subscribe my name this 24th day of August, A. D., 1926.

JOHN WICKS.