Nov. 12, 1929. E. JACOBSEN 1,735,575

AUTOMATIC TELEPHONE SYSTEM

Original Filed Oct. 13, 1917 3 Sheets-Sheet 1

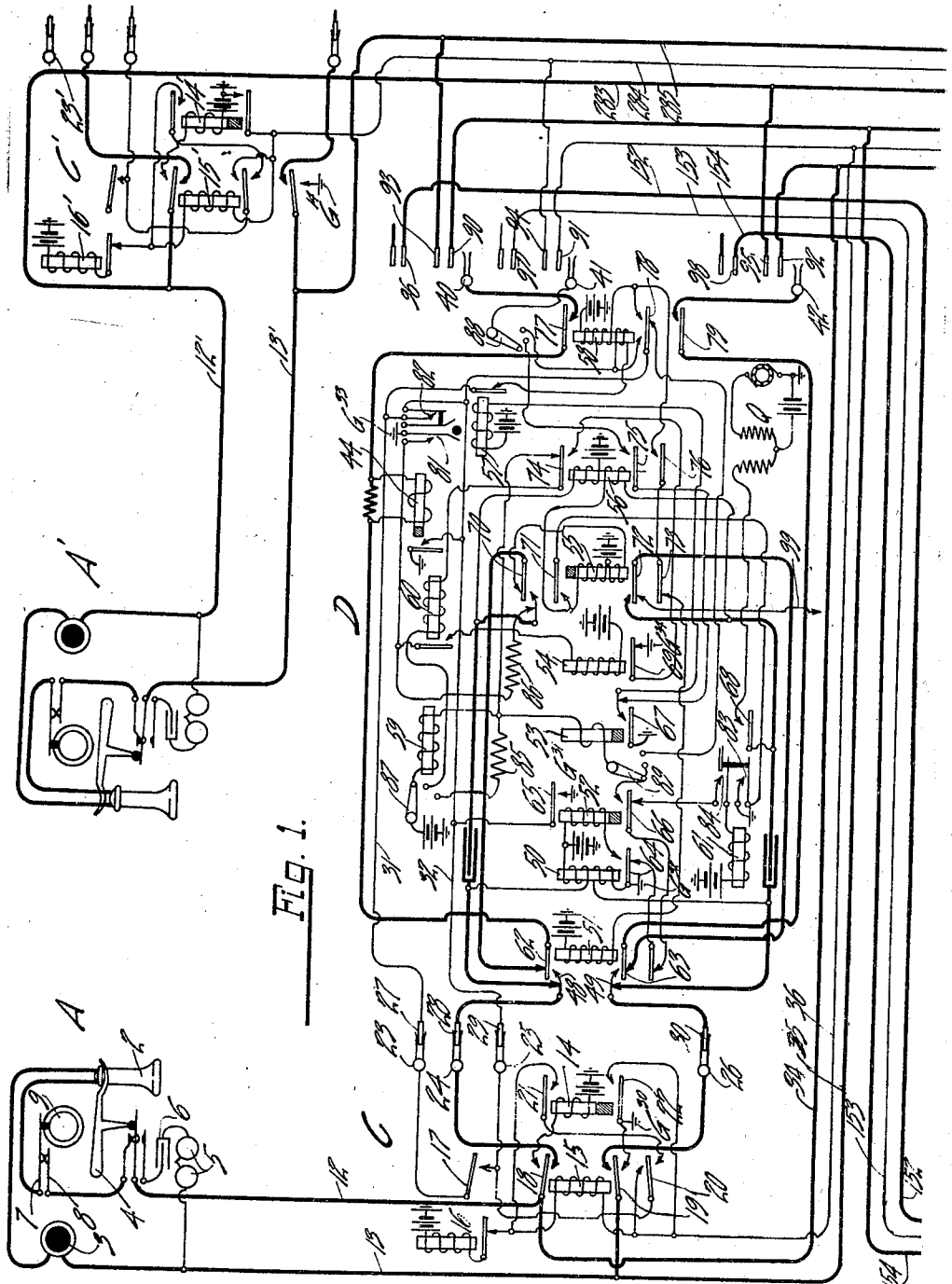

Fig. 1.

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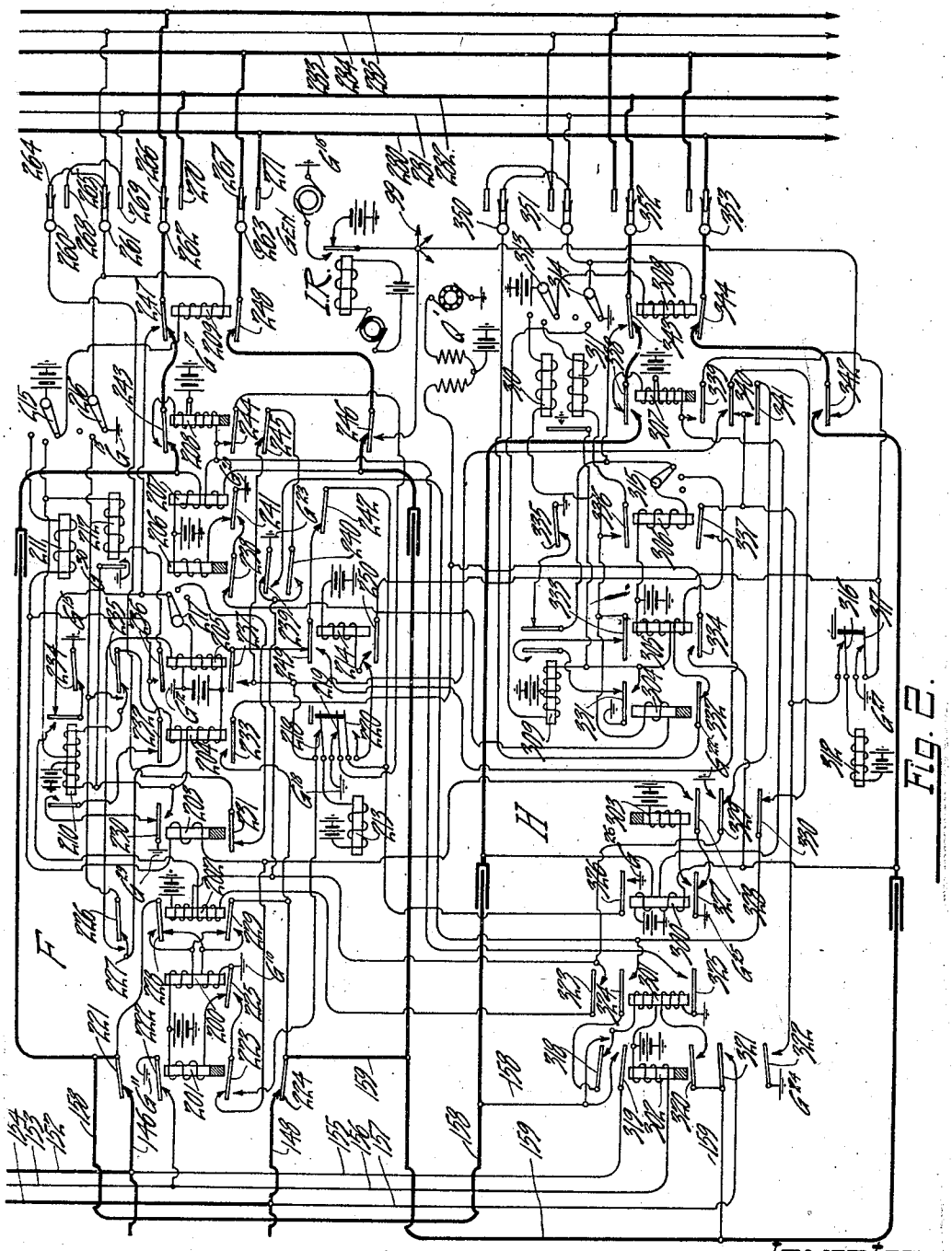

Fig. 2.

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Oct. 13, 1917 3 Sheets-Sheet 3

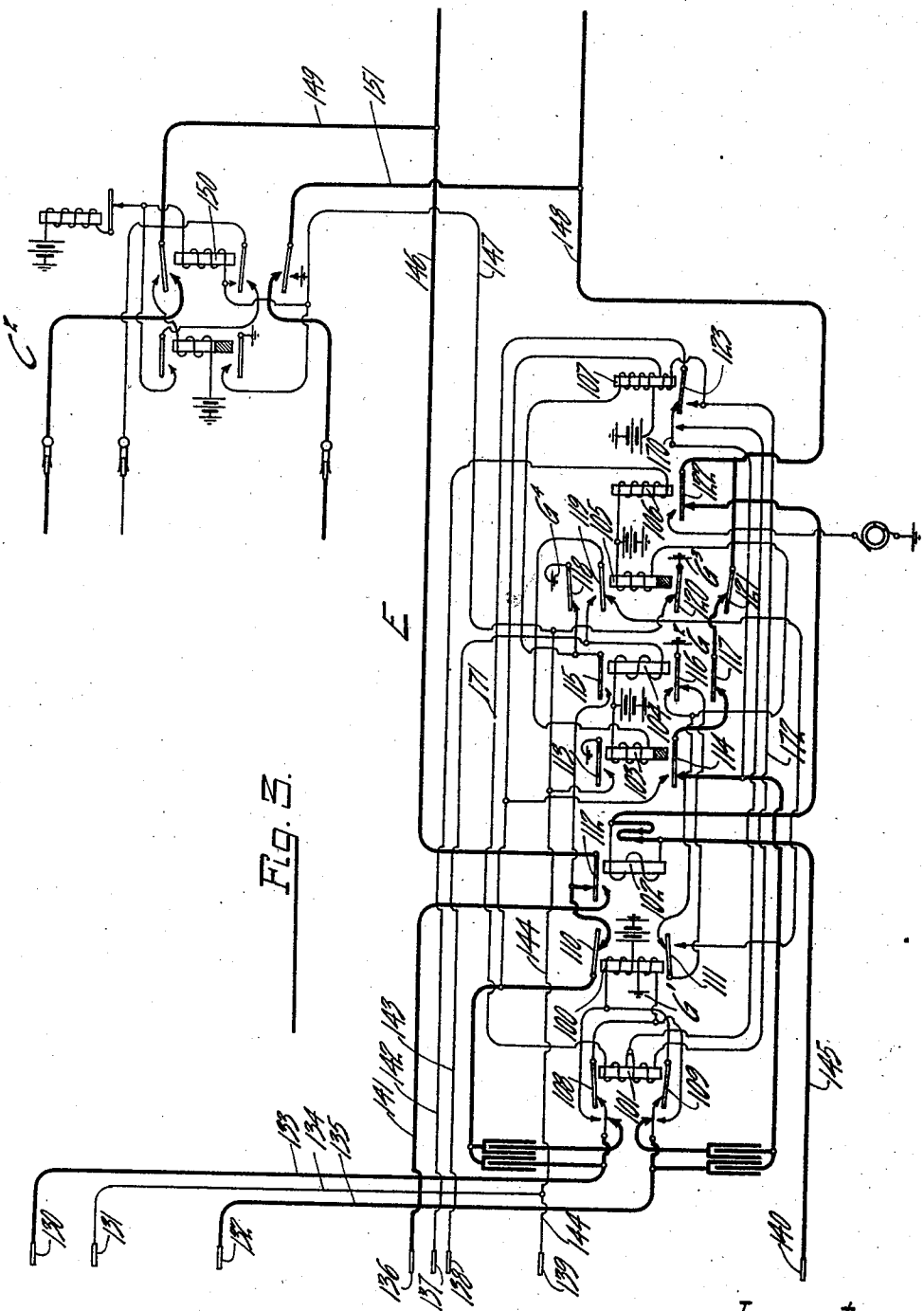

Fig. 5.

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UNITED STATES PATENT OFFICE

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AUTOMATIC TELEPHONE SYSTEM

Application filed October 13, 1917, Serial No. 196,367. Renewed May 4, 1923.

My invention relates in general to automatic telephone systems but is particularly serviceable in such systems as include a plurality of main exchanges and branch exchanges tributary or subsidiary to the main exchange. In such systems the main exchanges are interconnected by trunk lines and each main exchange is also connected to its several branch exchanges by trunk lines. Connections are established in the well known manner by automatic switches under the control of calling devices at the subscribers' stations.

The branch exchanges may be of any desired capacity but in the majority of cases will not exceed one hundred lines. Connections within a branch may then be made through the medium of connector switches which are responsive to two digits. This is only true of local connections, however, for in connections from a main exchange to a branch exchange generally at least three digits and perhaps four or five, depending upon the particular trunking arrangement in use, will have to be called before the calling subscriber obtains connection with a trunk line leading to the desired branch exchange, and if the calling subscriber is located in another branch exchange the number of digits to be called may be greater still. In any case, since only the final connectors are located at the branch exchange, the entire trunking operation is performed outside of it.

This fact, when considered in connection with the large number of transferred calls usual in the present practice, which it may be stated are made necessary by the extensive use of branch exchanges in factories, department stores, etc., where the employees are not listed by name, and where the duties of the employees and matters handled by the different departments are not widely known outside of the particular concern, will render apparent the decided disadvantage in prior automatic operating methods, which it is the object of the present invention to overcome; for it will be seen that if a main exchange subscriber calls a certain official in a branch exchange and finds, when a response is secured, that the person wanted is temporarily in another department, or, if present, that he is not the proper person with whom to transact the business in hand, it will be necessary to release the entire connection and call the entire number over again in order to obtain connection with the proper local station. The delay thus caused is a decided inconvenience and in addition may result in the loss of the trunk line during busy periods.

In manual systems transferred calls are handled readily by the operator at the branch exchange. The subscriber first called merely has to signal the operator by working his receiver hook up and down and when she responds tell her to whom the call is to be extended, whereupon the operator merely has to shift the plug in which the incoming trunk line terminates to a different jack.

In automatic systems, since there is no operator, it is desirable that any called subscriber in a private automatic exchange should himself be able to transfer an incoming call to any other subscriber in the branch, and the present invention provides an arrangement by which this can be done. Each incoming trunk line from the main exchange terminates in a dual or compound connector instead of the usual single connector switch. This dual connector comprises two separate and distinct switch mechanisms which, however, are permanently associated with one trunk and are mutually dependent so far as their circuits and operation are concerned.

When a call is received over a certain trunk line one of the two connectors associated therewith, which will be termed the main connector, is operated first to establish connection with the desired line in the branch exchange. After a response is had, if it is desired to transfer the call to another station the called subscriber at the branch exchange operates his dial in accordance with the number of the third station, (a two digit number), whereupon the other connector associated with the trunk in use, hereinafter termed the auxiliary connector, is actuated to establish connection with the line to which the call is to be transferred. When the party thus called answers his telephone the party first called and who has just transferred the call will replace his receiver, whereupon the

main connector is released and restored to normal. That is, the main connector usually releases at this time although provision is made whereby when calls are transferred by certain lines in the branch exchange the main connector will release immediately upon the response of the subscriber to whom the call has been transferred, thereby permitting but two stations to be connected at one time.

If it should be desirable or necessary to transfer the call to a third station, the second party called can operate his dial in accordance with the proper digits and operate the main connector again to connect with the desired third line; and furthermore, the subscriber on the third line can extend the call to a fourth by again operating the auxiliary connector. From this it will be understood that the main and auxiliary connectors which constitute the dual or compound connector of this invention are operable alternately by local subscribers at the branch exchange to transfer calls as desired, and that by this arrangement an incoming call from a distant main exchange can be transferred or switched from one station to another at the branch without it becoming necessary for the main exchange subscriber to replace his receiver and release the trunk connection.

The above is an outline of the operation of the invention in its simplest form. It has recently become the common practice in highly organized telephone systems to establish toll connections automatically by means of a separate trunking system which is independent of the local trunking system, the two separate systems being required principally on account of the fact that in toll or long distance work the signaling and busy test circuits required are different from those considered the best practice for local operation and on account of the necessity of providing better talking circuits. The embodiment of the invention herein shown is designed for use in a system of the above character and it has been considered best to show all the circuits which have to do with the invention complete although it will be understood that for straight local service in systems where toll connections are established manually the circuits may be considerably simplified. The apparatus and the circuit arrangements shown by which the foregoing and other useful objects are attained will be fully described and explained hereinafter, reference being had to the accompanying drawings, Figs. 1, 2 and 3, which form a part of this specification. For a clear understanding of the drawings Fig. 2 should be placed below Fig. 1, while Fig. 3 should be placed to the left of Fig. 2, in such a manner that the lines at the adjacent edges will be in alignment. When thus arranged it will be seen that I have shown an incoming trunk line comprising conductors 146 and 148, which extends from the repeater E (Fig. 3) in the main exchange and terminates in the dual or compound connector comprising main and auxiliary connectors F and H at the branch exchange. These main and auxiliary connectors are both permanently associated with the incoming trunk line and have access to the local lines in the branch exchange, two of which, the lines extending to substations A and A′, are shown in Fig. 1. In Fig. 1 are also shown line switches C and C′ which are associated, respectively, with the lines extending to substations A and A′; and the connector D, which is one of a group of connectors used for establishing local connections.

Substation A may be of any suitable common battery type and as shown herein consists essentially of the receiver 2, transmitter 3, switch hook 4, ringer 5, and condenser 6. Being an automatic substation there is also provided a calling device represented herein by the impulse springs 7 and 8 and the impulse wheel 9. This calling device likewise may be of any suitable or approved type as, for example, one in which a calling dial is provided which may be operated by the subscriber to produce series of interruptions in the line circuit in accordance with the digits in a number which it is desired to call. A calling device of the above type and one which is suitable for the purpose is shown in the British patent to Dicker, No. 29,654 of 1910.

The line conductors 12 and 13 terminate at the switch board of the branch exchange in the individual line or trunk selecting switch C which is adapted to operate when the receiver is removed at substation A to initiate a call to extend connection to a trunk line extending to a local connector switch. The line switch C may be briefly described as a rotary line switch whose wipers have no normal position, or, in other words, this line switch is of the type of line switch whose wipers remain on the contacts of the trunk line last used and when a call is initiated no trunk selecting operation will take place unless the trunk line on which the wipers happen to be resting is busy. A rotary line switch embodying these features is shown in the patent to Lamb, No. 1,193,160, granted August 1, 1916. Each local line in the branch exchange is provided with a line switch similar to the line switch C and the banks of all these line switches are connected in multiple and form terminals of trunk lines which extend to connector switches, one of which is the connector D.

The connector switch D is mechanically of the well known Strowger vertical and rotary type which is disclosed in the patent to Keith, Erickson and Erickson, No. 815,176, granted March 13, 1906. The circuits are modified to a great extent, however, principally in order

to permit the switch to be operated in accordance with the two wire system of control and also because of certain features desirable in a private branch exchange of the type herein described. The banks of all the local connectors are connected in multiple in the usual way and form terminals of normal conductors over which access is had to the various local lines. Not all the levels are used for this purpose, however, for where the branch exchange is connected by trunk lines to a main exchange, as in the present case, one or more levels must be reserved for these trunk lines. Thus in Fig. 1 I have shown the first contact sets in certain levels, to-wit, the first, second, ninth, and tenth, and it will be seen that the normal conductors associated with substations A and A′ terminate in the first contact sets of the first and second levels, respectively, while in the first contact set of the ninth level there is terminated a trunk line comprising conductors 152, 153, and 154, which may be considered as normal conductors associated with the conductors of the trunk line extending to the main exchange. From this it appears that the contact sets of the first eight levels of the local connectors are assigned to the local lines, while the contact sets of the ninth level are reserved for trunk lines extending to the main exchange. The tenth level is also reserved for trunk lines which, however, extend to a different exchange. The provision of this last group of trunk lines involves a somewhat novel operation in the connector D which will be explained fully hereinafter.

The main and auxiliary connectors F and H are similar in mechanical construction to the connector D. The circuits, of course, are radically different and will be described in detail in the description of the operation which is to follow. The main exchange end of the trunk line comprising conductors 146 and 148, has two branches, one of which terminates as before mentioned in the repeater E (Fig. 3), and the other of which terminates in the line switch C^2. The repeater E comprises the eight relays 100 to 107, inclusive, whose functions will be described later; and is accessible to selectors of the toll trunking system and also to selectors of the regular main exchange trunking system, thus forming the means by which selectors of both kinds are given access to the trunk line. In the case of the toll selectors connection may be extended to the repeater E by way of the bank contacts 136 to 140, inclusive, and similar multiply connected contact sets; while in the case of the selectors of the regular exchange trunking system access is had thereto by way of bank contacts 130 to 132, inclusive, and their multiples. Thus it will be seen that a connection may be extended to the repeater E over two different routes, depending on whether it is to be used by a local subscriber in the main exchange or a toll or long distance operator. At this time reference is had to the patent of Winfred T. Powell, No. 1,356,010, granted October 19, 1920, which shows a similar arrangement.

The line switch C^2 affords means whereby connection from the branch exchange may be extended to subscribers in the main exchange by way of the regular main exchange trunking systems. The line switch C^2 is similar to the line switch C, (Fig. 1), already described, and has access to selector switches over a group of trunk lines one of which is partially shown just to the left of the line switch.

For supplying current for operating and talking purposes I have shown throughout the drawings a plurality of batteries, but it is to be understood that there is preferably but one battery for each exchange, each of which has its positive terminal grounded. In order not to encumber the drawings reference characters have been omitted from the various batteries therein shown, and to avoid any confusion on this account it is noted that when in the specification a circuit is traced "to battery" it will be understood as extending to the ungrounded or live pole of a common exchange battery. The reference character IR in Fig. 2 indicates an intermittent ringing machine of the usual type common to automatic telephone systems. There is also provided a busy signaling machine shown at several places in the drawings and indicated by the reference characters Q and Q′.

Having described briefly the general layout of the system and the character of apparatus employed, I will now proceed to explain in a more detailed manner the operation of the circuits. For this purpose it will first be assumed that a subscriber in the main exchange desires to establish connection with a certain subscriber at the branch exchange who is ordinarily to be reached at the substation A′, and will be further assumed that the calling subscriber has operated a series of selector switches of the regular main exchange trunking system in the usual way to establish connection at terminals 130, 131, and 132 with the repeater E, and therefore with the trunk line shown in the drawings. As soon as the conductors of the calling line are extended to bank contacts 130 and 132 by the selector switch a bridge which may include either the calling subscriber's loop or an inductive winding in an intervening repeater, is closed across the conductors 133 and 135 and the line relay 100 of the repeater E is energized over the following circuit: ground at G′, lower winding of line relay 100, normally closed contacts controlled by armature 109 of relay 101, conductor 135, bank contact 132 and the selector wiper in engagement therewith, through the

calling subscriber's loop, and back to the selector wiper in engagement with the bank contact 130, conductor 133, normally closed contacts controlled by the armature 108 of relay 101, and the upper winding of the line relay 100 to battery. Upon attracting its armature the line relay completes a circuit for the slow acting release relay 105 as follows: ground at G^2, armature 116 and its resting contact, armature 111 and its working contact, and the winding of the relay 105 to battery. Upon energizing, relay 105 completes a holding circuit for the operated switches in the main exchange trunking system which may be traced as follows: ground at G^3, armature 120 and its working contact, conductor 144, and conductor 134 to the bank contact 131, and thence by way of the test wiper of the last selector switch to holding magnets or relays in the various switches in the usual manner. Conductor 134 being grounded, a ground potential will be placed upon the multiples of contact 131 with the result that repeater E is made busy to other selectors in the regular main exchange trunking system. A branch of the above traced holding circuit extends from the junction of conductors 144 and 134 to test contact 139 and its multiples in the banks of the idle toll selectors which have access to the repeater E where, by a ground potential on these test contacts, the repeater E is made busy to these selectors also. A second branch may be traced by way of conductor 147 and the switching relay 150 of the line switch C^2 to battery. By the energization of relay 150 the branch conductors 149 and 151 of trunk line are disconnected from their normal battery and ground connections in line switch C^2. Another circuit closed by the energization of relay 105 extends from ground G^4 by way of armature 118 and its working contact and the upper winding of relay 107 to battery. Relay 107 is not operated, however, for its upper winding is merely a polarizing winding, being composed of German silver wire, and does not energize the core of the relay sufficiently to enable it to attract its armature. Relay 105 also prepares a circuit for the relay 103 at its armature 119 which will be traced later, and finally at its armature 121 closes a bridge across the trunk conductors 146 and 148, and thereby causes the energization of the double wound line relay 200 of the main connector F (Fig. 2) at the branch exchange. The energizing circuit of relay 200 may be traced as follows: ground at G^{10}, lower winding of relay 200, resting contact of armature 229 and the said armature, conductor 159, armature 321 and its resting contact, conductor 157, trunk conductor 148, armature 121 and its working contact, armature 117 and its resting contact, armature 114 and its resting contact, spring 170 and its resting contact, upper and lower windings of relay 101 in parallel, conductors 171 and 172 in parallel, lower winding of electropolarized relay 107, armature 110 and its working contact, resting contact of armature 112 and the said armature, trunk conductor 146, conductor 155, armature 319 and its resting contact, conductor 158 armature 228 and its resting contact, and the upper winding of the relay 200 to battery. Upon energizing, the line relay 200 closes the usual energizing circuit for the slow acting release relay 201, and this latter relay, upon energizing in turn, at its armatures 221 and 224 connects the incoming trunk conductors 146 and 148 direct to the upper and lower windings of the line relay 200, respectively, by way of the armatures 228 and 229 of the relay 202. As a further result of its energization relay 201 prepares at its armature 223, the usual operating circuit for the rotary and vertical magnets 211 and 212, and at its armature 222 connects ground G^{11} to conductor 153 with the result that ground potential is placed upon the test contact 97 and its multiples in the banks of the local connectors in order to render the trunk line busy. Ground G^{11} also extends by way of conductor 156 and the winding of the cut-off relay 302 to battery. The cut-off relay 302 is accordingly energized and its armatures 318 and 320 disconnect the windings of the double wound relay 301 from the conductors of the incoming trunk line. At armatures 319 and 321 the original energizing circuit for the line relay 200 is broken also, but this latter operation is without effect because of the fact that another circuit for relay 200 has already been closed by the relay 201 as explained. It should be mentioned at this point that the relay 301 of the auxiliary connector H is normally bridged across the conductors 146 and 148 in parallel with the line relay 200 of the main connector F. Relay 301 does not energize when the bridge is closed at the repeater E, however, because it is differentially wound.

The foregoing operations have occurred automatically upon the seizure of the repeater E by the selector in the main exchange. The calling subscriber may now call the last two digits in the number for the purpose of operating the main connector F to complete the connection in the branch exchange. By the operation of the calling dial in accordance with the next digit a series of interruptions is produced in the energizing circuit of the line relay 100 of the repeater E, and this relay is accordingly deenergized a corresponding number of times to produce at its armature 110 a series of interruptions in the circuit of the line relay 200 of the main connector F at the branch exchange. At each deenergization relay 100 also completes a circuit for the slow acting relay 103, which

extends as follows: ground at G^2, armature 116 and its resting contact, armature 111 and its resting contact, working contact of armature 119 and the said armature, and the winding of relay 103 to battery. Relay 103 is energized, and being slow acting, remains in operated position during the series of impulses to ground the conductor 144 at its armature 113, (without function at this time), and to close at its armature 114 a direct bridge across the trunk conductors 146 and 148, which may be traced over the following path: conductor 146, armature 112 and its resting contact, working contact of armature 110 and the said armature, working contact of armature 114 and the said armature, resting contact of armature 117 and the said armature, working contact of armature 121 and the said armature, to conductor 148. This direct bridge of course includes the armature 110 of the line relay 100, and it will be understood that the principal function of the relay 103 is to cut out the impedance of relays 101 and 107 while the line relay 100 is transmitting impulses to the line relay 200 at the branch exchange. In response to the interruptions in its circuit which are produced at the repeater E the line relay 200 of the connector F is deenergized a number of times and at each deenergization transmits an impulse through the vertical magnet 211 as follows: ground at G^{10}, armature 225 and its resting contact, armature 223 and its working contact, winding of the low resistance slow acting private control relay 203, winding of the vertical magnet 211, and the side switch wiper 215 in first position, to battery. In response to these impulses the vertical magnet is operated to raise the switch shaft step by step until the wipers 260 to 263, inclusive, arrive opposite the horizontal level of bank contacts in which is located the contact set assigned to the line of substation A'. The relay 203 energizes in series with the vertical magnet and remains operated during the series of impulses to close at its armature 230 parallel energizing circuits for the lower winding of relay 204 and the left hand winding of the private magnet 210. The operation of relay 204 at this time is without function. The private magnet, however, controls the side switch in the usual manner, and upon deenergizing following the deenergization of the relay 203 at the end of the series of impulses, permits the side switch wipers to advance to their second position.

The calling subscriber may now operate his dial in accordance with the final digit in the called number, or the digit 1, (the line of substation A' is connected to the first set of contacts in the second level), thereby producing a single interruption in the circuit of the line relay 100 of the repeater E. Accordingly it follows that the line relay 100 will be deenergized once momentarily to interrupt the circuit of the line relay 200 of the main connector F. Now, however, the line relay 200 transmits an impulse of current to the rotary magnet 212, the circuit being traceable over the following path: ground at G^{10}, armature 225 and its resting contact, armature 223 and its working contact, winding of relay 203, resting contact of armature 236 and the said armature, winding of rotary magnet 212, and the side switch wiper 215 in second position, to battery. By the operation of the rotary magnet in response to the impulse of current which it receives, the switch shaft is rotated one step and the wipers 260 to 263, inclusive, are brought into engagement, respectively, with bank contacts 264 to 267, inclusive, comprising the contact set assigned to the line of substation A'. The relay 203 and the private magnet 210 are energized as before, and in case the called line is idle when the relay 203 deenergizes, the private magnet also deenergizes, and the side switch wipers are advanced to their third position.

It will be first assumed, however, that the line of substation A', when called as above described, was busy. In this case there would be a potential upon the test contacts 264 and 265 with the result that the private magnet 210 would not deenergize when the circuit of its left hand winding is broken at the relay 203, but is maintained over a test circuit extending as follows: ground on test contact 265, test wiper 261, side switch wiper 216 in second position, contact springs controlled by the armature 235 of relay 205, right hand winding of the private magnet 210, and the side switch wiper 215 in second position to battery. Also relay 205 is energized over the following circuit: ground on test contact 264, test wiper 260, armature 231 and its resting contact, side switch wiper 217 in second position, and the lower winding of relay 205, to battery. On energizing relay 205 closes a locking circuit for itself and the private magnet independent of the test wiper 261 which extends from ground G^{12} by way of the upper winding of the said relay 205, the resting contact of spring 227 and the said spring, the upper winding of relay 204, armature 235 and its working contact, the right hand winding of the private magnet 210, and the side switch wiper 215 in second position, to battery. Relay 204, being included in the above locking circuit, is energized and its armature 233 connects a lead from the busy signaling machine Q' to the conductor 148 of the trunk line. It is to be noted that by the attraction of armature 236 of relay 205 the circuit of the rotary magnet 212 is opened to prevent the calling subscriber from rotating the connector on to another line. The operation of armatures 237 and 234 of relay 205 and 232 of relay 204 is with-

out function at this time. When the calling subscriber hears the busy signal he will understand that the desired line is for the time being inaccessible, and will replace his receiver. The disconnection of the switches which follows will be described later on.

Having described the operation of the connector F when the called line is busy, it will now be assumed that when the connection therewith was attempted the line of substation A' was idle. Under these circumstances when the slow acting relay 203 deenergizes at the end of the final impulse or series of impulses, the private magnet 210 is deenergized also and the side switch wipers are advanced to their third position. By the advance of the side switch wipers to their third position two circuits are closed simultaneously. The first of these extends from ground G^{13}, through side switch wiper 216 in its third position, and has two branches, the first branch being traceable by way of the test wiper 261, test contact 265, private normal conductor 284, the winding of the cut-off relay 15' of line switch C', and the winding of stepping magnet 16', to battery. The current flow in this branch serves to energize the cut off relay 15', the low resistance stepping magnet 16' remaining deenergized, and the line conductors 12' and 13' are thereby disconnected from their normal battery and ground connections in the line switch C'. It should be mentioned that when the relay 15' is energized as above, it is prevented from completely attracting its armature by reason of an interlocking mechanism controlled by the armature of the line relay 14'. Accordingly the wipers of the line switch C' remain disconnected. This locking mechanism is fully described in the patent to Lamb previously referred to. Ground at G^{18} of course, also extends to multiples of test contact 265 in order to render the line of substation A' busy to other connector switches. The second branch circuit extends from the junction of side switch wiper 216 with the test wiper 261 by way of the winding of the switching relay 209, and the side switch wiper 215 in third position, to battery. Deferring for a moment the explanation of the effect produced by the energizing of relay 209, the second circuit which as before mentioned was closed simultaneously with the closure of the circuit extending from ground G^{13}, may be traced over the following path: ground at G^{14}, (line switch C', Fig. 1), resting contact of the lower armature of the cut off relay 15' and the said armature, normal conductor 285, bank contact 266, wiper 262, armature 247 and its resting contact, side switch wiper 217 in third position, and the lower winding of relay 205, to battery. The above circuit is broken an instant after it is completed by the operation of the cut-off relay 15' and also by the energization of the switching relay 209. Nevertheless, a momentary flow of current will be produced in the lower winding of relay 205, sufficient to enable this relay to attract its armature 234. An energizing and locking circuit is thereupon completed as follows: ground at G^{15}, armature 234 and its working contact, right hand armature of private magnet 210 and its resting contact, side switch wiper 217 in third position, and the lower winding of relay 205, to battery. The operation of the armatures 235 and 236 of relay 205 is without particular effect at this time, but the operation of armature 237 opens a circuit of the release magnet 213 for a purpose which will be fully described hereinafter.

Returning to the switching relay 209, when this relay energized a signaling circuit is completed over the following path: ground at G^{16}, generator Gen., contact controlled by the intermittent ringing equipment IR, resting contact of armature 246 and the said armature, working contact of armature 248 and the said armature, wiper 263, bank contact 267, normal conductor 283, line conductor 12', through the ringer and condenser at substation A', line conductor 13', normal conductor 285, bank contact 266, wiper 262, armature 247 and its working contact, armature 243 and its resting contact, upper winding of the ring cut off relay 208, and the exchange battery to ground at G^{17}. By the operation of the ringing apparatus IR the above circuit is closed intermittently to operate the ringer at the called substation. It will be observed that whenever the generator Gen. is disconnected from the circuit a small booster battery is substituted therefor in order to enable the cut off relay 208 to be energized during the silent periods. This relay 208 is so adjusted that it will not energize as long as the receiver remains on the hook at the called substation. When the receiver is removed, however, the relay 208 is instantly energized either by current from generator Gen. and the main exchange battery in series, or by current from the booster battery and the main exchange battery in series, and upon attracting its armature 244, closes a locking circuit for itself as follows: ground at G^{18}, off normal contact 219, (closed at the first upward movement of the switch shaft) armature 244 and its working contact, and the lower winding of the relay 208 to battery. The above circuit also supplies ground to the lower winding of the back bridge relay 207. Further results of the energization of relay 208 are the closure of a contact in the release circuit at armature 245, and the closure of the talking circuit at the working contact of armatures 243 and 246, the upper winding of relay 208 and the lead to the ringing machine being disconnected at the back contacts of these armatures, respectively. Upon the closure of the talking circuit the back bridge relay 207 which is bridged across the talking conduc-

tors in series with the battery is energized in the usual manner and completes a circuit for the slow acting relay 206. Relay 206 upon energizing prepares at its armature 238 a circuit for the vertical and rotary magnets 310 and 311 of the auxiliary connector H, opens a contact in the release circuit at its armature 240, and at its armature 239 closes an energizing circuit for the upper winding of relay 202. Relay 202, upon energizing, reverses the incoming line conductors 146 and 148 as regards their connections to the windings of the line relay 200, thereby reversing the direction of current flow in the conductors of the incoming trunk line. The operation of armature 226 of relay 202 is without function at this time. By the reversal of the current in the line, the relay 107, whose lower winding is included in the bridge at the repeater and which until now has remained inoperative because of the opposing magnetizing effects of its windings, is operatively energized, and upon attracting its armature, changes the circuit of the bridge at the repeater in such manner that the two windings of the relay 101 are connected in series rather than in parallel. This operation increases the impedance and resistance of the bridge to prevent transmission loss, and of course, also causes the energization of the relay 101. Upon attracting its armatures 108 and 109, relay 101 connects an additional pair of condensers in the talking circuit and also reverses the incoming trunk conductors 133 and 135 as regards their connections to the windings of the line relay 100. The direction of current flow in the calling line is accordingly reversed in the usual manner for the purpose of operating a meter or collecting a coin.

The required connection has now been established, and assuming that the calling subscriber has obtained the desired party at substation A′ the conversation can proceed as desired. Current for the transmitter at the called substation A′ is supplied through the windings of the back bridge relay 207 of the main connector F, while current for the transmitter at the calling substation may be supplied through the windings of the line relay 100 of the repeater E. The voice currents take the path shown in heavy lines which will be understood without further explanation.

When the conversation is finished both subscribers will replace their receivers. By the replacing of the receiver at the calling substation the energizing circuit of the line relay 100 of the repeater E is broken and this relay deenergizes to open the circuit of the slow acting relay 105. The deenergization of these two relays causes the bridge across the trunk conductors 146 and 148 to be permanently opened with the result that the line relay 200 of the main connector F is deenergized. The resulting deenergization of the slow acting release relay 201 causes the closure of the following circuit for the release magnet 213: ground G^{10}, armature 225 and its resting contact, armature 223 and its resting contact, off normal springs 218, and the winding of the release magnet 213, to battery. By the operation of the release magnet 213 the main connector F is restored to normal position in the usual manner, the circuit of the release magnet being opened at off normal springs when the shaft reaches its lowest position. At the repeater E when the slow-acting relay 105 was deenergized ground was disconnected from conductors 144 and 147, thereby permitting the operated selector switches in the main exchange trunking system to be released and also permitting the cut off relay of the line switch C^2 to deenergize. The apparatus is thus all restored to normal position when the receiver is replaced at the calling substation.

It will now be assumed that when the substation A′ was called, as described in the foregoing, the particular person wanted was absent from the department temporarily, having gone for some purpose or other to the department served by the substation A. The party who answers the telephone at substation A′ will ordinarily know where the party wanted has gone and will ask the calling subscriber to wait a minute while he is being called. This is accomplished by operating the auxiliary connector H to establish connection with the local line extending to the substation A. It will be recalled that when the receiver was removed at substation A′ the relays 207 and 206 were energized, the latter relay preparing a circuit for the operating magnets 310 and 311 of the auxiliary connector. When now the dial at substation A′ is operated in accordance with the digit 1 the relay 207 is deenergized momentarily and transmits an impulse of current to the vertical magnet 310 as follows: ground at G^{20}, armature 241 and its resting contact, armature 238 and its working contact, winding of the low resistance slow acting private control relay 304, winding of the vertical magnet 310, and the side switch wiper 313 in first position, to battery. By the operation of the vertical magnet the shaft of the auxiliary connector H is raised one step whereby the wipers 350 to 353, inclusive, are raised opposite the first horizontal level of bank contacts. The slow acting relay 304 is energized in series with the vertical magnet and closes the usual energizing circuit for the private magnet 309. Upon the deenergization of relay 304 and the private magnet the side switch wipers are advanced to second position in the usual manner. The dial at substation A′ is now operated in accordance with the final digit 1 of the number of substation A, and the relay 207 is accordingly again momentarily deenergized. Now, however, the side switch wiper

313 being in its second position, the rotary magnet 311 is operated and the switch shaft is rotated to bring the wipers 350 to 353, inclusive, in engagement with the first set of contacts in the first level, this being the contact set allotted to the normal conductors of the line of substation A. The slow acting relay 304 and the private magnet 309 are energized as before, and assuming that the line of substation A is idle when the relay 304 deenergizes, the private magnet will deenergize also, and the side switch wipers will be advanced to third position.

By the advance of the side switch wipers to their third position circuits are closed simultaneously for the relays 306 and 308 of the auxiliary connector H and for the cut-off relay 15 of the line switch C. These circuits are the same as corresponding circuits in the main connector H and need not be described in detail. By the energization of the cut off relay 15 the line conductors 12 and 13 are disconnected from their normal battery and ground connections in line switch C. Relay 306, upon energizing, closes a locking circuit for itself at its armature 335 and at its armature 337 opens a contact in the release circuit. Relay 306 corresponds to the relay 205 in connector F and the reason for operating these two relays when connection to the called line is completed will be explained fully later on. By the energization of the switching relay 308 a signaling circuit is completed for actuating the ringer at substation A. This circuit is similar to the one already described in connecton with substation A'.

In order to permit of a full explanation of the release it will now be assumed that no response is secured from substation A. Under these circumstances the party at substation A' may offer to try another number, perhaps having in mind some station at which the desired party is likely to be. If this is agreeable to the calling subscriber at the main exchange the party at substation A' will now hang up his receiver in order to release the connector H preparatory to calling the new number. By the replacement of the receiver on the hook relays 207 and 206 of the main connector F are deenergized and a circuit is completed for the release magnet 312 of the auxiliary connector H as follows: ground at G^{23}, armature 239 and its resting contact, armature 330 and its resting contact, armature 340 and its resting contact, the off normal springs 316, and the winding of the release magnet 312, to battery. By the energization of the release magnet 312 the auxiliary connector is restored to normal position in the usual manner, after which it may be again operated by the party at substation A' under the control of the relay 207 of the main connector to establish connection with another local station.

Having explained the release of the auxiliary connection under the above circumstances, it will now be assumed that the party at substation A is present when the signal is received and that he answers the telephone. When the receiver is removed the ring cut off relay 307 is energized and at its armature 339 completes a locking circuit for itself in a readily understood manner. Ground is also supplied by way of armature 339 to the lower winding of the back bridge relay 300. As a further result of the energization of relay 307 certain contacts in the release circuits are shifted at armatures 340 and 341; and at armatures 338 and 342 the line wipers are disconnected from the upper winding of relay 307 and from the generator lead, respectively, and are connected instead to the heavy talking conductors. Back bridge relay 300 is now energized over the called line circuit and upon attracting its armature completes an energizing circuit for the slow acting relay 303. This latter relay, upon energizing, prepares a circuit for the operating magnets of the main connector at its armatures 328, opens a release circuit contact at its armature 330, and at its armature 329 connects ground G^{22} to the upper winding of relay 202 of the main connector, thereby providing against the deenergization of this relay, should the relays 207 and 206 be deenergized to release the main connector.

The call has now been transferred through the medium of the auxiliary connector H to substation A and since the talking conductors of the two connectors are connected in multiple, the calling subscriber at the main exchange may now converse with the wanted party at substation A as desired. The party at substation A' who has just transferred the call, upon observing that conversation is proceeding satisfactorily will now replace his own receiver. Upon the resulting deenergization of relays 207 and 206 of the main connector, a circuit is now completed for the main connector release magnet which may be traced as follows: ground at G^{22}, working contact of armature 329 and the said armature, resting contact of armature 240 and the said armature, armature 245 and its working contact, off normal contact 218, and the winding of the release magnet 213, to battery. By the energization of the release magnet 213 the main connector is restored to normal as usual, relays 200 and 201 remain energized, however, as long as connection is held at the auxiliary connector H. The reversing relay 202 is also maintained energized, as previously explained, from ground G^{22} at the auxiliary connector. When the conversation is completed and the relays 200 and 201 are deenergized by the replacement of the receiver at the calling substation, relay 201 breaks the circuit of the cut off relay 302. By the deenergization of this latter relay a circuit for the release magnet 312 of the auxiliary con-

nector is closed as follows: ground at G^{24}, aramature 322 and its resting contact, off normal contact 316, and the winding of the release magnet 312 to battery. It follows that the auxiliary connector H will then be released and restored to normal position.

It may happen in the case of the connection last described that the party at substation A will find it necessary to refer the calling subscriber to someone else in the branch exchange. Perhaps it is found that the business in hand can best be transacted by some other department or that it requires the consideration of some other official before it can be definitely disposed of. However, we are not particularly concerned with the precise reasons for it will be understood that circumstances will arise where it is necessary to transfer a call two or more times before the calling subscriber finally completes his business. We will assume then, that the party at substation A, after conversing with the calling subscriber for a moment, finds it necessary to transfer the call to a third station. The main connector F has already been released and is now operated by the subscriber at station A under the control of the relay 300 of the auxiliary connector H. When the calling device at station A is operated in accordance with the first digit of the number, a series of impulses is transmitted to the vertical magnet 211 of the main connector over the following path: ground at G^{25}, armature 327 and its resting contact, armature 328 and its working contact, winding of the slow acting relay 203, winding of the vertical magnet 211, and the side switch wiper 215, in first position, to battery. By the operation of the vertical magnet the switch shaft and the wipers are raised to the required level of bank contacts, and, as before exlained, the side switch wipers are advanced to their second position at the end of the vertical operation of the switch by the private magnet 210 which is controlled by the relay 203. When the dial is operated in accordance with the next and final digit in the number, the rotary magnet 212 will be operated in a manner readily understood, and the switch wipers will be rotated on to the contacts of the desired line. The main connector, of course, is operated at this time in precisely the same way that it was operated first when the connection was first extended to the branch exchange, with the exception that its operation is controlled by the relay 300 of the auxiliary connector H instead of by the line relay 200.

Suppose now, that no response is secured from the station just called. This being the case the party at substation A will doubtless wish to try still another station and will accordingly replace his receiver to release the main connector. Upon the deenergization of relays 300 and 303 a circuit for the release magnet 213 is completed as follows: ground at G^{23}, armature 239 and its resting contact, armature 330 and its resting contact, armature 340 and its working contact, off normal contact 218, and the winding of release magnet 213, to battery. After the main connector has been restored to normal by the operation of the release magnet 213 it may be again operated by the party at substation A as before.

Suppose, however, that a response is secured from the station to which the call has been transferred by the party at substation A. In this case when the receiver at the called station is removed the relays 207 and 206 of the main connector are energized. Under these circumstances when the receiver is removed at the called station the talking circuit will be completed as in the first instance and conversation can proceed as desired. The party at substation A will now replace his receiver and upon the resulting deenergization of relays 300 and 303 an energizing circuit will be completed for the release magnet 312 as follows: ground at G^{23}, armature 239 and its working contact, armature 329 and its resting contact, armature 341 and its working contact, off normal contact 316, and the winding of the release magnet 312, to battery. The release magnet 312 is accordingly operated to restore the auxiliary connector to normal. From the foregoing explanation of the release circuits it will be seen that when a call is transmitted to another station by way of the auxiliary connector, for example, the replacement of the receiver at the station from which the transferring operation was controlled will result in the release of the main connector or in the release of the auxiliary connector, depending upon whether a response was secured or not.

In the operation of transferring calls as described in the foregoing, whenever a party at a certain station transfers a call to another station he can remain in on the connection if he so desires, as the connector which is standing on his line is not released until he replaces his receiver. This may be objectionable in some instances, and in the case of a mercantile establishment, for example, it will perhaps be found best to exclude all of the ordinary employees from being third parties to connections, only the higher officials or certain other designated persons being permitted to remain in on transferred calls. In order to accomplish this the normal conductors of all those lines whose subscribers are to be denied the privilege of listening on transferred calls are reversed. In order to explain the release of the switches when calls are transferred by this class of subscribers, let us assume that the subscribers at substations A and A′ are to be prevented from staying in on transferred calls, the normal conductors being reversed so that conductors 35 and 285 terminate in the line relays of the respective line switches C

and C′ rather than in the normal ground connections. Now, if we assume that the main connector F is operated from the main exchange to establish connection with the line of substation A′, when the side switch has advanced to third position the relay 205 will not be energized as in the connection previously described for the energization of this relay requires that the line wiper 262 shall find ground potential upon the bank contact with which it comes in engagement. Relay 205 therefore remains deenergized whenever a line is called whose normal conductors are reversed. This is also true of the relay 306 of the auxiliary connector H. Now suppose that the party at substation A′ transfers the call by means of the auxiliary connector H to the substation A. When the party at substation A responds by removing his receiver the relay 300 of the auxiliary connector is energized and a circuit is instantly completed for the release magnet 213 of the main connector over the following path: ground at G^{26}, working contact of armature 326 and the said armature, armature 242 and its working contact, armature 249 and its resting contact, armature 237 and its resting contact, (relay 205 being deenergized), off normal contact 218, and the winding of the release magnet 213, to battery. Thus it will be seen that the main connector F is released and restored to normal position as soon as the subscriber to whom the call is transferred answers his telephone. When the connector shaft reaches its normal position a circuit is completed for the relay 214 as follows: ground at G^{26}, off normal contact 220, contact springs controlled by the armature 250 of relay 214, and the winding of the said relay, to battery. Upon energizing, relay 214 at its armature 249 shifts the release circuit from the release magnet of the main connector to the release magnet of the auxiliary connector, and at its armature 250 establishes a locking circuit for itself as follows: ground at G^{27}, off normal contact 317, armature 250 and its working contact, and the winding of the said relay 214, to battery. Now let us assume that the party at substation A desires to transfer the call to a third party by operating the main connector F again. When the connection is completed and such third party removes his receiver the relay 207 of the main connector will be energized as is usual under these circumstances and will instantly close a circuit for the release magnet 312 which is traceable as follows: ground at G^{26}, working contact of armature 326 and the said armature, armature 242 and its working contact, armature 249 and its working contact, resting contact of armature 337 and the said armature, off normal contact 316, and the winding of the release magnet 312 to battery. The auxiliary connector H is accordingly released and restored to normal, and when the shaft is at its lowest position the locking circuit of relay 214 is broken and this relay is permitted to deenergize. It will be seen that whenever the two connectors are off normal and their back bridge relays 207 and 300 are energized simultaneously, a circuit will be closed either through the release magnet 312 of the auxiliary connector or the release magnet 213 of the main connector, depending upon whether or not the relay 214 is energized. In regard to this relay 214, it of course, is energized every time the main connector is released providing the auxiliary connector H is in operated position regardless of how the release of the main connector is brought about. When the release occurs in response to the replacing of the receiver, however, the operation of relay 214 is of no utility, and hence was not described before.

It will be observed that the main connector F, (and also the auxiliary connector H), is provided with two test wipers and with two associated banks of test contacts. This provision is made to enable the connector to operate as a rotary connector. Certain departments may require more than one telephone line, and it is desirable that when one of these departments is called, the connector in use will be capable of selecting the first idle line extending to such department. Let us consider a department served by three telephones. The test contacts in the upper test banks which are associated with the first two lines will then be left dead, only the upper test contact which is associated with the last line of the three being connected to the associated lower test contact. The number to be called when connection with this particular department is desired will be determined by the position in the bank of the contact set associated with the first line of the group. Or, in other words, when the department is called the number of the first line extending thereto will always be called. Now, supposing that the main connector F is operated to establish connection with the first line of the group, and let it be assumed further that the first two lines are busy. Under these circumstances there will be a ground potential upon the test contact with which the test wiper 261 is in engagement, while there will be no ground potential upon the test contact engaged by the wiper 260, for this latter test contact, as previously explained, is disconnected. It follows that when the slow acting relay 203 deenergizes at the end of the final series of impulses directed to the main connector the private magnet 210 will not deenergize, but will be held up over the following circuit: ground on busy test contact engaged by the test wiper 261, the said wiper 261, side switch wiper 216 in second position, contact springs controlled by the armature 235 of relay 205, the right hand winding of the private magnet 210, and the side switch wiper 215 in second position, to battery. Re-

lay 203 having deenergized, a circuit may now be traced through the rotary magnet 212 as follows: ground at G29, armature 230 and its resting contact, working contact of the left hand armature of the private magnet and the said armature, resting contact of armature 232 and the said armature, resting contact of armature 236 and the said armature, winding of the rotary magnet 212, and side switch wiper 215 in second position, to battery. The rotary magnet 212 is therefore energized and the wipers of the connector are advanced one step in to engagement with the second line of the desired group. Upon energizing, the rotary magnet connects ground G^{30} to the left hand winding of the private magnet and the lower winding of relay 204 in parallel. The private magnet is thus held energized independent of the test wiper while such wiper is passing from one contact to another in the bank and at the same time the relay 204 is energized to break the circuit of the rotary magnet. The rotary magnet is then deenergized and in turn breaks the circuit through the left hand winding of the private magnet and the relay 204. The relay 204 is therefore deenergized and since the test contact upon which the test wiper 261 is now resting is busy also, the private magnet is maintained energized, and the rotary magnet circuit is again completed. The second operation of the rotary magnet is effective to advance the connector wipers into engagement with the third line of the desired group, which it will be assumed is idle. The parallel energizing circuits through the left hand winding of the private magnet and the upper winding of the relay 204 are closed as before, and the said relay 204 again opens the circuit of the rotary magnet. Now, when the rotary magnet deenergizes and breaks the circuit of the private magnet and relay 204, since the test wiper 261 is now resting upon the ungrounded test contact, the private magnet will be instantly deenergized and will permit the side switch wiper 215 to advance to its third position and interrupt the rotary magnet circuit, thereby stopping the rotation of the switch. From this point on the operation is the same as has already been described. It may be mentioned that the connector will stop upon the last trunk line of every group whether it is busy or not, for since the two test contacts associated with the last trunk line of each group are tied together the connector will operate when it lands on the last trunk line, precisely the same as it does when calling an individual line. The axuiliary connector H is adapted to operate as a rotary connector also and its circuits are substantially like those of the main connector F, hence it will need no detailed description.

The principal feature of the invention, the dual connector, having been explained, it will now be necessary to devote a little space to a description of the operations which occur when the repeater E is seized by a toll selector, rather than by a selector of the regular trunking system, as under these conditions the operation of establishing a connection with a station in the branch exchange is slightly different. Accordingly it will be assumed that a long distance operator has extended a connection through the medium of toll first and second selectors to the trunk conductors terminating in the bank contacts 136 to 140, inclusive, these contacts being located in the bank of the toll second selector. The toll selectors are not operated over the two talking conductors in series but over a separate fourth conductor which is grounded at the point from which the control of the switches is to be exercised. The circuit thus formed is interrupted by the calling device to control the first switch of the series, or the first selector, and as soon as the operation of this switch is completed it is extended to the controlling relay of the next switch. When, therefore, the toll second selector has completed its operation the grounded operating conductor is extended by way of the selector wiper and the bank contact 138 to the conductor 143, and thence by way of the winding of line relay 104 and the winding of slow acting relay 103 connected in parallel therewith by way of the armature 119 of relay 105, to battery. Relays 104 and 103 are accordingly energized and the latter relay, upon attracting its armature 113, connects ground to the conductor 144 thereby establishing a ground potential on test contacts 139 and 131 and their multiples to render the trunk line busy. This ground potential also extends over conductor 147 to the line switch C^2 and operates the cut-off relay 150. upon the energization of the line relay 104 a circuit is completed for the slow acting relay 105 which, upon energizing, breaks the circuit of the slow acting relay 103 at its armature 119, and at its armature 120 connects ground G^3 to the conductor 144, in order to maintain this conductor grounded after the relay 103 is deenergized. Relay 103 is operated in parallel with the line relay as described in order to insure that the cut off relay of the line switch C^2 will be energized before the operating or control circuit is completed over the trunk line to the main exchange. The relay 105 also completes, as before, a circuit for the polarizing winding of relay 107 at its armature 118, (the closure of this circuit being merely incidental however), and at the same armature, the line relay 104 now being operated, completes an energizing circuit over the conductor 146 of the trunk line for the relays 200 and 301 of the main and auxiliary connectors F and H, respectively. This circuit, or rather the portion thereof which includes relay 301 may be traced as follows: ground at G^4, armature 118, and its working contact, armature 115

and its working contact, resting contact of armature 112 and the said armature, trunk conductor 146, conductor 155, armature 319 and its resting contact, contact springs controlled by the armature 318, and the upper winding of relay 301 to battery. The branch of the above circuit which includes relay 200 extends from the resting contact of armature 319 by way of conductor 158, armature 228 and its resting contact, and the upper winding of the said relay 200, to battery. Relays 200 and 301 are energized in parallel, and the former relay closes the usual circuit for the slow acting release relay 201. Relay 201 upon energizing performs the same functions as were described before, including the closure of an energizing circuit for the cut-off relay 302. By the operation of the relay 302 a locking circuit is established for relay 301 as follows: ground at G^{23}, armature 239 and its resting contact, working contact of armature 324 and the said armature, armature 318 and its working contact, and the upper winding of relay 301, to battery. This circuit is, of course, established before the original energizing circuit of relay 301 is broken at armature 319. In its energized position relay 301 prepares at its armature 323 a circuit including both windings of the reversing relay 202 in the main connector and at its armature 325 closes a circuit for the ring cut off relay 208 of the main connector. It follows that the ring cut off relay 208 is energized at once before the main connector is operated and becomes locked over the usual circuit as soon as the shaft of the main connector begins to rise.

The apparatus is now in condition for the transmission of impulses. When the toll operator operates her calling device in accordance with the first digit of the local number in the branch exchange the line relay 104 is deenergized a number of times and at each deenergization interrupts the circuit of the line relay 200 of the main connector F. In response to these interruptions of its circuit the line relay 200 is deenergized a corresponding number of times and operates to raise the shaft of the main connector F through the medium of the vertical magnet 211 in the usual manner, the side switch wipers being advanced to the second position at the end of the vertical movement. When the second digit is called the connector rotates under the control of the relay 104 of the repeater and its line relay 200, and the connection to the called line is completed. Assuming that the called line is idle, the side switch wipers will be advanced to third position, and the switching relay 209 will energize. No automatic ringing operation takes place, however, for the ring cut off relay 208 has already been energized. When the operator desires to signal the called subscriber, which usually is immediately, she will throw her ringing key and thus project alternating current out over the two talking conductors of the trunk extending to the toll first selector. At the toll second selector there is an alternating current relay bridged across the talking conductors which responds to this ringing current and operates to ground the wiper of the toll selector which is in engagement with bank contact 137. This operation serves to complete a circuit over the conductor 142 for the relay 106 of the repeater E. Upon energizing the relay 106 disconnects the trunk conductor 148 from the lower talking conductor extending through the repeater and connects it instead to one side of the grounded generator. Ringing current is then projected by way of conductor 148 and the lower heavy talking conductor extending through the main connector F and the lower wiper 263 of the connector to the called station. The return path for the ringing current is through the upper windings of relays 207 and 200 of the connector F and the exchange battery to ground. It will be observed that relays 207 and 200 are bridged across the line during the ringing operation and while this is, of course, not an ideal condition under which to perform the signaling operation, it has been found to work satisfactorily. When the called subscriber answers relays 207 and 206 at the main connector F are energized and the latter relay opens the locking circuit of relay 301 at its armature 239. Relay 301 therefore deenergizes and cannot again be energized during the call now under consideration. It will be evident therefore that any stations to which the call may be subsequently transferred either by the operation of the auxiliary connector H or by the reoperation of the main connector F will be signaled automatically in the usual way. When the relay 206 energized upon the response of the called subscriber it also closed at its armature 239 the energizing circuit for the upper winding of the reversing relay 202. The operation of this relay during a toll connection controls the supervision to the operator. At the toll second selector there is a double wound supervisory relay bridged across the talking conductors in series with the battery. The lower winding of this supervisory relay which is connected to the lower heavy talking conductor and the lower winding of the relay 200 are both connected to the same pole of the battery. Consequently, when the relay 200 is in normal condition there will be no current flow over the line. However, when the reversing relay 202 energizes, conductor 148 is connected to the upper winding of relay 200 whereupon a flow of current will be set up from ground through the lower winding of the supervisory relay at the toll second selector, over the line wiper of the said selector (now in engagement with the bank

contact 140), bank contact 140, conductor 145, winding of low resistance relay 102, (and the non-inductive resistance in parallel therewith), resting contact of armature 122 and the said armature, truck conductor 148, working contact of armature 224 and the said armature, armature 229 and its working contact, and the upper winding of the line relay 200 to battery. By current flow in the above circuit the relay 102 is energized and connects conductor 146 with conductor 141 thereby completing the talking circuit. The supervisory relay at the toll second selector may control the supervisory light at the toll operator's position in any suitable manner to advise her that the called subscriber has answered. In case the called subscriber at the branch desires to transfer the call to another station it is done in exactly the same manner as has been already described.

The apparatus is disconnected when the toll operator takes down the connection. This operation ordinarily removes the ground from the operating conductor and permits a relay in the toll second selector and the line relay 104 in the repeater E, to deenergize. By the deenergization of these relays the apparatus is restored to normal position in a manner which is similar to the disconnection of the apparatus in a local call and which will therefore require no detailed explanation.

It will now be assumed that a connection is attempted to be set up by a toll operator as described in the foregoing, and that the called line is busy. In this case at the end of the rotary operation of the main connector F the side switch is not permitted to advance to third position, but is held in second position by the private magnet 210 which is maintained energized temporarily over a circuit which includes its right hand winding and the test wiper 261. Relay 205 is also energized via test wiper 260 and immediately changes the temporary energizing circuit of the private magnet into a locking circuit which includes the upper winding of relay 205, the upper winding of relay 204, and the right hand winding of private magnet. Inasmuch as the connection now under consideration is a toll connection, however, the relay 301 of the auxiliary connector will be energized and since the relay 205 and private magnet 210 are now energized also, a circuit will be completed for the reversing relay 202 as follows: ground at G^{15}, armature 234 and its working contact, right hand armature of the private magnet and its working contact, lower winding of relay 202, armature 323 and its working contact, and the upper winding of relay 202, to battery. The lower winding of relay 202 is of such high resistance that the release magnet 213 is not energized, although it is connected in parallel with the upper winding of relay 202 in the above circuit. Relay 202 is energized and shifts the lower trunk conductor 148 from ground to the live pole of battery to control the supervision to the operator as before. Also at its armature 226 the locking circuit over which the relay 204 and the private magnet are being energized is altered so that it no longer includes the upper winding of relay 205, but instead includes the lower test wiper 261. After the operation of relay 202 this locking circuit extends as follows: grounded test contact, test wiper 261, side switch wiper 216 in second position, armature 226, spring 227, upper winding of relay 204, armature 235 and its working contact, right hand winding of private magnet, and the side switch wiper 215 in second position, to battery. With the circuits in this condition the private magnet and relay 204 are maintained energized via the test wiper 261, while the relay 205 is maintained energized via its wiper 260, and it follows, of course, that when the called line becomes idle these relays and the private magnet will deenergize and the side switch wipers will be advanced to third position. The operator, of course, knows by the presence of the busy signal on the line when the connector is being held up by the busy line and she is notified when the line becomes idle by the lighting of the supervisory lamp when the reversing relay 202 deenergizes. The foregoing operations occurring when calling a busy line only happen when the connector F is operated for the first time. On transferred calls both connectors lock on busy in the usual manner whether the call is coming from a local subscriber in the main exchange or from a toll operator's position.

Referring to Fig. 1 a brief description will now be given of the operation of the connector D in completing a local connection. Assuming that it is desired to call substation A′ from the substation A, when the receiver is removed at the latter substation an energizing circuit is completed for the line relay 14 of the line switch C as follows: ground at G^{30}, resting contact of armature 19 and the said armature, line conductor 13, transmitter 3, receiver 2, impulse springs 7 and 8, switch hook springs, line conductor 12, armature 18 and its resting contact, and the winding of line relay 14, to battery. Upon energizing, the line relay 14 operates a mechanical device which in its normal condition prevents the complete energization of the combined switching and cut-off relay 15 and its armature 22 completes a circuit for the said relay as follows: ground at G^{30}, armature 22 and its working contact, winding of the relay 15, and the winding of the stepping magnet 16 to battery. At the same time that it completes the above traced circuit the line relay connects the test wiper 25 to the junction of the relay 15 and the stepping magnet 16 as follows: test wiper 25, armature 20 and

its resting contact, armature 21 and its working contact, to the junction of the said relay and magnet. The operation now depends upon whether the test contact with which the test wiper 25 is in engagement is busy or not. If this test contact is busy there will be a ground potential upon it, the switching relay 15 will be short-circuited, and the stepping magnet 16 will be energized. Since the stepping magnet 16 interrupts its own circuit it will be operated intermittently to advance the wipers 23 to 26, inclusive, step by step as long as the test wiper 25 continues to engage busy or grounded test contacts. As soon as the test wiper 25 arrives at an ungrounded test contact, as for example the test contact 29, the operation of the stepping magnet will cease, and the switching relay 15, being no longer short circuited, will immediately energize. Owing to the high resistance of the switching relay the stepping magnet remains inoperative. It will be understood, of course, that if the test wiper 25 is already standing upon an idle or ungrounded test contact when the receiver is removed at substation A no rotation of the switch will take place, the switching relay 15 being energized immediately. Upon energizing, the relay 15 shifts the connection of the test wiper 25 from the line relay armature 21 to its own lower terminal and at armatures 18 and 19 extends the incoming line conductors 12 and 13 by way of the line wipers 24 and 26, bank contacts 28 and 30, and contact springs 48 and 49 to the windings of the double wound line relay 50 of the connector D. Upon energizing, the line relay 50 completes the usual energizing circuit for the slow acting release relay 52, which upon energizing in turn completes a holding circuit extending back to the line switch C as follows: ground at G^{31}, working contact of armature 65 and the said armature, conductor 32, bank contact 29, test wiper 25, armature 20 and its working contact, winding of switching relay 15, and the winding of the stepping magnet 16, to battery. It is understood that the above circuit is completed before the slow acting relay 14 has had time to deenergize. Ground potential on multiples of the test contact 29 renders the connector D busy to other line switches, and ground potential on its test contacts 91 and 269 and their multiples (by way of conductor 36) renders the line of substation A busy to the local and incoming connectors.

The dial of the calling device at substation A may now be operated in accordance with the first digit in the number of substation A′. A series of interruptions is thereby produced in the energizing circuit of the line relay 50 of the connector D and at each resulting deenergization of this relay an impulse is transmitted to the vertical magnet 59 as follows: ground at G^{32}, armature 64 and its resting contact, armature 63 and its resting contact, armature 66 and its working contact, side switch wiper 89 in first position, low resistance slow acting private control relay 53, winding of the vertical magnet 59, and the side switch wiper 87 in first position, to battery. By the operation of the vertical magnet the connector shaft is raised step by step until wipers 40, 41 and 42 stand opposite the required horizontal level of bank contacts. Relay 53 is energized in series with the vertical magnet and controls the private magnet 57 in the usual manner to advance the side switch wipers to their second position at the end of the vertical movement of the switch. When the calling dial is operated in accordance with the final digit in the called number the line relay 50 is again deenergized momentarily, and now, since the side switch wiper 87 is in second position, the rotary magnet 60 is operated to rotate the wipers 40, 41 and 42 into engagement, respectively, with the bank contacts 93, 94, and 95. The relay 53 and the private magnet are energized as before and at the end of the rotation of the deenergization of the latter the side switch wipers are advanced to their third position. A circuit is now completed for the lower winding of the switching relay 58 as follows: ground at G^{31}, working contact of armature 65 and the said armature, conductor 32, shaft controlled contact springs 82, armature of the private magnet 57, lower winding of switching relay 58, side switch wiper 88 in third position, test wiper 41, bank contact 94, conductor 284, winding of the cut off relay 15′ of line switch C′, and the winding of stepping magnet 16′, to battery. Simultaneously with the closure of the above circuit a circuit is completed through the slow acting relay 53 as follows: grounded conductor 32, armature 78 and its resting contact, side switch wiper 89 in third position, winding of the relay 53, resistance 85, and the side switch wiper 87, to battery. The operation now depends upon whether the line of substation A′ is busy or idle. If the line is busy there will be a grounded potential on the test contact 94 and the lower winding of the relay 58 will be short circuited, this relay accordingly being inoperative. When the relay 53 energizes the usual circuit is completed for the private magnet 57 which upon energizing disconnects the lower winding of the switching relay 58. As a further result of its energization relay 53 connects a lead from the busy signaling machine Q to the lower side of the calling line, and thereby notifies the calling subscriber that the desired line is for the time being inaccessible. The calling subscriber will therefore replace his receiver, and the switches C and D will be restored to normal in the usual and well understood manner.

We will suppose, however, that the line of substation A′ was idle rather than busy

when it was called. The switching relay 58 is so adjusted that it will energize slightly ahead of the slow acting relay 53 and when, therefore, the circuits of these two relays are closed simultaneously, as already explained, the switching relay 58 will operate in series with the cut off relay of the called line and will break the circuit of the slow acting relay 53 at the resting contact of armature 78 before the latter relay has had time to energize. In its energized position the switching relay 58 connects the grounded conductor 32 to its own upper winding at the right hand working contact of armature 78 and at the left hand working contact of the same armature connects this grounded conductor by way of the side switch wiper 88 in third position to the test wiper 41, thereby placing direct ground upon the test contact 94 and its multiples. As a further result of its energization relay 58 connects the line wipers 40 and 42 at its armatures 77 and 79, thereby establishing the usual signaling circuit for actuating the ringer at the called substation. Upon the response of the called subscriber the ring cut off relay 55 is operated to open the signaling circuit and to establish the usual locking circuit for itself by way of its armature 71 and the off normal contact 83. The ring cut off relay 55 also connects the back bridge relay 56 across the called line in series with the battery in the usual way to supply talking current to the called substation. The relay 56 is of course energized during the conversation, but the circuit changes which it produces are of no utility in connections of this kind.

The release of the connection occurs when the calling subscriber at substation A replaces his receiver. This act brings about the deenergization of the line relay 50 and the release relay 52 thereby completing a circuit for the release magnet 61 as follows: ground at G^{32} armature 64 and its resting contact, armature 63 and its resting contact, armature 66 and its resting contact, off normal contact 84, and the winding of release magnet 61, to battery. By the operation of the release magnet 61 the connector is restored to normal position, the release magnet circuit being then opened by the switch shaft at the off normal contact 84. The deenergization of relay 52 also removes ground from the conductor 32 thereby breaking the circuit of the switching relay 15 of the line switch C. By the deenergization of the said switching relay the line conductors 12 and 13 are disconnected from the wipers of the line switch and the line is placed in idle condition again ready for calling or to be called.

The connector D is capable of operating as a selector switch on the ninth and tenth levels and in order to accomplish this it is provided with a switching relay 51 and with contact springs 81 and contact springs 82. These latter are controlled by a cam on the shaft in such a manner that when the shaft is raised to either the ninth or tenth level the contact springs 81 will be closed, while if the shaft is raised to the tenth level the contact springs 82 will be separated. With this understanding a brief explanation will now be made of the operation of the connector D in selecting an idle trunk line such for example as the trunk line comprising conductors 146 and 148 which terminate in the first contact set of the ninth level. This trunk line, it will be understood, is one of a group of similar trunk lines which connect the branch with the main exchange. Since these trunk lines terminate in the ninth level, when a connection to the main exchange is desired, the first digit to be called will be the digit 9. When the receiver is removed at substation A line switch C is operated in the usual manner to extend the connection to an idle connector switch, which we will assume to be the connector D. The dial of the calling device being now actuated in accordance with the digit 9, the connector will be operated under the control of the line relay 50 to raise its shaft step by step until the wipers stand opposite the ninth horizontal level. At this time the contact springs 81 are closed by the shaft and a circuit is established for the upper winding of relay 56 as follows: ground at G^{33}, contact springs 81, resistance 86, contact springs controlled by armature 70 of relay 55, and the upper winding of said relay 56, to battery. Upon energizing, the relay 56 prepares a circuit for the switching relay 51 at its armature 76, at its armature 75 prepares a test circuit including the private magnet 57, which is held open temporarily by the slow acting relay 53, and at its armature 74 prepares a circuit for the rotary magnet 60. When the relay 53 deenergizes at the end of the vertical operation of the switch, the private magnet 57 is deenergized also and advances the side switch wipers to their second position. A circuit is immediately completed for the rotary magnet 60 as follows: ground at G^{34}, resting contact of armature 69 and the said armature, working contact of armature 74 and the said armature, winding of the rotary magnet 60, and the side switch wiper 87 in second position, to battery. The rotary magnet is accordingly operated and the switch wipers are advanced into engagement with the first contact set of the ninth level. The rotary magnet also closes a circuit for the relay 54 which extends from ground G^{33} by way of contact springs 81 the armature of the said rotary magnet, and the winding of relay 54, to battery. Relay 54 upon energizing opens the circuit of the rotary magnet and permits it to deenergize thereby breaking the circuit of the relay 54. The test wiper 41 is now in engagement with the test contact 97 and if we assume that the first trunk line is busy there

will be a ground potential upon test contact 97 with the result that the private magnet 57 will be energized over the following circuit: grounded test contact 97, test wiper 41, side switch wiper 88 in second position, working contact of armature 75 and the said armature, contact springs controlled by armature 67 of relay 53, and the winding of private magnet 57 to battery. By the energization of the private magnet over the above circuit the side switch wipers are held in second position and the switch will continue to rotate by the alternate energizations of the rotary magnet 60 and the interrupter relay 54. As soon as the test wiper 41 arrives at an idle or ungrounded contact the circuit of the private magnet will be broken and the side switch wipers will be advanced to third position, thereby breaking the circuit of the rotary magnet and stopping the rotation. If we assume that the first trunk line, which is the one shown in the drawing, is idle, the rotary magnet will only be operated once and the side switch wipers will be advanced to their third position immediately. The switching relay 58 is then energized in series with the cut off relay 302 (Fig. 2) with the usual results. The relay 56 being energized, a circuit is now completed for the switching relay 51 as follows: grounded conductor 32, armature 78 and its right hand working contact, working contact of the armature 76 and the said armature, armature 73 and its resting contact, and the winding of the relay 51, to battery. By the operation of the armatures 62 and 63 of the switching relay 51 the incoming line conductors are extended by a direct metallic connection to the armatures 77 and 79 of the switching relay 58 and thence to the line wipers 40 and 42 which are now in engagement with the conductors 152 and 154, respectively. The line switch C^2 at the main exchange is now operated to extend the trunk line to an idle selector switch in the main exchange The relay 44 of the connector D, being in series with the upper line conductor, is energized at this time and connects ground to the conductor 32 to guard against the release of the switch upon the deenergization of relays 50 and 52. The dial of substation A may now be operated in accordance with the digits in the number of the desired subscriber at the main exchange, thereby operating a series of switches in the main exchange trunking system to complete the connection. It should be noted that the relay 44 at the connector D is slow acting and does not respond to impulses. It is also understood of course, that the trunk will be clear of all connections in the dual connector at this time owing to the fact that the cut off relay 302 has been operated as explained. The release of the connection occurs in the usual manner when the calling subscriber at substation A replaces his receiver and will require no detailed explanation.

It has been mentioned before that there may be a second group of trunk lines accessible to the group of connectors of which the connector D is one, which trunk lines are adapted to be called only by certain subscribers of the branch exchange, the remaining subscribers being denied access thereto. These trunk lines may terminate in the tenth level and connection may be extended to an idle one of them by calling the digit 0 in substantially the same way that connection is extended to a trunk line of the other group by calling the digit 9. Special means are provided, comprising shaft controlled contact springs 82 which prevent the operation of the switching relay 58, when certain subscribers are calling, thereby preventing such subscribers from completing connection with one of these trunk lines. These contact springs 82 are separate whenever the connector D is raised to the tenth level and serve to disconnect the grounded conductor 32 from the lower winding of the said switching relay; however, all those lines which are to be given access to the trunk lines terminating in the tenth level are provided with means in their respective individual line switches for closing an alternative circuit for the switching relay of the connector in use. This means comprises a fourth wiper and a fourth set of bank contacts. Referring to the line switch C, when the switching relay 15 energizes on an outgoing call the wiper 23 is connected with the test wiper 25 and is accordingly grounded. This being the case, if the connector D should now be operated to select an idle trunk in the tenth level the relay 58 would be energized regardless of the fact that the contact springs 82 are separated, for its lower terminal is connected to ground by way of the conductor 31, bank contact 27, and the grounded wiper 23 of the line switch. Thus it will be seen that the subscriber at substation A having a line switch wired like the line switch C would have access to the trunks on both the ninth and tenth levels. Considering now the substation A′ and its associated line switch C′ it will be seen that the upper wiper 23′ is disconnected. It will be readily seen that if the subscriber at this latter substation should attempt to obtain a connection with a trunk line in the tenth level the switching relay of the connector in use will be prevented from energizing and the connection would be prevented.

Having described my invention what I consider to be new and desire to have protected by Letters Patent will be pointed out in the appended claims.

What I claim as my invention is:

1. In a telephone system, subscribers' lines of two classes, a trunk line, a pair of automatic switches, means for operating one of

said switches over said trunk line to connect with a called line of either class, connections between the said switches whereby the second switch may be operated over the connected called line to establish connection with a second called line, and a release magnet in said first switch controllable either by the subscriber on the line first called or by the subscriber on the line last called, depending upon the class to which the said first line belongs.

2. In a telephone system, a pair of automatic switches, means for operating said switches alternately to connect with called lines, a release circuit comprising a conductor extending between said switches, two branches for said release circuit, a release magnet in one of said branches for one of said switches, a release magnet in the other branch for the other of said switches, a grounded battery having its ungrounded pole connected to said release magnets, and means for grounding said branches alternately over said conductor to energize said release magnets alternately.

3. In a telephone system, means including a trunk line for connecting a calling and called subscriber's line, a pair of inductive windings connected in parallel across the said trunk line during the establishment of the connection, and means for connecting said windings in series across said trunk line during conversation.

4. In a telephone system, a trunk line in two sections, a repeater at which said sections are inductively connected, means for extending a calling line to the first section, means responsive thereto for completing a bridge across the second section, a differential relay having its two opposing windings connected in parallel in said bridge, means for interrupting said bridge and automatic switches responsive to such interruptions for completing connection to a called line, and means actuated upon the response of the called subscriber for altering the circuit of said bridge whereby the windings of said relay are connected in series

5. In a telephone system, a trunk line accessible from two different points and terminating in an automatic switch, a repeater in said trunk line, means for seizing said trunk line at either point and for transmitting impulses to said repeater, means in said repeater responsive to impulses from one point for repeating impulses over the two sides of said trunk line in series to operate said switch, and means in said repeater responsive to impulses from the other point for repeating impulses to said switch over one conductor of said trunk line and ground return, independent of the other conductor.

6. In a telephone system, a trunk line including a repeater, a talking conductor normally closed through said repeater and including a relay winding, a second talking conductor extending through said repeater and normally open at contacts of said relay, a third conductor over which impulses may be transmitted to said repeater, means in said repeater for repeating said impulses over one section of the normally open talking conductor to operate an automatic switch to extend a connection to a called line, and means actuated upon the response of the called subscriber to create a flow of current in the normally closed talking conductor to operate said relay and close the other talking conductor.

7. In a telephone system, a branch exchange comprising a group of subscribers' lines, local connectors for connecting said lines, two groups of trunk lines terminating in said connectors and extending to different points, means whereby any subscriber in the branch may operate any idle one of said connectors as a selector to select and connect with an idle trunk line in one of said groups, and means for permitting certain ones only of said subscribers to so operate an idle connector to select and connect with an idle trunk line in the other group, the remaining subscribers being denied access to the said second group of trunks.

8. In a telephone system, a calling station, automatic means for extending a talking connection to a called station, automatic means operated from the called station over a portion of said first extended connection for then extending the connection to a second called station, and means effective before the second called line is found whereby apparatus used in extending an incomplete call toward such second called station may be restored from said first called station while said first extended connection is still maintained.

9. In a telephone system, a calling station, automatic means for extending a talking connection to a called station, automatic means operated from the called station for then extending the connection to a second called station, means effective before the connection is established with the terminals of the second called station whereby apparatus used in extending an incomplete call toward such second called station may be restored from said first called station without releasing its own connection, and means controlled from the calling line for releasing both of said extended connections.

10. In a telephone system, a calling line, a first automatic switch for extending a connection to a first called line, a second automatic switch controlled from the first called line for then extending the connection to a second called line, a release circuit for said first automatic switch, a relay in said second automatic switch for controlling said release circuit, and a relay in said first switch cooperating with said first relay whereby the first automatic

switch may be released under the control of the first called line.

11. In a telephone system, a trunk line terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line and for operating one switch of said pair into connection with one of said lines, means for then operating the other switch of said pair to extend a connection in the direction of another of said lines, and means controlled from said first called line for releasing said other switch before said other switch has made connection with the terminals of said other called line while still maintaining said first established connection.

12. In a telephone system, a trunk line terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line and for operating one switch of said pair into connection with one of said lines, means controlled from the connected line for operating the other switch of said pair to extend a connection to another of said lines, and means controlled from said first called line for releasing only said other switch before said other switch has connected with the terminals of said other called line.

13. In a telephone system, calling lines, called lines divided into two classes, means for extending a connection from one of said calling lines to a called line in either of said classes, means for then extending the connection to a second called line, means operative for releasing said first extended connection upon the response of the subscriber on the second called line when the said first called line is in one of said classes, and means operative for preventing the release of said first established connection upon the response of the subscriber on the second called line in case the said first called line is in the other of said classes.

14. In a telephone system, calling lines, called lines divided into two classes, automatic switches controlled from one of said calling lines for establishing a connection with a called line in either of said two classes, other automatic apparatus controlled from the called line for then extending the connection to a second called line, means operative for releasing the first established connection upon the response of the second called subscriber when the first called line is a line in one of said classes, and means operative for preventing such release in case the first called line is a line in the other of said classes.

15. In a telephone system, calling lines, called lines divided into two classes, automatic switches controlled from one of said calling lines for establishing a connection with a called line in either of said classes, other automatic apparatus controlled from the called line for then extending the connection to a second called line, means operative for automatically releasing the first established connection independent of control from the first called line provided the said first called line is a line in one of said classes, and means operative for preventing such automatic release in case the said first called line is a line in the other of said classes.

16. In a telephone system, a trunk line terminating in an automatic switch, telephone lines accessible to said switch, two groups of trunk lines accessible to said switch, means for seizing said first trunk line and for operating said switch to connect with one of said telephone lines or to select and connect with an idle trunk in one of said groups, and service restricting means for preventing said switch from connecting with any trunk line in said second group.

17. In a telephone system, a trunk line terminating in an automatic switch, telephone lines accessible to said switch, two groups of trunk lines accessible to said switch, means for seizing said first trunk line and for operating said switch to connect with one of said telephone lines or to select and connect with an idle trunk in one of said groups, and service restricting means including a conductor of said trunk line for preventing said switch from connecting with any trunk line in the other of said groups.

18. In a telephone system, a four conductor trunk line terminating in an automatic switch, subscribers' lines accessible to said switch, two groups of trunk lines accessible to said switch, means for seizing said first trunk line and for operating said switch to connect with one of said subscribers' lines or to select and connect with an idle trunk in one of said groups, and service restricting means including the fourth conductor of said trunk line, for preventing said switch from connecting with any trunk line in the other of said groups.

19. In a telephone system, a branch exchange comprising a group of subscribers' lines, local connectors for connecting said lines, two groups of trunk lines accessible to said connectors, means controlled from any one of said lines for operating any idle one of said local connector switches as a selector to select and connect with an idle trunk line in one of said groups, and service restricting means whereby only the subscribers on certain of said lines can connect with an idle trunk line in the other of said groups.

20. In a telephone system, a trunk line terminating in an automatic switch, groups of lines accessible to said switch, means for seizing said trunk line and for operating said switch to select one of said groups of lines, means for initiating an automatic secondary movement of said switch to select any idle line in the selected group of lines, a relay energized when an idle line is found for com-

pleting a connection to said idle line, a circuit for said relay including a conductor of said trunk line, and means for maintaining said circuit open to prevent said relay from energizing.

21. In a telephone system, a trunk line terminating in an automatic switch, telephone lines accessible to said switch, operating magnets for said switch, means for making one of said lines busy, means for seizing said trunk line and for controlling the operation of said magnets to extend a connection to said busy line, a slow acting relay energized in series with said operating magnets for controlling the operation of said switch, and means for again energizing said relay when connection is made with said busy line to place a tone on said trunk line.

22. In a telephone system, a trunk line terminating in an automatic switch, telephone lines accessible to said switch, operating magnets for said switch, means for making one of said telephone lines busy, means for seizing said trunk line and for controlling the operation of said magnets to cause said switch to extend a connection to said busy telephone line, a slow acting relay, an energizing circuit for said relay including said magnets, a second circuit for said relay controlled by the test wiper of said switch, means controlled by said relay when energized over the first mentioned circuit for controlling the operation of said switch, and means controlled by said relay when energized over said second circuit for placing a busy tone on said trunk line.

23. In a telephone system, a trunk line accessible over two paths terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line over either path and for operating one switch of said pair to extend a connection to one of said lines, means controlled from the connected called line for operating the other switch of said pair into connection with another of said lines, automatic means in said first switch operative when said trunk line is seized over one of said paths for connecting ringing current to the first called line, and means operative when said trunk line is seized over said other path for preventing the application of said ringing current.

24. In a telephone system, a trunk line accessible over two paths terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line over either path and for operating one switch of said pair to extend a connection to one of said lines, means controlled from the connected called line for operating the other switch of said pair into connection with another of said lines, automatic means in said first switch operative when said trunk line is seized over one of said paths for connecting ringing current to the first called line, a differential relay in said first switch for preventing the application of said ringing current, and means for operating said differential relay when said trunk line is seized over said other path.

25. In a telephone system, a trunk line accessible over two paths terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line over either path and for operating one switch of said pair into connection with one of said lines, means controlled from the called line for then operating the other switch of said pair into connection with another of said lines, means operative when said trunk line is seized over one path and when said first line is busy for preventing the first switch of said pair from connecting therewith when said line becomes idle without releasing said first switch and means operative when said trunk line is seized over said path and said first line is busy for enabling said first switch to connect therewith immediately upon said line becoming idle.

26. In a telephone system, a trunk line accessible over two paths terminating in a pair of automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line over either path and for operating one switch of said pair into connection with one of said lines, means controlled from the called line for then operating the other switch of said pair into connection with another of said lines, means operative when said trunk line is seized over one path and said first line is busy for preventing the first switch of said pair from connecting therewith when said line becomes idle without releasing said first switch and a differential relay in said pair of switches operative when said trunk line is seized over said other path and said first line is busy for enabling said switch to connect therewith immediately upon said line becoming idle.

27. In a telephone system, a pair of automatic switches, means for operating said switches alternately to connect with called lines, a release circuit comprising a conductor extending between said switches and having a branch individual to each switch, a release magnet associated with each of said branches, a grounded battery having its ungrounded pole connected to said release magnets, means for substituting a ground connection for one of said branches, and means for connecting the other branch to its associated release magnet to energize said magnet over said conductor.

28. In a telephone system, a trunk line terminating in a pair of two motion automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line and for operating one of said switches in two movements to connect

with one of said called lines, means controlled from the said called line for operating the other switch of said pair in a primary and secondary movement to extend the connection in the direction of another of said lines, and means controlled from said first called line for releasing said other switch at any time before its secondary movement is terminated while maintaining the first established connection.

29. In a telephone system, a trunk line terminating in a pair of two motion automatic switches, telephone lines accessible to said pair of switches, means for seizing said trunk line and for operating one of said switches in two movements to connect with one of said called lines, means controlled from the said called line for operating the other switch of said pair in a primary and secondary movement to extend the connection in the direction of another of said lines, and means for releasing said other switch during its primary or secondary movement while maintaining said first established connection.

30. In a telephone system, a trunk line terminating in a pair of automatic switches, a line relay and a release relay controlled thereby in the first of said switches, a cut off relay in the second of said switches, a circuit including contacts of said cut off relay for energizing said line relay over said trunk line when the trunk is taken for use, contacts on said release relay for connecting the trunk line with the line relay over a direct path independent of the said cut off relay contacts, and a circuit for said cut off relay controlled by said release relay.

31. In a telephone system, a trunk line for handling two classes of calls, an automatic switch controlled over the two sides of said trunk in series if a call is of one class and over one conductor and ground return if the call is of the other class, a controlling line relay for said switch bridged across said trunk line, means for discriminating between the two classes of calls comprising a differential relay normally bridged across said trunk line in parallel with said line relay, and means for disconnecting said differential relay responsive to the energization of the line relay when the trunk line is taken for use.

32. In a telephone system, a trunk line for handling two classes of calls, an automatic switch controlled over the two sides of said trunk in series if a call is of one class and over one conductor and ground return if the call is of the other class, a controlling line relay for said switch bridged across said trunk line, a differential relay for discriminating between the two classes of calls normally bridged across said trunk line in parallel with said line relay, circuit arrangements controlled by the line relay when energized over the trunk whereby the line relay is separately connected to the trunk line over a new path, and means controlled by the line relay for opening the circuit connections by which the line and differential relays are normally connected to the trunk.

33. In a telephone system, a trunk line terminating in a pair of automatic switches, means whereby an operator can connect with said trunk line and operate the first of said switches to extend a connection to a called line, ringing equipment in said first switch controlled by the operator at any desired time after the connection is established for signalling the called subscriber, means whereby the subscriber on the connected called line can operate the second of said switches to transfer the call to a second called line, and ringing equipment in the second of said switches operating automatically as soon as the call is transferred to signal the second called subscriber independent of operator control.

34. In a telephone system, a trunk line terminating in a pair of automatic switches, means whereby an operator can connect with said trunk line and operate the first of said switches to extend a connection to a called line, means for temporarily preventing the completion of the connection in case the called line is busy and for automatically completing it when the called line becomes idle, means whereby the subscriber on the connected called line can operate the second of said switches to transfer the call to a second called line, and locking means for preventing the completion of the connection to the second called line if busy, said locking means being unaffected by a change from busy to idle condition.

35. In a telephone system, a main exchange and a branch exchange, an interconnecting trunk line, automatic switching mechanism controlled over said trunk line to extend a connection to a called line in the branch exchange, means for supplying signalling current from the main exchange over a conductor of said trunk line to signal the called subscriber, means controlled by the subscriber on the connected called line for transferring the call to a second called line, and means for supplying signalling current from the branch exchange to signal the second called subscriber.

36. In a passing call system, a main connector and means for operating it to extend a connection to a called line, an auxiliary connector permanently associated with said main connector and operable for transferring the connection to a second called line, a release magnet in the auxiliary connector, and a circuit for said magnet normally open at said auxiliary connector and maintained closed in said main connector until the subscriber on the first called line answers the call.

37. In a passing call system, a main connector and means for operating it to extend

a connection to a called line, an auxiliary connector permanently associated with said main connector and operable for transferring the connection to a second called line, a release magnet in the auxiliary connector, and a circuit for energizing said release magnet in case the auxiliary connector is accidentally moved off normal while the main connector is in operated position and before the subscriber on said first called line has answered.

38. In a passing call system, a pair of automatic switches for transferring calls under called subscriber control, a release magnet in each switch, a release circuit normally associated with one of said magnets, a switching relay for transferring said circuit to the other magnet, a back bridge relay in each switch, contacts on each of said back bridge relays included in said release circuit, an initial energizing circuit for said switching relay including contacts on the back bridge relay of the second switch and off normal contacts of the first switch, and a locking circuit for said switching relay including off normal contacts of the second switch.

39. In a passing call system, a pair of switches, circuit arrangements whereby said switches may be controlled by called subscribers to pass calls, a release magnet in each switch, a back bridge relay in each switch, a circuit for said release magnets including serially related contacts on said relays, a relay for switching the said circuit from one release magnet to the other, off normal contacts in each switch, an initial energizing circuit for said switching relay including the off normal contacts in one switch, and a locking circuit for said relay including the off normal contacts in the other switch.

40. In a passing call system, a main connector switch and an auxiliary connector switch for completing and transferring calls, an operating magnet for each switch, a back bridge relay for each switch, a circuit for the operating magnet of the main switch controlled by the back bridge relay of the auxiliary switch, and a separate circuit for the operating magnet of the auxiliary switch controlled by the back bridge relay of the main switch, the said second circuit being exclusive of any conductor or conductors included in the first circuit excepting the ground and battery feed conductors which extend to the two poles of the exchange battery.

41. In a passing call system, a main switch and means for operating it to extend a connection to a called line, an auxiliary switch permanently associated with said main switch controlled by the subscriber on the connected called line to transfer the call to a second called line, an operating magnet for each switch, circuit connections whereby one terminal of each magnet is connected to one pole of the exchange battery, the other terminals of said magnets being normally disconnected from each other, and circuit connections whereby the said other terminals of said magnets may be separately connected to the other pole of said battery.

42. In a passing call system, a main switch and means for operating it to extend a connection to a called line, an auxiliary switch temporarily associated with the connected called line controlled by the subscriber on the connected called line to transfer the call to a second called line, an operating magnet for each switch, terminals for said magnets normally disconnected from each other, terminals of said magnets connected to a grounded source of current, and means for separately grounding said normally disconnected terminals to energize the magnets and operate said switches as set forth.

43. In a passing call system, a main switch and means for operating it to extend a connection to a called line, an auxiliary switch temporarily associated with said main switch controlled by the subscriber on the connected called line to transfer the call to a second called line, and an operating magnet for each switch, said first mentioned operating means comprising a relay in the main switch and a circuit whereby a series of operating impulses may be transmitted to the magnet of the main switch by the calling subscriber while the current flow through the magnet of the auxiliary switch is maintained at zero during the entire time said impulses are being transmitted.

44. In a telephone system, a duplex connector, first and second lines leading from the connector bank, a trunk terminating at the incoming end of the connector, said connector being operable to transfer a call extending over the trunk from one line to the second line, and means for impressing one of two kinds of signalling current over a called line depending upon whether the call is over the trunk or a transferred call.

45. In a telephone system comprising a local trunking system for use by local subscribers and a toll trunking system for use by toll operators, an automatic switch common to both said trunking systems, means including said switch for extending a toll connection or a local connection to a called line, automatic ringing equipment associated with said switch, a ring cut-off relay in said switch, means effective only during the establishment of a toll connection for energizing said relay to disconnect said ringing equipment before the connection to the called line is completed, and a locking circuit for maintaining said relay energized.

46. In a telephone system, a subscriber's line, means including an automatic switch for extending a connection to said line, automatic ringing equipment associated with said switch,

a ring cut-off relay in said switch, means for energizing said relay during the establishment of the connection, and a locking circuit for maintaining said relay energized to prevent said ringing equipment from signalling the said line when the connection thereto is completed.

47. In a telephone system, a subscriber's line, means including an automatic switch for extending a connection to said line, a ring cut-off relay in said switch, a ringing circuit including contacts of said ring cut-off relay, means for energizing said relay to open said ringing circuit before the said line is connected with, and a locking circuit for said relay completed during the operation of said switch to maintain the relay energized.

48. In a telephone system, a subscriber's line, means including an automatic switch for extending a connection to said line, a ring cut-off relay in said switch, a ringing circuit including contacts of said ring cut-off relay, means for energizing said relay to open said ringing circuit when the switch is taken for use, and means for locking said relay in energized position while the switch is being operated.

49. In a telephone system, a subscriber's line, means including an automatic switch for extending a connection to said line, a ring cut-off relay in said switch, a ringing circuit including contacts of said ring cut-off relay, means for energizing said relay to open said ringing circuit during the establishment of the connection, and a self-locking circuit for maintaining said relay in energized position.

50. In a telephone system comprising a local trunking system for use by local subscribers and a toll service trunking system for use by toll operators, a final connector switch common to both trunking systems, means for operating said connector to complete a toll connection or a local connection to a called line, automatic ringing equipment normally connected to automatically ring any called line connected with in either type of connection, a ring cut-off relay in said connector, and means for energizing said relay and locking the same electrically while the connector is being operated to complete a toll connection while permitting said relay to remain deenergized to start the automatic ringing at once when the connector is operated to complete a local connection.

51. In a telephone system, lines, automatic switch mechanism, means for operating said switch mechanism in order to connect a calling to a called one of said lines, means for reversing the direction of current projected over the calling line consequent to a response on the said called line, means of control on the called line for restoring the direction of current on the calling line, alternative means for extending the said connection to a second called line to form a Y connection between the lines, means for disconnecting the first called line without restoring the current direction over the calling line, and means thereafter controlled over the second called line for restoring the current direction over the calling line.

52. In a telephone system, a calling line terminating in a pair of switch elements, lines, mechanism for reversing the current traversing the calling line, means for operating a first one of said switch elements into connection with a first one of said lines, manually controlled means on the said first line to operate the said reversing mechanism, means for operating the second of said switch elements into connection with a second one of said lines forming a Y connection between the calling and the said first called and second called lines, means for thereafter disconnecting the said first line without restoring the direction of current on the calling line, means for then operating the said first element into connection with a third said line forming a Y connection between the calling and the said second and third lines, means for thereafter disconnecting the said second line without restoring the direction of current on the calling line, and means manually controlled from the said third line for restoring the direction of current traversing the calling line.

53. In a telephone system, a subscriber's line, an automatic switch operated to seize said line, a ring cut-off relay in said switch, a ringing circuit extending through contacts of said relay, and means effective in certain instances to energize said relay to open the ringing circuit before the line is connected with and means effective in other instances to energize said relay after the line is connected with.

54. In a telephone system comprising a local trunking system and a toll trunking system, an automatic switch common to both systems, means including said switch for extending a toll or local connection to a called line, automatic ringing equipment associated with said switch, said equipment operated in a local call to signal a called subscriber, and means effective only during the establishment of a toll connection for preventing the operation of any ringing equipment in said connector to signal a called subscriber.

55. In a telephone system, a local and a toll trunking system for signalling a called subscriber including a final connector switch for seizing a called line, said switch operated by a toll operator or a subscriber to extend either a toll or local connection, a toll trunk line leading to said switch used in toll connections, means in the connector for applying signalling current to a called subscriber in a local connection and for disconnecting the

same, and means effective in toll calls for always preventing the application of ringing current from the connector and for applying signalling current over said trunk line to signal a called subscriber.

Signed by me at Chicago, Cook County, Illinois, this 9th day of October, 1917.

EMIL JACOBSEN.