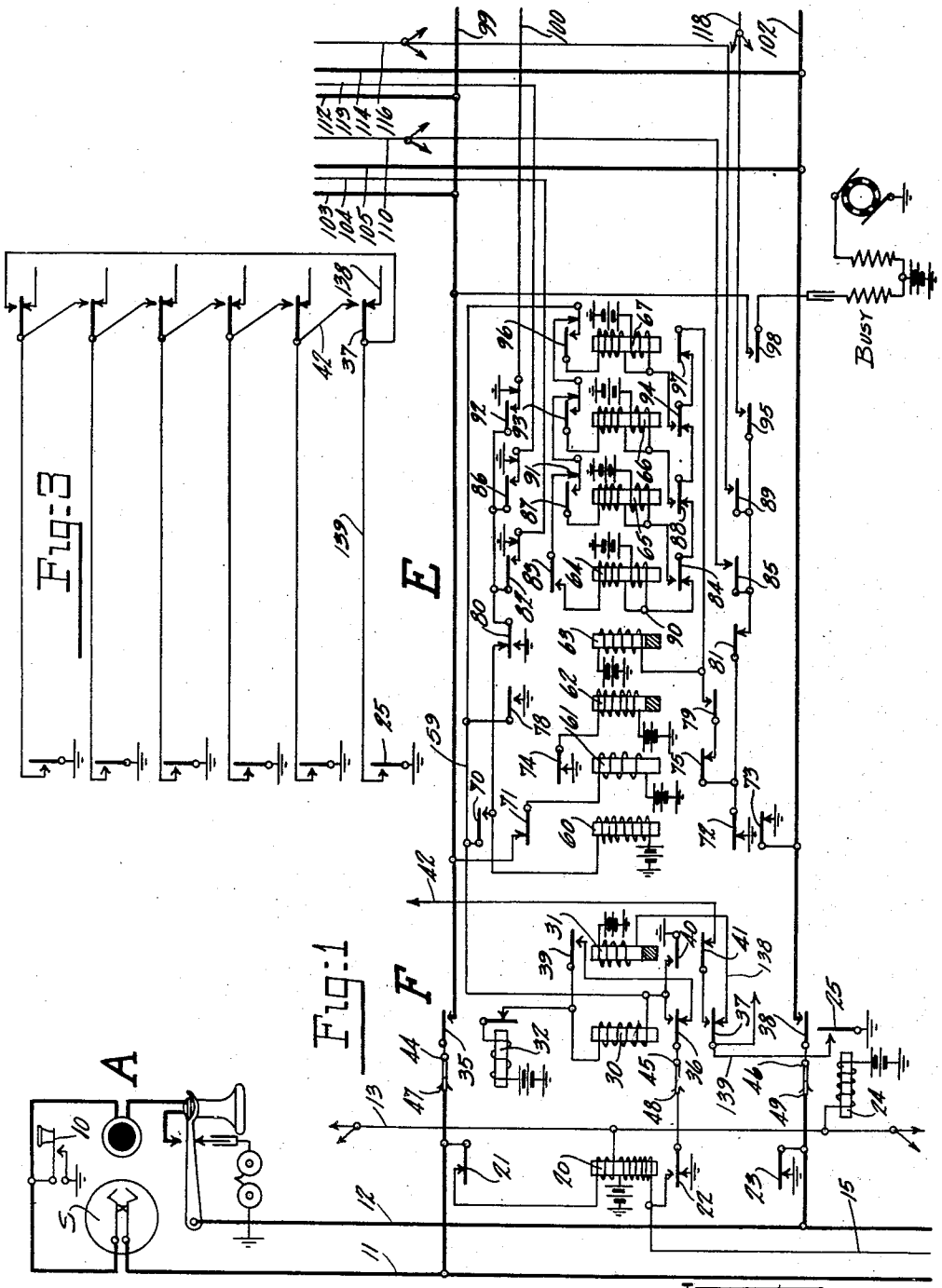
Sept. 9, 1924. 1,507,684

R. G. RICHARDSON

AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 1, 1921 3 Sheets-Sheet 1



Inventor

Rodney G. Richardson

Chas. Tu. Candy. Atty:

Sept. 9, 1924. 1,507,684

R. G. RICHARDSON

AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 1, 1921 3 Sheets-Sheet 2

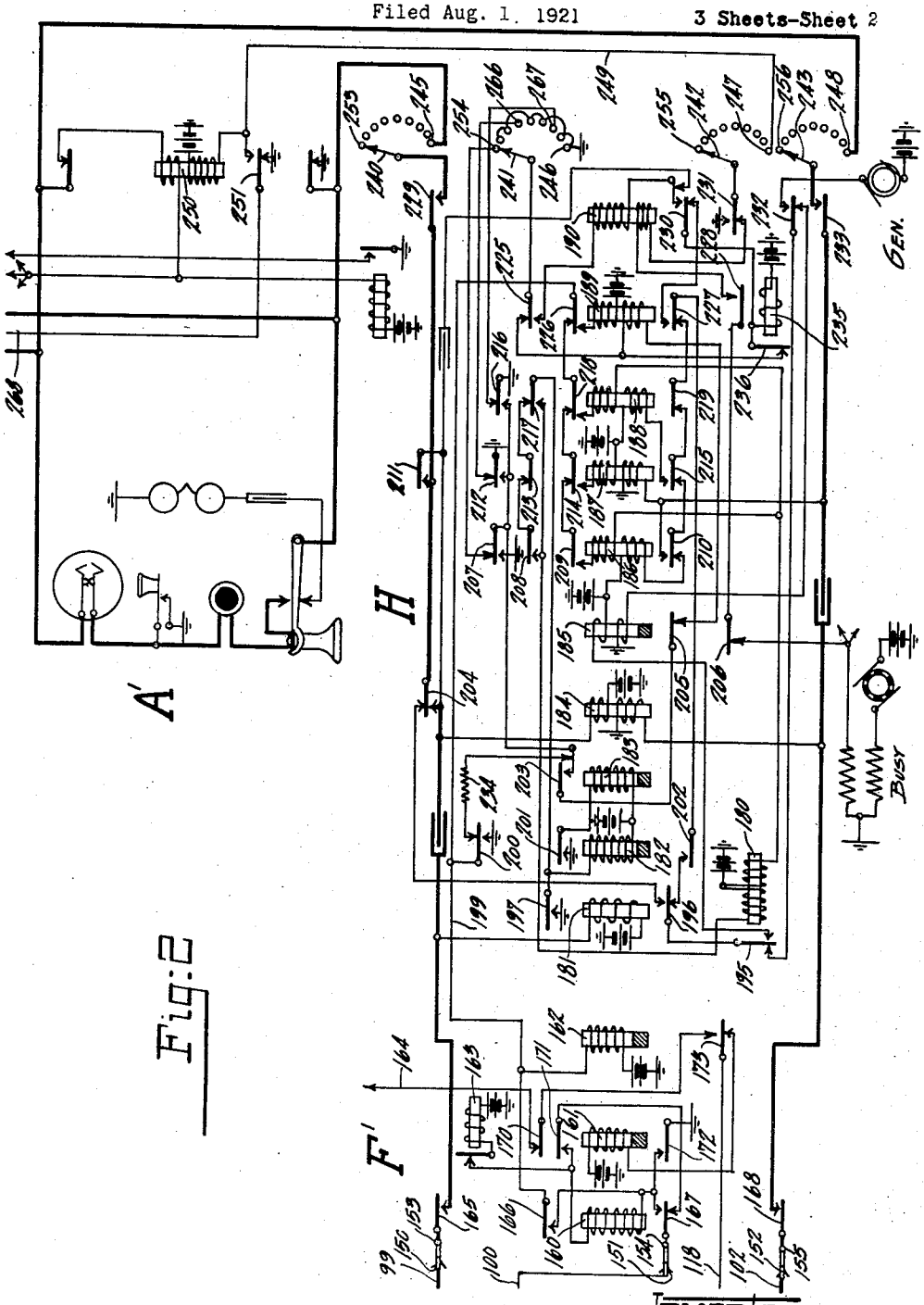


Fig. 2

Inventor
Rodney E. Richardson
Chas. H. Candy Atty.

Sept. 9, 1924. 1,507,684

R. G. RICHARDSON

AUTOMATIC TELEPHONE SYSTEM

Filed Aug. 1, 1921 3 Sheets-Sheet 3

Fig: 5

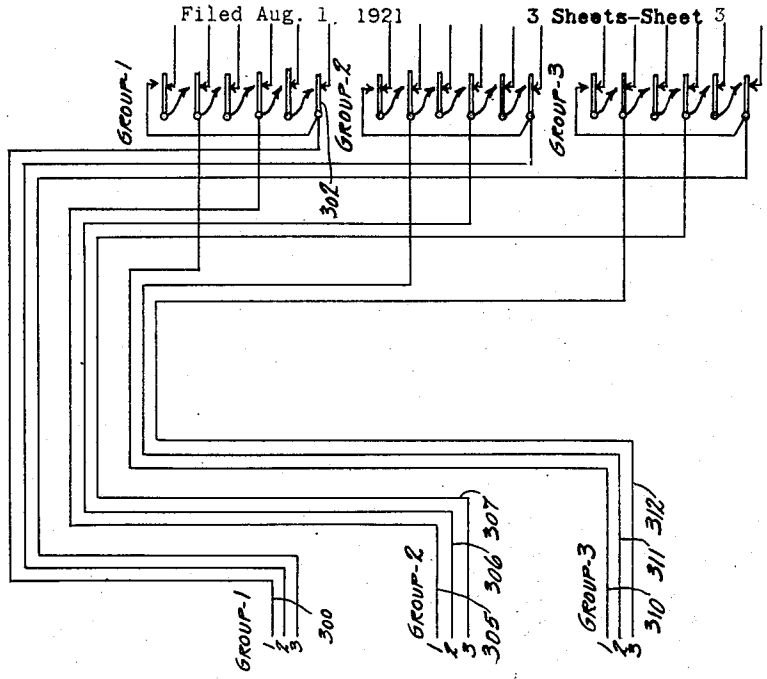
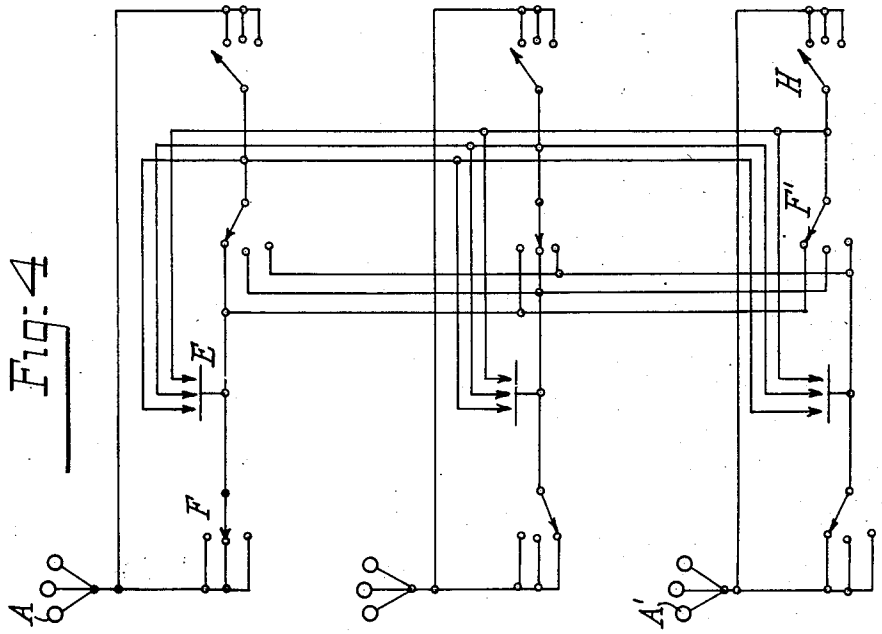


Fig: 4



Inventor

Rodney G. Richardson

Chas. M. Candy. Atty:

Patented Sept. 9, 1924. 1,507,684

UNITED STATES PATENT OFFICE.

RODNEY G. RICHARDSON, OF CHICAGO, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE SYSTEM.

Application filed August 1, 1921. Serial No. 489,052.

To all whom it may concern:

Be it known that I, RODNEY G. RICHARDSON, a citizen of the United States of America, and a resident of Chicago, Cook County, and State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

The present invention relates in general to automatic telephone systems but is more particularly directed to small automatic systems of the type which are commonly known as private automatic exchanges, although certain features of the invention may be found to be of value in larger systems.

More specifically, the present invention contemplates a novel system of the above type wherein automatic switches of simplified construction and having highly improved control circuits are employed, together with new trunking facilities between such switches which tend to increase the efficiency of the system as a whole.

From another view point, the general object of the invention is to provide a private automatic exchange system using rotary switches throughout which are of the same general mechanical construction as the well known rotary line switch, but which is capable, nevertheless, of giving service to sixty, ninety, or more subscribers' lines. In accomplishing this object these rotary switches are employed both as primary and secondary finder switches as well as connector switches. The secondary finder switches are connected directly to connector switches and the finder connector links so formed are divided into groups, there being as many groups of these link circuits as there are groups of thirty subscribers' lines. Thus, in a ninety line system there would be three groups of finder connector links. The trunk lines from the primary finders, of which there are also as many groups as there are groups of thirty subscribers' lines, are multipled in the banks of all secondary finders, and there is a group of counting relays, constituting a relay group selector, associated with each of these trunk lines. The relay group selectors control the starting of the finders in desired groups of finder connector links in accordance with digits dialled by calling subscribers.

In the preferred embodiment of the invention about to be described a private automatic exchange system of ninety lines capacity has been selected. That is, there are three groups of subscribers' lines in the exchange.

The rotary switches used as primary and secondary finder switches and connector switches have preferably thirty-three contacts in their banks instead of the usual twenty-five as have the ordinary rotary line switches. Of course, if desirable, this number may be varied to form various trunking arrangements.

Referring now to the drawings comprising Figs. 1–5 inclusive, Figs. 1 and 2 show a circuit diagram of a complete connection between a calling substation A and a called substation A′. Fig 3 shows the starting circuits diagrammatically of a group of primary finders. Fig. 4 shows the general trunking layout of the system, while Fig. 5 shows the starting circuits extending to the various groups of secondary finder switches.

Referring now particularly to Fig. 1 there is shown a subscriber's substation A of the well known automatic type having, in addition to the usual talking instrumentalities, a calling device S, and push button 10 which is used for ringing a called subscriber after a connection has been completed. The line of the substation A terminates in multipled bank contacts accessible to a group of primary finder switches, one of the latter being shown at F. In addition to the above the line of the substation A has associated with it at the exchange a combined line and cut off relay 20.

The finder switch F is one of a group of primary finder switches which have access to the line of the substation A. As before mentioned, the finder F has a contact bank of thirty-three contacts in which the thirty subscribers' lines of the group terminate, the three remaining sets of contacts being dead, and the test contact of each such remaining set being permanently grounded.

There are 6 primary finder switches such as F, associated with each group of thirty subscribers' lines and the lines of each one of these groups are divided into six sub-groups of five lines each. Associated with each one of these sub-groups is a starting relay which is common to the five subscribers' lines in the sub-group. By this arrangement it is possible to have a subscriber

in each sub-group calling or six calls in each group simultaneously.

The primary trunks of the various primary finders terminate in multipled bank contacts accessible to the secondary finders in each of the three groups, the primary trunk extending from the finder F terminates in multipled bank contacts in three groups of secondary finder switches, one of the latter being shown at F', Fig. 2. For example, the primary trunk from the finder F has the branch comprising conductors 103–105, inclusive, extending to multiple bank contacts in the first group of secondary finders, the branch comprising conductors 112–114, inclusive, in the second group of secondary finders and the branch comprising conductors 99–102, inclusive, in the third group of secondary finder switches, one of the latter being shown, as before mentioned at F', Fig. 2. In addition to this the primary trunks extending from the primary finder switches have relay group selectors associated with them such as the relay group selector E associated with the primary trunk extending from the finder F.

The relay group selector E is made up of a series of counting relays and is adapted to respond to a digit of a called number to render a branch of the primary trunk selectable to a certain group of secondary finders and at the same time start an idle finder switch in that group.

In the present system there are six secondary finder connector links for each group of thirty subscribers' lines, one of these secondary finder switches being shown, as before mentioned, at F', Fig. 2. The finder switch F' is similar to the primary finder switch F already mentioned.

The local connector switches of each group are of the same mechanical construction as are the primary and secondary finder switches except that these connector switches have an extra row of bank contacts and an extra test wiper. The purpose of this extra bank and wiper will appear fully hereinafter. These connector switches have access to called subscribers' lines in the various groups. One of the connector switches, the one linked with the primary finder switch F', is shown at H, Fig. 2, and has access to thirty subscribers' lines, one of these being shown at A'.

The substation A' is similar to the substation A and has associated with its line at the exchange the combined line and cut off relay 250.

Fig. 3 shows the starting circuit of one group of primary finder switches which have access to thirty subscribers' lines. As shown, the armatures on the left of the figure represent the armatures on the various starting relays, it being remembered that there are six starting relays in each group, one for each five subscribers' lines. The armature on each one of these starting relays closes the starting circuit to a particular primary finder switch. At the right of the figure are represented the armatures on the switching relays of the various finder switches in the group and the manner in which the starting wire is extended to the next idle finder switch as each finder becomes busy.

Fig. 4 shows a general trunking layout of the system.

In Fig. 5 is shown the starting wires associated with the primary trunks and extending to the various secondary finder switches in each of the three groups.

Having briefly described the apparatus involved in the invention a detailed description of its operation will now be given. In order to facilitate the description the invention will first be briefly described by tracing a call through the system with reference to the trunking diagram shown in Fig. 4. For this purpose it will be assumed that the subscriber at substation A in the first group of lines, desires to call the subscriber at substation A' whose line is located in the third group. In order to do this the calling subscriber will remove his receiver and operate his calling device in accordance with the number assigned to the substation A'.

When the receiver is removed at substation A an idle primary finder switch such as F is automatically operated to connect the calling line with a primary trunk line. The calling subscriber may then call the first digit in the desired number which is registered on the counting relays of the relay group selector E associated with the primary trunk line in use. A certain one of these counting relays is thus energized whose function it is to render the multiples of the primary trunk line in use selectable at a particular group of secondary finders, which in this case is the third group, as the line of the substation A' is located in this group, and also to place ground on the starting wire leading to the finder switches of the third group. The latter operation starts an idle finder switch, such as F', in the desired group which operates to locate the primary trunk line in use and extends it to the associated connector switch H. The calling subscriber then calls the remaining two digits of the required number and the connector switch H is operated to complete the connection. When the conversation is terminated the release takes place upon both subscribers replacing their receivers upon their respective switchhooks.

Having described the general method of establishing a connection with reference to the trunking diagram of Fig. 4, a detailed description of the circuit operation of the various switches will now be given. For

this purpose it will be assumed, as before, that the subscriber at substation A in the first group desires to call the subscriber at substation A' in the third group. In order to do this the subscriber will remove his receiver and operate his sender S in accordance with the three digits which constitute the number of the substation A'.

When the receiver is removed at substation A a circuit is completed for the upper winding of the relay 20 in series with the starting relay 24, over the line conductors 11 and 12 in series. Both the relays 20 and 24 are energized over this circuit. However, the upper winding of the relay 20 is only strong enough to operate the armature 22 thereby disconnecting ground from the multipled test contacts in the banks of the associated group of primary finder switches, thus rendering the line of the substation A selectable. Relay 24, upon energizing, at its armature 25 completes a circuit for starting the first idle finder switch which, we will assume, is the finder switch F. This circuit may be traced from ground by way of armature 25 and its front contact, armature 37 and its back contact, and thence through the winding of the line relay 31 to battery. Relay 31, upon energizing, at its armature 40 completes a circuit which includes the switching relay 30 and the motor magnet 32 in series, and at its armature 39 connects the test wiper 45 to the above circuit at a point midway between the switching relay and the said motor magnet. The operation of the finder switch F now depends upon whether its wipers are resting on the bank contacts associated with a line other than that of the substation A or not. Assuming this to be the case the test contact of this line will be grounded and the motor magnet being supplied with direct ground by way of the test wiper 45 will operate as a buzzer to advance the switch wipers 44–46, inclusive, in search of the bank contact set associated with the line of the calling substation A. When the switch wipers are operated into engagement with the bank contacts 47–49, inclusive, associated with the line of the substation A the test wiper 45 will find no ground potential present upon the test contact 48, the motor magnet 32 will cease operating, and the switching relay 30 being no longer short circuited will energize in series with the said magnet. Relay 30, upon energizing, at its armature 37 opens the circuit of the line relay 31, and at the front contact of this armature partially extends the starting wire to the next idle finder switch, this starting wire being completely extended upon the deenergization of the slow acting relay 31. In addition, at armature 36 relay 30 completes the circuit of the lower winding of the relay 20, and at armatures 35 and 38 extends the line conductors 11 and 12 of the substation A to the winding of the line relay 61 and to ground, respectively, in the relay group selector E. When the circuit for the lower winding of relay 20 is completed this relay is completely energized and operates to disconnect the line conductors 11 and 12 of the substation A from the upper winding of the relay 20 and from ground, respectively.

When the line of the substation A is extended to the line relay 61 as previously described this relay is energized over the calling line and, upon operating, at its armature 74 completes the circuit of the slow acting relay 62. The latter relay, upon energizing, at armature 79 prepares the impulsing circuits of the counting relays and at armature 78 places ground upon the release trunk conductor 59, thereby establishing a holding circuit for the switching relay 30 in the finder switch F and also completing a holding circuit for the lower winding of the relay 20. The latter circuit may be traced from ground on release trunk conductor 59, armature 22 and its front contact, and through the lower winding of relay 20 to battery. It will be understood that the above traced holding circuit is completed before the slow acting relay 31 has had time to deenergize. A branch of this holding circuit also extends by way of the private normal conductor 15 to multipled test contacts in the banks of connector switches which have access to the line of the substation A whereby the said line is protected from intrusion in the usual manner.

As the desired subscriber is located in the third group the calling subscriber at substation will now operate his sender S for the first digit 3 of this number. By this operation three interruptions are produced in the circuit of the line relay 61 and this relay retracts its armatures a corresponding number of times. At the first retraction of armature 75, a circuit is completed which may be traced from ground by way of back contact and armature 72, armature 75 and its back contact, armature 79 and its front contact, armature 97 and its back contact, armature 94 and its back contact, armature 88 and its back contact, armature 84 and its back contact, and through the lower winding of the first counting relay 64 to battery. The lower winding of the relay 64 is only strong enough to operate the armature 83. By this operation a circuit is completed which extends from ground on release trunk conductor 59, by way of the normally closed springs controlled by armatures 96, 93 and 87 on the counting relays 67, 66 and 65, respectively, armature 83 and its front contact, through the upper winding of the relay 64

to junction point 90 and thence through the lower winding of relay 64 to battery. However, as long as the armature 75 of the line relay 61 is in a retracted position the above traced circuit is ineffective as the upper winding of relay 64 is short circuited by ground from back contact and armature 72. Therefore the other armatures of counting relay 64 are not attracted until armature 75 of the line relay 61 is attracted. When this occurs the upper and lower windings of the counting relay 64 are energized in series and the relay operates all its armatures. Relay 64, upon operating, at armature 84 extends the impulsing conductor to the second counting relay 65, at armature 85 closes a point in the starting wire extending to the first group of secondary finder switches, and at armature 82 removes one ground from the test conductor associated with the primary trunk accessible to the secondary finder switches of the first group. It will be seen that the slow acting relay 63 is energized in multiple with the counting relay 64 and at its armature 80 keeps the above mentioned test conductor grounded and at armature 81 maintains the starting wire circuit open during dialling. Upon the next retraction of the armature 75 of relay 61, the second counting relay 65 is energized in a manner similar to relay 64. That is, when armature 75 is in a retracted position the lower winding of relay 65 is energized and the armature 87 only is attracted to engage its front contact but it does not break the normally closed contacts 91 at this time. When the armature 75 of the line relay 61 assumes an attracted position both windings of the relay 65 are energized in series and all the armatures are operated. The relay 65, upon operating, at armature 88 extends the impulsing lead to the third counting relay, at armature 87 opens the locking circuit of the two windings of the counting relay 64 and at the front contact of this armature establishes a locking circuit for itself, at armature 86 removes one ground from the test conductor 113 associated with the primary trunk line accessible to the second group of secondary finder switches, and at armature 89 prepares a point in the starting circuit extending to the second group of secondary finder switches. When the circuit of relay 64 is opened this relay deenergizes and at armature 82 again applies the normal ground to the test conductor 104 associated with the primary trunk extending to the first group of secondary finder switches and at armature 85 opens a point in the starting wire circuit extending to the secondary finders of the first group. When the line relay 61 again retracts and attracts its armature the third counting relay 66 is energized in the same manner as was the counting relay 65. Relay 66, upon energizing, at armature 93 opens the locking circuit of the second counting relay 65, and locks itself at the front contact of this armature, at armature 94 extends the impulsing lead to the last counting relay, at armature 92 removes the normal ground from the test conductor 100 associated with the primary trunk line and extending to the multipled bank contacts accessible to the third group of secondary finder switches and at armature 95 prepares a point in circuit of the starting wire 118 extending to the third group of secondary finder switches. Relay 65, upon deenergizing, again places the normal ground on the test conductor 113 extending to the test contacts of the primary trunk line accessible to the second group of secondary finder switches and at armature 89 opens a point in the starting wire circuit extending to the secondary finder switches of this group. Shortly after this series of impulses the slow acting relay 63 deenergizes and at armature 80 removes the ground from the test conductor 100 and at the back contact of this armature prepares a circuit for the relay 60, and at the back contact of armature 81 places ground upon the starting wire 118 extending to the third group of secondary finder switches. When ground is placed upon the common starting wire 118 extending to the third group of secondary finder switches, a circuit is completed for starting an idle finder switch in that group which, we will assume, is the secondary finder switch F′. This circuit extends from ground on the said starting wire by way of the armature 173 and its back contact, and through the winding of the line relay 161 to battery. Relay 161, upon energizing, at armature 172 completes a circuit which includes the switching relay 160 and the motor magnet 163 in series and at its armature 171 connects the test wiper 154 to the above circuit at a point midway between the switching relay and the said magnet. The operation of the finder switch F′ now depends upon whether its wipers are associated with the bank contacts of the primary trunk in use or not. If the switch wipers 153–155, inclusive, of the finder switch F′ are associated with the bank contacts of a trunk line other than the one in use, there will be a ground potential present upon the test contact engaged by the test wiper 154 and the motor magnet 163 being supplied with direct ground via the said test wiper will operate as a buzzer to advance the switch wipers step by step in search of the bank contacts associated with such primary trunk which, we will assume, are the bank contacts 150–152, inclusive. When the switch wipers are operated into engagement with this set of bank contacts there will be no ground potential present upon the test contact 151 engaged by the test wiper 154, motor magnet 163 will not operate farther and the switching relay 160 will be

immediately energized. Relay 160, upon energizing, at armature 166 completes the circuit of the slow acting relay 162, at armature 167 places ground upon the test conductor 100, and at armatures 165 and 168 extends the primary trunk comprising conductors 99 and 102 to the winding of relay 181 and to the lower winding of relay 184 of the connector switch H. Relay 162, upon energizing, at armature 173 opens the circuit of the slow acting relay 161 and at the front contact of this armature partially extends the starting wire 118 to the next idle finder switch in the third group, this extension being completed at armature 170 upon the deenergization of the slow acting relay 161.

Returning now to the operation of the relay group selector E, when ground is placed upon the test conductor 100 relay 60 is immediately energized. Relay 60, upon operating, at armature 72 removes ground from the starting wire 118, at armature 70 connects the release trunk conductor 59 with the test conductor 100, and at armatures 71 and 73 disconnects the line conductors 11 and 12 of the substation A from the winding of the line relay 61 and from ground, respectively.

When the trunk conductors 99 and 102 are extended to the winding of the line relay 181 and the lower winding of relay 184 in the connector H both these relays will energize over the calling subscriber's line loop. Relay 181, upon energizing, at armature 197 completes the circuit of the slow acting relay 182. The latter relay, upon energizing, at armature 201 completes the circuit of the slow acting relay 183, at armature 202 prepares the impulsing circuits of the connector H and at armature 200 places ground upon the release trunk conductor 199 thereby establishing a holding circuit for the slow acting relay 162 and the switching relay 160 in the finder switch F'. This holding circuit also extends by way of front contact and armature 167, test wiper 154, test contact 151, release or test conductor 100, front contact and armature 92, armature 80 and its back contact, through the winding of relay 60 to battery. Another branch of this holding circuit extends by way of front contact and armature 70, normally closed springs controlled by armature 96, front contact and armature 93, through the upper winding of relay 66, and through the lower winding of relay 66 to battery. This circuit also extends by way of the release trunk 59 to the previously traced holding circuit for the relays 30 and 20.

At this point it will be well to explain the operation of the relay group selector E should the calling subscriber at substation A dial a digit larger than 3. As there are only three groups of subscribers' lines in the exchange were no special provision made the calling subscriber would be likely to get a wrong number. In order to take care of this means are provided for giving the calling subscriber as busy tone should he dial a digit larger than 3. To describe this operation it will be assumed that the subscriber at substation A dialed a digit larger than 3. The counting relays 64, 65 and 66 in the relay group selector E are energized as before described and operate in the same manner. However, when the line relay 61 again retracts and attracts its armature the fourth counting relay 67 is energized. Relay 67, upon energizing, at armature 97 opens the impulsing lead, at armature 96 opens the locking circuit of the third counting relay 66 and at armature 98 places the busy tone upon the upper heavy talking conductor. Relay 66, upon deenergizing replaces the normal ground upon the test conductor 100 associated with the primary trunk line and extending to multiple bank contacts accessible to the third group of secondary finder switches and at armature 95 opens a point in the circuit by which ground is placed upon the starting wire 118. The busy tone which was placed upon the upper heavy talking conductor is audible to the calling subscriber and will replace his receiver upon the switchhook in order to release the operated switches. The manner in which this release takes place will be described fully hereinafter.

The calling subscriber at substation A may now operate his calling device in accordance with the next digit of his desired number, which, we will assume, is the digit 3. By this operation a series of interruptions is produced in the circuit of the line relay 181 and the relay 184. The operation of relay 184 is without function at this time. Relay 181, upon deenergizing, at armature 196 completes a circuit which extends from ground through the lower winding of the slow acting series relay 185, back contact and armature 232, back contact and armature 195, armature 196 and its back contact, front contact and armature 202, armature 227 and its back contact, armature 219 and its back contact, armature 215 and its back contact, armature 210 and its back contact, and thence through the lower winding of the first counting relay 186 to battery. The relays 185 and 186 are energized in series over this circuit. Relay 186, upon energizing, at armature 210 extends the impulsing lead to the lower winding of the second counting relay 187 and at armature 209 closes a locking circuit for itself which extends from ground on release trunk conductor 199, by way of armature 226 and its back contact, armature 218 and its back contact, armature 214 and its back contact, armature 209 and

its front contact, through the upper winding of relay 186 and thence through the right hand winding of relay 180 to battery. The right hand winding of relay 180 is not strong enough to attract the armature 195 though it creates a certain amount of magnetic flux so that relay 180 energizes very quickly immediately upon the circuit of its left hand winding being completed. Other results of the energization of relay 186 are that at armature 208 a circuit is prepared for the left hand winding of relay 180 and at armature 207 a circuit is prepared for the lower winding of the switching relay 189. When the line relay 181 attracts its armature 197 a circuit is completed which may be traced from ground by way of front contact and armature 197, armature 217 and its back contact, armature 213 and its back contact, armature 208 and its front contact, and thence through the left hand winding of relay 180 to battery. Relay 180, upon energizing, at armature 195 disconnects ground from armature 196 and connects battery to this armature through the upper winding of the relay 185. Now when the line relay 181 again retracts its armature a circuit is completed extending from battery, through the upper winding of the slow acting relay 185, front contact and armature 195, armature 196 and its back contact, front contact and armature 202, armature 227 and its back contact, armature 219 and its back contact, armature 215 and its back contact, armature 210 and its front contact, and thence through the lower winding of the second counting relay 187 to ground. The relay 187 is energized over this circuit and the slow acting relay 185 is maintained energized. It will be noted also that the line relay 181, upon retracting its armature 197, opens the circuit of the left hand winding of the relay 180. However, relay 180 does not retract its armature 195 at this time as the relay armature is adapted to be held in an operated position by its right hand winding. Relay 187, upon energizing, at armature 215 extends the impulsing lead to the lower winding of the third counting relay 188, at armature 214 breaks the locking circuit of the relay 186 and that of the right hand winding of the relay 180, and at the front contact of this armature completes a locking circuit for itself, at armature 213 opens another point in the circuit of the left hand winding of relay 180 and at armature 212 prepares a point in a circuit which is closed immediately upon the deenergization of the relay 186. The operation of armature 211 of relay 187 is without function at this time. As the circuits of both the windings of relay 180 are now open this relay will deenergize again connecting ground through the lower winding of relay 181. As the circuit of relay 186 is now open this relay will deenergize and complete a circuit extending from ground by way of front contact and armature 212, armature 207 and its back contact, bank contact 254, wiper 241, armature 225 and its back contact, back contact and armature 236 and thence through the winding of the motor magnet 235 to battery. Magnet 235 is energized over this circuit and operates to advance the switch wipers 240–243, inclusive, into engagement with the next set of contacts.

As was before mentioned, the local connectors are provided with an extra test bank and corresponding wiper which in the connector H is the wiper 241 and the bank contacts adapted to be engaged thereby. The wipers of the connector H are normally resting on the first set of contacts such as 253–256, inclusive. The connector H has access to thirty subscribers' lines the lines being divided into three groups of ten lines each there being a vacant set of contacts between each of these groups. In the test bank adapted to be engaged by the wiper 241, all the bank contacts except the ones corresponding to these vacant sets are permanently grounded, the ones that are not grounded being under the control of the counting relays such as 186, 187 and 188 in the connector H. Thus as soon as the switch wipers 240–243, inclusive, are advanced one step the wiper 241 will continue to engage grounded test contacts and the motor magnet operates until the switch wipers are rotated into engagement with the vacant contact set between the first and second groups whereupon the rotation of the switch will stop unless the counting relay 188 has been energized which would be the case when the digit 3 is the first digit dialled when the connection is extended to the connector H. As the digit 3 was called by the subscriber at substation A the line relay 181 will again retract its armature and complete the circuit of the third counting relay 188 in series with the lower winding of the series relay 185. Relay 188, upon energizing, opens the impulsing lead at armature 219, at armature 218 opens the locking circuit of the second counting relay 187, at the front contact of this armature establishes a locking circuit for itself in series with the right hand winding of the relay 180, at armature 217 prepares the circuit for the left hand winding of relay 180, at armature 216 removes ground from the test contact associated with the normally vacant set between the second and third groups of subscribers' lines and at the front contact of this armature maintains the test contact 254 grounded after the deenergization of relay 187. When the line relay 181 again attracts its armature the circuit for the left hand winding of relay 180 is completed and this relay immediately

energizes and again connects battery through the upper winding of the slow acting relay 185 to the armature 196. As the locking circuit of the relay 187 is opened this relay will deenergize and replace ground on the test contact 266 of the normally vacant contact set between the first and second groups the motor magnet 235 immediately operates as a buzzer to advance the switch wipers 240–243, inclusive, step by step until they are rotated into engagement with the vacant set of bank contacts between the second and third groups. As the third impulse constitutes the end of the digit dialled by the subscriber at substation A, the slow acting relay 185 will deenergize and a circuit is completed extending from ground by way of armature 216 and its front contact, front contact and armature 203, armature 205 and its back contact, through the lower winding of the switching relay 189, back contact and armature 236, and thence through the winding of the motor magnet 235 to battery. As long as the wiper 241 is engaging grounded test contacts the lower winding of the switching relay 189 is short circuited and this relay does not operate. However, immediately up the switch wipers being rotated into engagement with the vacant set of bank contacts between the second and third groups there will be no ground potential present upon the test contact 267, switching relay 189 is no longer short circuited and energizes in series with the motor magnet 235. It should be stated at this point that the lower winding of relay 189 is of such high resistance that the motor magnet 235 does not operate in series with it. Relay 189, upon energizing, at armature 227 prepares an operating circuit for the motor magnet 235, at armature 226 establishes a locking circuit for itself at the same time opening the locking circuit of the third counting relay 188 and at armature 225 prepares a point in the locking circuit of the switching relay 190. Another result of the energization of relay 189 is that at armature 228 a circuit is prepared for the switching relay 190. The locking circuit of the third counting relay 188 being opened by the operation of relay 189 the said counting relay will deenergize and open the circuit of the left hand winding of the relay 180 at armature 217, at armature 216 opens the circuit of the lower winding of relay 189, and at the back contact of this armature again connects ground to the contact 267 associated with the vacant set of contacts between the second and third groups. As the circuits of both windings of the relay 180 are opened by the deenergization of the third counting relay 188, the relay 180 will deenergize and again connect ground through the lower winding of the slow acting series relay 185 to the armature 196 of the line relay 181. The foregoing operations have all occurred in response to the second digit of the called subscriber's number and everything is now in readiness for the last digit to be dialled by the calling subscriber.

The subscriber at substation A may now operate his sender S in accordance with the last digit of his desired number which, we will assume, is the digit 0. By this operation ten interruptions are produced in the circuit of the line relay 181 and this relay retracts its armature a corresponding number of times. At each retraction of its armature 196 a circuit is completed extending from ground through the lower winding of the slow acting relay 185 by way of back contact and armature 232, back contact and armature 195, armature 196 and its back contact, front contact and armature 202, armature 227 and its front contact, back contact and armature 230 and thence through the winding of the motor magnet 235 to battery. Magnet 235 operates to rotate the switch wipers 240–243, inclusive, step by step until they are rotated into engagement with the tenth set of bank contacts in the third group in which is terminated the line of the substation A′ and which we will assume, are the bank contacts 245–248, inclusive. The slow acting relay 185 is energized in series with the motor magnet 235 and operates at armature 206 to open the circuit of the lower winding of the switching relay 190, shortly after the termination of the rotary movement of the switch, the slow acting relay 185 will deenergize and prepare a point in the circuit of the switching relay 190.

Assuming that the desired line is busy at the present time there will be a ground potential present upon the test contact 247 engaged by the test wiper 242 and there will be no circuit completed for the lower winding of the switching relay 190. As one side of the relay 190 is connected to ground through the secondary of the induction coil of the busy machine and the other side is connected to ground on the test contact 247, a busy tone will be induced in the upper winding of relay 190 which extends by way of the condenser to the upper heavy talking conductor. This signal is audible to the calling subscriber and he will replace his receiver in order to release the operated switches. The manner in which the release takes place will be explained later.

It will now be assumed that when the switch wipers 240–243, inclusive, are rotated into engagement with the bank contacts 245–248, inclusive, that the line of the substation A is idle. Under these conditions there will be no ground potential present upon the test contact engaged by the test wiper 242. Then, immediately following the deenergization of the slow acting relay 185, a circuit is

completed which may be traced from ground through the secondary of the induction coil on the busy machine, back contact and armature 206, armature 228 and its front contact, through the lower winding of the switching relay 190, back contact and armature 231, test wiper 242, test contact 247, private normal conductor 249, and thence through the lower winding of the relay 250 to battery. Relay 190 is energized over this circuit and, upon operating, disconnects the impulsing lead from the motor magnet 235 at armature 230 and at the front contact of this armature establishes a locking circuit for itself, at armature 231 opens the circuit of its lower winding, at the front contact of this armature places direct ground upon the private normal conductor 249 by way of the test wiper 242, at armature 232 prepares a point in the ringing circuit, and at armature 229 and 233 prepares certain points in the talking circuit. The locking circuit of the switching relay 190 may be traced from battery through the winding of the motor magnet 235, armature 230 and its front contact, through the upper winding of relay 190, front contact and armature 225, wiper 241, and bank contact 246 to ground. When ground is placed upon the private normal conductor 249 the relay 250 is immediately energized and disconnects the line of the substation A from its normal battery and ground connections, and at armature 251 connects ground to the conductor 268 extending to multiple bank contacts in the group of primary finder switches which have access to the line of the substation A'.

In order to signal the called subscriber the subscriber at substation A will operate the push button 10 at his substation. By this operation ground is placed upon the line conductors 11 and 12. When ground is placed upon the line conductor 12 the lower winding of the relay 184 is short circuited and this relay deenergizes. However, line relay 181 is maintained energized by the ground at the substation. Ringing current is now projected out over the called line over a circuit extending from the free pole of generator Gen by way of front contact and armature 232, back contact and armature 195, armature 196 and its front contact, back contact and armature 204, armature 229 and its front contact, wiper 240, bank contact 245, switchhook springs, condenser, and ringer at the called substation A' to ground. This ringing current serves to operate the ringer, thereby signalling the called subscriber at substantion A'. If the called subscriber should answer during the ringing operation the ringing circuit will be extended through the lower winding of relay 187 to ground. The relay 187 is immediately energized over this circuit and at armature 211 establishes a locking circuit for itself by connecting battery through the upper winding of relay 184 to the wiper 240, relay 184 is then energized in series with the lower winding of the relay 187. Relay 184, upon energizing, at armature 204 disconnects the ringing current from the called line and at the front contact of this armature completes the talking connection. The operation of armature 212 of relay 187 completes a circuit through the lower winding of the switching relay 189. The operation of the other armatures of relay 187 is without function at this time. The conversation may now be carried on between the calling and called subscribers, talking battery being supplied to the calling subscriber from the winding of the relay 181 and from the lower winding of the relay 184, and to the called subscriber from the upper winding of relay 184 and from the lower winding of relay 187. By this arrangement, it will be seen that the ring is cut off immediately upon the called subscriber answering, even though the calling subscriber still has his push button operated, and that after the answer of the called subscriber the calling subscriber cannot ring in the ear of the called subscriber. It will of course be apparent that should the called subscriber hang up the relay 187 will deenergize and the calling subscriber may again ring the called subscriber if he so desires.

When the conversation is terminated both subscribers will replace their receivers upon the switchhook. In order to describe this releasing operation in detail it will be assumed that the calling subscriber replaces his receiver before the called subscriber. When the receiver is replaced at the calling substation the line relay 181 deenergizes and at armature 197 opens the circuit of the slow acting relay 182. After a short interval slow acting relay 182 deenergizes and opens the circuit of the slow acting relay 183. Immediately upon the deenergization of relay 182 ground is removed from the release trunk conductor 199 and the circuits of the slow acting relay 162 and the switching relay 160 in the finder switch F' are opened. Ground is also removed from the release trunk conductor 100 and the circuits of the relay 66 and the switching relay 60 in the selector E, the switching relay 30 of the finder switch F and the circuit of the lower winding of cut off relay 20 are opened; consequently all these relays deenergize, restoring the respective switches to normal. Immediately upon the deenergization of the slow acting relay 182, ground is removed from the release trunk conductor 199 and the locking circuit of the upper winding of relay 189 is opened. However, this relay does not deenergize at this time as the circuit for its lower winding is com-

pleted from ground by way of armature 212 and its front contact, front contact and armature 203, armature 205 and its back contact, through the lower winding of relay 189, back contact and armature 236, and thence through the winding of relay 235 to battery. Upon the deenergization of the slow acting relay 183, ground is again replaced upon the release trunk conductor 199 over a circuit extending from ground by way of armature 212 and its front contact, normally closed springs controlled by armature 203, resistance 234, back contact and armature 200, release trunk conductor 199. By the deenergization of relay 183, the circuit of the lower winding of relay 189 is opened. However, immediately upon the deenergization of relay 183, ground is replaced upon the release trunk conductor 199 and the locking circuit of the upper winding of relay 189 is completed and consequently this relay does not deenergize. It should be stated at this point that the slow acting relay 162 is somewhat more slow acting than is the slow acting relay 183. Thus the relay 162 will not deenergize but will be maintained energized by the replacement of ground on the release trunk conductor 199. The starting wire 118 will therefore be maintained extended to the next idle finder switch and no other calling subscriber will be able to start the finder switch F' until the called subscriber replaces his receiver. When the called subscriber hangs up the relays 184 and 187 deenergize. Relay 187, upon deenergizing, at armature 212 removes ground from the release trunk conductor 199 thereby opening the circuit of the slow acting relay 162 and at the same time the locking circuit of the switching relay 189. At the back contact of armature 212 the relay 187 again connects ground to the test contact 266 in the contact bank adapted to be engaged by the wiper 241. Relay 189, upon deenergizing, at armature 225 opens the locking circuit of the switching relay 190 and at the back contact of this armature completes the circuit of the rotary magnet 235. As all the contacts in the bank adapted to be engaged by the wiper 241 are grounded except the contact 254, the motor magnet 235 will operate to rotate the switch wipers step by step until they are placed in engagement with this set of bank contacts, this being the normal position of the connector H. As the circuit of the relay 190 was opened by the deenergization of relay 189 the former relay deenergizes thereby disconnecting the wipers of the connector H from their normal connections in the connector and at armature 231 removes ground from the private normal conductor 249 whereby the circuit of the relay 250 is opened. Relay 250, upon deenergizing, again connects its upper winding to one of the line conductors of the substation A' and the other conductor to ground. As the circuit of the slow acting relay 162 is now open the relay will deenergize after a short interval thereby connecting the starting wire 118 to the line relay 161 of the finder F' thus allowing another calling subscriber to use the finder connector link comprising the switches F' and H. In this manner all the apparatus is restored to normal.

Should the called subscriber replace his receiver before the calling subscriber the relay 187 will deenergize and the circuit through the lower winding of the relay 189 will be opened and ground will be replaced upon the test contact 266. When the calling subscriber hangs up the release will take place in a manner similar to that described hereinbefore the only difference being that the connector H does not rotate to normal until after the calling subscriber has hung up.

Referring now to Fig. 3, as was mentioned before this diagram shows the starting circuit of the various finder switches in one of the groups. It will be apparent that as soon as one of the starting relays whose armatures are represented on the left of the figure energizes ground is placed upon the starting wire such as 139 and this extends by way of the armature 37 and its back contact to the starting conductor 138. This conductor 138 extends to the first primary finder switch of the group and by this operation the first finder switch is automatically operated to connect with the calling subscriber's line. Immediately upon so doing the starting wire is extended by means of armature 37 to the next finder switch. It will thus be seen that each finder in operating transfers the starting wire to the next idle finder switch. It will also be apparent that each of the starting relays, the armatures of which are shown at the left, have normally a first choice finder switch, that is each starting relay normally starts a different finder switch.

In Fig. 5 are shown the various common starting wires extending from the three groups of primary finders to the three groups of secondary finder switches. When the digit 1 is registered on a relay group selector in the first group ground is placed upon the starting wire 300 which extends to armature 302 of the first finder switch in the first group provided this finder switch is idle. Should this finder be busy the next one will be started and so on. If the digit 2 were dialled by a subscriber in the first group the first finder switch of the second group would be started. If the digit 3 were called the first finder switch of the third group would be started. If the digit 1, 2, or 3 were dialled by a subscriber in the second group ground would be placed on one

of the starting wires 305, 306, or 307 and the third finder switch in the first, second or third groups would be started. If a subscriber in group three were calling the digit 1, 2, or 3, ground would be placed on one of the starting wires each as 310, 311, or 312, and the fifth finder switch in the first, second or third groups would be operated. The above operations of course assume that these finders are idle, that is, the above mentioned finders are first choice from the different groups.

The features of the invention having been described and ascertained, what is considered to be new and desired 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, an automatic connector switch controlled over a calling line to connect with another line as a called line, a push button at the calling station, ringing equipment in said connector controlled by said push button to signal the called station, and circuit arrangements in said connector such that the ringing current is disconnected from the called line immediately upon the response of the called subscriber even though the said push button is still operated.

2. In a telephone system, a trunk line terminating in an automatic switch, called lines divided into groups accessible to said switch, an operating magnet for said switch, a group of counting relays in said switch, means for sending impulses over said trunk to energize a particular one of said counting relays, means controlled by the energized counting relay for operating said magnet to cause said switch to select a particular group of said lines and means responsive to another series of impulses for continuing the movement of said switch in the same direction to select a wanted line in the selected group.

3. In a telephone system, a trunk line terminating in an automatic switch, called lines divided into groups accessible thereto, an operating magnet for said switch, a line relay in said switch, counting relays in said switch, means for seizing said trunk line and for causing the operation of said line relay to energize a certain one of said counting relays corresponding to the number of impulses in the digit dialled, means controlled by the energized counting relay for causing said magnet to operate said switch into selective relation with one of said groups of lines, and means for then causing said line relay to transmit impulses corresponding to another digit directly to said motor magnet to operate said switch into connection with a particular line in the selected group.

4. In a telephone system, telephone lines divided into groups, primary finder switches having access to said telephone lines, trunk lines leading from said primary finder switches, means controlled from a calling one of said telephone lines for causing the automatic operation of an idle one of said primary finder switches to extend said telephone line over one of said trunk lines, a counting relay group associated with each of the said trunk lines, groups of secondary finders having access to said trunk lines, means controlled over the said calling line for energizing a certain one of the counting relays in the relay group associated with the connected trunk line, and means controlled by said relay for starting an idle secondary finder switch in a particular group.

5. In a telephone system, a calling line, a trunk line, means for connecting said calling line and said trunk line, finder switches divided into groups having access to said trunk line, a group of relays in said trunk line, means for sending impulses over said calling line to operate a certain one of said relays to cause the operation of a finder switch in one of said groups, and means operative if more impulses are sent than there are groups of finder switches for placing a busy tone on said calling line.

6. In a telephone system, a trunk line terminating in an automatic switch, called lines divided into groups accessible to said switch, an operating magnet for said switch, counting relays in said switch corresponding in number to the number of groups of said lines, means for sending impulses over said trunk line to energize one of said counting relays, means responsive to such energization for causing said magnet to operate said switch into selective relation with the group corresponding to the relay energized and means for causing said magnet to respond to another series of impulses independent of any counting relay to operate the switch into connection with a wanted line in the selected group.

7. In a telephone system, a trunk line terminating in an automatic switch, called lines divided into groups accessible to said switch, an operating magnet for said switch, a circuit for said operating magnet including a test wiper of said switch, bank contacts adapted to be engaged by said test wiper, a group of counting relays in said switch, means for sending impulses over said trunk line to energize a particular one of said relays, and means controlled by said relay for altering the potential on one of said bank contacts, whereby said switch is brought into selective relation with a certain particular group of said lines.

8. In a telephone system, telephone lines divided into groups, primary finder switches having access to said telephone lines, trunk lines leading from the primary finders in each of said groups, secondary finders di-

vided into groups having access to said trunk lines, a group of counting relays associated with each of said trunk lines, and starting circuits for the secondary finders controlled by said groups of counting relays.

9. In a telephone system, an automatic switch having variable automatic group and directive line selecting movements, means for transmitting any one of a plurality of different series of impulses to said switch to determine the extent of the group selecting movement and to initiate the same, mans for automatically continuing the group selecting movement to the predetermined extent, and means for then operating said switch in its line selective movement responsive to another series of impulses.

10. In a telephone system, an automatic switch having automatic group and directive line selecting movements, means in said switch responsive to a variable series of impulses for predetermining the extent of the group selecting movement, means for starting the group selecting movement before the said series of impulses is completed, means for automatically continuing the same to the predetermined point, and means for then operating said switch in its line selecting movement.

11. In a telephone system, an automatic switch having group and line selecting movements, a test circuit controlling the group selecting movement to a predetermined point, a circuit for operating said switch to restore the same to normal position, and a wiper for said switch included in both circuits.

12. In a telephone system, means for connecting a calling and called line including a finder connector link, means for releasing the connector controlled by the last party to hang up his receiver, and means for making the link busy until the connector is released.

13. In a telephone system, a link circuit for connecting a calling and called line, said link including a finder for extending the link toward the calling line, a starting circuit for said finder, a relay for transferring said circuit to another finder, and means whereby the called subscriber controls said relay.

14. In a telephone system, means including a finder connector link circuit for connecting a calling and a called line, means for releasing the finder when the calling subscriber hangs up, means for preventing the release of the connector until the called subscriber hangs up, and means for making the link busy until the connector is released.

15. In a telephone system, means including a finder connector link circuit for connecting a calling and a called line, means for releasing the finder when the calling subscriber hangs up, means for preventing the release of the connector until the called subscriber hangs up, a starting circuit for said finder, a relay energized when the link is taken for use to transfer said starting circuit to the finder of another link, and means for preventing the deenergization of said relay after the said first finder is released and until the connector is released.

16. The combination, with a series of counting relays connected alternately to ground and battery, of a line relay and associated means for transmitting alternate battery and ground impulses to said relays.

17. The combination, with a series of counting relays connected alternately to ground and battery, of a line relay having an armature spring for transmitting impulses to said relays, and a reversing relay for connecting said spring alternately to battery and ground.

18. The combination, with a switch responsive to two series of impulses, of a line relay responsive to said impulses, and switching means for causing said line relay to transmit alternate battery and ground impulses responsive to the first series of impulses, and ground impulses only responsive to the second series of impulses.

19. In a telephone system, an automatic switch, means for sending two successive series of impulses to said switch, and a motor magnet in said switch responsive to the first series of impulses only in case the series consists of more than one impulse and responsive to the second series regardless of the number of impulses.

20. In a telephone system groups of lines, an automatic switch normally positioned adjacent the first group, means responsive to any series of group selecting impulses for preparing the switch for operation responsive to a succeeding series of line selecting impulses, the switch being moved only in case the group selecting series does not correspond to the first group, and means for operating the switch responsive to any series of line selecting impulses.

21. In a telephone system, groups of lines, an automatic switch, means in said switch responsive to a series of group selecting impulses for marking a desired group, a motor magnet for said switch for giving the same an automatic hunting movement to find the selected group, the hunting movement being started before the series is finished, and a relay energized when the selected group is found to shift the circuit of said magnet and adapt it for directive control responsive to a succeeding series of impulses.

22. In a telephone system, groups of lines, an automatic switch, a line relay in said switch responsive to series of controlling impulses, a train of counting relays, and a single motor magnet in said switch controlled by said line relay through the medium of said counting relays for accomplishing group selection and controlled directively

by said line relay independent of said counting relays for accomplishing line selection.

23. In a telephone system, an automatic switch, a group test wiper for said switch, a motor magnet controlled by said test wiper to give the switch an automatic group selecting hunting movement, means for rendering said magnet responsive to digit impulses after the group is selected, and means for again placing the magnet under control of said test wiper to cause the switch to restore to normal.

24. In a telephone system, an automatic switch, a group test wiper for said switch, means controlled by group impulses for marking a contact in the bank of said wiper, a motor magnet controllable by said test wiper to give the switch an automatic group selecting hunting movement, means for rendering the magnet responsive to digit impulses after the group is selected, means for restoring the marked contact to normal electrical condition, and means for again placing the magnet under control of said test wiper to cause the switch to hunt for its normal position.

25. In a telephone system, an automatic switch, groups of lines, means responsive to group impulses for marking a desired group, a motor magnet for giving the switch an automatic group selecting hunting movement, a switching relay energized in series with the motormagnet when the group selecting movement is completed, means controlled by said relay for rendering the magnet subject to directive control by digit impulses, a locking circuit for said relay, and means for opening the initial energizing circuit of said relay to enable said magnet to respond to the digit impulses.

26. In a telephone system, automatic switching mechanism for completing a talking connection between a calling and a called line, inductive connections dividing the talking circuit into two sections, a battery feed coil individual to the calling line, a battery feed coil individual to the called line, a double wound coil common to both lines, a winding on the common coil in series with said first coil, and another winding on said common coil in series with said second coil.

27. In a telephone system, a connector switch having group and line selecting movements for connecting with called lines, a train of counting relays controlling the group selecting movements of said switch, and circuit connections for supplying called lines with talking currents through a winding of one of said counting relays.

28. In a telephone system, a connector switch for connecting with a called line, a line relay having an armature spring with front and back contacts, a ringing current generator, a motor magnet, a stepping circuit including said magnet and the said spring and its back contact, and a signalling circuit for the called line including said generator and the said spring and its front contact.

29. In a telephone system, an automatic connector switch for connecting a calling and a called line, inductive connections dividing the established connection in two sections, a battery feed relay individual to the calling section, a double wound battery feed relay common to both sections, and a signalling circuit for the called line controlled jointly by both relays.

30. In a telephone system, automatic switching mechanism for connecting a calling and a called line, a relay under the sole control of the calling line, a second relay adapted for joint control by both lines, but initially controlled only by the calling line, a signalling circuit completed by the de-energization of the second relay while the first is energized, a third relay energized when the called party responds, and contacts on the third relay for placing the second relay under the control of the called line whereby the second relay is energized and the signalling circuit is broken.

In witness whereof, I hereunto subscribe my name this 21st day of July, A. D. 1921.

RODNEY G. RICHARDSON.