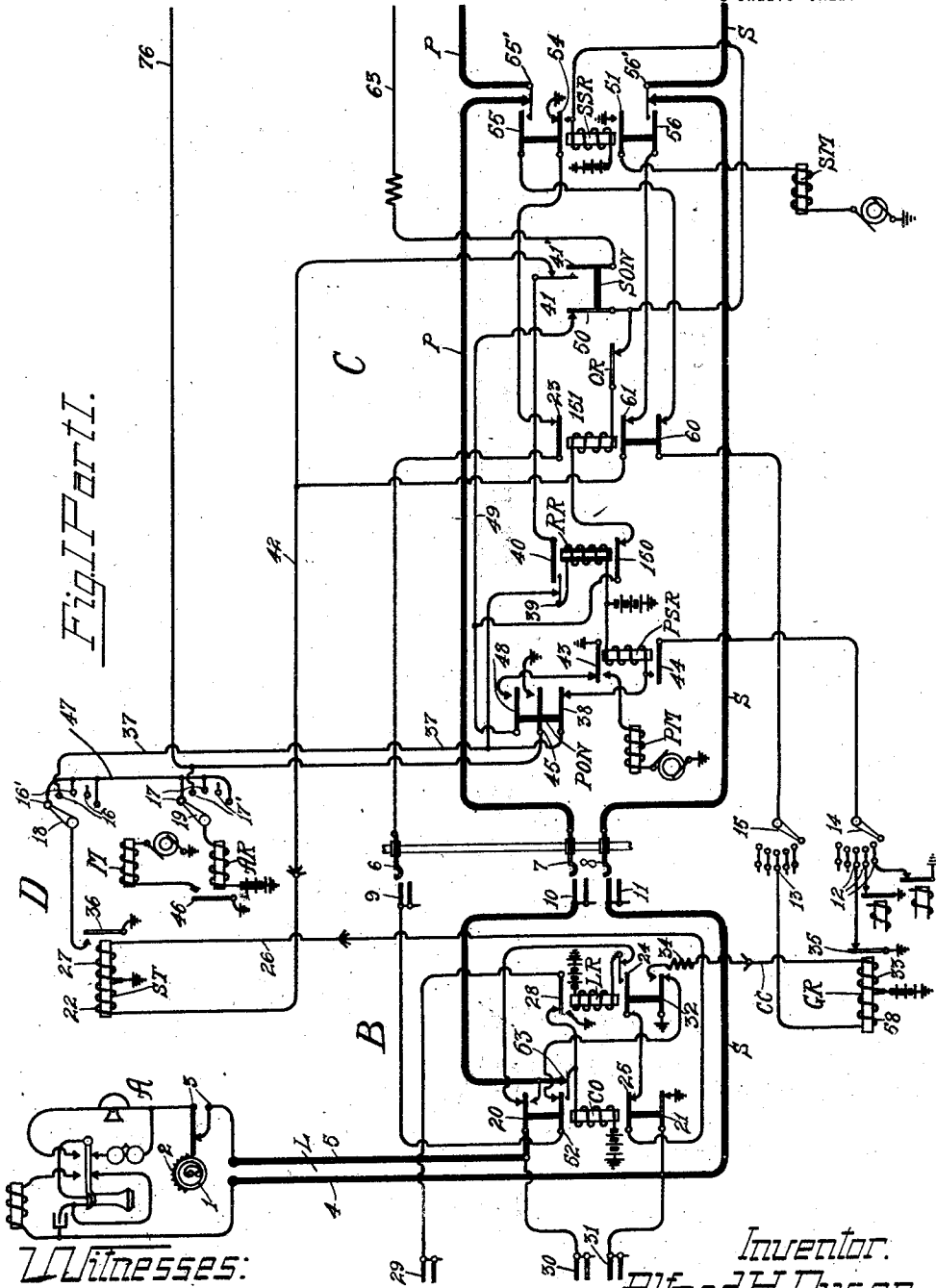


A. H. DYSON.
 AUTOMATIC TELEPHONE SYSTEM.
 APPLICATION FILED SEPT. 9, 1912.

Patented Sept. 14, 1915.

3 SHEETS—SHEET 1.

1,153,542.



Witnesses:

G. E. Mueller
Wm. Berghahn

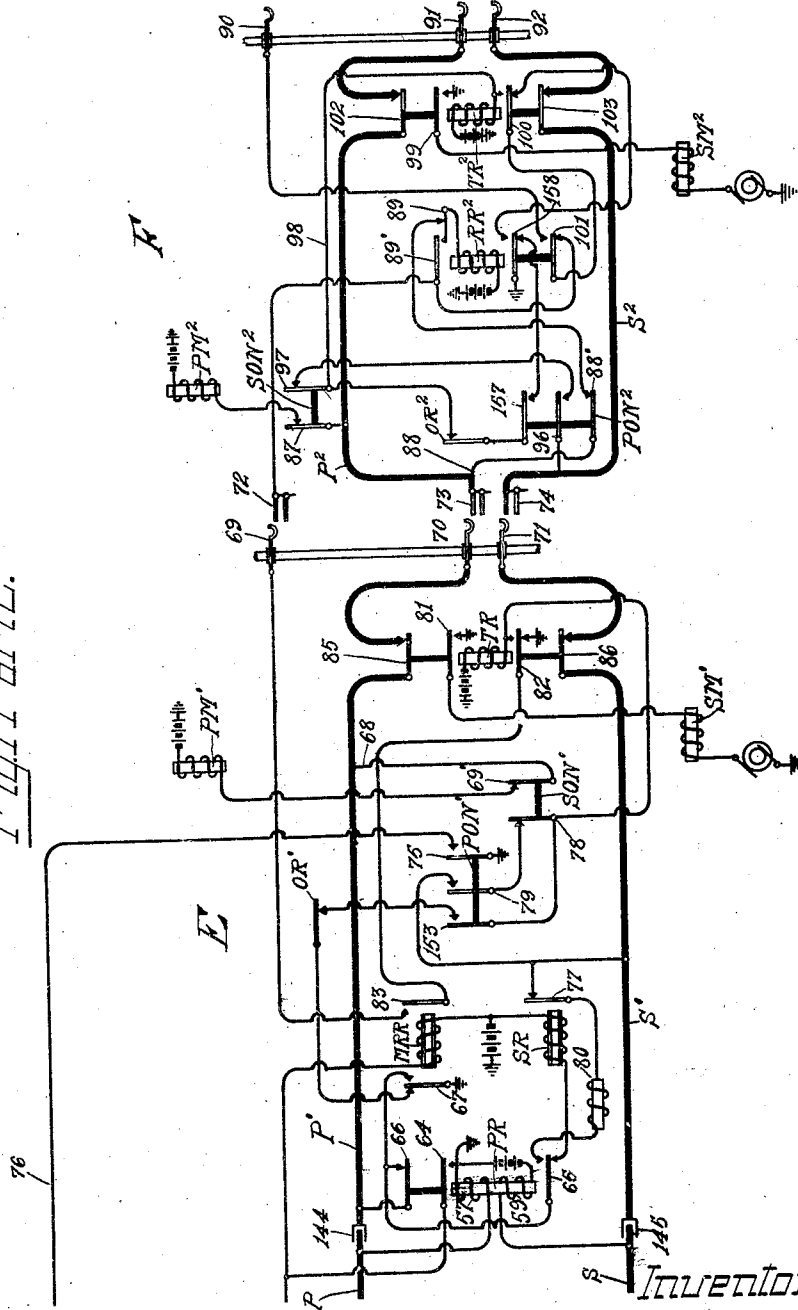
Inventor.
Alfred H. Dyson.
 By *Curtis Blum*
 Attorney.

A. H. DYSON.
AUTOMATIC TELEPHONE SYSTEM.
APPLICATION FILED SEPT. 9, 1912.

1,153,542.

Patented Sept. 14, 1915.
3 SHEETS—SHEET 2.

Fig. 1 Part C.



Witnesses:

G. E. Mueller
Wm. Berghahn

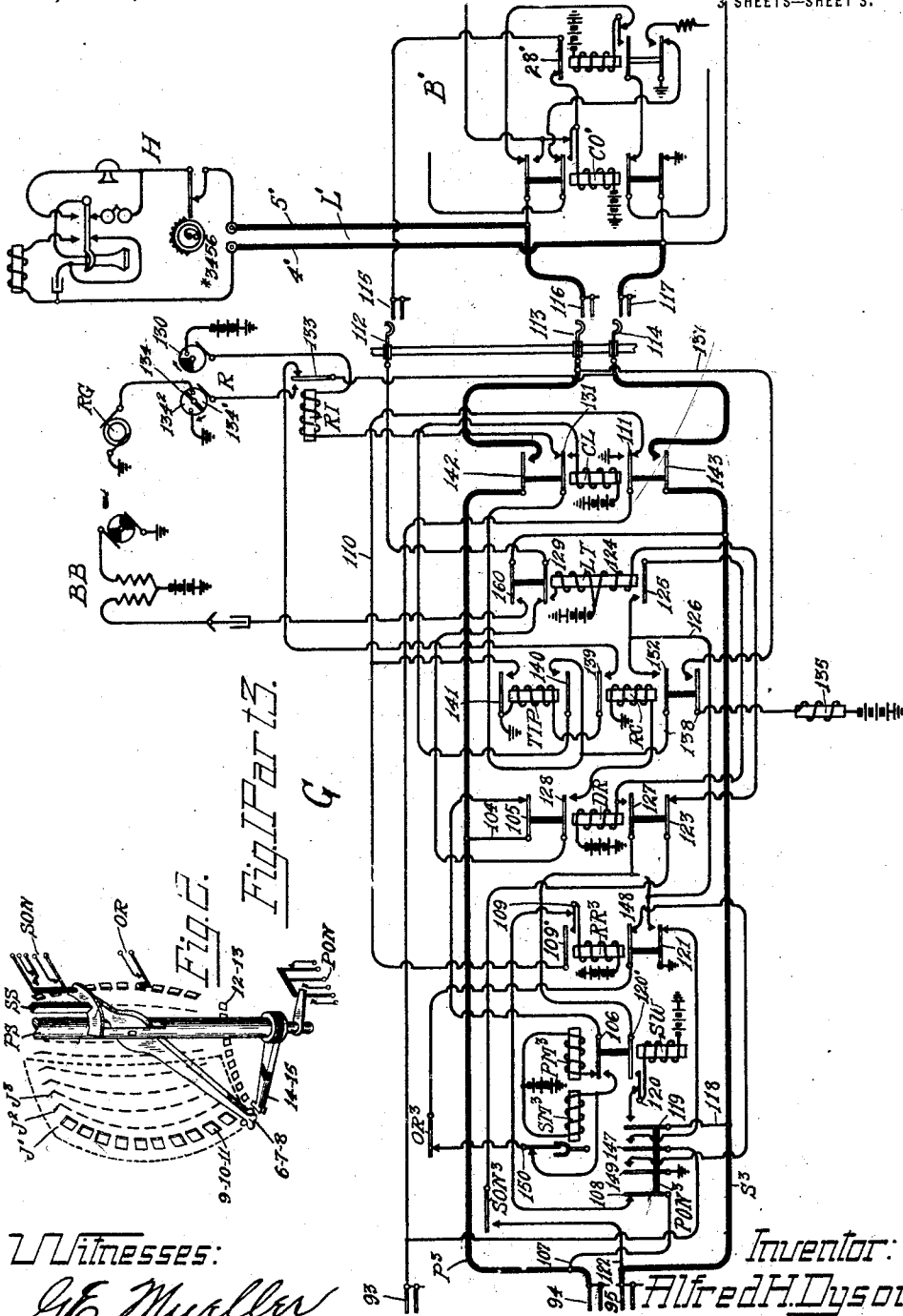
Inventor:
Alfred H. Dyson.
By Curtis Blamp
Attorney.

A. H. DYSON.
AUTOMATIC TELEPHONE SYSTEM.
APPLICATION FILED SEPT. 9, 1912.

1,153,542.

Patented Sept. 14, 1915.

3 SHEETS—SHEET 3.



Witnesses:

GE. Mueller
Wm. Berghahn

Inventor:

Alfred H. Dyson.
By *Curtis Blumf.*
Attorney.

UNITED STATES PATENT OFFICE.

ALFRED H. DYSON, OF NEW YORK, N. Y., ASSIGNOR TO KEELLOGG SWITCHBOARD AND SUPPLY COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE SYSTEM.

1,153,542.

Specification of Letters Patent.

Patented Sept. 14, 1915.

Application filed September 9, 1912. Serial No. 719,303.

To all whom it may concern:

Be it known that I, ALFRED H. DYSON, a citizen of the United States of America, residing in New York, county of New York, and State of New York, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates in general to telephone systems in which automatic switches are employed for extending connections of calling telephone lines and in the preferred embodiment of my invention, as herein disclosed, I preferably employ switches of the two-dimension type, that is switches having bank contacts divided into groups and associated wipers adapted to receive a primary adjustment to select a group and thereafter a secondary adjustment to select a contact in a group. The preferred type of switch employed does not include a release magnet but the release of the wipers is effected by continuing the secondary travel thereof until they have advanced beyond the last contact of the selected group whereby they are automatically restored by spring tension. These switches may be referred to as of the two-dimension step ahead release type. In the preferred embodiment of my invention I also use line selector switches and associated master switches for starting an idle line selector to seek connection with the calling line.

Certain features of my invention relate more particularly to an improved circuit arrangement of the line selector and master switch.

Another feature is the provision of means for automatically cutting off the secondary magnet when, in its release operation, it has stepped the wipers beyond the last contact of the row.

Other features of my invention will be more particularly pointed out in the specification and the appended claims.

For a more complete understanding of my invention reference will be made to the accompanying drawings, in which—

Figure 1 comprising parts 1, 2, and 3 illustrates diagrammatically an automatic telephone system and Fig. 2 is a perspective view of the contact bank and wiper arrangement.

Referring now more particularly to the system of Fig. 1, by placing part 2 to the right of

part 1 and part 3 to the right of part 2, the description of operation will be more readily followed. In general the system of Fig. 1 comprises substation telephones A, line circuits B, line selectors C, master switches D, first selectors E, second selectors F and connectors G. The system of Fig. 1 is adapted for interconnecting 10,000 telephone lines L, the lines and line circuits B being divided into groups of 100 lines each and for each such group, 10 line selectors C are provided, each 100 associated lines being multiply connected to terminals of 10 line selectors C so that each line selector C has access to any one of its group of 100 lines. In the illustration but two such multiple connections are shown. For each such group of 100 lines and 10 associated line selectors, a common master switch D is provided being adapted upon initiation of a call over one of the associated lines to start an idle line selector C to seek connection with the calling line. A first selector E is connected to each line selector C so that it may be operated by the calling subscriber to extend the circuit of the calling line. 1000 second selectors F are provided and 1000 connectors G are also provided these being distributed and multiplied in a well known manner. Substation H line L' and line circuit B' of Fig. 1 part 3 represent a called-for substation and associated circuits.

Selector and connector switch construction.—Before proceeding further with the description of the circuits, it is believed that their operation will be more readily understood by referring to the type of selector and connector switch mechanism preferably used.

For use with the selector and connector circuits of the system of Fig. 1, a switch such as is shown in an application of William Kaisling for automatic switch for telephone systems, Serial No. 600,664, Pat. No. 1,131,140, filed January 3, 1911, may be used.

The switch referred to in the previous paragraph, in general comprises a bank of contacts made up of 100 sets of contacts with three contacts 9, 10, 11, to each set, and divided into ten groups of ten contact sets each as illustrated diagrammatically in Fig. 2. A set of wipers 6, 7, 8, are provided, to cooperate with the bank contacts, a primary magnet (corresponding to P. M. of the

switch circuits) being adapted to primarily adjust the wipers through the medium of a primary shaft PS to select a group of contacts, and a secondary magnet (corresponding to S. M. of the switch circuits) is provided to step the wipers through the medium of a secondary shaft SS in a secondary direction in a plane at right angles to the primary, to select a contact set of the selected sub group. The switch construction is such that the wipers are advanced against the tension of a pair of so-called watch springs, one spring opposing each movement respectively.

To release the wipers, that is, to restore them to normal, the secondary magnet is again actuated to step the wipers beyond the last contact of the sub group whereby they are automatically restored to normal by the springs referred to, but over a different path than that taken by the wipers in the advance movement of the switch in selecting a contact. Thus, in the operation of the switch the contacting ends of the wipers travel in a primary direction to select a sub group of contacts, then in a secondary direction to select a contact in the sub group, and in the release of the wipers this secondary travel is continued until the contacting ends have passed beyond the last contact in the group, whereby they are automatically released to continue their restoration to normal, this continued movement being in a plane parallel to the primary movement but in an opposite direction until they reach a point directly above the starting point when they are moved downward through a plane parallel to the secondary movement, but in a direction opposite to the secondary movement, until they reach their normal starting point. A complete travel of the wipers is indicated by the dotted line in Fig. 2.

A set of primary off-normal spring contacts PON are moved upon the first primary step of the switch while a set of secondary off-normal spring contacts SON are moved upon the first secondary step of the switch. It is to be understood that for a more complete understanding of this switch, reference is to be had to the above identified application.

Each substation comprises preferably a well known form of switch hook and receiver, a call bell and condenser normally bridged across the line which are adapted to have their circuit interrupted and the circuit of a transmitter and impedance coil bridged across the line upon removal of the receiver. A calling device 1 is also provided comprising a toothed dial member 2 adapted to cooperate with impulse springs 3 in such a manner that when the dial is advanced contacts 3 are not interrupted but when the dial is released to be restored by

its spring, contacts 3 are interrupted according to the number of teeth on dial 2 which were initially advanced.

Substation A is connected to the central office by means of a pair of line limbs 4, 5 terminating in a line circuit B comprising preferably a line relay LR and cut-off relay CO. Line relay LR is adapted to be energized upon initiation of a call over its associated line to start an idle line selector C and upon connection being made with the calling line by such line selector, cut-off relay CO is energized to extend the calling line circuit and interrupt the circuit of the line relay LR.

As previously referred to, the lines are divided into groups of 100 each and these groups are further divided into 10 sub groups of 10 lines each, corresponding to the 10 groups J¹, J², J³, etc., of contacts of the line selector such as illustrated in Fig. 2. In starting a line selector C to select a calling line, its wipers such as 6, 7, 8, are first operated to pick out the group of line contacts 9, 10, 11 which include the contacts of the calling line and for each such group of line contacts or terminals 9, 10, 11, a pair of group contacts, 12, 13 are provided together with cooperating wipers 14, 15. For each such group of 10 line circuits B a group relay GR is provided for controlling its group contacts, being connected through a common conductor CC to the 10 line relays LR of its group. Each relay GR is also connected to its group contacts 12, 13, as shown in Fig. 1, Part 1. When a line as L is calling, the associated group relay GR is energized to remove ground from the associated group contact 12 so the line selector C in seeking the calling line stops its wipers in their primary movement upon reaching the ungrounded contact 12.

Master switch D.—Common to each group of 100 lines is a master switch D which is preferably a simple rotary switch comprising two sets of contacts 16 and 17 and cooperating wipers 18 and 19, said wipers being insulatively mounted upon a common shaft adapted to be rotated by means of a suitable ratchet or pawl arrangement driven by a motor magnet M. As previously stated I preferably employ 10 line selectors C for each group of 100 lines and therefore I provide as many contact sets 16, 17 (in this case 10 sets), as there are line selectors C. Intermediate contacts 16', 17' are provided to prevent starting two line selectors after a single line as will be more clearly set forth.

Master switch D is so arranged with respect to line circuits B, and line selector C, that should there be more than one line simultaneously calling, master switch D starts an idle line selector C and upon the first step of such switch C, master switch D advances to the next idle set of contacts and starts an-

other line switch C and so on according to the number of lines calling. The starting relay ST is differentially connected and when a circuit is closed through its winding 5 27 and LR in series, contact 36 is closed, and when relay RR of C is connected in series with winding 22, which occurs when switch E starts after the calling line, a differential effect is produced, causing the interruption of contact 36. The windings of LR and RR 10 are so related to windings 27, 22 of ST, that when the two series circuits as above referred to are closed, the magnetic action of windings 27, 22 neutralize each other. If 15 several lines are simultaneously calling, there would be more than one relay LR connected in series with winding 27, and therefore the starting relay ST is not neutralized to open contact 36 until as many line selectors C have been started as there are lines 20 calling. This will be described more in detail.

Line selector C.—Each line selector C comprises a primary magnet PM and a secondary magnet SM controlled by a primary 25 selecting relay PSR and secondary selecting relay SSR respectively. A release relay RR is also provided preferably of the slow acting type. Primary off-normal contacts 30 PON, secondary off-normal contacts SON, and over-run contacts OR are also provided, being operated as pointed out in connection with Fig. 2.

First selector E.—The first selectors E 35 comprise primary and secondary magnets PM¹ and SM¹ respectively. Off-normal and over-run switch contacts, PON¹, SON¹, OR¹, are also provided these being indicated by reference characters corresponding to the 40 reference characters indicating like parts at line selector C. A primary or impulse relay PR is also provided being bridged across the talking strands and adapted to be energized by current over the calling line. A main 45 release relay MRR is also provided being of a slow acting type and adapted to be energized responsive to relay PR and maintained energized until a prolonged deenergization of relay PR is effected, which occurs when the receiver is replaced at the 50 calling substation. A so-called secondary relay SR is also controlled by relay PR and is adapted to effect a secondary circuit change after each set of primary impulses have been 55 transmitted by impulse relay PR. Test relay TR controls magnet SM¹ when operating the switch to select an idle set of contacts, or in causing a release of the switch.

Second selector F.—Second selector F 60 includes relays, magnets, and off-normal switches similar to the selector E already referred to and indicated by corresponding reference characters but with the suffix "2".

Connector G.—Certain relays, magnets

and off-normal switches of connector G are similar in function to parts of the previously described switches and have corresponding reference characters, but with the suffix "3". Switch G also includes a switching 70 relay SW which is operated after the first set of primary impulses to disconnect the primary magnet and connect the secondary magnet in circuit, a line test relay LT which is initially energized responsive to the second secondary circuit change transmitted to 75 switch G, to test the terminals of the called line to determine their idle or busy condition. A so-called ringing relay RI is also provided, a tip relay TIP which is actuated 80 upon response of the called subscriber, a circuit closing relay CL energized after the called subscriber has answered to close the circuit between the calling and called lines, a busy back apparatus BB and ringing apparatus R. 85

The called substation H is connected to a line L¹ and a line circuit B¹ similar to the line circuit B.

Operation.—Having described in general 90 the apparatus involved in establishing a connection, the operation of the system in establishing a connection between a calling and called substation will now be described: Assuming a subscriber at A desires to connect 95 with a subscriber at substation H whose telephone number is 3456, he will remove his receiver from its switch-hook whereby a circuit for line relay LR is established traced from battery through the winding of LR, 100 normal contact 20, line conductor 5 substation A, line conductor 4 and normal contact 21 to ground. Relay LR is thus energized and a series circuit including its winding and winding 27 of the differential starting 105 relay ST (master switch D.) is established traced through LR, alternate contact 24, normal contact 25, common conductor 26 and the winding 27 to ground. Starting relay ST is therefore energized over the path 110 traced and the relays ST and LR remain energized over said series circuit. The closing of alternate contact 28 of relay LR connects a ground or busy potential to the test 115 contacts 29 to prevent any connector switch from connecting to the terminals 29, 30, 31, of the line of substation A. Responsive to the closing of alternate contact 32 of relay LR a circuit through winding 33 of group relay GR is established through resistance 120 34, energizing relay GR and causing interruption of its contact 35 to remove ground from its group contact 12. Responsive to energization of relay ST its alternate contact 36 is closed establishing a circuit for 125 advancing relay AR, traced from ground at alternate contact 36, wiper 18, contact 16¹, common 47, contact 17¹, wiper 19 and the winding of AR to battery. Relay AR therefore closes its alternate contact 46, causing 130

M to advance the wipers one step. If the contacts 16, 17, thus engaged lead to an idle pair of switches C E, test contact 17 is on open circuit, and relay AR deenergizes rendering the wipers inert. A starting circuit for the idle line selector C is therefore established traced from ground through alternate contact 36, wiper 18, contact 16, conductor 37, normal contact 38 and the winding of PSR to battery. This ground connection over conductor 37 also extends through normal contact 39 and the winding of release relay RR to battery, causing its energization. Alternate contact 40 of relay RR is thereby closed connecting the winding of relay RR in circuit with winding 22 of relay ST, (master switch D) this circuit being traced from battery through the winding of RR, alternate contact 40, normal contact 41, conductor 42 and winding 22 to ground. If at this time no other line in the group of master switch D is calling, due to the equal flow of current through windings 22, 27 of differential relay ST, its armature is retracted interrupting alternate contact 36. It will be remembered that the circuit through winding 27 included the winding of relay LR and as the resistance of the winding of LR is substantially the same as the resistance of RR, it will be apparent that the differential effect upon relay ST causes its armature to retract. Of course if any other line or lines of the group of master switch D be calling at this time, due to the greater flow of current through winding 27, contact 36 will be maintained closed in order to start another line selector when master switch D is advanced as will be described.

Referring again to line switch C it will be remembered that primary selecting relay PSR is energized. Therefore its alternate contact 43 is closed establishing an operating circuit for primary magnet PM whereby the wipers 14, 15 of switch C are advanced to the first group contacts 12, 13, respectively, while wipers 6, 7, 8, are advanced opposite the first row or group of contacts 9, 10, 11. I have indicated the line of substation A as being associated with the third sub group of lines, and assuming no other line is calling at this time, the first two sub group contacts 12 are at a ground potential as indicated. Therefore a locking circuit for relay PSR is established through its alternate contact 44. Magnet PM therefore advances the wipers another step and finding the second group contact 12 also grounded the wipers are advanced another step, and contact 12 of this third sub group being ungrounded the circuit for relay PSR is interrupted allowing it to deenergize and interrupt the circuit for magnet PM. Upon the first primary step of switch C, contacts PON are moved to their alternate position and due to the closing of alternate contact

45, ground is connected to contact 17, wiper 19, and the winding of advancing relay AR to battery, causing its energization whereby alternate contact 46 is closed establishing a circuit for motor magnet M which advances wipers 18, 19, a single step. If at this time no other line in the group is calling, starting relay ST has its contact 36 interrupted as described and therefore relay AR deenergizes and the wipers 18, 19 remain inert. If on the other hand, some other line in the group also be calling, alternate contact 36 of starting relay ST is closed (due to the preponderance of current in winding 27) and due to said single step of wipers 18, 19, a circuit from ground at alternate contact 36 is established through wiper 18, contact 16, conductor 47, contact 17, wiper 19 and the winding of AR to battery maintaining said relay energized, and the wipers are advanced another step. Assuming the contacts 16, 17 now engaged lead to an idle selector C, relay AR deenergizes interrupting the circuit for M and rendering wipers 18, 19 inert. As soon as wiper 18 engaged the contact 16 leading to such an idle line selector C, with starting relay ST energized, (due to another calling line) a starting circuit for such an idle line selector C will be established whereby it will be started from normal to seek this second calling line. Thus it will be apparent should more than one line be calling at one time, as soon as one line selector C makes a step, a second switch will be started and upon the second switch making a step a third switch will be started and so on until as many line selectors C have been started as there are simultaneous calls up to the number of line selectors C consigned to the group.

Referring again to relay PSR, upon its deenergization when the calling group is reached as previously referred to, a circuit for secondary selecting relay SSR is established from ground through normal contact 43 of PSR alternate contact 48, conductor 49, normal contact 50, and the winding of SSR to battery causing the energization of the said relay SSR whereby its alternate contact 51 is closed establishing an operating circuit for magnet SM. Magnet SM therefore steps wipers 6, 7, 8, in a secondary direction to engage the first set of contacts 9, 10, 11, in the selected sub group. With a line circuit at normal, its test contact 9 is connected to ground through normal contacts 52, 32, but while a line is calling, due to the interruption of normal contact 32, test contacts 9 thereof are on open circuit and upon a calling line being selected its test contacts 9 are again connected to ground potential as will be more clearly pointed out. From this it will be seen that only during the period between initiation of a call and until a line is selected are its test

contacts 9 selectable. Therefore, if the first test contact 9 connected with is associated with a line which is not calling, or has already been connected with, it will be connected to ground and therefore a locking circuit for relay SSR is established traced from the said contact 9, wiper 6, normal contact 23, alternate contact 54 and the winding of SSR to battery maintaining said relay energized. Magnet SM therefore advances the wipers another step and in fact continues to do so until wiper 6 reaches an ungrounded test contact 9 whereby the circuit for relay SSR is interrupted causing it to deenergize and interrupt the circuit for magnet SM whereby wipers 6, 7, 8, remain in engagement with the terminals 9, 10, 11, of the calling line.

Referring again to relay SSR, upon its said initial energization its alternate contacts 55 and 56 are closed thereby connecting the winding 57 of relay PR in series with winding 58 of group relay GR, and the lower winding 59 of relay PR in series with winding 22 of starting relay ST. The circuit including winding 57 of relay PR and winding 58 of GR is traced from ground through the winding 57, primary conductor P, alternate contact 55, normal contact 60, wiper 15 contacts 13, and winding 58 to battery. It will be noted that the initial energizing circuit for relay GR includes resistance 34 and the windings of relay GR are preferably proportioned so that when winding 57 of relay PR (which is substantially the same resistance as resistance 34) is connected in series with the winding 58 of relay GR, due to the differential effect produced, relay GR retracts its armature closing normal contact 35 and thereby again connecting ground to group contacts 12 rendering the associated group of contacts 9, 10, 11, unselectable. Thus, it will be seen that as soon as the secondary selecting relay SSR is energized to close the circuit for secondary magnet SM, group relay GR deenergizes to again ground its group contact 12 so that if some line in a sub group beyond sub group 12 is calling and another line selector C is started, such selector can pass all sub group contacts 12 to reach the sub group of the other calling line. Of course if some other line in the sub group of line A is also calling at this time, a circuit through its resistance 34 and winding 33 of GR is sufficient to maintain the armature of relay GR attracted, so that when the other started line switch C reaches the sub group contact 12 in which the line of substation A and this other calling line is located its movement will be stopped in a manner similar to that described in connection with line selector C. Also upon the first secondary step of line selector C, secondary off-normal contact 41 is interrupted whereby the starting relay

ST has its winding 22 connected in series circuit with the winding 59 of relay PR, this circuit being traced from battery through said winding 59, secondary conductor S, alternate contact 56, normal contact 61, conductor 42 and winding 22 to ground maintaining relay ST neutralized and its contact 36 interrupted until the line has been selected. Upon wipers 6, 7, 8, reaching the terminals 9, 10, 11, of the calling line, there being no ground upon test contact 9 the circuit for relay SSR is interrupted whereby it deenergizes rendering magnet SM inert and due to the interruption of the alternate contacts 55, 56, the circuit from windings 57, 59 of relay PR through windings 58 and 22 of relays ST and GR respectively are interrupted. After the circuit through winding 22 is interrupted by contact 56 as stated, the circuit through winding 27 is momentarily maintained closed thereafter because relay CO does not interrupt its contact 25 until after contact 56 interrupts, but I have found this does not cause sufficient attraction of the armature of ST to close alternate contact 36. Therefore wipers 18, 19 remain in engagement with contact 16¹ 17¹ until another call.

Referring again to relay SSR, upon its deenergization after connecting with the terminals of the called line and due to the closure of its normal contact 55¹ a circuit for cut-off relay CO is established from ground through winding 57 of relay PR, conductor P, normal contact 55¹, wiper 7, contact 10, normal contact 63 and the winding of CO to battery causing its energization, and maintaining PR energized. The closing of alternate contact 52 establishes a locking circuit for CO traced through contact 9, wiper 6, normal contacts 23 and 54 to ground. This ground connection is also effective to maintain a busy potential upon the multiple test terminals 9. Due to the interruption of normal contact 25 of CO, the series circuit including line relay LR and winding 27 of relay ST is interrupted, causing deenergization of LR. Upon said restoration of relay LR its alternate contact 32 is interrupted, thereby interrupting the circuit through winding 33 of GR, and as the circuit through winding 58 thereof was interrupted due to the interruption of alternate contact 55 when relay SSR deenergized, relay GR keeps its armature retracted thereby maintaining its sub group contact 12 unselectable. Should another line in the same sub group as line L be calling, there would be a preponderance of current through winding 33 of relay GR and therefore its armature would remain attracted, and its group contact 12 selectable until this other said line is selected and its relay LR deenergized.

Referring to relay RR it will be remem-

bered that it was initially energized by a circuit from grounded contact 36 of relay ST and then established a locking circuit for itself through its alternate contact 40, normal contact 41, and winding 22 to ground. Upon the first secondary step of switch C, secondary off-normal contact 41 is interrupted and alternate contact 41¹ closed, and as relay PR was energized responsive to the initial energization of relay SSR, due to the closing of alternate contact 41¹ a substitute locking circuit for relay RR was established over conductor 63 to ground at alternate contact 64, of PR. Relay RR being a slow acting relay does not retract its armature until a prolonged interruption of said alternate contact 64. That is, while relay PR is vibrating to transmit primary impulses, the rapid interruptions of alternate contact 64 do not allow retraction of the armature of relay RR, but when the receiver is replaced, a prolonged deenergization of PR allows relay RR to restore. Upon said energization of cut-off relay CO, due to the closure of its alternate contact 20, impulse relay PR is maintained energized by a circuit over the calling line, this circuit being traced from ground through winding 57 of relay PR, primary conductor P to line conductor 5, substation A, line conductor 4, secondary conductor S through winding 59 of relay PR to battery.

The circuit of the calling line having been extended to first selector E, the subscriber at A operates dial 1 to cause three interruptions of contacts 3, corresponding to the first digit of the called substation number, these interruptions causing three interruptions of the metallic energizing circuit of relay PR whereby it retracts its armature three times causing three operations of its contact springs. Relays RR and MRR being slow acting relays do not retract their armatures responsive to these rapid interruptions of alternate contact 64. Upon the first closure of normal contact 65 of relay PR, a circuit for slow acting secondary relay SR is established, causing its energization and due to the ensuing impulses through said normal contact 65, maintaining its armature attracted until the cessation of the primary operations of relay PR. These impulses flow from battery through SR, normal contact 65 to ground, at alternate contact 67. Responsive to the three closures of normal contact 66 of relay PR, three primary impulses are transmitted through primary magnet PM¹, traced from ground at alternate contact 67, normal contact 66, primary conductor P¹, conductor 68, normal contact 69, and the winding of PM¹ to battery, causing three operations thereof. This effects three steps of wipers 69, 70, 71 to select the third row of contacts 72, 73, 74 which group leads to second selectors F hav-

ing access to connectors in the third thousand group which is the group including the line of substation H.

Upon the first primary step of the switch, primary off-normal switch PON¹ moves to its alternate position whereby alternate contact 75 is closed connecting ground over conductor 76 to the corresponding master switch contact 17 thus maintaining the pair of switches C E unselectable while switch E is off-normal.

Following the said three operations of relay PR a prolonged energization thereof follows, that is it remains energized until the next operation of the calling device, and therefore, due to the prolonged interruption of normal contact 65 secondary relay SR is deenergized to allow its armature to retract, whereby normal contact 77 is closed establishing a secondary circuit change to effect the energization of test relay TR. This circuit is traced from battery through the winding of TR, normal contact 78 of SON¹, alternate contacts 79, 77, impedance coil 80, alternate contacts 65, 67 to ground. Responsive to said energization of TR its alternate contact 81 is closed establishing a circuit for the secondary magnet SM¹ whereby magnet SM¹ advances wipers 69, 70, 71 into engagement with the first set of contacts 72, 73, 74 in the selected group. On the first secondary step of the switch, the secondary off-normal contact 78 is interrupted, thereby interrupting the initial energizing circuit for test relay TR which now becomes dependent for further energization upon a circuit extending through alternate contacts 82, 83, wiper 69 and the first encountered test contact 72 which if busy has a ground or busy potential connected thereto, as will be pointed out. Assuming this first encountered set is busy, relay TR is maintained energized and therefore magnet SM¹ advances the wipers another step and in fact continues such advancement as long as its wiper 69 is in engaging busy test contacts 72. Upon the test wiper 69 engaging test contact 72 of the idle second selector F, the circuit for relay TR is interrupted whereby it deenergizes interrupting the circuit for magnet SM¹ and rendering wipers 69, 70, 71 inert. Also upon deenergization of relay TR, due to the closing of its normal contact 82, ground is connected to wiper 69 and the multiple test terminals 72 of the selected switch F, thereby rendering it unselectable by any other switch. It will be noted that during the secondary operation of switch E while its wipers are passing over bank contacts, due to the interruption of normal contacts 85, and 86, line wipers 70 and 71 are disconnected so they will not interfere with any existing connections.

As the next step in establishing the connection, the subscriber operates calling de-

vice 1 to cause four interruptions of its contact springs 3, corresponding to the second digit in the called substation number, thereby interrupting the circuit of relay PR four times, causing four operations of its contact springs. Responsive to the first closure of its normal contact 65, secondary relay SR is again energized and maintained energized while relay PR is operating. Responsive to the four closures of normal contact 66, four impulses of current are transmitted through primary magnet PM² of second selector F, being traced from ground at alternate contact 67, normal contact 66, primary conductor P¹, normal contact 85, wiper 70, contact 73, primary conductor P², normal contact 87 and the winding of PM² to battery causing four operations thereof. The first one of these four primary impulses also follows a path from conductor P², over conductor 88, primary off-normal contact 88¹, normal contact 89 and the winding of release relay RR² to battery, causing its energization whereby its alternate contact 89¹ is closed establishing a locking circuit to the grounded test contact 72, so that release relay RR² is now controlled from first selector E. Responsive to the said four operations of magnet PM², wipers 90, 91, 92, are advanced four steps to select the fourth sub group of contacts 93, 94, 95, which are the sub group contacts leading to connectors in the fourth hundred group, which group includes the line of called substation H. Upon cessation of the said primary operations of relay PR, secondary relay SR retracts its armature as before, effecting another secondary circuit change whereby an energizing circuit for test relay TR² is established, traced from ground over the previously described circuit through normal contact 77 of relay SR, then over conductor S¹, normal contact 86, wiper 71, contact 74, alternate contact 96, normal contact 97, conductor 98 and the winding of TR² to battery. Its alternate contact 99 is therefore closed, establishing an operating circuit for secondary magnet SM² whereby wipers 90, 91, 92 are stepped into engagement with the first set of contacts 93, 94, 95. Idle sets of contacts 93, 94, 95, have their test contact 93 preferably on open circuit, while such contact sets when busy have their test contact 93 connected to the busy or ground potential as will appear from the following. Therefore when the initial energizing circuit for relay TR² is interrupted at normal contact 97 of SON², upon the first secondary step of switch F, relay TR² being connected through its alternate contact 100 and alternate contact 101 to test wiper 90, is maintained energized (assuming the first test contact 93 is busy) so that magnet SM² continues to advance the wipers until an idle set of contacts 93, 94, and 95 is reached. Upon engaging such an idle set of contacts

which we will assume are the contacts leading to switch G illustrated, relay TR² is de-energized interrupting the circuit for magnet SM² whereby wipers 90, 91, 92 remain in engagement with the selected idle set of contacts. During this secondary adjustment of switch F, due to the interruption of its normal contacts 102, 103, line wipers 91, 92, are on open circuit so that there is no interference with any existing connections they might engage.

The calling line has now been extended to connector G, and the subscriber at substation A operates calling device 1 to cause 5 interruptions of its contacts 3, corresponding to the third digit of the called substation number, thereby effecting five interruptions of the circuit of primary relay PR and causing five operations of its contact springs. Responsive to these operations secondary relay SR is energized and maintained energized in a manner as previously described and due to the five closures of normal contact 66 of relay PR, five primary impulses are transmitted over primary conductor P¹, P², P³, conductor 104, normal contact 105, normal contact 106, and the winding of PM³ to battery. The first one of the last said series of primary impulses divides at conductor 107 of connector G, following a path through normal contacts 108, 109, and the winding of release relay RR³ to battery causing its energization. Its alternate contact 109¹ is therefore closed establishing a locking circuit for itself traced over conductor 110, normal contact 111 to grounded test contact 93. Thus release relay RR³ is controlled from second selector F, and by the calling subscriber through the medium of main release relay MRR as will be more particularly pointed out.

Responsive to the five operations of primary magnet PM³, wipers 112, 113, 114, are advanced five steps to select the fifth sub group of contacts 115, 116, 117, which is the sub group including terminals of the line of called substation H. Following the last said series of five primary operations of relay PR, relay SR de-energizes as before, effecting a secondary circuit change whereby ground is connected to secondary conductor S¹, S², S³, conductor 118, alternate contact 119 (which is now closed), normal contact 120 and the winding of switching relay SW to battery, causing its energization. Its alternate contact 120¹ is therefore closed establishing a locking circuit for relay SW to ground at alternate contact 121. The operation of switching relay SW disconnects primary magnet PM³ from the primary conductor P³, and connects secondary magnet SM³ thereto, so that the final set of primary impulses are effective to operate said magnet SM³.

The calling subscriber again actuates call-

ing device 1, to effect six operations of contact springs 3 whereby relay PR is operated 6 times to permit 6 primary impulses over the primary conductor to connector switch G, while the closing of alternate contact 65 effects energization of secondary relay SR as before. The said 6 primary impulses flow over the previously described path along the primary conductor and then to contact spring 106, through the alternate contact thereof and the winding of secondary magnet SM³ to battery causing 6 operations of SM³. This operation steps wipers 112, 113, 114, to the sixth set of contacts 115, 116, 117 of the row, which are the terminals of the called line. Following the said 6 primary operations of relay PR, secondary relay SR deenergizes as before transmitting a secondary impulse over the secondary conductor to connector switch G, conductor 122, alternate contact SON³, normal contact 123, and winding 124 of line test relay LR to battery causing the energization thereof. Up to this point the operation of the system is the same whether wipers 112, 113, 114, have connected to the terminals of an idle or a busy line. If the called line is busy, upon connecting to its terminals, relay LT is energized and a characteristic busy signal from busy back BB is transmitted to the calling subscriber, but if on the other hand terminals of the called line are idle, relay LT retracts and ringing current is applied to the terminals of the called line.

Called line idle.—Assuming now that the called line is idle, its test terminal 115 has no busy potential connected thereto so that no locking circuit for relay LT is established and therefore immediately deenergizes as will be described. Responsive to the closing of alternate contact 125 of relay LT at the said energization thereof, a circuit for the disconnect relay DR is established from battery through the winding thereof, alternate contact 125, conductor 126, to ground at alternate contact 121. Relay DR is therefore energized and its alternate contact 127 is closed establishing a direct locking circuit to grounded alternate contact 121. The interruption of normal contact 123 of relay DR interrupts the circuit for line test relay LT which therefore deenergizes, while the opening of contact 105 disconnects the operating magnet from the primary conductor.

Responsive to the closing of alternate contact 128 of relay DR, and normal contact 129 of LT, ringing control relay RC is connected in series with cut-off relay CO¹, this circuit being established from ground through the winding of RC, alternate contact 128, normal contact 129, wiper 112, contact 115, normal contact 28¹ and the winding of CO¹ to battery, causing the energiza-

tion of both said relays. The energization of CO¹ removes the substation control of line circuit B¹, while the energization of RC establishes an operating circuit for ringing relay RI traced from battery through the interrupter wheel 130, the winding of RI, normal contact 131, alternate contact 132, conductor 126 to ground at alternate contact 121. Due to the interruption of this circuit by interrupter wheel 130, ringing relay RI is periodically energized to operate its contact 133.

Interrupter wheels 130 and 134 are preferably arranged upon a common shaft in the relation illustrated, so that while ringing relay RI is energized and its alternate contact 133 closed, the ringing segment 134¹ is connecting ringing generator RG to the terminals of the called line, and before the circuit of relay RI is interrupted by interrupter wheel 130, the grounded section 134² is connected to alternate contact 133 momentarily. This momentary application of direct ground is to prevent kicking up of tip relay TIP from the discharge of ringing current from the called line conductors, after each application of ringing current. Upon each deenergization of relay RI, due to the closing of its normal contact 133, tip relay TIP, and impedance coil 135, and a source of battery are connected in bridged circuit of the called line to be energized upon response of the called subscriber.

Responsive to each application of ringing current to the called line, the call bell at substation H is operated over a circuit traced from ringing generator RG, segment 134¹, alternate contact 133, wiper 114, terminal 117, line conductor 4¹, the call bell and condenser at substation H, conductor 5¹, terminal 116, wiper 113, conductor 137, alternate contact 138, impedance coil 135 and battery to ground.

The called subscriber in response to the call removes the receiver at substation H from its switch-hook, thereby providing a direct current path, and upon the immediately following closure of normal contact 133 of RI, (if it is not already closed), a circuit for tip relay TIP is established traced from ground through the winding thereof, alternate contact 139, normal contact 133, wiper 114, terminal 117, called line, and substation H, terminal 116, wiper 113, conductor 137, alternate contact 138 and impedance 135 to battery. Relay TIP is therefore energized, closing its alternate contact 140 resulting in the energization of closing relay CL, which interrupts the circuit for RI to prevent any further application of ringing current to the called line. This is brought about in the following manner. The circuit for relay CL is traced from battery through the winding thereof, alternate contact 140, alternate contact 132, con-

ductor 126, to ground at alternate contact 121, and due to the closing of alternate contact 131 of CL, a locking circuit therefor is established in shunt of alternate contact 140 so that relay CL is not directly controlled by tip relay TIP. Otherwise the replacing of the receiver at H would cause another application of ringing current. Responsive to energization of CL, and due to the interruption of its normal contact 131, the circuit for RI is interrupted rendering it inert.

It will be remembered that release relay RR³ was locked up through normal contact 111 of CL, so that upon interruption of this normal contact 111 the initial locking circuit for RR³ is interrupted, but due to the fact that the tip relay TIP closed its alternate contact 141 previous to the interruption of normal contact 111, a substitute locking circuit for RR³ was established through said alternate contact 141 to ground thereby placing the release relay RR³ under control of the called substation. Up to the time of the response of the called subscriber the release of connector J was controlled from the calling substation, but upon response of the called subscriber due to the change of locking circuit for RR³, the release of connector G is controlled at the called substation H. Also, responsive to energization of closing relay CL, its alternate contacts 142, 143 are closed, thereby establishing a talking connection between the calling and called substations, this circuit being traced over the heavily marked primary and secondary conductors. Talking battery for the called substation is supplied through tip relay TIP and impedance coil 135 while, talking battery for the calling substation is supplied through relay PR. Condensers 145, 144 are interposed in the talking circuit at first selector E, to prevent interference between the relays controlled over the opposite ends of the connection.

Release.—After finishing conversation the subscribers replace their receivers upon their respective switch-hooks, this act of the called subscriber effecting the restoration of connector switch G and line circuit B¹, while this act of the calling subscriber effects the restoration of line circuit B, line selector C, first selector E and second selector F.

Assuming that the subscriber at H be the first to replace his receiver, the circuit for relay TIP is interrupted at the called substation whereby the said relay restores and by the interruption of its alternate contact 141 interrupts the locking circuit for RR³ which deenergizes. Alternate contact 121 thereof is thereby interrupted effecting the restoration of relays SW, DR and CL, these relays having been held energized over locking circuits including this alternate contact 121. Due to the interruption of alternate

contact 128 of relay DR, the circuit for relays RC and CO¹ is interrupted allowing restoration of these relays.

Upon restoration of RR³, due to the closing of its normal contact 121, ground is connected through alternate contact 147 to test contacts 93 rendering them busy during restoration of switch G. Also, upon restoration of RR³, due to the closing of its normal contact 148, a release circuit for secondary magnet SM³ is established, traced from ground at alternate contact 149 of switch PON³, normal contact 148, overrun contact OR³, interrupter 150, and the winding of SM³ to battery. Magnet SM³ thereupon steps the wipers of switch G in a secondary direction until they have reached a point beyond the last contact in the group, whereupon overrun contact OR³ is interrupted stopping the operation of magnet SM³. Also upon the wipers reaching this point they are automatically restored by spring tension as previously described. Responsive to restoration of the switch all off-normal contact sets are restored.

Responsive to the replacing of the receiver calling substation A, the circuit for relay PR is interrupted causing its restoration and due to the interruption of its alternate contact 64, main release relay MRR, and release relay RR of line selector C are restored, as it will be remembered that both of these relays have been maintained energized over a circuit including this alternate contact 64.

Referring first to the restoration of switch C, and line switch B, upon restoration of relay RR, its normal contact 150 is closed establishing an energizing circuit for relays SSR and 151 in series, the circuit therefor being traced from battery through the winding of SSR, contact OR, winding of 151, normal contact 150, alternate contact 48, and normal contact 43 to ground. Relay 151 energizes and due to the interruption of its normal contacts 60, 61, a circuit through windings 22 and 58 of relays ST and GR respectively is prevented, although alternate contacts 55, 56 of relay SSR are closed. The interruption of normal contact 23 of relay 151, interrupts the locking circuit for cut-off relay CO, causing its deenergization and restoring control of line circuit B to substation A, also disconnecting the busy potential from test terminals 29. Responsive to said energization of relay SSR, and due to the closing of its alternate contact 51, magnet SM advances the wipers of switch C to a point beyond the last contact in the bank whereby they are automatically restored in a manner as previously described. Upon the wipers reaching this over-run point, that is a point beyond the group, contact OR is interrupted effecting restoration of relays 151 and SSR, the

restoration SSR interrupting the circuit for magnet SM. Responsive to restoration of switch C, its three off normal contact sets are also restored, the restoration of normal contact 45 of PON, removing the ground or busy potential from its master switch contact 17 so far as switch C is concerned, but it will be noted that this contact is maintained busy over conductor 76 to alternate contact 75 until first selector E is restored.

Referring now to first selector E, responsive to restoration of relay MRR, the closing of its normal contact 67 establishes an energizing circuit for relay TR traced from said ground at normal contact 67, contact OR¹, alternate contact 153, and the winding of TR to battery causing its energization whereby the closing of its alternate contact 81 establishes an operating circuit for secondary magnet SM¹. The wipers of switch E are then stepped to a point beyond the last contact in the row and from there automatically restored by spring tension in a manner as previously described. Upon interruption of over-run contact OR¹, the circuit for relay TR is interrupted causing its restoration and preventing any further operation of magnet SM¹. The restoration of switch E effects the restoration of the off-normal contact sets and upon interruption of alternate contact 75 of PON¹, the ground is disconnected from its test contact 17 at master switch D, and switches C and E being at normal and the ground or busy potential having been removed from their test contact 17, they are now selectable and available for use in establishing other connections. Now as to restoration of second selector F, at the time relay MRR restored as just described, due to the interruption of its alternate contact 83, the locking circuit for relay RR² of switch F is interrupted causing restoration of said relay RR², whereby circuit for relay TR² is established from battery through the winding of TR², contact OR², alternate contact 157, normal contact 158 to ground. Alternate contact 99 of TR² is thereby closed causing the releasing operation of secondary magnet SM², whereby the wipers are stepped beyond the last contact in the row and from there automatically restored by spring tension in the manner as previously described. Over-run contacts OR² are operated as in the case of the other switches, interrupting the circuit for TR² which restores and interrupts the circuit for magnet SM². Second selector F having been restored to normal is available for use in establishing other connections.

Called line busy.—Assuming now that the connection has been extended to the terminals of a busy called line, test terminal 115 thereof will have a busy or grounded potential connected thereto, so that when line test

relay LT energizes responsive to the last secondary impulse, a locking circuit for it will be established from the grounded contact 115, wiper 112, alternate contact 129 and the upper winding of LT to battery maintaining said relay energized. As in the previous case where connection was made to an idle line, relay DR is energized and locked up through its alternate contact 127, and although its alternate contact 128 is closed as before due to the failure of relay LT to retract and close its normal contact 129, ringing control relay RC is not energized. Therefore ringing current is not applied to the terminals of the called line, and relay LT being maintained energized, by the closure of its alternate contacts 160 a characteristic busy signal is transmitted to the calling substation traced from busy back BB, alternate contact 160, back over the lower heavily marked secondary conductor, out over line conductor 4, receiver of substation A, returning over conductor 5 along the upper heavily marked primary conductor and through the upper winding 57 of relay PR, to ground, this signal indicating to the subscriber at substation A that the called line is busy.

Referring to connector G, it will be noted that release relay RR³ is still controlled from second selector F or in fact from the calling substation, so that due to the failure to make connection with an idle line and to receive a response thereover, the release of connector switch G is controlled at the calling substation.

The subscriber at A in response to the signal received, replaces the receiver upon its switch-hook whereby the circuit for relay PR is interrupted causing its deenergization and the consequent restoration of release relays MRR and RR as before.

The restoration of relay RR causes a restoration of line selector C and line circuit B as before and the restoration of MRR effects the restoration of first selector E and second selector F as before.

In the present case connector G is also to be restored, this being effected responsive to the restoration of release relay RR² of selector F whereby the interruption of its alternate contact 101 interrupts the locking circuit of release relay RR³ of connector G, whereby it restores closing its normal contact 148 and establishing a release circuit for secondary magnet SM³ as before. The interruption of its alternate contact 121 allows restoration of relays SW and DR so that upon restoration of the wipers and off normal switch contacts connector switch G is available for use in establishing other connections.

What I claim as new and desire to secure by Letters Patent is:

1. A telephone system comprising a group

of lines, line selectors for said lines, a master switch for said selectors, a differential starting relay for said master switch, means for closing an energizing circuit through one of its windings upon initiation of a call, whereby an idle line selector is started, a primary relay, and means for including a winding of said primary relay in circuit with the other winding of said differential relay during the selecting operation of said selector to neutralize said differential relay.

2. A telephone system comprising a group of telephone lines, line selectors, said lines being divided into sub-groups and multiplied to corresponding sub-groups of contacts of said selectors, a master switch, a differential starting relay for said master switch, a differential group relay for each sub-group of lines, means effective upon initiation of a call over one of said lines to close a circuit through one of the windings of said starting relay and a winding of the corresponding group relay, means for starting an idle one of said line selectors responsive to said starting relay, a double wound primary relay, means for connecting one of the windings thereof in circuit with the other winding of the said group relay upon selection made with the sub-group of the calling line whereby said group relay is de-energized to render said sub-group non-selectable and means for closing the other primary winding in circuit with the other winding of the starting relay to render said starting relay ineffective.

3. A selector switch including bank contacts divided into groups, a cooperating wiper, a primary magnet, a secondary magnet, suitable circuits adapted to cause the operation of said primary magnet to select a group, suitable circuits to cause said secondary magnet to select a contact in the group, suitable circuits adapted to cause said secondary magnet to advance the wiper beyond the last contact of the selected group whereby said wiper is automatically restored, and means for automatically interrupting the release operation of said secondary magnet upon said wiper being advanced beyond said group.

4. A selector switch comprising groups of bank contacts and a cooperating wiper, primary and secondary magnets with suitable circuit arrangements for causing said magnet to advance the wiper to a group and then to a contact in a group, means when a release is desired to cause said secondary magnet to advance the wipers beyond the last contact of the selected group whereby said wipers automatically restore, and an over-run contact included in the release circuit for rendering said secondary magnet inert upon said wiper being advanced beyond said last contact.

5. A telephone system comprising tele-

phone lines, a line selector having terminal contacts for said lines arranged in groups and adapted for selecting a group and then a set of terminals in the group, a common or group contact for each said group, means responsive to the initiation of a call in one of said lines for altering the electrical condition of its group contact to cause selection of its group, means operative upon selection of said group contact to render it unselectable, a directly operable selective switch connected to said line selector, and means responsive to the transmission of impulses over the two sides of the calling line in series for operating said last switch to extend the circuit of the calling line.

6. A telephone system comprising telephone lines, line selectors having multiply connected terminal contacts for said lines arranged in groups, said line selectors being adapted for selecting a group and then a set of terminals in the group, multiply connected common or group contacts one for each group at each selector, means responsive to a call in one of said lines for altering the electrical condition of its corresponding group contacts and to cause one of said selectors to select the corresponding group, means operative upon selection of said group to render its multiply connected group contacts unselectable, a directly operable selective switch associated with each line selector, and means responsive to the transmission of impulses over the two sides of the calling line in series for operating the associated selective switch to extend the circuit of the calling line.

7. A telephone system comprising telephone lines, line selectors having multiply connected terminal contacts for said lines arranged in groups, said line selectors being adapted for selecting a group and then a set of terminals in the group, means responsive to a call in one of said lines to cause one of said selectors to select the group corresponding to the calling line, means operative by said selection to render the multiply connected groups of the selected group non-selectable, means for thereafter rendering said multiply connected groups selectable, a selector switch associated with each line selector, and means responsive to the transmission of impulses over the two sides of the calling line in series for operating the associated selective switch to extend the circuit of the calling line.

8. A telephone system comprising telephone lines, line selectors having multiply connected terminal contacts for said lines arranged in groups, said line selectors being adapted for selecting a group and then a set of terminals in the group, means responsive to a call in one of said lines to cause one of said selectors to select the corresponding group of the calling line, means operative

by said selection to render the multiply connected groups of the selected group non-selectable, means responsive to the selection of the calling line terminal contacts to render the associated groups selectable, a directionally operable selective switch associated with each line selector, and means responsive to the transmission of impulses over the two sides of the calling line in series for operating the associated selective switch to extend the circuit of the calling line.

9. A selector switch including bank contacts arranged in rows, a cooperating wiper therefor, a primary magnet and a secondary magnet for said switch, means for operating said primary magnet to select one of said rows, means for operating said secondary magnet to select a contact in the selected row, means for afterward operating the secondary magnet to advance the wiper beyond the last contact in the said selected group whereby said wiper is automatically restored, and means for automatically interrupting the release operation of the secondary magnet upon the wiper advancing past the last contact of said group.

10. In a telephone system the combination with contacts arranged in groups, a line selector for selecting a group and for then selecting a contact in the group, a common contact for each group, means for altering the electrical condition of one of said common contacts to cause selection of its group by the selector, means responsive to the initial travel of the selector to select a contact in the selected group to render the said common contact unselectable, a directionally operable selective switch connected to said line selector, and means responsive to the transmission of impulses over the two sides of the calling line in series for operating said last mentioned switch to extend the circuit of the calling line.

11. A selector switch including bank contacts divided into groups, a cooperating wiper, a primary magnet and a secondary magnet, means for operating said primary magnet to cause a selection of one of said

groups, means for operating said secondary magnet to cause a selection of a contact in the selected group, suitable circuits adapted to cause said secondary magnet to advance the wiper beyond the last contact of the selected group whereby said wiper is automatically restored, and means for automatically interrupting the operation of said secondary magnet when said wiper is advanced beyond said group.

12. A selector switch comprising groups of bank contacts and a cooperating wiper, primary and secondary magnets, suitable circuits for advancing the wiper to a group and then to a contact in a group, means when release is desired to cause said secondary magnet to advance the wiper beyond the last contact of the selected group whereby said wiper automatically restores, and an over-run contact included in the release circuit of the secondary magnet for rendering said secondary magnet inert upon the said wiper being advanced beyond said last contact.

13. A telephone system comprising telephone lines, a line selector having terminals for said lines arranged in groups, electromagnetic means for operating the line selector to select a group and then a terminal in the group, a group contact for each of said groups, means responsive to the initiation of a call over one of said lines for altering the electrical condition of its group contact to cause a selection of its group, means operative upon such selection to render said group contact unselectable, a directionally operable selective switch connected to said line selector, and means for controlling the operation of said switch over the two sides of the calling line in series.

Signed by me at New York, county of New York and State of New York in the presence of two witnesses.

ALFRED T. DYSON.

Witnesses:

C. F. BALDWIN,
K. B. DOHERTY