F. SCHOENWOLF.

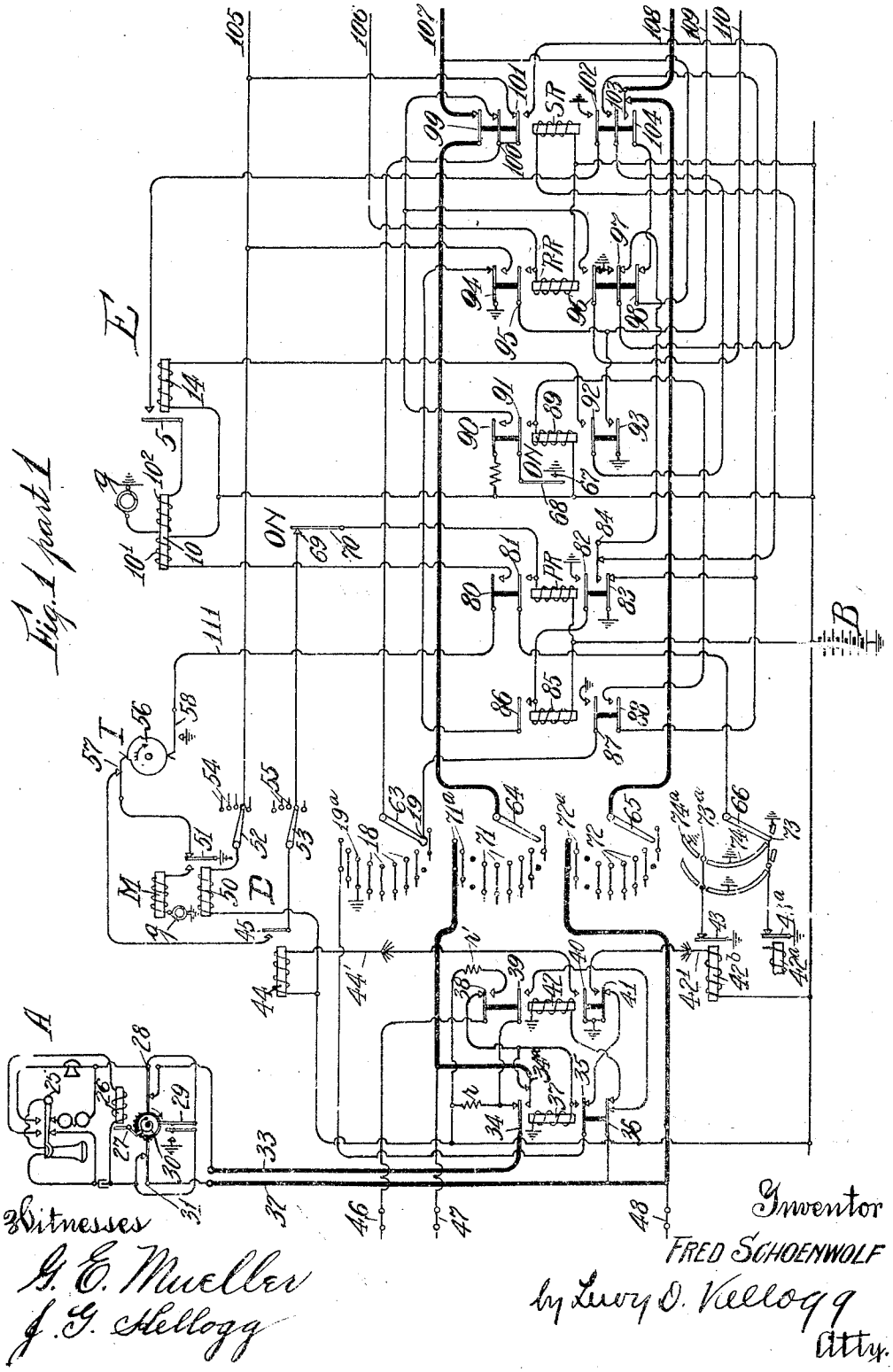
AUTOMATIC TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED APR. 15, 1908.

1,110,460.

Patented Sept. 15, 1914.

8 SHEETS—SHEET 1.



Witnesses

G. E. Mueller

J. G. Kellogg

Inventor

FRED SCHOENWOLF

by Leroy D. Kellogg

Atty.

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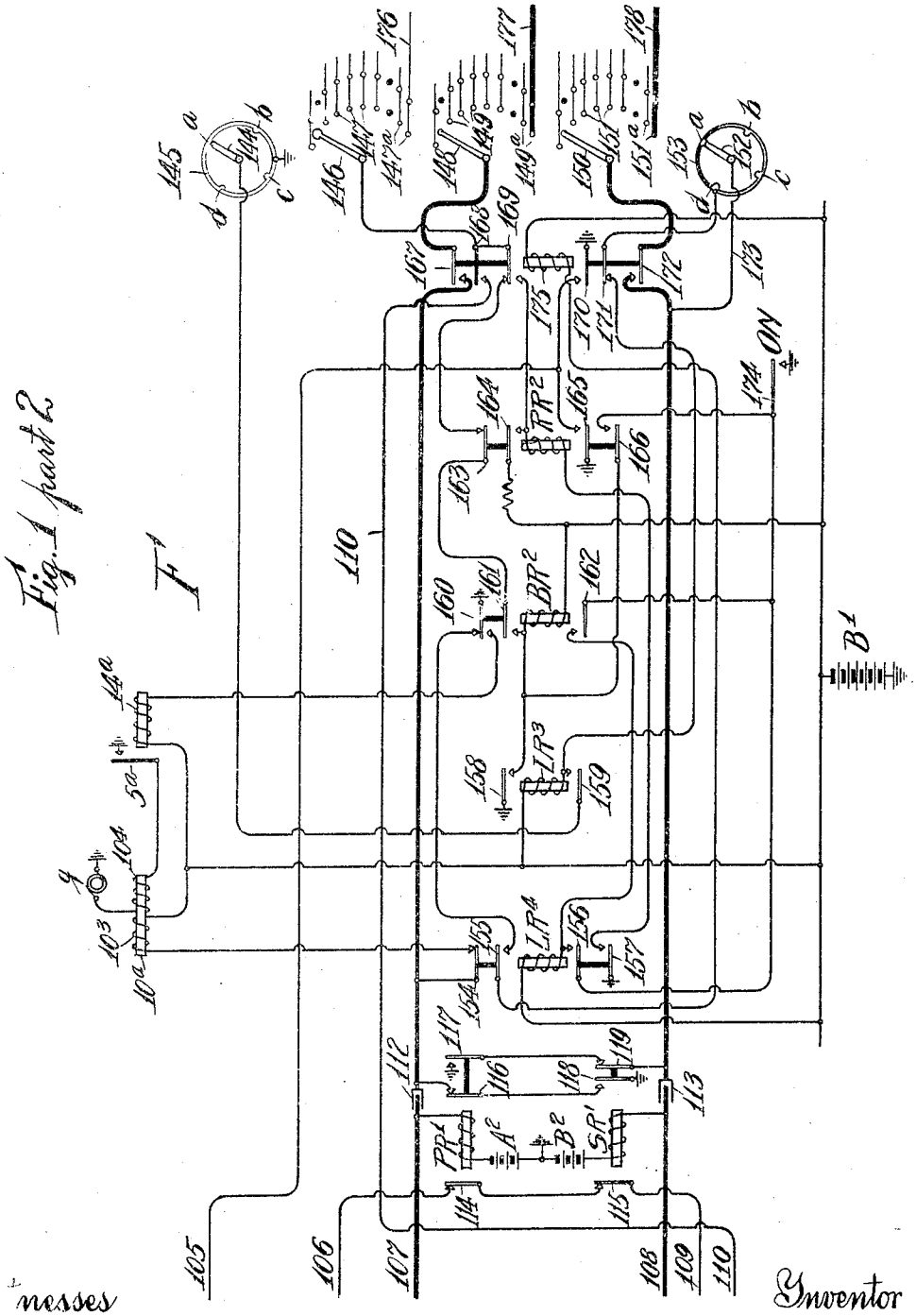

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J. G. Kellogg

Inventor

Fred Schoenwolf

by Leroy D. Kellogg

Atty.

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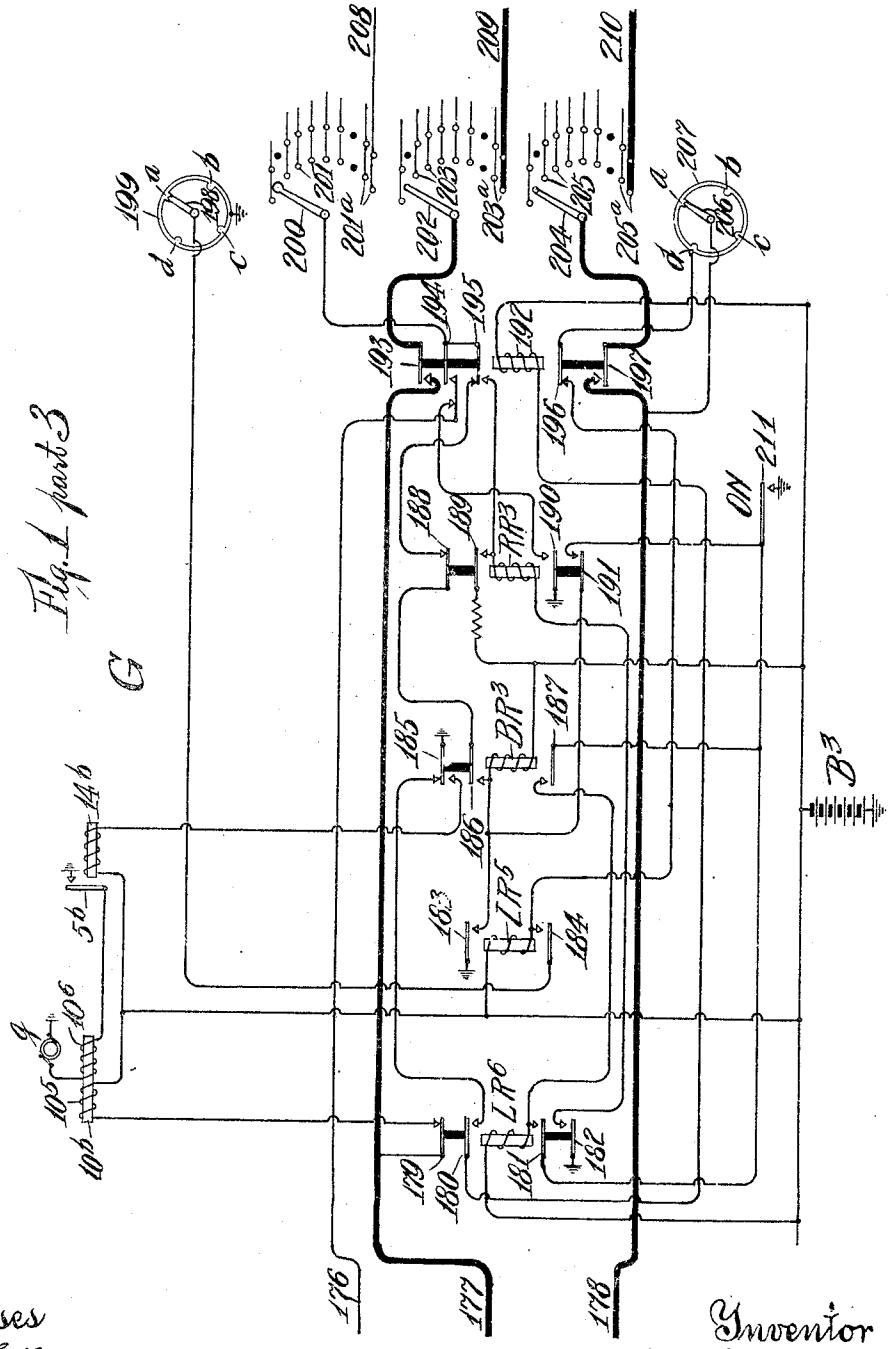

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J. G. Kellogg

Inventor

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by Leroy D. Kellogg

Atty.

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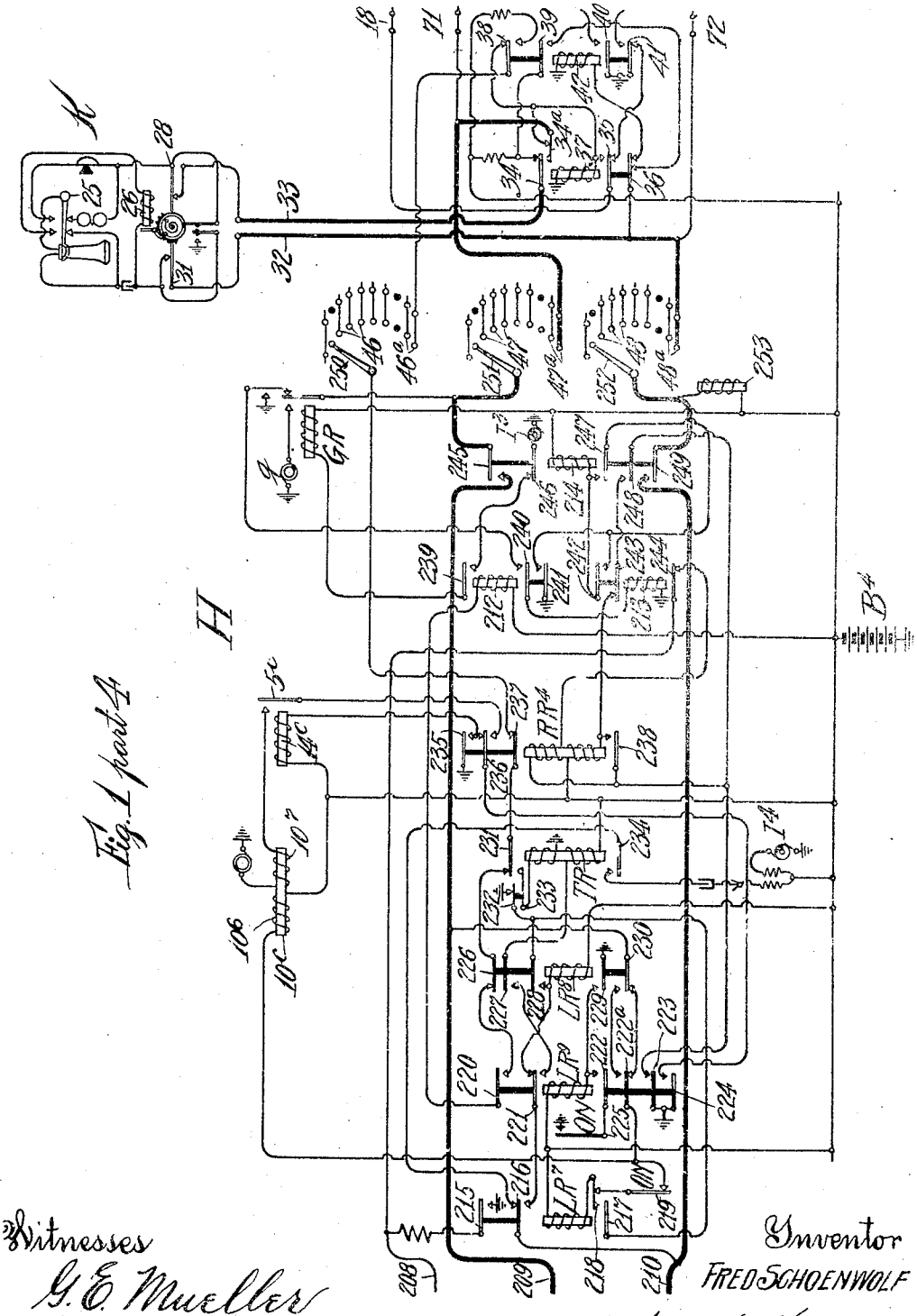

Fig. 1 part 4

Witnesses

G. E. Mueller

J. G. Kellogg

Inventor

FRED SCHOENWOLF

by Le roy D. Kellogg

Atty.

F. SCHOENWOLF.

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8 SHEETS—SHEET 5.

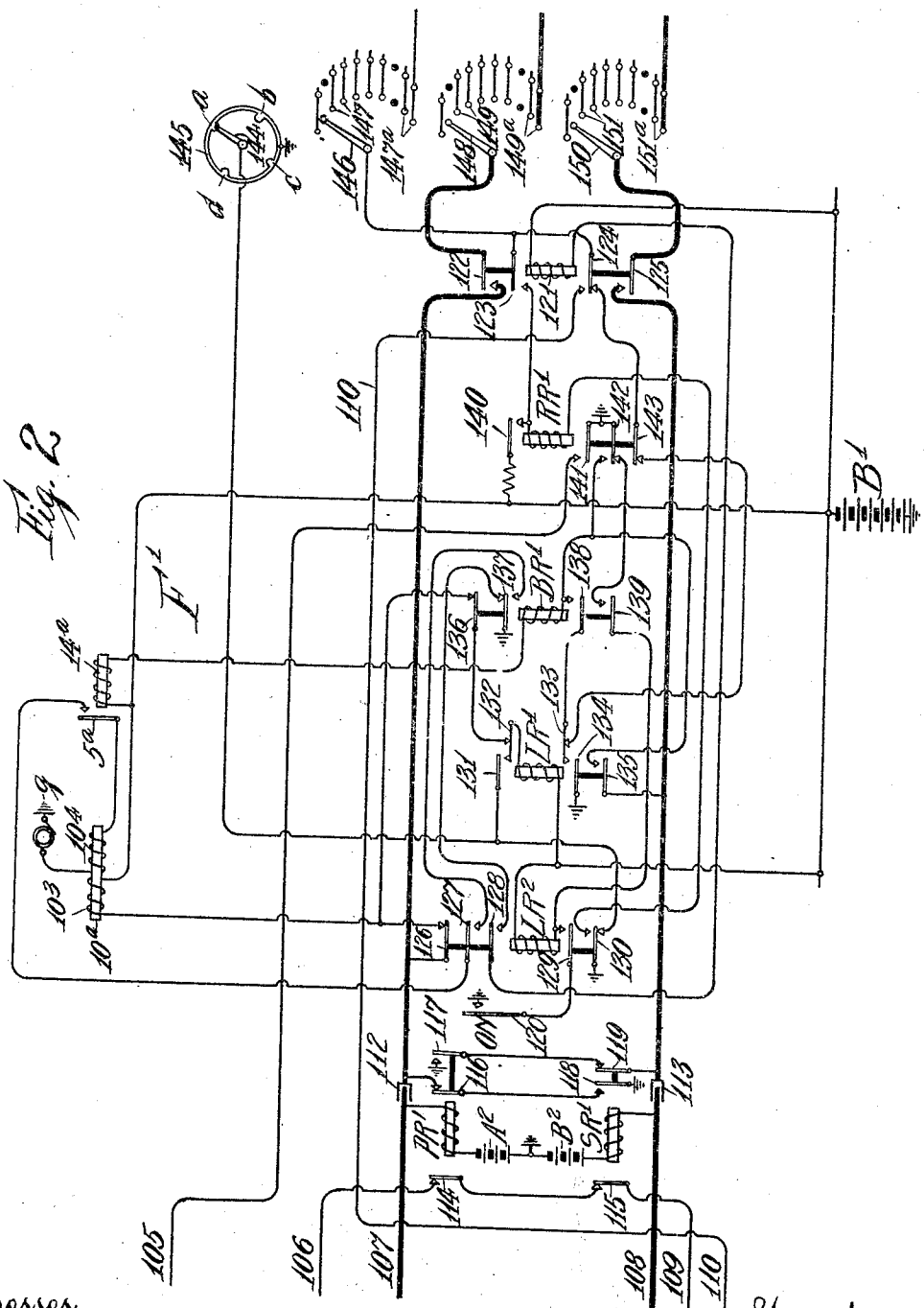

Fig. 2

Witnesses

G. O. Mueller

J. G. Kellogg

Inventor

FRED SCHOENWOLF

by Leroy D. Kellogg

Atty

F. SCHOENWOLF.

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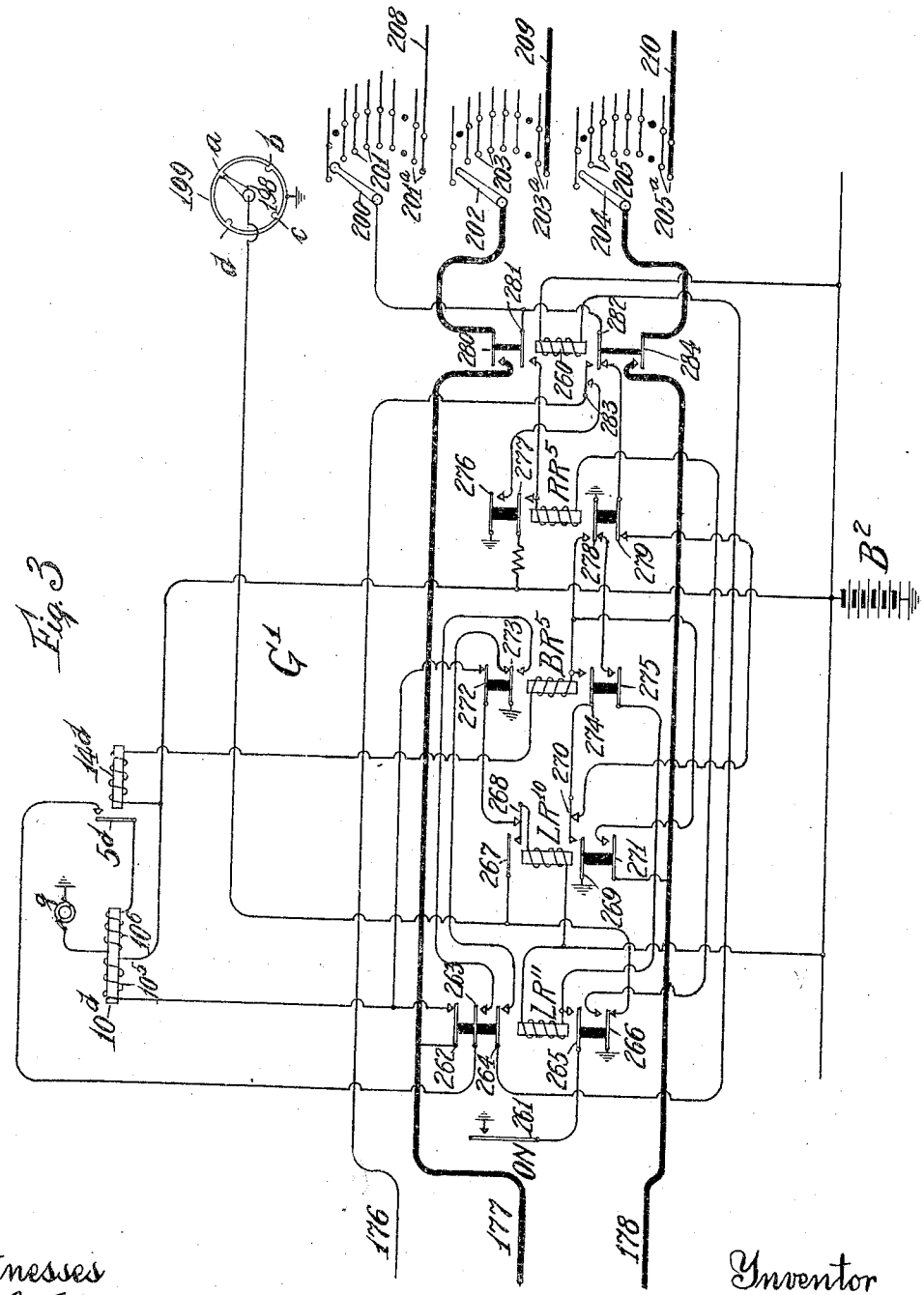

Witnesses

G. E. Mueller.

J. E. Kellogg

Inventor

FRED SCHOENWOLF

by Leroy D. Kellogg

Atty.

F. SCHOENWOLF

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8 SHEETS—SHEET 7.

Fig. 4

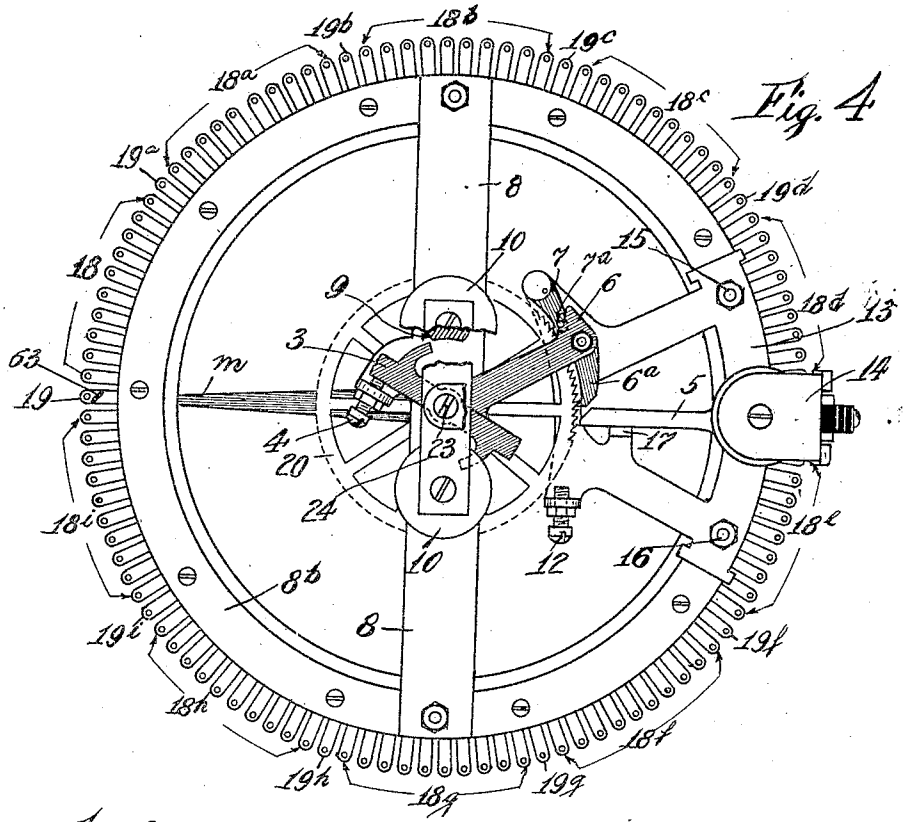

Fig. 6

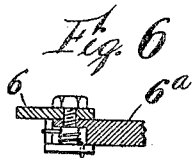

Fig. 5

Witnesses

G. E. Mueller

J. G. Kellogg

Inventor

FRED SCHOENWOLF

by Leroy D. Kellogg

Atty

F. SCHOENWOLF.

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8 SHEETS—SHEET 8.

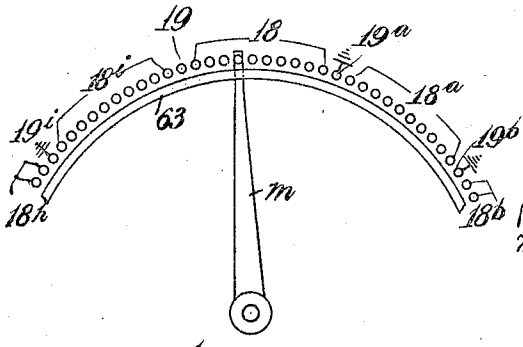

Fig. 7

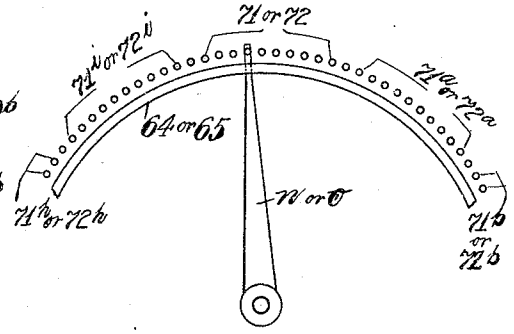

Fig. 8

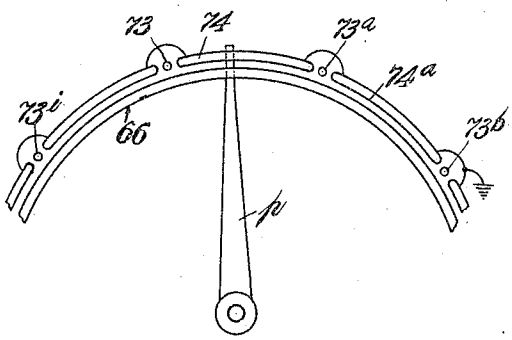

Fig. 9

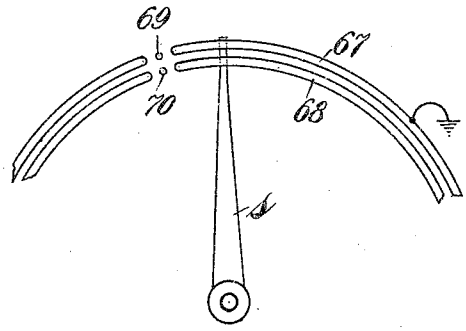

Fig. 10

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G. E. Mueller

J. G. Kellogg

Inventor

FRED SCHOENWOLF

by Leroy D. Kellogg

Atty

UNITED STATES PATENT OFFICE.

FRED SCHOENWOLF, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE-EXCHANGE SYSTEM.

1,110,460. Specification of Letters Patent. Patented Sept. 15, 1914.

Application filed April 15, 1908. Serial No. 427,225.

To all whom it may concern:

Be it known that I, FRED SCHOENWOLF, residing in Chicago, county of Cook, and State of Illinois, have invented new and useful Improvements in Automatic Telephone-Exchange Systems, of which the following is a specification.

The invention is adapted for use in connection with automatic or semi-automatic telephone exchange systems and the structure in which I have, in the present application, shown the invention embodied is an automatic system.

One object of my invention is to provide means permitting the effective employment of selective switching mechanisms of a novel and preferred character, although I do not claim the mechanism itself specifically as my invention. A feature of the said mechanism is found in the fact that a plurality of groups of contacts are provided, which may be on one level, and that in connection with these groups of contacts, wipers are provided and arrangements are made to cause long steps of the wipers, for instance, in a circular direction to select the required group of contacts whereafter, the group being selected, short step travel of the wipers in the same rotary direction is effected, each such short step moving the wipers from contact to contact in a selected group. A single magnet is employed to effect both the long step travel and the short step travel of the wipers, an auxiliary magnet being provided to throw in a stop to limit the stroke of the armature of the actuating magnet whereafter each step of the wipers effected is limited.

Other objects of the invention are directed to a specific arrangement in connection with the line selector or line finding switch, which I employ to select the calling line, whereby the same may be started properly in its travel and partial long or incomplete steps of the wipers of such switch are prevented. In addition to the line selectors, I employ in connection with the invention, first and second selectors and connectors and additional objects of the invention are to provide improved circuit connections for controlling the adjustment of these switches in completing the desired connections.

Other features of the invention will appear in connection with the specific description of the drawings and will be more specifically pointed out in the appended claims.

Referring to the drawings, Figure 1, consisting of parts 1, 2, 3, and 4, illustrates, when the parts are arranged side by side in numerical order, circuits of an automatic telephone system constructed in accordance with the present invention. Fig. 2 illustrates a modified circuit for the first selector. Fig. 3 is a modified circuit of a second selector. Fig. 4 is a plan view of a long and short step switch. Fig. 5 is a side view thereof, a portion of the driving magnet being omitted and the switch bank being in part cut away to disclose the mechanical arrangement of the wipers. Fig. 6 illustrates a detail of the driving pawl of the switch magnet; Figs. 7, 8, 9 and 10 show mechanical arrangements of contacts and wipers when the switch shown in Fig. 4 is employed as a line selector.

As the circuit arrangement in Fig. 1 is drawn out, the system illustrated has a capacity of ten thousand subscribers' lines, first selectors F being provided for the purpose of selecting the thousands, second selectors G for selecting the hundreds, and connectors H for selecting the tens and units.

I preferably employ one hundred point switches having their contacts arranged in ten groups of ten contact sets each. Assuming ten thousand subscribers' lines, the lines would be divided, as called lines, into one hundred groups of one hundred lines each, and each such group on the usual ten per cent. trunking basis would be provided with their multiple called contacts appearing in the banks of ten connectors. The group to which any line as a called line is assigned, will be determined by the directory number which the line bears, so that all the lines having their multiple called contacts at a group of ten connectors would have directory numbers of the same hundreds value. Further, the multiple called contacts of the one hundred lines at their assigned connectors would be arranged in ten sub-groups of ten contact sets each, the position of each such sub-group, as to the serial order in which their contacts will be engaged by the wipers of the connectors, being determined by the tens value in the hundred.

For the one hundred groups of called lines there will, therefore, be one hundred groups of ten connectors each, making a thousand

connectors in all. The one hundred connectors for the ten one hundred line groups constituting the first thousand lines of the exchange will have their contacts 201, 203, 205 multipled at the banks of the second selectors G assigned for that thousand, and the multiple contact sets of the ten connectors for the first hundred of the first thousand will constitute the first group of ten contacts of each second selector for that thousand; the contacts for the connectors for the second hundred of the first thousand will constitute the second group of contacts of the second selectors for that thousand, and so on for the other groups for the first thousand. Corresponding connections will be made from the different groups of ten connectors of the hundreds of the other thousands to the second selectors assigned to those thousands. On the usual ten per cent. trunking basis, there will, of course, be one hundred second selectors G for each thousand of the exchange and the contacts of the connectors will therefore, if uniform multipling be observed, be multipled one hundred times, once at each second selector for the respective thousand.

Each second selector G is provided with multiple contacts 147, 149, 151 appearing in the banks of first selectors F, which first selectors are, of course, common for connection with all subscribers in the exchange. On a ten per cent. basis there would be one thousand first selectors F and each such first selector would have before its wipers 146, 148, 150, ten groups of multiple contacts, the contacts of each group being connected to the second selectors G for a different thousand. There being one thousand first selectors F and one thousand second selectors G, there will be a total of one hundred thousand multiple contact sets 147, 149, 151, at the first selectors, so that each second selector G will have its contacts multipled only at one-tenth of the first selectors F in the usual course of multipling.

Each first selector F has permanently joined to it a line selector E before whose wipers 63, 64, 65, appear multiple contact sets 18, 71, 72, of one hundred lines, which sets of contacts may be called "multiple calling contacts." The lines of the exchange as calling lines are divided into groups of one hundred and on a ten per cent. basis, the multiple calling contacts of each one hundred line group will be multipled before the wipers 63, 64, 65, of ten line selectors assigned to that group of lines as calling lines. Further, the multiple contact sets of each one hundred line group would be divided into ten sub-groups of ten contact sets each, and when any calling line initiates a call, a line selector E will operate to select the group in which the calling line has its contact set included and then will pick out the individual multiple contacts of the calling line whereby the line selector E will have caused its paired first selector F to be operatively connected with the calling line. After this, directive impulses will be transmitted from the calling line to cause the first selector to pick out the group of second selectors for the wanted thousand and then an idle selector out of such group; thereafter directive impulses will adjust the selected idle second selector to pick out the group of connectors wanted and then an idle connector out of such group; whereafter the selected connector will be adjusted to pick out the required group of lines and then the required line out of such group.

In the diagram, Fig. 1, part 1, I have illustrated a calling substation A connected by the line conductors 32 and 33 with a suitable line circuit arrangement at the exchange. The substation at A includes the customary hook switch 25, normally holding the call-bell in an operative bridge of the line limbs and, adapted, on the removal of the receiver, to be lifted, disconnecting the call-bell and operatively connecting the talking set with the line. A calling device or dial 30 is provided, said calling device being normally locked by a pivoted pawl 27 controlled by the magnet 26 whose winding also serves as the impedance coil for the talking set. When the coil of 26 is energized, its armature is attracted and the pawl 27 withdrawn from engagement with the dial 30 so that the same may be rotated by hand in the direction of the arrow. The dial 30 has attached to it suitable teeth of insulating material which control the connections of the impulse springs 28 and 31, and the said dial also carries upon its lower part a stud of insulating material, which, when the dial is at normal, as shown, holds the spring 29 disengaged from its associated spring. When the dial is rotated by hand in the direction of the arrow, the said stud frees spring 29 which, by its tension, engages its contact and makes connection with ground. When released, the dial rotates back to normal and when it reaches this point, the said stud restores spring 29 to its normal relation shown. It is obvious that the rotation of dial 30 in the direction of the arrow has no operative effect upon the springs 28 and 31. When, however, it is released, the teeth of insulating material operate to momentarily open contact 28 as many times as there have been teeth brought below said spring. After the last tooth passes above spring 28, the tooth at the extreme left causes a momentary opening of contact 31 whereafter the calling device reaches normal and its motion is arrested. While the openings of circuit were being made at contact 28 in the line limb 33, it is apparent that line limb 32 will be connected through contact 31 to ground through the

contact of spring 29. Conversely, when the circuit of limb 32 is opened at contact 31, limb 33 will be grounded through contact 28 and spring 29. Also when the calling device reaches normal, a conductive bridge of line limbs 33 and 32 will be established through the substation before contact 29 is opened, it being remembered that the dial 30 is only operable when magnet 26 is energized and magnet 26 can only be energized when hook switch 25 is in its alternate position. It is thus apparent that by the operation of the dial 30, a calling subscriber can cause a number of sets of openings of line limb 33 at contact 28, while line limb 32 continues grounded, each set of openings of line limb 33 being necessarily followed by one opening of line limb 32, while limb 33 remains grounded. By successive actuations of the dial 30, the calling subscriber is enabled to count out the digits comprising the number of the called subscriber and the various openings of line limbs 33 and 32 coöperate with the directively operable switches at the exchange in completing the connection with the called-for line.

As before indicated, the lines as calling lines, are divided into groups of one hundred by having their multiple contacts grouped at the exchange before the line selectors. The ten line selectors E for each such group of one hundred lines are preferably not constantly operating devices, but are normally at rest, their wipers having a fixed or normal position. For starting an idle line selector E when a call is initiated, a master-switch mechanism D is provided, one for the one hundred lines, including wipers 52, 53, having before them contacts 54, 55, one such set being provided for each of the ten line selectors of a one hundred line group. Each line of a group has its line relay 42; and a common conductor 44′ is provided, connected to the master-switch relay 44 and having branches, one to each of the line relays of the one hundred lines whereby any calling line of the one hundred may control the master-switch D to start an idle line selector. Each line, in addition to its line relay 42 individual to it, has its cut-off relay 37, the latter being employed to render the line relay inoperative when the line is connected with.

As before indicated, the multiple contacts 18, 71, 72, of the one hundred lines of a group of calling lines, are divided into ten groups of ten contact sets each at the line selector banks, whereby the one hundred lines are divided into ten sub-groups of ten lines each. Each such sub-group has a sub-group relay 42^a, 42^b, etc., and a sub-group contact 73, 73^a, etc., appearing before the group selecting wipers 66 of the line selectors E. The group relay 42^b of each sub-group has an armature 43 controlling the electrical condition of the group contact 73. Each such group relay 42^a, 42^b, etc., is connected by a common conductor 42′ having ten branches, one extending to each line relay of its sub-group, so that the line relay of any line of a sub-group can control the respective group-relay.

The constantly rotating common interrupter I is provided, having two contact springs 57 and 58 and a cam projection which latter, as the interrupter travels, closes in rapid succession the springs 57 and 58 alternately to their associated contacts. The spring 58 is connected to a common conductor having branches 111 extending to armatures 80 of the relays PR of the different line selectors E and the interrupter I is employed among other uses to transmit currents over the branches 111 to operate the windings 10′ of the driving magnets 10 to produce the long step travel of the line selectors E. To prevent a winding 10′ from being actuated by a partial impulse over a branch 111, whereby but a partial long step might be produced, the circuit at each switch E is so arranged that its relay PR controlling the long step travel, can be actuated only by current through spring 57. By this arrangement no current can flow through a winding 10′ when relay 42 of a calling line and common relay 44 are actuated until after contact 57 has been closed to operate the relay PR of the line selector E to be started. Thus the interrupter I by its alternating circuit closing function preserves a proper sequence of operation between the closing of a contact (80) in the circuit of magnet 10 and the transmission of actuating current over the said circuit.

Before going more specifically into the description of the circuit diagram, the preferred mechanical arrangement of the switch will be referred to. As indicated in Fig. 4, ten groups, of ten contacts each, 18, 18^a, 18^b, etc., to 18^i are provided arranged in a circle, making one hundred of such contacts, while between the groups of contacts 18, contacts 19, 19^a, 19^b, etc., to 19^i are located. A rotary shaft 1 is provided suitably journaled, as indicated in Fig. 5, to the circular base plate 8^a and to the bridge 8 upon which shaft are mounted the wipers *m*, *n*, *o*, *p*, *s*, and the ratchet wheel 20 which of course has one hundred and ten ratchet teeth. The magnet 10, whose spools are mounted upon the bridge 8, has a pole piece 24 connecting the upper extremities of the cores, and through this pole piece extends a slotted stud 23 with which is associated the friction piece 23^a and the screw 25 threaded to the piece 23^a, the whole furnishing a convenient means for adjusting the tension of the spiral spring 21, one end of which is attached to the end of the armature 3 and the other to the stud 23.

The armature 3 is supported by the auxiliary shaft 1^a which is journaled to the wiper shaft 1 and to the stud 23. The spring 21 serves of course as a retracting spring for the armature after each actuation of the magnet 10, being adjustable as described. The core of each spool of magnet 10 has, at its end adjacent to bridge 8, a pole piece of the shape indicated at 9, the transversely disposed armature 3 having the projections shown best in Fig. 4, extending to proximity with the respective concave surfaces of the pole pieces 9, the whole producing an arrangement well calculated to give a strong initial pull upon the armature 3 when magnet 10 is operated, permitting along with this, a relatively great movement of the said armature, an adjustable stop 4 is provided to limit the back stroke of the armature away from the pole piece. The arm 6 carrying the driving pawl 6^a, which is provided with a suitable spring to hold it in engagement with the ratchet as indicated in Fig. 6, is fastened to the armature shaft 1^a so as to partake of the rocking movements of the armature, the pawl 6^a being by them effective to drive the ratchet wheel 20 step-by-step. The adjustable stop 12 is provided threaded to a projection of the piece 13 which is fastened by the bolts 15, 16 to the circular bank of the switch, and the said stop serves to limit the length of the stroke of the pawl 6^a and of the armature 3 when the switch is performing its long step travel. The piece 13 also has a projection to which is suitably pivoted the pawl 7 which engaged the teeth of the ratchet 20 and serves to prevent back movement of the ratchet which might otherwise occasionally occur from the jar occasioned by the armature 3 when forcibly retracted by the spring 21 at the conclusion of one of its long strokes. The pawl 7 carries a pin engaged by the arm 6 so that when the latter is fully retracted, the two interlock and the pawl 7 is forcibly held in engagement with the ratchet 20. A further important function of this arrangement is to render impossible a between-contact position of the wipers. Thus, if the pawl 7 is, at the time pawl 6^a is retracted, not engaging a full tooth of ratchet 20, the impact of arm 6 will force the pawl 7 to fill the tooth upon whose surface it rests, whereby the wipers will be carried back to one of their definite operative positions. Upon the piece 13 is mounted the stop magnet 14, controlling the stop pawl 5 forming its armature; in Fig. 5 it is shown below the pawl 6^a; being therefore normally out of engaging relation therewith. The said stop pawl 5 abuts upon the projection 17 of the piece 13 and when the magnet 14 is energized, is brought forward so that its upper extremity is in the path of the pawl 6^a, thus limiting the stroke of armature o, piece 6 and pawl 6^a. It is now apparent that when magnet 14 is deenergized, actuations of the magnet will, by pawl 6^a, produce long steps of the switch wipers, and for each such long step, it will be understood that the wipers will be moved from a position engaging a between-group contact 19 over an entire group of contacts 18 to engagement with the next between-group contact 19. Thus, to select the group of contacts 18^c, for instance, three actuations of the magnet 10 will be produced while magnet 14 remains inert and the wiper *m* and the others will then have advanced three long steps to rest in a position where wiper *m* engages the contact 19^c. When, now, magnet 14 is energized, the movable stop 5 is substituted for the stationary stop 12 as the member limiting the stroke of the armature of the magnet 10, and successive actuations of magnet 10 will now obviously produce short steps of the wipers, each step moving them the space from one contact 18^c to another. When the switch of Fig. 4 is to be restored to normal, this is effected by short step travel of the switch around in the initial direction of travel to the normal point to complete a circle of travel.

Switches similar in mechanical construction to that shown in Figs. 4 to 6 are also employed for the first selectors F, second selectors G and connectors H, the contact arrangements for wiper contacts and off-normals being of course provided in the mechanical structures to correspond with the circuit drawings.

The remaining features of the circuit connections will best be understood when given in connection with the narrative of operation. Let it be assumed that the calling subscriber A desires his line to be connected for conversation with that of the called subscriber whose substation is indicated at K and whose directory number will, for the purposes of description, be assumed to be 1112.

The calling subscriber at A removes his receiver and an idle line selector E is set in travel and immediately picks out the calling line, thereby connecting the paired first selector F with such line. The wipers of the line selector normally rest between the tenth and first contact groups. The calling line A, as indicated by the position of its multiple contacts 18^a, 71^a, 72^a and the group contact 73^a, is included in the second subgroup of lines, so that one long step of the wipers of the line selector will be required to bring them adjacent to this group of contacts.

By the removal of the receiver at A, current flows from ground, through line relay 42, armature 36, wire 32, contact 31, magnet 26, the raised hook-lever 25, returning through the transmitter at the substation,

contact 28, wire 33 and normal contact 34 to battery B. This flow of current energizes for a moment the winding 26, but the current flow and energization are momentary only, since the relay 42, by attracting its armature 39, locks itself to battery through resistance r, whereby the line circuit is short-circuited and the flow of current reduced to a point where magnet 26 releases its armature to again lock the calling device 30. Armature 41 now removes ground from the multiple contacts 18^a of the calling line, rendering them selectable, and also energizes the group relay 42^b whereby armature 43 leaves its contact, ungrounding the multiple group contacts 73^a of the second sub-group at the line selectors and rendering them selectable. The armature 38 disconnects the cut-off relay 37 from the multiple called contacts 46 of the calling line and connects battery B to said contacts through the protective resistance r', whereby the multiple contacts 46, 47, 48 at the connectors are rendered busy against incoming calls. Armature 40 operates the master-switch relay 44, whose attracted armature 45 closes a circuit to the wiper 53 of the master-switch D, each line selector E assigned for a group of one hundred lines having contacts 54, 55 before the wipers 52, 53 of the master-switch serving the corresponding line group, and the said wipers 52, 53 normally resting engaging the contacts 54, 55 of an idle line selector E.

If at the time the relay 44 operates, the cam projection of interrupter I is engaging the contact spring 58 and so holding its contact closed, the initiation of travel of line selector E will be delayed until the said cam projection rotates free of spring 58 and comes around to closed contact at 57. This delay is caused because relay PR, controlling the long-step travel of the switch, can only be operated to close its contact 80 and so connect spring 58 with the long step winding 10′ of magnet 10 by current through contact 57. The circuit for relay PR is closed from ground at switch D, through normal contact 51, contact 57 when interrupter I closes the same, attracted armature 45, contact 53—55, off-normal contact 69—70, relay PR to battery B. Relay PR for a moment locks to ground via armature 81, wiper 66 and contact 73 of the first sub-group, said contact being grounded because no line in that sub-group is calling. Armature 82 of relay PR operates relay 85 which, by armature 86, locks to ground via normal contact 94 of release relay RR. Armature 83 closes a circuit from ground through contact 83—84, normal contact 97 and secondary relay SR to battery. As interrupter I continues to travel, it closes contact 58, whereupon circuit may be traced from ground through the branch wire 111, closed contact 80, long-step winding 10′ to battery B. Stop magnet 14 being inert at this time, a long step of the switch wipers is produced, moving them from position between the tenth and first contact groups to positions between the first and second contact groups. While this long-step is being made, the relay PR will continue operated by ground through armature 81, wiper 66 and the grounded segment 74, the off-normal contact 69, 70 having been opened on the initiation of the long step, and the initial energizing circuit of relay PR thereby destroyed. When the switch wipers complete the step, wiper 66 will be ungrounded at contact 73^a of the first sub-group, the relay 42^b having been operated as described, and relay PR will become deënergized and circuit connections shifted to produce short-step travel of the line selector in search of the individual contacts of the calling line.

By the retraction of armature 83 to engage its normal contact, a circuit is closed from ground through attracted armature 88 and the relay 89 to battery, which relay, by armature 91, locks to ground through off-normal contact 68, 67, closed on the initiation of travel of the switch. By the make-before-break arrangement at contact 84, relay SR has its circuit continued through normal contact 84, alternate contact 101, and wiper 63 engaging the grounded between-group contact 19^a, so that relay SR at this time continues operated. Circuit may now be traced from battery B through the stop magnet 14, attracted armatures 92, 103, and to ground through normal contact 83, whereby magnet 14 is actuated and attracts its armature 5, constituting the stroke-limiting stop for the driving magnet 10. The impulses will now flow from generator g through the short-step winding 10^2 of magnet 10, contact 5, attracted armature 102 to ground, winding 10^2 now producing short steps of the wipers of the line selectors E, moving them step by step in search of the individual multiple contacts of the calling line. Relay SR controls the circuits of winding 10^2 and of magnet 14, and said relay will continue operated by current flowing through its winding over a before-traced circuit to wiper 63 and to successive contacts 18^a of non-calling lines, such contacts being grounded through the normal contacts 35 and 41 of their respective line circuits. When, however, wiper 63 engages the contact 18^a of the calling line, such contact will be ungrounded because of the attraction of armature 41 of the line relay 42, relay SR will deënergize, opening the circuit of winding 10^2 at armature 102 and that of magnet 14 at armature 103, short-step travel of the switch then of course ceasing and the wipers 63, 64, 65 remain engaging the multiple contacts 18^a, 71^a and

72[a] of the calling line. At this time the wiper 66 will of course be grounded at the segment 74[a] between the group contacts 73 of the second and third sub-groups, but this will have no effect upon the relay PR, armature 81 having retracted.

When relay SR was initially actuated in response to the operation of relay PR as described, armatures 99 and 104 placed the line wipers 64, 65 on open circuit. Armature 104 further closed a circuit extending from the positive side of the battery B^2 through relay SR′ over conductor 108, attracted armature 104, normal contact 98, conductor 107, relay PR′ to the negative side of battery A^2, said batteries A^2 and B^2 being connected in series and grounded at their intermediate point. By this means the relays PR′ and SR′ were simultaneously operated to open the release contacts 114, 115 when the switch E started. When, now, relay SR deënergizes, the circuit traced for relays PR′ and SR′ no longer exists, but a new circuit for relay PR′ may be traced from battery A^2, conductor 107, contact 99, contact 64—71[a], normal contact 34[a], cut-off relay 37 to ground, which relay operates and, by the closure of contacts 34—34[a], bridges the relays PR′ and SR′ directly across the limbs 33, 32 of the calling line, the shifting of their circuits being thus accomplished without deënergization of the relays. Armature 34 of relay 37 also disconnects the relay's winding from contact 71[a], but armature 35 has closed an alternate circuit for said relay 37 extending through contact 18[a]—63, normal contact 100, attracted armature 90 to battery B, whereby the relay 37 remains locked. The opening of contact 36 deënergizes line relay 42, whereon the relays 44 and 42 are also deenergized.

Upon the actuation of the relay 37 and the closure of contact 35, ground through said relay is, over a circuit branching from the one previously traced and extending through normal contact 101, placed upon the contact 54 of the line selector E at master-switch D. This causes the energization of the relay 50 whose armature 51 closes a circuit of motor-magnet M which, by a suitable pawl and ratchet, drives the wipers 52, 53 rotarily to sweep over the contacts 54, 55 of the different line selectors. The said wipers have a continuous rotary direction, that is, without return movement, and the contacts 54, 55 are in practice arranged to form a complete circle. As long as the wiper 52 sweeps over contacts 54 connected to line selectors E connected to calling lines therefore busy, the relay 50 will remain operated by current flowing to ground over the successive contacts 54, and pulsations from generator *g* will continue flowing through the magnet M. As soon, however, as wipers 52, 53 engage contacts 54, 55 of an idle line selector E, the open circuit condition of the contact 54 deënergizes the relay 50 whose armature 51 opens the circuit of magnet M and the wipers 52, 53 remain engaging the contacts of the idle line selector, ready to start the same when a new call is initiated.

It may be stated at this time that the normal position of the wipers of the first selector F, of the second selector G and the connector H, is between their ninth and tenth groups of contacts so that one long step of each is required to bring them adjacent to their first contact group.

The subscriber at A now actuates his dial 30 to open contact 28 once, thereby causing the line limb 33 to be opened and relay PR′ deënergized a single time, while relay SR remains operated by current flowing to ground through contact 31 and contact 29. After this, of course, contact 31 will, with the return of dial 30 to normal, be opened to deënergize relay SR′ while relay PR′ will remain operated by current flowing through contacts 28, 29 to ground. The deënergization of relay PR′ transmits a current impulse from ground through contacts 118, 116, 154 and the long-step winding 10^3 of the driving magnet 10^a of first selector F to battery, the actuation of said winding 10^3 producing a long step of the wipers 144, 146, 148, 150 and 152, causing them to move to a position between the tenth and first groups of contacts. On the initiation of short-step travel of the first selector F, the said wipers will now move rotarily step by step over the contact sets constituting the first group, which contacts are multiple terminals of second selectors G assigned for connections to the first thousand of the exchange. It will of course be understood that had the first digit of the called subscriber's number been 5, the calling device 30 would have been actuated to produce five deënergizations of relay PR′, followed by one of relay SR′, and each deënergization of relay PR′ would have produced a separate actuation of winding 10^3 and the wipers of the first selector F would have been advanced five long steps to select the fifth group of contacts, and so for the other thousands.

In the present case, after the single deënergization of relay PR′ whose results have been described, the deënergization of relay SR′, occuring while relay PR′ is operated, transmits an impulse of current from ground through contacts 117, 119, over conductor 173, the wiper 152 now engaging the contact-point *b* of the ring 153, contacts *a*, *b*, *c* and *d* being placed between each contact group, through contact 171 and locking relay LR^3 to battery, actuating the said relay which, by armature 159, locks for a moment to ground through the wiper 144 now en-

gaging the contact projection *b* of ring 145 adjacent to the first group of contacts. Armature 158 actuates busy relay BR^2, whose armature 162 instantly energizes locking relay LR^4 by current to ground at 174 which, by armature 156, locks itself to ground at said contact 174, closed when the long step began. Attracted armature 160 of relay BR^2 operates stop magnet 14^a which throws in the stop pawl and closes contact 5^a, whereby generator circuit through winding 10^4 of magnet 10^a is closed and the short-step travel of the switch initiated. At the first step, the opening of contact 144—145 at projection *b* deënergizes relay LR^3, so that relay BR^2 now depends for its continued energization upon a circuit extending through attracted armature 161, contacts 163, 169, to wiper 146 and to grounds upon successive contacts 147^a encountered by said wiper, the private contacts 147^a of busy second selectors of the first group having been grounded by other first selectors F having previously selected them. In the present case, it is assumed that the second second selector G of the first group is idle and its contact 147^a so ungrounded. When, therefore, wipers 146, 148 and 150 engage contacts 147^a, 149^a, 151^a, connected to conductors 176, 177, 178, respectively, the wiper 146 will be ungrounded and busy relay BR^2 will be consequently deënergized, armature 160 deënergizing magnet 14^a and the deënergization of the latter opening the circuit of winding 10^4, whereby travel of the first selector F stops with the wipers engaging the contacts specified.

Circuit may now be traced from ground through normal contact 160 of relay BR^2, through attracted armature 155, relay 175 to battery, which relay at once energizes, its armatures 167 and 172 closing circuit from condensers 112, 113, to the talking wipers 148, 150 of the first selector; a clean circuit now existing to these points, winding 10^3 being disconnected at contact 154 and contact 152—153 having been opened on the first short step of the first selector F. Ground upon the wiper 146 rendering multiple contacts 147^a of the second selector G busy, may now be traced through alternate contact 169, the winding of release relay RR^2 and through attracted armature 157. Another branch of this circuit, which short-circuits the relay RR^2, exists over the wire 110 and through normal contact 96 of release relay RR at the line selector E. The calling subscriber A now actuates his dial 30 to record the second digit of the called subscriber's number, the action resulting in a single deënergization of relay PR′ followed by one relay SR′, resulting impulses being transmitted to the second selector G to operate the same in a manner quite similar to that in which the first selector F operated.

The deënergization of relay PR′ transmits a current impulse from ground through contacts 118, 116, 167, 148—149^a, over wire 177, contact 179, the long step winding 10^5 of magnet 10^b to battery B^3. The resulting actuation of magnet 10^b steps the wipers 198, 200, 202, 204, 206 of second selector G over the entire tenth group of contacts to positions adjacent to their first group; wipers 200, 202, 204, being then adjacent to the contacts 201^a, 203^a, 205^a, forming terminals of connectors assigned to the first hundred of the first thousand. At this time the wipers 198 and 206 will of course be engaging the corresponding contact projections *b*, *b* of the rings 199 and 207.

If the called line had been in the fifth hundred, the calling device 30 would of course have been operated to produce five deënergizations of relay PR′ and the transmission of five impulses through winding 10^5, whereby five steps of the wipers of switch G would have been produced to select the fifth group of contacts whereafter the selection of idle contacts in that group would have been produced in a manner similar to that in which the said wipers are now to select idle contacts of the first group.

A deënergization of relay SR′ following the one described of relay PR′ now transmits a current impulse from ground through contacts 117, 119, 172, 150—151^a, over wire 178, contact 206—207 at *b*, through contact 196, locking relay LR^5 to battery B^3, which relay, by armature 184, locks itself to ground through contact 198—199 at *b*. Armature 183 actuates the busy relay BR^3, which, by armature 187, closes a circuit from ground at contact 211, closed on initiation of travel of the switch G, and through relay LR^6 to battery, which relay by armature 181 locks itself to ground at contact 211. Relay BR^3, by closing alternate contact 185, actuates the stop magnet 14^b, throwing the stroke limiting stop in and armature 5^b then closes generator circuit for the short step winding 10^6 of magnet 10^b. Short steps of the wipers of switch G will now of course be produced as long as winding 10^6 and magnet 14^b continue to receive current. On the first short step, contact 198—199 at *b* is opened and relay LR^5 is deënergized whereupon relay BR^3 depends for its continued energization on current through armature 186, contacts 188, 195, to wiper 200 and to successive grounds encountered upon multiple contacts 201^a pertaining to connectors H which have already been seized by some other second selector G and so grounded. In the present case, it is assumed that the second set of contacts 201^a, 203^a, 205^a, connected respectively to wires 208, 209, 210 are those of the idle connector H. When the wipers of switch G engage these contacts, contact 201^a will be ungrounded, circuit through busy relay BR^3 will be opened and the relay deëner-

gized whereupon armature 185 deënergizes magnet 14^b, the latter, by armature 5^b, then opening the circuit of winding 10^6 whereby further short steps of switch G are prevented. The closing of alternate contact 185 completes the circuit traced through attracted armature 180 and relay 192 to battery B^3 whereupon armatures 193 and 197 close conductors 177 and 178 to wipers 202, 204, now in contact with wires 209, 210 respectively. A clean circuit now exists through the second selector G to the connector H, the opening of contact 179 having disconnected the winding 10^5 from wire 177 and the opening of contacts 206, 207 at *b* having cleared the wire 178. A ground upon attracted armature 182 through relay RR^3 and alternate contact 195 is now connected to the wiper 200 and the multiple contacts 201^a of the selected connector H. A branch circuit also extends from wiper 200 through alternate contact at 194 over wire 176, wiper 146, armature 168, wire 110, and to ground through normal contact 96, at the line selector E. Contacts 201^a of the selected connector H are thus made busy. The calling subscriber now actuates his dial 30 to register the third digit of the called subscriber's number, the operation of the dial causing a single deënergization of relay PR′ followed by one of relay SR′. The deënergization of relay PR′ transmits a current impulse from ground through contacts 118, 116, 167, 148—149^a, 193, 202—203^a, wire 209, normal contacts 230 and 222^a, the current then branching, a part flowing upward through winding 10^6 of magnet 10^c and to battery actuating said winding and producing a long step of the wipers 250, 251, 252 of the connector H causing them to advance over their tenth group of contact sets 46, 47, 48, to positions adjacent to the first group of contact sets 46^a, 47^a, 48^a, the same forming terminals of lines 1111 to 1119 inclusive, followed by the terminal of line 1110, the naught being represented by ten impulses. The remaining portion of the current transmitted over wire 209 flows through the off-normal contact 219 and through locking relay LR^7 to battery which relay at once locked by the closure of contact 217 to ground at spring 232.

Had the called subscriber been in any other group at the connector H, say in the fifth group, the substation calling device would of course have been actuated to transmit five impulses over wire 209. The first of these would have produced the first long step of the switch wipers as just described, and have operated the locking relay LR^7. The remaining four impulses would have passed in their entirety through the winding 10^6 of magnet 10^c, the off-normal contact 219 having been opened at the initiation of the first long step. In such case, the subsequent operations of the connector would be the same as those now to be described for selecting the line out of the first group.

After the single impulse over wire 209, above referred to, a deënergization of relay SR′ will transmit a current impulse from ground through contacts 117, 119, 172, 150—151^a, wire 178, contacts 197, 204—205^a, wire 210, alternate contact 216, normal contact 221, locking relay LR^8 to battery, said relay, by armature 228, locking itself to ground at contact 232. Armature 229 of relay LR^8 operates the relay LR^9 which, by armature 222 locks to ground via the closed off-normal contact 225. Armature 224 of the latter now energizes the stop magnet 14^c, via contact 236, which throws in the stroke limiting stop and the connector H is ready for its short step travel. The calling subscriber A now actuates his dial 30 to produce two deënergizations of relay PR′ and each transmits a current impulse over the before traced path to wire 209, the current now flowing through alternate contacts 230, 222^a, winding 10^a to battery B^4, and two short steps of wipers 250, 251, 252 are thereby produced bringing them to engage the multiple contacts 46^a, 47^a, 48^a, of the called subscriber's line K, #1112.

Following the impulse over wire 209, a deënergization of relay SR′ transmits a final impulse over wire 210 for the purpose of causing a test of the called-for subscriber's line to determine its idle or busy condition. This impulse of current flows through alternate contacts 216, 221, 227, lower winding of test relay TR to battery which relay is immediately energized. Its armature 231, by engaging contact 233, connects its upper winding through contact 237, with the test wiper 250, contact 232 at relay TR being thereon opened and locking relays LR^8 and LR^7 deënergized. Assuming first that the called line is idle, the condition illustrated at K, the multiple contacts 46^a will be connected to ground through cut-off relay 37. Under these circumstances, the upper winding of relay TR being also grounded, said relay TR deënergizes as soon as the impulse over wire 210 is disconnected from the lower winding, and the armatures 231 and 234 of relay TR are retracted. A circuit may now be traced from battery B^4 through the relay 212 through contact 220, normal contacts 226, 231, 237, contact 250—46^a, normal contact 38 of line K through cut-off relay 37 to ground whereby relays 212 and 37 are energized. By the operation of relay 37, the line relay 42 is cut-off from the called line, ground through armature 35 is placed on the multiple contacts 18 at the line selectors to hold them busy and the closure of contact 34^a connects the line wire 33 with the multiple contact 47^a, thus completing the talking circuit to the connector.

On the operation of relay 212, the closing

of contact 239 connects the constantly operating interrupter I^3 with the ringing or generator relay GR and said relay is, with the travel of said interrupter, alternately energized and deënergized, connecting and disconnecting the generator *g* from the called line to periodically ring the substation bell. The path for generator current includes contact 251—47^a, 34^a—34, contact 28, the bell and the depressed hook lever at the substation K, the condenser, contact 31, wire 32, contact 48^a, 252, and through inductance 253, to ground through battery B^4. Whenever the armature of relay GR is retracted, the relay 213 is, via attracted armature 240 of relay 212, connected with the wiper 251 and contact 47^a. When the called subscriber answers the call by removing his receiver, the closing of the alternate contacts 25 will, as soon as the armature of relay GR is retracted, close a circuit including the relay 213 and the line limb 33, the transmitter and impedance 26 at the substation, the limb 32, contact 48^a—252, inductance 253 to battery B^4. This flow of current of course energizes the relay 213 and furthermore supplies energy for the substation transmitter at K for talking purposes. The closing of contact at 242 operates the relay 214 by current therethrough and through closed contact 241, said relay 214 by armature 247 locking itself over a branch through armature 247. Armature 246 opens circuit for relay GR so that the same remains inert with its armature retracted and generator *g* excluded from the called line. Armatures 245 and 249 now complete the talking circuit through the connector H.

The calling subscriber A and the called-for subscriber K are now ready for conversation, the talking circuit throughout the exchange and over the telephone lines being indicated by the heavily marked conductors. The supply of current for the calling subscriber's line is fed from the serially connected batteries A^2 and B^2 through the impedances of relays PR′ and SR′, the condensers 112 and 113 being interposed between the battery connections for the two substations so that each receives its supply of current independently of the other.

When the two subscribers have completed their conversation they replace their receivers. The act of the called-for subscriber K restores the connector H to normal and the act of the calling subscriber A restores to normal the line selector E, the first selector F and the second selector G.

The replacing of the receiver at the called substation of course opens the circuit of the relay 213, and on its deënergization, current will flow from battery B^4 through the lower winding of release relay RR^4, normal contact 243, contact 248 and through contact 223 to ground. Release relay RR^4 thereon energizes and attracts its armatures whereof 238 locks the said relay to ground at contact 223, armature 235 closes the circuit of stop magnet 14^c, throwing the stop in, whereon circuit may be traced from generator through winding 10^7, closed contacts 5^c, alternate contact 236, contact 224 to ground. Short-step travel of the connector H will now necessarily take place turning the wipers around in the original direction of travel until they reach normal. At this time off-normal contact 225 will be opened, relay LR^9 will deënergize and the opening of contacts 223, 224, will deënergize relay RR^4 and winding 10^7 of magnet 10^c respectively, the switch wipers then stopping at normal. As soon as wiper 250 leaves contact 46^a, the circuit through relays 212 and 37 is open and by the resulting opening of contact 241, the relay 214 is deënergized and its armatures retracted. During the restoration of the connector H, a ground upon the multiple contacts 201^a has been retained over wire 208 through normal contact 244, the upper winding of release relay RR^4 and to ground through attracted armature 223 of relay LR^9, whereby the connector is held busy until it has fully restored and improper selection prevented.

When the calling subscriber replaces his receiver, the opening of the conductive circuit through the substation deënergizes for the first time simultaneously the relays PR′ and SR′, and the simultaneous closing of contacts 114, 115, completes a circuit extending from battery B at line selector E through the release relay RR over wire 106, returning over wire 109 and through attracted armature 93 of relay 89 to ground, whereupon relay RR locks itself by armature 95 to ground at armature 93. By armature 96, ground is removed from conductor 110 and battery connected thereto from B, through attracted armature 90 of relay 89 and current flows over the wire 110, through alternate contacts 168, 169 at F and through release relay RR^2 to ground at attracted armature 157, whereupon release relay RR^2 locks itself from battery by its armature 164. The battery current over wire 110 passes in part through contact 146, 147^a over wire 176 through alternate contacts 194, 195, release relay RR^3 at second selector G and to ground through attracted armature 182 of relay LR^6, relay RR^3 then locking itself from battery B^3 by armature 189.

The release relays RR of switch E, RR^2 of switch F and RR^3 of switch G are now all energized and cause the restorations of their respective switches independently of each other.

Referring first to the line selector E, armature 97 of relay RR energizes secondary relay SR, whereupon circuit is closed from battery through the stop magnet 14, at-

tracted armatures 92 and 103 and through normal contact 83 to ground. By the actuation of magnet 14, the stop is thrown "in" and circuit closed from venerator g, through the short-step winding 10^2, contact 5 and contact 102 to ground. Short steps of the line selector E will now be produced until the wipers 63, 64, 65, 66 complete a revolution around to normal, when the opening of contact 67—68 deënergizes relay 89, whose armature 93 deënergizes relay RR which, by armature 97, in turn deënergizes relay SR. Retracted armature 92 of relay 89 opened the circuit of stop magnet 14, and the resulting opening at contact 5 prevented further actuations of winding 10^2 and the continuing of the wipers at rest. The mechanism of the line selector E is now at normal, the relay 85 having been deënergized when release relay RR first attracted its armature 94.

When relay RR^2 at first selector F energized, its armature 166 operated busy relay BR^2 by current to ground through off-normal contact 174. Attfacted armature 160 of relay BR^2 deënergized relay 175 so that wipers 148, 150, were on open circuit during restoration and said armature 160 also energized the stop magnet 14^a whose armature 5^a is attracted to the "in" position, also closing the generator circuit for winding 10^4 of magnet 10^a. Short-step travel of the wipers of the first selector F will now be produced until they have completed a revolution around to normal. At this time the opening of off-normal contact 174 deënergizes relays BR^2 and LR^4. The opening of contact 157 deënergizes release relay RR^2 while the retraction of armature 160 of relay BR^2 opens the circuit of magnet 14^a, whose retracted armature 5^a prevents further actuations of winding 10^4 and first selector F is at normal.

The contact 54 of the switch pair EF at the master-switch D was held grounded until both switches E and F were fully restored. At line selector E, ground was maintained through attracted armature 94, and at first selector F attracted armature 165 maintained the required ground until the switch reached normal.

When release relay RR^3 of second selector G energized, its armature 191 operated busy relay BR^3 by current to ground at closed off-normal contact 211. Armature 185 of relay BR^3 opened the circuit of relay 192, and said armature 185, in engaging its alternate contact, operated the stop magnet 14^b which in turn closed, at contact 5^b, the circuit for the short-step winding 10^6. The wipers of switch G now travel by short steps around to normal at which time contact 211 is opened, deënergizing relays LR^6 and BR^3. The opening of contact 182 deënergizes release relay RR^3. The opening of contact 185 of relay BR^3 deënergizes stop magnet 14^b, whose armature 5^b opens the circuit of winding 10^6 and the switch wipers rest at normal. During the restoration of second selector G, the multiple contacts 147^a at the first selector F are held grounded and so busy by attracted armature 190 of release relay RR^3, circuit being traced through normal contact at 194.

Let it now be assumed that the called line K was busy at the time the last impulse was transmitted over wire 210, through alternate contacts 216, 221, 227, and the lower winding of test relay TR. The called line being busy, its multiple contacts 46^a will be connected to battery in one of three ways. First, if the called subscriber K had removed his receiver and his line had not yet been selected, the contacts 46^a would be connected to battery through alternate contact 38. If the line K had been a calling line and had been selected by a line selector E, said contact 46^a would be connected to battery (see switch E), through attracted armature 90, normal contact 100, wiper 63 of a line selector in connection with the line, through its contact 18, and through attracted armature 35 and retracted armature 38. If the called line were busy because some other connector H had already selected the line, the multiple contacts 46^a would have battery upon them through wiper 250 of such other connector H having already seized the line. In any of these cases, the closure of contact 231—233 would permit the flow of current from battery at the multiple contact 46^a, over wiper 250, normal contact 237, contact 231—233 and through the upper winding of test relay TR to ground, said relay therefore continuing energized. Since armature 234 remains attracted, the busy tone from interrupter 1^4 will be transmitted through normal contact 216 to wire 210, over the lower talking conductor, through the exchange and through the telephone at the calling substation A, returning over the upper talking conductor and through the winding of relay PR′ at the first selector F. The calling subscriber, being thus advised that the called line is busy, replaces his receiver, and switches E, F and G restore to normal as before. Under the present circumstances, the replacing of the receiver at the calling substation also restores to normal the switch H. This is effected by the restoring battery impulse, passing over wire 176, finding its way through attracted armature 194, contacts 200, 201, conductor 208, normal contact 244, the winding of release relay RR^4 to ground at contact 223. The said release relay is thereupon energized and locked over the previously described path to ground at contact 223 of relay LR^9. The stop mag-

net 14^c is now energized resulting in the restoration of the wipers of switch A as previously described.

Referring to the line selector E, Fig. 1, part 1, an especial feature of operation is employed when the line selector is to select a calling line in the sub-group immediately adjacent to the normal position of the wipers 63, 64, 65, 66. The group relay 42^a for this sub-group is shown, having the armature 43^a controlling the grounded condition of the multiple group contacts 73 for the sub-group. When a line in this sub-group initiates a call, the group relay 42^a will of course be operated in a manner similar to that in which the group relay 42^b of the sub-group of A was operated, ground being removed from the contact 73. When interrupter I closes contact 57 the relay PR will be operated to energize the relay 85 which, by armature 86, locks to ground at normal contact 94. With the travel of interrupter I, relay PR deënergizes since contact 73 is ungrounded before contact 58 becomes closed, and since contact 80 is open, no circuit for winding 10′ is completed and no long step of the wipers is produced. The relay SR was operated as before by the closure of contact 83—84 and for the proper operation of switch F, must continue operated when relay PR deënergizes to close circuit at contact 83 for the locking relay 89, so that the short-step travel of line selector E may be initiated by current from generator g passing through contacts 5 and 102. In this particular situation, attracted armature 87 of relay 85 keeps the circuit closed from ground through normal contact 19, wiper 63, attracted armature 101, normal contact 84, and contact 83—84 opens normal contact 97 and the relay SR. Relay 89 now operates by current through closed contact 88 and normal contact 83, and the selection of the individual contacts of the calling line proceeds as before.

Referring to first selector F, second selector G and connector H, it will be seen that if contacts in their tenth groups are to be selected, ten long steps of the wipers will be produced so that they will be brought around to normal and the travel to select idle contacts in the tenth group will start the switches on a second revolution. In such cases, the restorations to normal will be accomplished by causing the switches to complete a second revolution. Referring to the first selector F, the tenth step of the first selector will, at its conclusion, leave the off-normal contact 174 open, the secondary impulse will operate the relay LR^3 as before, which will lock to ground through the tenth contact of ring 145, operating the relay BR^2 as before. The operation of that relay, by closing contact 162, does not instantly actuate the locking relay LR^4, as in the previous description, but a first short step of the switch wipers is produced as before, contact 174 is closed, and locking relay LR^4 then operates instantly, the remaining operations being as before.

In the second selector G, the operation of selecting idle contacts of the tenth group is similar to the operation described for the selector F, relays LR^5, BR^3 and LR^6 corresponding to the relays LR^3, BR^2 and LR^4 of first selector F, and contact 211 corresponding to contact 174.

In the connector H, there are no essential differences in the method of operation when contacts of the tenth group are selected. At the conclusion of the tenth step, the off-normal contact 225 will, of course, be opened, but relay LR^6 will remain energized via closed contact 229 of relay LR^3 and accordingly stop-magnet 14^c will be energized by way of contact 224 as before, and the subsequent impulses will give the short-step travel to the desired contacts. And in the case of release, circuit is completed through contact 200—201^a, wire 208, normal contact 244, (the relay 213 having, of course, remained unoperated,) and through the upper winding of relay RR^4 to ground via 223. The relay RR^4, by armature 238, locks itself to ground at attracted armature 223, as before, and the release of the connector H proceeds in a manner which will be understood from the preceding description.

Figs. 2 and 3 show circuits adapted to be employed in the place of Fig. 1, part 2, and Fig. 1, part 3, respectively, of the complete circuit diagram previously described. The second complete diagram would therefore include Fig. 1, part 1, at the left, Figs. 2 and 3, and Fig. 1, part 4, placed side by side consecutively. The first selector F′ and second selector G′ are quite similar to the first selector F and second selector G respectively, but provision is made in F′ and G′ whereby the use of the contacts 152 and 206 is avoided. In a system operating in accordance with this second complete diagram, the operation of the line selector and of the relays PR′ and SR′ of first selector F′ is the same as in the previous case, including the control of said relays from the substation.

Assuming the same number is to be selected, the deënergization of relay PR′ transmits an impulse from ground through contacts 118, 116, through contact 126 and long step winding 10^3, producing a long step as before. The current, after passing through contact 126 in the present case, divides, a portion flowing through normal contacts 136 and 132 to operate locking relay LR′ which, at the conclusion of the impulse, will, by armature 131, be held locked through contact 144—145 at b. Thereafter the im-

pulse transmitted by the deënergization of relay SR′ passes through contacts 117, 119, attracted armature 135, relay BR′, and stop magnet 14^a to battery operating said magnet. The attraction of armature 139 of relay BR′ energizes the locking relay LR^2 which, by armature 129, locks to ground at off-normal contact 120. The circuit for the short-step winding 10^4 is now closed through contacts 5^a, 127, and alternate contact 137. On the resulting first short step of the switch wipers, relay LR′ is unlocked and deënergized by opening of contact 144—145 at *b*, and a previously existing locking circuit for magnet 14^a and relay BR′, extending through attracted armature 138 and closed contact 133—134, is opened, and the make-before-break spring 133 shifts the circuit of magnet 14^a and relay BR′ via contacts 143 and normal contact 124 to the private wiper 146. The relay BR′ and magnet 14^a of course remain operated until wiper 146 reaches an idle or ungrounded contact 147^a, when circuit through them will be opened and their deënergization will prevent further steps of the switch. The retraction of armature 137 in the present case operates the relay 121 by current through closed contact 128 and the connection is extended to the talking wipers 148, 150. In releasing the first selector F′, the battery impulse is transmitted as before over wire 110, the current traversing alternate contacts 124, 123, release relay RR′, passing to ground through alternate contact 130. Armature 142 of relay RR′ operates busy relay RR′ and stop magnet 14^a in series, and short-stop travel of the first selector F is completed around to normal in an obvious manner, at which time the opening of contact 120 will deënergize the relay LR^2, whose armature 130 opens the locking circuit for relay RR′ and the deënergization of this relay, by opening contact 142, of course deënergizes the relay BR′ and the stop magnet 14^a. On the energization of relay BR′, at initiation of the release, the opening of normal contact 137 deënergized the relay 121 so that the first selector F′ is now at normal.

Referring to Fig. 3, the operation of the second selector G′ there shown is substantially like that of the first selector F′. The transmission of the first impulse over wire 177 operates long step winding 10^5 and the locking relay LR^{10}, which, by armature 267, locks to ground through the contact 198—199 at *b*. The secondary impulse over wire 178 passes through contact 271, relay BR^5 and magnet 14^d, operating the same, whereon armature 275 of relay BR^5 energizes the locking relay LR^{11} which locks to ground at off-normal contact 261. The short-step travel of the switch is now produced by current from generator *g* through winding 10^6, contacts 5^d, 263, and alternate contact 273, and the selection of idle contacts proceeds as before, which being effected, the relay 260 operates to extend the connection to the wipers 202 and 204 by current through attracted armature 264 and normal contact 273. The release impulse, as in the case of Fig. 1, part 3, comes in from battery over wire 176, through alternate contacts 282 and 281 and release relay RR^5 to ground at alternate contact 266. The operation of release relay RR^5, by armature 278, operates in series, relay BR^5 and magnet 14^b, and short-step travel of the second selector G′ is produced until the wipers reach normal, when the opening of off-normal contact 261 initiates circuit changes, placing the mechanism of the second selector at normal, which occurs in an obvious manner.

The operation of the connector H, when employed in connection with the circuits of Figs. 2 and 3, differs in no respect from that in which it was operated when employed in the first circuit diagram.

While I have shown in the circuit diagrams the conductors of the various selector switches as connected directly to wiper contacts for the sake of securing greater simplicity in the diagrams, I prefer in practice to terminate the conductors, shown as terminating in wipers in the diagrams, in stationary contacts in the mechanical switches, forming what are called "common strips," which are preferably of circular form. The contacts, to which these common strips are to be connected, are placed adjacent to them, respectively, and the switch wipers mounted upon the shaft have in themselves no circuit connections, serving merely to cross the respective commons to their associated contacts. In Fig. 5, the strips 63, 64, 65, 66 represent the corresponding wiper contacts shown in Fig. 1, part 1, the wipers *m*, *n*, *o* and *p*, with the travel of the switch, operate to close the commons 63, 64, 65, 66 to their respective associated contacts. The wiper *s* has associated with it the off-normal contacts 69^a—70 and 67—68. When the switch leaves normal, the wiper *s* disengages the contacts 69, 70, thus opening circuit between them; and on the first step, it engages the contacts 67, 68, making a bridged connection between them, thus producing the closed circuit condition required by the circuit diagram of Fig. 1, part 1. In Figs. 7, 8, 9 and 10, are given views illustrating the common conductors for the line selector E, their associated contacts and the manner in which the various wipers bridge the commons to the other contacts. Reference characters are supplied to these figures, corresponding to Fig. 1, part 1, and the electrical equivalency between the two modes of representation is apparent.

For the first selectors, the second selectors and connectors, the conductors shown in the diagrams as connected to wiper contacts are preferably, in practicing the invention in connection with switches of the mechanical structure herein illustrated, terminated in common strips in a manner similar to that of the conductors of the line selector, the wipers being used merely to bridge the commons to the different contacts. The off-normal contacts of the selectors and connectors are also preferably operated by wiper means in the manner of the off-normal contacts of the line selector. The proper arrangement of switch contacts to meet the requirements of the different first and second selectors and connectors is sufficiently obvious from the illustrations given of the line selector when taken in conjunction with the circuit diagrams.

While I have shown a plurality of batteries and alternating current generators, it will be understood that when the apparatus is all located in one exchange, but a single source of direct current of each polarity is required and but a single generator.

The circuit diagrams, in order to secure a convenient spacing of parts, show the different electromagnets as provided with a plurality of armatures, but it will of course be understood that any suitable form of electromagnets may be employed, a single armature actuating a plurality of switch contacts.

Various modifications may be made in the system of the invention herein shown and described, without departing from the substance thereof, and I do not wish to be limited to the precise structure shown and described, but

What I claim is:

1. A telephone system including a calling line, a line selector to make connection therewith, a relay for said selector, an actuating magnet therefor in a circuit controlled by said relay, means controlled by current over said line to effect a step toward energizing said relay, and independently actuated means for thereon actuating said relay and magnet in proper sequence.

2. A telephone system including a calling line, a line selector to make connection therewith, a relay for said selector, an actuating magnet therefor in a circuit controlled by said relay, means controlled by current over said line to effect a step toward energizing said relay, independently actuated mechanism at the exchange, a pair of contacts having connections alternately changed by said mechanism, one of said contacts being included in the circuit for said magnet, and a circuit for energizing said relay including the other of said contacts.

3. A telephone system including telephone lines, a selective switch to connect with said lines, a relay for initiating travel of said switch, a circuit for said relay, mechanism operating responsive to current over said lines to close one contact in the circuit of said relay, and independently actuated means at the exchange, operated independent of any control of the telephone lines for closing another contact in said circuit.

4. A telephone system including telephone lines, a selective switch to connect with said lines, a relay for initiating travel of said switch, a circuit for said relay, mechanism operating responsive to current over said lines to close one contact in the circuit of said relay, a second contact in said circuit, and independently actuating mechanism at the exchange, operated independent of any control of the telephone lines, alternately opening and closing said contact.

5. A telephone system including a selective switch, a magnet controlling travel thereof, a circuit therefor, a relay controlling a contact of said circuit, and interrupter means adapted to transmit energizing current to said relay to cause it to close said contact, said means also comprising time correlated mechanism to thereafter actuate said magnet.

6. A telephone system including a selective switch, a relay for said switch, a switch actuating magnet controllable by said relay, a contact in circuit with said magnet, a contact in circuit with said relay, and means continuously changing the connection of said contacts in alternation.

7. A telephone system including a plurality of lines, a line selector to select the calling line, a switch actuating magnet for said selector, a relay controlling said magnet, a contact in circuit with said magnet, another contact in circuit with said relay, and interrupter means at the exchange operating to close and open one of said contacts, said means also serving to close and open the other contact alternately with the operation of said first contact after a definite time interval.

8. A telephone system including a plurality of telephone lines, contacts for said lines arranged in groups, a line selector having movable contacts adapted to select any group of said first-mentioned contacts, and then contacts of a calling line from the selector group, a relay for said selector, means controllable by current over any line to perform a step toward operating said relay to place said selector in operation to select the group, an independently actuated periodic circuit changer at the exchange adapted to coöperate with said means in operating said relay, a magnet for said selector, a circuit for said magnet having a contact controlled by said relay whereby said relay determines the operation of said magnet in adjusting the selector to select the group, said magnet

also serving to thereafter adjust said selector to select contacts of the calling line from the group.

9. A telephone system including a plurality of telephone lines, contacts for said lines arranged in groups, a line selector having movable contacts adapted to select any group of said first-mentioned contacts, and then contacts of a calling line from the selected group, a relay for said selector, means controllable by current over any line to perform a step toward operating said relay to place said selector in operation to select the group, an independently actuated periodic circuit changer at the exchange adapted to coöperate with said means in operating said relay, a magnet for said selector, a circuit for said magnet having a contact controlled by said relay whereby said relay determines the operation of said magnet in adjusting the selector to select the group, a second relay for said selector, and means for placing said magnet under control of said second relay to select contacts of the group.

10. A telephone system including multiple telephone line contacts arranged in groups, a line selective switch to select the group and then contacts of the group, a magnet for adjusting said switch, a circuit for said magnet, a relay having a switch contact included in said circuit, means for causing said magnet to produce long steps of said switch, when operated responsive to said relay, to select the group, a second relay having a contact in a circuit of said magnet, and means for causing said magnet to produce short steps of said switch, when operated responsive to said second relay, to select contacts of a group.

11. A telephone system including multiple telephone line contacts arranged in groups, a line selective switch to select the group and then contacts of the group, a magnet for adjusting said switch, a circuit for said magnet, a relay having a switch contact included in said circuit, a second relay having a contact in a circuit of said magnet, means for causing said magnet to produce long steps of said switch, when operated in response to said first relay to select the group and to produce short steps of said switch, when operated responsive to said second relay, to select contacts of a group, subscriber's telephone lines connected to said contacts, and means responsive to current over a calling line to cause operation of said relays.

12. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, and a magnet for each of said switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines.

13. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, a magnet for each of said switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, a pair of relays for each of said line selecting switches, one of said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment.

14. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, a magnet for each of said switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, a pair of relays for each of said line selecting switches, one of said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment, and an electrically adjustable stop member coöperating with said other relay in said short step adjustment.

15. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, a magnet for each of said switches, said magnet serving to effect long and short steps of their respective switches to select the calling lines, a pair of relays for each of said line selecting switches, one of said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment, and line circuit mechanism for each line serving, when operated, to cause the operations of the relays of an idle line selecting switch to control the magnet of said switch to place the latter in connection with the respective line.

16. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, auxiliary selective switches paired with said first-mentioned switches for extending the circuits of calling lines, and a magnet for each of said first-mentioned switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines.

17. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, auxiliary selective switches paired with said first-mentioned switches for extending the circuits of calling lines, a magnet for each of said first-mentioned switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, and a pair of relays for each of said line selecting switches, one of

said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment.

18. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, auxiliary selective switches paired with said first-mentioned switches for extending the circuits of calling lines, a magnet for each of said first-mentioned switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, a pair of relays for each of said line selecting switches, one of said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment, and an electrically adjustable stop member coöperating with said other relay in said short step adjustment.

19. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, auxiliary selective switches paired with said first-mentioned switches for extending the circuits of calling lines, a magnet for each of said first-mentioned switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, and impulse transmitting means for adjusting the selective switches paired with said line selecting switches in completing connections to desired lines.

20. A telephone system including telephone lines, a plurality of line selecting switches each adapted to connect with any line as a calling line, auxiliary selective switches paired with said first-mentioned switches for extending the circuits of calling lines, a magnet for each of said first-mentioned switches, said magnets serving to effect long and short steps of their respective switches to select the calling lines, a pair of relays for each of said line selecting switches, one of said relays serving to control a magnet in the long step adjustment of its switch, and the other serving to control said magnet in the short step adjustment, an electrically adjustable stop member coöperating with said other relay in said short step adjustment, line circuit mechanism for each line serving, when operated, to cause the operations of the relays of an idle line selecting switch to control the magnet of said switch to place the latter in connection with the respective line, and impulse transmitting means for adjusting the selective switches paired with said line selecting switches in completing connections to desired lines.

21. A telephone system including a group of telephone lines, line selectors common to said group for selecting the calling lines, a conductor common to said selectors for starting an idle one, mechanism for shifting said conductor from operative relation with one selector to similar relation with another, means operable from the substation of any of said lines for altering the connections of said conductor, and an independently actuated periodic circuit changer at the exchange also serving to alter the connections of said conductor.

22. A telephone system including a group of telephone lines, line selectors common to said group for selecting the calling lines, a conductor common to said selectors for starting an idle one, means operable from the substation of any of said lines for altering the connections of said conductor, and an independently actuated periodic circuit changer at the exchange also serving to alter the connections of said conductor, whereby said means and said circuit changer jointly control the electrical condition of said conductor.

23. A telephone system including a group of telephone lines, line selectors common to said group for selecting the calling lines, a conductor common to said selectors for starting an idle one, means operable from the substation of any of said lines for altering the connections of said conductor, an independently actuated periodic circuit changer at the exchange also serving to alter the connections of said conductor, a magnet for controlling the movement of each selector, and a common circuit wire for said magnets also controlled by said circuit changer.

24. A telephone system including a group of telephone lines, line selectors common to said group for selecting the calling lines, a conductor common to said selectors for starting an idle one, means operable from the substation of any of said lines for altering the connections of said conductor, an independently actuated periodic circuit changer at the exchange also serving to alter the connections of said conductor, magnets for said selectors, a common conductor for operating said magnets having a branch for each said magnet, and a contact in the common portion of said conductor controlled by said circuit changer.

25. A telephone system including a group of telephone lines, line selectors common to said group for selecting the calling lines, a conductor common to said selectors for starting an idle one, means operable from the substation of any of said lines for altering the connections of said conductor, an independently actuated periodic circuit changer at the exchange also serving to alter the connections of said conductor, magnets for said selectors, a common conductor for operating said magnets having a branch for each said magnet, a contact in the common portion of

said conductor controlled by said circuit changer, and a contact in each branch of said conductor for controlling actuation of its respective switch magnet, the electrical conditions of said last-mentioned contacts being controlled responsive to the connections of said starting conductor.

26. A telephone system including telephone lines, extending from substations, a line selector for selecting said lines having multiple contacts of said lines arranged in groups, electromagnetic means for said selector having armature mechanism for causing long steps of said selector to select the group and short steps thereof to select contacts of the group, a relay controlling said electromagnetic means during long step travel, another relay for controlling said electromagnetic means during short step travel, a periodic circuit closer, a starting conductor for said selector controlling circuit changes for energizing both said relays, and a pair of contacts in said conductor, one contact being controlled responsive to circuit changes produced at a substation of a line, the other contact being controlled by a periodic circuit closer at the exchange.

27. In a telephone system, the combination with a selective switch having contacts arranged in groups, of a switch adjusting magnet for producing long steps of said switch to select a group, and short steps thereof to select contacts of a group, a long step winding for said magnet, a relay for said switch adapted, when energized, to close circuit for said long step winding, and an independently operating periodic circuit closer at the exchange for initially actuating said relay.

28. In a telephone system, the combination with a selective switch having contacts arranged in groups, of a switch adjusting magnet for producing long steps of said switch to select a group, and short steps thereof to select contacts of a group, a long step winding for said magnet, a short step winding for said magnet, a relay for said switch adapted, when energized, to close circuit for said long step winding, an independently operating periodic circuit closer at the exchange for initially actuating said relay, and means for deënergizing said relay on selection of the group to open said long step winding.

29. In a telephone system, the combination with a selective switch having contacts arranged in groups, of a switch adjusting magnet for producing long steps of said switch to select a group, and short steps thereof to select contacts of a group, a long step winding for said magnet, a short step winding for said magnet, a relay for said switch adapted, when energized, to close circuit for said long step winding, an independently operating periodic circuit closer at the exchange for initially actuating said relay, means for deënergizing said relay on selection of the group to open said long step winding, and connections changed responsive to the deënergization of said relay to close the circuit of said short step winding.

30. In a telephone system, the combination with a selective switch having contacts arranged in groups, of a switch adjusting magnet for producing long steps of said switch to select a group, and short steps thereof to select contacts of a group, a long step winding for said magnet, a short step winding for said magnet, a relay for said switch adapted, when energized, to close circuit for said long step winding, an independently operating periodic circuit closer at the exchange for initially actuating said relay, means for deënergizing said relay on selection of the group to open said long step winding, connections changed responsive to the deënergization of said relay to close the circuit of said short step winding, and a stop magnet in a circuit controlled by said relay.

31. A telephone system including a directively operable selector, multiple contacts at said selector arranged in groups, an adjusting magnet for said selector adapted to effect long steps thereof to select a group and short steps to select contacts of a group, means for transmitting directive currents to said magnet to produce long steps to select the group, a relay for initiating circuit changes to cause short step travel of the selector to select contacts of a selected group, means for energizing and locking said relay, and a switch contact opened on the first short step to unlock said relay.

32. A telephone system including a directively operable selector, multiple contacts at said selector arranged in groups, an adjusting magnet for said selector adapted to effect long steps thereof to select a group and short steps to select contacts of a group, a long step winding for said magnet and means for transmitting directive impulses thereto, a short step winding for said magnet, a relay for initiating circuit changes to actuate said winding, means for energizing and locking said relay, and a switch contact opened on the first short step to unlock said relay.

33. The combination with a pair of connected telephone lines, of selective switches including a line selector, a plurality of directively operable selectors and a connector having contacts included in the connection existing between said lines, a magnet for each said directively operable selector adapted to effect long steps to select the group and short steps to select contacts of the group, a connection adapted to be closed at the line

selector to simultaneously alter the connections at said other selectors to restore them to normal.

34. The combination with a pair of connected telephone lines, of selective switches including a line selector, a plurality of directively operable selectors and a connector having contacts included in the connection existing between said lines, a magnet for each said directively operable selector adapted to effect long steps to select the group and short steps to select contacts of the group, a connection adapted to be closed at the line selector to simultaneously alter the connections at said other selectors, and means responsive to such alteration to cause short step travel of the selectors to normal.

35. A telephone system including telephone lines, a line selector to select said lines, a magnet for said selector to adjust the same, a controlling relay for said magnet, a common interrupter for transmitting impulses to said magnet, and means controlled by said interrupter for energizing said relay and producing a time interval between said energization and the beginning of the first impulse transmitted to said magnet.

36. A telephone system comprising line selector switches, directive selector switches, connector switches for interconnecting the lines of said system, said switches having their bank contacts arranged in groups, and means including a single driving magnet for operating said switches to select a group and thereafter a contact in the group in extending such interconnections.

37. A telephone system including a selector switch, an electromagnet for operating said switch, an impulse transmitting device adapted for transmitting impulses to operate said electromagnet, means for connecting said impulse device in circuit with said magnet for operating the switch, and means to prevent such connection from being made effective until a period between impulses of said device.

38. A telephone system including a selector switch, an electromagnet for operating said switch, an impulse transmitting device adapted for transmitting impulses to operate said electromagnet, a primary or control relay having normally open contacts included in said impulse circuit, means for closing an energizing circuit for said primary relay, and means to prevent closure of said energizing circuit except between impulse periods of said device.

39. A telephone system including a selector switch having terminals arranged in groups, telephone circuits extending from said terminals, an electromagnet for operating said switch from group to group, an impulse transmitting device adapted for transmitting impulses to said electromagnet, a primary relay having normally open contacts included in said impulse circuit, an energizing circuit for said primary relay, means for closing said circuit, means to prevent closure of said energizing circuit except between impulse periods of said device, and means for operating said switch to select a contact in the selected group.

40. A telephone system including a selector switch having terminals arranged in groups, telephone lines connected to said terminals, an electromagnet for operating said switch from group to group, an impulse transmitting device adapted for transmitting impulses to operate said electromagnet, a primary or control relay having normally open contacts included in said impulse circuit, means effective upon initiation of a call over one of said lines for closing an energizing circuit for said primary relay to cause said magnet to select the group including the called line, means to prevent closure of said energizing circuit except between impulse periods of said device, and means for thereafter operating said switch to select the contacts of the calling line.

41. A telephone system comprising telephone lines, a line selector switch for connecting calling and called lines, said switch having terminals of said lines arranged in groups and an electromagnet and associated ratchet mechanism and control circuit therefor for producing long step travel of said switch to select a group and short step travel to select a contact in a group.

42. A telephone system comprising telephone lines, line selector switches for connecting calling and called lines, said switches having terminals of said lines multiply connected and arranged in groups, and an electromagnet and associated ratchet mechanism and control circuit therefor for producing long step travel of said switches to select a group and short step travel to select a contact in a group.

In witness whereof, I hereunto subscribe my name this 9th day of April, 1908.

FRED SCHOENWOLF.

Witnesses:
CAROLYN WEBER,
BESSIE SKINNER.