G. E. MUELLER.

TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 9, 1909.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 1.

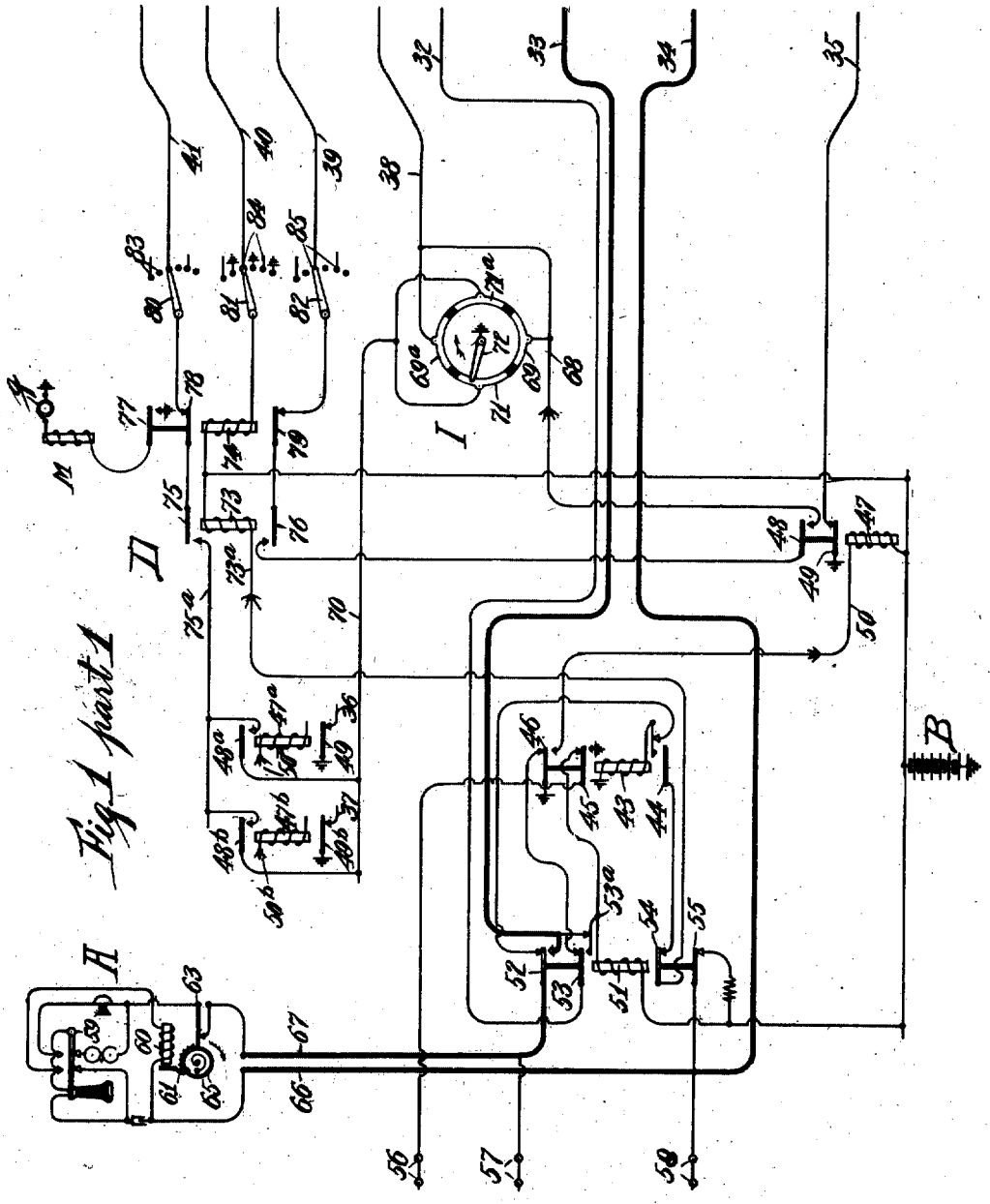

Fig. 1 part 1

Witnesses

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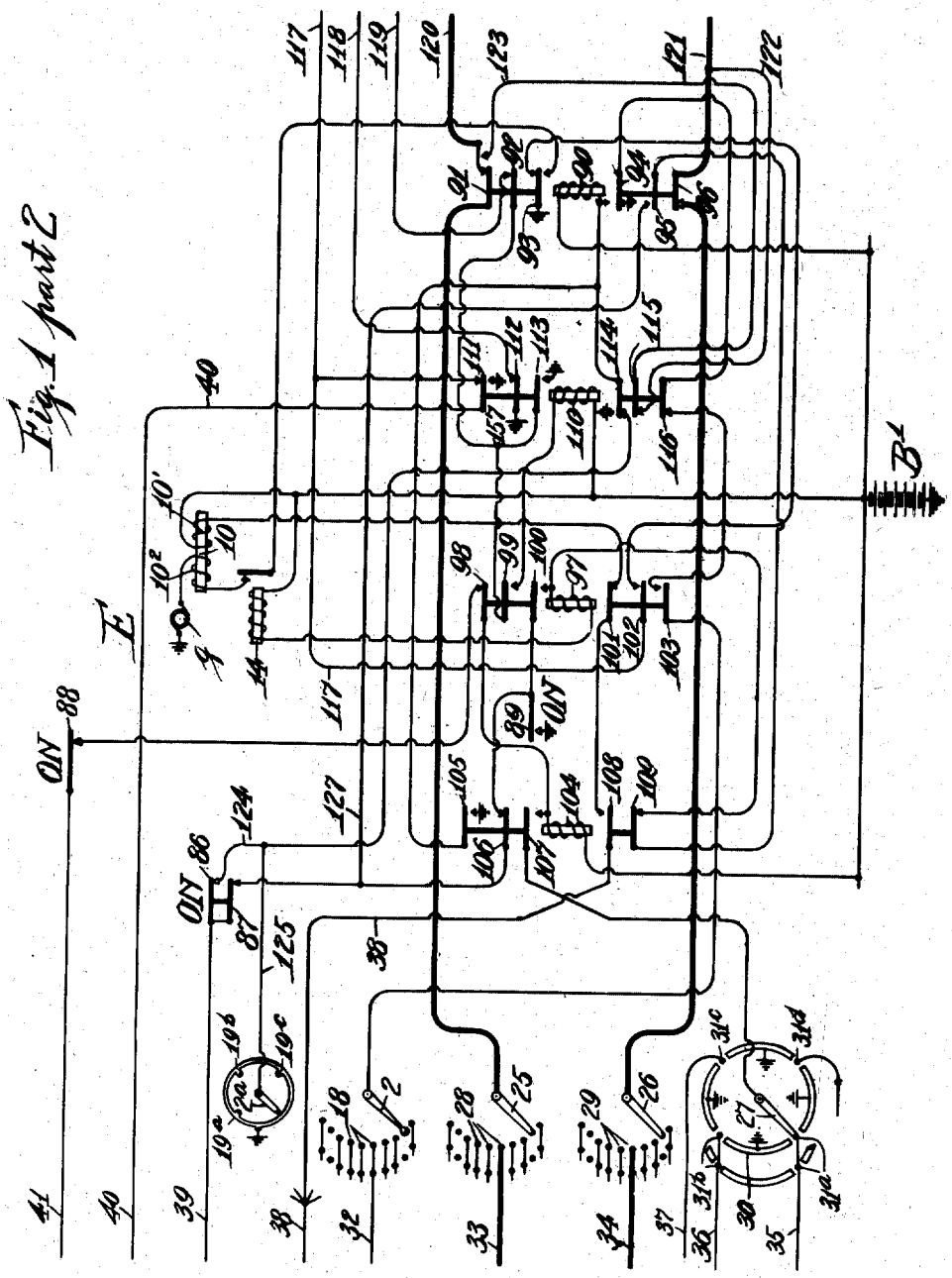
12 SHEETS—SHEET 2.

Fig. 1 part 2



Witnesses

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12 SHEETS—SHEET 3.

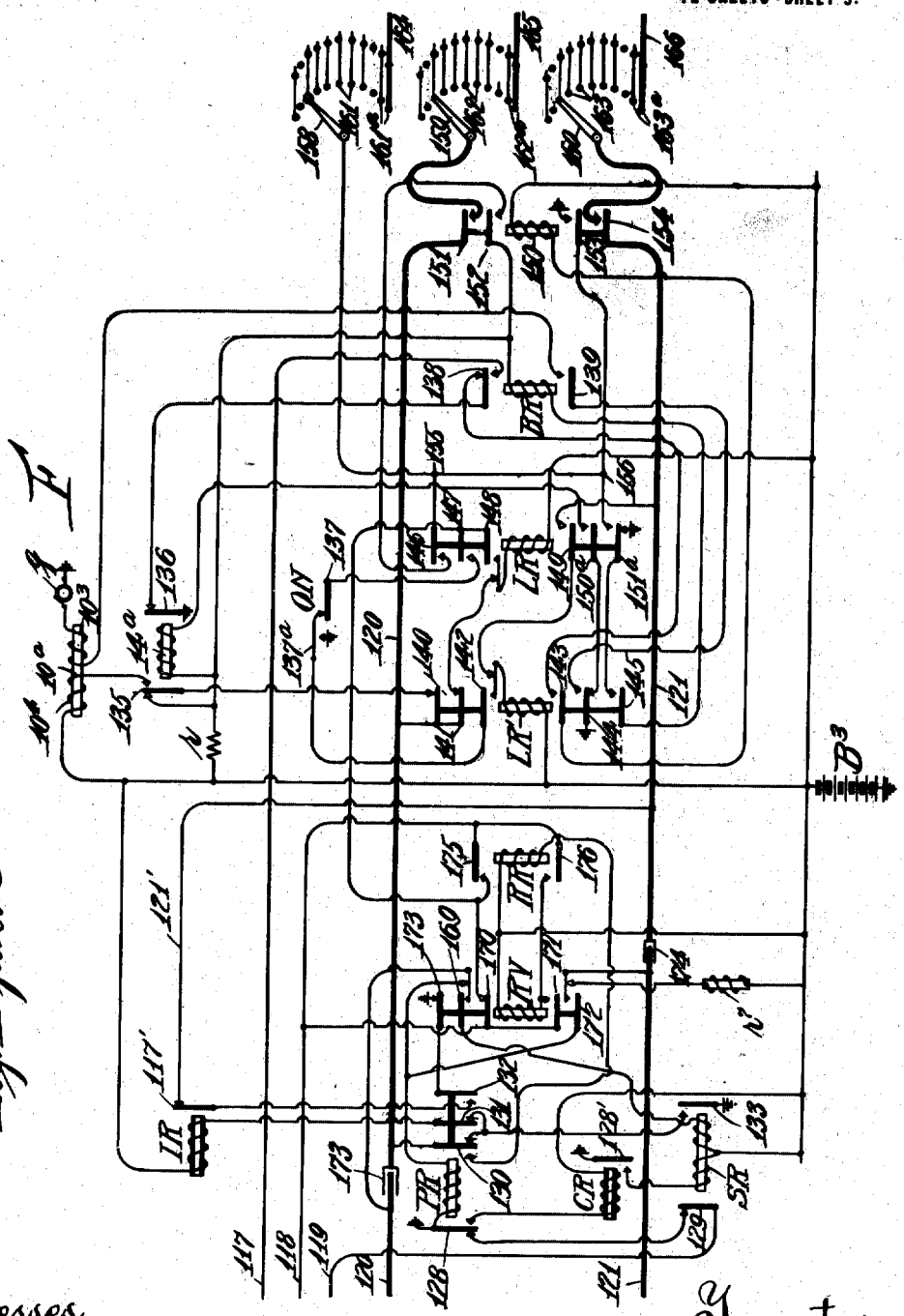

Fig. 1 part 3

Witnesses

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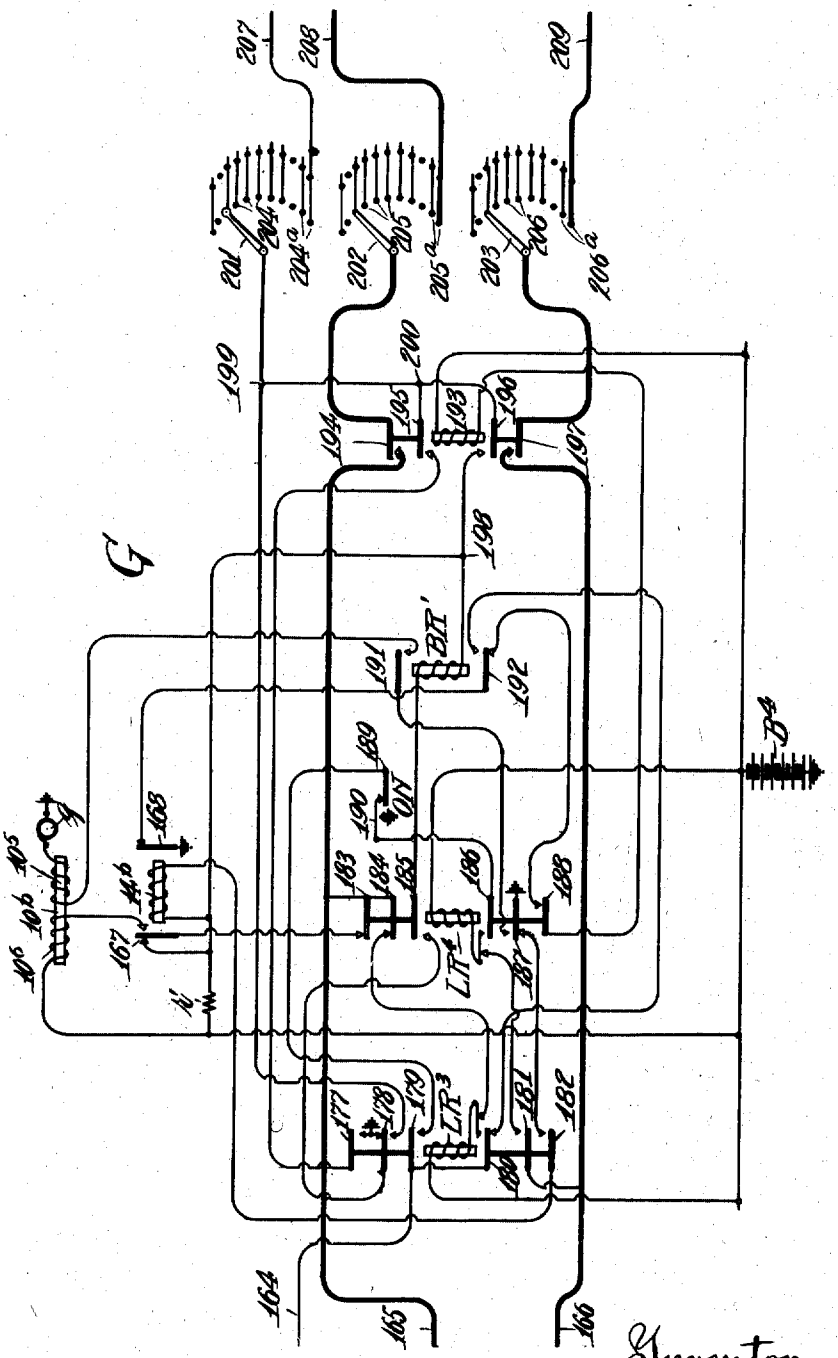
12 SHEETS—SHEET 4.

Fig. 1 part 4



Witnesses

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12 SHEETS—SHEET 5.

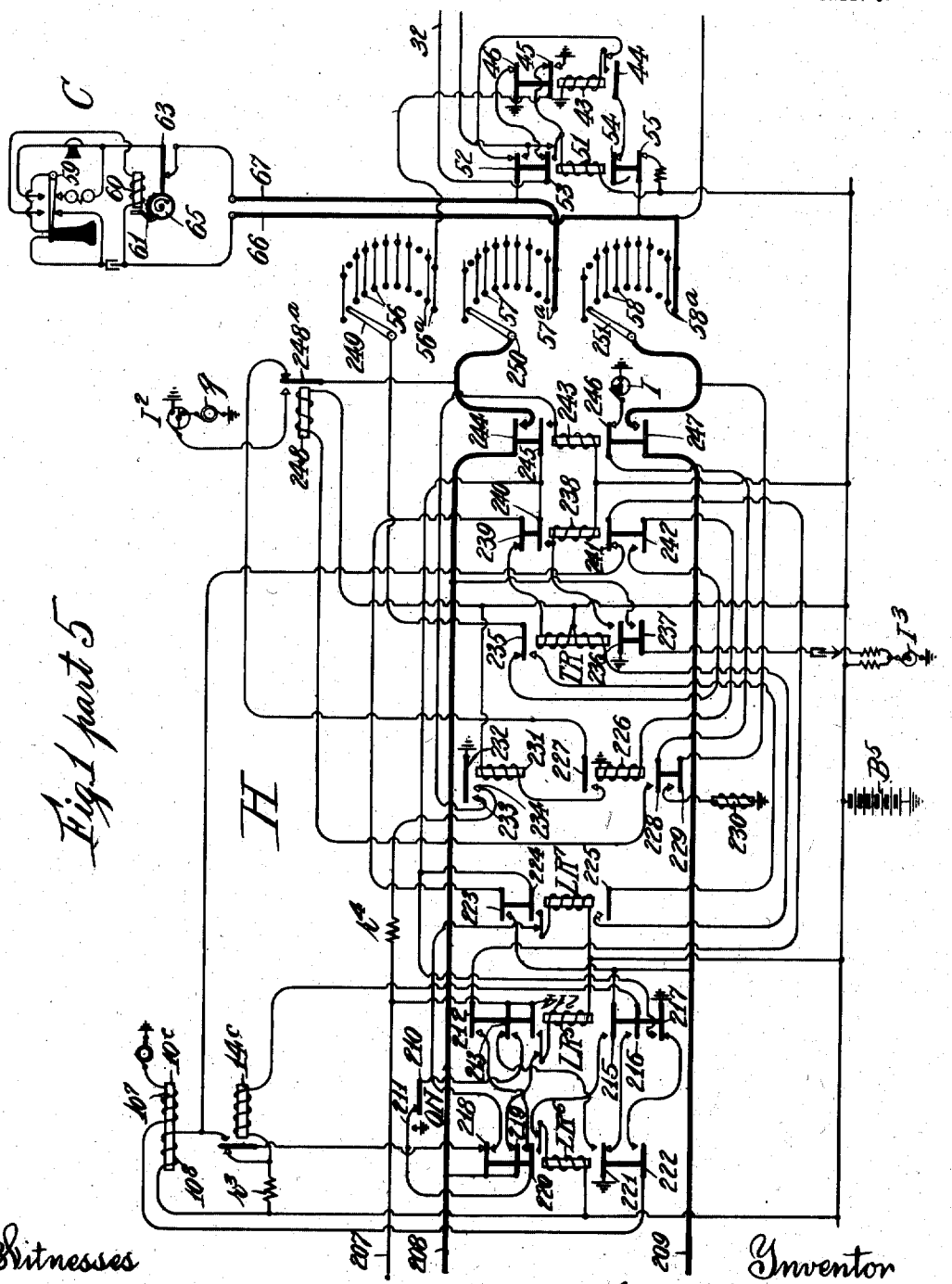

Fig 1 part 5

Witnesses

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TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

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1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 6.

Fig. 2

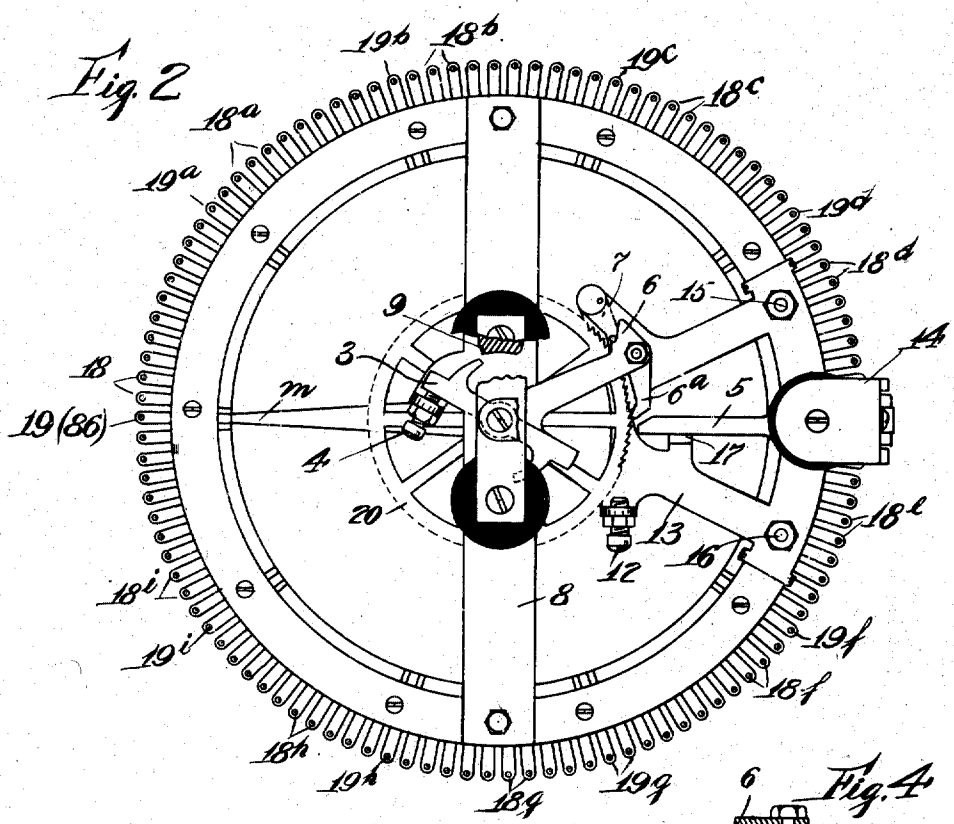
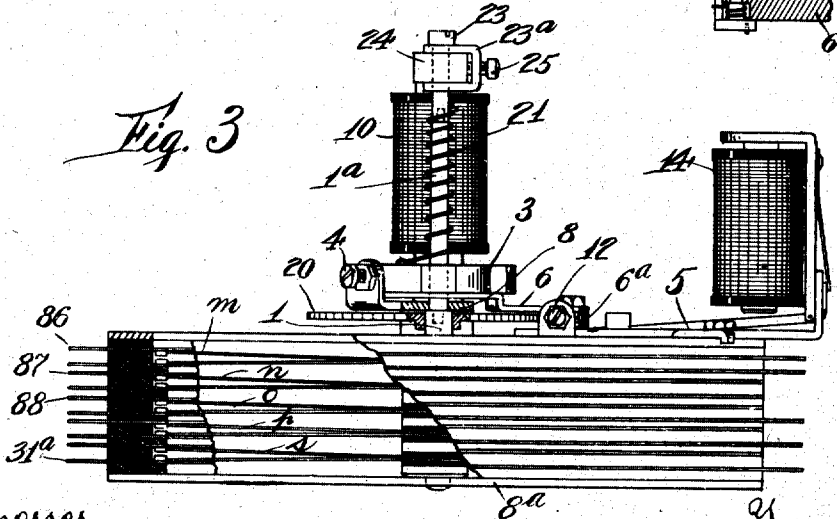


Fig. 4

Fig. 3



Witnesses

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APPLICATION FILED APR. 9, 1909.

1,237,214. Patented Aug. 14, 1917.

12 SHEETS—SHEET 7.

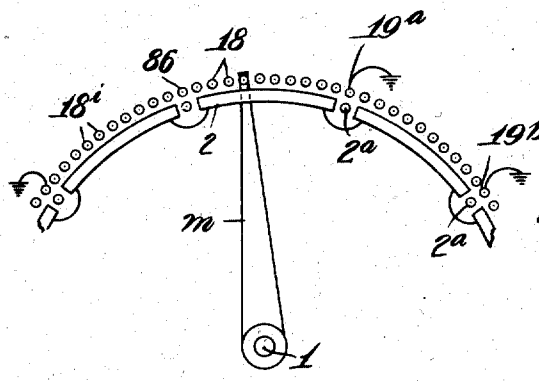

Fig. 5

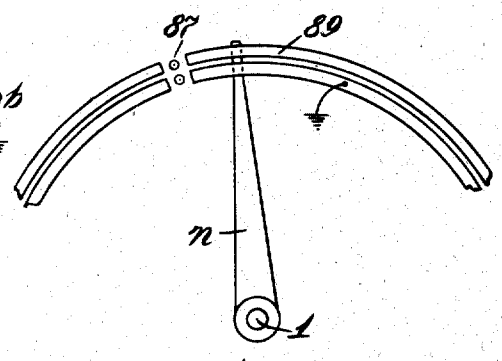

Fig. 6

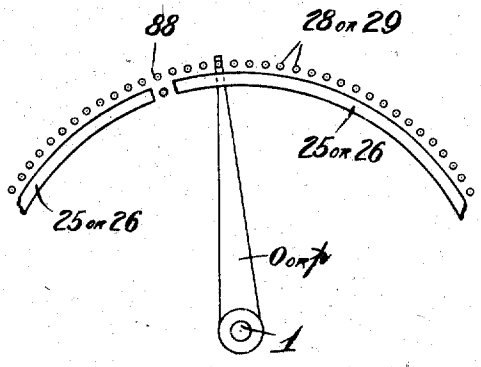

Fig. 7

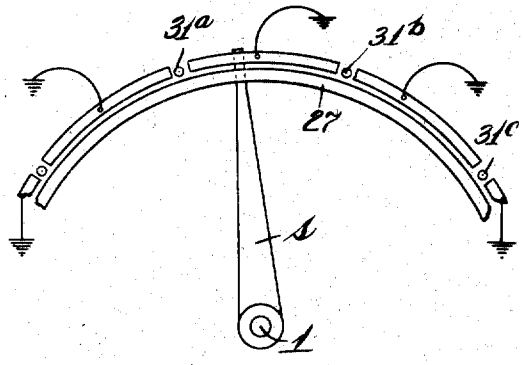

Fig. 8

Witnesses
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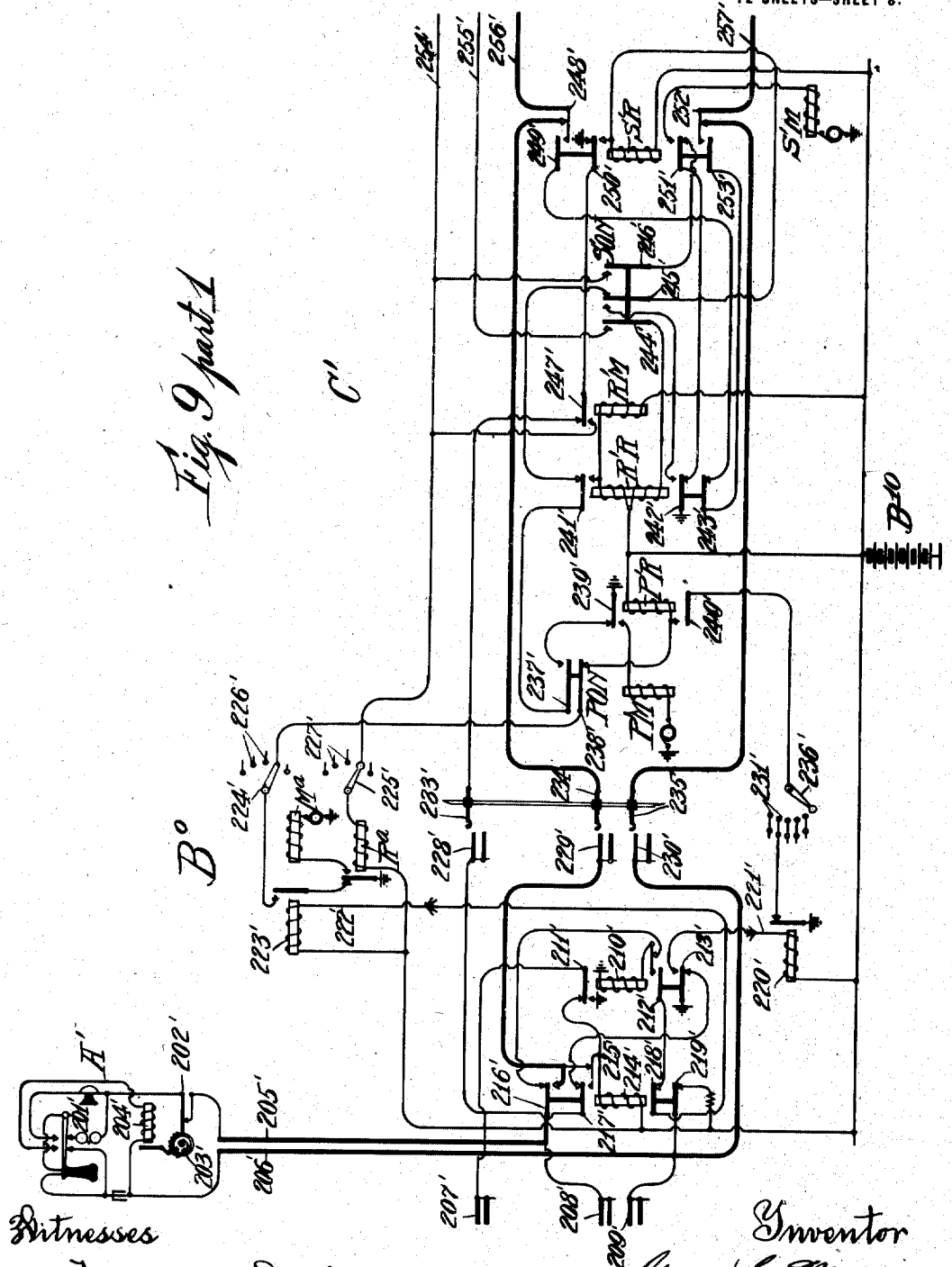
TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 9, 1909.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 8.



Witnesses

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TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 9, 1909.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 9.

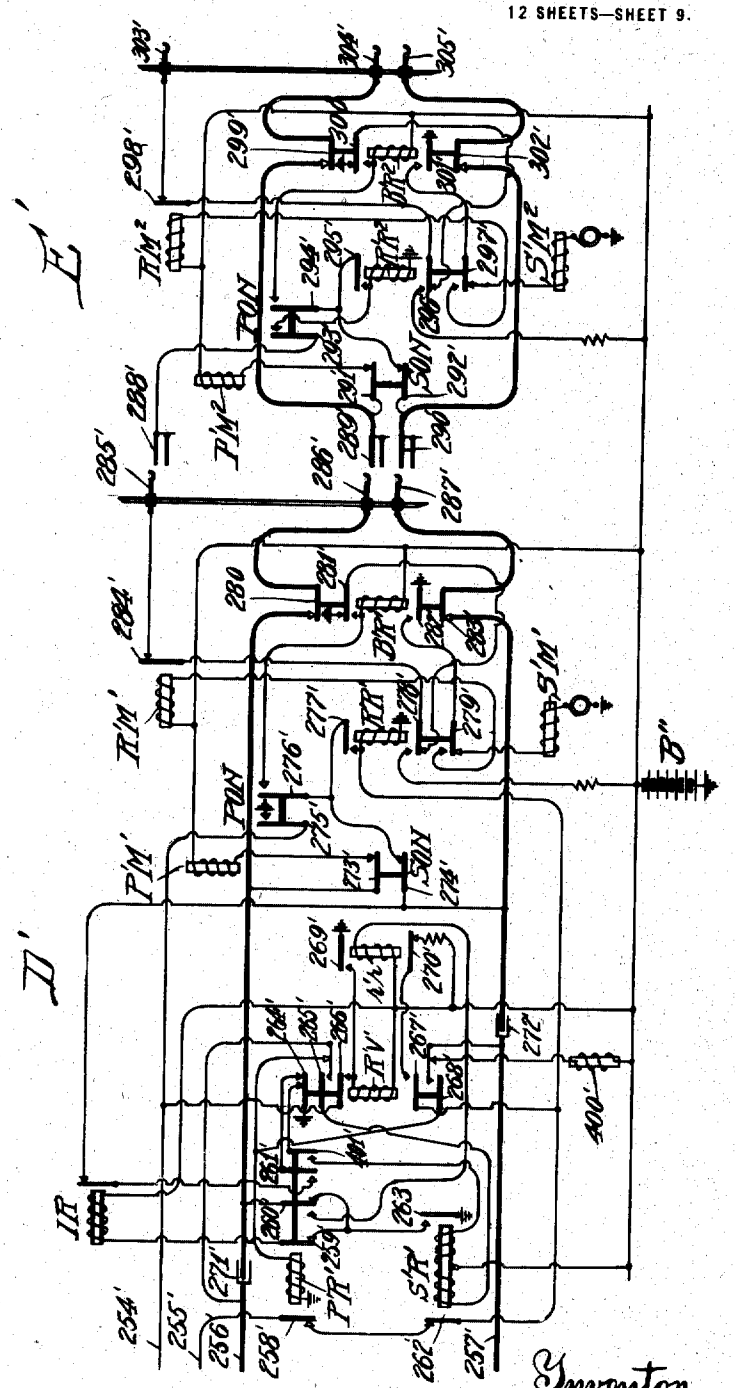

Fig. 9 part 2

Witnesses

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TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 9, 1915.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 10.

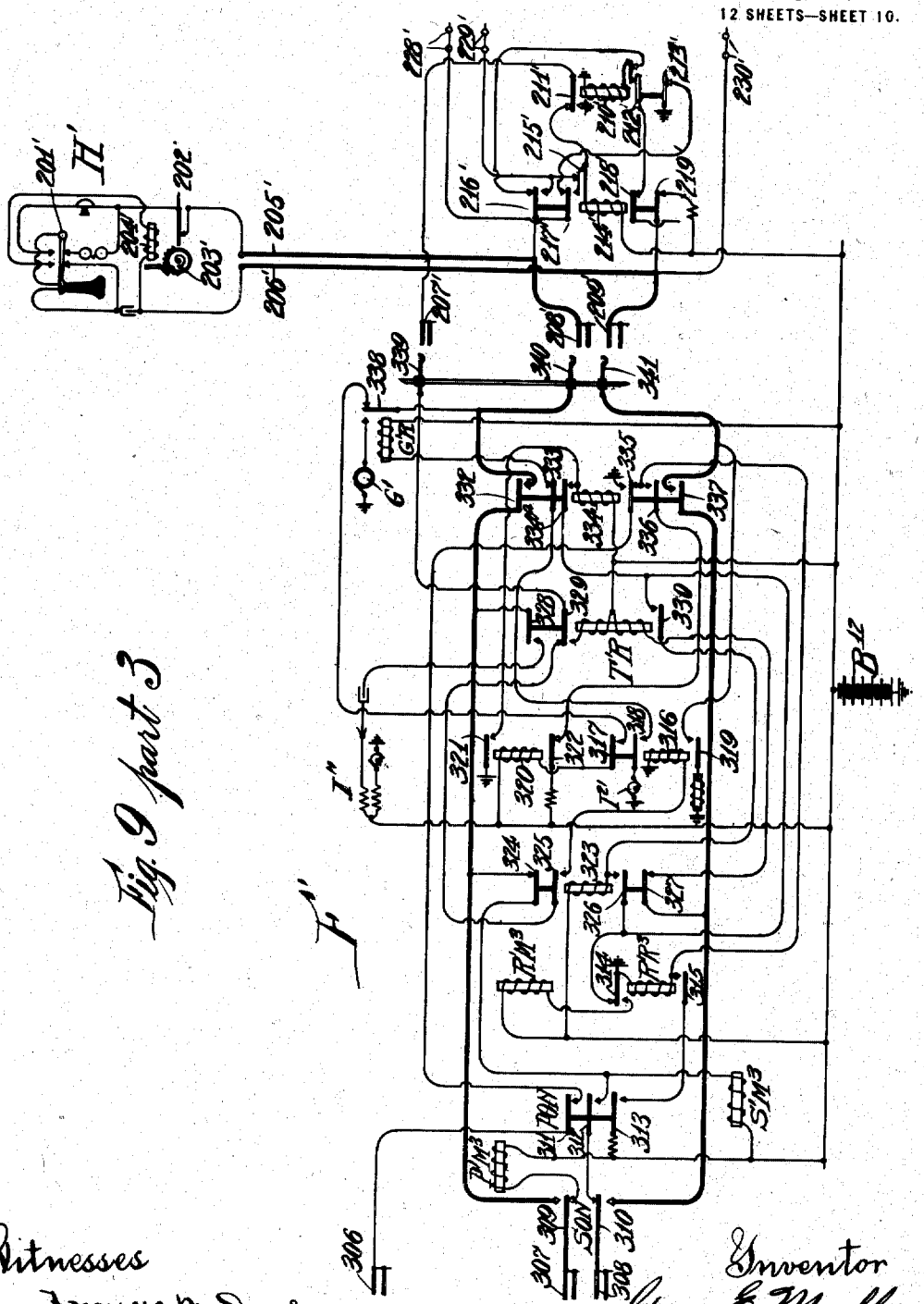

Fig. 9 part 3

Witnesses

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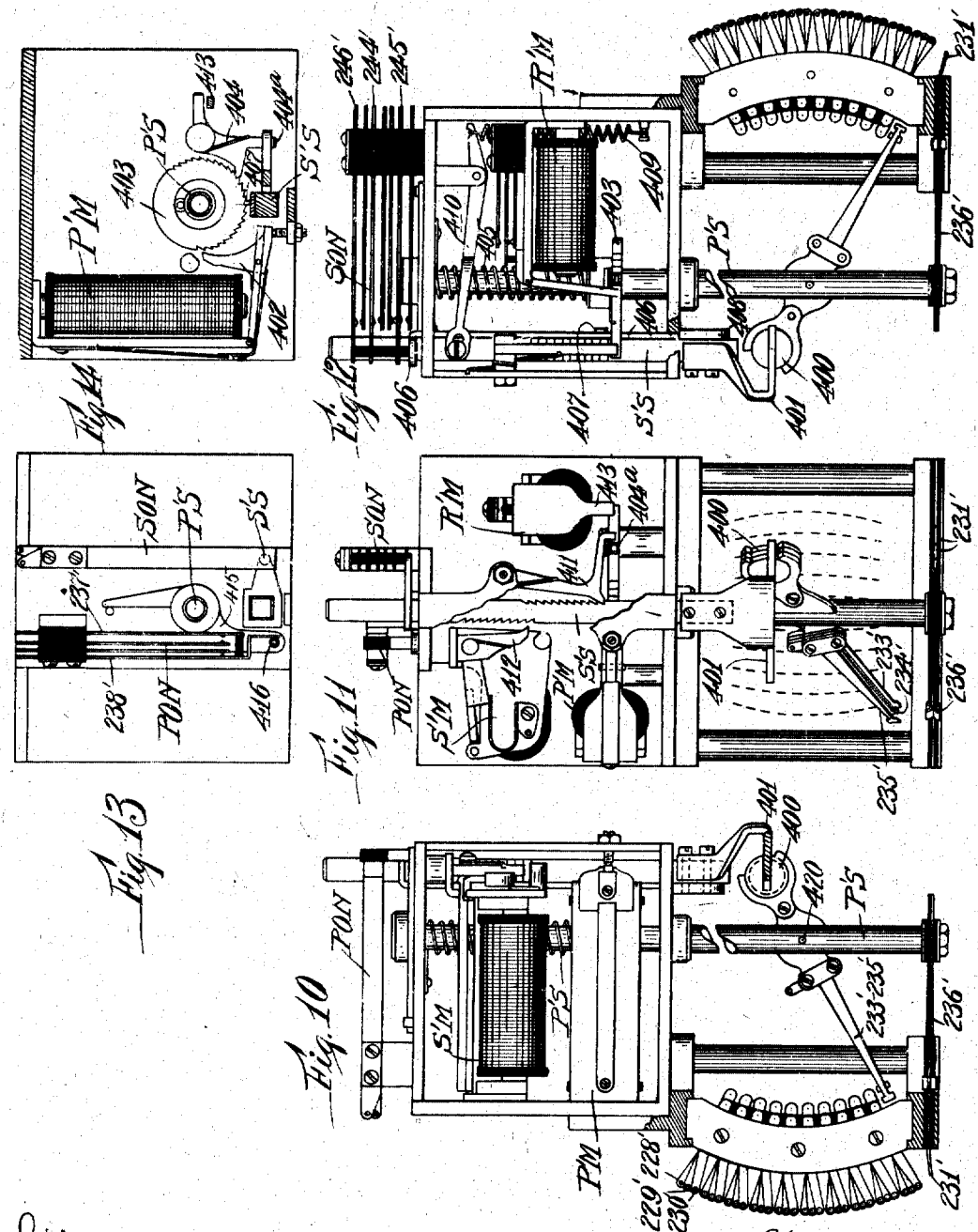
TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED APR. 9, 1909.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 11.



Witnesses

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TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

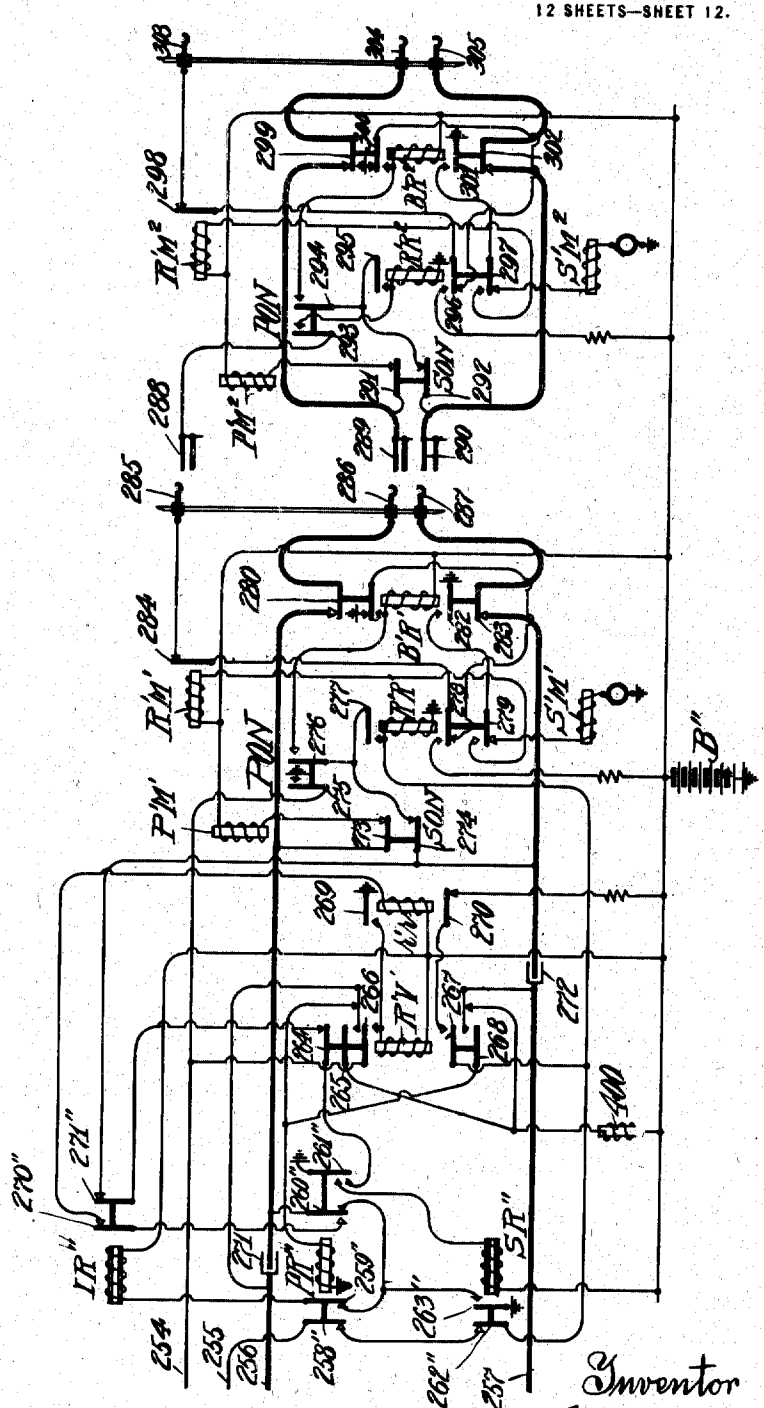
APPLICATION FILED APR. 9, 1909.

1,237,214.

Patented Aug. 14, 1917.

12 SHEETS—SHEET 12.

Fig. 15



Witnesses

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Atty.

UNITED STATES PATENT OFFICE.

GEORGE E. MUELLER, OF AURORA, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

TWO-WIRE AUTOMATIC TELEPHONE SYSTEM.

1,237,214. Specification of Letters Patent. Patented Aug. 14, 1917.

Application filed April 9, 1909. Serial No. 488,857.

To all whom it may concern:

Be it known that I, GEORGE E. MUELLER, a resident of Aurora, county of Kane, State of Illinois, have invented new and useful Improvements in Two-Wire Automatic Telephone Systems, of which the following is a specification.

The present invention is directed to securing improved and simplified circuit arrangements, whereby automatic selectors and connectors may be adjusted primarily to select desired groups of contacts and thereafter secondarily to select individual contact sets out of the pre-selected groups responsive to substation transmitters, which operate only to produce series of rapid interruptions in the subscribers' line circuits.

I am aware that systems of this general character, often referred to as "two wire systems" and so distinguished from systems wherein a common return conductor is employed together with the usual pair of line wires, have been heretofore proposed and the present invention is directed to certain improved relations of parts and circuits.

In the arrangement now proposed, a so-called primary relay is connected directly in a calling subscriber's line and has its armature vibrated responsive to line circuit interruptions to directively adjust the automatic switches to select the required groups of contacts. The usual first selectors are provided and each one has its individual primary relay, which, in addition to its directive impulse transmitting function, also controls two local circuits, each of which contains a so-called slow release relay, namely a relay slow to release its armature when its circuit is interrupted, a feature of operation that may be secured in electromagnetic relays, in several well known ways, as by placing copper shells about their cores, or by providing short-circuited secondary windings for them, etc.

In accordance with the present invention, one of these slow release relays has its circuit adapted to be closed when the primary relay attracts its armature and the other when said primary relay retracts its armature, and the circuits of both slow release relays so controlled are local circuits, the result being that the values of the energizing currents supplied to the slow release relays may be more accurately adjusted than in systems wherein the said slow release relays have to depend for their currents upon the telephone lines directly, which may obviously be of widely varying resistances. Those points of novelty forming the present invention will be more particularly pointed out when the drawings are described and in the appended claims.

Referring to the accompanying drawings forming a part of this application, Parts 1, 2, 3, 4 and 5 of Figure 1, when arranged in consecutive order, show circuits of a telephone system embodying the present invention; Fig. 2 is a plan view of a selector for the circuits of Fig. 1, and Fig. 3 a side elevation thereof partly in section; Fig. 4 shows a detail of the connection between the driving pawl of said selector and its actuating member; Figs. 5, 6, 7 and 8 show details of the wiper and contact arrangements of said selector; Parts 1, 2, and 3 of Fig. 9, when arranged in consecutive order, illustrate a modified automatic telephone system circuit embodying the invention; Figs. 10, 11 and 12 are, respectively, left, front and side elevations of a selector for use with the circuits of Fig. 9; Fig. 13 shows its primary off-normal switch; Fig. 14 is a detail of the primary magnet and its associated parts; and Fig. 15 illustrates a modification of the circuit of Fig. 9, Part 2.

Referring first for a moment to Fig. 1, Part 3, the wires 120, 121 are in the operation of the system extended to the left so as to reach the calling substation and be there connected together. When this occurs, the relay PR will obviously be held energized, its winding being connected to the wire 120 from one side of the battery B^3, while the opposite side of said battery is connected through resistance r^7 and normal contact 172 with wire 121. When relay PR first energizes, armature 131 opens a contact in the circuit of relay IR and simultaneously armature 128 energizes relay CR, whose armature actuates secondary relay SR. The latter, by armature 133, closes ground to normal contact 130 preparatory to the primary adjusting operations of relay PR. As before indicated, these are produced by rapid interruptions in the calling line at the substation, whereby wires 120, 121 are correspondingly rapidly interrupted and relay PR first deënergizes and then energizes with each interruption, its armature being thus vibrated. On the first de-

energization of relay PR, relay IR operates by current through normal contact 131. On the succeeding operations of relay PR, the interruptions in their circuits are so brief that neither relay IR nor CR retracts its armatures, although each back stroke of armature 130 transmits an adjusting impulse over wire 120 to the right.

When at the conclusion of the interruptions between wires 120, 121, relay PR remains energized for a space, obviously the circuit of relay IR remains open correspondingly and its armature soon retracts to connect ground traced through contacts 173, 132, to the secondary impulse wire 121, whereby the secondary adjustment of the selector is initiated. At this time relays CR and SR will obviously remain operated, since they are not operatively affected by the vibrations of the armature of relay PR, nor by its continuing energized. A prolonged interruption in the circuit of wires 120, 121 will, however, result in their deenergizations and avail is made of this fact for restoring the apparatus to normal, as hereafter explained at length.

Referring now generally to Fig. 1 with its parts adjacently disposed in consecutive order, as the circuit arrangement of 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, as called lines, the lines would be divided 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 204, 205, 206 multipled at the banks of the second selectors G assigned for that thousand, and the multiple contacts of the 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 161, 162, 163, 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 158, 159, 160 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 161, 162, 163 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 2, 25, 26 appear multiple contact sets 18, 28, 29, 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 2, 25, 26 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 a 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 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 gronp.

In the diagram, Fig. 1, Part 1, I have illustrated a calling substation A connected by the line conductors 66 and 67 with a suitable line circuit arrangement at the exchange. The substation at A includes the customary hook switch 59, 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 65 is provided, said calling device being normally locked by a pivoted pawl 61 controlled by the magnet 60 whose winding also serves as the impedance coil for the talking set. When the coil of 60 is energized, its armature is attracted and the pawl 61 withdrawn from engagement with the dial 65 so that the same may be rotated by hand in the direction of the arrow. The dial 65 has attached to it suitable teeth of insulating material which control the connections of the impulse spring 63. It is obvious that the rotation of dial 65 in the direction of the arrow has no operative effect upon the spring 63. When, however, it is released, the teeth of insulating material operate to momentarily open contact 63 as many times as there have been teeth brought below said spring.

It is thus apparent that by the operation of the dial 65, a calling subscriber can cause a number of sets of openings of line limb 67 at contact 63, and by successive actuations of the dial 65, the calling subscriber is enabled to count out the digits comprising the number of the called subscriber.

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 80, 81, 82, having before them contacts 83, 84, 85, one such set being provided for each line selector of a one hundred line group. Each line of a group has its line relay 43; and a common conductor 73^a is provided, connected to the master-switch relay 73 and having branches, one to each of the line relays of 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 43, individual to it, has its cut-off relay 51, the latter being employed to render the line relay inoperative when the line is connected with.

As before indicated, the multiple contacts 18, 28, 29, 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 47, 47^a or 47^b, etc., and a sub-group contact 31^a, 31^b or 31^c, etc., appearing before the group selecting wipers 27 of the line selectors E. The group relay 47 of each sub-group has an armature 49 controlling the electrical condition of the group contact 31 and an armature 48 which coöperates with the constantly traveling interrupter I and with the master-switch mechanism D in starting an idle line selector E. Each such group relay 47 is connected by a common conductor 50 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 common interrupter I is provided having two pairs of segments 69—69^a and 71—71^a, and the grounded wiper 72 is constantly traveling over the segments at a rapid rate, successively grounding them. The segments 69 and 69^a are connected to a common conductor 38 which has branches extending to armatures 108 of the relays 104 of the different line selectors E, and the interrupter is employed, among other uses, to transmit currents over the conductor 38 to operate the windings 10′ of the driving magnets 10 to produce the long step travel of the switches E. In order to prevent a winding 10′ from being actuated by a partial impulse over a wire 38, whereby but a partial long step of a switch E might be produced, the circuit at each switch E is so arranged that its relay 104, which controls the contact 108 in the circuit of winding 10′, can be actuated only by current through one of the segments 71 or 71^a of the interrupter I. By this arrangement, no current can be passed through a winding 10′ upon the energization of the line relay 43 of a line and the consequent energization of the respective group relay, until the wiper 72 engages a contact 69 or 69^a after having first been in engagement with the contact 71 or 71^a to operate the relay 104, since the line and group relays were operated, where-

by such operation of the line and group relays, which may occur at a time when the wiper 72 is about to pass off a segment 69 or 69ª, is ineffective to produce a wrong operation of the line selector E by causing it to make a partial long step.

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. 2, ten groups of ten contacts 18, 18ª, 18ᵇ, etc., to 18ʲ are provided arranged in a circle, making one hundred of such contacts, while between the groups of contacts, contacts 19, (86), 19ª, 19ᵇ, etc., to 19ʲ are located. A rotary shaft 1 is provided suitably journaled, as indicated in Fig. 3, to the circular base plate 8ª 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 23ª and the screw 25 threaded to the piece 23ª, 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 1ª 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. 2 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 6ª which is provided with a suitable spring to hold it in engagement with the ratchet as indicated in Fig. 4, is fastened to the armature shaft 1ª so as to partake of the rocking movements of the armature, the pawl 6ª 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 6ª 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 engages 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 6ª 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, by its armature, the stop pawl 5 which, in the line selector, Fig. 3, is shown as below the pawl 6ª 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 6ª, thus limiting the stroke of armature 3, piece 6 and pawl 6ª.

It is now apparent that when magnet 14 is deënergized, actuations of the magnet 10 will, by pawl 6ª, 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 18ᶜ, 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 19ᶜ. 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 18ᵉ to another. When the switch of Fig. 3 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.

For the first and second selectors and for the connector, the stop magnet arrangement indicated in Fig. 2 is preferably employed, the said arrangement being one in which the pawl 5 is normally in stroke limiting relation

with the pawl 6. With this arrangement, in order to secure long step travel of the switch, the magnet 14 must be energized to withdraw the stop pawl 5 from the path of pawl 6, and when short step travel is to be produced, magnet 14 must be deënergized to allow the stop pawl 5 to assume its normal engaging relation. This arrangement is in some respects a preferred one, since if the pawls 6 and 5 be both made of magnetic material, there is a slight tendency to stick or freeze when the two pawls are in engaging relation, magnets 10 and 14 being simultaneously energized. Making one pawl of non-magnetic material, or providing air-gap spacers of course obviates any such effect. While I have, in Fig. 1, at E, shown the circuit closers or wipers 2^a, 2, 25, 26 and 27 diagrammatically, as connected directly with the conductors of the line selector E, I have preferred, in the mechanical switch structure, to terminate the conductors, shown connected to the said wipers in Fig. 1, in stationary contacts while the switch wipers themselves in the mechanical structure have, in themselves, no circuit connection, but act merely to close conductive bridges between bank contacts with which they are associated. The electrical equivalency of the arrangement shown in Fig. 1 to those shown in Figs. 3, 5, 6, 7 and 8 will be apparent. In Fig. 3, five sets or pairs of wipers *m*, *n*, *o*, *p* and *s* are indicated, mounted one pair above the other upon the main switch shaft 1. Referring now to Figs. 5 to 8 inclusive, when the wipers are in their normal positions, they will be engaging respectively the contacts 86, 87, 88 and 31^a. By referring now to Fig. 1, it will be apparent that when wipers *m* are in their normal position, they close the off-normal contact 86 to its associated contact, thus producing the normal circuit condition of contact 86 shown in Fig. 1. Similarly, when wipers *n* and *o* are in their normal positions, they close respectively the off-normal contacts 87 and 88 to their respective associated contacts, as indicated in Fig. 1. It is also apparent that when shaft 1 is caused to make its first step, each of these off-normal contacts 86, 87, 88 will be opened, wiper *n* then closing the off-normal contact 89 to ground, the said contact continuing closed to ground until the wiper has completed its revolution and is restored, while the other off-normal contacts remain open until the line selector reaches normal.

The private wiper 2 indicated in Fig. 1 is, in its mechanical embodiment as shown in Fig. 5, represented by the conductively joined segments 2, while the contacts 18 are those adjacent to the said segments. The between-group contacts 19^a, etc., are plainly indicated in Fig. 5 and the wiper 2^a is represented by the contact 2^a of Fig. 5, whereby the wiper *m*, in a between-group position, conductively bridges or closes a contact $19—2^a$.

In Fig. 7, the common strip 25, which extends circularly complete except for the break at the off-normal contact 88, represents the wiper 25, while its adjacent sets of contacts 28 represent the multiple contacts of Fig. 1 and the same arrangement as that shown in Fig. 7 is employed for the wiper 26 and the contacts 29 as indicated by the alternate reference characters given in Fig. 7. The ring 27 in Fig. 8 is the equivalent of wiper 27 in Fig. 1. The wiper *s* has a between-group position closing contacts $27—31^a$, $27—31^b$ just indicated in Fig. 1, while the grounded segments of Fig. 1, Part 2, are plainly indicated in Fig. 8.

It will be understood that switches of the general character shown in the mechanical figures are used for the first and second selectors and connectors, commons being employed for the wiper contacts shown in Fig. 1, the switch wipers thus being, as in the case of the line selector, without circuit connections in themselves and being used to cross the commons to the private contacts and the line contacts. The off-normal switch arrangements of the first selector, second selector and connector will be secured in the manner obvious from the description given of the off-normal arrangements of the line selector and need not be specifically referred to.

The detail of the circuit arrangements of Fig. 1 will best be understood when explained in connection with a description of the operation of the system and will now be described, it being assumed that A is a calling subscriber and desires his line to be connected with that of the subscriber whose substation is indicated at C and whose number will be assumed to be 2222.

Subscriber A, by removing his receiver to initiate a call, establishes a path for a flow of current from ground, through line relay 43, through contacts 52, 63, the substation transmitter, the raised hook-lever 59, through magnet 60, over line limb 66, armature 55 to battery B, operating line relay 43, which, by armature 44, is locked to battery over the common conductor 73^a and relay 73 of master-switch D. The flow of current through the substation may momentarily actuate the magnet 60 to unlock dial 65, but as soon as relay 43 attracts armature 44, the circuit through the substation is interrupted, magnet 60 will be deënergized and pawl 61 will return to locking relation with dial 65 which now continues locked until a line selector E shall have selected the calling line. Thus the subscriber A will be prevented from actuating his calling device until his line shall have been brought into operative relation with the first selector F.

It will be seen that the multiple contacts 18 of the calling line are grounded over conductor 32 and through normal contacts 53 and 46 as long as the line circuit of A is at normal, the said multiple contacts 18 being thus normally unselectable at the line selector. Attracted armature 46, however, removes ground from the contacts 18, thus rendering them selectable, and grounds the common conductor 50 energizing the group relay 47, which, by armature 49, removes ground from the group contact 31^a. As soon as wiper 72 engages one of the segments 69 or 69^a, a circuit is completed from ground through attracted armature 48, over attracted armature 76, armature 79, wiper 82 of master switch D (wipers 80, 81, 82 of master-sw tch D normally engaging contacts 83, 84, 85 of an idle line selector E) through contact 85 of such idle line selector, over conductor 39, closed off-normal contact 86, normal contact 114, and the relay 90 to battery B′, energizing the said relay 90. Since, as indicated by the location of the multiple contact 31^a normally engaged by the wiper 27, the calling line is included in the first sub-group of ten, no long steps of the line selector E are required to be made to select the calling line in the present case, so that the winding 10′ of magnet 10 is not employed, but the stop magnet 14 must be actuated at once and circuit must be closed through the short step winding 10^2 to initiate the short step travel of the switch. On the energization of relay 90, circuit is closed as follows: from battery B′, through magnet 14, through relay 97, contact 109, attracted armature 95, wire 127, normal contact 87, conductor 39 and to ground at segment 69 or 69^a through interrupter I. Attracted armature 93 has closed one break in the circuit of winding 10^2 and magnet 14 is now actuated to close the second break therein and to throw the stop pawl into operative relation with the mechanism of magnet 10. Circuit may now be traced from ground, through generator g, winding 10^2, attracted armature of relay 14, alternate contact 93 to ground and magnet 10 will now be actuated by successive impulses from generator g until the relay 90 is deënergized, each actuation of winding 10^2 producing a short step of wipers 2, 2^a, 25, 26 and 27.

It will be noted that on the first step of the switch E, the off-normal, ON, contacts were shifted to alternate position whereby electromagnets 14 and 97 were locked to ground via contact 89 by means of the attracted armature 100. Armature 103 of relay 97 has now connected the winding of relay 90 through alternate contact 94 and normal contact 116 with the private wiper 2 of the line selector, and since on the first step of the line selector, contacts 86 and 87 are opened, the relay 90 now depends for its continued energization upon the grounded contacts 18 to be encountered by wiper 2 as the wipers progress in their short step travel. Contacts 18 of non-calling lines will be grounded at armature 46 of their respective line relays 43, and since wiper 2 engages a new contact 18 before leaving the previously engaged one, relay 90 will continue energized until the switch wipers in their travel have reached a point where wiper 2 engages an ungrounded contact 18, such being one pertaining to the calling line. At this time, circuit through relay 90 will obviously be opened, the relay will become deënergized and its armature 93 being retracted, will prevent further actuations of winding 10^2 of magnet 10 and the wipers of the line selector E will come to rest, the wipers 2, 25 and 26 engaging respectively the multiple contacts 18, 28 and 29 of the calling line, that of A. On the retraction of armature 93, ground is placed, via normal contact 93, alternate contact 102 and contact 111, upon the conductor 40 extending to the private contact 84 at the master-switch D, through its private wiper 81 and to battery through operating relay 74, energizing said operating relay, which opens contacts 78 and 79 to prevent any possible ground upon wipers 80 or 82. The armature 77 closes circuit for generator g through motor magnet M of the master-switch. Wipers 80, 81, 82 being mounted upon a rotary shaft in operative relation with the driving magnet M, are rotated step by step in search of contacts 83, 84, 85, pertaining to an idle line selector. The contacts 84 of line selectors in use will be connected to ground and relay 74 will continue energized, holding contact 77 closed until the master-switch wipers engage the contacts of an idle line selector, at which time the circuit for relay 74 will be opened, the relay deënergized, its armature retracted, and wipers 80, 81, 82 will rest engaging the contacts 83, 84, 85 of such idle line selector and ready to start the same when another call is initiated from one of the lines of the group that the master-switch D serves.

As soon as relay 90 was first operated, it closed alternate contact 91, whereby a flow of current was produced from the positive pole of battery B^3, Fig. 1, Part 3, through resistance r^7, normal contact 172 of relay RV, link-circuit strand 121, conductor 122, closed contact 115 of relay 110, conductor 123, alternate contact 91 of relay 90, link-circuit strand 120, normal contact 169 of relay RV, and primary relay PR to ground. By the closing of this circuit, primary relay PR is energized. The actuation of its contact 128 completes a circuit for control relay CR, which it may be noted is rendered slow to release by some suitable means as the copper shell shown. The actuation of relay

CR in turn closes a circuit through the left-hand winding of secondary relay SR and grounded contact 128′ of relay CR. The closing of this circuit in turn actuates secondary relay SR which opens its contact 129 and closes its contact 133. The connection from ground through contact 133 and alternate contact 130 to the link-circuit strand 120 will, upon the deënergization of primary relay PR, apply ground to said strand at the right of condenser 173. When relay 90 is deënergized, as heretofore described, current will flow from the live pole of battery B, Fig. 1, Part 1, through cut-off relay 51, normal contact 53^a, link-circuit strands 33 and 120, normal contact 169 of relay RV, through primary relay PR to ground. In this way, relay PR is maintained energized, with the resulting energization of relays CR and SR, and the cut-off relay 51 is operated and locks itself energized through contact 53—53^a, conductor 32, contact 18—2, closed contacts 103, 116, and normal contact 94 to ground. The operation of cut-off relay 51 will also connect line limb 67 through alternate contact 52 to strand 33 and accordingly there will also be a path for current from the live pole of battery B^3, Fig. 1, Part 3, through resistance r^7, normal contact 172 of relay RV, to link-circuit strand 121, thence over the sleeve side of the circuit, through strand 34, line limb 66, locking magnet 60, the switch-hook 59, the transmitter, closed contact 63 of the calling device at the substation, thence over the tip side of the circuit through line limb 67, strands 33 and 120, to ground through relay PR and normal contact 169 of relay RV. Thus a circuit is provided under the control of the calling device at station A which will operate relay PR, which is instrumental in connecting strand 120 to ground through closed contact 133 of relay SR, to transmit impulses to operate the first selector F, second selector G, and the connector H.

The ground at contact 94 of relay 90, placed upon the multiple contacts 18 through the wiper 2, has made the contacts of the calling line unselectable to other selectors. Since the armature 54 of relay 51 opens the circuit of relays 43 and 73, normal contact 45 is again closed and the ground on conductor 32 is extended through said normal contact 45 to the multiple private contacts 56 of the calling line at the connectors, holding them grounded and unselectable. The said multiple contacts 56 were, on the initial operation of relay 43, grounded by attracted armature 45 so that the calling line was held busy against incoming calls during the travel of the line selector E.

It is now apparent that the calling line has, by the operation of the line selector E, had connected to it the relays PR and SR of the first selector F, paired with the line selector that was operated, and the said relays are now controllable by means of the dial 65 at the calling substation, which dial was unlocked as soon as cut-off relay 51 operated, by the current holding relays PR and SR energized which traversed the magnet 60.

Before proceeding with a description of the operation of the first selector F and of the other directively operable switches, certain further explanation with respect to the line selector E is in order. The operation of this switch, when the calling line is in a sub-group other than the first, differs from that heretofore described in that the long step winding 10′ of the magnet 10 is employed to cause the line selector's wipers to select the sub-group in which the calling line is included; whereafter the short step winding 10 is employed to select the individual contacts of the calling line out of the selected group. The wire 39, employed to start the line selector E when the calling line is in the first group as hereinbefore described, is not employed when the calling line is in any other sub-group than the first, the wire 41 being the starting wire for all other sub-groups.

I have shown at 47^a a sub-group relay for the second sub-group and at 47^b a sub-group relay for the third sub-group. The common conductor 50^a has branches to alternate contacts 46 of the ten line relays of the second sub-group, and the common conductor 50^b has branches to the alternate contacts 46 of the ten line relays of the third sub-group, and it will be understood that there will be other sub-group relays 47^c, 47^d, etc., for the fourth, fifth, etc., to the tenth sub-groups with corresponding connections similar to those of relays 47^a and 47^b. The conductor 36 at relay 47^a connects with the conductor 36 of Fig. 1, Part 2, connecting to the multiple sub-group contacts 31^b of the second sub-group; so the conductor 37, associated with relay 47^b, connects to the conductor 37 of Fig. 1, Part 2, which is in connection with the multiple sub-group contacts 31^c of the third sub-group; a fourth sub-group contact 31^d of Fig. 1, Part 2, of the fourth sub-group is shown and it will be of course understood that although but four sub-group contacts are shown associated with the wiper 27, there will in fact be ten such contacts, a corresponding number of sub-group relays 47 and a corresponding number of grounded segments for the wiper 27; also, that although but three contacts 19 are shown associated with the wiper 2^a of Fig. 1, Part 2, there will be nine such between-group contacts.

It being now assumed that the calling line is in the third sub-group, the one having the sub-group relay 47^b, the removal of the receiver at the substation will operate the line

relay 43 of such calling line which relay will lock in series with the master-switch relay 73, as before. The armature 46 of such line relay will remove the ground from the individual multiple contacts 18 of the calling line in the third sub-group at the line selectors, and will close circuit to operate the sub-group relay 47^b by current over the common conductor 50^b, while armature 45 will ground the multiple private contacts 56 at the connectors to render them busy. The operated sub-group relay 47^b, by armature 49^b, removes ground from the conductor 37 and from the multiple sub-group contacts 31^c at the line selectors E. Armature 48^b closes a bridge between conductors 70 and 75^a. As soon as the interrupter wiper 72 is disconnected from one of the segments 69 or 69^a and makes connection with one of the segments 71 or 71^a, circuit will be closed from ground over the conductor 70, closed contact 48^b, conductor 75^a, contacts 75, 78, 80—83, conductor 41 of the line selector engaged by wiper 80, through contacts 88, 98, and relay 104 to battery B′, the relay 104 locking itself by armature 107 to ground via wiper 27, multiple contact 31^a of the first sub-group and contact 49, the relay 47 being unoperated because the call is not that of the line of the first sub-group. With the operation of relay 104, the relay 90 is energized by current through attracted armature 105. The stop magnet 14 and relay 97 are, however, not operated at this time, contact 109 being open. When now wiper 72 of interrupter I passes over contact 69 or 69^a, current impulses will flow over the conductor 38 through contacts 108, 101 and winding 10′ of magnet 10 to battery and obviously, the continued travel of wiper 72 and successive actuations of winding 10′ will be produced as long as contacts 108, 101 remain closed. The first impulse through winding 10′ effects a long step of the wipers 2, 2^a, 25, 26, and 27 (the stop magnet 14 not having been energized as mentioned), and at the end of this first step, of course, the wiper 2^a will be engaging the grounded contact 19^a, the wipers 2, 25 and 26 will be between the first and second groups of their respective contacts 18, 28 and 29, and the wiper 27 will be engaging the multiple group contact 31^b of the second sub-group. Since a line of the second sub-group is not calling, relay 47^a will be inert, conductor 36 will be grounded at armature 49^a and the relay 104 will continue energized by current through attracted armature 107, contacts 27—31^b, conductor 36, contact 49^a to ground. With the continued rotation of interrupter arm 72, another impulse will be caused to flow through the winding 10′ of magnet 10 and a second long step of the wiper will be effected, at which time wiper 2^a will engage contact 19^b, wiper 27 will engage contact 31^c, and wipers 2, 25 and 26 will be adjacent to the third group of multiple contact sets. Contact 31^c having been ungrounded by the operation of armature 49^b of relay 47^b of the third sub-group, circuit for relay 104 is opened and the relay is deënergized, its armature 108 preventing further actuations of winding 10′ by interrupter I.

It will be of course understood that the off-normal contacts 86, 87, 88 and 89 were all shifted to their alternate circuit conditions on the initial step of the switch, the opening of contact 88 making relay 104 entirely dependent upon circuit through wiper 27 for its continued energization after the switch started.

On the deënergization of relay 104, relay 90 continued energized by current through normal contact 114, over conductor 125 and to ground through contact 2^a—19^b. The closing of contact 109 will now complete an energizing circuit for stop magnet 14 and relay 97 extending through attracted armature 95, over conductor 127, closed contacts 106 and 89 to ground, whereon armature 100 of relay 97 closes a locking circuit to ground at closed contact 89. As described in connection with the selection of the calling line in the first sub-group, magnet 14 has now thrown the stop into limiting position and has attracted its armature to close circuit from generator g through the short-step winding 10^2 to ground through alternate contact 93. On the first actuation of winding 10^2, the resulting first short step of the wipers will open contact 2^a—19^b so that the relay 90 will thereon depend for its continued energization upon circuits extending through alternate contact 94, contact 116, contact 103, through the private wiper 2 and to ground upon multiple contacts 18 of non-calling lines. Relay 90 will therefore continue energized until wiper 2 engages the multiple contact 18 of the calling line, which contact will be ungrounded, due to the attracted condition of armature 46 of line relay 43 of such calling line, deënergizing the relay 90 and the armatures of said relay will be retracted whereof 93 will open the circuit of winding 10^2, and wipers 2, 25 and 26 will rest engaging the multiple contacts 18, 28, 29 of the calling line of the third sub-group. At this time, of course, the wiper 2^a will be somewhere between contacts 19^b and 19^c and wiper 27 will be in engagement with the grounded contact segment between contacts 31^c and 31^d, but since armature 107 was retracted before wiper 27 engaged such grounded segment, the relay 104 is inert.

It will be observed that the alternate contact 91 of relay 90 caused the preliminary energizing circuit for relay PR to be closed during both the long and short step travel of the line selector E. From the time the

calling line in the third sub-group is selected, the operations involved in holding energized the relay PR, with the resulting energizations of relays CR and SR, the energization of the cut-off relay 51 which results of course in the deënergization of relays 43, 73, and of the sub-group relay 47^b, and the moving along of the master-switch wipers 80, 81, 82, proceed in the manner before described.

The selection of calling lines in the second, fourth, fifth and other sub-groups other than the first, will be effected in the manner apparent from the description of the selection of a line in the third sub-group, the operation being like that given, except as to the point at which the relay 104 finds an ungrounded sub-group contact 31.

Returning now to the description of the connection between the calling line A in the first sub-group and the called line B, No. 2222, the subscriber at A operates his dial 65 to cause two breaks in the line circuit including the conductive bridge through contact 63 of his calling device. As before traced, this circuit includes primary relay PR; it also contains locking relay 60. The energization of the latter frees the calling device for operation as soon as the cut-off relay 51 has been operated, as before explained. Each break in this control circuit for relay PR deënergizes said relay once. The interruptions provided by the calling device are of short duration; and although the contacts of relay PR return to normal upon each such deënergization, the time of each such deënergization is so short that relay CR does not have time to open its contact 128′ and thereby deënergize secondary relay SR. As a result then of the operation of the dial 65 at the calling station, relay PR is deënergized twice without causing the deënergization of relay SR. On the first deënergization of relay PR, an impulse of current flows from ground, through closed contacts 133, 130, strand 120, contact 141, locking relay LR, to the live pole of battery B^3, said relay LR by armature 148, locking itself to ground through contact 170, conductor 118 and contact 112. It will be remembered that in the directively operated switches such as first selector F, the winding of the stop magnet is normally in the stroke-limiting position. On the energization of relay LR, the stop magnet 14^a has its winding included in circuit with battery B^3, resistance r, and contacts 150^a and 144. Said magnet, however, remains unenergized until after relay PR is again actuated at the conclusion of the first break in the line circuit, for the reason that the winding of said magnet is, while relay PR continues deënergized, short-circuited to ground through normal contact 135, contact 140, the strand 120, normal contact 130 and closed contact 133. When, however, the break at contact 63 at the calling substation is closed, relay PR again energizes, and the opening of its contact 130 removes the short-circuit about the winding of magnet 14^a and the said magnet energizes, withdrawing the stop and, by armature 135, closes the long-step winding 10^4 of the private magnet 10^a to connection via armature 140 with the contact of armature 130. The second deënergization of relay PR, which now follows, closes circuit from ground through contacts 133, 130, 140, alternate contact 135, winding 10^4 to battery B^3, and the magnet 10^a thereon effects a long step of wipers 158, 159, 160, from engagement with the first set of multiple contacts 161, 162, 163, of ten such sets assigned for connection to the first thousand of the exchange, to engagement with the first set 161^a, 162^a, 163^a, of the second group of contact sets, such sets being connected to second selectors G for the second thousand of the exchange.

Having thus selected the group of second selectors, one of which is required to complete the desired connection to line 2222, the wipers 158, 159, 160 are now moved through short-step travel to select the contacts of an idle second selector of the second group. This is brought about by the energization of relay PR following its two short deënergizations. It will be noted that upon the first deënergization of relay PR, a circuit is completed for the interrupter relay IR, from the live pole of battery B^3, through the winding of said relay, closed contacts 131 and 133 to ground. This relay IR is also rendered slow to release its armature 117′, although it quickly attracts the same. It therefore follows that the branch from link-circuit strand 121, through conductor 121′, closed contacts 117′, 132 and 173, to ground, is interrupted at contact 117′ upon the first short deënergization of relay PR. The two short deënergizations of this relay, which were instrumental in giving the wipers of the first selector F their long-step travel, do not maintain the circuit of relay IR interrupted at contact 31 long enough to allow the release of said relay and the closing of its contact 117′ until all of the desired short impulses have been transmitted. Thus in this instance, the relay IR remains energized until the two short impulses have been transmitted. The following energization of relay PR opens contact 131 a sufficient length of time to allow relay IR to deënergize and thereby connect strand 121 to ground through contacts 117′, 132 and 173. As a result of the application of this ground connection, locking relay LR′ will be energized over a circuit extending from the live pole of battery B^3, through the winding of said relay, normal contact 142, closed contact 149, strand 121 and thence to ground over this

ground connection. Relay LR′ immediately locks itself to ground via its alternate contact 142 and shifted contact 137^a of the off-normal switch ON. Armature 140 of course disconnects the winding 10^4 of magnet 10^a from link-circuit strand 120, while armature 145 connects the winding of relay BR, via alternate contact 151^a, with the private wiper 158 of the first selector. Armature 144 deënergizes the stop magnet 14^a and the retraction of its armature ensues, whereby the stroke-limiting stop is placed in the path of the armature-actuated pawl of magnet 10^a. Wipers 158, 159, 160, having by the long step of the switch been moved into engagement with the first contact set 161^a, 162^a, 163^a, short-step travel of the switch F will be initiated only in case the first contact set 161^a, 162^a, 163^a has already been rendered busy by some other first selector, in which case the private contact 161^a will be grounded. Assuming first that the first contact set is busy, current will flow from the grounded multiple contact 161^a to wiper 158, attracted armatures 151^a, 145, relay BR and through resistance r to battery, actuating the said relay BR before relay 150 has time to attract its armatures over a circuit which would be established, but for the energization of relay BR, via attracted armature 143, normal contact 138 to ground through normal contact 136. Attracted armature 139 has now connected the generator circuit of the short-step winding 10^3 to ground via alternate contact 144, and stop magnet 14^a being deënergized and the stop "in", short steps of the wipers 158, 159, 160 will be produced as long as the relay BR remains energized by successive circuits established via wiper 158 and busy, that is, grounded contacts 161^a. As soon as the wipers of the first selector engage the multiple contacts of an idle second selector G, the contact 161^a will be ungrounded, relay BR will have its circuit opened and its armature will be retracted, armature 139 preventing further actuations of magnet 10^a while armature 138 will close a circuit as follows: from battery B^3, through relay 150, attracted armature 143, normal contact 138, normal contact 136, to ground whereby relay 150 is energized and attracts its armatures, whereof armatures 151 and 154 extend the talking conductors of the first selector to wipers 159, 160, now at rest engaging contacts 162^a, 163^a of an idle second selector. Armature 153 places ground upon wiper 158, whereby the multiple private contacts of the selected second selector are held busy. A circuit is then established from ground through attracted armatures 153, 151^a, 145 and through relay BR and resistance r to battery, but this circuit is ineffective to energize the relay BR because of a short circuit at this time extending from point 156 to point 155 through contacts 146 and 152, which prevents sufficient current flowing through the relay BR to energize the same.

Had the first set of contacts 161^a, 162^a, 163^a been idle instead of busy, the absence of ground upon private contact 161^a would have prevented the flow of energizing current for relay BR at the time its winding was, by the operation of armature 145, connected to the wiper 158. Owing to the continued deënergization of relay BR, no circuit for winding 10^3 is completed and relay 150 is at once operated via contact 143, normal contacts 138 and 136 to ground, the operation of the said relay 150 having the effects before mentioned, that of grounding the multiple contacts of the second selector engaged by wiper 158, that of closing circuit through relay BR, and that of establishing a short circuit about the one closed so that relay BR remains unoperated.

A clear circuit has now been established from condensers 173, 174, through contacts 151, 154 to the wipers 159, 160 and the idle contacts 162^a, 163^a and to the mechanism of the second selector G, assumed to be the one selected, which is now ready to be operated in response to the second set of deënergizations of relays PR and IR to be produced by subscriber A by the further actuation of its calling device.

Before proceeding with this, however, it is in order to refer to the operation of the first selector F when its wipers 158, 159, 160 are to be caused to select contacts of the first group of second selectors, those of the first thousand. This operation differs somewhat from that in which contacts of other groups are to be selected because no long step of the wipers 158, 159, 160 is produced, inasmuch as the normal position of the wipers 158, 159, 160 is one in which they rest engaging the first contact set of the first group of second selectors. To cause selection of idle contacts of the first group, the calling subscriber would operate his dial to cause one deënergization of relay PR, followed by one of relay IR. The deenergization of relay PR would, as before mentioned, result in the operation of locking relay LR and the locking thereof, as before described, and the actuation of the stop magnet 14^a would follow as soon as the short circuit about its winding at armature 135 was removed on the subsequent energization of relay PR. The deënergization of relay IR following the single deënergization of relay PR results in the energization of locking relay LR′, as before described, the said relay now locking itself, however, via armature 142, contact 137^a—137, contact 147 and over conductor 118 to ground instead of to ground via alternate contact 137^a as before. The wipers of the first selector F have, in this case,

remained at normal, and from this point on the initiation of short-step travel of the switch is produced in the manner before described and the selection of idle contacts is effected in the same manner as that before described, in case the first contact set, that normally engaged by wipers 158, 159, 160, has been rendered busy. However, if the first contact set is idle at the time the relay LR′ is operated, relay BR receives no current and relay 150 is immediately energized, as before described, by its armature 153 placing ground upon the first contact set that is now assumed to be connected with a subscriber's line in the first thousand of the exchange, and if the first contact set of that thousand be idle, the first selector that is connected with the calling line is on a contact set of an idle second selector, and the impulses transmitted to the first selector, while producing the proper changes in the electrical circuit of the switch, do not cause any travel of the switch wipers at all.

The calling subscriber at A now actuates his dial 65 to produce breaks in the line circuit corresponding to the second digit of the called subscriber's number, namely, two breaks, whereby relay PR will be twice deenergized and two impulses of current will be transmitted from ground through contacts 133, 130, 151, 159—162ᵃ, conductor 165, contact 184, locking relay LR^3 to battery B^4, relay LR^3 energizing and, by armature 180, locking itself to ground at the first selector F, via conductor 164, contact 161ᵃ—158, through points 155, 156 and armature 153. Armature 182 connects battery through resistance r', stop magnet 14^b to ground via normal contact 187, but magnet 14^b is not actuated by current over this circuit until after relay PR is operated at the conclusion of its first deënergization, a short circuit about the winding of magnet 14^b extending via contact 183 and to ground through contacts 130 and 133 as long as relay PR is deënergized. With removal of this short circuit, however, magnet 14^b attracts its armatures and withdraws the limiting stop, armature 167 connecting the long-step winding 10^c of driving magnet 10^b to conductor 165 via contact 183. The first impulse transmitted from conductor 165 therefore produces no steps of the wipers 201, 202, 203, and they remain engaging the first contact set 204, 205, 206 of their first group of connectors, this being the normal position of the wipers. The second deenergization of relay PR transmits a current impulse over the before traced path through conductor 165, through normal contact 183, alternate contact 167, long-step winding 10^c and to battery B^4, whereby a long step of wipers 201, 202, 203 is produced and they are brought to engage the first set of contacts 204ᵃ, 205ᵃ, 206ᵃ of the group connected to connectors for the second hundred lines of the second thousand.

After the second deënergization of relay PR, a single deënergization of relay IR will of course be produced and an impulse of current transmitted from ground, through contacts 173, 132, 117′, over link-circuit strands 121, 166, contact 181, and locking relay LR^4 to battery B^4, the said relay LR^4 then locking itself to ground at shifted off-normal contact 190. Attracted armature 185 connects the winding of relay BR′, via alternate contact 178, to wiper 201 and the engaged contact 204ᵃ of the first set of the second group. Assuming first that the set belongs to a busy connector, it will be understood that the relay BR′ will be operated and armature 192 will prevent actuation of the relay 193 upon the deënergization of magnet 14^b which occurs as soon as armature 187 of relay LR^4 was attracted. Stop magnet 14^b being deënergized and its stop "in," short steps of the second selector G will be produced by current pulsations through the short-step winding 10^5, attracted armature 191 and alternate contact 187 to ground as long as relay BR′ remains operated, in which condition said relay will remain by current via wiper 201 and to ground through successive contacts 204ᵃ, multiple terminals of busy connectors, until the wipers 201, 202, and 203 engage contacts 204ᵃ, 205ᵃ and 206ᵃ of an idle connector. The contact 204ᵃ then engaged will be ungrounded, relay BR′ will be deënergized and its armature 191 will prevent further actuations of the winding 10^5, whereby the switch wipers stop. Relay 193 now operates by current through attracted armature 188, normal contact 192 and normal contact 168 to ground. Armature 195 of relay 193 connects ground to the private multiple contacts 204ᵃ of the selected connector of the second group, circuit being traced through wiper 201, points 199 and 200, attracted armature 195, attracted armature 177 of relay LR^3 to ground. The winding of relay BR′ is connected from battery at this time through alternate contacts 185, 178 and 200 with ground at attracted armature 177, but current over this path does not sufficiently energize the relay BR′ to cause it to attract its armatures because of the short-circuit extending around its winding from point 198 through attracted armatures 196 and 200 to ground.

Had the first contact set of the second group been idle, the private contact 204ᵃ would have been ungrounded and relay BR′ would have received no energizing current. The relay 193, would, therefore, have immediately operated upon the energization of locking relay LR^4 and the attraction of its armature 188, by current through normal contact 192 and to ground through contact

168 as soon as the magnet 14^b deënergized, the relay 193 then placing ground upon the multiple contact 204, as before described, and closing circuit through relay BR' with the accompanying short circuit to render it ineffective as described.

Had the calling subscriber desired his line to be connected with that of a subscriber included in the first hundred group of the second thousand, no long step of the wipers 201, 202, 203 would have been produced, when relay PR was deënergized a single time. When relay IR was thereafter deënergized, the busy relay BR' would have been connected to the private wiper 201, and if the first contact set of the first group had been busy, the second selector would have started on short step travel, in a manner obvious from what has preceded, to select idle contacts of the first group. If the first contact set of the first group had been idle, no travel of the wipers 201, 202, 203 would have been occasioned for reasons similar to those explained in connection with the first selector circuit diagram.

By the energization of relays LR^3 and LR^4 and 193, a clear circuit has been established from condensers 173, 174 at F, over the conductors 165, 166 to wipers 202, 203, and the multiple contact 205^a, 206^a of the selected connector assumed to be the one shown at H, and over its wires 208, 209 to the mechanism thereof.

The calling subscriber A now operates his dial 65 to produce two deënergizations of relay PR representing the third digit in the called subscriber's number, which deënergizations will be followed by the single deënergization of IR. On the first deënergization of relay PR, a current impulse is transmitted from ground over a before traced circuit to conductor 165, thence via contacts 194, 202—205^a, wire 208, normal contact 219, locking relay LR^5 to battery B^5 which relay operates and, by armature 214, locks itself to ground over the private conductor 207. Armature 216 of relay LR^5 connects battery B^5 through stop magnet 14^c with ground, but the stop magnet cannot be energized to withdraw the stop pawl of driving magnet 10^c until a short circuit at closed contact 132 of relay SR of the first selector F is removed on the energization of relay PR, the said short circuit being traceable from the normal armature contact of magnet 14^c and normal contact 218. As soon, however, as the first impulse over wire 208 ceases, the short circuit will be removed and magnet 14^c actuated to withdraw its stop from the path of the driving pawl. On the second deënergization of relay PR, therefore, the transmitted current impulse will flow over conductor 208, through normal contact 218, attracted armature of magnet 14^c, the long-step winding 10^8 of magnet 10^c and to battery B^5, producing a long step of the switch wipers 249, 250, 251 to a position adjacent to the second group of ten line contact sets of the second hundred of the second thousand, the said group comprising multiple contacts of lines numbered from 2221 to 2229 consecutively, followed by contacts of line 2220.

After the second impulse over conductor 208, a deënergization of relay IR will transmit an impulse over conductor 209, through attracted armature 215, locking relay LR^6 to battery, and said locking relay, by armature 220, connects its winding to ground at the shifted off-normal spring contact 211. Attracted armature 221 immediately opens the circuit of stop magnet 14^c and the said magnet is deënergized, its retracted armature placing the stop pawl in the stroke-limiting position.

The subscriber A now actuates the dial 65 to produce two openings in the line circuit corresponding to the last digit in the number. The first break of course deënergizes relay PR and an impulse is transmitted from ground over conductor 208, a part of the current flowing through alternate contact 218 and locking relay LR^7 which energizes and, by armature 224, locks to ground at alternate contact 217. The rest of this first impulse flows through alternate contact 219, contact 212, contact 241 and the winding 10^8 of magnet 10^c, causing an actuation thereof; and since stop pawl is "in," a first short step of wipers 249, 250, 251 is produced. A second impulse transmitted over conductor 208 by the second deënergization of relay PR passes over the last traced circuit including alternate contact 219 and the winding 10^8 of relay 10^c and a second short step of the wipers is produced, which will then engage the second contacts of the second group, the said contacts being multiple terminals of line 2222 connected to substation C. A final deënergization of relay IR now transmits a current impulse over conductor 209, through contact 223, contact 239, the upper winding of test relay TR and to battery, energizing the said relay. Upon the attraction of its armature 235, the lower winding of the relay TR is connected from battery through contact 225, alternate contact 235, to the test or private wiper 249, now engaging the multiple contact 56^a of the called-for line. When relay TR energized, armature 236 actuated the relay 238 which, by armature 240, locked itself to ground at alternate contact 217, the armature 239 opening the initial energizing circuit of relay TR. Assuming first that the called-for line is idle, the said multiple contact 56^a will be connected with the active side of battery B^5, as shown, and, since the lower winding of relay TR is also connected with the active side of said battery, the re-

lay becomes deënergized and its armatures are retracted. On the retraction of the armatures of relay TR, a circuit is completed as follows: from ground through the relay 226, attracted armature 242, normal contact 235, contact 249—56[a], normal contact 45 of the called line and to battery through cut-off relay 51, actuating the said relay which, by armature 53, puts ground from contact 56[a] upon the conductor 32 leading to the private banks at the line selectors, whereby the called-for line remains unselectable at the line selectors. The ground upon the multiple contact 56[a] from relay 226 renders the called multiple contacts 56[a], 57[a], 58[a] of the called line busy with respect to the other connectors having access to them.

The winding of relay 248 now has its circuit closed from ground through the constantly rotating interrupter I′, attracted armature 228, said relay 248 to battery, and relay 248 will be alternately energized and deënergized with the travel of the interrupter I′, alternately connecting wiper 250 with generator *g* when energized, and with relay 231 when deënergized. The substation bell will ring when generator *g* is connected with the wiper 250, the circuit being traced through contact 57[a], over line limb 67, through call-bell and condenser at the substation, returning over conductor 66, contact 58[a], 251, armature 229 and impedance 230 to battery. The interrupters I′ and I[2] are preferably mounted upon the same shaft so that their travel is synchronous and the interrupter I[2] will disconnect the generator *g* from the called line and substitute therefor a short circuit to ground a short period before each deënergization of relay 248 occurring with the rotation of the interrupter I′. This arrangement is to secure a discharged condition of the line circuit before the relay 231 is placed in connection therewith, in order to with certainty prevent said relay from being actuated by current discharges from the telephone line and before the called subscriber removes his receiver.

The called subscriber in answering his call removes his receiver and hook-lever 59 is raised to alternate position closing a conductive bridge through the substation. As soon as this occurs and relay 231 is, by retraction of armature 248[a], connected with the wiper 250, circuit may be traced from the live pole of battery B[5], through said relay, contact 227, normal contact 248[a], contact 250—57[a], over conductor 67 through the transmitter and the inductance of magnet 60 of the substation, returning over limb 66, contact 58[a]—251, impedance 230 to ground, this path supplying talking current to the called-for substation. The closing of contact 232—234 establishes a branch locking path for the relay LR[5], which serves as a release relay, and the connector H now depends for its restoration upon the called-for station C. The closing of contact 232—233 operates the relay 243, which, by armature 245, locks to ground at alternate contact 217. Attracted armatures 244 and 247 of this relay complete the circuit of the talking strands of the connector and armature 246 opens the circuit of interrupter I′ so that the relay 248 continues unoperated and generator *g* excluded from circuit with the called-for line.

As soon as contact 244 was closed by the operation of relay 243 as described, a circuit is completed through release relay RR associated with the first selector F, Fig. 1, Part 3. This energizing circuit may be traced from the live pole of battery B[3], through the winding of relay RR, alternate contact 130, thence over the talking conductors 120, 165, 208, line limb 67, through the conductive bridge at the substation, line limb 66, a part of conductor 209, and thence to the return side of battery, through closed contact 229 and impedance coil 230. The operation of relay RR closes a circuit for reversing relay RV, extending from battery B[3], through the winding of relay RV, closed contact 176, conductor 118 to ground at the line selector E. Relay RV, being operated, locks itself up over closed contact 171 and conductor 118. Armatures 169 and 172, by their make-before-break arrangements, reverse the connections of battery B[3] to the limbs of the calling line, whereby the direction of current flow in said line is reversed. This reversal may be employed for the purpose of operating a polarized call-counting or coin-controlling device, used in measuring the service supplied to the subscribers.

The calling subscriber A and the called-for subscriber C are now in conversation through condensers 173, 174. Talking current is supplied to the calling line from the battery B[3], through the inductive resistances of relay PR and the right-hand winding of relay SR. Talking current is supplied to the called-for line from battery B[5], through the inductive resistance of relay 231 and impedance coil 230.

When the subscribers have finished their conversation, they replace their receivers. When the calling subscriber A so does, all switches except the connector H will be restored to normal and the restoration of this switch will remain to be accomplished from the called substation. If the called subscriber first replaces his receiver, all the switches except the line selector E will be restored to normal, the latter remaining to be restored by the calling subscriber when he replaces his receiver.

Let it be assumed first that the calling subscriber A first hangs up his receiver. In such case, hook-lever 59 opens the conductive circuit of line limbs 66, 67, and the relay

PR, which has been held up over this line circuit, is deënergized for the first time. The deënergization of relay PR opens the circuit of relay CR and this relay in turn, releasing slowly, opens the circuit of relay SR and the latter closes a release circuit from ground at contact 128, through closed contact 129, conductor 119, normal contact 92, attracted armature 99 and relay 110 to battery, the said relay immediately energizing and, by armature 114, operating the relay 90. It will be remembered that magnet 14 and relay 97 are locked over a series circuit including armature 100 and shifted off-normal contact 89 so that the stop pawl of magnet 14 is in the stroke-limiting position. Generator current now passes through winding 10^2 of magnet 10, attracted armature of magnet 14, alternate contact 93 to ground. Since relay 110 has, by armature 113, locked itself to ground, it is apparent that short steps of switch E will continue to be produced. When the wipers of the line selector E have made enough short steps to reach normal, the off-normal contact 89 is opened, magnet 14 and relay 97 have their locking circuit opened, and the retracted armature of magnet 14 will prevent the further actuations of winding 10^2. Retracted armature 99 of relay 97 deënergizes relay 110, and retracted armature 114 of the latter deënergizes relay 90 when the mechanism of the line selector will be at normal. As soon as the wipers of the line selector E left the multiple calling contacts of the line of A, the cut-off relay 51 of said line had its circuit opened and the line circuit of A was in its normal condition.

On the deënergization of relay PR as described, the retraction of armature 130 opened circuit of release relay RR, and the armatures of the said relay were retracted. Locking relay LR is now deënergized, contact 175 having been opened and ground having been removed from the conductor 118 by armature 112 at switch E. On its retraction, armature 151^a energizes the relay BR by current through attracted armature 145, and, armature 138 of said relay BR, being attracted, deënergizes the relay 150 whose retracted armatures 151, 154 place the wipers 159, 160 upon open circuit during release. Armature 139 of relay BR now closes a circuit from generator g through winding 10^8 to magnet 10^a and through alternate contact 144 to ground. As long as relays BR and LR′ remain energized, it is apparent that successive short steps of the first selector F will be produced, turning the wipers 158, 159, 160 around until they reach normal. When they do reach this point, the locking circuit for relay LR′, extending through alternate contact 137^a, will be opened and retracted armature 144 will prevent further actuations of magnet 10^a, whereby the switch wipers rest in their normal positions. On the retraction of armature 145, relay BR will be deënergized and the mechanism of first selector F is then at normal, the reversing relay RV having had its locking circuit opened when ground was removed from conductor 118, on the initial restoring movement of line selector E.

It will be observed that the conductor 40, connected to the controlling contact 84 at the master-switch D, is, during the release of the line selector E, held grounded at alternate contact 111 so that the master-switch D will be prevented from stopping upon the contact 84 of the releasing line selector. In case the line selector E reaches normal before its paired first selector F reaches normal, the contact 84 is not rendered selectable until the selector F reaches normal. It will be seen that conductor 40, upon the retraction of armature 111, is connected to the wire 117 which extends to the first selector F and during the restoration thereof, is connected to ground via alternate contact 138 and normal contact 136. Thus, until the switch pair EF is fully restored, the contact 84 remains unselectable.

As soon as the first selector F started to be restored, the wiper 158 was placed on open circuit and consequently ground was removed from the private contacts 161^a of the second selector G. The locking circuit of relay LR^3, which serves as a release relay, is thereby opened and the relay deënergized. The closure of normal contact 178 operates relay BR′ by current through closed armature 185 of relay LR^4. Attracted armature 192 of relay BR′ deënergizes relay 193 so that the contact wipers 202, 203 are on open circuit at contacts 194, 197 during the release. The closure of alternate contact 192 places ground from armature 168 via normal contact 180 over conductor 164 upon the multiple private contacts 161^a of the second selector G, this circuit continuing closed until the second selector G reaches normal, whereby its seizure by any other first selector prior to its complete restoration is prevented. Circuit may now be traced from generator g through winding 10^5, through attracted armatures 191—187 to ground, and successive actuations of magnet 10^b will be produced, causing short steps of the second selector G until it reaches normal. Normal being reached, off-normal contact 190 is placed in its original condition and the locking circuit of relay LR^4 is opened and the relay deënergized. Its armatures are retracted, armature 185 deënergizing the relay BR′ and the mechanism of the second selector G is fully restored, the actuations of magnet 10^b having been previously terminated by the opening of alternate contact 187.

Since it has been assumed that the called

subscriber C has not yet replaced his receiver, the relay 231 at connector H has continued operated and the continued closure of contact 232—234 prevented locking relay LR^5, which serves as a release relay for the connector, from being deënergized when ground was removed from conductor 207 by the initiation of the release of the second selector G. When, however, the called-for subscriber now replaces his receiver, relay 231 deënergizes and the opening of contact 232—234 deënergizes relay LR^5 whose retracted armature 217 terminates the flow of current through relays LR^7, 238 and 243. Said armature 217, by engaging its normal conta t, now closes a circuit for generator g through winding 10^7 of driving magnet 10^c through attracted armature 222 of relay LR^6 to ground. Short steps of the connector H will now be produced, continuing until the wipers 249, 250, 251 complete a revolution. The wipers being then at normal, alternate contact 211 opens, causing the deenergization of locking relay LR^6 whose retracted armature 222 prevents further actuations of magnet 10^c, the wipers then resting at normal. When relay 238 became deënergized by the opening of alternate contact 217, as before described, relay 226 had its circuit opened at contact 242 and the cut-off relay 51 of the called-for line also had its circuit opened, whereby the line circuit of G was restored to its normal condition.

Let it be assumed that the called-for subscriber replaces his receiver in advance of the calling subscriber. In such case, relays PR, CR and SR at first selector F remains unaffected, but the opening of the conductive circuit between line limbs 66 and 67 at substation C opens the circuit of release relay RR at F. The said relay therefore deënergizes, but reversing relay RV remains operated because conductor 118 is still grounded at E. The opening of contacts 175 and 176 will leave no path for the flow of current through the locking armature 148 of relay LR, the said relay consequently is deënergized and the release of the second selector F, second selector G and of the connector H proceed in the manner before described. When now the calling subscriber replaces his receiver, the relays PR and SR will be deënergized, as before explained, closing contacts 128, 129, whereby the energization of relay 110 at line selector E is produced in the manner before described, and the release of the line selector proceeds as before.

Let it now be assumed that the called-for line was found busy at the time the last impulse was transmitted from conductor 209 by relay IR, whereby relay TR was energized and connected to the test wiper 249. The called line being assumed busy, its multiple private contact 56^a engaged by wiper 249 will be grounded and current will find its way from the grounded contact 56^a, through wiper 249, alternate contact 235, contact 225, and through the lower winding of relay TR to battery B^5, the relay TR being thereby locked and its energization continued. Since armature 235 continues attracted, the relay 226 remains unoperated. The busy interrupter I^3 is now held connected to conductor 208 through the continuance of the attracted armature 237 of relay TR and the busy signal is transmitted to the left, over the upper talking conductor, through the substation A, giving the customary busy tone in the receiver, returning over the lower talking conductor and through the impedance coil r^7 to battery. Upon hearing the signal, the calling subscriber knows that the called-for line is busy and replaces his receiver, causing the restoration of line selector E, first selector F and second selector G, in the manner before described when the calling subscriber replaced his receiver before the called subscriber. In the present case, however, the act of the calling subscriber restores to normal also the connector H. It will of course be apparent that since the relay 226 at connector H was not operated, the relay 231 has remained inert. Therefore, the locking relay LR^5, which serves as a release relay, depends for its continued energization entirely upon the ground connected to conductor 207 at the second selector G. When this ground is removed, upon the initiation of the release of the second selector G, relay LR^5 deënergizes and the mechanism of the connector H is restored to normal in a manner similar to that before described; the test relay TR being, of course, deënergized as soon as contact 225 is opened.

It is of course apparent that, had the called-for line had its contacts included in the first group of contacts before the wipers 249, 250 and 251, no long step of the wipers would have been produced, a single impulse over the wire 208 only having, in such case, been transmitted to represent the third digit of the called number. In such case, the relay LR^5 would have operated as before, and upon the transmission of a secondary impulse over conductor 209, the relay LR^6 would have been operated as before, except that under the present circumstances it would, by armature 220, have been locked via normal contact 211, 210 and alternate contact 213 to the private wire 207. Of course, when thereafter the first adjusting impulse was caused to flow over wire 208 to produce short steps of the connector's wipers to select the contact of the line in the first group, alternate contact 211 would be closed on the first short step and the re-

maining operations would have been as before described.

As has been heretofore indicated, if the first selector F had been so operated as to select multiple contacts 161, 162, 163 out of its first contact group, and if the first contact set of the first group had been idle, there would have been no travel of the switch wipers 158, 159, 160. Similarly, if the second selector G has been caused to select idle contacts of its first group and the first contact set 204—205—206 of the first group had been idle, no movement of the switch wipers would have been produced. In such case, the locking relay LR′ at first selector F would have its locking circuit completed through contact 137ª—137, through attracted armature 147 and through armatures 170 and 175 over conductor 118 to ground, alternate contact 137ª having not been closed at all, owing to the failure of the switch wipers to travel. Therefore, assuming this condition when ground was removed from conductor 118 at the initiation of the release of the line selector, relays LR and LR′ would both have been simultaneously deënergized. Since contact 145 would be opened before the closure of normal contact 151ª could energize the relay BR, the said relay BR would remain inert and accordingly no circuit for generator *g* through winding 10^3 would be closed, and the switch wipers 158, 159, 160 would continue at normal. The opening of contact 143 would deënergize the relay 150 and the mechanism of the first selector F would be at normal. The wipers of the first selector would remain stationary, no matter from which end of the talking circuit the release was initiated, since if relay RR was deënergized from the called station, the relay LR would be deenergized and the opening of its contact 147 would deënergize the relay LR′ and the time relations of the break of contact 145 and the make of normal contact 151ª would of course be so adjusted as to prevent the operation of relay BR and the consequent complete circular travel of the switch wipers.

So in the case of the second selector G when it employs the first contact set of its first group in establishing connection, the relays LR^3 and LR^4 both depend for their locking circuits upon the private conductor 164 whose grounded condition is controlled at the first selector F, since contact 190—189 remains closed and alternate contact 190 has remained opened therefore. The removal of ground from the private wire 164 at the beginning of the release operations of the first selector F will therefore deënergize both relays LR^3 and LR^4 and no operation of relay BR′ will result so that no actuating circuit for magnet 10^b will be produced, the switch wipers 201, 202, 203, therefore remaining at rest.

In Fig. 9, I have illustrated a modified circuit arrangement embodying my invention and particularly adapted for switches designed to partake of two movements at an angle to each other in order to first pick out a desired group and then a particular contact in that group in contra-distinction to the long and short step switches heretofore described. Placing the parts of this figure together in their numerical order, the circuits necessary for the completion of a connection between the calling station A′ and the called station H′ are shown.

This form of the invention, as illustrated, is arranged for ten thousand lines as maximum, and accordingly, first selectors D′ to select the thousands, second selectors E′ to select the hundreds, and connectors F′ to select the tens and units, are provided. The lines, as called lines, are divided into groups of one hundred, and each such group may have, say, ten connectors F′ assigned for connections to its lines. Multiple called contacts 207′, 208′, 209′, for each line are provided, appearing with those of the other ninety-nine lines of the group in the banks of each of the ten connectors. The contact sets of the called lines at the connectors are preferably arranged in ten groups of ten contact sets each, according to the tens values of the numbers of the lines, and adjustments of the wipers 339, 340, 341, of the connectors are made in one place to select the tens group, whereafter secondary adjustments are produced in another plane to select the units, *i. e.*, the contact set of the called line. The one hundred connectors F′ of the ten groups of called lines of the same thousands value have each their stationary multiple contact sets 306, 307, 308, appearing before the wipers 303′, 304′, 305′, of one hundred second selectors E′, the said contact sets being arranged in groups, so that the sets of the ten connectors for a given one hundred lines form one group. Thus the wipers 303′, 304′, 305′, of a second selector E′ are adjusted in one plane to select the group of contact sets of the one hundred wanted, and then adjusted in an intersecting plane to select the contact set of an idle connector. On the usual ten per cent. trunking basis, there will be one hundred second selectors E′ for each thousand, and each second selector will have stationary contacts 288′, 289′, 290′, multipled to, say, one hundred first selectors D′. Each such first selector D′ will have before its wipers ten groups of ten contact sets each, the sets of each group being connected to second selectors E′, assigned to a different thousand, so that also in the case of the first selector D′, primary adjustments of the wipers are made in one plane to select the group of the wanted thousand, and thereafter, secondary

adjustments in an intersecting plane to select the contact set of an idle switch.

The first selectors D′ are preferably not individual to calling lines, but each one has paired with it a line selector C′ whose wipers 233′, 234′, 235′ are adapted to select multiple contacts of any one of one hundred calling lines; each line, as a calling line, is provided with multiple contacts 228′, 229′, 230′, which may appear along with similar contact sets of ninety-nine other lines in the banks of a suitable number of line selectors C′, say ten. The multiple calling contact sets are preferably arranged in ten groups of ten contact sets each and the travel of the line selector C′ will be first in one plane to select the sub-group of the calling line, and then in another plane to select the contact set of such line out of the sub-group. Each such sub-group of ten lines is provided with a multiple group contact 231′ which appears in each of the line selectors serving the one hundred line group. The line selectors C′ are not constantly traveling devices, but are so arranged that when any line of the group initiates a call, a starting device B° is operated to initiate travel of an idle line selector which thereupon, by means of the group wiper 236′, seeks out the group contact 231′ of the sub-group containing the calling line. On the primary travel of the line selector, which is controlled by the group wiper 236′, the wipers 233′, 234′, 235′ move along with said group wiper 236′ and are so brought adjacent to the group of contacts 228′, 229′, 230′, among which those of the calling line are included. After the primary adjustment of line selector C′, under the control of wiper 236′, secondary adjustments are produced in which the wipers 233′, 234′, 235′ move under control of wiper 233′ in an intersecting plane, until they reach the contact set of the calling line. During the secondary travel, the wiper 236 remains stationary engaging the group contact selected.

Each subscriber's line, such as A′ and H′, is provided with a line relay 210′ which is adapted for operation on the initiation of a call at the substation of its line to render the multiple called contacts of the line 207′, 208′, 209′ busy at the connectors; to render the multiple calling contacts 228′, 229′, 230′ at the line selectors C′ selectable; to operate the master-switch relay 223′ to start an idle line selector C′; and finally, to operate a common or group relay 220′ whose armature will then remove a normal ground connection from the group contact 231′ of the sub-group including the calling line to render the sub-group selectable. The master-switch relay 223′ is common to the entire one hundred lines of a calling line group being so made by the common conductor 222′ which has one hundred branches, one to each line relay of the group. For each sub-group of ten calling lines, a group relay 220′ is provided which is rendered common to the ten lines of its appropriate sub-group by means of the common conductor 221′ which has ten branches, one extending to the line relay of each line of the sub-group. In addition to the line relay 210′, each line is provided with an individual cut-off relay 214′ which is so arranged in circuit as to be operated when connection is made to the line either as a calling line or as a called line, when the said cut-off relay will, in the well known manner, render the line relay 210′ inoperable.

Assuming that the calling substation A′ desires to converse with the subscriber at substation H′, whose number may be assumed to be 3456, the subscriber at A′ first removes his receiver, whereupon hook-lever 201′ rises and completes a conductive bridge through the substation, giving rise to a flow of current from battery B^{10}, through contact 219′, line limb 206′, the impedance of magnet 204′, the upper hook-switch contacts, returning through the transmitter, contact 202′, line limb 205′, normal contact 216′, line relay 210′ to ground. Said relay 210′ operates and its armature 212′ disconnects the relay from the line and establishes a locking circuit traced through contact 218′, the common wire 222′, and master-switch relay 223′ to battery. Armature 213′ of relay 210′ removes ground from the multiple contacts 228′ at the line selectors C′, altering their electrical condition to render them selectable, and said armature 213′ further operate the group relay 220′ by current over the common wire 221′ to remove ground from the sub-group contacts 231′, to render them selectable. Armature 211′ connects ground to the multiple called contacts 207′ at the connectors and renders them busy against incoming calls. Operated relay 223′, at master-switch B°, closes circuit from ground through armature of relay R^a, contact 224′—226′ (the wipers 224′ and 225′ of master-switch B° normally engaging contacts 226′ and 227′ of an idle line selector now assumed to be C′), through contact 238′, of the engaged idle line selector, and its primary relay P′R to battery B^{10}. Operated relay P′R, by armature 239′, closes generator circuit for primary magnet P′M which will step wipers 233′, 234′, 235′, 236′ on their primary travel, each step bringing the wipers to select the different sub-group of lines. Relay P′R, by armature 240′, is now connected to wiper 236′ and said relay will continue operated by current flowing through said armature 240′, wiper 236′ to ground at engaged multiple contacts 231′ of the sub-groups not having a calling line, until wiper 236′ en-

gages the contact 231′ of the sub-group of A′. This contact will be ungrounded, as before described, and relay P′R will therefore deënergize, the primary off-normal contacts 237′ and 238′ having been shifted on the first primary step of the switch C′ to disconnect the relay P′R from its initially energizing circuit. Armature 239′ now prevents further actuation of magnet P′M and, by engaging its back contact, closes circuit through contacts 237′, 241′, 245′, secondary relay S′R to battery, and this relay, by armature 251′, closes a generator circuit for secondary magnet S′M extending to ground at normal contact 242′, whereby secondary travel of line selector C′ is initiated. The relay S′R, by armature 250′, has connected its winding to the private wiper 233′ which now engages successive contacts 228′ of the lines of the selected sub-group. Relay S′R will continue energized (and magnet S′M will so produce successive secondary steps of switch C′) until the wiper 233′ engages the contact 228′ of the calling line, since as long as wiper 233′ is passing over successive contacts 228′ of non-calling lines, successive locking circuits for relay S′R will be established to grounds via contacts 217′ and 213′ of non-calling line circuits. When wiper 233′ engages the contact 228′ of line A′, the fact that armature 213′ of the line circuit of the calling line is attracted occasions a deënergization of relay S′R, whose retracted armatures prevent further actuations of magnet S′M so that the wipers 233′, 234′, 235′ remain engaging the multiple contacts 228′, 229′, 230′ of the calling line. On the first secondary step of line selector C′, the secondary off-normal (SON) contacts 244′, 245′, 246′ were all shifted, contact 245′ then opening the initial energizing circuit of relay S′R and rendering it solely dependent for current upon the wiper 233′.

As soon as relay S′R is operated, a circuit is closed from ground at relay P′R′. through the winding of said relay, normal contact 265′, conductor 256′, contact 248′—249′, closed contact 243′, contact 253′—252′, conductor 257′, normal contact 268′, and resistance coil 400 to battery B^{11}, whereby relay P′R′ is energized. The energization of relay P′R′, by its contact 401′, completes a circuit through the right-hand winding of secondary relay S′R′, and actuates the latter to close its contact 263′ and open its contact 262′. Relay S′R′ is rendered slow to release by means of a copper shell upon its core, or otherwise, as preferred. When relay S′R at C′ allows its armatures to be retracted, a substitute circuit for relay P′R is extended via contacts 234′—229′, 215′, cut-off relay 214′ of the calling line, to battery B^{10}. Relay 214′ energizes and by its armature 216′ establishes a new substitute circuit for relay P′R′, extending out over line 205′, through the conductive path at the substation, returning over line limb 206′, contact 230′—235′, normal contact 252′, normal contact 268′, resistance 400′ to battery B^{11}. By suitably adjusted make-before-break contacts, these shiftings of the circuits of relay P′R′ occur without permitting the retraction of its armature, and consequently without permitting the deënergization of secondary relay S′R′.

It will be observed that an armature-controlled pawl of magnet 204′ at substation A normally engages the notch in the calling device 203′ and prevents the same from being actuated by hand. At the instant the calling subscriber A′ first removes his receiver, magnet 204′ momentarily energizes, but as soon as armature 212′ of relay 210′ disconnected ground from the line limb 205′, said magnet 204′ deënergized and calling device 203′ remained locked until the operation of relay 214′ extended ground through relay P′R′ to line limb 205′, thus energizing the magnet 204′ and rendering the dial 203′ now operable by the subscriber at A′.

It will be observed that the operation of relay 214′, by the closure of contact 215′—217′, has now locked said relay 214′ through contacts 228′—233′, 247′, 250′, to ground. Furthermore, armature 219′ has disconnected battery B^{10} from line limb 206′, and armature 218′ has opened the locking circuit of relays 210′ and 223′, which both deënergize.

When relay S′R deënergized, upon selection of the calling line as before described, circuit was completed from ground, through normal contacts 242′ and 251′, through contact 246′, and to the left through contact 227′—225′, relay R^a to battery B^{10}. Operated relay R^a, by its armature, closes generator circuit for magnet M^a, which steps the wipers 224′ and 225′ rotarily over contact sets 226′, 227′, of the different line selectors C′ in search of contacts of an idle one. Until contacts of an idle one are reached, relay R^a will be continued energized by a current to grounds through wiper 225′ and successive contacts 227′ of busy line selectors C′. When, however, the contact 227′ of an idle one is reached, such contact will be ungrounded as an inspection of Fig. 1, Part 1, shows, relay R^a deënergizes and its armature prevents further actuation of magnet M^a, the wipers 224′, 225′ then remaining engaging the contacts 226′, 227′ of the line selector so selected. It will be understood that the master-switch B^c may comprise mechanically a rotary shaft carrying wipers 224′ and 225′, and a ratchet wheel which the customary armature-actuated pawl of magnet M^a may drive. The contact sets 226′, 227′, of which one set is provided for each line selector C′, serving the one hundred lines to which the master-switch

B° is individual, are preferably arranged to form a circle so that the wipers of switch B° will always be engaging a contact set of one or another of the line selectors. It will be understood that by this arrangement no spring return for switch B° is necessary, and that the wipers are always caused to travel in one direction of rotation.

The line selector C′ has now connected the relays P′R′ and S′R′ of the first selector D′ with the limbs of the calling line, and the calling device at A′ is now to be operated to produce the necessary directive adjustments of a first selector, a second selector, and a connector to establish connection to the called telephone.

To transmit the thousands digit 3 of the called subscriber's number 3456, the subscriber at A′ rotates dial 203′ until three insulating teeth are brought below spring 202′. When dial 203′ is now released, its spring returns it to normal and three breaks in the conductive circuit of the substation are produced at contact 202′. The breaks follow one another rapidly and will cause three deenergizations of the relay P′R′ whose armatures will be thrice retracted and attracted. During this, however, the relay S′R′ continues to hold its armatures attracted, said relay S′R′ being rendered slow to release its armatures when its circuit is broken, by any of the well known expedients of the art, such as a shell of copper about its core, or by a non-inductive shunt, or otherwise. On the first deënergization of relay P′R′, its armature 259′ closed circuit from ground through attracted armature 263′, the relay IR′, which like the relay S′R′ is slow to release its armature, and to battery B^{11}. During the subsequent breaks and makes at substation A′, the relay IR′ continues to hold its armature attracted. Each deënergization of relay P′R′ transmits a current impulse from ground through contact 263′, normal contact 260′, contact 273′, primary magnet P′M′ to battery, and said magnet causes three primary steps of wipers 285′, 286′, 287′, to select the group of multiple contact sets 288′, 289′, 290′, of second selectors E′ assigned for connections to the third thousand. When, after the last break in the circuit at substation A′, the dial 203′ reaches normal, relay P′R′ will hold its armatures in their attracted positions and this will maintain contact at 259′ open a sufficient length of time to cause the relay IR′ to allow its armature to be retracted, whereupon current will flow from ground, through contact 264′, contact 261′, armature of relay IR′, through secondary off-normal (SON) contact 274′, primary off-normal (PON) contact 276′, shifted, as was also 275′, on the first step of switch D′, through busy relay B′R′ to battery B^{11}. Relay B′R′, by armature 282′, closes generator circuit for secondary magnet S′M′, which steps the wipers of the switch D′ on their secondary travel in search of the contact set of an idle second selector E′ of the selected group. Magnet S′M′ will continue to receive actuation until relay B′R′ deënergizes, which will only occur when wiper 285′ engages contact 288′ of an idle second selector E′, because as long as wiper 285′ is passing over successive contacts 288′ of busy second selectors (which contacts will be grounded), successive locking circuits will be established for relay B′R′, through alternate contact 281′, normal contacts 278′, 284′, to wiper 285′ and to successive grounded contacts 288′. The secondary off-normal (SON) contacts 273′, 274′ are opened on the first secondary step of switch D′, whereby relay B′R′ is rendered solely dependent upon wiper 285′ for current. When wiper 285′ does strike contact 288′ of an idle second selector which will be ungrounded, relay B′R′ deënergizes and its armature 282′ prevents further actuation of magnet S′M′, whereby wipers 285′, 286′, 287′ rest engaging the contacts 288′, 289′, 290′, respectively, of the second selector selected, assumed to be E′. Armature 281′, in engaging its normal contact, has now connected ground to the wiper 285′ and to the multiple contacts 288′ of the selected switch E′, rendering it busy to other first selectors D′ having access to it.

The calling subscriber at A′ now actuates dial 203′ to produce four short breaks in the line circuit, whereby four deënergizations of relay P′R′ are produced, while relay S′R′ remains operated. On the first deenergization of relay P′R′, circuit is closed through relay IR′, and said relay, as before, holds its armature attracted during the subsequent operations of relay P′R′ and until the calling device at substation A′ reaches normal, when a prolonged energization of relay P′R′ occurs. Each deënergization of relay P′R′ transmits a current impulse from ground through contact 263′, normal contact 260′, contacts 280′, 286′—289′, 291′, magnet $P'M^2$, to battery B^{11}, and four actuations of magnet $P'M^2$ step wipers 303′, 304, 305′, four primary steps to select the group comprising contact sets 306, 307, 308 of connectors F′ assigned to the lines of the fourth hundred of the third thousand. When, after this adjustment, the armature of relay IR′ retracts, current flows over a before-traced path through said armature, through contact 283′, 287′—290′, 292′, 294′ (primary off-normal, PON, contacts 293′, 294′, having shifted on the first step of the switch E′), through busy relay $B'R^2$, to battery. Relay $B'R^2$, by armature 301′, closes generator circuit for secondary magnet $S'M^2$, which steps the wipers 303′, 304′, 305′ over the contact sets of the selected group to select a set con-

nected to an idle connector, this selection occurring in a manner understood from the preceding description, the relay B′R² having connected its winding by armature 300′ with private wiper 303′ and secondary off-normal (SON) contacts 291′, 292′, having been opened on the first secondary step. When the idle connector has been selected, ground from normal contact 300′ will be connected to wiper 303′ and the multiple contacts 306 of the selected connector to render it busy to other second selectors having access to it.

The calling subscriber A′ now operates his calling device to produce five breaks in the conductive circuit of substation A′, and this operation, in a manner obvious from what has proceeded, will effect transmission of five impulses of current through contacts 286′, 289′, 299′, 304′—307, normal contact 309, primary magnet P′M³ to battery B¹² and the magnet P′M³ will then cause five primary steps of wipers 339, 340, 341 to select the fifth group of contact sets of called line terminals, which contact sets will be those of lines 3451 to 3459 inclusive, followed by the contacts of line number 3450, naught being ten impulses. After this, relay IR′ deënergizes and current flows as before through contact 287′—290′, thence through contacts 302′, 305′—308, normal contact 310, closed contact 312 (primary off-normal, PON, contacts 311, 312, 313 having been shifted on the first primary step of switch F′), whence through magnet S′M³ to battery B¹². The resulting actuation of magnet S′M³ produces a first secondary step of the switch wipers, but they are not moved sufficiently to engage the first contact set of the selected group, the mechanism of the connector being so arranged that, after primary adjustment, two secondary steps of the wipers are required to bring them to engage the first contact set. By the first step, however, the secondary off-normal (SON) contacts are shifted, 309 to engage its alternate contact, and 310 to disengage its normal contact, but not sufficiently to engage its alternate contact, which latter occurs only on the second secondary step of the switch F′.

The subscriber at A′ now actuates his dial 203′ to produce six breaks in the line circuit of the substation and six resulting deënergizations of relay P′R′ transmit current impulses as before through contacts 286′—307′, 304′—307, thence through alternate contact 309, contact 324, secondary magnet S′M³, to battery B¹², whereby magnet S′M³ is caused to produce six additional secondary steps of the switch wipers, at the conclusion of which said wipers 339, 340, 341 will rest engaging contacts 207′, 208′, 209′ of the called line 3456, to which is connected the substation H′. After this, a continued energization of relay P′R′ will cause the armature of relay IR′ to fall back to transmit a current impulse from ground, through contacts 287′—290′, 305′—308, alternate contact 310, normal contact 327, lower winding of test relay T′R to battery B¹². The test relay T′R is thus energized and by its armature 329 connects its upper winding with private wiper 339 to test the called-for line. Immediately on the energization of relay T′R, relay 323 is energized by current through contact 330, and normal contact 314 to ground, whereupon armature 326 locks the said relay 323 to ground at said armature 314. The opening of contact 327 has now disconnected the relay T′R from its initial energizing circuit and whether or not it continues operated will depend upon the electrical condition of the private or test contact 207′ of the called line. If the called line is idle, the contact 207′ will, as shown, be connected through normal contact 211′ and cut-off relay 214′ of the line circuit to the active side of battery B¹², and since the winding of relay T′R is also connected with the active side of said battery, the relay deënergizes and the following circuit changes are occasioned. Current flows from ground, through relay 316, through attracted armature 325, normal contact 329, contact 339—207′, normal contact 211′ and the cut-off relay 214′ to battery B¹². The relay 214′ operates, and by closing the contact 215′—217′, connects ground traced through relay 316 at F′ to the multiple contacts 228′ of the line of H′ at the line selectors, maintaining the called line busy there; while armature 216′ disconnects the line relay 210′ from the called line so that it will remain unoperated when the called subscriber removes his receiver.

Upon the operation of relay 316, the constantly operating interrupter I²¹ alternately energizes and deënergizes the relay G′R by current from ground through said interrupter I²¹, attracted armature 318, normal contact 333, to battery B¹² through relay G′R, and the armature 338 of said relay attracts and releases, alternately including and excluding the ringing generator G′ with, and from, circuit with the called substation. Whenever the armature 338 is attracted, the current from generator G′ passes through contact 340—208, over the called line, through condenser and bell, ringing the latter, returning through contact 209′—341, attracted armature 319 to ground. When the called subscriber answers the call and removes his receiver, the relay 320 energizes, as soon as armature 338 is engaging its normal contact, by current flowing from battery B¹², through said relay 320, contact 317, normal contact 338, contact 340—208′, line limb 205′, contact 202′, through transmitter and raised hook-lever,

magnet 204′, line limb 206′, contact 209′—341, contact 319, and associated retardation coil to ground. This supplies current to the transmitter of the called substation for talking purposes. Attracted armature 321 of relay 320 operates relay 334 which, by armature 334ᵃ, locks to ground at normal contact 314. Armatures 332 and 337 complete the talking circuit at H′, the talking circuit being indicated throughout the circuit drawings by the heavily marked conductors. Armature 333 disconnects generator relay G′R from interrupter I′ so that ringing current remains excluded from the called line. The armatures 335 and 336 shifted the connections of the release relay R′R³ at switch F′ so that from this time on, the connector F′ depends for its restoration upon circuit connections controlled at substation H′. The ground at armature 319 is, on the operation of relay 334, extended over the called line and through contacts 307—304′, 289′—286′, alternate contact 260′, to battery B¹¹ through the relay *r′r*, which relay, by armature 269′, operates the reversing relay R′V′ whose armature 266′ establishes a locking circuit extending to the primary off-normal contact 275′. On the actuation of relay R′V′, the connections of battery B¹¹ to the limbs 205′, 206′ of the calling line are reversed and this reversal may be profitably employed for operating any of the polarized special service devices of the art. The attraction of armature 264′ of relay R′V′ has removed the operating current from the lower talking conductor. The transmitter at the substation A′ is now energized for talking through the impedances of relays P′R′ and S′R′ and the talking circuit may be traced from substation A′ to substation H′ by the heavily marked conductors, the said circuit being inductively completed at switch D′ by the condensers 271′ and 272′.

When the subscribers finish their conversation, they replace their receivers upon the hook-switch and the central office mechanism is restored to normal. If the subscriber A′ first replaces his receiver, switches C′, D′ and E′ will be restored, switch F′ remaining to be restored when subscriber H′ replaces his receiver. If subscriber H′ first hangs up his receiver, switches D′, E′ and F′ will be restored, switch C′ remaining for subscriber A′ to restore.

Assuming the called subscriber H′ hangs up his receiver first, the hook-lever 201′ opens the conductive circuit through the substation, relay 320 at F′ deënergizes, as does also the relay R′R′ at D′, which has been held energized by current over the called line. Referring first to F′, the falling back of armature 322 operates release relay R′R³ by current through alternate contact 336. Relay *r′r*, by armature 351, locks to battery through off-normal contact 313, and by armature 314, energizes release magnet R′M³, which withdraws the retaining pawls of the connector F′ which then restores to normal, the primary off-normal (PON) and secondary off-normal (SON) contacts being also restored in the process. On the attraction of armature 314, relays 323 and 334 have their locking circuits opened and they deënergize. Armature 325, falling back, deënergizes relay 316 at F′ and the cut-off relay 214′ at H′ so that the line circuit of A′, as well as connector F′, is at normal. On the deënergization of relay *r′r* at D′, circuit is closed from battery, through contact 270′, contact 267′, release relay R′R′, which, by armature 277′, locks in series with busy relay B′R′. Release magnet R′M′ now energizes by current through alternate contacts 279′, 282′, to ground and withdraws the retaining pawls of first selector D′, whose wipers restore to normal, the primary and secondary off-normal contacts being also restored in the process. The opening of contact 276′ deënergizes relays B′R′ and R′R′, and the deënergization of release magnet R′M′ necessarily follows. The relays P′R′ and S′R′ remain energized by current over the calling line A′, and relay R′V′ remains locked by current over wire 254′, through contacts 246′, 251′, 242′, to ground. When relay R′R′ at D′ first operated, its armature 278′ connected battery (before armature 284 of magnet R′M′ was attracted) through contact 285′—288′, contact 293′, to ground through release relay R′R² of switch E′. Relay R′R², by armature 295′, locks in series with relay B′R², whereupon energizing current for release magnet R′M² flows through alternate contacts 297′ and 301′ to ground. The actuated magnet R′M² withdraws the retaining pawls of switch E′, and the switch wipers are restored, as are the primary and secondary off-normal switch contacts. The resulting opening of contact 294′ deënergizes relays R′R² and B′R², and the second selector E′ is at normal. When, now, the calling subscriber A′ replaces his receiver, the conductive circuit through the substation is interrupted and relays P′R′ and S′R′ are together deënergized for the first time since their initial operation, closing a circuit from ground through release relay R′R′, contacts 262′, 258′, wire 255′, contact 244′, lower winding of release relay R′R, to battery B¹⁰. Armature 242′ operates relay S′R during the release by current through alternate contact 245′. Armature 241′ of relay R′R locks said relay to ground at normal contact 239 and connects the winding of release magnet R′M over a branch circuit with said ground so that the magnet is actuated and withdraws the retaining pawls of the line selector C′, which restores. The primary and

secondary off-normal switches are also restored and the opening of contact 237′ deenergizes relay R′R and magnet R′M. The opening of alternate contact 242′ then deenergizes secondary relay S′R and the line selector C′ is at normal, as is first selector D′ by the deënergizations of relays P′R′, S′R′ and R′V′, the latter having had its locking circuit, traced over wire 254′, opened as soon as armature 242′ was attracted. It will be observed that when line selector C′ is restoring, ground is maintained upon contact 227′ of master-switch B°, over a circuit traced through alternate contacts 247′, 250′, 245′, and 242′.

Had the calling subscriber A′ first replaced his receiver, the deënergization of relays P′R′ and S′R′ would have completed the before-traced path for current including the winding of relay R′R′, and the operation of this relay would have caused the restorations of switches D′ and E′ in the same manner that they occurred when relay R′R′ was operated from substation H′. Then, when the receiver would be replaced at substation H′, the connector F′ would be restored as before. Until this occurred, however, the multiple contacts 306, 307, 308 of the switch F′ at the second selector E′ would continue busy, since the multiple contact 306 would be connected to ground through alternate contacts 311, 335.

Returning now to the point when the test relay T′R at F′ was energized by the transmission of the secondary impulse to test the called line, and assuming that at such time the called line was busy, then the multiple contacts 207 of the called line would have been connected to ground in one of the several ways heretofore indicated as possible; and on the attraction of armature 329 of T′R, said relay would have continued energized, being locked to ground at the engaged contact 207′ of the busy called line. The contact 328 would therefore remain closed and the busy signal from interrupter I^{11} would be transmitted over the upper talking conductor, through the exchange to substation A′, giving the usual audible busy signal in the receiver. The calling subscriber A′ will thereupon replace his receiver, and switches C′, D′ and E′ will be restored in the manner before described. The continued energization of relay T′R has prevented any of the relays 316, 320 and 334 from operating, and the release relay $R'R^8$ remains connected, through normal contact 335 and contact 311, with the private contact 306. Thus, when, at the initiation of release of switch E′, relay $R'R^2$ operates, current flows from battery B^{11}, through alternate contact 296′, normal contact 298′ (before magnet $R'M^2$ energizes), contact 303′—306 to ground through relay $R'R^3$, which relay operates and restores the connector F′ in the manner before described. With respect to the line circuit of substation A′, it is of course apparent that as soon as switch C′ starts to restore, cut-off relay 214′ deënergizes and the line circuit is placed in its normal condition.

The switch structure diagrammatically shown in Figs. 10 to 14, inclusive, is more specifically a line selector C′, although a similar structure may be employed in connection with the circuits shown at D′, E′ and F′ of Fig. 1.

In Fig. 10, the main contact bank is shown in section, one group of ten contact sets being indicated as extending vertically. In Fig. 11, showing a front view of the contact bank, each set of three contacts is indicated by a single short line, and in this figure are illustrated the ten vertically extending groups of contact sets having their contact ends projecting as through the inner surface of a section of a hollow sphere. The contact wipers 233′, 234′, 235′ have their contact ends rotated step by step from left to right, each step bringing them below a different group of contact sets, whereafter said contact ends are rotated step by step upwardly to engage successive contact sets of the selected group. For the primary adjustment, to select the group, a rotary primary shaft P′S is provided, through which the wipers 233′ to 235′ extend and are fastened by a pivoted bearing at 420. The group-selecting wiper 236′ is rigidly attached at the base of shaft P′S and its coöperating contacts 231′ are arranged in a horizontally extending curved group below the main switch bank. The primary magnet P′M, best shown in the sectional top view, Fig. 14, has an armature-actuated pawl 402 adapted, on actuations of said magnet, to engage successive teeth of the rotary ratchet 403, firmly attached to shaft P′S, and so rotate shaft, ratchet and wipers step by step. A pivoted retaining pawl 404 is provided to engage the ratchet 403 and hold it against back movement during the primary adjustment of the switch. The wipers 233′ to 235′ have a rearwardly extending portion 400 provided with a suitable bearing engaging the broad piece 401, screwed to secondary shaft S′S. When actuations of secondary magnet S′M are produced, its armature-driven pawl 412 engages successive teeth of an associated ratchet of shaft S′S and drives the shaft downwardly, whereby the piece 401 rotates the wiper ends upward about the pivot 420, moving them to engage successive contact sets of the selected group. As best shown in Fig. 11, the piece 401 is sufficiently broad so that it is continued in engagement with the bearing of the piece 400, irrespective of the primary position to which the wipers may have been rotated. To hold the secondary shaft S′S against

back movement, a secondary retaining pawl 411 is provided to engage successive teeth of a ratchet cut in said shaft.

It is thus seen that by means of primary magnet P'M and secondary magnet S'M, the wipers 233', 234', 235' may be adjusted to select any group of contacts and then any contact set of the group.

To restore the switch, the release magnet R'M is actuated, whose attracted armature 413 rotates the primary retaining pawl 404 about its pivot, which pawl, by an arm 404a, withdraws the secondary retaining pawl 411 and the two shafts are then free to be restored. First the spring 409, engaging the short end of the pivoted rocker arm 410, whose distant end engages loosely a screw threaded to shaft S'S, is effective to raise said shaft upward, whereby the wipers are rotated downwardly to free the contact bank. As soon as this occurs, the spring 405, one end of which is attached to the main switch frame and the other end to the primary shaft P'S, is effective to rotate the primary shaft reverse clockwise back to normal. The tension of spring 405 is ineffective while shaft S'S is being restored, because of the piece 406 which extends parallel with the shaft S'S and has a tooth 407 which engages some adjacent tooth of the rotary ratchet 403 at all times when the secondary shaft is in other than normal position. Thus on the first downward step of shaft S'S, the piece 408, fastened thereto, disengages the piece 406, which drops down through the switch frame, the tooth 407 then engaging an adjacent tooth of the ratchet 403. When the secondary shaft S'S, in its restoration, reaches normal, the piece 408 again raises the piece 406, disengaging the tooth 407 from ratchet 403. The piece 406 permits the secondary off-normal springs 244', 245', 246' to shift on the first secondary step of the switch and restores them to normal as the restoration of the secondary shaft is completed, in an obvious manner.

The primary off-normal switch arrangement indicated in Fig. 13, which is a top view of the selector, includes the piece 415, rigidly fastened to the primary shaft P'S and having a stud 416 normally engaging the end of the primary off-normal spring 238' which is mechanically linked with the associated spring 237' by an insulating spacer. On the first rotary step of the shaft P'S, stud 416 frees spring 238 and the two springs 237' and 238' assume their alternate positions. When shaft P'S is subsequently rotated back to normal, stud 416 engages spring 238' and restores it and spring 237' to their normal circuit relations.

When the switch, indicated in Figs. 10 to 14, is employed in connection with the circuits indicated at D', E' and F', the group wiper 236' and the group contact 231' may be omitted or left disconnected. When the switch mechanism is used for these other circuits, they will be provided with the particular primary and secondary off-normal switch combinations indicated in said circuits. When the switch mechanism is used for the purposes of the connector F', the normal relation of the contact ends of wipers 233' to 235' to the lower edge of the contact bank will be two secondary steps below.

In Fig. 15, I have illustrated a third modification in which the primary and secondary relays are provided with somewhat more simple circuits than the corresponding parts in Fig. 9. This figure is a duplicate of Fig. 9, Part 2, except for these changes, and the unchanged parts are provided with the same reference characters. In this form, primary relay PR'' is connected the same as relay P'R' in Fig. 9. Secondary relay SR'' is connected through contact 261'' of the primary relay directly to ground, instead of through a contact of the reverse relay R' V' This relay differs from relay S'R' in Fig. 9 in having but a single winding, but, like it, controls two contacts 262'', 263'', the former included with contact 258'' of relay PR'' in the release circuit, and the latter controlling, with contact 260'', a grounded branch from the primary side of the circuit. Relay SR'' is also rendered slow to release. Relay IR'' is connected the same as relay IR', but is provided with an additional contact 270'', through which the circuit of release relay $r'r$ extends.

In operation, the initial application of the current by the closing of the circuit at the calling station energizes relay PR'' and holds it energized. The subsequent impulses as before cause a definite number of breaks in the circuit of this relay, and it is correspondingly deënergized a given number of times, followed by its continued energization the same as before the impulses were sent. The first energization of the relay PR'' energizes secondary relay SR'' by closing its circuit at contact 261''. Relay SR'', by closing its contact 263'', thereby closes its portion of the grounded branch leading from the primary strand of the link-circuit. Then, upon the first deënergization of relay PR'', corresponding to the first impulse transmitted over the line, contact 260'' closes this grounded branch and transmits an impulse over the primary side of the circuit to the connected selector switch, as in the case of Fig. 9. This first deënergization also results in actuating relay IR'' by closing its circuit through contacts 259'' and 263''. The following energizations and deënergizations, as before, occur rapidly and transmit corresponding impulses over the primary

side of the circuit. The energization of relay PR″, following the final impulse, breaks the circuit of relay IR″ and allows it to close contact 271″ to transmit a single impulse over the secondary side of the circuit, as before explained. Having pointed out the differences between this circuit and that of Fig. 9, and explained the operation of the changed portion, it will be readily understood from the explanation of Fig. 9 how the circuit of this figure is to be used and operated.

It will be apparent from the above descriptions of the different embodiments of my invention and the apparatus employed therein that many alterations and modifications may be made in the arrangement of the circuits and in the details of the apparatus, as well as location of the same, without departing from the spirit and scope of my invention. I therefore do not wish to be limited to the specific matter disclosed, but aim to cover, by the terms of the appended claims, all such alterations and modifications.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. An automatic switch for telephone systems comprising wipers and coöperating contacts, a suitable source of current, a driving magnet for said wipers, primary and secondary control relays, the secondary relay being slow to release its armature relative to said primary relay, means for closing a circuit to actuate said primary relay, connections whereby said secondary relay is actuated in consequence of the actuation of said primary relay, and a control circuit extending through said driving magnet through contacts of said relays, a second slow-acting relay connected in multiple with said driving magnet, and a secondary circuit controlled by said last relay.

2. A telephone system comprising a plurality of coöperating switch wipers and contacts, primary and secondary driving magnets for certain of said wipers, release magnets for said wipers, primary and secondary relays and a third relay, said secondary and third relays being slow to release their armatures relative to said primary relay, means for closing a circuit to actuate said primary relay, circuits under the control of said primary relay for energizing said secondary and third relays, a control circuit for said primary magnet including contacts of said primary and secondary relays, a control circuit for said secondary relay including contacts of said primary and third relays, and a control circuit for one of said release magnets including contacts of said primary and secondary relays.

3. A telephone system including a telephone line; a plurality of coöperating switch wipers, contacts and circuit connections for extending the circuit of said line; primary and secondary driving magnets for certain of said wipers; release magnets for said wipers; primary and secondary relays and a third relay, said secondary and third relays being slow to release their armatures relative to said primary relay; a calling device associated with said line at a point distant from said relays; connections whereby a circuit for actuating said primary relay may be completed at said device; circuits under the control of said primary relay for energizing said secondary and third relays; a control circuit for said primary magnet including contacts of said primary and secondary relays; a control circuit for said secondary magnet including contacts of said primary and third relays; and a control circuit for one of said release magnets including contacts of said primary and secondary relays.

4. A telephone system including a calling subscriber's line and a called subscriber's line, a two-dimension automatic switch for connection to said calling line, a two-dimension automatic switch for connection to said called line, automatic switching means controlled over the two sides of the calling subscriber's line in series for connecting said two-dimension switches in circuit, means under the control of the calling subscriber for releasing all but the two-dimension switch associated with the called subscriber's line, and means under the control of the called subscriber for releasing all but the two-dimension switch associated with the calling subscriber's line.

5. An automatic switch for telephone systems including wipers and coöperating contacts, a suitable source of current a driving magnet for said wipers, a primary and a secondary control relay, the secondary relay being slow to release its armature relative to said primary relay, subscriber-controlled means for closing a circuit to actuate said primary relay, connections whereby said secondary relay is actuated in consequence of the actuation of said primary relay, a control circuit connected to said driving magnet and extending through contacts of said relays, a second slow-acting relay connected in multiple with said driving magnet, and a secondary circuit controlled by said last relay.

6. A telephone system including an automatic switch, a driving magnet for said automatic switch, a primary relay under sub-station control, a secondary relay slow to release its armature relative to said first relay and controlled through contacts of said first relay, a third relay also slow to release its armature and jointly controlled by said first and second relays; means for intermittently interrupting the energizing circuit of said first relay to cause its intermit-

tent operation without deënergizing said second and third relays, a circuit for said driving magnet including contacts of said first and second relays, a control circuit under the control of said first and third relays, and sub-station controlled means for connecting said second relay in circuit with said first relay.

7. A telephone system including a calling telephone line, a calling device connected to said line at one point, a source of current and a primary relay connected to said line at another point, a secondary relay, actuated over a local circuit controlled by said primary relay, means for rendering said secondary relay slow to release its armature relative to said primary relay, a plurality of two-dimension automatic trunking switches provided with driving magnets, and control circuits extending through contacts of said relays direct to said driving magnets.

8. A telephone system including a telephone line, a quick acting and a pair of slow acting relays adapted to be associated with said line, subscriber-controlled means for closing an energization circuit for said quick acting relay and subsequently interrupting said circuit and then closing it, a plurality of automatic switches adapted to be controlled by said relays, driving magnets for said automatic switches, circuit connections whereby one of said slow acting relays is energized as the result of the energization of said quick acting relay and the third relay is energized as a result of the interruption of the energizing circuit of said first relay, and circuit connections extended to said driving magnets and including contacts of two of said relays.

9. A telephone system including a subscriber's telephone line, a progressively movable mechanism comprising a normally inoperative motor magnet, non-numerical trunking means for connecting said telephone line to said progressively movable mechanism, electromagnetic mechanism for said first mechanism governed by current impulses despatched over the calling line to control the operation of the motor magnet in synchronism with said impulses, means controlled by said impulses for rendering and retaining the motor magnet operative during the transmission of successive current impulses of given regularity, said last means including a slow acting relay energized responsive to the energization of said electromagnetic mechanism, and other progressively movable mechanism directly controllable by impulses repeated from said electromagnetic mechanism.

10. A telephone system comprising a relay, a secondary relay slow to release its armature relative to said first relay and controlled through contacts of said first relay, means for intermittently and rapidly interrupting the circuit of said first relay to cause its intermittent deënergization without deënergizing said second relay, and means for removing the control of said second relay from said first relay and for connecting said second relay in circuit with said first relay.

11. A telephone system including a primary relay, a suitable source of current, a secondary relay slow to release its armature relative to said first relay, means for closing a circuit to actuate said primary relay, connections whereby said secondary relay is actuated in consequence of said primary relay, and means for removing the control of said secondary relay from said primary relay and for connecting it in circuit with said primary relay.

12. A telephone system comprising a telephone line, a calling device connected to said line at one point, a primary relay and a suitable source of current connected to said line at another point, a double wound secondary relay actuated over a local circuit controlled by said primary relay, an impulse circuit extending through contacts of said relays over which impulses are repeated from said calling device, and subscriber-controlled means for connecting said secondary relay in circuit with said primary relay over said telephone line.

13. A telephone system including three relays, a suitable source of current, the second and third being slow to release their armatures relative to the first, means for closing an energizing circuit for said first relay, intermittently and rapidly interrupting said circuit and again closing it, and circuit connections whereby said second relay is actuated upon the first closing of said circuit and maintaned actuated thereafter and said third relay is actuated upon the first interruption of said circuit, maintained actuated during such interruptions and released upon the subsequent closing of said circuit, and a fourth relay for including said first and second relays in series circuit.

14. A telephone system including coöperating switch wipers and contacts, driving magnets and release magnets for said wipers, primary and secondary control relays, the secondary relay being slow to release its armature relative to said primary relay, means for closing a circuit to actuate said primary relay, connections whereby said secondary relay is actuated in consequence of the actuation of said primary relay, control circuits for one of said driving magnets and one of said release magnets extending through contacts of said relays, and a fourth relay for including said primary and secondary relays in series circuit.

15. A telephone system comprising a telephone line, a primary relay connected to

said line at one point, second and third relays slow to release their armatures relative to said primary relay, a suitable source of current, a calling device connected to said line at a distant point and connections for closing an energizing circuit for said primary relay and subsequently interrupting said circuit and again closing it, local circuit connections whereby the second relay is energized as a result of the energization of said primary relay and the third relay is energized as a result of the interruption of the energizing circuit of said first relay, and a substitute circuit for said second relay including a line conductor.

16. A telephone system including a primary relay, a double wound secondary relay slow to release its armature relative to said primary relay, a third relay slow to release its armature relative to said primary relay, a suitable source of current, means for closing a circuit to actuate said primary relay, circuits under the control of said primary relay for energizing said secondary and third relays, a control circuit extending through contacts of said primary and secondary relays, a second control circuit including contacts of said primary and third relays, and means for opening the operated circuit of one winding of said secondary relay and for closing a substitute circuit through its other winding.

In witness whereof, I hereunto subscribe my name this 6th day of April, 1909.

GEORGE E. MUELLER.

Witnesses:

CAROLYN WEBER,

L. D. KELLOGG.