G. E. MUELLER.

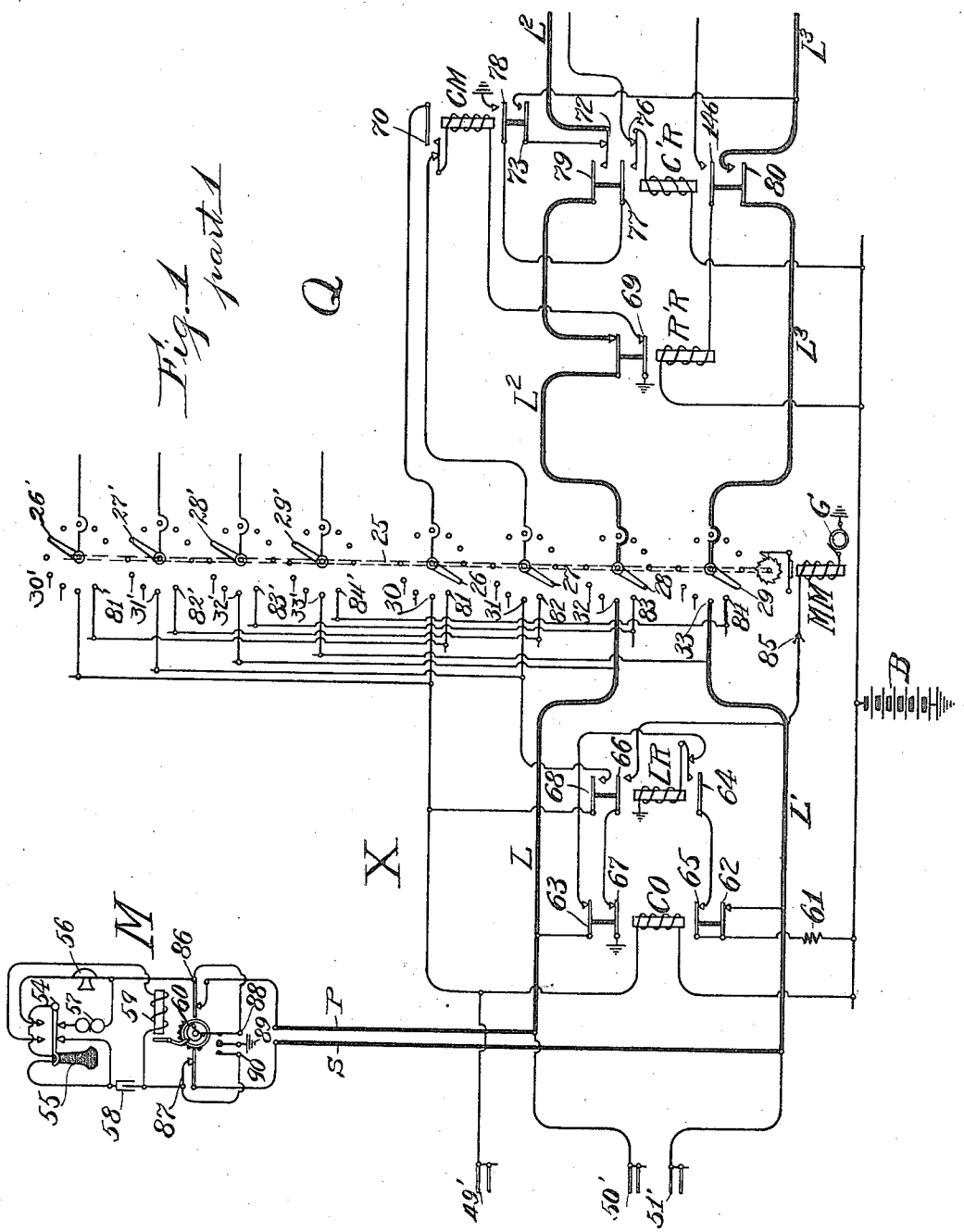
AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED MAR. 5, 1910.

1,239,207.

Patented Sept. 4, 1917.

7 SHEETS—SHEET 1.



Witnesses

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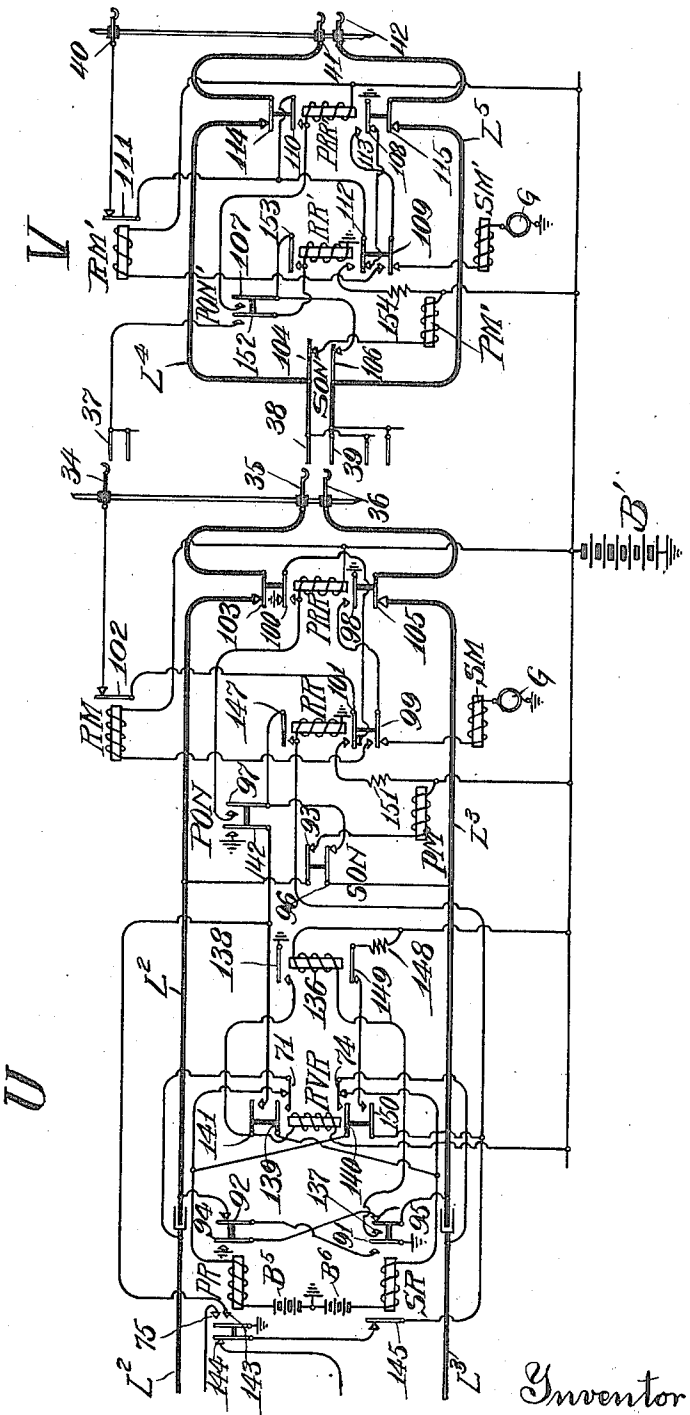

Fig. 1 part 2

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7 SHEETS—SHEET 3.

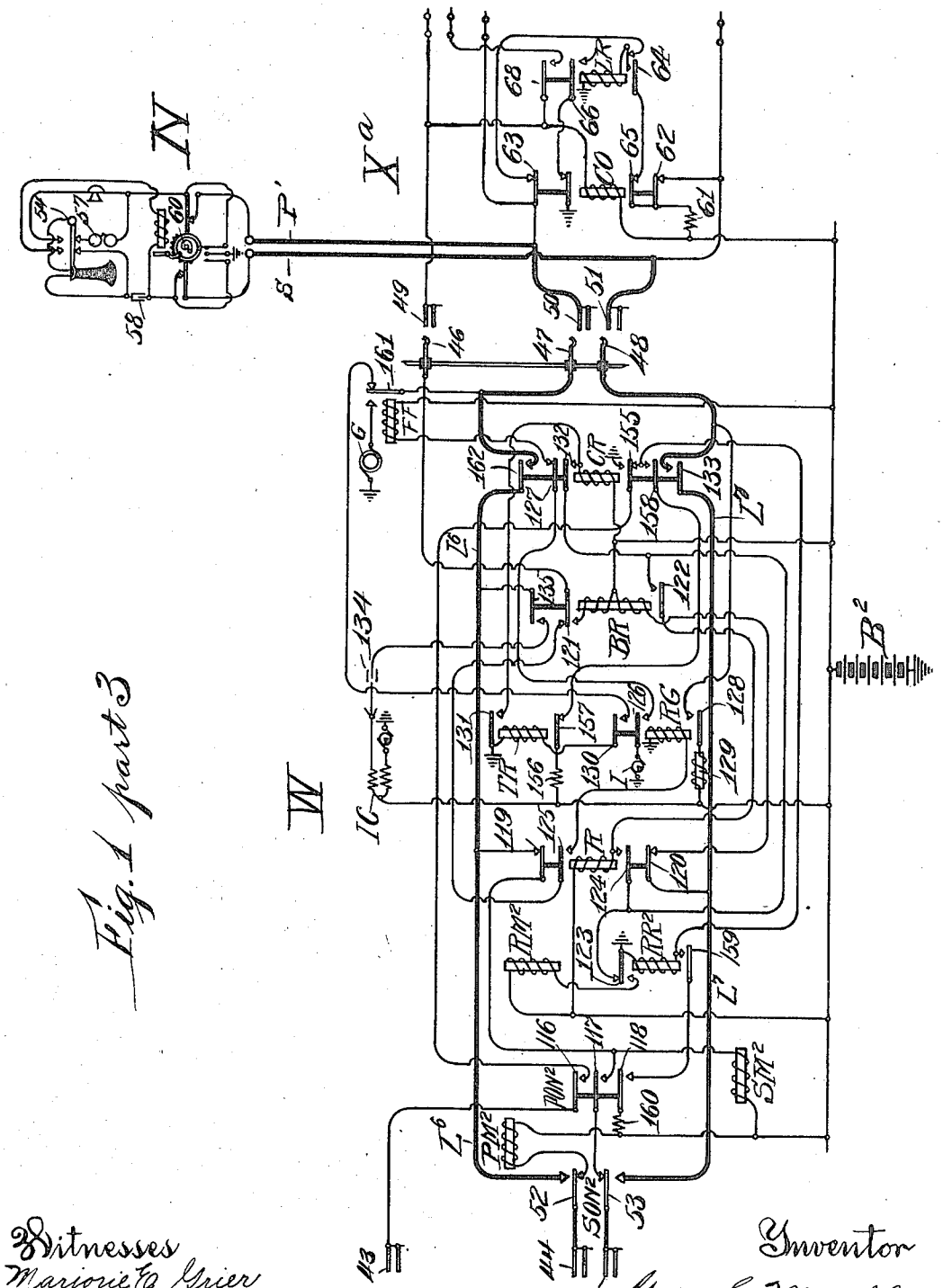

Fig. 1 part 3

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7 SHEETS—SHEET 4.

Fig. 2

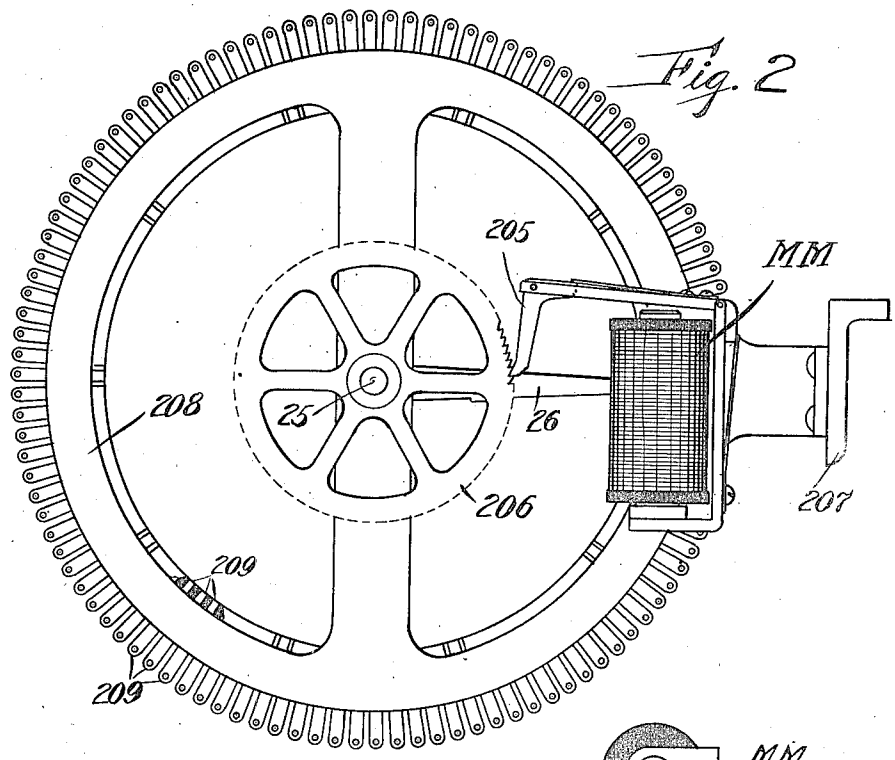
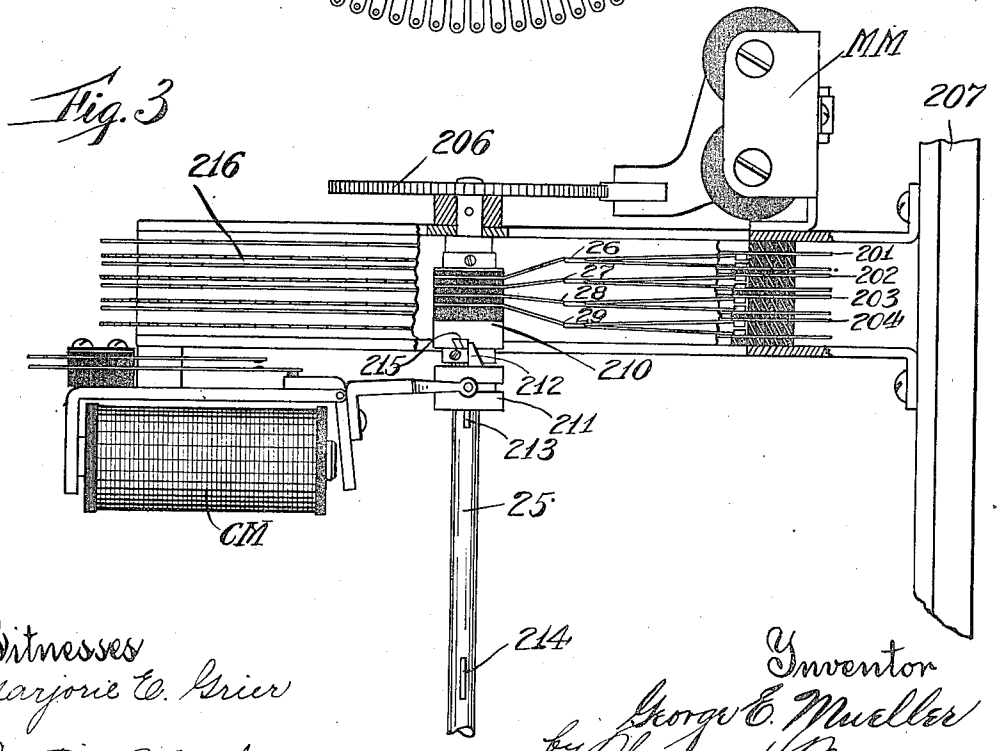


Fig. 3



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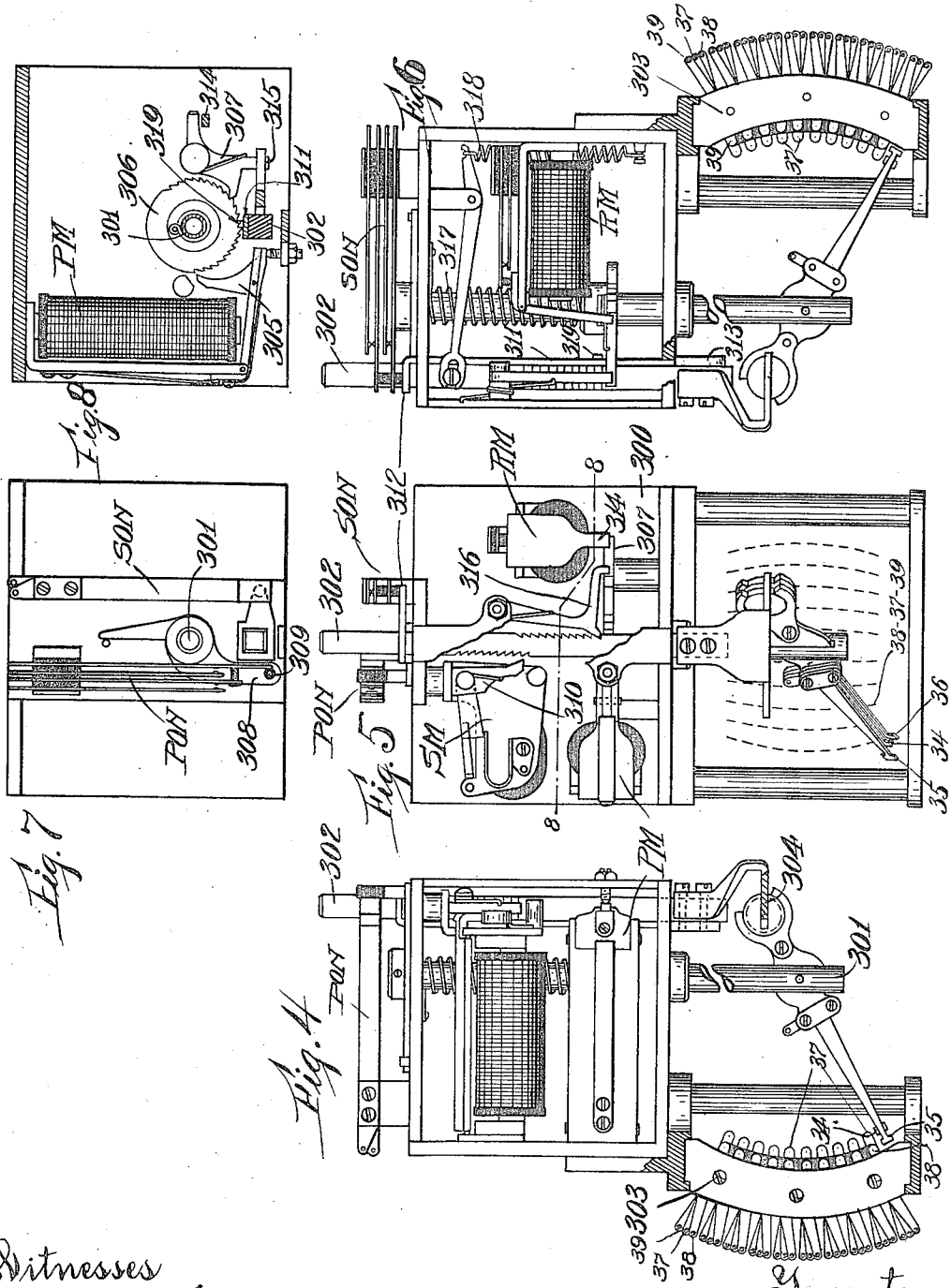
7 SHEETS—SHEET 5.



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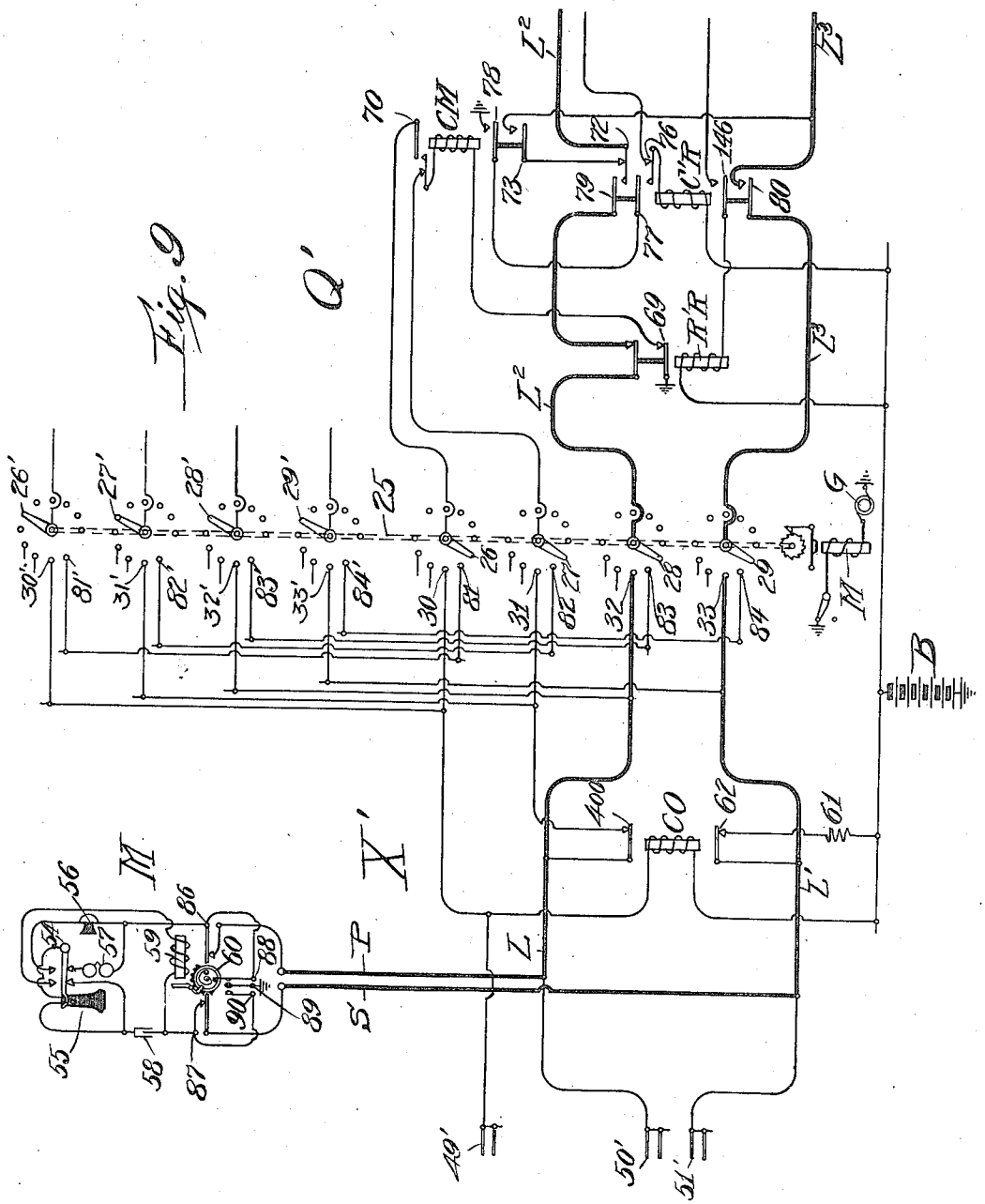
7 SHEETS—SHEET 6.

Fig. 9



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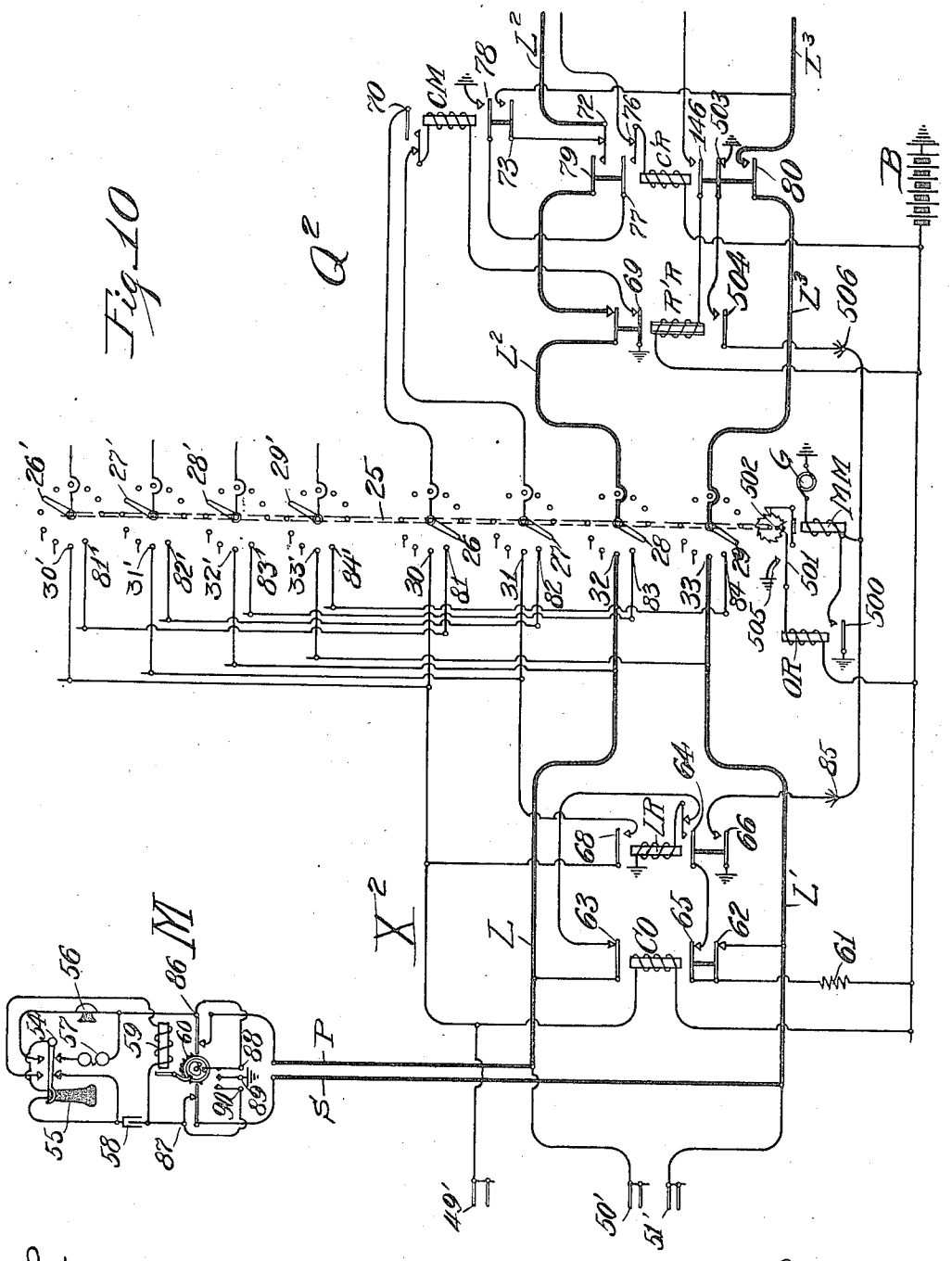
7 SHEETS—SHEET 7.

Fig. 10



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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

1,239,207. Specification of Letters Patent. Patented Sept. 4, 1917.

Application filed March 5, 1910. Serial No. 547,464.

To all whom it may concern:

Be it known that I, GEORGE E. MUELLER, a citizen of the United States, residing in La Grange, county of Cook, State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

The present invention relates to automatic telephone systems generally, and more particularly to that type in which selector and connector switches are employed in conjunction with line selecting switches. In such systems, the switch structure is one in which movable contacts, or wipers, are associated with a large number of fixed or passive contacts arranged in a bank, and the wipers are first given a so-called "primary" movement in one direction to bring them to a desired group of bank contacts, and then a so-called "secondary" movement to cause them to engage desired bank contacts in the selected group. In such a system, on the basis of ten thousand lines, ten per cent. trunking and hundred point switches, there would be one thousand line selectors, one thousand first selectors, one thousand second selectors and one thousand connectors. Each subscriber's line would be multipled to ten line selectors and ten connectors. The line selectors and first selectors would have their wipers connected in pairs. The wipers of the second selectors would be multipled to the bank contacts of one hundred first selectors, and the wipers of each connector would be multipled to the bank contacts of one hundred second selectors. Obviously, in exchanges of smaller capacity, or upon different percentages of trunking, or different numbers of switch points, the numbers of the switches and the arrangement of connections would differ from that above given, but this specific example will suffice to indicate the character of the system to which my invention belongs.

The principal object of my invention is to devise a system of the character indicated, having simplified line selecting mechanism and circuits. To this end, I preferably do away with line selectors of the art which have primary and secondary movements and replace the same by switches having simple rotary movements and a single driving means for a plurality of such switches and employ a novel arrangement of circuits in which ordinary telephone relays are used, to bring about the desired results. In working out my invention, I have necessarily provided apparatus and circuits which are capable of use in other systems than so-called "full" automatic systems and in other relations than those herein disclosed. With this general statement of the object and nature of my invention, I will now proceed with a detailed description of the same in connection with the accompanying drawings, and will then point out the scope of the invention more particularly in the appended claims.

Referring to the drawings, Figure 1, which includes Parts 1, 2 and 3, illustrates diagrammatically an automatic telephone system constructed in accordance with my invention; Fig. 2 is a plan of a line selector mounted upon a shaft common to other line selectors; Fig. 3 is a side elevation of the same, parts being broken away, and parts being shown in section; Figs. 4, 5 and 6 are elevations of a selector viewed from different sides; Fig. 7 is a plan view of the same, illustrating particularly the off-normal contacts; Fig. 8 is a sectional plan of the same taken on a plane indicated by the line 8—8 of Fig. 5; and Figs. 9 and 10 illustrate, respectively, in diagram, modifications of the line and line selector circuits of Fig. 1.

Main system.

Referring now more particularly to Fig. 1, which may be considered the main diagram, M at the left of the figure designates a subscriber's station united to the main exchange by the line limbs P and S, which terminate in multiple contacts of line selectors and connectors. At the opposite end of the diagram, N designates a subscriber's station, which is similarly connected to the main exchange by the line limbs P^1S^1, which likewise terminate in multiple contacts of connectors and line selectors. Connection is obtainable between the calling station M and the called station N through the agency of line circuit X, line selector Q, first selector U, second selector V, connector W, and the line circuit X^a. Assuming that the selectors and connectors employed in establishing this connection are each provided with one hundred bank contacts, and assuming that there are ten thousand lines in the exchange, arranged on a basis of ten

per cent. trunking, then, as heretofore outlined, there would be one thousand line selectors Q, one thousand first selectors U, one thousand second selectors V, and one thousand connectors W. The subscribers' lines would be divided into groups of one hundred, and ten line selectors would be assigned to each group, thus enabling each line to be multipled to the corresponding bank contacts on ten line selectors. Each group of ten line selectors would be under the control of the one hundred lines to which they have access. Each subscriber's line would also be multipled to the bank contacts of ten connectors which have access to the group of one hundred lines, in which said line is located. In the diagram, only two of the ten sets of multiple contacts of the line selectors and connectors are illustrated. The movable contacts, or wipers, of each line selector Q are tied to the corresponding wipers of a first selector U, thus providing one thousand sets of connected line selectors and first selectors.

The wipers of the second selectors are multiply connected to bank contacts of the first selectors; and since there are one thousand of each of these switches, and each first selector has one hundred bank contacts, the wipers of each second selector are multiply connected to the corresponding bank contacts of one hundred first selectors. Similarly, the wipers of the one thousand connectors are multiply connected to the corresponding bank contacts of one hundred second selectors. As previously indicated, this apportionment of values may be varied at will to suit the conditions of any particular sized exchange, or any modified arrangement of trunking or switch structure.

In establishing connection between the calling station M and the called station N, the calling subscriber first removes his receiver from its hook and thereby causes the line selectors of the group, to which his line belongs, to seek out connection with the terminals of his line, with the result that one of such line selectors extends the circuit of his line to a first selector. The next step in the operation is for the calling subscriber to operate his calling device. Assuming that the number of the called subscriber is 3456, the first operation causes the wipers of the connected first selector to advance three primary steps and then automatically to select an idle second selector V in the thousand group to which the called line belongs; the second operation of the calling device causes this connected second selector V to advance four primary steps and then automatically to select an idle connector W in the group of one hundred, to which the called line belongs; the third operation of the calling device causes the connector to advance five steps to that group of ten contacts in which the called line is included; and the fourth and final operation of the calling device causes the connector to move over the contacts in that group to the sixth set of contacts, which are contacts of the called line. Thus connection is completed between the stations M and N.

Each telephone line circuit X at the exchange is provided with a line relay LR and a cut-off relay CO; the first being effective to start a group of line selectors to select a calling line, and the latter being effective to destroy the normal substation control of the line relay and to otherwise change the line connections. Each line circuit also includes connections to the multiply connected contacts 30, 31, 32 and 33 of ten line selectors Q, as well as connections to the multiply connected contacts 49^1, 50^1 and 51^1 of ten connectors.

In the case of the line selectors Q, I preferably employ ten switches for each group of one hundred lines and connect the ten sets of wipers of these switches to the common shaft 25. In the drawing, however, I have found it practicable to illustrate but two such line selectors Q. Obviously, the proportion of line selectors to the lines in a group may be varied at will. For each group of line selectors, I provide a common motor magnet MM, which, upon the initiation of a call, rotates the shaft 25 and moves the wipers of the idle line selectors Q of the group forward to seek connection with the calling line. Each line selector is provided with a clutch magnet CM, arranged to stop the wipers upon connecting with the calling line. Each selector circuit also includes a release relay R^1R and a so-called connecting relay C^1R. Each line selector has four wipers which coöperate with associated passive contacts. Two of these sets are illustrated in Fig. 1; the wipers of one set being designated 26, 27, 28, 29, and those of the other 26^1, 27^1, 28^1, 29^1, while the corresponding associated bank contacts are designated 30, 31, 32, 33, and 30^1, 31^1, 32^1, 33^1. Each of these sets of wipers is angularly displaced with reference to the adjacent set, so that the wipers of the ten line selectors of the group are angularly different distances from a given starting point, producing a sort of spiral arrangement of the sets of wipers about their common shaft. Consequently, in operation, as the common shaft is rotated, the several sets of wipers will not engage their bank contacts simultaneously, but one set will engage its contacts before the others and that one will stop with its wipers in engagement with the bank contacts of the calling line.

Each first selector U includes wipers 34, 35, 36, arranged to coöperate with bank contacts 37, 38, 39, in response to the operation

of a primary magnet PM, controlled by the primary relay PR, and the secondary magnet SM, controlled by the secondary relay SR, and the switch is released through the operation of the release magnet RM, controlled by the release relay RR. The primary and secondary off-normal springs PON and SON are moved to their alternate positions upon the initial primary and secondary movements of the wipers, respectively. The circuit associated with this first selector switch also includes the reversing relay RVR for reversing the direction of battery flow supplied to the calling line.

Each second selector switch V includes the wipers 40, 41, 42, with their associated bank contacts 43, 44, 45. The wipers partake of the same primary and secondary movements as the first selector, and the relays, magnets and off-normal springs are designated by primed (1) reference characters corresponding to those of the first selector.

Each connector W includes wipers 46, 47, 48, coöperating with the bank contacts 49, 50, 51, and in this switch, as in the others, they partake of both the primary and secondary movements in response to the operation of the primary magnet PM^2 and the secondary magnet SM^2, respectively, and return to normal upon the operation of the release relay RR^2 and the release magnet RM^2. In this instance, the primary off-normal contacts are designated PON^2, and the secondary off-normal contacts are designated SON^2. In addition to these parts, the circuit is provided with a busy relay BR, a ringing relay RG, a control relay R, a tip relay TR, a so-called "flip-flop" relay FF, and a closing relay CR, all of which coöperate in a manner hereinafter described. The secondary off-normal springs SON^2 are so arranged that upon the first secondary movement of the connector, contact spring 52 is moved into engagement with its alternate contact, and spring 53 is moved out of engagement with its normal contact, and then upon the second step, said spring 53 is moved into engagement with its alternate contact; and in this switch, the wipers are positioned two steps below the first bank contact so that it requires two secondary steps to bring them into engagement with the first set of bank contacts.

The line circuit X^a of line S^1P^1 is the same as the line circuit X of the line SP.

The substation equipment at the subscribers' stations M and N includes the customary switch-hook 54, receiver 55, transmitter 56, call-bell 57, condenser 58, impedance coil 59, and calling device 60.

Operation.

Having now given a general description of the character of the apparatus diagrammatically illustrated in Fig. 1, it is believed that the invention will be best understood by entering at once into a complete description of the operation of the system illustrated in that figure.

Assuming that the subscriber at substation M desires to converse with the subscriber at substation N, and assuming that the number of the latter's telephone is 3456, the subscriber at M removes his telephone 55 from its switch-hook 54, thereby closing circuit from the live side of battery B, through resistance coil 61, armature 62, conductor L^1, limb S, winding of magnet 59, switch-hook 54, transmitter 56, limb P, conductor L, armature 63, line relay LR to ground. This energizes the line relay which locks itself through armature contact 64, contact 65 of the cut-off relay CO and resistance coil 61, to the live side of battery B. A circuit is therefore closed through motor magnet MM from generator G, through contact 66, contact 67 to ground. The motor magnet MM thereupon steps the common shaft 25, with its attached sets of idle line selector wipers, forward to select the calling line. In the illustration, I have shown two sets of wipers, but in practice I preferably employ ten sets, as previously stated. As the wipers 26, 27, 28, 29, and 26^1, 27^1, 28^1, 29^1 step forward to seek connection with the calling line, on account of the spiral disposition of the wipers previously pointed out, the wipers 26, 27, 28, 29 will be the first set to reach contacts 30, 31, 32, 33 of the calling line. Upon the energization of line relay LR, circuit is closed from the live pole of battery B, through cut-off relay CO, through contact 68 of relay LR to bank contact 31. As soon as wiper 27 connects to bank contact 31, clutch magnet CM is energized by a circuit from ground at contact 69 of relay R^1R, through the winding of clutch magnet CM, wiper 27, contact 31 and along the previously described path to battery B and stops wipers 26, 27, 28 and 29 in engagement with contacts 30, 31, 32 and 33, respectively. As this circuit includes both the windings of clutch magnet CM and the cut-off relay CO both are energized. Upon the energization of cut-off relay CO, the locking circuit for the line relay LR is opened at contact 65, restoring line relay LR to normal. The circuit for the motor magnet MM is opened at contact 67, thus preventing further operation of the said magnet. Contacts 63 and 62 are also opened to prevent a re-energization of line relay LR. Upon the energization of clutch magnet CM, a locking circuit is established from ground at contact 69 of relay R^1R through the winding of said clutch magnet, contact 70, wiper 26, contact 30, and the winding of cut-off relay CO, to the live pole of battery B. The cut-off relay CO and clutch magnet CM

now remain energized until the calling subscriber restores his telephone for disconnection. Upon the energization of clutch magnet CM, a circuit is also established from battery B^5 (Fig. 1, Part 2), through primary relay PR, contact 71, conductor L^2 contact 72 of relay C^1R, contact 73, conductor L^3, contact 74 of relay RVR, the winding of secondary relay SR to battery B^6. Relays PR and SR are now energized and a circuit is established from ground at contact 75 of primary relay PR, contact 76 of relay C^1R, through the winding of said relay to the live pole of battery B. Relay C^1R now becomes energized and a locking circuit is established through contact 77 to ground at contact 78 of clutch magnet CM. Upon the energization of relay C^1R, the aforesaid circuit through the primary and secondary relay is interrupted at contact 72 of relay C^1R, but is closed through contact 79, conductor L^2 of switch Q, wiper 28, contact 32, conductor L of circuit X, limb P, transmitter 56, switch-hook 54, winding of magnet 59, limb S, conductor L^1, contact 33, wiper 29, contact 80 of relay C^1R, and conductor L^3, thus putting the primary relay PR and secondary relay SR directly under the control of the calling subscriber.

Assuming now that another subscriber in this same group, whose line terminates at contacts 81, 82, 83, 84, desires a connection, the removal of his telephone from its hook operates the line relay associated with his line and thereby closes a starting circuit for the motor magnet MM through the common connecting point 85. Thereupon the motor magnet MM advances the common shaft 25 until the wipers 26^1, 27^1, 28^1, 29^1 connect with contacts 81^1, 82^1, 83^1 and 84^1, whereupon the same circuit changes take place in the line circuit associated with contacts 81^1, 82^1, 83^1, 84^1, and the line selector circuit associated with wipers 26^1, 27^1, 28^1, 29^1, as was described in the previous connection. From this description, it will be seen that, on a basis of ten per cent. trunking, it is possible in each group of one hundred lines, to have ten simultaneous connections.

Having had his circuit extended through to the first selector U and the relays PR and SR placed under his control, the calling subscriber first operates the dial 60 of his calling device to send three impulses over the primary side of the line, followed by a second impulse over the secondary side. In this operation, the dial 60 is moved in a clockwise direction until three projections pass the end of the contact spring 86, one projection passing over contact 87 during this operation. When freed, the dial returns to normal under the tension of the return spring associated with it, and each time that a projection passes contacts 86 and 87, such contacts are opened. Upon the first movement of the dial from normal, contacts 88, 89 and 90 are brought into engagement and remain so until the dial is restored again to normal. Accordingly, upon the return of the dial to normal, contact 86 opens the connection of line limb P to ground at 89 three times, followed by a single opening of the connection of the line limb S to ground at 89 once. The three primary impulses, thus given, actuate the primary relay PR three times, and the single secondary impulse actuates the secondary relay SR once. At the substation, magnet 59, through its armature fitting into a notch in the disk 60, normally locks the same against rotation. However, as previously noted, as soon as the circuit for the primary and secondary relays PR and SR is completed through the substation, magnet 59 is energized to attract its armature and thereby unlock the dial. This locking of the dial is for the purpose of preventing its operation until the line circuit has been extended to a first selector. In the above operation, as soon as the dial is moved off normal, the single circuit for relays PR and SR through the substation is replaced by two circuits over the two sides of the line to ground at contact 89. One of these may be traced from battery B^5, through the winding of relay PR, contact 71 of relay RVR, conductor L^2, wiper 28, contact 32, limb P, primary springs 86, springs 88 and 89 to ground; and the other from battery B^6, through the winding of relay SR, contact 74, conductor L^3, wiper 29, contact 33, limb S, secondary springs 87, contact springs 90, 89, to ground. Upon the return of the dial to normal, the circuit from primary relay PR to ground at 89 is interrupted three times at primary contact springs 86, deënergizing and energizing the primary relay PR three times, as above noted. Upon each deënergization of relay PR, a circuit is traced from ground at contact 91, through contact 92, conductor L^2, secondary off-normal contact 93, primary magnet PM to the live pole of battery B^1, operating the primary magnet three times and stepping the wipers 34, 35, 36 to the third group of bank contacts which are multiply connected to second selectors in the third thousand group of lines. Following the primary impulses, the single secondary impulse deënergizes and energizes the secondary relay SR a single time; the previously described circuit from battery B^6, through secondary relay SR to ground at contact spring 89, being interrupted a single time at secondary impulse springs 87. Upon the deënergizing of the secondary relay SR, a circuit is completed from ground at contact spring 94 of the primary relay PR, contact 95, conductor L^3, secondary off-normal contact 96, primary off-normal contact 97 which had closed upon the first primary

step of the switch, the winding of relay PRR to the live pole of battery B^1, thus energizing private relay PRR and moving its contacts to their alternate position. A circuit is now established from ground at contact 98 of relay PRR, through contact 99 and the winding of secondary magnet SM to generator G; and the wipers 34, 35, 36 will move forward one step and engage the first set of contacts in the group. Assuming that the second selector connected to the first set of contacts in the bank had been previously selected, a ground (or busy) condition would have been placed upon the multiple contacts 37 by the first selector which had connected thereto, as will be hereinafter described. Thus upon wiper 34 engaging the first contact 37, which we have assumed has already been selected, a locking circuit for relay PRR is established from the live pole of battery B^1, through the winding of relay PRR, contact 100, contact 101 of relay RR, contact 102 of release magnet RM, wiper 34, multiple contact 37 to the wiper 34 of the first selector which is connected thereto, contacts 102, 101, and normal contact 100 to ground. The relay PRR remaining energized, secondary magnet SM steps the wipers 34, 35, 36 along to the next set of contacts in the bank and, assuming that they are connected to an idle second selector, relay PRR deënergizes and opens the energizing circuit for secondary magnet SM at contact 98, stopping the wipers 34, 35, 36, which are now in engagement with contacts 37, 38, 39 of second selector V.

The subscriber now operates his calling device once more to send four primary impulses, to be followed by the single secondary impulse. Primary relay PR now energizes and deënergizes to send four impulses from ground at contact 91, through contact 92, conductor L^2, contact 103, wiper 35 and contact 38, conductor L^4, secondary off-normal spring 104, through the winding of primary magnet PM^1 of second selector V, to the live pole of battery B^1, thus energizing and deënergizing primary magnet PM^1 four times and stepping the wipers 40, 41, 42 to the fourth group of bank contacts. This is followed by the secondary impulse to deënergize secondary relay SR a single time, and a circuit is now established from ground at contact 94 of primary relay PR, through contact 95, conductor L^3, contact 105, wiper 36, bank contact 39, conductor L^5, secondary off-normal spring 106, primary off-normal spring 107, which closed upon the first primary movement of the switch, the winding of relay PRR^1, live pole of battery B^1. The relay PRR^1 now becomes energized and moves its armature contacts to their alternate position. A circuit is now established from ground at contact 108, normal contact 109, through the winding of secondary magnet SM^1 to generator G, causing the wipers 40, 41, 42 to advance a single step to engage the first set of contacts 43, 44, 45. Assuming the first two sets of contacts in the bank leading to connectors similar to W have been previously selected, a grounded or busy condition would have been placed upon the multiple contacts 43 of the connectors referred to, as hereinafter described. As soon as the wiper 40 engages bank contact 43 of the first busy connector, a locking circuit for relay PRR^1 is established along the following path: from the live pole of battery B^1, through the winding of relay PRR^1, contact 110, contact 111 of release magnet RM^1, wiper 40, the multiple contact 43 to the contact 43 of the busy connector W, through wiper 40 of the second selector connected thereto, contacts 111, 112 and normal contact 108 of said second selector, to ground. Relay PRR^1 remaining energized, the secondary magnet SM^1 steps the wipers 40, 41, 42 to the second set of contacts, and assuming these to be busy also, relay PRR^1 remains energized and magnet SM^1 steps wipers 40, 41, 42 to engage the third set of contacts 43, 44, 45 of the idle connector W. The locking circuit for relay PRR^1 now being interrupted, due to wiper 40 having reached a contact of an idle connector, the said relay PRR^1 deënergizes and interrupts the circuit for secondary magnet SM^1 at contact 113.

It will be noted that while the wipers 35 and 36 of first selector U are moving over contacts 38 and 39 of busy second selectors V, they are disconnected from first selector U at contacts 103 and 105 of relay PRR. This is to prevent first selector U from interfering with any established connection over which the wipers 35 and 36 are passing when stepping forward to select an idle second selector. This is also true of the wipers 41 and 42 of second selector V, which are disconnected at contacts 114, 115, of relay PRR^1 when the said wipers 41 and 42 are passing over contacts 44 and 45 leading to busy connector switches W.

The calling subscriber M now having established connection with the connector switch W which has access to the one hundred lines in which the called line is located, he operates his dial to transmit five primary impulses, to be followed by a single secondary impulse. The primary relay PR, now deënergizing and energizing five times in response to the impulses transmitted from the calling device in the manner previously described, will transmit five impulses from ground at contact 91, over the previously described path to wiper 41 of second selector V, through contact 44, secondary off-normal contact 52 of connector W, through the winding of primary magnet

PM², to the live pole of battery B², energizing and deënergizing primary magnet PM² to step the wipers 46, 47, 48 of connector W to the fifth group of bank contacts in which the line of subscriber N terminates. On the first movement of the connector switch W, the primary off-normal springs PON² move to their alternate position and contact springs 116, 117, 118 engage their respective contacts. Following the primary impulses just described, a single secondary impulse is sent, deënergizing and energizing secondary relay SR, which transmits one impulse of current from ground at contact 94 over the previously described path to wiper 42 of second selector V, contact 45, secondary off-normal spring contact 53, primary off-normal contact spring 117, through the winding of secondary magnet SM² to the live pole of battery B², to step the wipers 46, 47, 48 forward one step. The wipers of the connector switch W, as before noted, are adjusted in such a manner that it requires two secondary steps to connect to the first set of bank contacts. As the wipers 46, 47, 48 have only been advanced one step, they are still one step from the first set of bank contacts, but the following changes have taken place in the secondary off-normal spring contacts. Secondary off-normal contact 52 upon the first secondary movement of the switch has advanced to its alternate position and made connection to its alternate contact. Contact spring 53 has moved out of engagement with its normal contact, but as yet has not engaged its alternate contact, which does not occur until the second secondary step.

The calling subscriber, now having advanced the connector switch W to the group of ten lines which include the line extending to substation N, operates his calling device 60 to send six primary impulses, to be followed by a secondary impulse, to advance the wipers 46, 47 and 48 to make connection with the bank contacts 49, 50 and 51 of the called line, namely, that extending to substation N. Upon the operation of the dial, the primary relay PR is deënergized and energized six times and thereby six impulses of current are transmitted from ground at contact 91, over the previously described path to secondary off-normal contact 52 of connector switch W. Circuit now may be traced along conductor L⁶, contact 119 of relay R, through the winding of secondary magnet SM² to the live pole of battery B², energizing and deënergizing secondary magnet SM² to advance the wipers 46, 47, 48 six steps to connect with the bank contacts 49, 50, 51, which are the terminals of the called line N, which we have assumed is number 3456. Following the last primary impulse, a single secondary impulse is transmitted from the secondary relay SR, as previously described, to contact 53 of secondary off-normal springs on connector W, through its alternate contact which it engaged on the second secondary step, along conductor L⁷, contact 120 of relay R, the lower winding of relay BR to the live pole of battery B², energizing relay BR and moving its armature contacts to their alternate positions. A complete circuit is now established from substation M along the heavily marked conductors to the substation N, except that it is broken at the relay CR of connector W, which I will term the closing relay.

Called line idle.

We will now assume that the called line is in an idle condition. Upon the energization of the busy relay BR, caused by the last secondary impulse, the upper winding of said relay is connected through alternate contact 121 to the wiper 46, and as we have assumed the called line to be idle, the circuit X^a is in the condition shown and, no locking circuit being established for the busy relay BR, it will deënergize and restore to normal upon the cessation of the last secondary impulse. It will be noted that upon the energization of relay BR, contact 122 of said relay is momentarily closed. This is for the purpose of establishing a circuit from ground at contact 123 of relay RR², through said contact 122, through the winding of relay R to the live pole of battery B², energizing said relay R, which locks itself through contact 124 to ground at contact 123 of relay RR². It will be noted that upon the energization of relay R, the busy relay BR and the secondary magnet SM² are cut off from the line at contacts 119 and 120 of relay R. Upon the deënergization of relay BR, a circuit is established from the ground at relay RG through the winding of said relay, contact 125 of relay R, normal contact 121 of relay BR, wiper 46, bank contact 49, the winding of cut-off relay CO to the live pole of battery B², thus energizing both relay RG and relay CO. The energizing of relay CO disconnects the line relay LR and the live pole of battery B² from the line. The energization of relay RG establishes a connection from ground at interrupter I, through contact 126, contact 127 of relay CR, the winding of "flip-flop" relay FF, to the live pole of battery B², causing the said relay FF to attract and retract its armature 161 to periodically project ringing current from generator G out over limb P¹, through the call-bell 57, condenser 58, back over limb S¹, bank contact 51 and wiper 48, contact 128 of relay RG, and winding of impedance coil 129, returning to the ground at generator G, through the battery B² and its ground connection and ringing the call-bell of substation N.

The called subscriber, in response to the call, now removes his telephone from its switch-hook and a circuit is established from ground at tip relay TR, through the winding of said relay, contact 130, contact 161 of relay FF, wiper 47, bank contact 50, limb P^1, through substation N, back over limb S^1, contact 51, wiper 48, contact 128, through the winding of impedance coil 129 to the live pole of battery B, thus energizing tip relay TR, which now remains energized and is directly under the control of the called subscriber N. Upon the energization of tip relay TR, a circuit is established from ground at contact 131, through the winding of closing relay CR, to the live pole of battery B^2, thus energizing relay CR, which is now locked over a circuit established from the live pole of battery B^2, through the winding of relay CR, locking contact 132, to ground at contact 123 of release relay RR^2. The circuit through relay FF is interrupted at contact 127 of relay CR and relay FF thereby deënergized. Likewise complete connection is established between substations M and N by the closing of contacts 162 and 133 of closing relay CR. With the connection thus established for conversation, transmission current to the calling substation M is supplied from the battery B^5, B^6, and to the called party from battery B^2 over the previously described path, which includes impedance coil 129 and tip relay TR. A grounded or busy condition is also placed upon the bank contact 49 and all of its multiples, traced from the ground through the winding of relay RG. This is to prevent any other subscriber from making connection to the called line, as I shall now describe.

Called line busy.

Now, if it be assumed that the called line is busy by reason of some other connection to it, then, as previously stated, the bank contact 49 will be connected to ground through the winding of the tip relay TR of the connector which is connected to a multiple of contact 49. In such event, following the last secondary impulse, the busy relay BR, which had been momentarily energized through its lower winding, remains locked, by a circuit traced from the ground at contact 49, through wiper 46, alternate contact 121 and the upper winding of relay BR to the live pole of battery B^2. The relay BR now remaining energized, a busy signal is transmitted back to the calling subscriber from the secondary winding of induction coil IC, through condenser 134, closed contact 135 of busy relay BR, back over the upper heavily traced conductor, limb P, through the receiver and condenser at the calling substation M, back over the limb S to ground through connections to conductor L^1. Due to the characteristic busy signal, the calling subscriber will know that the line desired is not available for connection thereto. He will therefore restore his telephone to its switch-hook to cause the release and restoration of the switches and circuits to normal, as will be hereinafter more fully explained.

Before entering upon a description of the release operation, I will first call attention to the operation of reversing relay RVR associated with the first selector U. The purpose of this relay is to reverse the direction of battery flow over the calling line and it is brought into operation upon the response of the called party. Such reversals are commonly employed for operating coin-collecting mechanism, meter mechanism, and the like, at the calling substation. This operation of relay RVR is brought about in the following manner. Upon the response of the called subscriber N, a circuit is established from the live pole of battery B^1 at first selector U, through the winding of relay 136, alternate contact 137 of secondary relay SR, along the lower heavily marked conductor, out over limb S^1, through the telephone of the called substation N, back over limb P^1, bank contact 50, wiper 47, normal contact 161 of relay FF, closed contact 130 of relay RG, through the winding of tip relay TR to ground. Relay 136 of first selector U now being energized, a circuit is established from ground at contact 138, through the winding of reversing relay RVR to the live pole of battery B^1. The connections of battery B^5, B^6, through the primary relay PR and the secondary relay SR to the respective conductors L^2 and L^3, are reversed, due to the closing of armature contacts 139 and 140 of reversing relay RVR. Relay RVR now is locked up by a circuit established through contact 141 to ground at primary off-normal contact 142, which closed upon the first primary movement of the switch. A locking path is also established from the connection to ground at contact 143 of relay PR, the purpose of which will be explained later on.

Release.

Having now fully described the connection from a calling subscriber to both an idle and a busy called subscriber, the next step naturally leads to the consideration of the release of the switches employed in making the connections just described. The circuits of the different switches, used in making the connections, are so arranged that where a connection has been completed for conversation between two subscribers, should the calling subscriber be the first one to restore his telephone to the hook, the line circuit, line selector switch, first selector, and second selector will restore to normal, but

the release of the connector in this instance is under the control of the called subscriber and is restored to normal when he replaces the receiver upon its hook. Should the called subscriber be the first one to restore his telephone to the hook, he will restore the first selector, second selector and connector switches to normal, and in this instance the line circuit and line selector switch will be restored to normal when the calling subscriber restores his telephone to its hook. Again, if the line circuit has been extended through from the calling line to a busy line, the calling subscriber, upon restoring his telephone to the hook, will release all the switches used in making the connection. Likewise, should the subscriber desire, at any time, not to complete any connection once started, he may replace his receiver upon its hook, and all switches, which have been operated up to that time, will be released.

Now, considering the releasing operations just described more in detail, it will be remembered that the relays PR and SR remain energized, due to a circuit established over the line and through the substation of the calling subscriber M. The conversation being finished, we will now assume that the calling subscriber is the first to replace his telephone upon its switch-hook. Relays PR and SR are now deënergized and close their contacts 144, 145, and establish a releasing circuit, traced from ground at release relay RR of first selector U, through the winding of said relay, contacts 145, 144, contact 146 of relay C^1R, and the winding of release relay R^1R of the line selector Q to the live pole of battery B. The release relays RR and R^1R are now energized to effect the release of the line selector and first selector. Due to the energization of the release relay R^1R of line selector Q, the circuit from ground at contact 69, through the winding of clutch magnet CM and cut-off relay CO is broken and the said clutch magnet and cut-off relay are deënergized. The deënergization of clutch magnet CM is instrumental in restoring the relay C^1R to normal, due to the breaking of its locking circuit at contact 78. The said clutch magnet also releases its hold upon the wipers 26, 27, 28, 29 of the line selector, and the release relay R^1R having deënergized upon the breaking of its energizing circuit at contact 146 of relay C^1R, all parts of the line selector Q are restored to normal and again it is available for connection to any calling line of the group with which it is associated. Cut-off relay CO of line circuit X also having deënergized and restored its contacts to normal, all parts of the line circuit X are again at normal and are available for another connection. Now, returning to the release of the first selector U, it will be noted that a locking circuit for release relay RR is established upon its energization, through contact 147, primary off-normal contact 97, the winding of relay PRR, to the live pole of battery B^1, thus energizing the relay PRR also. A circuit through the release magnet is now established from ground at contact 98 of relay PRR, through alternate contact 99 of release relay RR, the winding of said release magnet RM to the live pole of battery B^1, energizing the said release magnet, and due to the mechanical construction of the switch, the wipers and off-normal contacts are restored to their normal position. At the time the calling subscriber restores his telephone to its hook and deënergizes the relays PR and SR, the circuit through the winding of relay 136 is broken at contact 137 of secondary relay SR, thus allowing the relay 136 to deënergize. This has no material effect upon the releasing circuit just described, although it serves to furnish a multiple path from battery B^1, through resistance coil 148, contact 149, contact 150 of relay RVR, and the winding of the release relay to ground. The purpose of this circuit is to establish a release, should the called subscriber hang up first, and will be more fully explained farther on. The first selector having returned to normal and the locking circuit for the reversing relay RVR, through the primary off-normal contact 142 to ground, having been broken, due to the opening of said circuit at contact 142, the reversing relay RVR is deënergized and restored to normal. It will now be noted that all the apparatus included in the line circuit X, line selector Q, and first selector U, have been restored to normal and are available for use in making another connection. The second selector V is also released at the time the calling subscriber restores his telephone in the following manner. Returning now to that point in the release of the first selector U, at which the release relay RR first became energized, it will be noted that a circuit is established from the live pole of battery B^1, through the resistance coil 151, alternate contact 101 of release relay RR, contact 102 of release magnet RM, wiper 34, bank contact 37, contact 152 of the primary off-normal switch PON^2, and the winding of release relay RR^1 to ground, thus energizing the said release relay RR^1 of the second selector V. This energizing circuit is only of short duration, since as soon as enough time has elapsed for the release relay RR of the first selector U, relay PRR and release magnet RM, to energize in the order named, the energizing circuit for release relay RR^1 is broken at contact 102 of release magnet RM. As in the first selector, the energization of release relay RR^1 of the second selector establishes a locking circuit through contact 153,

primary off-normal 107, and the winding of relay PRR¹ to the live pole of battery B¹, thus energizing the relay PRR¹. As in the first selector, a release circuit is now established from ground at alternate contact 108, through alternate contact 109, and the winding of release magnet RM¹ to the live pole of battery B¹, energizing the said release magnet RM¹, which, due to the mechanical construction of the switch, restores the wipers and associated parts to their normal position. The locking circuit established from the ground at release relay RR¹ to the live pole of battery B¹, through the winding of relays RR¹ and PRR¹, is broken at primary off-normal contact 107, upon the restoration of the switch to normal. Thus said relays are deënergized and the circuit for the release magnet RM¹ is broken at alternate contact 109 of release relay RR¹, and the switch and its associated parts, being thus restored to normal, are available for another connection. As previously stated, the calling subscriber having first restored his receiver to the switch-hook, the line selector, first selector and second selector are only restored to normal. Although upon the energization of release relay RR¹ of second selector V, an impulse of current is sent from battery B¹ through the resistance coil 154 and on through the wiper 40 and contact 43, this has no effect upon the connector W, as in tracing the circuit through from bank contact 43, it will be noted that a direct ground is connected thereto at alternate contact 155 of the closing relay CR.

The called subscriber now restores his telephone to its switch-hook, and the circuit, which was established from ground at the tip relay TR, through the winding of said relay, out over the line and through the telephone at N, back over the line and through the impedance coil 129, to the live pole of battery B², is interrupted at the switch-hook 54 and the tip relay TR is deënergized. The release relay RR² is now energized by a flow of current from the live pole of battery B², through resistance coil 156, normal contact 157, contact 158 of relay CR, and the winding of said release relay RR² to ground, energizing the said release relay; and a locking circuit is now established for said release relay through the contact 159, contact 118 of primary off-normal switch PON², and the resistance coil 160, to the live pole of battery B². The relay RR² being energized, the ground is removed from normal contact 123 and the relays R and CR are deënergized and restored to normal. The deënergizing of relay R breaks the circuit through relay RG at contact 125, and the said relay, and also the cut-off relay CO, which were connected in series, are restored to normal. The release relay RR² being energized, the circuit is closed through the release magnet RM², from the live pole of battery B², through the winding of release magnet RM² to ground at alternate contact 123, energizing the said release magnet, which, on account of the mechanical construction of the switch, restores the wipers and off-normal springs to their normal position. The locking circuit for the release relay RR² is broken at primary off-normal contact 118 upon the return of the connector switch to normal. The release relay, now being deënergized, opens the circuit for the release magnet RM², and the connector switch W, with its associated relays and mechanism, is restored to normal and is available for another connection. The cut-off relay CO of line circuit X^a, being deenergized, restores the line circuit X^a to its normal condition and the telephone of the subscriber N is now available for another connection.

Assuming now that the called subscriber was the first to replace his telephone on its switch-hook, the previously described path through substation N would be broken at the switch-hook 54 and the tip relay TR would be deënergized, the same circuit changes would take place as before, and the connector switch W would be released and its associated parts returned to normal. As previously stated, when the called subscriber is the first one to restore his telephone to the hook, he releases the first selector, second selector and connector. The manner in which the connector has been restored being described, I will now describe the manner in which the first and second selectors are released. The called subscriber having replaced his telephone and the circuit being broken at the substation as previously described, relay 136 of first selector U is deenergized and a circuit is closed from the live pole of battery B¹, through resistance coil 148, contact 149, contact 150, and the winding of release relay RR to ground. The release relay RR now becomes energized and is locked up over the path leading through the winding of relay PRR to battery B¹, energizing the relay PRR, which in turn establishes a release circuit for the first selector U as previously described, and a release impulse is repeated to the second selector V as before, releasing the said second selector and restoring it and its associated relays to normal. It will be noted that the relays PR and SR remaining energized, due to the circuit through the calling substation, the reversing relay RVR remains energized, due to the locking circuit established from the ground at contact 143 of relay PR, through contact 141 and the winding of relay RVR to battery B¹. The first selector and all its associated parts, with the exception of the three relays just mentioned, have now been restored to nor-

mal. The calling subscriber, now replacing his telephone on the switch-hook, interrupts the circuit of relays PR and SR at the switch-hook 54 and the said relays PR and SR de-energize, and a releasing circuit for the line selector switch is thereby closed through contacts 144, 145 of the relays PR and SR. The release relay R^1R of the line selector Q is thereupon energized in the previously described manner, releasing the line selector Q and line circuit X, and as the reversing relay RVR became deënergized upon the opening of contact 143 of relay PR, all of the apparatus is now in a normal condition and is available for another connection. If, now, the calling subscriber has made connection to a busy line, the replacing of his telephone on its hook will cause the release of all the switches used in making the connection. The replacing of his telephone causes the deënergization of relays PR and SR, as heretofore explained, and consequently the first selector U and line selector Q immediately return to normal and transmit a releasing impulse to the second selector V, which in turn transmits a releasing impulse from battery B^1, Fig. 1, Part 2, through resistance coil 154, alternate contact 112 of relay RR^1, contact 111 of the release magnet RM^1, wiper 40, contact 43, primary off-normal contact 116 of connector W, normal contact 155 of relay CR, and back through the winding of release relay RR^2 to ground. The release relay RR^2 energizes, closing a circuit for the release magnet RM^2, and the connector W is restored to normal in the manner previously described.

Now, referring to the manner in which a subscriber may release the switches of any partially completed connection, we will assume that the calling subscriber's receiver is removed from the switch-hook and replaced before the dial is moved. In this instance, the line relay LR energizes and remains locked until the line has been selected by line selector Q. This having taken place, the relays PR and SR will, of course, energize; but the subscriber having replaced his telephone on the hook, the circuit at the substation will again be interrupted at switch-hook 54, the relays PR and SR will de-energize, closing a releasing circuit through the contacts 144 and 145 and releasing the line selector Q and line circuit X by a circuit extending from ground at release relay RR of the first selector U, back through the release relay R^1R of the line selector Q. Now, assuming that the calling subscriber has operated his dial a single time, the first selector U will, of course, operate to select an idle second selector V; and the subscriber having replaced his telephone on the switch-hook, the relays PR and SR will deënergize, closing the release circuit through contacts 144 and 145 and restoring the line circuit X, line selector Q and first selector U to normal. If the calling subscriber has operated his dial two times, the second selector V, of course, will have been operated, and should the telephone now be restored to the switch-hook, the relays PR and SR will, of course, de-energize, releasing the line selector Q and first selector U, and a release impulse will be transmitted to the second selector V, restoring it to normal. Should the subscriber extend the line circuit to the connector and operate the dial the third time, causing a primary movement of the connector, and then replace his telephone receiver on its hook, the circuit for relays PR and SR will be broken at the switch-hook 54, releasing the line selector Q, first selector U, second selector V, and transmitting a releasing impulse from the second selector V over the wiper 40, bank contact 42, primary off-normal contact 116, normal contact 155 of relay CR, back through the winding of release relay RR^2, energizing the said release relay, which in turn will operate the release magnet of the connector switch W and restore it to normal. Should the subscriber complete the call and then restore the telephone before the called subscriber has answered, the switches would be released in the manner similar to that just described.

Switch construction.

It is obvious that in the telephone system just described, many different forms of switching devices may be used to perform the different functions described, but I preferably employ switches of the type illustrated in Figs. 2 to 8, inclusive. Referring to Figs. 2 and 3, which illustrate the preferred line selector construction, MM is the motor magnet which, with its associated pawl 205, operates to step the ratchet wheel 206, with its common shaft 25, forward. 207 is an angle iron which serves as a common means of support for the ten line selectors in a group. 208 is a frame which serves as a bearing at one end for shaft 25 and also upon which the bank contacts of each line selector are mounted. At 209 are shown several bank contacts, of which there would be one hundred and ten. In line selector Q, Fig. 1, Part 1, it will be noted that the lines L^2 and L^3 are directly connected to their respective wipers 28 and 29. In the actual construction of the switch, the lines are not directly connected to the wipers, but are connected to the common plates 203, 204, and in this instance the wipers simply serve to connect the common plates 201, 202, 203, 204 to their respective contacts. The wipers 26, 27, 28, 29, are securely fastened to the hub 210, which is loose upon shaft 25. The collar 211, with arm 212, is loosely keyed to shaft 25 by key 213 and moves with shaft 25 when it is stepped forward. As previ-

ously stated, there would be ten banks of contacts 216 and ten clutch magnets CM to each group of line selectors. These would be mounted side by side on angle iron 207 and the wipers of the ten line selectors would be connected to the common shaft 25. Key 214 is similar to key 213 and is the one which would connect to the second line selector. The common shaft 25 is shown broken at its lower extremity, as is also the angle iron 207. These may be extended to the proper length so that the ten line selector switches may be mounted thereon. 215 is a catch pin projecting from the hub 210 and engaged by arm 212. Now as to the operation of the switch when the motor magnet MM advances the common shaft 25, collar 211 is carried around with the shaft and, due to the arm 212 engaging catch pin 215, the hub 210, with its associated wipers, is also carried forward with the shaft. As soon as the wipers 26, 27, 28, 29 engage a calling line, the clutch magnet will energize and move collar 211 with its arm 212 downward to disengage the catch pin 215; and the wipers, being free from their engagement with the shaft 25, remain in connection with the selected line. It is obvious that should the motor magnet MM advance the shaft 25 forward once more, the wipers 26, 27, 28 and 29 of the busy line selector will remain in engagement with their selected contacts so long as clutch magnet CM is energized, but wipers of the other idle line selectors will advance with the shaft to select a calling line. When the clutch magnet CM is deënergized, which occurs when the calling subscriber has restored his telephone to its switch-hook, the collar 211 will move upward and the arm 212 will now be in a position to engage catch pin 215 once more when it comes around to advance the wipers 26, 27, 28 and 29 forward.

Figs. 4 to 8, inclusive, illustrate the preferred form of structure for the first and second selectors and, with a slightly different adjustment of the wipers and secondary off-normal springs, for the connectors also. The switch comprises the frame 300, the primary shaft 301, the secondary shaft 302, the wipers 34, 35, 36, primary magnet PM, secondary magnet SM, release magnet RM, the primary off-normal switch PON, secondary off-normal switch SON and ten banks of contacts, as shown at 303 in Figs. 4 and 6. The bank contacts, as shown in Figs. 4, 5 and 6, are arranged in a bank forming the segment of a sphere with the ends of the said bank contacts pointing toward the sphere's center. The wipers 34, 35 and 36 are pivotally mounted on primary shaft 301 and also have a sliding connection at 304 with the secondary shaft 302. In the lower portion of Fig. 5, a bank of one hundred sets of contacts is indicated. For each line, whether subscriber's line or trunk line, there are three contacts 37, 38 and 39. In Figs. 4 and 6, but a single row or section of ten sets of contacts is shown, but it is to be understood that there are ten such sets for each switch. In operation, the primary magnet PM, by means of its armature and pawl 305, operates to step the ratchet wheel 306 forward to advance the wipers 34, 35 and 36 to the desired group of bank contacts. Check pawl 307 prevents the return of the wipers until the said pawl is operated by the release magnet RM. Upon the first step of the primary magnet, the arm 308, which is secured to the primary shaft 301, moves the insulated pin 309 toward the left and the primary off-normal springs PON move to their alternate position and remain so until the primary shaft returns to normal. Having moved the wipers opposite to the bank with which connection is desired, the secondary magnet SM is now operated, and through the action of its armature and pawl 310, the secondary shaft 302 is moved downward. Due to the sliding connection at 304 between the wipers and secondary shaft 302, the wipers are advanced one step upward along the row of bank contacts for each operation of the secondary magnet SM. In the operation of the secondary off-normal switch SON, it will be noted that a sliding bar 311 is located alongside of the secondary shaft 302 and bearing in the upper and lower parts of frame 300. The secondary off-normal springs SON normally rest under tension upon a projection 312 of the sliding bar 311, which in turn, being free to move downward through its bearings in the frame 300, rests upon the block 313, which is securely fastened to the secondary shaft 302. Upon the first downward movement of secondary shaft 302, block 313, being carried with it, allows the sliding bar 311 to move downward, and as the secondary off-normal springs rest upon the projection 312 at the upper end of sliding bar 311, the springs are moved to their alternate position. They remain in this position until the shaft 302 is restored to normal. Having described the manner in which the switch is operated to make connection to a set of bank contacts, the method of releasing will now be considered. To release the switch and restore all its parts to their normal condition, the release magnet RM is energized and attracts its armature, and the lower extremity 314 of the armature engages the check pawl 307 and moves it out of engagement with ratchet wheel 306. The projection 315 of check pawl 307 engages the check pawl 316 and moves it out of engagement with the secondary shaft 302. The two shafts are now restored to normal, due to being under tension of their respective restoring springs 318, 319. To prevent the wipers from rubbing against the sides of the contacts in re-

leasing, due to being under the tension of the spring 317, a small key 319 is provided upon the sliding bar 311. Upon the first downward movement of the secondary shaft 302, the bar 311 also moves downward and the key 319 engages a tooth in the ratchet wheel 306, as shown in Fig. 8. Now when the two retaining pawls 307 and 316 are moved from engagement with their respective ratchets, the secondary shaft 302 first returns to normal and the block 313, which is fastened to it, moves upward and engages the sliding bar 311 and moves it upward to normal, while the key 319 disengages the ratchet wheel 306 and allows the primary shaft 301 to return to normal.

The mechanism of the connector is similar to that described in Figs. 4 to 8, inclusive, except that the wipers are adjusted so as to be two steps distant from the first set of bank contacts and the secondary off-normal springs are provided in number and adjustment as previously described and as indicated in Part 3 of Fig. 1.

In Fig. 9 of the drawing, I have shown a line circuit X^1 and line selector switch Q^1, which are modified in certain respects from those shown in Fig. 1. In the line selector Q^1, the common shaft 25 is constantly rotated by the motor magnet MM, while in the line selector Q (Fig. 1), the common shaft 25 is rotating only while moving the wipers of the idle line selectors to make connection to a calling line. And in the line circuit X^1, there is but one relay,—the cut-off relay CO. By using the constantly rotating shaft 25, it is possible to use a very simple line circuit. These line and line selector circuits X^1 and Q^1 will operate in connection with the first selector U, second selector V and connector W, the same as the circuits X and Q of Fig. 1. And in operation, the subscriber M, desiring to make a call, removes his receiver from its switch-hook and closes a circuit which may be traced from the live pole of battery B, through resistance coil 61, contact 62, conductor L^1, out over limb S, through the substation and back over limb P of the line, conductor L, and contact 400 of cut-off relay CO, to the multiple contact 31. As previously stated, the wipers of the different line selectors, associated with the common shaft 25, are constantly stepping around over the passive contacts of the said line selectors, and consequently as soon as the wipers 26, 27, 28, 29, of the line selector Q^1 (assuming them to be the nearest to their passive contacts) reach their contacts 30, 31, 32, 33, battery will flow over the previously described path to contact 31, over wiper 27, through the winding of clutch magnet CM to ground at contact 69 of release relay R^1R, energizing the said clutch magnet CM and stopping the wipers 26, 27, 28 and 29 in engagement with the contacts 30, 31, 32 and 33 of the calling line. Upon the energization of clutch magnet CM, a circuit is established through the locking contact 70, wiper 26 and contact 30, then through the winding of cut-off relay CO to the live pole of battery B, energizing the said cut-off relay, and the two relays remain energized until their locking circuit is broken at contact 69 of release relay R^1R. The energization of cut-off relay CO breaks the initial energizing circuit for the clutch magnet CM at contacts 400 and 62. Now, by placing Fig. 9 of the drawing to the left of Fig. 1, Part 2, and the latter to the left of Fig. 1, Part 3, it will be noted that after the energization of the clutch magnet CM, the same circuit changes take place at first selector U as described in connection with Fig. 1, Parts 1 and 2. In extending his line circuit beyond the first selector, the calling party operates his calling device 60 and the connection is completed in the manner described in connection with the system disclosed in Fig. 1, Parts 1, 2 and 3. At the time the line selector Q^1 makes connection with the calling line, a busy condition, or ground, is placed upon the contact 49^1 to prevent any connector from making connection to that line. The circuit just referred to is traced from the ground at contact 69 of release relay R^1R, through the winding of clutch magnet CM, locking contact 70, wiper 26, bank contact 30, to bank contact 49^1 which is associated with contacts 50^1, 51^1 which are located at the connector having access to the line of substation M. Now, assuming that the calling subscriber has completed connection to the desired substation and conversed with the desired party, then upon replacing his telephone upon its switch-hook, the circuit for the relays PR and SR, which extended through said subscriber's transmitter, is broken and said relays deënergize and establish a release circuit similar to that described in connection with Fig. 1. Upon the establishment of this circuit, release relay R^1R of the line selector Q^1 is energized and opens the circuit established from ground at 69 through the clutch magnet CM and the cut-off relay CO; and as a consequence, the line selector circuit Q^1 and the line circuit X^1 are restored to their normal condition and are available for another connection.

When the subscriber at station M restores his receiver to its hook and the clutch magnet CM is deënergized, the wipers 26, 27, 28, 29, which have been held in engagement with the bank contacts 30, 31, 32, 33, are free to be picked up by the constantly rotating shaft 25 and are now stepped around until stopped in connection with another calling line. It is obvious that any suitable

means may be used to constantly rotate shaft 25, and I do not wish to be limited to the specific means shown.

In Fig. 10 of the drawing, I have illustrated other modified line and line selector circuits X^2 and Q^2. The line selector Q^2 differs from that of Fig. 1 in that the shaft 25 makes one complete revolution each time it is started. This is for the purpose of picking up any sets of wipers which have been disengaged from the clutch magnets after a connection has been released, so that it will require less time to make connection to a calling line after a call has been initiated. The operation of the line selector Q^2 in connecting to a calling line and again releasing therefrom, is the same as that of the line selector Q of Fig. 1, except as to the operation of the added contacts 503 and 504 which are for the purpose of closing a circuit through the motor magnet MM at the time of release. The closing of this circuit causes the initial energization of the motor magnet MM to advance the shaft 25 one revolution so it may pick up the wipers 26, 27, 28 and 29 after they are released. The line circuit X^2 operates the same as the line circuit X of Fig. 1. Now, placing Fig. 10 of the drawing to the left of Fig. 1, Parts 2 and 3, as heretofore, and assuming that the subscriber at substation M desires to converse with called party, the removal of his receiver from its switch-hook will close a circuit from the live pole of battery B out over the line, through substation M, back over the line, through the winding of the line relay LR to ground, energizing the line relay which is locked up in a manner similar to that described in Fig. 1 and closes a circuit from the ground at contact 66, through the winding of motor magnet MM, to the ungrounded side of generator G. The motor magnet MM now operates to step the wipers 26, 27, 28, 29, to seek connection with the calling line, and upon reaching their respective contacts 30, 31, 32, 33, an energizing circuit will be established for the clutch magnet CM which operates to disengage the wipers 26, 27, 28 and 29 from the shaft 25 and leave them in connection with the terminals of the calling line. Upon the first step of the shaft 25, the contact spring 501, which normally rests upon the insulated pin 502, moves out of engagement with the said pin 502 and a circuit is established from ground at contact 505, through contact spring 501, the winding of off-normal relay OR, to the live pole of battery B, energizing the said off-normal relay OR and establishing a circuit from ground at contact 500, through the winding of motor magnet MM to the ungrounded side of the grounded generator G. The circuit traced from the ground at contact 66 of the line relay LR, which initially energized the motor magnet MM, is broken at the time the lime selector connects with the calling line, but the off-normal relay OR having been energized and having established a circuit from the contact 500 through the winding of the motor magnet MM, the shaft 25, with its connected wipers, is stepped around until the insulated pin 502 again engages the spring 501, interrupting the circuit through the off-normal relay OR, which in turn interrupts the circuit from the ground at contact 500 through the motor magnet MM, and stopping the further movement of the shaft 25. When line selector Q^2 connects to the calling line, the same circuit changes take place at the first selector U and the line selector Q^2 as were described in connection with the selection of a line in connection with Fig. 1. After the subscriber at substation M has completed a connection and finished conversation, he replaces his receiver upon its switch-hook. This results in a releasing circuit being established through the release relay R^1R, which in turn opens the circuit for the clutch magnet CM and the cut-off relay CO, and the clutch magnet in turn opens the locking circuit for the relay C^1R, and the latter deënergizes and restores its armature contacts to their normal position. The release relay R^1R is provided with any suitable means, such as a copper sleeve over its core, for rendering it slow to release its armature when its energizing circuit is broken. As the relay C^1R must retract its armature, thereby opening the circuit through relay R^1R, before the said relay R^1R can release, a momentary circuit is closed from the ground at contact 503 of relay C^1R through the contact 504 of the release relay R^1R, then through the winding of the motor magnet MM to the ungrounded side of the generator G. The motor magnet MM then steps the shaft 25 forward, again closing a circuit from the ground at contact 505, through the winding of the off-normal relay OR to the live pole of battery B, whereupon the latter closes a circuit from ground at contact 500, through the motor magnet MM to the generator G and the shaft 25 is stepped around until the circuit through the off-normal relay OR is again broken at contact 505, 501, which in turn opens the circuit through motor magnet MM and the shaft 25 comes to rest. As the shaft 25 has made a complete revolution, it has picked up the wipers 26, 27, 28, 29 and restored them to their normal resting place. 506 designates a common connecting point from the armature contacts 504 of the other nine line selectors in the group. Thus it will be seen that every time a connection is made to a line by the

line selector Q^2, or is broken, the shaft 25 will make one complete revolution.

I claim:

1. A telephone system comprising a plurality of telephone lines, a plurality of line selectors for connecting to and extending the talking circuit of said lines, means including a common driving device operative upon initiation of a call over one of said lines to start all of said selectors to seek connection with said line, and means for stopping one of said line selectors when it has connected with said line, said last means including an electromagnet provided with a locking circuit including mechanism individual to said line.

2. A telephone system comprising a plurality of telephone lines, a plurality of line selectors, each including a set of wipers for connecting to and extending the talking circuit of said lines, means including a common driving device operative upon initiation of a call over one of said lines for advancing all of said wipers to seek connection with said line, and means for stopping one of said sets of wipers when it has connected with said line, said stopping means including an electromagnet having a locking circuit including a contact individual to said line.

3. A telephone system comprising a plurality of telephone lines, a plurality of line selectors, each including a set of wipers for connecting to and extending the talking circuit of said lines, a common shaft supporting all of said wipers, means operative upon initiation of a call over one of said lines for operating said shaft to advance all of said wipers to seek connection with said line, and electromagnetic means for stopping one of said sets of wipers when it has connected with said line, said means being provided with a retaining circuit including a wiper of said set of wipers.

4. A telephone system comprising a plurality of telephone lines, a plurality of normally passive line selectors, each including a set of wipers for connecting to and extending the talking circuit of said lines, a common shaft supporting all of said wipers, electromagnetic means effective upon initiation of a call for operating said shaft to advance all of said wipers to seek connection with a calling line, an electromagnet for stopping one of said sets of wipers when it has connected with said line, and a retaining circuit for said electromagnet including a wiper of said set of wipers.

5. A telephone system comprising a plurality of telephone lines, a cut-off relay for each line, a plurality of line selectors, each including a set of wipers for connecting to and extending the talking circuit of said lines, a clutch magnet for each said set of wipers, means operative upon initiation of a call over one of said lines for advancing all of said wipers to seek connection with said line, and means for closing a series circuit through the cut-off relay of said line and one of said clutch magnets when its associated set of wipers have connected to said line.

6. A telephone system comprising a plurality of telephone lines, a cut-off relay for each of said lines, a plurality of normally passive line selectors for connecting to and extending the talking circuit of said lines, a common driving means effective upon initiation of a call for operating said line selectors, means operative upon initiation of a call over one of said lines to place said line in condition for selection by any one of said line selectors, and electromagnetic stopping means for one of said line selectors included in circuit with the cut-off relay of said line when said selector has connected with said line.

7. A telephone system comprising a calling line, a plurality of normally passive line selectors for connecting to and extending the talking circuit of said line, a common driving means for operating all of said line selectors to seek connection with said line effective upon initiation of a call over said line, means for stopping one of said line selectors when it has connected with said line, and means for operating said common means when said calling line desires disconnection.

8. A telephone system comprising a plurality of telephone lines, a plurality of normally passive line selectors, each including a set of wipers for connecting to and extending the talking circuits of said lines, a common shaft connected to all of said wipers, electromagnetic means effective upon initiation of a call for operating said shaft to advance all of said wipers to seek connection with a calling line, means adapted upon initiation of a call over said calling line to place said line in condition for selection by any one of said sets of wipers, a clutch magnet for each said set of wipers, means for operating one of said clutch magnets, when its associated set of wipers have connected to said line, to disconnect said wipers from said shaft, and a retaining circuit for said clutch magnet including one of said wipers.

9. A telephone system comprising a calling line, a plurality of line selectors, each including a set of wipers for connecting to said line, a single wound clutch magnet for each said set of wipers, means operative upon initiation of a call over said calling line for advancing all of said wipers to seek connection with said calling line, a circuit adapted when a set of said wipers have connected to said calling line to operate its associated clutch magnet to hold them in connection with said line and extend the talking circuit thereof through said set of wipers.

10. A telephone system comprising a plu-

rality of telephone lines, a line relay for each line energized upon the initiation of a call, a cut-off relay for each line, a plurality of line selectors having access to said lines, electromagnetic means common to and adapted for advancing said line selectors to connect with said lines, a circuit closed upon the operation of one of said line relays to operate said electromagnetic means to advance said line selectors to seek connection with a calling line, an electromagnet for stopping one of said line selectors when it has connected with said line, a circuit for said electromagnet including one of said cut-off relays, a link circuit for establishing a conversational circuit with a called line, and means under the control of the calling line to operate said electromagnet to disconnect said line selector from said line.

11. A telephone system comprising telephone lines, line selectors for connecting to and extending the talking circuits of said lines, means for rendering some of said line selectors busy, a common driving means operative responsive to initiation of a call over one of said lines to start the idle ones of said selectors to seek connection with said line, and means for stopping one of said line selectors upon connection with said calling line for extending the talking circuit thereof, said means including a clutch magnet provided with a series control circuit including a cut-off relay individual to said telephone line.

12. A telephone system comprising telephone lines, cut-off relays for said telephone lines, line selectors provided with clutch controlling magnets, each selector including a set of wipers and circuit connections thereto, for connecting to and extending the talking circuits of said lines, means for rendering certain of said selectors busy, motor mechanism common to said selectors operative responsive to initiation of a call over one of said lines for advancing the wipers of the idle ones of said selectors to seek connection with said line, and means for stopping one of said idle sets of wipers when it has connected with said line by including a clutch controlling magnet in series circuit with a subscriber's cut-off relay.

13. A telephone system comprising telephone lines, line selectors, each including a set of wipers and circuit connections thereto, for connecting to and extending the talking circuits of said lines, a common shaft supporting all of said wipers, means for rendering certain of said wipers busy, motor mechanism operative upon initiation of a call over one of said lines for operating said shaft to advance the idle ones of said wipers to seek connection with said line, and a circuit including the magnet of an idle one of said selectors in circuit connection with the cut-off relay of a calling one of said telephone lines whereby the wipers of said selector are stopped in connection with said telephone line.

14. A telephone system comprising telephone lines, line selectors, each including a set of wipers and circuit connections, for connecting to and extending the talking circuits of said lines, a common source of motive power for advancing said wipers, a clutch magnet for each set of wipers, means for rendering certain of said wipers busy, means effective upon initiation of a call over one of said lines to cause said motive power to advance the idle ones of said wipers to seek connection with said line, means for operating one of said clutch magnets when its associated set of wipers have connected with said line, and a locking circuit for said clutch magnet including a wiper of one of said sets of wipers.

15. A telephone system comprising telephone lines, line selectors for connecting to and extending the talking circuits of said lines, passive contacts for said selectors multiply connected as terminals of said lines and normally unselectable, a common motor mechanism for operating said line selectors, means for rendering certain of said selectors busy, means effective upon initiation of a call over one of said lines to place said line in condition for selection and to cause said motor mechanism to effect an operation of the idle ones of said line selectors, means for stopping one of said line selectors upon connection with said calling line, and means for operating said common motor mechanism when said calling subscriber releases.

16. A telephone system comprising telephone lines, normally passive line selectors for connecting to and extending the talking circuits of said lines, a common driving device effective upon initiation of a call over one of said lines for operating the idle ones of said line selectors to seek connection with said line, means for stopping an idle one of said line selectors upon connection with a calling line, and a locking circuit for said means including mechanism individual to said calling line.

17. A telephone system comprising substation telephones lines, a line relay for each line adapted to be energized upon initiation of a call, a cut-off relay for each line, line selectors having access to said lines, a common motor mechanism for advancing said line selectors to connect with said lines, circuit connections effective upon the operation of one of said line relays to render said motor mechanism operative to advance the idle ones of said line selectors to seek connection with a calling line, electromagnetic means for stopping one of said line selectors upon connection with said line, a locking circuit for said electromagnetic means including the winding of one of said cut-off

relays, a link circuit for establishing a conversational circuit to a called line, and means controlled at the substation of the calling line to operate said electromagnetic means to disconnect said line selector from said line.

18. A telephone system comprising telephone lines, a plurality of link circuits for extending the talking circuit of said line, normally passive selector switches for connecting said lines and link circuits interchangeably, a common operating magnet for said selectors, means effective upon initiation of a call over one of said lines to cause said magnet to operate the idle ones of said selectors to connect a calling line with an idle link circuit, means for disconnecting said calling line from said link circuit, and means for operating said common magnet responsive to the disconnection of said line from said link circuit.

19. A telephone system comprising telephone lines, link circuits for extending the talking circuit of said lines, line selectors for connecting said lines and link circuits interchangeably, a common driving means effective upon initiation of a call over the metallic circuit of a calling line for operating the idle ones of said selectors to connect a calling line with an idle link circuit, and means for operating said common means when said calling line is disconnected from said link circuit.

20. A telephone system comprising telephone lines, link circuits for extending the talking circuits of said lines, selector switches for connecting said lines and link circuits interchangeably, a driving magnet for said switches, a relay effective upon initiation of a call over the metallic circuit of a telephone line to close a circuit through said magnet for operating the idle ones of said selectors to connect the calling line with an idle link circuit, means for disconnecting said calling line from said link circuit, and means for operating said driving magnet when said disconnection takes place.

21. A telephone system comprising telephone lines, link circuits for extending the talking circuits of said lines, selector switches individual to said link circuits for connecting said lines and link circuits, means including a common driving motor effective upon initiation of a call over the metallic circuit of a telephone line, for operating the idle ones of said selectors to connect the calling line with an idle link circuit, and means responsive to the disconnection of said calling line from said link circuit for reoperating said common driving motor.

22. A telephone system including a plurality of telephone lines, a plurality of line selectors for connecting to and extending the talking circuit of said lines, means operative upon initiation of a call over one of said lines to start all idle selectors to seek connection with said line, means for stopping one of said line selectors when it has connected with said line, a directively controlled selector connected to said line selector having a contact maker movable in one direction to select groups of lines and movable in another direction to select lines in a group and a connector switch for extending the circuit of said line to a called line.

23. A telephone system comprising a plurality of telephone lines, a plurality of line selectors, each including a set of wipers for connecting to and extending the talking circuit of said lines, means operative upon initiation of a call over one of said lines for advancing all of said wipers to seek connection with said line, means for stopping one of said sets of wipers when it has connected with said line, and directively controlled selectors individually connected to the line selectors and connector switches for extending the circuit of said line to a called line, each of said directively controlled selectors and connectors being provided with a contact maker movable in one direction to select groups of lines and movable in a second direction to select a line in a group.

24. A telephone system comprising telephone lines, line selectors for connecting to and extending the talking circuits of said lines, means for rendering some of said line selectors busy, a common driving means operative responsive to initiation of a call over one of said lines to start the idle ones of said selectors to seek connection with said line, means for stopping one of said line selectors upon connection with said calling line for extending the talking circuit thereof, and directively controlled selector and connector switches for extending the circuit of said line to a called line, each of said directively controlled selector and connector switches having a contact maker movable in one direction to elect groups of lines and in a second direction to connect with a line in the elected group.

25. A telephone system comprising telephone lines, a plurality of link circuits for extending the talking circuit of said line, normally passive selector switches for connecting said lines and link circuits interchangeably, a common operating magnet for said selector switches, means effective upon initiation of a call over one of said lines to cause said magnet to operate the idle ones of said selectors to connect a calling line with an idle link circuit, and directively controlled selector and connector switches for extending the selected link circuit to a called telephone line, each of said directively controlled selectors having a contact maker movable in one direction to elect groups of lines and movable in another direction to select lines in the groups.

26. A telephone system comprising telephone lines, link circuits for extending the talking circuits of said lines, selector switches individual to said link circuits for connecting said lines and link circuits, means effective upon initiation of a call over the metallic circuit of a telephone line, for operating the idle ones of said selectors to connect the calling line with an idle link circuit, and directively controlled selectors individually connected to the link circuits and connector switches for extending the selected link circuit to a called telephone line, each of said directively controlled selectors having contact wipers movable in one direction to select groups of trunk lines and movable in another direction to select idle lines in the groups of lines.

27. A telephone system comprising telephone lines, line selectors for connecting to and extending the talking circuit of said lines, first selector switches individually connected to the line selectors, each of said first selector switches having contact wipers movable in one direction to elect groups of trunk lines and movable in another direction to select idle trunk lines in the elected group, connector switches, means operative upon initiation of a call over one of said lines to start the idle line selectors to seek connection with the calling line and for stopping one of said line selectors when it has connected with said line, and means controlled at the calling substation for operating a first selector and connector to extend the connected line selector circuit to a called line.

28. A telephone system comprising telephone lines, line selectors for connecting to and extending the talking circuit of said line, means operative upon initiation of a call over one of said lines to start the idle ones of said selectors to seek connection with the calling line, means for stopping one of said selectors when it has connected with said line, and calling substation directively controlled selector and connector switches for extending the circuit of the connected line selector to a called line, each of said directively controlled selectors having contact wipers movable in one direction to elect groups of trunk lines and movable in a second direction to select idle trunk lines in the elected groups.

29. A telephone system comprising telephone lines, line selectors each including a set of wipers for connecting to and extending the talking circuit of said lines, means operative upon initiation of a call over one of said lines for advancing the wipers to seek connection with said line, means for stopping one of said sets of wipers when it has connected with said line, and directively controlled selector and connector switches under calling substation control for extending the circuit of the connected line selector to a called line, said directively controlled selector having a contact maker movable in one direction to elect groups of trunk lines and movable in a second direction to select an idle trunk line in the selected group.

Signed by me at Chicago, county of Cook, and State of Illinois, in the presence of two witnesses.

GEORGE E. MUELLER.

Witnesses:
CAROLYN WEBER,
J. E. HILBISH.