T. H. FERGUSON.

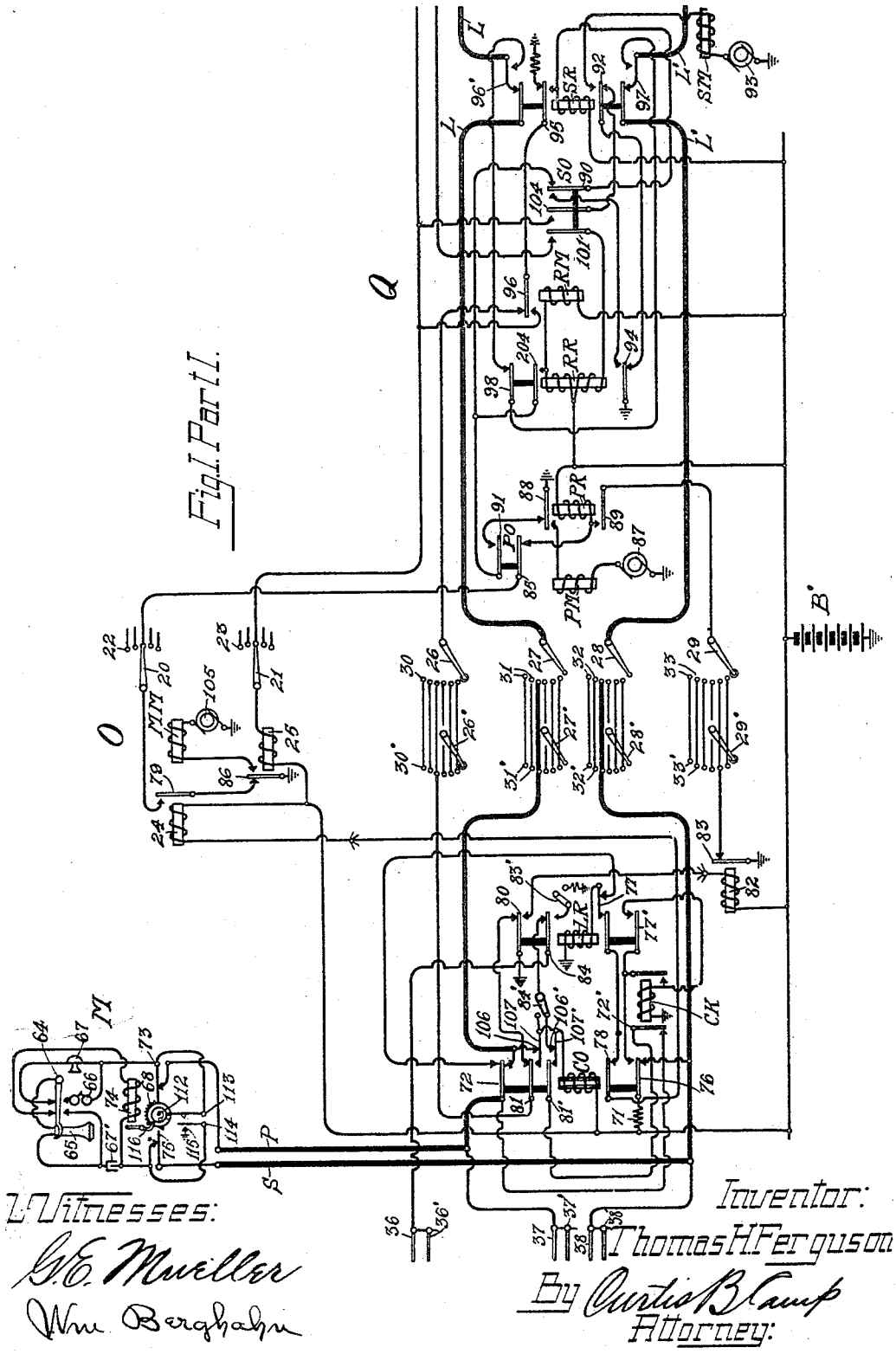
TELEPHONE SYSTEM.

APPLICATION FILED AUG. 15, 1912.

1,235,302.

Patented July 31, 1917.

6 SHEETS—SHEET 1.



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6 SHEETS—SHEET 2.

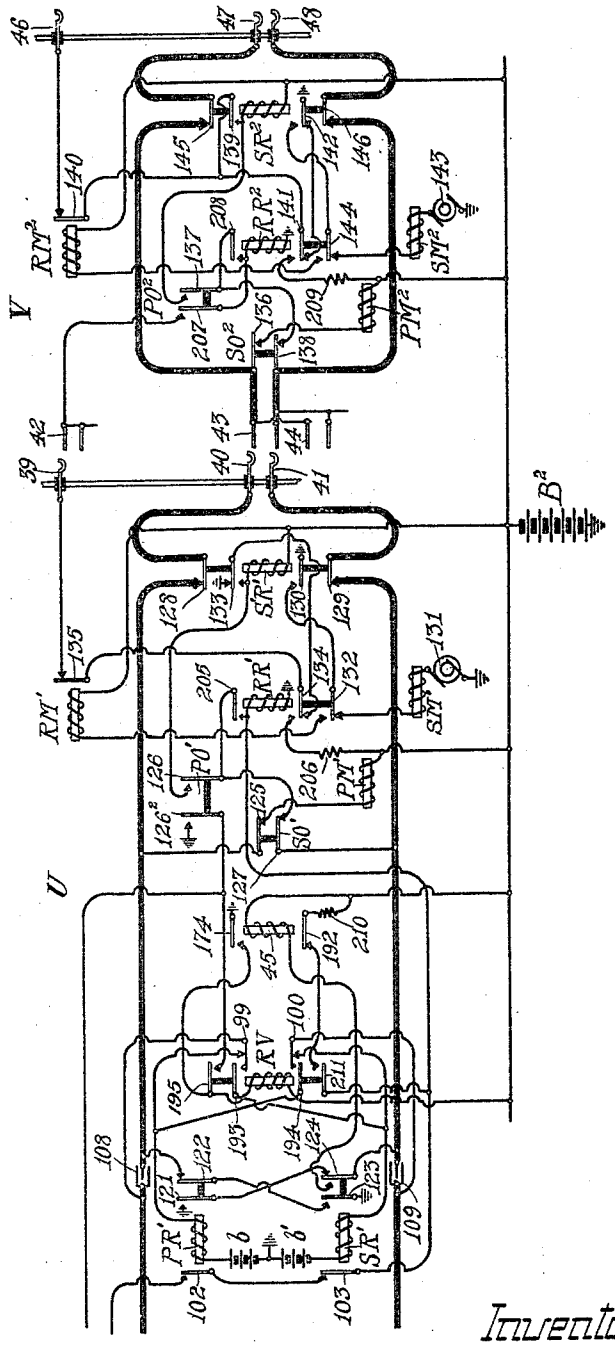

Fig. 1 Part 2.

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6 SHEETS—SHEET 3.

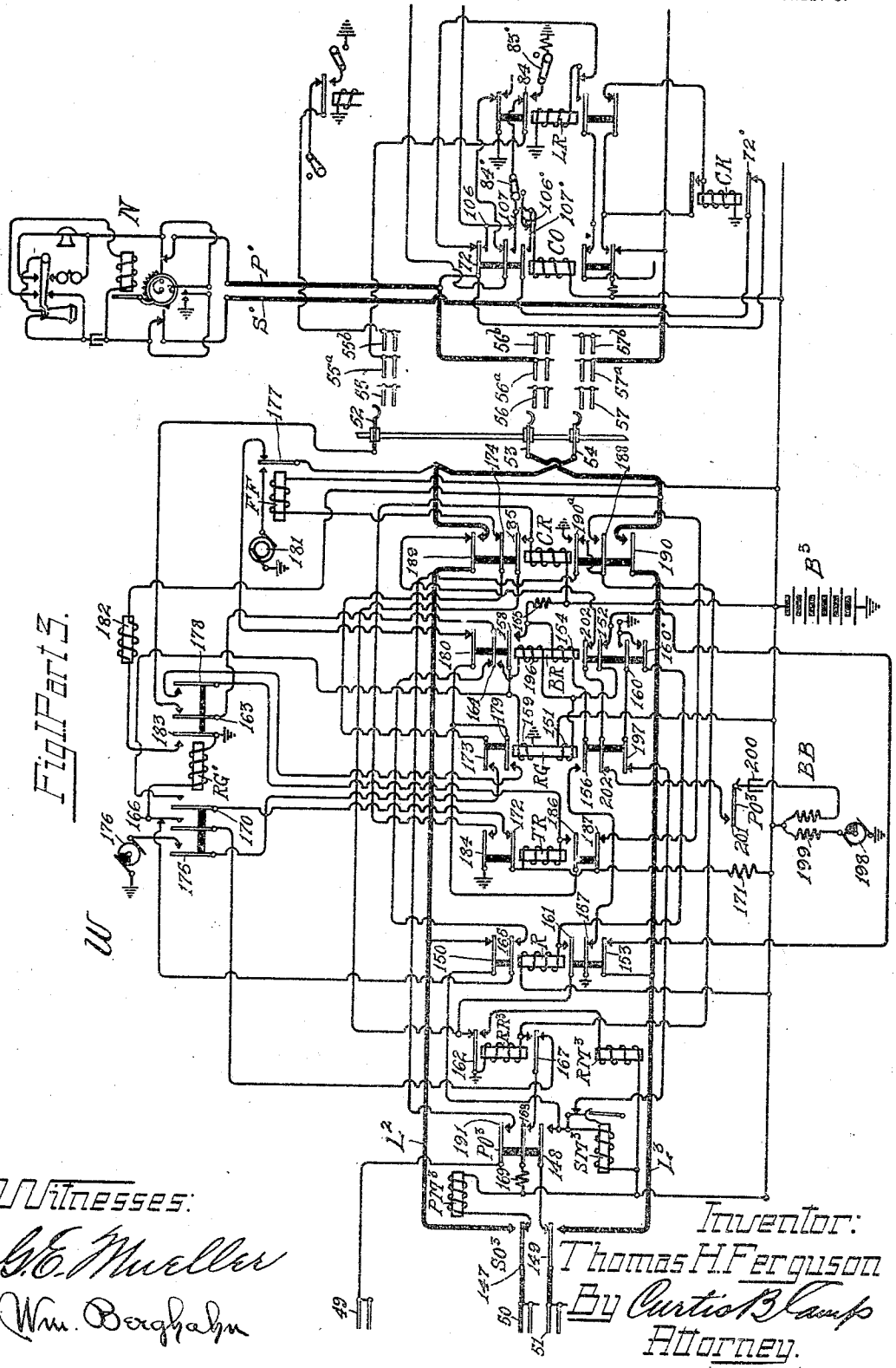

Fig. 1 Part 3.

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6 SHEETS—SHEET 4.

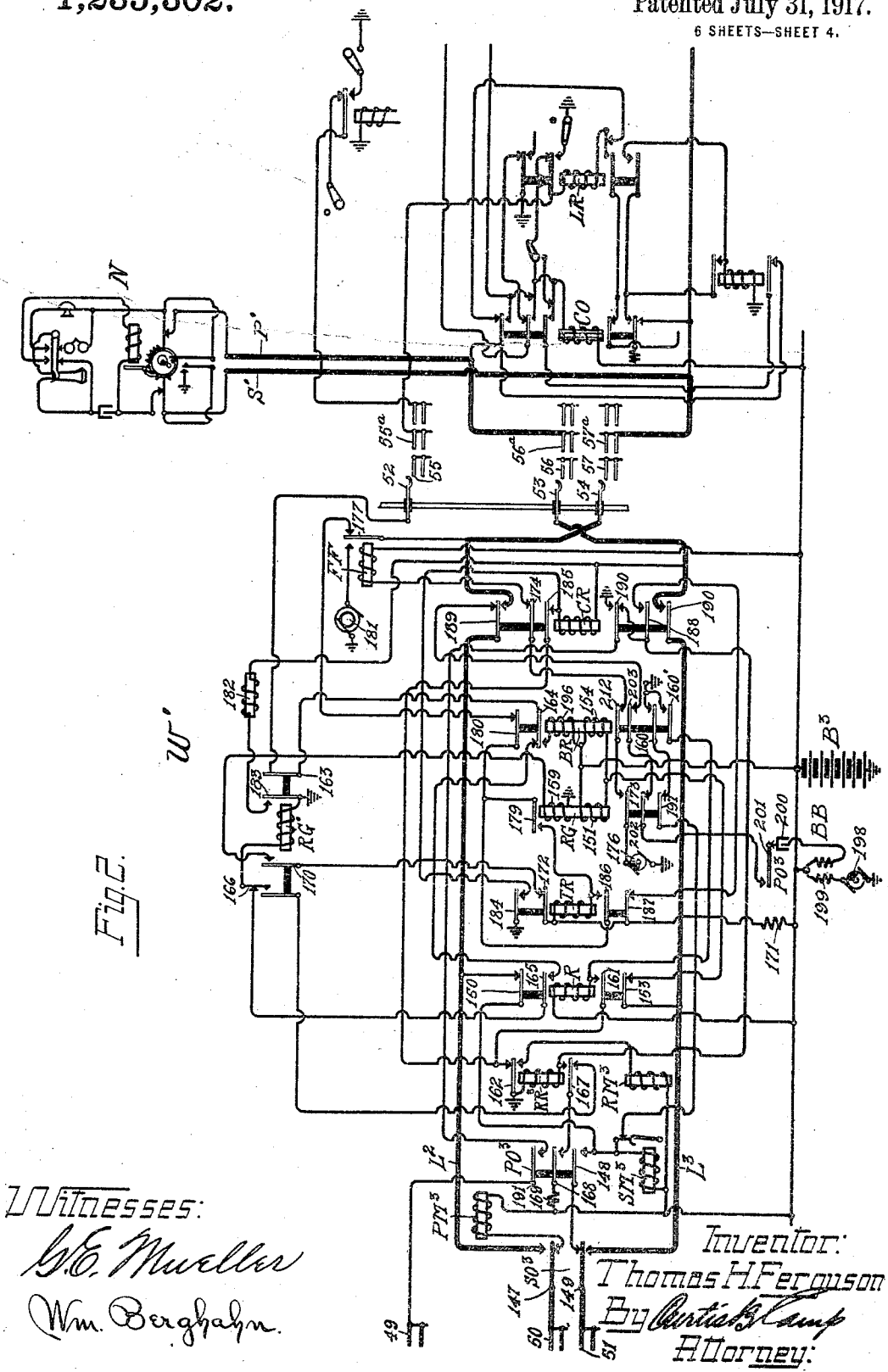

Fig. 2.

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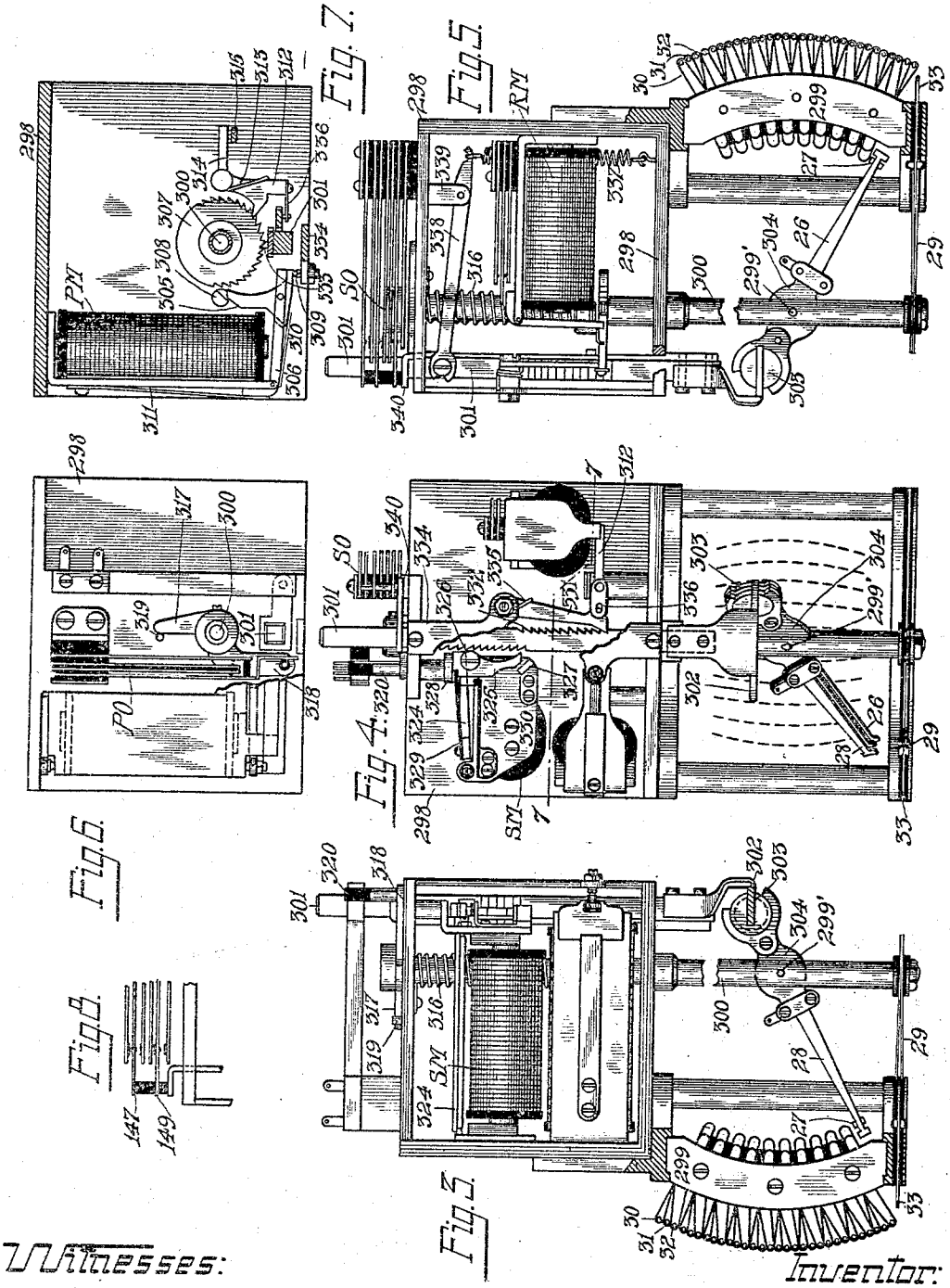
6 SHEETS—SHEET 5.



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6 SHEETS—SHEET 6.

Fig. 9.

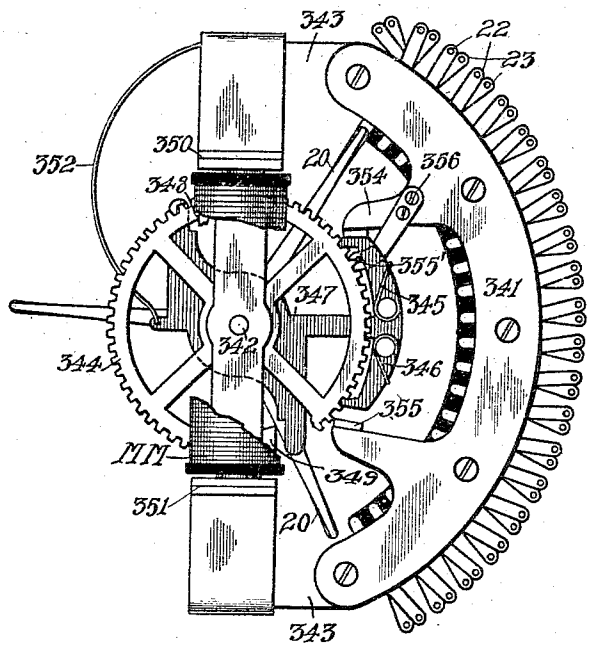
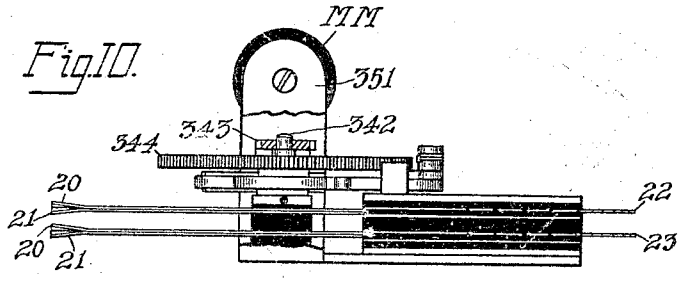


Fig. 10.



Witnesses:

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UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

1,235,302. Specification of Letters Patent. Patented July 31, 1917.

Application filed August 15, 1912. Serial No. 715,170.

To all whom it may concern:

Be it known that I, THOMAS H. FERGUSON, a citizen of the United States, residing in Oak Park, county of Cook, and State of Illinois, have invented new and useful Improvements in Telephone Systems, of which the following is a specification.

The present invention relates to automatic telephone systems generally, and more particularly to that class in which a number of lines extend to one location, such as a private branch board, and are severally called by transmitting impulses corresponding to a single number.

Heretofore it has been the practice, where a number of lines have run to a private branch board, (1) to give each line a separate number so that it may be called just as any other number, or (2) to assign one number to the several lines and to provide a so-called "selector connector" which, when stepped to the contacts of the first of said lines, would automatically step into engagement with the contacts of the second line if the first be found to be busy, and would continue its advance until it found an idle one of said lines; or if all of said lines were busy, it would step to an extra set of contacts, from which a busy back signal would be transmitted to the calling party. The latter arrangement, although a decided advance over the former, because of the saving of time in obtaining connection with the branch board, nevertheless requires a large number of "dead", or extra, contacts on its connectors which, on the average, would approximate anywhere from twenty to forty per cent. of the total number of contacts.

The object of the present invention is to avoid the necessity of using these extra busy back contacts and to transmit the busy back signal from the last line of the group running to the branch board in case it is also found busy. By this arrangement, the so-called extra contacts may be utilized as the terminals of other lines, and the connectors thus given their full quota of connections.

Another object of the invention is to bring about this economy of contacts without increasing the number of relays or other substantial parts of prior systems to which the invention is applicable.

In carrying out my invention, I associate, with the testing wiper of the "selector connector", apparatus which will (1) apply ringing current, (2) step the connector ahead one step, and (3) transmit a busy back signal to the calling party, in exact accordance with three different electrical conditions of the test contact of the line tested. Thus, in the embodiment herein disclosed, ringing current will be transmitted over the calling line when the test contact of the line is connected to battery; the connector will be stepped ahead if the contact tested is connected to ground; and a busy back signal will be transmitted if the contact tested is open, that is, disconnected from other parts.

From this outline, it will be apparent that my invention is of broad scope, and although disclosed in connection with a specific type of electrical apparatus, is not necessarily limited thereto, but is capable of broader application.

In applying my invention to a telephone system, I have selected a full automatic system of the class in which the well known selectors and connectors of the two-dimension type are employed in conjunction with similarly constructed line selectors controlled by master-switches. In such systems, the movable contacts or wipers of the two-dimension switch are associated with a large number of fixed, or passive, contacts arranged in a bank, and the wipers are first given a movement in one direction and then a movement at an angle thereto, the former, or primary, movement bringing the wipers to a desired group of bank contacts, and the latter, or secondary, movement causing the wipers to engage the desired bank contacts in the selected group. On a basis of a ten thousand line exchange, provided with hundred point switches and ten per cent. trunking, there would be one hundred master-switches, 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 be united in pair without multipling; the wipers of the second selectors would be multipled to the bank contacts of one hundred first selec-

selectors; and the wipers of each connector would be multipled to the bank contacts of one hundred second selectors.

With the above outline, the invention will be best understood by referring to the accompanying drawing and the following detailed description.

In said drawing, Figure 1, including Parts 1, 2 and 3, illustrates the preferred embodiment of the present invention applied to an automatic system of the class mentioned; Fig. 2 is a modified connector circuit adapted to be used in the circuit of Fig. 1 instead of the connector circuit illustrated in Part 3 of that figure; Figs. 3, 4, and 5 are elevations of a line selector viewed from different sides, the switch being also typical of the other selectors and connectors employed in the system; Fig. 6 is a plan view of said switch; Fig. 7 is a sectional plan of a portion of the same, taken on a plane indicated by the line 7—7 of Fig. 4; Fig. 8 is a detail view of certain of the connector off-normal contacts; and Figs. 9 and Fig. 10 are top and side elevations, respectively, of a master-switch employed in the control of the line selectors. Throughout these views, like characters refer to like parts.

Before proceeding with a detailed description of the circuits and apparatus of the system to which my invention is applied, it may be pointed out that the changes over prior systems of the art, in order to embody the present invention, are limited to (1) changes in the line circuit, and (2) changes in the connector circuit. For a full understanding of the invention, however, it will be necessary to explain the remaining circuits of the system, and this will be done in the regular order.

Apparatus.

In Fig. 1, M at the left of the diagram designates a subscriber's station, united to the main exchange by the line limbs P—S, which terminate in the multiple contacts of line selectors and connectors. At the opposite end of the diagram, N designates a similar subscriber's station which is united by line limbs P′, S′ to the exchange, and the line limbs are similarly connected to the multiple contacts of line selectors and connectors. Connection is obtained between the line at the left and the line at the right through the agency of a master-switch O, a line selector Q, a first selector U, a second selector V, and a connector, or "selector connector", W. Upon the previously noted basis of a ten thousand line exchange employing hundred point switches and ten per cent. trunking, there would be one hundred master-switches O and one thousand of each of the switches Q, U, V and W. Upon this same basis, 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 corresponding bank contacts on ten different line selectors. Each group of line selectors would be under the control of one master-switch having a pair of bank contacts assigned to each line selector. Each subscriber's line, or each line of a group of lines running to one subscriber, would also be multipled to the corresponding bank contacts of ten connectors. In the diagram, only two of the ten sets of multiple contacts of the line selectors and connectors are illustrated, while but five pairs of bank contacts of the master-switch are shown. 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 direct connections between the one thousand line selectors and the one thousand first selectors. The wipers of the second selectors are multiply connected to the bank contacts of the first selectors, and since there are one thousand of each of these switches, the wipers of each second selector are connected to the corresponding contacts of one hundred first selectors. Similarly, the wipers of each of the one thousand connectors are connected to the corresponding contacts of one hundred second selectors.

In operating the parts to establish connection between stations M and N, the calling party at station M removes his receiver from its hook and thereby through the agency of the master-switch O, sets an idle line selector Q in operation to automatically seek out and establish connection with his line, thus extending the calling line circuit to the first selector U, paired with the actuated line selector Q. The calling party then, by means of his calling mechanism, transmits a number of impulses, corresponding to the digits of the number of the subscriber wanted, and this method will be pursued even though the wanted subscriber have a number of lines running to his station. The first series of these impulses operates the connected first selector U so as to cause it to pick out an idle second selector V, associated with the thousand group to which the called line belongs. Thus, if the number of the calling party were 2000 some odd, the first set of impulses would move the wipers of the first selector to the second group of its bank contacts, and these wipers would then automatically move over the contacts in this group until an idle contact was encountered, thereby extending the circuit of the calling party to an idle second selector in the second thousand group. The second series of impulses would similarly operate the second selector V to pick out and establish connection with a connector associated with the hundreds group to which the called station

belongs. Thus if three impulses were transmitted over the circuit, the second selector V would move its wipers to the third group of its bank contacts, and the wipers would then automatically move over the contacts in that group until an idle one was selected, thereby extending the circuit of the calling line to a connector having access to the called station. The third series of impulses would cause the connector to move its wipers to that group of ten contacts in which the contacts of the called line or lines were included, and the final series of impulses would cause the wiper to move over the contacts in this group until the contacts corresponding to the first line running to the called station were encountered. If this line were found to be busy, the connector would step into engagement with the contacts of the next line running to the same substation, and so on automatically until the last line running to the same station was encountered; and then, if this were busy, a busy back signal would be transmitted to the calling party. However, if any of the lines running to the called station were idle, the connection would be completed and the called party signaled.

Each line is provided at the exchange with a line relay LR, which is instrumental in closing a circuit through the master-switch O upon the initiation of a call, and a cut-off relay CO, which is used to destroy the normal substation control of the line relay and to otherwise vary the line connections. A circuit opening relay CK is also provided for interrupting the normal connection to spring 81′ whenever the line is a calling line.

The master-switch O comprises a pair of wipers 20, 21, coöperating with bank contacts 22, 23 and actuated by a motor magnet MM, the complete operation being controlled by the relays 24, 25, as hereinafter more fully pointed out.

The line selector includes the wipers 26, 27, 28 and 29, coöperating with bank contacts 30, 31, 32, 33. Wipers 26, 27 and 28 partake of the two movements of the switch, that is, the primary and secondary movements, while wiper 29 partakes only of the primary movement. This primary movement is brought about by primary magnet PM, controlled by primary relay PR, while the secondary movement is similarly brought about by secondary magnet SM controlled by secondary relay SR. The release of the switch, which permits its return to normal position, is brought about by release magnet RM, controlled by release relay RR. The switch is also provided with primary and secondary off-normal contacts PO and SO, which are operated respectively upon the first primary and the first secondary movements of the switch. Although each subscriber's line is multiply connected to ten line selectors and ten connectors, two such multiple connections only are shown in the drawing, wherein bank contacts 30′, 31′, 32′, 33′, and coöperating wipers 26′, 27′, 28′ and 29′ belong to a second line selector, and contacts 36, 36′, 37, 37′, 38 and 38′ are bank contacts of two connectors.

The first selector U includes the wipers 39, 40 and 41, which coöperate with bank contacts 42, 43 and 44, also multipled, in response to the operation of the primary magnet PM′, controlled by the primary relay PR′, and the secondary magnet SM′, controlled by the secondary relays SR′ and S′R′. The wipers in this case all partake of the primary and secondary movements, and the switch is released through the operation of the release magnet RM′ and the release relay RR′. The primary off-normal contacts PO′, and the secondary off-normal contacts SO′, here, as before, are operated upon the first primary and secondary movements of the wipers, respectively. The circuit associated with this selector also includes a reversing relay RV for reversing the direction of current applied to the calling line, and an associated relay 45, all of which will be more fully understood from the subsequent description.

The second selector V comprises wipers 46, 47, 48, which coöperate with bank contacts 49, 50, 51, in the same manner as first selector U. In this case, the corresponding relays, magnets and off-normal contacts are designated by the corresponding reference characters having the exponent 2 instead of the prime.

The connector W is provided with wipers 52, 53, 54, coöperating with the bank contacts 55, 56, 57, 55^a, 56^a, 57^a, 55^b, 56^b, 57^b, and in this instance, as before, they partake of both primary and secondary movements in response to the primary magnet PM^3 and the secondary magnet SM^3 respectively, and return to normal upon the operation of the release relay RR^3 and release magnet RM^3. In this instance, the primary off-normal switch contacts are designated PO^3, and the secondary off-normal contacts SO^3. In addition to these parts, the circuit is provided with a busy relay BR, a ringing relay RG, an auxiliary ringing relay RG′, a control relay R, a tip relay TR, a "flip-flop" relay FF, and a "closing" relay CR, all of which coöperate in the manner hereinafter more fully set forth.

The equipment at each substation includes the usual switch-hook 64, receiver 65, call-bell 66, transmitter 67, condenser 67′, and calling mechanism 68.

The line circuit at the right of Fig. 1 is the same as that at the left and is provided with a line relay LR, cut-off relay CO, and circuit closing relay CK. The line circuit here shown in full is associated with the connector contacts 55^a, 56^a and 57^a. It may

be assumed for the purpose of description that both the line associated with contacts 55, 56, 57, and the line associated with contacts 55^b, 56^b, 57^b, run to the same station as the line associated with contacts 55^a, 56^a, 57^a. In other words, for the purposes of this description, it may be assumed that three lines run to substation N. Under this assumption, as will hereinafter more fully appear, the first two lines have the same connections, while the third line has its connections slightly modified.

Operation.

With this description of the character of the apparatus diagrammatically illustrated in Fig. 1, it is believed that a description of the operation will most clearly bring out the functions of the apparatus and the nature of the invention of the present application.

Assuming that a party at substation M desires to converse with a party at substation N, and assuming that the number of the latter's telephone is 3456, and, as before indicated, that three lines, associated with the contacts illustrated at the right of the diagram, run to substation N and are to be reached by calling the same number, namely, 3456; then the calling party first removes his receiver 65 and thereby establishes a circuit which may be traced from the live, or negative, pole of the battery B′, through resistance 71, closed contact 76 of the cut-off relay CO, line limb S, closed contact 75, the winding of the lock controlling magnet 74 switch hook 64, transmitter 67, closed contact 73, line limb P, normal contact 72 of the cut-off relay CO, normal contact 77, and the winding of relay LR to the grounded pole of the battery B′. The resulting movement of the contact 77 to its alternate position closes a new energizing circuit for the line relay LR, which may be traced from the live pole of battery B′, through the winding of relay 24 of the master-switch O, closed contact 78 of the cut-off relay CO, and alternate contact 77 of the line relay, through the winding of said relay to ground. The closing of this circuit continues the energization of the line relay and actuates relay 24 so as to close its contact 79 to complete a starting circuit for one of the line selectors Q, as will be hereinafter explained. The movement of the contact 80 of the line relay LR removes the normal ground connection from the contacts 30, 30′, corresponding to the calling line, this ground connection normally existing through normal contact 81 of the cut-off relay CO and normal contact 80 of the line relay LR. In addition to the removal of this ground, which establishes that condition which will cause the line selector wipers to step in engagement with the contacts of the line after they have been moved to the desired group, the actuated contact 80 closes an energizing circuit for relay 82 which in turn opens its contact 83 to remove the normal ground from contacts 33, 33′, which correspond to the group of contacts in which those of the calling line are located, thereby establishing that condition which will cause the line selector to stop its primary movement at the proper group of bank contacts. Normally, contacts 36, 36′ are connected to battery through the winding of the cut-off relay CO. This is the electrical condition of the test contact which corresponds to the idle condition of the line. If the line is an individual line, that is, the only one going to a substation, or is the last one of a group of lines going to a substation, its circuit connections are those produced by the manual switches 83′, 84′ when in the positions illustrated at the left in Fig. 1. This arrangement places the contacts 36, 36′ on open circuit when the line is busy. When the line is one of a group going to a substation other than the last, its circuit connections are those produced by placing the manual switches 83′, 84′ in their alternate positions, as illustrated at the right of Fig. 1 by the circuit of line S′ P′. With this arrangement, contacts 36, 36′ are grounded to establish the busy condition of the line. As far as the line running from substation M is concerned, it may be either, but for the purpose of simplifying the description, it may be assumed to be an individual line having circuit connections produced by the manual switches 83′, 84′ when in the positions illustrated. With this assumption then, the shifting of contact 84 of relay LR will interrupt the normal battery connection of contacts 36, 36′ and will replace such connection by an open circuit.

The master-switch wipers 20, 21 are brought, after each operation of the line selector Q, into engagement with contacts 22, 23, assigned to an idle line selector, as will be hereinafter explained. Thus, as soon as relay 24 is energized, a starting circuit for such line selector is completed by a connection from battery B′, through the winding of primary relay PR, off-normal contact 85, contact 22, wiper 20, closed contact 79, and normal contact 86 to ground, thus operating relay PR to complete a circuit from the live pole of the alternating or pulsating current generator 87, through the winding of the primary magnet PM, and alternate contact 88 of primary relay PR to ground, thus causing the wipers 26, 27, 28 and 29 to move in a primary direction. The said group relay 82 has its winding connected to a plurality of alternate contacts 80, as indicated by the symbol shown (which sign serves throughout the drawing to indicate a common connecting point) on as many different line relays LR. Thus in the

example chosen, there would be one hundred line relays and ten group relays for a group of one hundred calling lines. Each group relay would then be connected to ten different line relays. Each of the ten bank contacts 33 therefore corresponds to a different sub-group of ten calling lines. Since the primary off-normal contacts PO are actuated upon the first primary movement of the switch wipers, the initial energizing circuit of the primary relay PR is interrupted, but in the meantime the closing of contact 89 of said relay has completed a new path through wiper 29 which is maintained as long as said wiper engages grounded contacts 33. The end of the wiper 29 is preferably made broad enough to bridge adjacent contacts so that it will not pass out of engagement with one contact before engaging the next, thus insuring a circuit at all times except when an ungrounded contact 33 is engaged. It should also be noted that although the wiper 29 is normally out of engagement with contact 33, it engages said contact at the time the primary off-normal contact 85 breaks, thus insuring a suitable circuit for the relay PR until the wipers have been moved to that group of bank contacts which includes the contacts assigned to the calling line. Just as soon as this group of contacts is reached, the primary movement of the switch wipers will be discontinued, and the contacts 88, 89 of the relay PR will return to normal. The return of contact 88 will immediately energize the secondary relay SR over a circuit extending from the live pole of battery B′, through the winding of said relay, secondary off-normal contact 90, primary off-normal contact 91, normal contact 88 to ground. The movement of contact 92 of relay SR to its alternate position will at once close an energizing circuit for the secondary magnet SM extending from the live pole of the alternating or pulsating current generator 93, through the winding of the secondary magnet, alternate contact 92 and normal contact 94 of release relay RR, to ground. The resulting repeated energizations and deënergizations of the secondary magnet will cause the wipers 26, 27, 28 to move in a secondary direction over contacts 30, 31, 32, respectively, of that group of bank contacts including the contacts of the calling line. Since, upon the first secondary movement, the contacts of the secondary off-normal switch SO are actuated, the initial energizing circuit of the relay SR will be interrupted, but in the meantime the closing of its contact 95 will provide a new path through normal contact 96 of release magnet RM to wiper 26 and thence to ground so long as said wiper engages a grounded contact 30. It will be noted in this case, as in the case of wiper 29, that the end of the wiper is preferably made broad enough to bridge the space between contiguous contacts, and that although normally out of engagement with the nearest bank contact, it will engage said contact by the time the secondary off-normal contacts are moved from normal. Thus the secondary movement of the switch wipers will continue until wiper 26 engages an ungrounded contact. Since the contact 30, corresponding to the calling line, has been ungrounded as previously pointed out, the wipers will be stepped into engagement with the contacts corresponding to said line. Since other subscribers' lines are multiply connected to contacts over which the wipers 27, 28 pass during this secondary movement, and since conversation may be going on over a connection including said contacts, the relay SR is arranged to electrically disconnect the wipers 27, 28 from other parts during this secondary movement. This is brought about by the contacts 96′, 97, which in their normal positions join the adjacent portions of the strands L, L′, but, when actuated, separate them, thus disconnecting the said wipers. Thus as soon as the wiper 26 engages an ungrounded contact 30, the relay SR is deënergized and the contacts 92, 95, 96′, 97 return to their normal positions, thereby disconnecting the further secondary movement of the wipers and restoring the normal connections of the wipers 27, 28. The contacts 96′, 97, when in their alternate positions, connect the right-hand portions of the strands L, L′ by a bridge which includes alternate contact 96′, closed contact 98 of release relay RR, and alternate contact 97. The same portions of the strands L, L′ are united by a bridge including normal contacts 99, 100 of reversing relay RV, windings of primary and secondary relays PR′ and SR′ and batteries b, b'. These batteries, being arranged in series, supply current over a circuit including both of these bridges and thereby energize relays PR′ and SR′ to actuate their contacts. This prevents the possible closing of the release circuit (when the secondary off-normal contacts SO are actuated) from battery B′, through the winding of release relay RR, closed contact 101, contacts 102, 103 of relays PR′ and SR′, and the winding of release relay RR′ of the first selector U to ground.

The restoration of the contact 92 to normal, since the contact 104 of the secondary off-normal switch SO is now closed, immediately completes a circuit which is instrumental in causing the movement of the master-switch O to engage contacts of an idle line selector. This circuit extends from ground at contact 94 of release relay RR, through said normal contact 92, closed contact 104, contact 23 and wiper 21 of the

master-switch, and winding of relay 25 to the live pole of the battery B′, thus energizing said relay to move its contact 86 to its alternate position and thereby close an energizing circuit for the motor magnet MM, which includes the alternating, or pulsating, current generator 105. Due to the mechanical relation of the parts, the energization and deënergization of this magnet will step the wipers 20, 21 into engagement with the next pair of bank contacts. If the line selector, corresponding to this pair, is in use, there exists a ground at one point or another, as will be explained, on the corresponding contact 23, which will maintain the relay 25 energized and thereby maintain the circuit of the motor magnet. As soon, however, as an ungrounded contact 23 is encountered, this energizing circuit for relay 25 will be interrupted. Contacts 23, corresponding to busy line selectors, will always be grounded, while those corresponding to idle line selectors will be ungrounded, thus securing the stopping of the master-switch with its wipers in engagement with contacts corresponding to an idle line selector. The ground connection with the contact 23 may exist over the path just traced through contacts 104, 92, 94, or by way of alternate contact 96, alternate contact 95, closed contact 90, closed contact 91, and alternate contact 88 to ground. Or the said ground may be obtained through the off-normal contact 126^2 of the primary off-normal switch PO′ of the first selector U, or at other times through the closed contact 195 of the reversing relay RV and closed contact 174 of the relay 45.

As soon as the secondary relay SR of the line selector has been deënergized and the adjacent portions of the strand L, L′ united, circuits are at once established for the primary and secondary relays PR′ and SR′ in lieu of that circuit previously traced through alternate contacts 96′, 97 of relay SR. Thus a circuit extends from the live, or negative, pole of the battery B′, through the winding of cut-off relay CO, contact 106—107 of said relay, bank contact 31, wiper 27, strand L, normal contact 99 of reversing relay RV, winding of the primary relay PR′, to the live, or positive, pole of the grounded battery *b*. At the same time, a circuit is completed from the live, or negative, pole of the battery *b*′, through the winding of secondary relay SR′, normal contact 100 of the reversing relay RV, strand L′ including contact 97, wiper 28, contact 32, normal contact 76, and coil 71 to the negative pole of battery B′, prior to the operation of the cut-off relay CO; and immediately subsequent thereto, over line limb S, contact 75, lock-magnet 74, switch-hook 64, transmitter 67, contact 73, line limb P, alternate contact 72 of cut-off relay CO, contact 31, wiper 27, link strand L including contact 96′, normal contact 99 of reversing relay RV, the winding of primary relay PR′, to the positive pole of battery *b*. The closing of these circuits maintains the relays PR′ and SR′ energized and, in addition, energizes the cut-off relay CO and the lock controlling relay 74 of the calling line. The movement of contact 72 of the cut-off relay to its alternate position continues line limb P to contacts 31, 31′, and interrupts the initial energizing circuit of the line relay LR and thus destroys the normal substation control of said relay. The opening of its contact 78 likewise interrupts the circuit established through relay 24 of the master-switch and the line relay. The opening of contact 76 interrupts the normal connection of battery B′ to the line limb S closing a circuit through relay CK from battery at alternate contact 76, contact 77′, winding of said relay CK to ground, energizing said relay CK which locks itself through the upper contact thereof and also opens the contact 72′. The opening of the contact 72′ prevents the relays CO and PR′ from locking up, in series through alternate contacts 107′ and 72 and along the upper heavily marked conductors when alternate contact 72 is closed. The subscriber's circuit is thus completed over the heavily marked lines to the sections of the strands L, L′, lying beyond the condensers 108, 109. The movement of contact 81 interrupts the path for current over the strand L, through the cut-off relay CO, but before said circuit is interrupted, a new circuit is provided for the cut-off relay, through contact 107—81, engaged contact 30, wiper 26, normal contacts 96 and 95 to ground. Thus the cut-off relay CO is maintained energized. With the manual switches 83′, 84′ in the position illustrated, giving connections for individual lines and the last lines of groups, the guard upon contacts 36, 36′ is provided by opening the circuit of such contacts, first, at normal contact 84 during the energization of relay LR, and later, at contacts 106′ during the energization of the cut-off relay CO. With the manual switches 83′, 84′ in their alternate position, giving the connections for the lines of a group other than the last, contacts 36, 36′ are connected to ground, first, at alternate contact 84 during the energization of relay LR, and later, during energization of cut-off relay CO, via normal contact 84, manual switch 84′, contact 107—81, contact 30, wiper 26, normal contacts 96 and 95, to ground. The guard is placed upon contacts 30, 31 over this same path to ground, through alternate contacts 96, 95. The disconnection and consequent deënergization of line relay LR causes the release of the group relay 82 unless there is another line relay belonging to the same sub-group

of ten energized at this time for the purpose of also initiating a call. Assuming no such condition to exist, the release of relay 82 will restore the ground via contact 83 to bank contacts 33, 33′, etc., thereby permitting wipers 29 of said other line selectors to rotate past the sub-group containing the calling line whose call has been "picked up". Also, the deënergization of the line relay LR causes that of the relay 24 of the master-switch O, unless there be at that time another line relay belonging to the same group of subscribers then initiating a call. Assuming there be no such other call existing, the release of such relay 24 will prevent the starting of another line selector when the master-switch steps its wipers 20, 21 around to engage the bank contacts corresponding to the next idle line selector. All of the operation thus far described results from the removal of the receiver at the calling station, and as we have seen, extends the subscriber's line to a first selector U.

With the parts in this position, the calling party begins to operate his calling mechanism 68 to extend his circuit through to the called line. The calling mechanism is diagrammatically represented by a disk having a number of teeth adapted to engage spring 73 to cause it to break contact upon the return of the disk under the influence of its return spring 112, and a single tooth similarly coöperating with contact spring 75 to cause it to open its contact after the contact 73 has completed its interruptions. The disk is also provided with a pin which engages the spring contact 113 to hold it out of engagement with a similar spring contact 114 and a grounded contact 115. The disk is normally locked by means of a hook 116 arranged to engage a notch in the disk and normally held in engaging position by a spring and moved out of engaging position by the energizations of the magnet 74. In operation, the disk is moved against the tension of its return spring until a definite number of teeth have passed below the spring 73, and it is then allowed to return to normal with the resulting breaking of contacts 73 and 75. Under the assumption that the number of the called station N is 3456, the calling party will rotate his dial far enough to bring three teeth below the contact 73 and will then release the same to allow it to return to its normal position, and he will follow this operation by similar operations in which he will rotate the dial sufficiently to bring, next, four teeth, then five teeth, and finally six teeth below the spring contact 73. Considering only the effect of the first operation, it will be noted that as soon as the dial is removed from normal, contact 73 will be grounded through contacts 113, 114, 115; and while this ground remains, the primary relay PR′ will be energized from the battery b, over the strand L, line limb P, through contact 73 to this ground at the substation, while secondary relay SR′ will be energized from battery b', over the strand L′, line limb S, and contact 75 to the same ground. Consequently, the three resulting breaks and makes of the contact 73 will cause three deënergizations of the primary relay PR′, and the single following break and make of the the contact 75 will cause a single deënergization of the secondary relay SR′. An inspection of the contacts 121, 122, 123, 124 of the primary and secondary relays PR′, SR′ will show that the three deënergizations of the primary relay PR′ will cause the section of the strand L to the right of condenser 108 to be grounded three times, while the single deënergization of the secondary relay SR′ will cause the section of the strand L′ to the right of the condenser 109 to be grounded once. While relays PR′ and SR′ are energized, these sections of the strands are not grounded by reason of the open contact 122 in one case, and the open contact 124 in the other. From this it will be seen that the passage of each tooth past the contact 73 has the effect of producing a momentary ground upon the section of strand L to the right of condenser 108, and that each movement of the single tooth past contact 75 has the effect of producing a single momentary ground upon the section of the strand L′ to the right of condenser 109. Thus the grounding of the strand L three times has the effect of producing three distinct energizations of the primary magnet PM′ of the first selector U, the circuit being from the live pole of the battery B^2, through the winding of said magnet, closed contact 125 of the secondary off-normal switch SO′, and strand L to ground. These three energizations will cause the wipers 39, 40, 41 to move to the third group of bank contacts 42, 43, 44. Upon the first movement in this direction, the primary off-normal contacts PO′ will be closed. Consequently, upon the subsequent grounding of strand L′, secondary relay S′R′ will be energized over a circuit extending from the live pole of the battery B^2, through the winding of said relay, closed primary off-normal contact 126, closed secondary off-normal contact 127, and strand L′ to ground. The energization of relay S′R′ will open its contacts 128, 129 to disconnect the wipers 40, 41 to prevent interference with possible conversation over multiply connected bank contacts in the manner heretofore pointed out in describing the line selector. The closing of contact 130 of relay S′R′ will energize secondary magnet SM′ by closing a circuit extending from the live pole of alternating or pulsating current generator 131, through the winding of said magnet,

normal contact 132 of release relay RR′, and closed contact 130 of relay S′R′ to ground. Due to the mechanical relation of the parts, the repeated energizations and de-energizations of the secondary magnet will cause the wipers to move in their secondary magnet will cause the wipers to move in their secondary direction. Upon their first step in this direction, secondary off-normal contacts SO′ will be opened, thus interrupting previous circuits for the primary magnet PM′ and the secondary magnet S′R′. In the meantime, the movement of contact 133 to its alternate position provides a substitute energizing circuit for relay S′R′ which extends via said contact, normal contact 134 of release relay RR′, and closed contact 135 of release magnet RM′ to wiper 39 and thence to ground as long as said wiper engages grounded contacts 42. In this case, as in the case of wipers 26 and 29, the end of the wiper is made sufficiently broad to engage a new contact before disengaging a previous one. In case the encountered contact 42 is that of a busy second selector V, its ground connection will extend over a wiper 39 of another first selector, through its closed contact 135 and normal contacts 134, 133. This secondary movement of the selector will continue until an ungrounded contact 42 is encountered, whereupon the selector will stop. As soon as this happens, relay S′ R′ will be deënergized, with a resulting connection of the wipers 40, 41 to the strands L, L′, a resulting interruption of the secondary magnet circuit and the restoration of ground to the wiper 39 and to multiply connected bank contacts 42, thus rendering the selected second selector busy to other seeking first selectors. Thus, by this operation of the calling mechanism, the circuit of the calling line is extended over the heavily marked path to a second selector of the third thousand group.

The next step in the operation consists in operating the calling device to first ground the strand L four times and then to follow with a single grounding of the strand L′ through the agency of the primary and secondary relays PR′ and SR′, as heretofore. The operation of the second selector in response to these impulses is substantially the same as that of the first selector just described. The grounding of the strand L four times causes four distinct energizations of the primary magnet PM^2 to cause the wipers 46, 47, 48 to advance to the fourth group of bank contacts 49, 50, 51, and the single grounding of the strand L′ through the agency of the secondary relay SR^2 and secondary magnet SM^2 starts the wipers over the contacts in this group of bank contacts, and this secondary movement of the wipers is continued until an idle contact is encountered. The circuit of the primary magnet extends from the live pole of the battery B^2, through the winding of said magnet, secondary off-normal contact 136, contacts 43, 40, 128, strand L to ground via contacts 122, 123. The initial energizing circuit for the secondary relay SR^2 extends from the live pole of the battery B^2, through the winding of said relay, closed primary off-normal contact 137 (closed upon the first primary movement of the switch) and closed secondary off-normal contact 138, contacts 44, 41, 129, strand L′ to ground via contacts 124, 121. A maintaining circuit is then established for the relay SR^2 by way of the closed contact 139, closed contact 140 of release magnet RN^2, to wiper 46 and contact 49 to ground, as long as grounded contacts are encountered. The ground connection, as in the case of the first selector, is obtained by way of a multiple contact 49, a wiper 46 of some other second selector V engaging said contact, closed contact 140, and normal contacts 141, 142 of said other second selector. The circuit of the secondary magnet similarly runs from the live pole of an alternating or pulsating current generator 143, through the winding of said magnet, normal contact 144 of release relay RR^2 and alternate contact 142 to ground. The wipers 47, 48 are also disconnected during the secondary movement by contacts 145, 146 of the secondary relay SR^2. Thus, as a result of the transmission of the four impulses, the circuit of the calling line is extended to a connector having access to the fourth hundred group of the third thousand subscribers' lines.

The next step in the operation consists in grounding the strand L five times, followed by a single grounding of the strand L′, through the agency of the primary and secondary relays PR′ and SR′ as before. The grounding of the strand L five times causes five distinct energizations of the primary magnet PM^3, which, due to the mechanical construction of the parts, causes the connector wipers 52, 53, 54 to be moved to the fifth group of bank contacts including contacts 55, 56, 57. The energizing circuit for the primary magnet extends from the live pole of the battery B^3, through the winding of said magnet, contact 147 of the secondary off-normal switch SO^3, contacts 50, 47, closed contact 145, contacts 43, 40, closed contact 128, and strand L to ground. On the first primary movement, as usual, the primary off-normal contacts PO^3 are closed, and consequently upon the single grounding of the strand L′, a circuit is completed through the winding of the secondary magnet SM^3, which may be traced from the live pole of battery B^3, through the winding of said magnet, closed contact 148 of the primary off-normal switch PO^3, contact 149 of the secondary off-normal

switch SO^3, contacts 51, 48, closed contact 146, contacts 44, 41, closed contact 129, and strand L′ to ground. In the construction of the connector, the wipers are located two steps distant from the first set of bank contacts, and the resulting single momentary energization of secondary magnet SM^3 is instrumental in stepping these wipers one step nearer the said bank contacts; and, due to the spacing of the contacts of the secondary off-normal switch SO^3, this first secondary step of the wipers causes contact 147 of off-normal switch SO^3 to move to its alternate position and causes contact 149 of said switch to move out of engagement with its normal contact, but not into engagement with its alternate contact, the later movement being performed by the next secondary step of the wipers.

The next step in the operation consists in grounding the strand L six times, followed by a single grounding of the strand L′. Due to the position of the contact 147, the grounding of the strand L six times causes six distinct energizations of the secondary magnet SM^3 over a circuit extending from the live pole of the battery B^3, through the winding of said magnet, closed contact 150 of relay R, alternate contact 147, contacts 50, 47, and so on over the heavily marked path to ground at strand L. The first energization of the secondary magnet SM^3 steps the wipers into engagement with the first set of bank contacts in the desired group and moves contact 149 to its alternate position. The six distinct energizations, therefore, move the wipers into engagement with the sixth set of bank contacts in the particular selected group, and these, under the assumptions made, are the contacts 55, 56, 57, the contacts of the first line running to substation N. Thus a complete connection is established from the substation M, over the heavily marked circuit, to the substation N, except that the strands L^2, L^3 are interrupted at the relay CR, which I may term a "closing" relay. The further action of the apparatus depends upon the electrical condition of the test contact 55 encountered by the wiper 52. These different conditions may now be considered.

First called line idle.

It will be noted that the above connection is completed without the application of the final ground to the strand L′. When this is applied, a circuit is completed through the lower winding of the relay RG, which, for convenience, I may term a "ringing" relay because part of its function is to control the application of ringing current to the called line. The energizing circuit for this relay extends from the live pole of the battery B^3, through the lower winding 151 of said relay, closed contact 152 of busy relay BR, normal contact 153 of relay R, strand L^3, alternate contact 149, contacts 51, 48, and thence over the lower heavily marked path to strand L′ and ground. The energization of relay RG, resulting from the closing of this circuit, is momentary only. Under the assumption that the first line of the group running to substation N, which line has contacts 55, 56, 57, is idle, contact 55 will be connected to battery B^3 by a path extending from the live pole of battery B^3, through cut-off relay CO of that line, manual switch 84′, normal contact 84, to contact 55. The momentary energization of relay RG completes a circuit through the lower winding 154 of busy relay BR, which may be traced from the live pole of the battery B^3, through protective resistance 155, winding 154, closed contact 156 of relay RG, and normal contact 157 of relay R, to ground. Accordingly, relay BR is energized and thereby immediately completes a circuit through its closed contact 158 and the upper winding 159 of relay RG. Its energization also breaks the initial energizing circuit for relay RG at contact 152. In order to insure the closing of the circuit through the upper winding of relay RG before that through its lower winding is broken, contact 152 should be adjusted so as to break after or substantially at the same instant that contact 158 is made. The energization of relay BR also closes a circuit for relay R through its contact 160′, to ground, thereby energizing the said relay R to interrupt the circuit through the lower winding 154 of relay BR at contact 157. Under the assumed condition of encountered contact 55, relay BR thereupon drops back and interrupts the circuit of winding 159 of relay RG and allows that relay to return to normal also. The relay R, however, remains energized, locking itself up through its contact 161 and contact 162 of release relay RR^3. The initial energizing circuit for relay RG is also interrupted at contact 153 upon the energization of relay R; and at the same time, the connection of secondary magnet SM^3 to the primary side of the circuit is broken at contact 150. From this description, it will be seen that when battery is connected to the test contact 55 of the called line, relays RG and BR operate and then return to normal and relay R operates and is locked up. In the operation of relays RG and BR, relay RG is the first to attract its armature and the last to retract its armature. This relation in the operation of relays RG and BR prevents the improper operation of the circuits by which the switch is stepped ahead automatically and by which the busy back signal is transmitted to the calling party and obviates careful adjustment of these relays. As soon

as relay BR returns to its normal position after this preliminary operation, a circuit is completed to operate the secondary ringing relay RG′. This circuit extends from battery, through cut-off relay CO to the test contact 55, and thence through wiper 52, contact 163 of relay RG′, normal contact 164 of relay BR, closed contact 165 of relay R, normal contact 166 of relay RG′, and the winding of said relay to ground. Relays CO and RG′ are thereupon actuated; relay CO locking itself up via alternate contact 107′, normal contact 72′, contact 56, wiper 53, impedance coil 182 and closed contact 183 of relay RG′ to ground, and relay RG′ locking itself up through its alternate contact 166, normal contact 167 of release relay RR³, the closed primary off-normal contact 168, protective resistance 169 to the live pole of battery B³. In this operation, contact 183 of relay RG′ makes before contact 163 breaks. By closing its contact 170, relay RG′ completes a circuit from the live pole of battery B³, through protective resistance 171, normal contact 172 of tip relay TR, closed contact 170 and the upper winding 159 of relay RG to ground, thereby energizing relay RG to close its contact 173 to complete a circuit for the "flip-flop" relay FF. This circuit extends from the live pole of the battery B³, through the "flip-flop" relay FF, normal contact 174, closed contact 173, and closed contact 175 through interrupter 176 to ground. At this time, tip relay TR has its winding connected to the back contact 177 of "flip-flop" relay FF, through contact 178 of relay RG′, contact 179 of relay RG, and contact 180 of relay BR. The front contact 177 of relay FF is connected to a suitable ringing source such as the grounded alternating or pulsating current generator 181. By the operation of the "flip-flop" relay, the tip relay TR, and the generator 181 are alternately connected to the tip side of the circuit. During the ringing interval, current flows out over the line, through the condenser and call-bell at the substation, and back to ground at the central station through impedance coil 182 and grounded contact 183 of relay RG′. During the non-ringing interval, the generator tap is replaced by a tap through the tip relay TR, as just traced. The circuit by which relay RG′ was actuated also actuated cut-off relay CO of the called line, since the battery connection to contact 55 included the winding of said latter relay. Since the busy condition of the line, having the contacts 55, 56, 57, is that in which a ground is placed upon contact 55, a ground connection must be found running to said contact as soon as the wiper 52 engages contact 55. This ground connection extends from contact 55, through normal contact 84 of line relay LR, manual switch 84′, alternate contact 107′, normal contact 72′, bank contact 56, wiper 53, impedance coil 182 and closed contact 183 to ground. As soon as the called party responds to the signal of his call-bell by removing his receiver from its hook, a conductive path is completed between the limbs of his line; and as soon as the "flip-flop" relay is brought into its non-ringing position, the tip relay TR is energized over a circuit which also constitutes the circuit for supplying transmission current to the transmitter at the called substation. This circuit extends from the live pole of the battery B³, through protective resistance 171, tip relay TR, closed contacts 178, 179, 180, normal contact 177, to one side of the circuit, thence out over the line, through the called station, back over the line, returning to the opposite pole of the battery through impedance coil 182 and closed contact 183 of relay RG′. The actuation of tip relay TR interrupts the circuit through the upper winding 159 of relay RG, by opening its contact 172. By closing its contact 184, relay TR causes the energization of closing relay CR, which immediately locks up through its contact 185 and contact 162 of release relay RR³. The deënergization of ringing relay RG interrupts the circuit of "flip-flop" relay FF and also interrupts the connection from the tip relay to the sleeve side of the circuit previously traced. Before this latter connection is broken, however, a substitute path is provided from said relay TR, through its contact 186, contact 180 of relay BR, and normal contact 177 of relay FF to the same side of the circuit. The opening of contact 187 of relay TR prevents the closing of a release circuit through relay RR³ upon the subsequent operation of closing relay CR, this circuit extending through protective resistance 171, contacts 187, 188, and the winding of relay RR³ to ground. The operation of relay CR opens contact 189 to disconnect the busy back device BB; and by the operation of said contact 189 and contact 190, the talking strands L², L³, are completed so as to complete the conversational circuit between the substations M and N. Contact 174 of this relay also interrupts the circuit of "flip-flop" relay FF. Contact 190ª places a ground upon the bank contact 49 of the associated second selector as a guarding potential. While relay CR remains deënergized, this path extends from contact 49, through contact 191 of the primary off-normal switch PO³, normal contact 190ª, and winding of release relay RR³ to ground. As we have seen, contact 188 of this relay closes a normally open point in the release circuit of release relay RR³.

From the previous description, it will be seen that as soon as the called party has responded to the call and the tip relay has been operated, there will be a flow of current through the relay 45 associated with the reversing relay RV, which may be traced from battery B^2, through the winding of relay 45, alternate contact 124 of relay SR′, strand L′, over the lower heavily marked circuit to strand L^3, thence through closed contact 190 of relay CR, impedance coil 182 and closed contact 183 of relay RG′, to ground. The opening of contact 192 of relay 45 will prevent a possible release circuit through release relay RR′ when the reversing relay RV is energized. As is clear from the cross connections 193, 194, the energization of relay RV disconnects primary relay PR′ from strand L and connects it to strand L′, and similarly disconnects relay SR′ from strand L′ and connects it to strand L. Thus the supply of current from batteries *b*, *b*′ to the sub-station M is reversed. This reversal of current is for the purpose of operating any of the well-known devices such as pay-station and meter devices, which are commonly employed in systems of this class. As pointed out heretofore, the ground connection with the contact 23 of the master-switch O is obtained through a contact 195 of the reversing relay RV.

During conversation, current for transmission is supplied to the calling party from the batteries *b*, *b*′, and to the called party from the battery B^3, over circuits which have been previously traced.

First called line busy.

Now, if it be assumed that the first line running to substation N is busy, either because a call has been initiated over it, or because it has been connected with as a called line, then, as previously noted, it being the first line of the group, its test contact 55 will be connected to ground. This ground connection may be over any one of several paths depending upon the state of operation. It may extend through alternate contact 84 and manual switch 83′; or through normal contact 84, manual switch 84′, alternate contact 107, and thence through bank contact 30 to ground at contact 95; or through normal contact 84, alternate contact 107′, closed contact 72′, contact 56, wiper 53, impedance coil 182, and closed contact 183, the latter giving a ground connection when the line is in use as a called line. With this ground connection upon test contact 55, the relays of the connector circuit will operate somewhat differently than before described. The final secondary impulse, transmitted to the connector, will, as before, result in momentarily energizing relay RG with a consequent momentary energization of relay BR, but this latter relay will not be allowed to return to normal as in the previous case, but will be held up by current over a circuit extending from the live pole of the battery B^3, through the lower winding 151 of relay RG, the upper winding 196 of relay BR, alternate contact 164 of said relay, normal contact 163 of relay RG′, wiper 52 and test contact 55, to ground. It will be noted that this circuit includes the lower winding of relay RG, but the contacts of said relay are allowed to return to normal under the differential action of the winding 159, which was brought into circuit upon the closure of contact 158 of relay BR, as before explained. Thus, under this condition, relay BR maintains its contacts in their attracted position, while the contacts of relay RG return to normal. The effect of this action of the relays is to close a circuit which will cause connector W to advance one step. This circuit may be traced from the live pole of the battery B^3, through secondary magnet SM^3, its vibratory contacts, normal contact 197 of relay RG, and closed contact 160 of relay BR to ground. Because of the relation of the mechanical parts of the switch, the actuation of relay SM^3 will step the wipers 52, 53, 54 into engagement with contacts 55^a, 56^a, 57^a, corresponding to the second line running to substation N. If this line be found busy— in other words, if it be found with its test contact 55^a grounded—then the relay BR will be maintained in its attracted position, and the secondary magnet SM^3 will cause an additional step of the switch. If the second line, namely, that having the test contact 55^a, is idle, said contact will be connected to battery and the further advance of the switch will be prevented and relay BR will return its contacts to normal and ringing current will be applied to the called line in the manner heretofore explained in connection with the first line running to substation N.

Upon reference to the circuits, it will be noted that when connector switch W is operated to connect with the line terminals 55, 56, 57 of a busy line, any one of several conditions may exist upon test contact 55, depending upon whether the line be busy as a called or calling line. For instance, if the line be a calling line, its test contact 55 will be connected to ground over a circuit, extending to the ground at normal contact 95 of a line selector Q. Second, if the line be a calling line, until said line is picked up by a line selector, the ground connection to its test contact 55 will extend from the ground through switch 83′ during the time the line relay is energized. Third, if the line be busy as a called line and the called subscriber has not yet removed his receiver from its switch hook, the test contact 55 will be connected through impedance coil 182 of the connector switch to ground

at the closed contact 183. Another circuit will extend from the test contact 55 through the cut-off relay CO to the live pole of battery B^3. Fourth, if the line be busy as a called line, and subscriber has responded to the call, a circuit will extend from test contact 55 through the impedance coil 182 to ground, a second circuit from said test contact 55, through the cut-off relay CO to the live pole of battery B^2, and a third circuit will extend from this test contact 55, normal contact 84, closed contact 107′, closed contact 72′ out over the called line, returning over contact 57, wiper 54, and through test relay TR to the live pole of battery B^3. So it will be seen that when wiper 52 engages the test contact 55 of a busy line, any one of said four conditions may be encountered, and therefore the differential relay RG and the winding of the relays, resistances or impedance coil which have to do with any of these four conditions are to be so related that the differential relay RG will retract its armature upon its test wiper 52 engaging the first test contact 55, if connected under any of the four conditions described, and maintains its armature retracted while the wiper is engaging test contacts connected under any of the said conditions. In practice I have found that with a battery strength of 50 volts and with the following resistances, the system will operate satisfactorily although it is to be understood that I do not wish to be limited to thse resistances of voltage as others suitable may be used; relay TR, 200 ohms; relay RG, 100 ohms in each winding; relay BR 100 ohms in each winding; cut-off relay CO, 1000 ohms; protective resistance 155, 300 ohms; impedance coil 182, 200 ohms; resistance connected to switch 83^1, 200 ohms; and the resistance connected between ground and normal contact 95 of line switch Q 200 ohms.

Last called line busy.

From the description of the operation thus far given, it is clear what will happen if the first two lines of the group of three running to substation N are idle, or busy. Now, if it be assumed that the first two lines—those having test contacts 55, 55^a—are busy, and that therefore the connector has been automatically stepped so as to bring its wipers 52, 53, 54 into engagement with contacts 55^b, 56^b, 57^b, namely, those of the last line of the group running to substation N, then the operation will be the same as in the case of either of the preceding lines, if said last line is idle; but if said line be busy, then the operation is different than heretofore described. In the latter event, it will be remembered, test contact 55^b is on open circuit. It has connection neither with ground nor battery. As before, the final secondary impulse transmitted over the line from the calling station to the connector will momentarily energize relays RG and BR. The return of the contacts of both of these relays to their normal positions will be instrumental in closing a circuit from the busy back device BB, so as to indicate to the calling party that all the lines running to substation N are in use. The primary portion of the busy back circuit extends from the live pole of the grounded interrupter 198, through the primary winding of the induction coil 199, through the various battery connections to ground. The secondary portion of this circuit extends from the live pole of said battery, through the secondary winding of induction coil 199, the condenser 200, the off-normal contact 201 (here designated as a primary off-normal contact, although a secondary off-normal contact may be employed for this purpose), closed contact 202 of relay RG, closed contact 203 of relay BR, normal contact 189 of relay CR, to the strand L^2 and thence over the heavily marked circuit through the calling substation M, and back over the opposite side of the circuit to the ground, between batteries b, b', or elsewhere, on that side of the circuit.

From this description, we have seen that the relays RG and BR assume different relative positional conditions, according to the different electrical conditions of the encountered test contact 55, 55^a or 55^b, and that in accordance with the condition of these relays, ringing current is applied to the called line, the connector is automatically advanced, or the busy back signal is transmitted to the calling party.

Release.

The manner of releasing the various switches employed in establishing either a portion of a connection or a complete connection may now be considered. Assuming that the connection has been completed between substations M and N, and conversation has been carried on between these stations, if the calling party at substation M first hangs up his receiver, all the switches will be released and restored to normal except the connector W; if then, the called party at station N hangs up his receiver, this connector too will be released. If, on the other hand, the called party first hangs up his receiver, then the first selector U, second selector V, and connector W will be released; and then, as soon as the calling party restores his receiver, the line selector Q will be released. Again, if it be assumed that the line circuit of a calling line has been extended through to the desired called line and the latter is found to be busy, then if the calling party restores his receiver to its hook, all the switches will be released and

restored to normal. Likewise, if at any time in the process of extending the calling subscriber's circuit, he decides not to complete the call, he may restore his receiver to its hook and thereby release all the switches which have thus far been operated, and they will be restored to normal.

Considering these releasing operations more in detail, it will be remembered that, during conversation, the relays PR′ and SR′ are maintained continuously energized over the calling line circuit. The restoration of the calling party's receiver to its hook interrupts this energizing circuit and these relays become deënergized, thereby allowing their contacts 102, 103 to close, thus completing a release circuit which may be traced from the live pole of the battery B′, through the lower winding of release relay RR, closed contact 101 of off-normal switch SO, closed contacts 102, 103 of said relays PR′ and SR′, and the winding of release relay RR′ of the first selector U to ground. The closing of this circuit energizes both release relays RR and RR′; the former, by closing its contact 204, completes a locking circuit extending through its upper winding, closed contact 91 of the primary off-normal switch, and normal contact 88 of primary relay PR, to ground. This connection to ground from contact 204 also causes the energization of release magnet RM, which, due to the mechanical construction of the parts, releases the switch wipers and other parts and allows them to return to normal under the action of returning springs, as will be more fully explained hereinafter. In order that the wipers 27 and 28 may be disconnected from other parts while returning over the bank contacts 31 and 32, thereby preventing interference with conversation through multiply connected contacts, the relay SR is energized during this return movement. The energizing circuit for this relay extends from the live pole of the battery B′, through the winding of said relay, alternate contact 90 of secondary off-normal switch SO, and alternate contact 94 of release relay RR, to ground. The locking circuit of the release relay RR is maintained until the primary off-normal contact 91 is opened upon the return of the switch to normal. The energizing circuit of relay SR is also maintained until the wipers have completed their return movement in a secondary direction. At this time, the circuit is interrupted at contact 90 of the secondary off-normal switch SO. Alternate contact 96 of the release magnet RM is instrumental in placing a ground upon the associated master-switch bank contact 23 to cause the operation of the master-switch in case the release relay RR and release magnet RM are energized upon the line selector selecting the calling line, which would occur if the calling party hung up his receiver before the line selector had completed the selection.

The energization of release relay RR′ of the first selector U, by closing its contact 205, completes a circuit from the live pole of battery B^2, through the winding of relay S′R′, closed contact 126, of the primary off-normal switch PO′, closed contact 205 and the winding of relay RR′ to ground, thereby maintaining the release relay RR′ energized and energizing the secondary relay S′R′. The energizing of these relays closed a circuit for the release magnet RM′ which extends from the live pole of the battery B^2, through the winding of said magnet, alternate contact 132 and closed contact 130, to ground. The structure of the parts is such that the energization of this magnet releases the switch and allows its parts to return to normal. The energization of relay S′R′ also disconnects wipers 40, 41 during their return movement so as to prevent interference with existing conversation over multiple connections. The circuit for the relays RR′ and S′R′ is interrupted by the primary off-normal contact 126 when the switch has reached its normal position. The release of the first selector U is relayed to the second selector V by the closing of alternate contact 134 of release relay RR′, over a circuit which extends from the live pole of battery B^2, through protective resistance 206, alternate contact 134, closed contact 135, wiper 39, bank contact 42, closed contact 207 of the primary off-normal switch PO^2, and winding of release relay RR^2 to ground. This circuit is momentary only, being interrupted by contact 135 upon the energization of release magnet RM′, but is of sufficient duration to allow relay RR^2 to lock itself up. This locking circuit extends from the live pole of battery B^2, through the winding of relay SR^2, off-normal contact 137, closed contact 208, and the winding of relay RR^2 to ground, thereby continuing the energization of the secondary relay SR^2 and the release relay RR^2, as in the case of the first selector U. As in such case also, the joint energization of these relays closes an energizing circuit for release magnet RM^2, which may be traced from the live pole of battery B^2, through the winding of magnet RM^2, and alternate contacts 144 and 142 to ground. The energization of the release magnet, as before, causes the restoration of the switch parts to normal; and during this return movement, the energization of secondary relay SR^2 maintains the wipers disconnected to prevent interference with conversation over multiple connections. Upon the return of the switch parts to normal, the contacts of the primary off-normal switch PO^2 are opened, and the previously traced circuit of relays SR^2 and RR^2 is interrupted.

As before, the release of the second selector V closes a circuit which may be traced from the live pole of battery B^2, through protective resistance 209, alternate contact 141 of relay RR^2, closed contact 140 of release magnet RM^2, wiper 46, bank contact 49, closed contact 191 of off-normal switch PO^2, and alternate contact 190^a of relay CR to ground. Under the assumption that the calling party has first hung up his receiver, the completion of this circuit does not cause the release of the connector W. This release will not occur until the called party at substation N restores his receiver to its hook. Thus it will be seen that if the calling party restores his receiver before the called party, switches Q, U and V will be restored to normal. Now, when the called party hangs up his receiver, he will interrupt the circuit over the line limbs by which the tip relay TR was maintained energized, and at once a release circuit will be closed from the live pole of the battery B^3, through protective resistance 171, normal contact 187, alternate contact 188, and the winding of release relay RR^3 to ground, thereby energizing said relay to close its alternate contact 162 and thereby energize release magnet RM^3, which, due to the mechanical construction of the parts, releases the switch mechanism and allows it to return to normal. Since, during conversation, the relays R and CR are locked up over a circuit including the normal contact 162, it will be seen that these relays will be deënergized upon the energization of release relay RR^3. The energization of relay RR^3 by its contact 167 will open the locking circuit of ringing relay RG' and allow it to return its contacts to normal. Since the cut-off relay CO is held up by current flowing through closed contact 183 of relay RG', it follows that when this latter relay is deënergized, relay CO will also be deenergized. Likewise, the return of the wipers 52, 53, 54 to normal will restore the primary and secondary off-normal contacts PO^3 and SO^3 to their normal positions. It may also be noted that the energization of relay RR^3 interrupts the locking circuit of closing relay CR so that said relay is deenergized, and upon its deënergization it in turn opens the circuit of release relay RR^3, and thus all the parts are restored to normal. Now, if it be assumed that all the called-for lines are busy and that the calling party receives the busy signal, then the restoration of such party's receiver to its hook would cause the release of the switches Q, U, V by the closing of the circuits in the manner just described; and furthermore, this act will restore the connector W. From the previous description, it will be remembered that relay CR is not actuated until the called party responds to the call. Accordingly, the relayed action of the second selector V will not be impotent, as in the case just considered, but a circuit will be completed upon the energization of release relay RR^2 which, as before, will extend from the live pole of the battery B^2, through protective resistance 209, alternate contact 141, closed contact 140, wiper 46, bank contact 49, closed off-normal contact 191, and thence, instead of direct to ground, through normal contact 190^a and the winding of release relay RR^3 to ground. Thus the release relay is energized with the consequent energization of the release magnet RM^3 and the restoration of the switch parts, as before described. To give time for this restoration, the release relay RR^3 is locked up over a circuit extending from the live pole of battery B^3, through protective resistance 169, closed off-normal contact 168 and closed contact 167 of release relay RR^3, to ground.

Now consider the case in which the called, instead of the calling, party first restores his receiver to its hook. In such event, as heretofore, the circuit of the called line is broken with the consequent deënergization of the tip relay TR and the connector W is released by the closing of its circuits in the manner heretofore described. At this point, it will be remembered that the reversing relay RV, by which the substation special devices are actuated by a reversal of current, is maintained energized during conversation by the continued energization of relay 45, whose energizing circuit extends over one side of the heavily marked circuit through impedance coil 182 to ground, as before traced. Consequently, when the called party restores his receiver to its hook, relay 45 is deënergized. Thus a circuit for the release relay RR' is completed. This circuit extends from the live pole of the battery B^2, through protective resistance 210, closed contact 192 of relay 45, closed contact 211 of relay RV, and winding of the release relay RR' to ground. The energization of this relay is instrumental in causing the release of the first selector U with the subsequent release of the second selector V in the manner heretofore fully described. From this description, it will be seen that if the called party first restores his receiver to its hook, all the switches employed in the connection are restored to normal, except the line selector. This, however, is restored to normal as soon as the calling party interrupts his line circuit by restoring his receiver to its hook. This, as before explained, causes the closing of contacts 102, 103 of the relays PR' and SR', with the consequent energization of release relay RR of the line selector and the return of the parts of the line selector to normal.

It remains now to consider the effect of

the calling party restoring his receiver to its hook at various times prior to the completion of the connection. Thus, for example, if he immediately restores his receiver after having removed it, the effect will be to cause an idle line selector to select the calling party's line, and then immediately release, restoring all the parts to normal. From the previous description, it will be seen that the closing of the calling line circuit by the removal of the receiver, initially energizes the line relay LR and that this line relay is then locked up over a local circuit independent of the manipulation of the switch-hook at the substation. Consequently, the conditions which determine the operation of an idle line selector are maintained until such operation is completed. As soon as this takes place, however, the primary and secondary relays PR′ and SR′ will not be energized, as before described, over the calling line circuit, since the immediate restoration of the receiver to its hook interrupts the energizing circuit for these relays. It therefore follows that as soon as the actuated line selector has accomplished connection with the calling line, it is immediately released in the manner heretofore described by the closing of the release circuit from the live pole of the battery B′, through the lower winding of release relay RR, closed contacts 101, normal contacts 102 and 103, the winding of release relay RR′ to ground. As before indicated, at this time the necessary ground connection to the contact 23 of the master-switch O, causing the operation of the master-switch, extends through alternate contact 96 and either to ground through normal contact 95, or to ground through alternate contacts 95, 90 and 94. Thus the master-switch is operated in the manner heretofore described to bring its wipers into engagement with bank contacts corresponding to an idle line selector. From this it will be seen that the removal of the calling party's receiver always extends the calling line circuit to a first selector U, and the restoration of the receiver either before this connection has been completed, or after it has been completed, and before the calling mechanism has been operated, is instrumental in releasing the parts and placing them in condition for subsequent operation.

Obviously, from the preceding, if the calling line circuit has been extended through to a first selector U, and the calling party's receiver is then restored, the same release of the line selector will be obtained, with the accompanying release of the first selector U in the manner heretofore described. Likewise, if the connection has been extended to a second selector V, the same releasing operations will occur and the release of the first selector will be relayed to the second selector V, with a resulting restoration of its parts to normal in the manner heretofore described.

The connector W′.

In Fig. 2 of the accompanying drawings, I have illustrated a modified connector circuit, which differs principally from the connector W of Fig. 1 in the circuit connections of the relays RG, BR and RG′. By this circuit, fewer relay contacts are employed, but a somewhat more careful adjustment of the relays is necessary. In this connector, the circuit of the "flip-flop" relay includes a contact 212 of the relay BR, in addition to the contact 173 of the relay RG, but does not include a contact of the relay RG′, as in the case of connector W. Again, the connection from the winding of the tip relay does not include contacts of the relay RG′, but goes directly to contact 179 of relay RG. In this instance, relays RG and BR are actuated in parallel by the final impulse coming over the secondary side of the line from the calling station, and accordingly there is no connection for a winding of relay BR through contacts of relay RG. Likewise, the relay BR has no control over the upper winding 159 of relay RG. In operation, as just stated, the final grounding of the secondary side of the line actuates both relays RG and BR. The circuit by which this is done extends from the live pole of the battery B^3, through the windings 151 and 154 of relays RG and BR, respectively, in parallel, and thence through contact 153, of relay R to the strand L^3 and on to the ground at the first selector of the calling station. In case the test contact 55 is connected to battery, thereby indicating an idle condition of the called line, relays BR and RG immediately become deënergized and thereupon current flows from contact 55, through wiper 52, closed contact 163 of relay RG′, normal contact 164 of relay BR, closed contact 165 of relay R, normal contact 166 of relay RG′, through the winding of said relay to ground, relay R having been actuated by the connection of its winding to ground through contact 160′. Relay RG′ is at once locked up through contacts of release relay RR^3, as before. By the closing of its contact 170, it also causes the energization of relay RG, as before. The energization of the latter relay closes a circuit of the "flip-flop" relay FF, through the interrupter 176 and closed contacts 173, normal contacts 212 and 174. The operation of the relay FF in alternately connecting the ringing generator 181 and the tip relay TR is the same as before, the connection of the latter, however, being directly through contacts 179 and 180; instead of through an additional contact of relay RG′, as in the case of connector W. In case the test contact 55 is grounded,

corresponding to the busy condition of one of the first lines of a group running to one substation, then, upon the energization of relays BR and RG, relay BR will be maintained actuated by current from the live pole of battery B^3, through its upper winding 196, alternate contact 164, closed contact 163, wiper 52 and test contact 55 to ground. Under this condition, secondary magnet SM^3 will have its circuit closed through contacts 197 and 160 of relays RG and BR, respectively. Relay BR will be maintained energized so long as grounded contacts 55 are encountered. If a contact connected to battery is encountered, then the relay BR will drop back and ringing current will be applied in the manner just described. If, on the other hand, the test contact encountered by the wiper 52 be on open circuit, as in the case of individual lines or the last line of a group of lines going to one substation, then relays RG and BR will be but momentarily energized by the final impulse over the secondary side of the line; and upon restoring their contacts to normal, there will be no circuit to energize relay RG, as in the case of encountering an idle line, but contacts 202 and 203 will remain in their normal positions and thereby close the busy back circuit from the busy back device BB, through the off-normal contact 201 in the manner heretofore described in connection with connector W. In other respects, the operation is the same as the connector W and therefore need not be repeated.

Switch construction.

Obviously, in the practice of the different embodiments of the invention herein disclosed, switching devices of various mechanical constructions and arrangements may be employed for performing the switching functions therein indicated. The switching mechanisms for performing the various functions heretofore described are illustrated in Figs. 3 to 10, inclusive, of the accompanying drawing.

The selectors and connectors may be of the type illustrated in Figs. 3 to 6 inclusive. These figures specifically illustrate the parts of the line selector Q, but, as will hereinafter more fully appear, the same switch structure may be employed for the selectors and connectors by slight modifications which will be pointed out. In the construction illustrated in these figures, 298 designates a suitable supporting frame for the switch mechanism, which includes a primary magnet PM, secondary magnet SM, release magnet RM in association with wipers 26, 27 and 28, coöperating with the bank contacts 30, 31 and 32, which are arranged in the bank 299, with their free ends adapted for the attachment of suitable conductors, in accordance with the diagram of the previous figures, and having their contacting inner ends terminating in a spherical surface. These bank contacts may be arranged in any desired number of rows of any desired number of contacts each. In the present instance, ten rows of ten sets of contacts each are illustrated. The set of wipers 26, 27 and 28 are pivoted at the center of rotation of the spherical surface formed by the inner ends of the contacts. The pivotal support for the wipers is provided by a pivot 299′, located near the lower end of the rotary shaft 300, suitably journaled in the frame 298. The wipers are rotatable with the shaft in a horizontal or primary direction, and, in addition, may be rotated about their pivot 299′ through the agency of an additional longitudinally movable shaft 301, having a broad strip 302 at its lower end which engages a transverse slot in a disk 303, which is rotatably mounted in a bearing formed at the rear end of the member 304, which carries the wipers. Thus by rotating the shaft 300, the wipers may be given their primary movement to the desired group, or row, of bank contacts, and by subsequently giving the shaft 301 a longitudinal movement, the wipers may be moved to the desired bank contact in the selected group. The strip 302 on the shaft 301 is sufficiently broad to engage the slot in the disk 303, no matter what the position of the wipers may be. In addition to the wipers and bank contacts thus provided, the fixed contacts 33 are arranged in a row at the lower side of the bank 299 in the arc of a circle in a position to have their inner ends engaged by the wiper 29, carried by, and insulated from, the shaft 300. As will be apparent, the wiper 29 is capable of a horizontal, or primary, movement only and therefore does not partake of the secondary movement of the wipers 26, 27, 28. The mechanism associated with the primary magnet PM, by which the shaft 300 is given its primary, or rotary, movement, comprises an actuating pawl 305, carried by the armature 306, adapted to engage the teeth of the ratchet-wheel 307, rigidly secured to the shaft 300 and adapted to step it around upon successive energizations and deënergizations of the primary magnet PM. The forward movement of the pawl 305 is limited by the beveled stop 308 secured to a portion of the frame 298. The return movement of the pawl is limited by an adjustable stop 309 also carried by the frame 298 and adapted to engage the pawl 305, so as to throw its engaging end outward away from the engaging teeth of the ratchet 307. A spring 310, carried by the armature 306, bears against a portion of the pawl 305 and tends to force it into its engaging position. The armature 306 is normally held in its

retracted position by means of a leaf-spring 311 carried by the magnet frame. The shaft 300 is retained in its various positions by the retaining pawl 312 pivoted upon the frame 298 and normally pressed into engaging position by a spring 313. The pawl 312 is provided with a tail 314, adapted to be engaged by the armature 315 of release magnet RM upon the energization of the latter. When the release magnet is thus energized, the retaining pawl is therefore moved out of retaining position. The upper end of the shaft 300 is surrounded by a coiled retracting spring 316, which is placed under tension by the movement of the wipers from normal and co-acts between the frame 298 and the shaft. The upper end of the shaft is also provided with two lateral projections 317 and 318. The former of these normally rests against a fixed stop 319, while the latter carries an upwardly projecting insulating pin 320. This pin coöperates with the contacts of the primary off-normal switch PO, and when in a normal position, holds these contacts against their inherent tension in the position illustrated in the drawings, but as soon as moved from normal, the contacts freely move under their own spring action to their alternate positions. The secondary magnet SM, through the agency of its armature 324, actuating pawl 325, and the ratchet teeth 326 on the shaft 301, steps the latter downwardly to carry the contacting ends of the wipers to their various engaging positions. The downward movement of the pawl 325 is limited by a beveled stop 327 carried by the magnet frame, while a similar square stop 328, when engaged, forces the pawl out of engaging position so that when the pawl is in normal position, it is freed from the teeth 326. The pawl is moved into its engaging position by a leaf-spring 329 carried by the armature 324; and a similar spring 330, carried by the magnet frame, moves the armature to its retracted position. A suitable retaining pawl 331 engages teeth 332 upon the shaft 301 to hold it in its different operating positions. The shaft 301 is also provided with a suitable spline 333, which, after the first movement of the shaft, engages the teeth of the ratchet-wheel 307 to lock the shaft 300 against rotation. The retaining pawl 331 is pivotally secured to a bracket 334 carried by the upper portion of the switch frame 298, and is normally pressed into engaging position by a suitable spring 335, coiled about its pivot. The free end of the retaining pawl 331 is connected by a link 336 to the free end of the primary retaining pawl 312. A pin and slot connection between the link 336 and the pawl 331 enables the latter to move freely as the shaft 301 is moved downward, but causes it to be moved out of engaging position whenever the release magnet is energized. The secondary shaft 301 is restored to normal through the agency of a coiled tension spring 337, secured at one end to a portion of the frame 298, and at the other end to one end of a lever 338, pivoted at an intermediate point to a projection 339 extending downward from the upper portion of the frame 298, and having a pin and slot connection at its opposite end with the shaft 301. Thus it will be seen that upon each energization of the release magnet RM, the retaining pawls 312 and 331 are moved out of engaging position, and the shafts 300 and 301 are returned to their normal positions. Since the shaft 300 has its ratchet-wheel 307 engaged with the spline 333, it cannot begin its return movement until the shaft 301 has moved the wipers beyond the first set of bank contacts, the spline 333 being so positioned with reference to the ratchet-wheel 337 and of such a length as to bring about this result. The contacts of the secondary off-normal switch SO are normally held against their spring tension in the position illustrated in Fig. 1 through the agency of a projection 340, carried at the upper end of the shaft 301.

In the case of the first and second selectors U and V, a switch of the same construction as the line selector Q, just described, may be employed, but in each instance there would be no function for the wiper 29 and associated contacts 33 and therefore these would ordinarily be omitted, and in each case the proper arrangement of primary and secondary off-normal switch contacts would supplant those provided for the line selectors, in accordance with the arrangements illustrated in Fig. 1. In the case of the connector, the same switch may also be employed with slight modifications. In such case, the wiper 29 and the associated contacts 33 would be omitted, as before. Again, the terminal-piece 302 should be secured to the shaft 301 a little higher up so as to bring the contacting ends of the wipers two steps distant from the nearest set of bank contacts. The primary off-normal switch contacts should be replaced by a proper number of off-normal contacts, and the secondary off-normal contacts should be replaced by those illustrated in Fig. 8, wherein the projection 340 controls the movement of contacts 147 and 149. As previously explained in considering Fig. 1, contact 147 moves to its alternate position upon the first downward step of the shaft 301, while the contact 149 moves from its normal position upon the first downward step of said shaft, but does not move to its alternate position until said shaft has taken a second step. This is brought about by properly spacing the spring contacts coöperating with contacts 147 and 149, as illus-

trated in Fig. 8. It will be noted that the coöperating contacts below contacts 147 and 149 in said figure are located different distances away. In other words, the contact below 149 is two steps distant from said contact, while that below 147 is but one step distant. Consequently, upon the first downward step of the shaft 301, contact 147 will move from its normal to its alternate position, while contact 149 will break its normal contact, but will not move to its alternate position until said shaft has made a second step.

The master-switch, by which the various line selectors U are controlled, may also take various forms, but is preferably constructed along the lines indicated in Figs. 9 and 10. As therein indicated, the fixed contacts 22, 23 are located in a bank 341, preferably arcuate in form, and have their inner ends arranged concentrically to the shaft 342, which carries the wipers 20 and 21, whose outer ends are adapted to engage the inner ends of the bank contacts. The latter are suitably insulated from each other, and their outer ends are arranged for connection to conductors adapted to extend to the various line selectors. Although, in the diagram, but a single set of wipers and bank contacts is shown, I preferably employ three sets of wipers in association with bank contacts, which embrace one hundred and twenty degrees of the arc of a circle. This is clearly the equivalent of one set of wipers associated with bank contacts extending completely around the circle. The switch structure comprises, in addition, a motor-magnet MM, but does not necessarily include the control relays 24 and 25. The wipers are suitably insulated from each other and their supporting shaft 342, which is journaled in the frame 343, which also supports contact bank 341. The shaft 342 carries a toothed wheel 344 which is rigidly secured thereto, the said wheel and shaft being adapted to be rotated in response to the movements of the pawls 345, 346, carried by an irregularly shaped armature 347, rotatably supported upon the shaft 342 and coöperating with the poles 348 and 349 of the motor-magnet MM. These pole-pieces are angular in form and one leg of each is secured to the end of the magnet core, which, together with the pole-pieces, is located between the upward projections 350, 351 of the frame 343. Each of the pawls 345 and 346 is spring-pressed into engaging position, while the armature itself is restored to its retracted position by means of a leaf-spring 352 which, at one end, engages said armature and, at the other end, is secured to the projection 350 of the frame. The movement of the armature 347 is limited by the pawls 345 and 346 engaging stops 354 and 355, respectively, carried upon the contact bank 341. The pawl 345 is also adapted to ride upon the pin 355′ carried upon a strip 356, secured adjacent to the stop 354. In the operation of the switch, upon the energization of the motor-magnet MM, its armature is attracted and thereby pawl 346 is advanced until it engages stop 355. During this advance movement, pawl 345 rides upon pin 355′ and thereby moves its end out of engagement with the tooth 354. Upon the return movement of the armature, pawl 345 drops into the next notch of the toothed wheel and comes up into engagement with the stop 354. With the parts in the position illustrated, or when the armature 347 has moved far enough to bring pawl 346 into engagement with stop 355, one of the sets of wipers 20, 21 will be exactly over the center of the corresponding bank contacts 22, 23. If the energization of the motor-magnet MM is such that the pawl 346 is not advanced a complete step, the pawl 345, upon return, due to the proportioning of the parts, will engage a notch in the wheel 344 and will return the wheel and the wipers to their previously occupied positions. Thus it is impossible to leave the wipers in other than a position in exact registry with the set of bank contacts.

From the above description, it will be seen that I have made use of a principle of wide application which need not be limited to its specific use in telephone systems. It will also be apparent that many changes in the mechanical construction of the various switching elements entering into the system, and in many of the circuit arrangements, may be made without departing from the spirit and scope of my invention. In many instances, batteries, diagrammatically illustrated as separate and distinct, may be one and the same. Likewise, various types of generators and interrupters may be employed to perform the functions enumerated. These various alterations and modifications will be apparent to those skilled in the art and need not be further detailed. In view of these many changes which may be made within the scope of my invention, I have sought to use such terms in the appended claims as will fully cover them.

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

1. In a telephone system, the combination of a passive contact, means for giving said contact three different electrical conditions, a coöperating wiper for engaging said contact, electrically controlled circuit controlling devices associated with said wiper, and means for causing said devices to assume three different conditions corresponding respectively to said three conditions of said contact.

2. In a telephone system, the combination of a passive contact, means for giving said contact three different electrical conditions,

a coöperating wiper for engaging said contact, a plurality of relays associated with said wiper, and means for causing said relays to establish three different circuit connections corresponding respectively to said three conditions of said contact.

3. In a telephone system, the combination of a passive contact, means for giving said contact three different electrical conditions, a coöperating wiper for engaging said contact, a plurality of relays associated with said wiper, electrically controlled means for moving said wiper, a control circuit for said moving means including contacts of certain of said relays, a source of ringing current and connections therefrom through contacts of certain of said relays, a busy back device and connections therefrom through contacts of certain of said relays, and means for causing said relays to operate to advance said wiper, apply ringing current and transmit the busy signal according to said three electrical conditions of said contact respectively.

4. A telephone system comprising a calling line, a called line having a test contact, a link-circuit for uniting said lines, a cooperating test wiper associated with said link-circuit, means for giving said test contact three different electrical conditions corresponding to the service conditions of said called line, electrically controlled means for moving said wiper, a source of ringing current, a busy back device, and means for actuating said moving means, applying current from said source to said called line and transmitting a busy signal from said device over said calling line according to said three electrical conditions of said contact respectively.

5. A telephone system comprising a calling line, a called line having a test contact, a link-circuit for uniting said lines, a cooperating test wiper associated with said link-circuit, means for giving said test contact three different electrical conditions corresponding to the service conditions of said called line, a plurality of relays associated with said wiper, electrically controlled means for moving said wiper, a control circuit for said moving means including contacts of certain of said relays, a source of ringing current and connections therefrom through contacts of certain of said relays, a busy back device and connections therefrom through contacts of certain of said relays, and means for operating said relays to move said wiper, apply ringing current and transmit the busy signal in accordance with said three electrical conditions of said contact respectively.

6. A telephone system comprising a telephone line having a test contact, talking contacts independent of said contact, a plurality of link-circuits for individually connecting with said line, a source of current, means for establishing electrical conditions of said contact corresponding to the idle and busy conditions of said line, the one by connecting said contact to one pole of said source and the other by disconnecting said contact, and means associated with each said link-circuit for indicating the condition of said contact.

7. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits individually operative to connect to said line, a source of current a normal connection from one pole of said source to said test contact producing the idle electrical condition of said contact, means responsive to the connection of one of said link-circuits to said line to disconnect said contact to establish the busy electrical condition of said contact, and means associated with each said link-circuit for indicating the condition of said contact.

8. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits individually operative to connect to said line, a source of current, a normal connection from one pole of said source to said test contact producing the idle electrical condition of said contact, means responsive to the connection of one of said link-circuits to said line to disconnect said contact to establish the busy electrical condition of said contact, and means associated with each said link-circuit for producing a busy signal upon encountering the said busy condition of said contact and for applying ringing current to said line upon encountering the said idle condition of said contact.

9. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits for individually connecting with said line, a source of current, a connection from said contact to one pole of said source establishing an electrical condition of said contact corresponding to the idle condition of said line, means for establishing alternative electrical conditions of said contact corresponding to the busy condition of said line, by disconnecting said contact and by connecting it to the opposite pole of said source, respectively, and means associated with each link-circuit for indicating certain of said conditions of said contact.

10. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits for individually connecting with said line, a source of current, a connection from said contact to one pole of said source establishing an electrical condition of said contact corresponding to the idle condition of said line, means for establishing alternative electrical conditions of said contact corresponding to different busy conditions of said line by disconnecting said contact and by connecting it to the opposite

pole of said source respectively, and means associated with each said link-circuit for automatically distinguishing between said alternative busy conditions and operating differently according to the condition met.

11. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits for individually connecting with said line, a source of current, a connection from said contact to one pole of said source establishing an electrical condition of said contact corresponding to the idle condition of said line, means for establishing alternative electrical conditions of said contact corresponding to different busy conditions of said line by disconnecting said contact and by connecting it to the opposite pole of said source respectively, and means associated with each said link-circuit for disconnecting its circuit from said line upon encountering one of said alternative busy conditions and for signaling upon encountering the other said busy condition.

12. A telephone system comprising a telephone line having a test contact, a plurality of link-circuits for individually connecting with said line, a source of current, a connection from said contact to one pole of said source establishing an electrical condition of said contact corresponding to the idle condition of said line, means for establishing alternative electrical conditions of said contact corresponding to different busy conditions of said line by disconnecting said contact and by connecting it to the opposite pole of said source respectively, and means associated with each said link-circuit for disconnecting its circuit from said line upon encountering one of said alternative busy conditions, for producing a busy signal upon encountering the other said busy condition and for applying ringing current to said line upon encountering the said idle condition of said contact.

13. In a telephone system, two control relays, a source of current, a simple energizing circuit for the first of said relays, and connections whereby the closing of said simple circuit causes the energization of said first relay, then the energization of said second relay, then the deënergization of said second relay, and finally the deënergization of said first relay, all in the order given.

14. In a telephone system, the combination with a telephone line, of a test contact for said line, a link circuit having testing and talking contacts for establishing connection with said line, a source of current, means for establishing the busy condition of said line by connecting said contact with one pole of said source, means for establishing the idle condition of said line by disconnecting said contact, and means associated with said link circuit for indicating the idle or busy condition of said line.

15. A telephone system including a step-by-step connector switch having a movable test wiper, a calling telephone line, a group of called telephone lines and corresponding test terminals for said connector switch equal in number to the number of called lines, selective switches under the control of the calling subscriber for extending a call to the said connector switch, means whereby said test wiper is operated to test said group of terminals to automatically select the first idle line of the group, and means whereby if all of the lines of the group are busy said connector switch upon reaching the last test terminal of the group will connect an audible busy signal to the subscriber's line.

16. A telephone system including a step-by-step connector switch having a movable test wiper, a calling telephone line, groups of called telephone lines and corresponding groups of test terminals for said connector switch equal in number to the number of called lines, selective switches under the control of the calling subscriber for extending a connection to said connector switch, means whereby said test wiper is operated to select a group of terminals and thereafter test said group to automatically select the first idle line of the group, and means whereby if all of the lines of the selected group are busy said connector switch will indicate busy upon reaching the last test terminal of said group.

17. A telephone system including a step-by-step connector switch having movable test and line wipers, a calling telephone line, groups of called telephone lines and corresponding groups of line and test terminals for said connector switch equal in number to the number of lines, a selective switch provided with a contact maker capable of assuming a plurality of selective positions under the control of the calling subscriber for use in connecting his line to said connector switch, means whereby said wipers are operated to automatically select the first idle set of terminals of a group, and means whereby if all of the lines of a group are busy said connector switch upon reaching the last set of terminals of the group will connect an audible busy signal to the telephone line of the calling subscriber.

18. A telephone system including a connector switch having a movable test wiper, a group of telephone lines and corresponding test terminals for said connector switch equal in number to the number of lines, a source of current, said test terminals being adapted to be connected to either pole of said source or on open circuit, means for connecting all but the last of said test terminals to one or the other of the poles of said source according to the idle or busy condition of the line, means for connecting the last of said test terminals to one pole of said

source or on open circuit according to the idle or busy condition of the corresponding line, means whereby said test wiper is operated to successively test said terminals to automatically select the first idle line of the group, and means associated with said connector switch whereby if all of the lines of the group are busy said connector switch will indicate busy upon reaching the last test terminal of the group.

19. A telephone system including an automatic step-by-step connector switch having a movable test contact, a calling telephone line, a group of called telephone lines provided with corresponding test terminals terminating in the banks of said connector switch and equal in number to the number of lines, automatic switches controlled over the calling line for connecting with said connector switch, means for operating said connector switch to test said group of terminals for automatically selecting the first idle line in the group, and means including said test contact whereby if all the lines of the group are busy the said connector switch will operate to transmit a busy signal upon reaching the last terminal in the group.

20. A telephone system including a step-by-step connector switch, a calling line, a group of called lines having test terminals arranged to be tested by said automatic switch, subscriber controlled means for connecting said calling line with said connector switch, means for operating the said connector to test said group of test terminals to automatically pick out the first idle line of the group, and means whereby if all the lines of the group are busy the said connector will transmit a busy signal to the said calling line upon reaching the last test terminal in the group.

21. A telephone system including a called telephone line, a test contact for said called line, a cut-off relay connected to said test contact, a link circuit, means including said link circuit for extending a connection to said called line, and means controlled by said link circuit for disconnecting said cut-off relay from said test contact so that said line will test busy if another link circuit should attempt to effect connection with said line.

22. A telephone system including a telephone line, a test contact for said line, a cut-off relay normally connected to said test contact, an automatic switch for connecting with said test contact, and means controlled by said switch for disconnecting said cut-off relay from said contact whereby said test contact will test busy to a second connector switch.

23. A telephone system comprising a telephone line, a test contact for said line, a relay normally connected with said test contact, an automatic switch for connecting with said line, and means controlled by said switch for disconnecting said relay whereby said test contact is rendered busy to other automatic switches.

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

THOMAS H. FERGUSON.

Witnesses:
IDA E. LARSEN,
BERTHA M. DELVIN.