March 16, 1926. 1,576,814

F. W. DUNBAR

AUTOMATIC TELEPHONE SYSTEM

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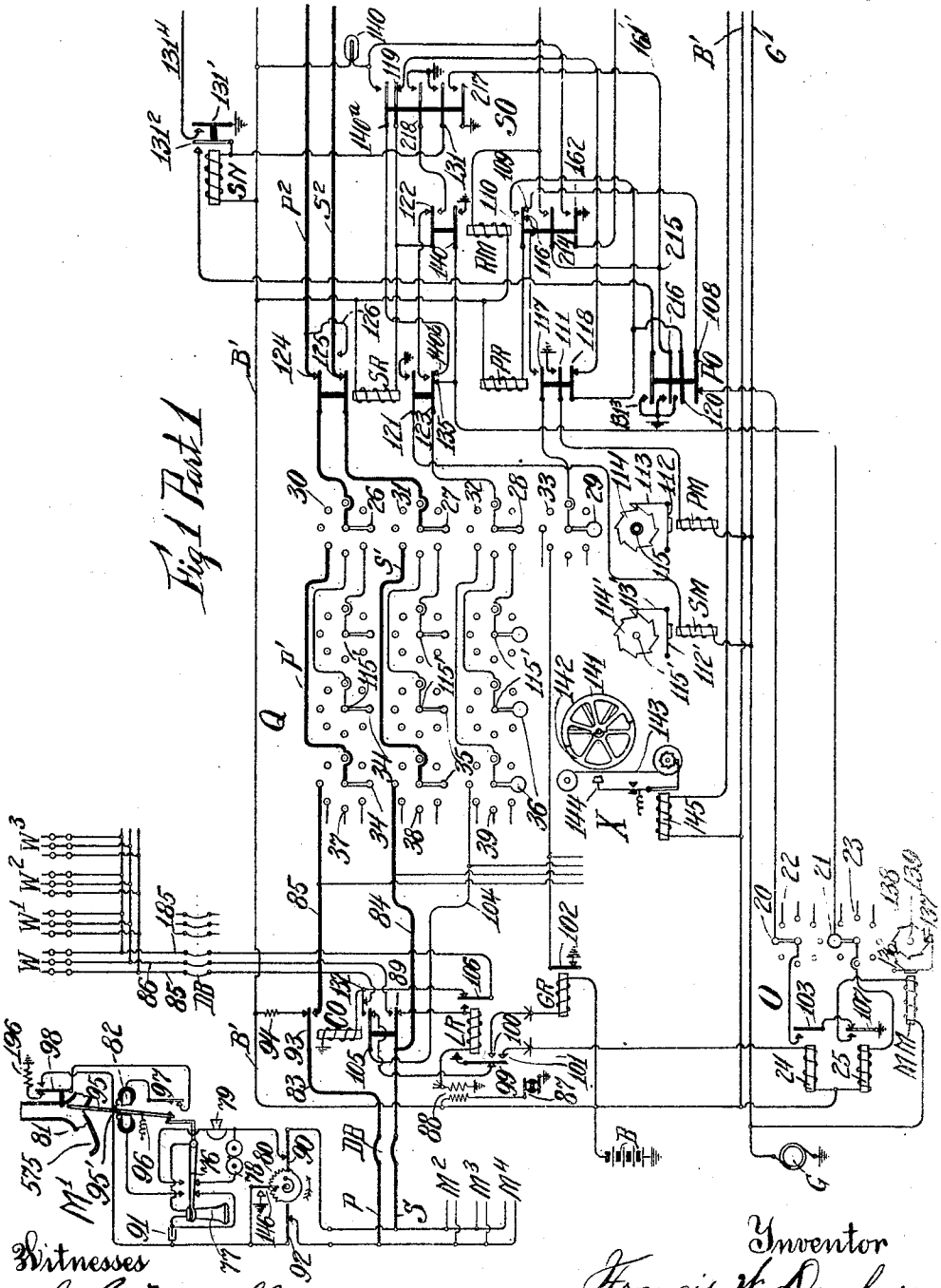

Fig. 1 Part 1

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AUTOMATIC TELEPHONE SYSTEM

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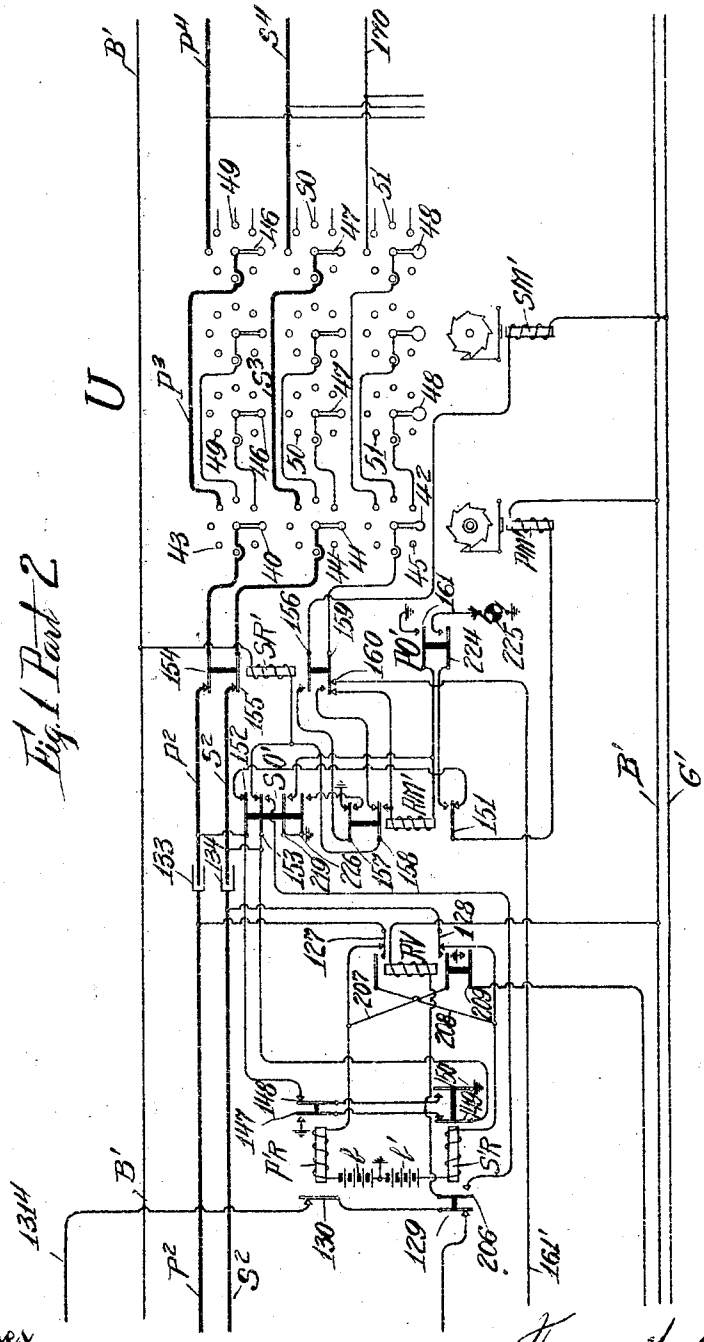

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AUTOMATIC TELEPHONE SYSTEM

Filed Feb. 18, 1908 16 Sheets-Sheet 3

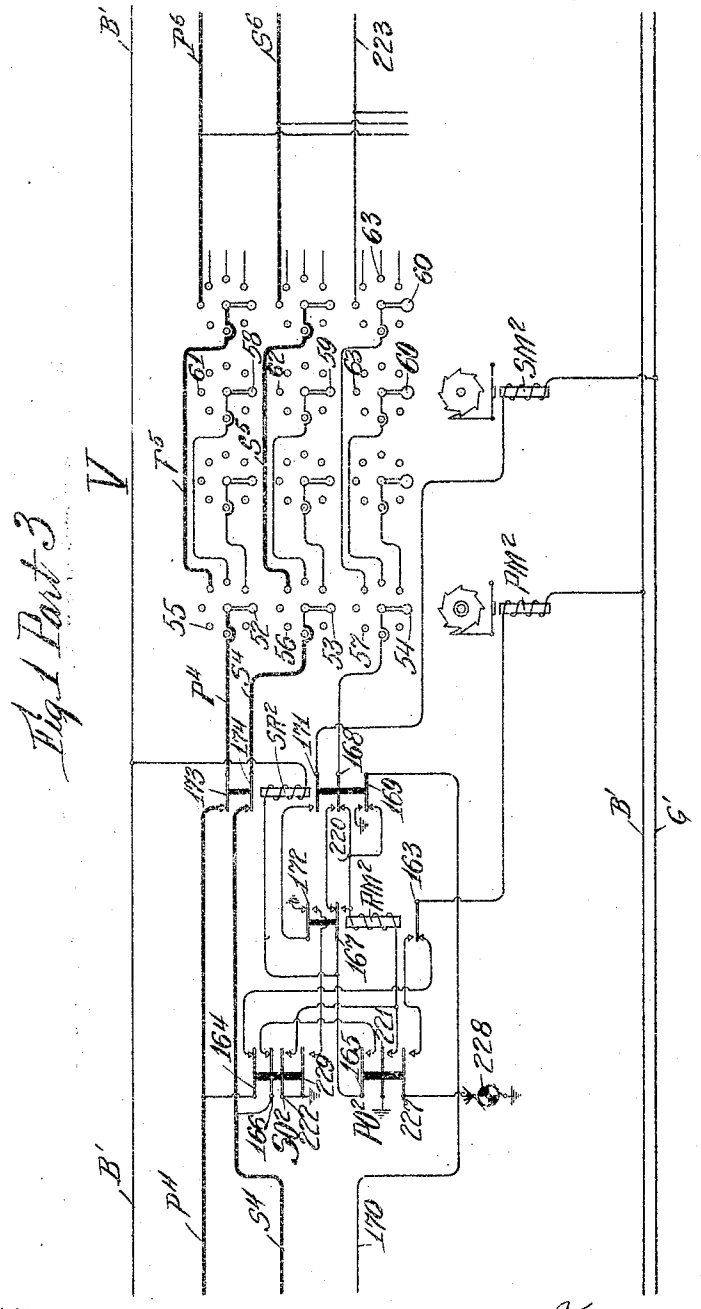

Fig. 1 Part 3

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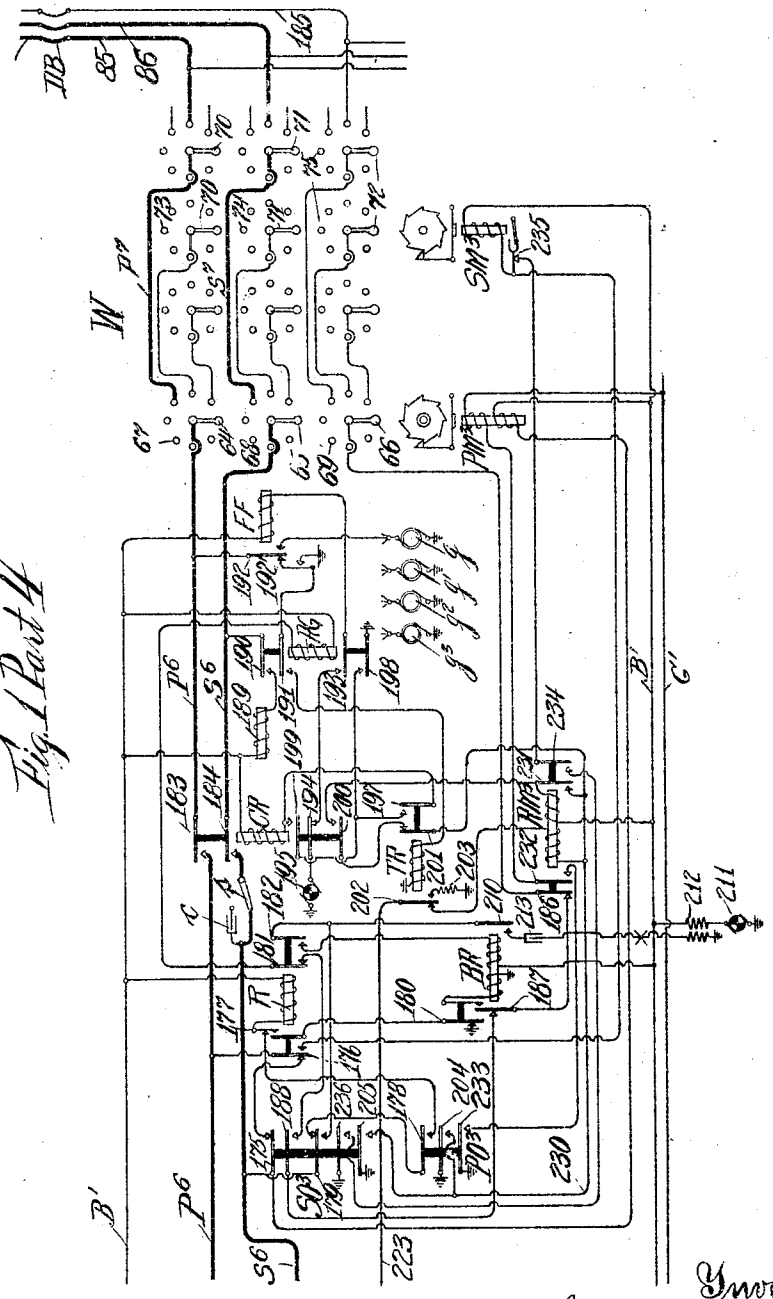

Fig. 1 Part 4

Witnesses
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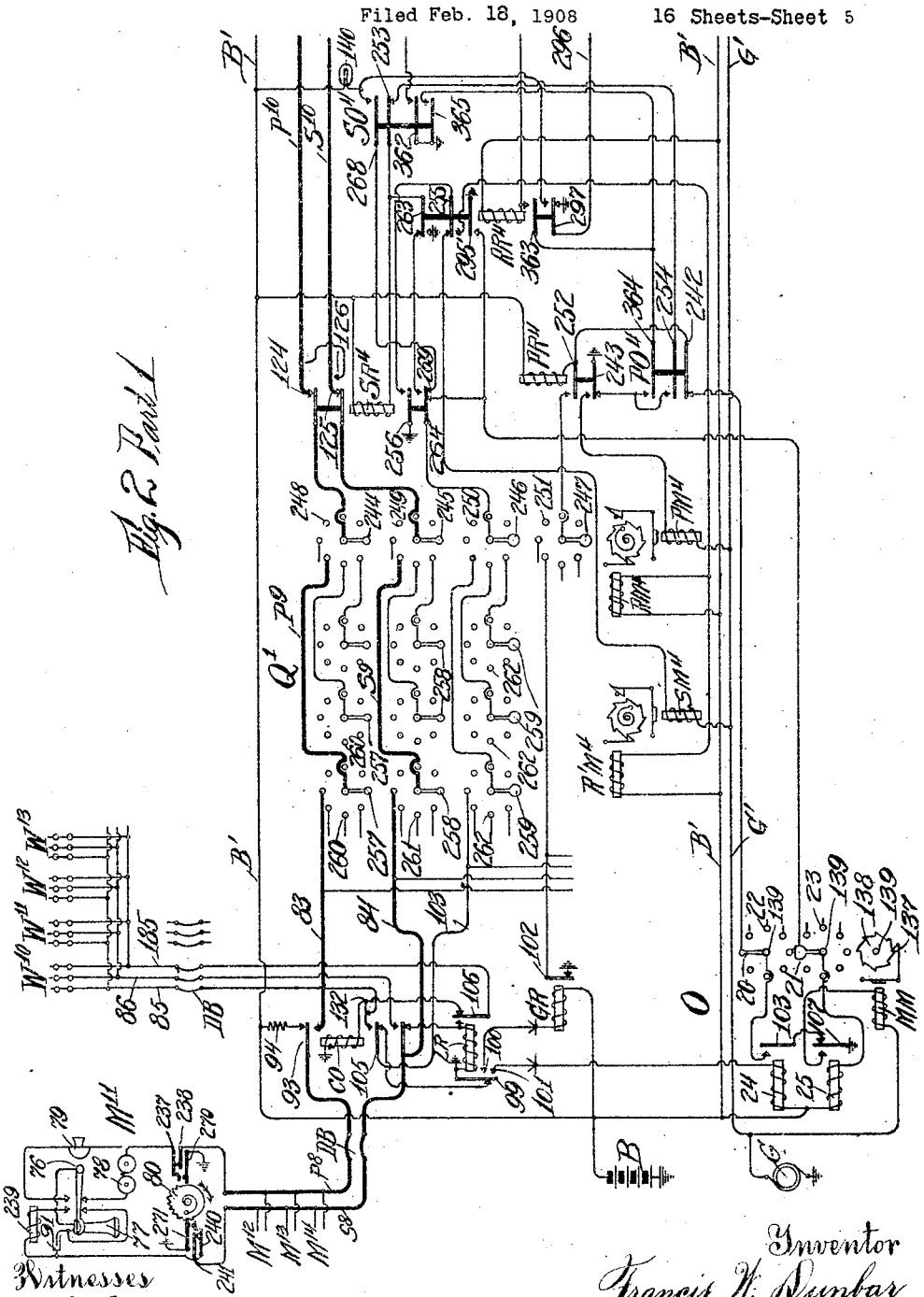

Fig. 2 Part 1

Witnesses
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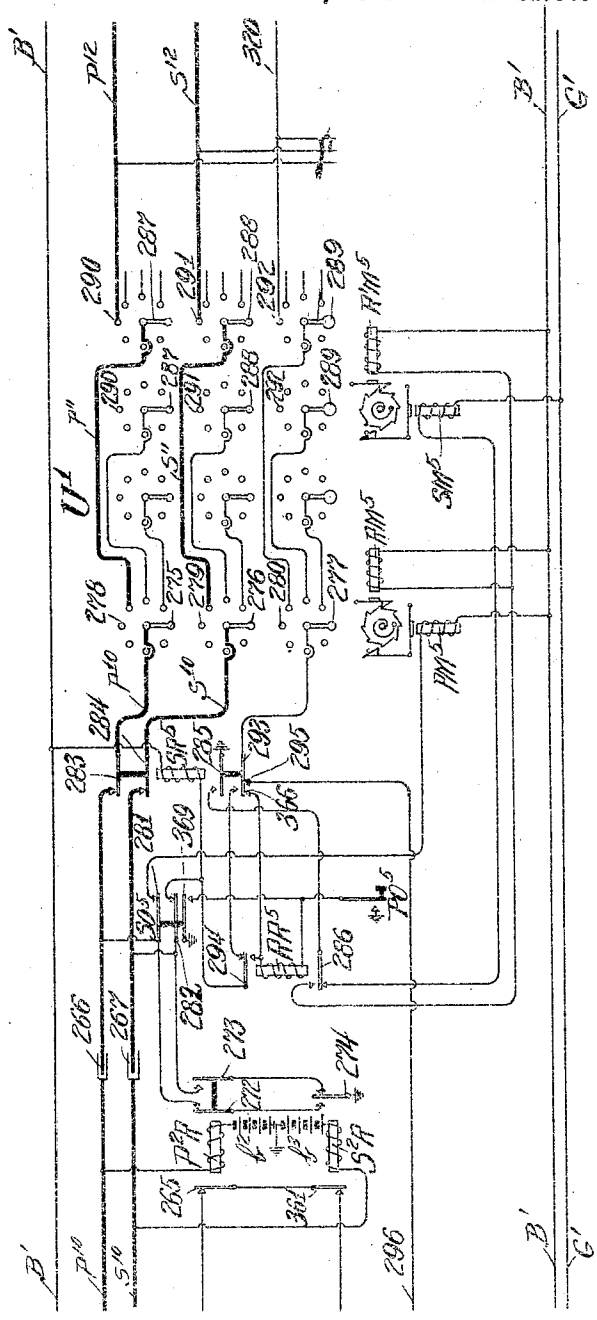

Fig. 2 Part 2

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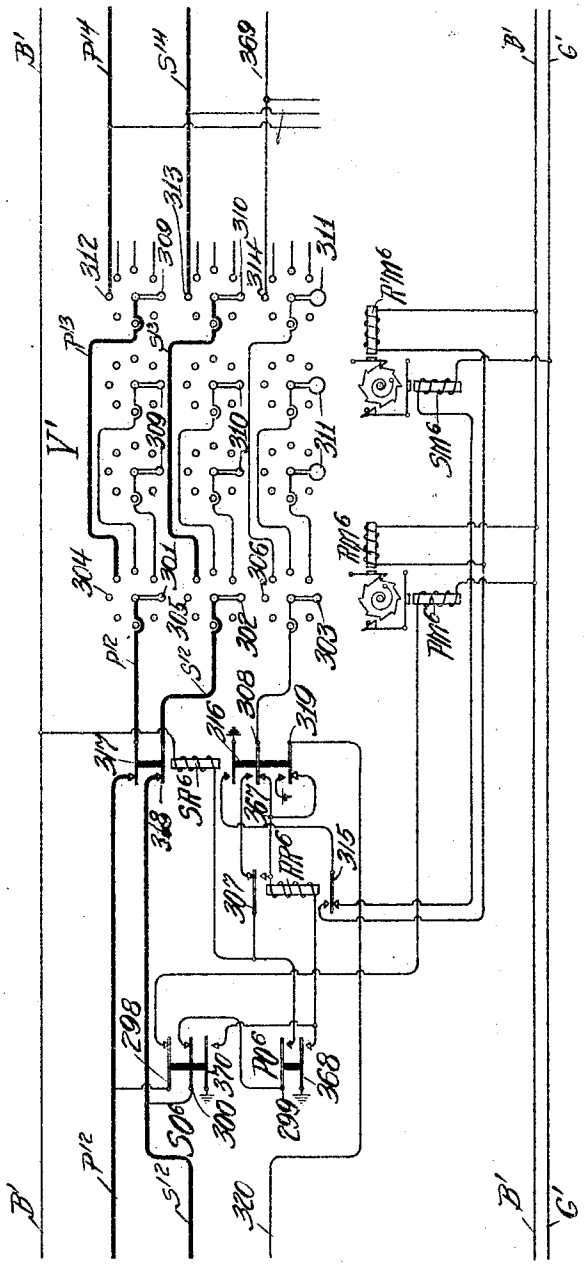

Fig 2 Part 3

Witnesses
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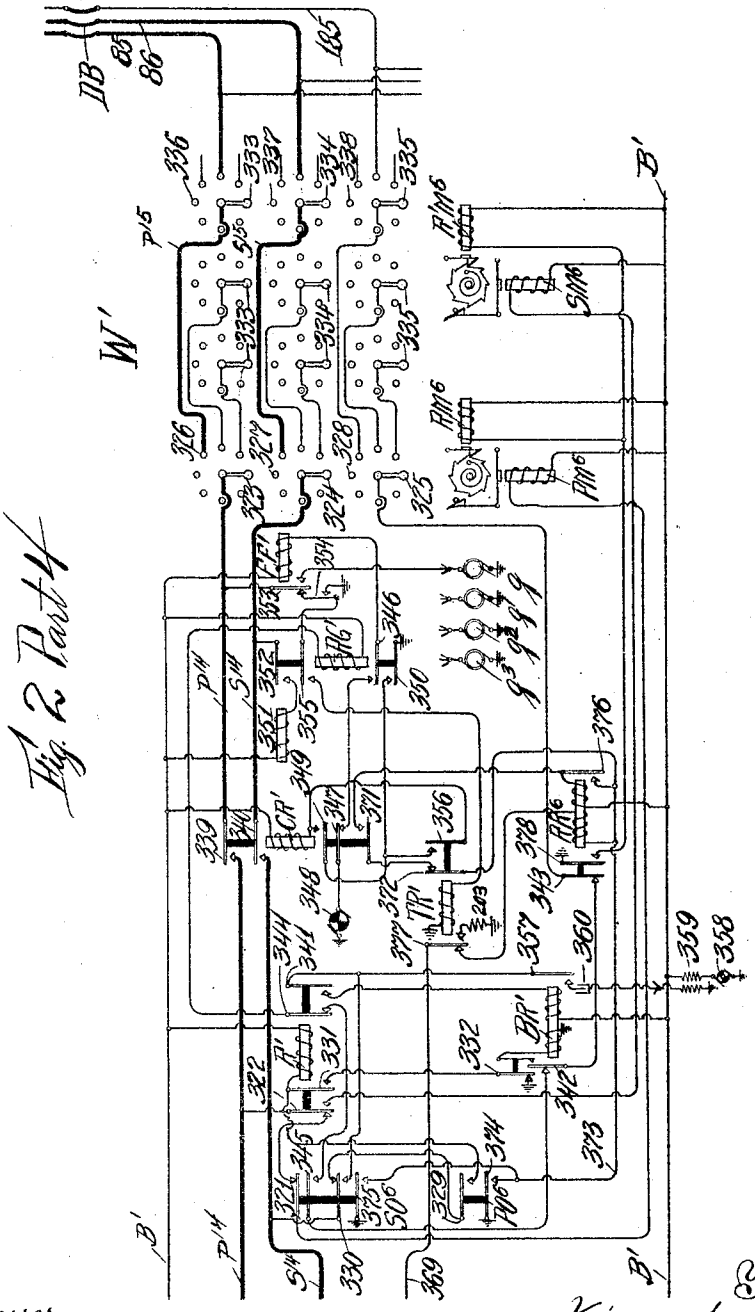

Fig. 2 Part 4

Witnesses
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Filed Feb. 18, 1908 16 Sheets-Sheet 9

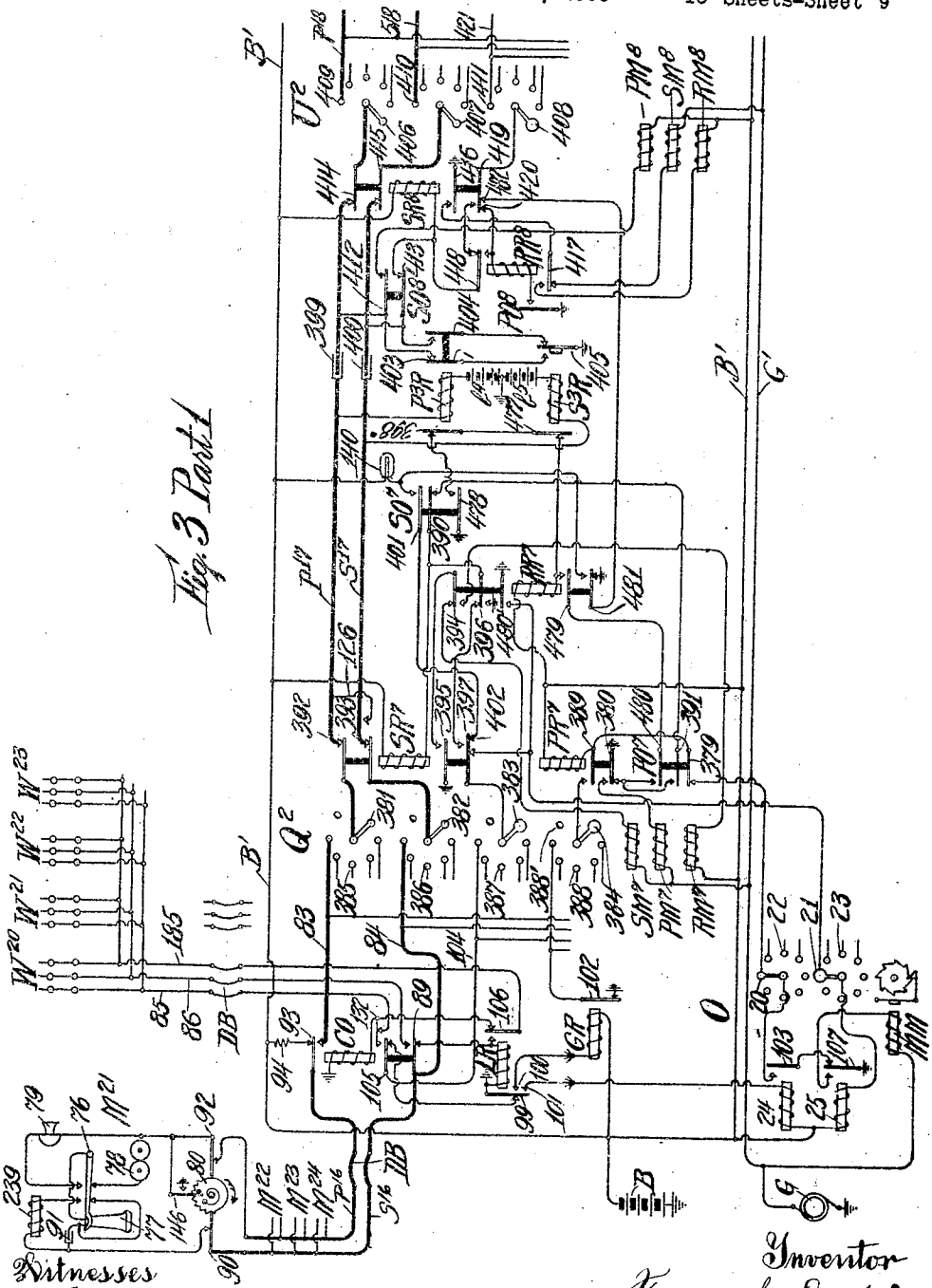

Fig. 3 Part 1

Witnesses
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AUTOMATIC TELEPHONE SYSTEM

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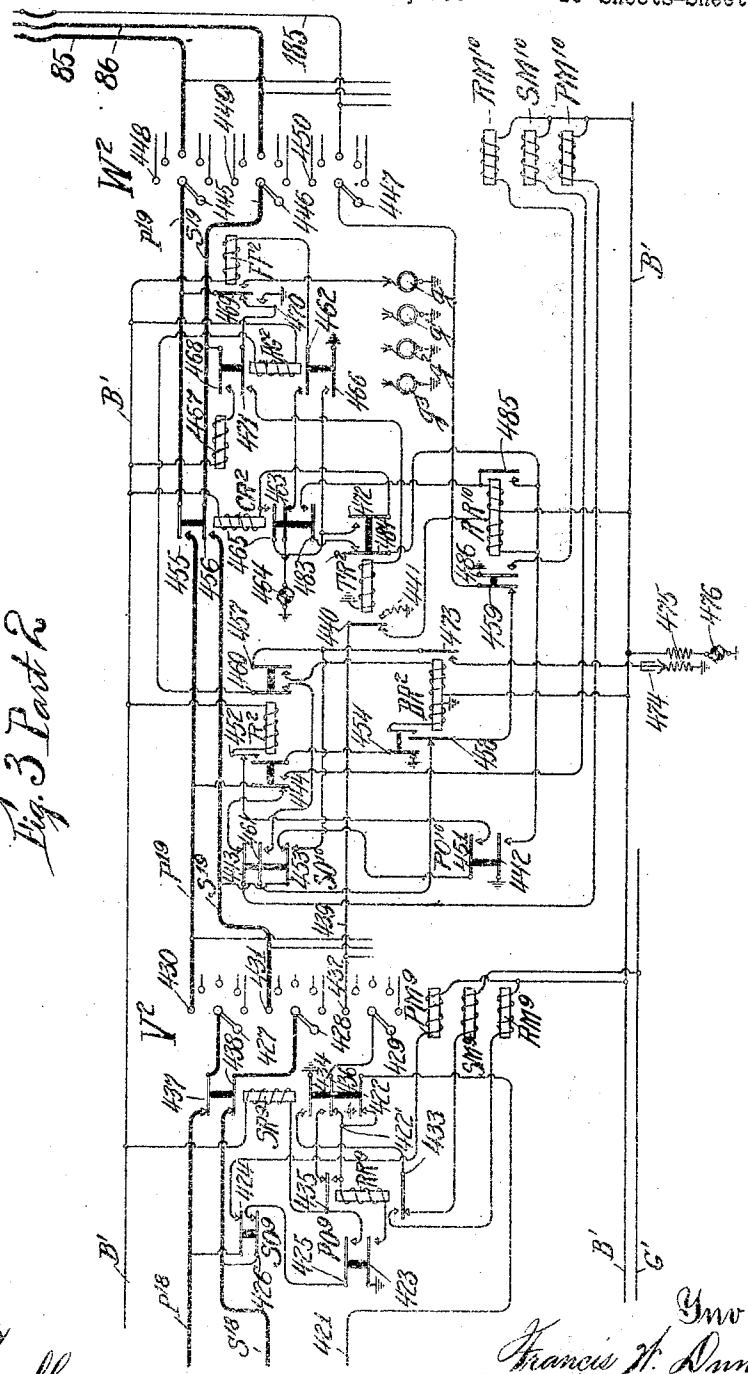

Fig. 3 Part 2

Witnesses
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Filed Feb. 18, 1908 16 Sheets-Sheet 11

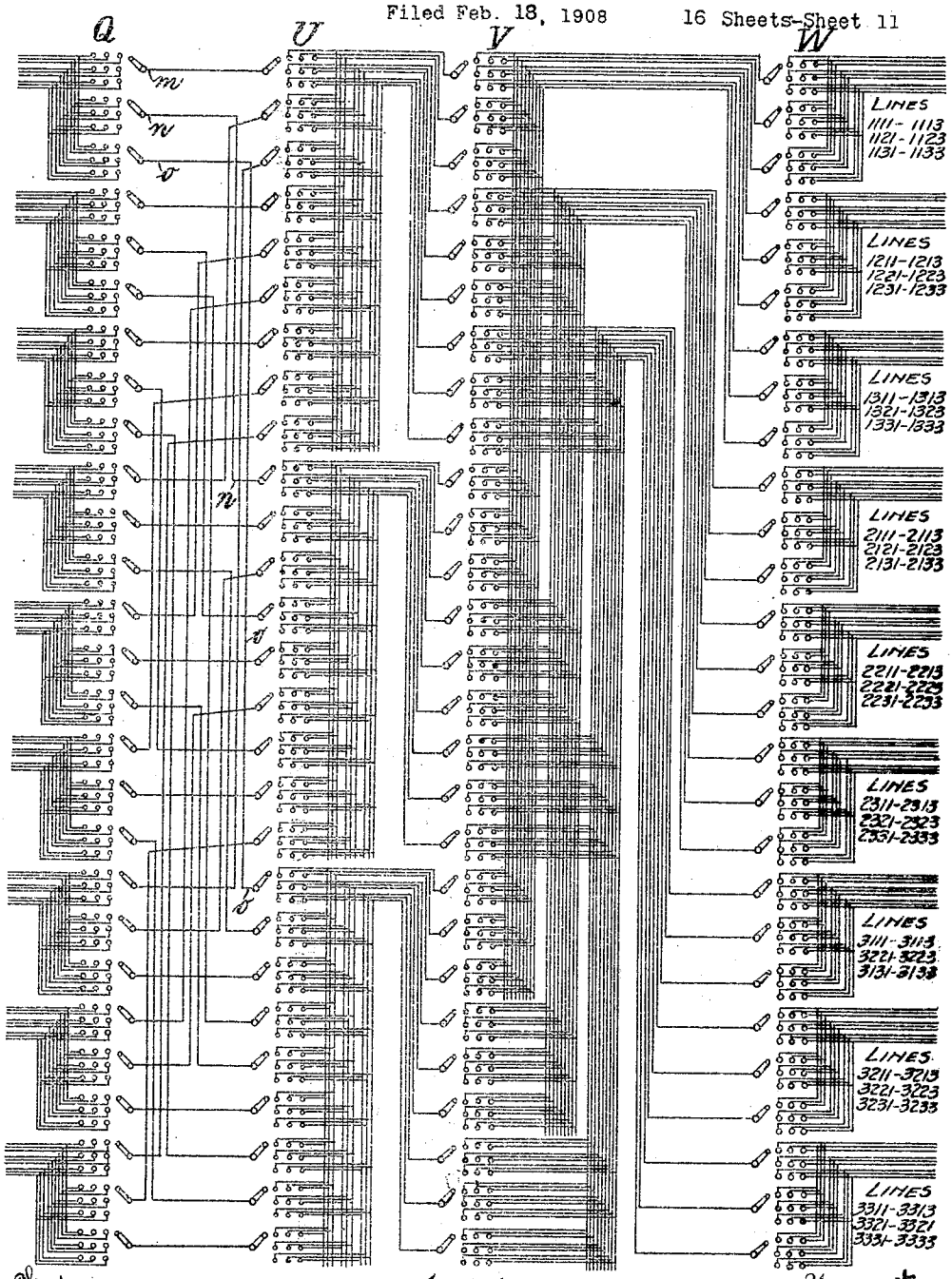

Fig. 4

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AUTOMATIC TELEPHONE SYSTEM

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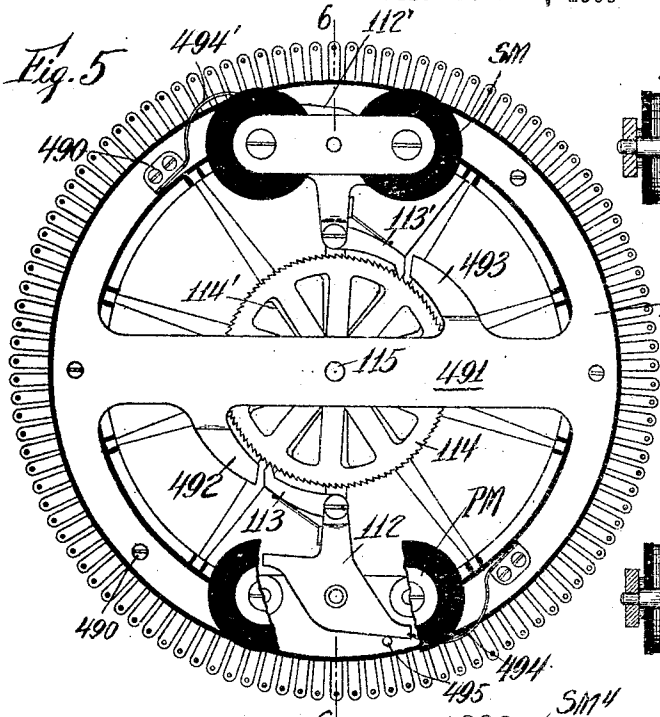
Fig. 5



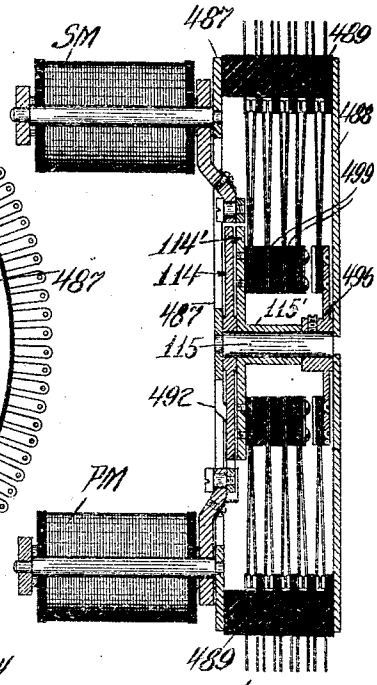
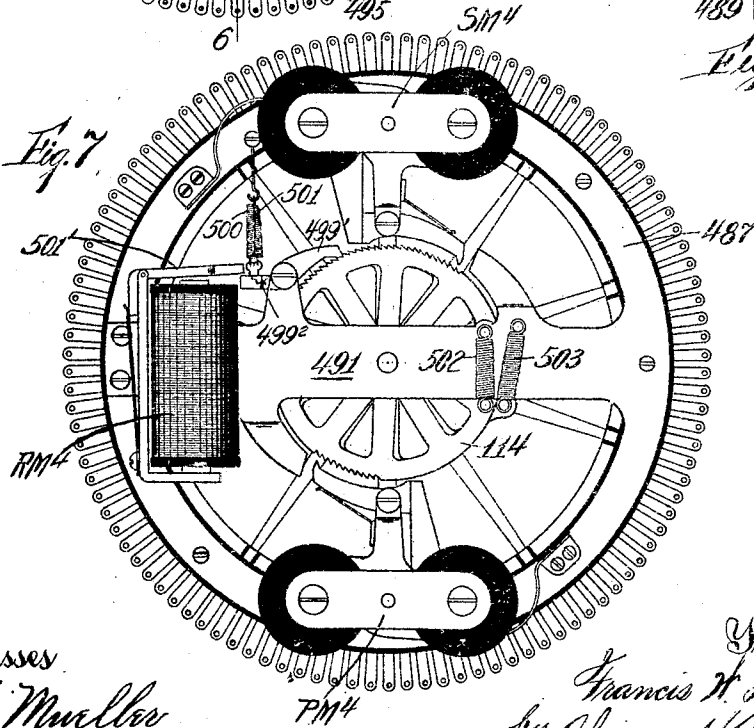


Fig. 6

Fig. 7



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AUTOMATIC TELEPHONE SYSTEM

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Fig. 8

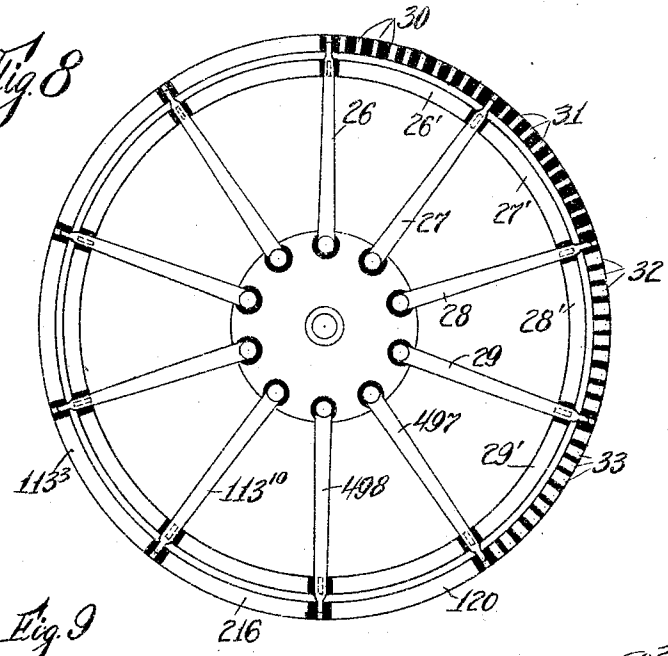


Fig. 9

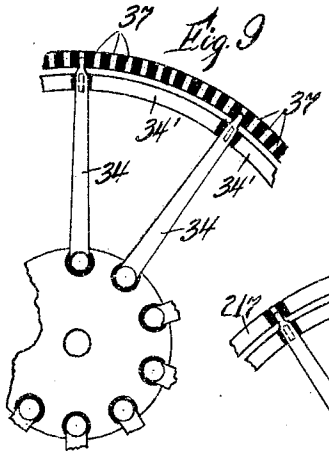


Fig. 11

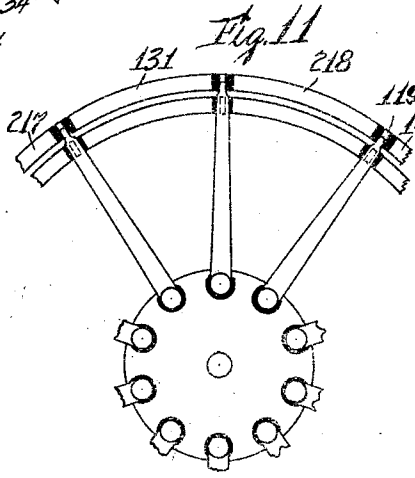
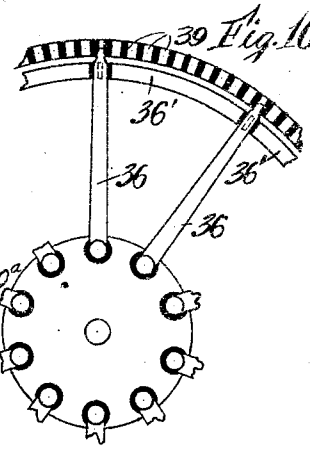


Fig. 10



Witnesses

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AUTOMATIC TELEPHONE SYSTEM

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Fig. 12

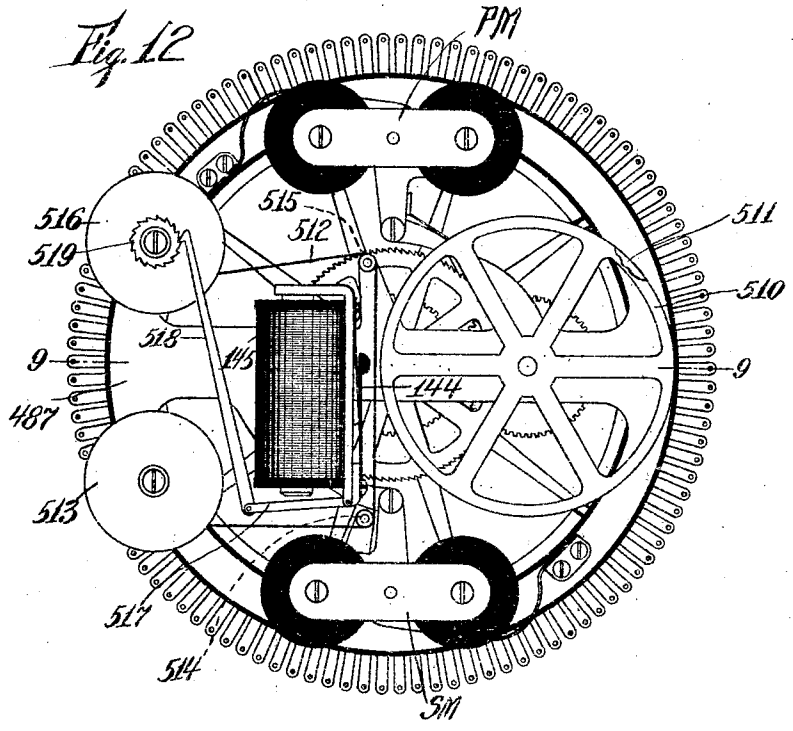
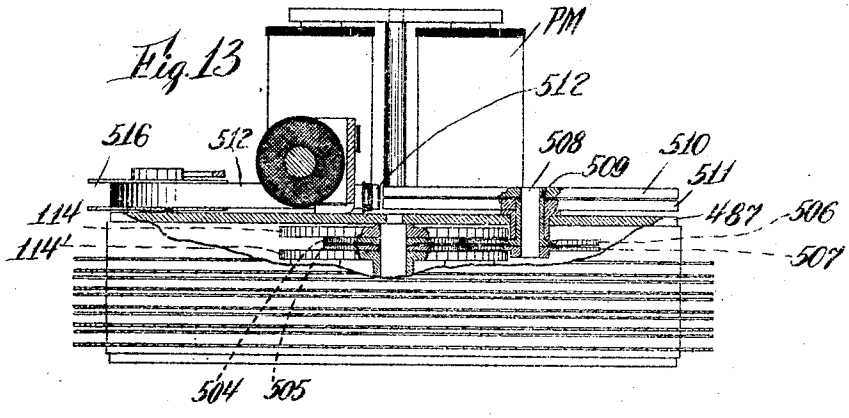


Fig. 13



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March 16, 1926. 1,576,814

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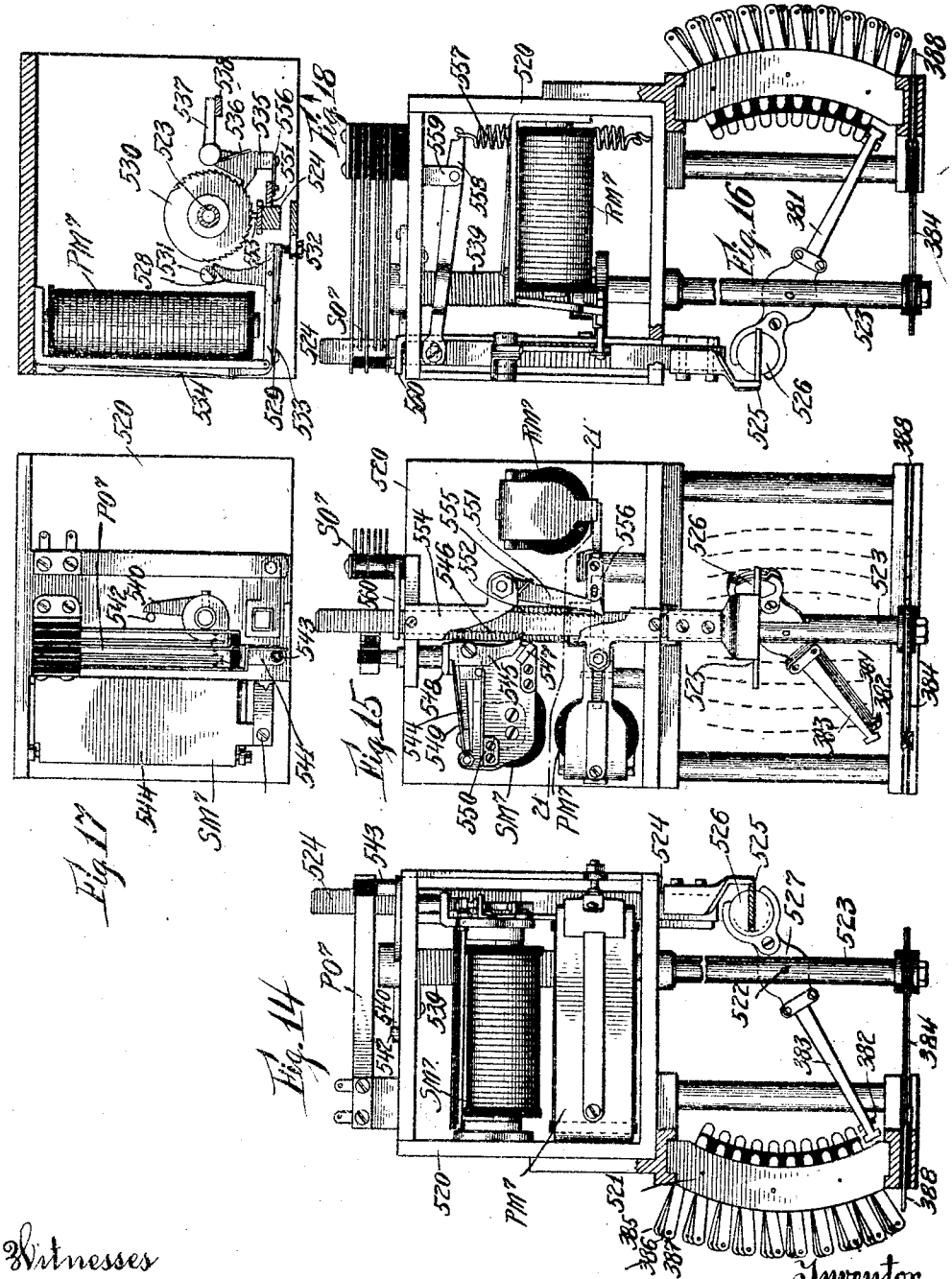
AUTOMATIC TELEPHONE SYSTEM

Filed Feb. 18, 1908 16 Sheets-Sheet 15



Witnesses
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AUTOMATIC TELEPHONE SYSTEM

Filed Feb. 18, 1908 16 Sheets-Sheet 16

Fig. 19

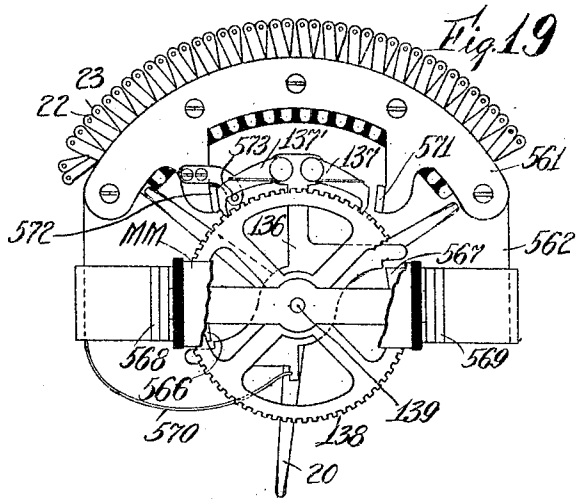


Fig. 20

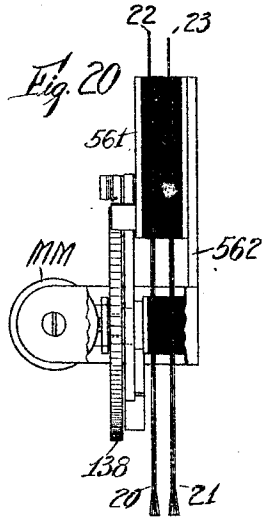
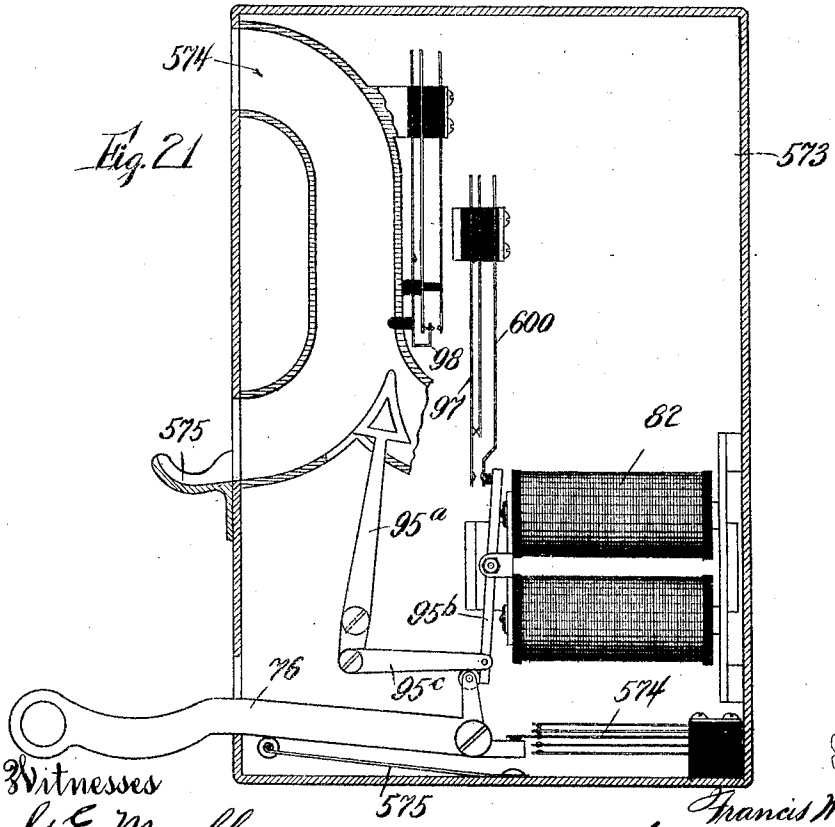


Fig. 21



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Patented Mar. 16, 1926. 1,576,814

UNITED STATES PATENT OFFICE.

FRANCIS W. DUNBAR, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

AUTOMATIC TELEPHONE SYSTEM.

Application filed February 18, 1908. Serial No. 416,607.

To all whom it may concern:

Be it known that I, FRANCIS W. DUNBAR, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

The present invention relates to automatic telephone systems generally and has to do more particularly with systems of the so-called "master-switch type", in which the so-called "selectors" and "connectors" are employed in conjunction with similarly constructed "line selectors" controlled by "master-switches". To give a cleaner idea of this type, it may be stated that with one hundred point switches and on a basis of ten per cent trunking, a ten thousand line exchange might be provided with 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 then be multipled to ten line selectors and ten connectors; and line selectors and first selectors would be united in pairs without multiplying; the wipers of the second selectors would be multipled to bank contacts of one hundred first selectors, and the wipers of each connector would be multipled to bank contacts of one hundred second selectors. These values, of course, may be departed from, but they serve to indicate fully the character of the type of system referred to.

In systems of this type and in other automatic systems heretofore proposed, the construction of the switches employed has been more or less complicated in order to bring about the proper operation of the system.

One of the principal objects of the present invention is to devise a system of the character indicated, in which comparatively simple switch mechanism may be employed in conjunction with ordinary relays to bring about the proper operation of the system. In other words, instead of relying on mechanical movements to bring about certain necessary circuit changes, it is sought to provide novel circuits for accomplishing these results with comparatively simple mechanism. The invention contemplates the use of such simplified circuits in connection with three classes of switching mechanism which may be defined as (1) poly-wiper, circular, step-by-step release, switches; (2) poly-wiper, linear, circular or arcuate, spring release switches; and (3) double-motion, or two dimension, arcuate switches with spring release. In the latter class, the movable contacts, or wipers, are associated with a large number of fixed, or passive, contacts arranged in a bank, and the wipers are first given a movement in one direction, followed by 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 desired bank contacts in the selected group. These switches are returned to normal through the agency of retractile springs In the switches of the other classes, a wiper and bank contacts perform a function equivalent to the primary movement of the wipers of the two dimension switch, and a second wiper and associated bank contacts perform a function similar to the secondary movement of the wipers of the two dimension switch. In the case of the first class, the release is obtained by continuing the forward motion of each set of wipers until their normal positions are reached; while in the second class, the release, is obtained by the use of retractile springs.

Another object of the invention is to extend this idea of simplification to all commercial adaptation of straight automatic systems so as to include "nickel-in-the-slot" service, measured service, party line service, and unlimited service.

Still another object of the invention is to provide a novel arrangement of electrical connections between the switches whereby any calling line may be connected to any second selector, thereby decreasing the chances of being unable to complete a desired conversational circuit.

The invention also includes other features and details which, together with the above, will be more fully understood upon reference to the following detailed description, taken in connection with the accompanying drawings, and the scope of the invention will be particularly pointed out in the appended claims.

Before considering the drawings, however, it may be noted that in developing the invention along the lines indicated, many fea-

tures have been devised which are capable of use in other relations than those herein indicated and in the various telephone systems including manual systems and so-called "semi-automatic" systems, as well as straight automatic systems.

Referring to the drawings, Fig. 1, which includes parts 1, 2, 3 and 4, illustrates diagrammatically a preferred embodiment of telephone system employing switches of the first class and illustrating individual lines, party lines, slot service lines, and meter service mechanism at the central office; Fig. 2, which includes parts 1, 2, 3 and 4, illustrates diagrammatically a modified automatic telephone system employing switches of the second class adapted to secure service similar to that of Fig. 1, but omitting the slot service and meter service equipment; Fig. 3, which includes part 1 and 2, illustrates diagrammatically a second modified automatic telephone system employing switches of the third class and likewise omitting slot service and meter service equipment; Fig. 4 illustrates a novel method of interconnecting and trunking between switches; Fig. 5 is a top view of a switch of the first class designed for use in the circuits of Fig. 1; Fig. 6 is a central section of the same taken on a plane indicated by the line 6—6 of Fig. 5; Fig. 7 is a top view, similar to Fig. 5, of a switch of the second class, designed for use in the circuits of Fig. 2; Fig. 8 is a diagram of the wipers and bank contacts of the primary portion of the switches of the first and second classes; Figs. 9, 10 and 11 are similar diagrams of the secondary portion of said switches; Fig. 12 is a similar top view of a modified switch of the first class provided with meter service mechanism; Fig. 13 is a partial sectional view of the same taken on the line 9—9 of Fig. 12; Figs. 14, 15 and 16 are elevations of a line selector of the third class of switches designed for use in the circuits of Fig. 3, the selector illustrated being typical of other selectors and the connectors employed in the form of the invention illustrated in said figure; Fig. 17 is a top view of said switch; Fig. 18 is a section plan of a portion of the same taken on a plane indicated by the line 21—21 of Fig. 15; Figs. 19 and 20 are front and side elevations respectively of a master-switch employed in the control of the line selectors; and Fig. 21 is a sectional view of slot mechanism of the type diagrammatically represented in Fig. 1. Throughout these views, like characters refer to like parts.

System of Fig. 1.

Apparatus.—Referring to the diagram of Fig. 1, M at the left designates a subscriber's station provided with "slot" equipment designed for either individual or party line service. In the diagram, party line connections of three other similar substation equipments are indicated at M^2, M^3, M^4. These substations are united to the exchange line limbs P—S which extend, by extension conductors, to the multiple contacts of line selectors Q and connectors W, as will be hereinafter more fully explained. Connection is obtained between the subscriber's line at the left of the diagram and that 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 W. Assuming that the selectors and connectors employed are provided with one hundred line bank contacts in the secondary portion of the switch, and assuming that there are ten thousand lines in the exchange arranged on a basis of ten per cent trunking, then, where individual lines are employed, the number of switches (considering the primary and secondary portions of each switch as a single switch) and their multiple arrangement would be that heretofore outlined; namely, one hundred master-switches O, one thousand line selectors Q, one thousand first selectors U, one thousand second selectors V, and one thousand connectors W. The subscribers' lines would be divided into groups (for the initiation of calls) of one hundred lines each and ten line selectors would be assigned to each such group, thus enabling each line to be multipled to the corresponding bank contacts of ten different line selectors. Each group of line selectors would be under the control of one master-switch having a pair, or set, of bank contacts assigned to each line selector. Each subscriber's line would also be multipled to the bank contacts of ten connectors whereby a group of ten connectors become available for establishing connections to a group of one hundred lines. The lines comprising said latter group of one hundred lines may, however, be distributed among a large number, or all, of the groups provided for the initiation of calls.

Now, in case party lines are employed, each such line is multipled to a number of sets of connectors corresponding to the number of selectively signalled substations on the line. Thus in the diagram, the bank contacts of four sets of ten connectors each are represented at W, W′, W^2 and W^3, corresponding to the four selectively signalled substations M′, M^2, M^3 and M^4 on the line. From this it will be seen that with a four-party line, such as illustrated, each line may, if desired, be multipled in the bank contacts of forty connectors. On the other hand, in the case of individual lines as previously pointed out, only the connections of one of these sets would be employed, such as that indicated at W, thus providing but ten multiple connections per line. Of the ten

multiple connections between each individual line and the line selectors Q, only one set of such connections is illustrated, but others are indicated by the multiple taps. Similarly, in a party line, the number of multiple connections to the line selectors may be greater than ten. Moreover, it is obvious that in the case of either individual or party lines, the number of line selectors provided for a group of calling lines, or the number of connectors provided for a group of called-for lines, may be increased above ten, as desired. All of this will more fully appear from the following description.

In outline, the connections between the switch contacts are as follows: The movable contacts, or wipers, of each line selector Q are tied to corresponding wipers of a first selector U, thus providing one thousand direct connections between one thousand line selectors and the one thousand first selectors. The wipers of the second selectors V are connected to the bank contacts of the first selectors U; and since there are in the illustration assumed, one thousand of each of these selectors, the wipers of each second selector are connected to the corresponding bank contacts of one hundred first selectors. Similarly, the wipers of each of the thousand connectors W are connected to the corresponding bank contacts of one hundred second selectors V. As previously indicated, this apportionment of values, either as to the number of switch points or percentage of trunking in any part of, or throughout, the system, may be varied to suit the exigencies of any particular case.

In the operation of these instrumentalities in establishing connection between a substation on the line P—S at the left, as substation M′, and one located on the line associated with extension conductors at the right, the calling party at substation M′ first removes his receiver from its hook and, if the line be idle, deposits his token in the slot mechanism and thereby, through the agency of a 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. The first series of these impulses operates the connected first selector U so as to cause it to pick out and establish connection with an idle second selector V associated with the thousands group to which the called line belongs. Thus if the number of the calling party be 2000 and some odd, the first set of two impulses will move the wipers of the primary portion of the first selector U to establish connection with a particular set of wipers of the secondary portion of the switch which will then automatically move over the contacts associated with it until an idle set of contacts is encountered, thereby extending the circuit of the calling party to an idle second selector in the second thousands group The second series of impulses will similarly operate the second selector V to pick out and establish connection with an idle connector W associated with the hundreds group to which the called line belongs. The third series of impulses may then be transmitted over the circuit to cause the operation of the primary wipers of the connector W to establish connection with the secondary wipers having access to the contacts of the sub-groups of ten lines containing the called line; and the final series of impulses will cause the selected secondary wipers to move over their bank contacts until they encounter the contacts corresponding to the called-line, thus completing connection between the calling and the called lines.

Each line is provided at the exchange with a line relay LR, which is instrumental in closing, through the master-switch O, a starting circuit for an idle line selector Q upon the initiation of a call; also with 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.

The master-switch O, in the present instance, comprises a pair of wipers 20—21 co-operating with bank contacts 22—23 and caused to step over said contacts by motor magnet MM, the complete operation being controlled by relays 24—25, as hereinafter more fully pointed out.

The line selector Q includes the primary wipers 26, 27, 28, 29, co-operating with primary bank contacts 30, 31, 32, 33 respectively, and a plurality of sets of secondary wipers 34, 35, 36, co-operating with secondary bank contacts 37, 38, 39, respectively. The movement of the primary wipers 26, 27, 28, 29 will be brought about by the primary magnet PM controlled by primary relay PR; and the movement of the secondary wipers, brought in the circuit by the operation of the primary wipers, will be similarly brought about by the secondary magnet SM controlled by a secondary relay SR. The release of the switch, which permits the return of all its parts to normal position, is brought about by the release magnet RM. The line selector is also provided with primary and secondary off-normal switches PO and SO which are operated upon the first movement of the primary wipers and the first movement of the secondary wipers, respectively. This switch may also be provided with a printing or recording mechanism indicated at X, which will be described more fully hereinafter.

The first selector U includes the primary wipers 40, 41, 42, co-operating with the primary bank contacts 43, 44, 45, respectively, in response to the operation of the primary magnet PM′ controlled by the primary relay PR′; and a plurality of sets of secondary wipers 46, 47, 48 co-operating with bank contacts 49, 50, 51 respectively, and in turn actuated by the secondary magnet SM′ controlled by the secondary relays S′R and SR′. The release of the switch parts, which permits their restoration to normal, is brought about through the release magnet RM′. This switch is also provided with a primary off-normal switch PO′ and a secondary off-normal switch SO′, here as before operated by the first movements of the primary and secondary wipers respectively. The circuit associated with this selector also includes a reversing relay RV for reversing the direction of current supply to the calling line for purposes which will hereinafter more fully appear.

The second selector V is similar in construction and circuit arrangement to the first selector U and comprises primary wipers 52, 53, 54 co-operating with primary bank contacts 55, 56, 57, respectively, and actuated by primary magnet PM^2; and a plurality of sets of secondary wipers 58, 59, 60, co-operating with secondary bank contacts 61, 62, 63, and actuated by a secondary magnet SM^2, controlled by the secondary relay SR^2. In this instance, the restoration of the switch parts is accomplished by the release magnet RM^2 and the switch, as before, is provided with primary and secondary off-normal switch contacts, designated PO^2 and SO^2 respectively.

The connector W is provided with primary wipers 64, 65, 66, co-operating with primary bank contacts 67, 68, 69 respectively, and actuated by a primary magnet PM^3; and a plurality of sets of secondary wipers 70, 71, 72, co-operating with secondary bank contacts 73, 74, 75, respectively, and actuated by secondary magnet SM^3. As before, the switch parts are restored to normal by the actuation of a release magnet, designated RM^3. The connector is also provided with primary and secondary off-normal contacts designated respectively PO^3 and SO^3. In addition to these parts, associated circuits are provided with a busy relay BR, a ringing relay RG, a closing relay CR, a tip relay TR, a so-called "flip-flop" relay FF, and a relay R, all which co-operate in a manner more fully set forth hereinafter.

The equipment at substation M′ includes the usual switch-hook 76, receiver 77, call-bell 78, transmitter 79, calling mechanism 80, and "slot" mechanism 81, including a polarized relay 82.

At the exchange, the connections of the subscribers' lines to the multiple contacts of the line selectors Q and to the connectors W will be brought about through the agency of a distributing board DB and extension conductors 83, 84, 85, 86, preferably arranged in the manner illustrated.

Operation.—Having now given a general description of the character of the apparatus diagrammatically illustrated in Fig. 1, it is believed that a further understanding of the invention will be best accomplished by entering at once into a description of the operation of the system therein depicted.

Assuming that a party at substation M′ on the line P—S at the left desires to converse with a party at a substation on the line associated with extension conductors 85—86 at the right, and assuming that the number of the latter's telephone is 3333, then the calling party first removes his receiver 77 from its hook 76 and places the receiver 77 to his ear to determine whether or not the line is idle. This, of course, will only be necessary in the case of a party line. The idle indication is obtained from an interrupter 87, acting through an induction coil 88, one of whose windings is included in the local circuit with the interrupter, the other of whose windings is included in the grounded branch leading through the line relay LR. This ground branch may be of low resistance and made common to a number of line relays, as indicated in the drawing. Circuit through the calling party's receiver 77, may be traced from the ground at the induction coil 88, through one winding of said coil, line relay LR, normal contact 89 of cut-off relay CO, line limb S, closed contact 90 of the substation calling mechanism 80, transmitter 79, switchhook 76, receiver 77, condenser 91, closed contact 92 of calling mechanism 80, line limb P, normal contact 93 of cut-off relay CO, protective resistance 94 to ground through battery B. The inductive action, produced in this secondary circuit by the interrupter 87 in the local circuit, produces a characteristic signal in the receiver 77 of the calling party as an indication to him that the line is idle and that he may proceed to make a call. This he does by depositing his nickel, or token, in the slot mechanism 81. It will be observed that the previous movement of the switch-hook 76, occasioned by the removal of the receiver 77, rocks the armature arm 95 pivoted at 95′ against the tension of the return spring 96 far enough to bring the upper end of the arm into a position to hold the token against delivery through either of the outlets of the slot. This movement of the arm 95, however, is not sufficient to cause its lower end to engage contact 97. The deposit of the token, by engaging the insulating piece on the spring contact 98, forces the latter from its normal to its alternate posi-

tion, thereby completing a conductive bridge between the two sides of the line, which is instrumental in energizing the line relay LR. At this point, it may be observed that if the token is deposited in the slot before the receiver is removed from its hook, it will at once be returned, through the opening at the left, into a suitable socket from which it may be readily withdrawn by the calling party. Furthermore, it will be observed that the removal of the receiver alone is insufficient to energize the line relay LR at the exchange and thus cause the operation of a line selector Q. The circuit, which is completed upon the movement of contact 98 to its alternate position, may be traced from the live pole of the battery B, through protective resistance 94, normal contact 93 of cut-off relay CO, line limb P, closed contact 92, alternate contact 98, closed contact 97, the winding of polarized relay 82, switch-hook 76, transmitter 79, closed contact 90, line limb S, normal contact 89 of cut-off relay CO, the winding of line relay LR, and a winding of induction coil 88 to the grounded side of battery B. The closing of this circuit permits a flow of current through the polarized relay 82 in a direction to force the lower end of the arm 95 to the left against the upturned and insulated end of the switch-hook 76. This, however, has no effect upon the relative position of the parts, but the latter remain unchanged. The supply of current to the line relay LR, however, causes it to break its normal contact 99 and close alternate contacts 100 and 101 to ground. The closing of contact 100 to ground energizes group relay GR which thereupon, by opening its contact 102, removes the normal ground on the primary bank contact 33. The said group relay GR has its winding connected to a plurality of alternate contacts, 100, 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 subgroup of ten calling lines. The sets of secondary wipers and their associated bank contacts are divided into similar groups whereby a particular contact 33 corresponds to a particular set of wipers 34, 35, 36 and to their associated line contact points 37, 38, 39. The common connecting point for relay GR is indicated by the star * adjacent to the relay. This same sign throughout the diagram indicates a common connecting point. The grounding of contact 101 of line relay LR energizes relay 24 of the master-switch O and causes the latter to close its contact 103 to thereby complete a starting circuit for the particular line selector Q, whose master-switch bank contacts 22—23 are at that time engaged by the wipers 20—21 of the master-switch. In the example chosen, relay 24 is connected to a similar contact 101 of each of the other ninety line relays of the group. The opening of normal contact 99 of line relay LR also removes a normal ground connection from the bank contacts 39 of the line selectors Q corresponding to the group containing the calling line, thereby establishing that condition which will cause the switch wipers to stop in engagement with the contacts of the particular line calling. This normal ground connection extends from the contacts 39 of the several line selectors, through conductor 104, normal contact 105 of cut-off relay CO, and said normal contact 99 to ground. The energization of line relay LR also moves contact 106 from its normal to its alternate position, thereby disconnecting the cut-off relay CO from the private bank contacts of the connectors W, W′, W², W³, etc., having access to the line and replacing the normal ground connection through the winding of said relay by a connection extending to battery B via said alternate contact 106, line limbs S and P, normal contact 93, and coil 94, as previously traced in the reverse direction through the line relay LR. The conductors 185 leading to the connectors W, W′, W², W³, are thus provided with a battery connection for the purpose of rendering them busy as will be explained later. The starting circuit for the line selector Q, which is brought about by the energization of relay 24, may be traced from the normal grounded contact 107 of relay 25, closed contact 103 of relay 24, wiper 20, engaged contact 22, normal contact 108 of primary off-normal switch PO, contact 109—110 of release magnet RM, winding of primary relay PR to the battery bus-bar B′. The closing of this circuit energizes primary relay PR to actuate its contacts. The closing of contact 111 to ground completes an energizing circuit for the primary magnet PM, from generator bus-bar G′, supplied with alternating, pulsating, or like current from a suitable source, such as the generator G. As diagrammatically illustrated, the primary magnet, by means of an armature 112 and a driving pawl 113, rotates a ratchet wheel 114 mounted on a shaft 115 which carries the primary wipers 26, 27, 28, 29. In their normal positions, the wipers rest on insulated contacts, but upon the first step, wiper 29 moves into engagement with a contact 33 which may be either grounded or non-grounded, according to the condition of the group relay GR which controls its connection. The first movement of the primary wipers also, as previously noted, actuates the contacts of the off-normal switch PO, thereby interrupting the initial energizing cir-

cuit of the primary relay PR at contact 108. This circuit, however, is replaced by a maintaining circuit for said relay which extends from the battery bus-bar B′ through the winding of relay PR, contact 110—116 of release magnet RM, closed contact 117 of primary relay PR, and wiper 29 to ground at contacts 102 so long as grounded contacts 33 are encountered. The resulting continued movement of the primary wipers will ultimately bring the wiper 29 into engagement with the ungrounded contact 33 corresponding to the group containing the calling line. As soon as this contact is reached, the maintaining circuit for the primary relay PR is interrupted, with a consequent interruption of the circuit of primary magnet PM, and the primary wipers are thereby left in engagement with the bank contacts corresponding to those secondary wipers having access to multiple contacts 37, 38, 39, of the sub-group containing the calling line. This primary selecting movement is followed immediately by the operation of the selected secondary wipers. This occurs as soon as primary relay PR is deenergized, since the latter, by closing contact 118, completes an energizing circuit for secondary relay SR which may be traced from battery bus-bar B′ through the winding of said relay, closed contact 119 of secondary off-normal switch SO, said closed contact 118 and closed contact 120 of off-normal switch PO to ground. Secondary relay SR being thus energized, closes its contact 121 to ground and completes the energizing circuit for secondary magnet SM to the generator bus-bar G′ and generator G.

It will be understood that the secondary magnet actuates a ratchet wheel 114′ mounted on the same shaft 115′ which carries the ten sets of secondary wipers 34, 35, 36. The resulting selecting operation is similar to that of the primary wipers. The initial energizing circuit of the secondary relay SR is interrupted at contact 119 of off-normal switch SO., upon the first movement of the secondary wipers, but a maintaining circuit has been previously established for said relay by way of normal contact 122 of release magnet RM, alternate contact 123 of secondary relay SR, primary wiper 28, engaged contact 32, (the third in order) secondary wiper 36 and contact 39 to the grounds on conductor 104 provided at normal contacts 99 of the line relays as previously described, so long as grounded contacts are encountered. As before, however, as soon as the ungrounded contact, corresponding to the calling line, is engaged, this maintaining circuit will be interrupted, with a resulting interruption of the circuit of the secondary magnet SM and the stopping of the switch. It will be noted that the primary wipers 29 and the secondary wipers 36 are made broad enough to bridge the space between contiguous contacts and also that, although normally out of engagement with the nearest bank contacts, they will engage said contacts as soon as the corresponding off-normal contacts have moved from normal. By this means, a continued movement of the switch wipers is maintained until an ungrounded contact is encountered. Since other subscribers' lines are multiply connected to contacts over which the secondary wipers 34—35 pass during their selecting operation, and since conversation may be going on over a connection including said contacts, the relay SR is arranged to electrically disconnect the primary wipers 26—27, and consequently the secondary wipers 34—35, during the movement of the latter. This is brought about by contacts 124—125 which, in their normal positions, unite the adjacent portions of the link-circuit strands P^2—S^2, but, when actuated, interrupt them, thus disconnecting said wipers. Thus, during the movement of the secondary wipers, they are disconnected from the strands P^2—S^2, but the normal connection is restored as soon as their movement is completed. Contact 125 of the relay SR, when in its alternate position, unites the strands P^2—S^2 by a conductive bridge 126. It will be noted, by referring to part 2 of Fig. 1, that the same strands are also united through normal contacts 127—128 of reversing relay RV, windings of primary and secondary relays P′R—S′R, and batteries *b*—*b*′. These batteries, being arranged in series, supply current over a circuit including said bridge 126 and thereby energize said relays P′R and S′R to actuate their contacts. The energization of these relays prevents the possible closing of the release circuit which might otherwise occur, after the secondary off-normal switch SO has been actuated (thus operating relay SN through contact 131), from bus-bar B′, through the winding of release magnet RM, closed contacts 129—130 of relays S′R and P′R and contact 131′ of said relay SN to ground.

As soon as the contacts 124—125 of the secondary relay SR have been restored to normal, thus disconnecting the bridge 126, it will be seen that other circuits are already established for the primary and secondary relays P′R—S′R. One of these may be traced from the live, or negative, pole of the battery *b*, through the winding of primary relay P′R, normal contact 127 of relay RV, strand P^2 including contact 124, wiper 26, strand P′, wiper 34, extension conductor 83, normal contact 132 of cut-off relay CO, and the winding of said cut-off relay CO to ground. The closing of this circuit maintains the primary relay P′R temporarily en-

ergized, and energizes the cut-off relay CO. The other of these two circuits may be traced from the live, or positive, pole of the battery b', through the winding of secondary relay S'R, normal contact 128 of relay RV, strand S^2 including contact 125, wiper 27, strand S', wiper 35, extension conductor 84, line limb S, contact 90, transmitter 79, switch hook 76, polarized relay 82, contacts 97, 98 and 92, line limb P via normal contact 93 and coil 94 to the negative pole of battery B, prior to the operation of cut-off relay CO and immediately subsequent thereto to the negative pole of battery b via alternate contact 93 and the path previously traced (in the reverse direction), for the initial energization of said cut-off relay CO. Relays P'R and S'R are thus held energized to prevent the premature closing of the release circuit through magnet RM. The closing of contacts 105—132, upon the energization of cut-off relay CO, results in a transfer of the energizing circuit of said relay from the primary strand of the heavily marked circuit, as previously traced, to a local circuit which extends from the battery bus-bar B', through a resistance lamp 140, preferably of comparatively low resistance (for example, one hundred ohms), closed contact 140^a of off-normal switch SO, contact 140^b—123, primary wiper 28, engaged contact 32, secondary wiper 36, engaged contact 39, conductor 104, contact 105—132 of cut-off relay CO, and the winding of said relay to ground. The said latter circuit is established prior to the opening of the initial energizing path. The energization of the said cut-off relay CO, therefore, by its contact 93, disconnects battery from the primary side of the circuit and completes the normally disconnected portions of the extension conductor 83, thereby extending the calling line circuit through the line selector Q to the associated first selector U. This extended circuit is conductively continuous to the condensers 133—134 located in the strands P^2—S^2 respectively and is completed conductively at said selector U through the primary and secondary relays P'R—S'R and the batteries b and b' as above traced. It will be noted that the direction of flow of current from the batteries b—b' over the line circuit is the same as that initially supplied from the battery B, and consequently polarized relay 82 will have its armature arm 95 pressed in the same way against the upturned end of the switch-hook 76. The movement of contact 89 of cut-off relay CO to its alternate position disconnects the line relay LR from the line and thereby removes it from the calling party's control and, at the same time, unites the limb S to extension conductor 86. This latter connection is brought into play only when the line S—P is selected as a called line.

The disconnection, and consequent de-energization of line relay LR causes the release of the group relay GR unless there be 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 GR will restore the ground via contact 102 to bank contact 33 and to its other multiple contacts on the nine other line selectors, thereby permitting wipers 29 of said other line selectors to rotate past the sub-group containing the calling line whose call has now been "picked up." Also the de-energization of said line relay LR causes the release of relay 24 of the master-switch O unless there be at that time another line relay belonging to the same group of one hundred subscribers then initiating a call. Assuming there be no such other call existing, the release of said relay 24 will prevent the starting of another line selector Q when the master-switch steps its wipers 20, 21 around to engage the bank contacts corresponding to the next idle line selector. The closing of contact 105—132 is instrumental in thus causing the stepping forward of the master-switch. Thus upon the closing of contact 105—132, circuit may be traced from the live pole of the battery B, through the winding of relay 25, wiper 21 and engaged contact 23 of the master-switch O, contact 135—123, primary wiper 28, engaged contact 32, secondary wiper 36, engaged contact 39, conductor 104, contact 105—132 of relay CO, and the winding of said relay to ground. Relay 25 is thus placed in multiple circuit with the lamp 140, its circuit as previously traced extending from said battery B through said lamp and closed contact 140^a to closed contact 123—140^b where it joins the above traced circuit of relay 25 through the cut-off relay. Relay 25 is therefore preferably wound to relatively low resistance, say one hundred ohms, so as to properly operate in multiple with said low resistance lamp 140. It is apparent, however, that relay 25 cannot operate until after the cut-off relay CO has been energized, thus permitting the release of relay 24 (as hitherto described), prior to the stepping forward of the master-switch to an idle line selector whereby said selector will not be needlessly started as might occur should relay 24 be delayed in its release. The actuation of relay 25 causes its contact 107 to complete the actuating circuit of the motor magnet MM which thereupon, through the agency of its armature 136, driving pawl 137, and ratchet wheel 138, mounted on the wiper shaft 139, steps the wipers 20 and 21 into engagement with the next set of bank contacts 22—23. If these

contacts be those of a busy line selector Q, the contact 23 will be connected to ground over the path just traced through contacts of the cut-off relay or, during the release of the line connector, by way of closed contact 140 of release magnet RM. If, on the other hand, they be those of an idle line selector, these circuits will be opened either at the primary wiper 28 or at said contact 140. In the latter event, the relay 25 will be thus de-energized and the further advance of the master-switch discontinued. In this instance, as before, the private wiper 21 of the master-switch is broad enough to bridge the space between contiguous contacts, but the switch is not provided with a normal position to which it is returned after each operation.

The printing, or meter, mechanism X, which may be employed or not, as desired, is diagrammatically represented in this figure as comprising two type-wheels 141—142 mounted on concentric shafts and co-operating with a record strip 143 and a hammer 144 adapted to record an impression upon the strip each time the magnet 145 is actuated. As will be explained hereinafter, the circuit of this magnet is completed only upon the response of the called party. As will also appear hereinafter, the primary and secondary wipers are also preferably mounted on concentric shafts and to these shafts are geared the concentric shafts which carry the type-wheels 141 and 142. From this it will be seen that upon a given rotation of the primary type-wheel, a given designation will appear opposite the hammer 144 and will remain independent of the operation of the secondary type-wheel. The latter in turn will also present a definite designation opposite the hammer 144 corresponding to its position. Thus by means of the two type-wheels side by side, an impression is placed upon the recording strip which corresponds exactly with the joint position of the primary and secondary wipers and consequently may be arranged to print the number of the calling line.

The calling line circuit, having now been extened to a first selector U in response to the removal of the receiver and the deposit of a token at the calling station, it remains for the calling party to extend his line circuit by operating his calling mechanism 80 in accordance with the number of the called party, which has been asumed to be 3333. The calling apparatus is diagrammatically represented by a spring returned disk having a number of teeth adapted to engage spring contact 92 to cause it to break contact a number of times upon the return of the disk, and a single tooth similarly co-operating with a spring contact 90 to cause it to open its contact once after the contact 92 has completed its interruptions. The disk is also provided with an insulating pin which normally engages a mounting spring contact 146 to hold it open. In operation, the disk is moved in the direction of the arrow until a definite number of teeth have passed below the spring contact 92 and it is then allowed to return to normal with the resulting interruptions of the line limbs at contacts 92 and 90.

At this point, it may be noted that any operation of the dial before contact 98 has been moved to its alternate position by the deposit of a token in the slot mechanism, will not be instrumental in actuating any mechanism at the exchange. The line limb S, even though the receiver be removed from its hook, will be grounded at both the substation and the exchange and interruptions of it will not produce any results in the operation of the mechanism. On the other hand, line limb P, which is connected to battery at the exchange, is open at contact 98 until the token is deposited.

With this explanation, it will be seen that the calling party will therefore rotate his dial far enough to bring three teeth below the spring contact 92 and will then release the same to allow it to return to its normal position, and he will then follow this operation by three similar operations. Considering now the effect of the first operation, it will be noted that as soon as the dial is moved from normal, both limbs of the line will be grounded at contact 146. The purpose of this ground is to continue the energization of the primary relay P′R from the grounded battery b over the primary side of the circuit and this ground at the substation, in case the secondary side of the line be then open; also to continue the energization of the secondary relay S′R from the grounded battery b' over the secondary side of the circuit and the same ground, in case the primary side of the line be then open. Consequently, the three resulting breaks and makes of the contact 92 will cause three deenergizations of the primary relay P′R, and the single following break and make of the contact 90 will cause a single de-energization of the secondary relay S′R. An inspection of the contacts 147, 148, 149, 150, of the primary and secondary relays P′R—S′R show that the three de-energizations of the primary relay P′R will be instrumental in grounding the strand P^2 at the right of condenser 133 three times, while the single de-energization of secondary relay S′R will be instrumental in grounding the section of strand S^2 to the right of condenser 134 once. While the relays P′R and S′R remain energized, these sections or portions of the strands P^2—S^2 are not grounded by reason of open contact 148 in the one case, and open contact 149 in the other. From this it will be seen that the passage of each tooth of the calling

mechanism past the contact 92 has the effect of producing a momentary ground upon the section of the primary strand P^2 at the right of condenser 133, and each movement of a single tooth past contact 90 of said mechanism has the effect of producing a single momentary ground upon the corresponding section of the secondary strand S^2. Thus the initial operation of the calling device at the calling station, by grounding the strand P^2 three times and the strand S^2 once, produces three distinct energizations of the primary magnet PM′, followed by a subsequent operation of the secondary magnet SM′. The primary magnet PM′ is energized over the circuit extending from battery bus-bar B′, through the winding of said magnet, normal contact 151 of release magnet RM′, normal contact 152 of off-normal switch SO′, closed contact 148 of primary relay P′R and closed contact 150 of secondary relay S′R to ground. These three energizations will cause the primary wipers 40, 41, 42, to move to the third set of bank contacts 43, 44, 45, which are connected to the third set of secondary wipers 46, 47, 48. Upon the first movement of the primary wipers, the contacts of off-normal switch PO′ will be closed, thereby establishing conditions suitable for the release of the selectors, subsequently to be described. Thus at the expiration of the movement of primary wipers 40, 41, 42, the line circuit is extended through to the secondary wipers 46, 47. The following single secondary impulse, by grounding strand S^2, completes a circuit for the secondary relay SR′, which may be traced from the battery bus-bar B′, through the winding of said relay, normal contact 153 of off-normal switch SO′, closed contact 149 of relay S′R and closed contact 147 of relay P′R to ground. The resulting energization of secondary relay SR′ will, by opening its contacts 154—155, disconnect wipers 46—47 to prevent interference with possible conversation over multiply connected bank contacts. The closing of contact 156 of said relay will complete an energizing circuit for the secondary magnet SM′, which may be traced from the generator bus-bar G′, through the winding of said magnet, said closed contact 156 and normal contact 157 of release magnet RM′ to ground. It will be understood in this instance, as before, that the secondary magnet SM′ actuates the ten sets of secondary wipers 46, 47, 48. Consequently, upon the completion of its energizing circuit, these wipers will be moved one step from their normal position into engagement with the first set of bank contacts. At the same time, the contacts of the secondary off-normal switch SO′ are moved to their actuated positions. The movement of contact 153 of this switch thus interrupts the initial energizing circuit of secondary relay SR′; but in the meantime, the maintaining circuit for said relay has been completed by way of normal contact 158 of release magnet RM′, alternate contact 159 of secondary relay SR′, primary wiper 42, engaged contact 45, secondary wiper 48 and engaged contact 51 to ground, so long as grounded contacts 51 are encountered. As soon, however, as an ungrounded contact 51 is met with, relay SR′ is de-energized thus opening the circuit of magnet SM′ and the further advance of the secondary wipers is stopped, thereby continuing the calling line circuit through the secondary wipers of the first selector. Assuming that the contacts thus selected are those in which the strands P^4—S^4 terminate, then it will be seen that the calling line circuit is extended through the first selector U to the primary wipers 52—53 of a selected idle second selector V (Fig. 1, part 3). In the case of the first selector U, as before, and also as in the case of the second selector V, the ends of the secondary private wipers are made of sufficient breadth to bridge contiguous contacts to thereby better maintain proper operation of the switch. Contacts 51 associated with idle second selectors V are free from grounds as each conductor 170 stands normally open. The de-energization of the said relay SR′ will restore contacts 154—155 to thereby complete the strands P^2—S^2 at these points. Also upon the return of contact 159 of said relay SR′ to normal, a ground is applied to the multiply connected secondary bank contacts 51, thus guarding the contacts of the selected link-circuit P^4—S^4 and the second selector V, from selection by other first selectors U. This ground connection extends via secondary wiper 48, engaged primary contact 45, primary wiper 42, contact 159—160, conductor 161′ and normal contact 162 of release magnet RM of the line selector Q to ground. Thus it will be seen that by this operation of the calling mechanism, the circuit of the calling line is extended to a second selector V of the third thousand group, and said selector rendered busy.

The next step in the operation consists in operating the calling mechanism to first ground the right-hand portion of the strand P^2 three times and then following this by a single grounding of the right-hand portion of the strand S^2 in a manner heretofore explained. The operation of the second selector V is substantially the same as that of the first selector just described. The grounding of the primary strand three times produces three distinct energizations of the second selector primary magnet PM^2 to cause the primary wipers 52, 53, 54, to advance from normal to the third set of primary bank contacts 55, 56, 57, which are connected with the third set of secondary wipers 58, 59, 60,

and the single grounding of the secondary strand causes the secondary wipers to advance over the secondary bank contacts 61, 62, 63 and continue until they encounter contacts of an idle link-circuit P^6—S^6. The circuit of the primary magnet PM^2 extends from the battery bus-bar B′ through the winding of said magnet, normal contact 163 of release magnet RM^2 of the second selector V, closed contact 164 of off-normal switch SO^2, and thence over the primary side of the circuit to the strand P^2 and ground via contacts 148 and 150. The initial energizing circuit for the secondary relay SR^2 extends from the battery bus-bar B′ through the winding of said relay, contact 165 of primary off-normal switch PO^2, (closed upon the first primary movement of the switch) closed contact 166 of secondary off-normal switch SO^2 and thence over the secondary side of the circuit to strand S^2 and ground via contacts 149 and 147. A maintaining circuit is then established for the relay SR^2 by way of normal contact 167 of release magnet RM^2, alternate contact 168 of said secondary relay SR^2, primary wiper 54, engaged contact 57, secondary wiper 60, and engaged contact 63 to ground so long as grounded contacts 63 are encountered. The ground connection in this case is obtained by way of a multiple contact 63, a secondary wiper 60 of some other second selector V engaging said contact, a primary bank contact 57 and a wiper 54 of said other second selector V, normal contacts 168—169 of its secondary relay SR^2, a conductor 170 and a secondary bank contact 51 of some other first selector U, a secondary wiper 48, a primary bank contact 45, and a primary wiper 42 belonging to said other first selector, a contact 159—160 of its secondary relay SR′, a conductor 161′, and normal contact 162 of its release magnet RM to ground. In this instance, the circuit of the secondary magnet SM^2, which operates the ten sets of secondary wipers, may be traced from the generator bus-bar G′, through the winding of said magnet, closed contact 171 of secondary relay SR^2, and normal contact 172 of release magnet RM^2 to ground. The selected second selector wipers are also disconnected during the movement of the secondary wipers by contact 173—174 of the secondary relay SR^2. The initial energizing path for said relay SR^2 is broken at contact 166 upon the first step of the secondary wipers thereby allowing the release of said relay SR^2 as soon as wiper 60 of the third set reaches an idle or ungrounded contact 63, just as described with respect to the first selector. Conductors 223 stand normally open in the idle connectors. Thus, as a result of the transmission of the second set of three impulses, the circuit of the calling line is extended through link-circuit P^6—S^6 to a connector W having access to the third hundreds group of the third thousands subscribers' lines.

The next step in the operation consists in again grounding the primary strand P^2 three times, followed by a single grounding of the secondary strand S^2, as before explained. The grounding of the primary strand produces three distinct energizations of the primary magnet PM^3 which causes the primary wipers 64, 65, 66 to advance from normal to the third set of primary bank contacts 67, 68, 69, which are connected to the third set of secondary wipers 70, 71, 72. The energizing circuit for the primary magnet PM^3 extends from the battery bus-bar B′, through the lower winding of said magnet, contact 175 of the secondary off-normal switch SO^3, normal contact 176 of relay R and thence by the primary side of the circuit to strand P^2 and ground. On the first movement of the primary wipers, as usual, the primary off-normal switch PO^3 is actuated to close its contacts, and consequently, upon the single grounding of the secondary strand S^2, a circuit is completed through the relay R, which may be traced from the battery bus-bar B′ through the winding of relay R, its normal contact 177, closed contact 178 of off-normal switch PO^3, normal contact 179 of secondary off-normal switch SO^3 to strand S^6 and thence to the secondary side of the circuit to strand S^2 and ground. The resulting energization of relay R closes a locking circuit for its winding which may be traced from the battery bus-bar B′ through the winding of said relay, alternate contact 177 and closed contact 180 of busy relay BR to ground. This locking circuit is closed prior to the opening of its initial energizing circuit at normal contact 177. The said initial energizing path is opened at this time to prevent the premature operation of relay RV of the first selector U. Thus, it will be seen that as soon as relay S′R of said selector U is again energized by the closing of contact 90 at the subscriber's station, the circuit for said relay RV is extended from bus-bar B′, via the winding of said relay, closed contact 206, alternate contact 153 of secondary off-normal switch SO′, to strand S^2 and thence to said normally closed contact 177 of relay R over the path previously traced. The opening of said normal contact 177, however, prevents the operation of relay RV through the grounded contact 180 of the relay BR. The operation of relay R also closes contact 176 to its alternate position, whereby the secondary magnet SM^3 of the connector is connected between the battery bus-bar B′ and the primary strand P^6, while the primary magnet PM^3 is disconnected from said strand by the same movement. By the opening of its contact 181, the closing of an en-

ergizing circuit for local relay RG is prevented until relay R is again de-energized. By the closing of its contact 182, the right-hand winding of the busy relay BR is included between the battery bus-bar B′ and the secondary strand S^2, except for a single break at alternate contact 179 of secondary off-normal switch SO^3.

In view of the above, the next step in the operation, which consists in again grounding the primary strand P^2 three times and following this by a single grounding of the secondary strand S^2, causes three distinct energizations and de-energizations of the secondary magnet SM^3, followed by a momentary energization of the busy relay BR as will shortly appear. The three energizations of the secondary magnet SM^3 will advance the secondary wipers 70, 71, 72 so as to bring their third set into engagement with the third set of secondary bank contacts 73, 74, 75, which are bank contacts of the desired called line. As before, upon the first movement of the secondary wipers, the off-normal switch SO^3 is actuated and by this means the circuit for the busy relay BR is completed between the battery bus-bar B′ by way of closed contact 182 and alternate contact 179 to secondary strand S^6 so that, upon the application of ground to the secondary strand S^2, by the sending of the final impulse from the sub-station, said relay BR is momentarily energized. One result of said energization is to open contact 180, thereby opening the locking circuit of relay R to cause its release. A complete connection, except for the interruption at contacts 183–184 of ringing relay CR, has now been established from the calling sub-station M′ over the heavily marked circuit to the called line associated with the extension conductors 85–86.

Called line idle.—If it be assumed that the called line is idle, then the multiple contact 75, corresponding to the said line, will be connected to ground via conductor 185, normal contact 106 (Fig. 1, part 1) of the line relay LR, and the winding of cut-off relay CO corresponding to said line. On the other hand, if said line is in use, battery will be supplied to the said multiple contact 75 as already explained. In the latter event, then, a circuit will be completed from the said battery to engaged contact 75, through the secondary wiper 72, engaged contact 69, primary wiper 66, closed contact 186 of release magnet RM^3, alternate contact 187 of busy relay BR, through the left-hand winding of said relay to ground. It will be first assumed that the called line is idle. Under this assumption no maintaining circuit for the relay BR will be completed through said winding and said relay will immediately return to its normal position. Thereupon a circuit will be completed for the ringing relay RG and the cut-off relay CO of the called line as follows: from the battery bus-bar B′ through the winding of relay RG, closed contact 181 of relay R, closed contact 188 of the secondary off-normal switch SO^3, normal contact 187 of relay BR, closed contact 186 of release magnet RM^3, primary wiper 66, secondary wiper 72, conductor 185, normal contact 106 of line relay LR of the called line and winding of its cut-off relay CO to ground. Before considering the effect of the energization of relays RG and CO, it may be noted that the return of contact 182 of relay R to normal disconnects the right-hand winding of relay BR from strand S^6, and the return of contact 176 to normal does not again connect primary magnet PM^3 to the primary strand P^6, since at this time contact 175 of secondary off-normal switch SO^3 is open, nor does the return of contact 177 of relay R to its normal position again include the winding of said relay in circuit with the strand S^6 because of the previous operation of contact 179 of the secondary off-normal switch. Thus the primary magnet PM^3, the secondary magnet SM^3, the busy relay BR, and the relay R have their windings disconnected from the strands P^6 and S^6 and remain deenergized. As will be apparent from the previous consideration, the energization of the cut-off relay CO of the called line will be instrumental in cutting off the line relay from said line, maintaining a ground connection (through the cut-off relay CO) to the contacts 39 of the line selectors Q, having access to said line, as previously described, and completing the talking strands by the movement of contacts 89 and 93 to their alternate positions. The energization of ringing relay RG connects battery from the battery bus-bar B′, through impedance coil 189 and closed contact 190 to secondary strand S^6. At the same time, by closing its contact 191, it connects the primary strand P^6 to ground by way of contact 192—192′ of flip-flop relay FF, closed contact 191 and the winding of tip relay TR. The closing of contact 193 of relay RG completes an interrupter circuit for the flip-flop relay FF, which may be traced from the battery bus-bar B′ through the winding of relay FF, closed contact 193, closed contact 194 of closing relay CR (which may also be termed a ringing relay, because it is employed to discontinue the application of ringing current to the called line), and interrupter 195 to ground. Due to the presence of the interrupter in this circuit, the relay FF is repeatedly energized and de-energized and alternately connects the tip relay TR and the ringing generator g to the tip or primary strand P^6. During the time contact 192 is in its alternate position, a ringing circuit over the called line is completed.

This circuit may be traced from the live pole of the grounded generator g, through alternate contact 192, primary strand P^6, primary wiper 64, primary strand P^7, secondary wiper 70, extension conductor 85, alternate contact 93 of cut-off relay CO of the called line, extension conductor 83, primary limb P, closed contact 92 of the calling device at the called station, condenser 91, switch-hook 76, call-bell 78, closed contact 90, secondary strand S, alternate contact 89 of cut-off relay CO, extension conductor 86, secondary wiper 71, strand S^7, primary wiper 65, strand S^6, closed contact 190 of relay RG, impedance coil 189 to the battery bus-bar B′ and ground. Thus ringing current is intermittently applied to actuate the call-bell of the called party, and, during the non-ringing intervals, the tip relay TR is included in circuit. Consequently, as soon as the called party responds by removing his receiver from its hook, a circuit for the flow of battery current is completed from the battery bus-bar B′, through the impedance coil 189, closed contact 190, the secondary side of the called subscriber's circuit, closed contact 90 at the called station, transmitter 79, switch-hook 76, polarized relay 82, normal contact 97, 98, and resistance 196 to ground. It will be noted that upon the closing of this circuit, the direction of current flow through the said polarized relay 82 is such as to move the lower end of the armature arm 95 to the right against the tension of the spring 96 into engagement with contact 97, thus breaking the previously existing circuit through the resistance 196 but prior thereto substituting a path through alternate contact 97 and arm 95, thus completing a conductive bridge between the two sides of the line at the substation, the said flow of current continuing through closed contact 92, thence over the primary side of the circuit via strand P, alternate contact 93, extension conductor 85 and wipers 70 and 64 to strand P^6, and through the tip relay TR to ground via contacts 192—192′ of relay FF and closed contact 191 of relay RG. At this point, it will be noted that upon the de-energization of relay FF, contact 192 engages contact 192′ before disengaging said latter contact from its grounded stop. Thus upon each de-energization of the flip-flop relay FF, the primary strand P^7 is momentarily grounded to momentarily short circuit the tip relay TR. This is done for the purpose of preventing the discharge of the condensers on the called line from prematurely operating the said tip relay TR. The relay TR is thus energized only upon the response of the called party. The resultant closing of contact 197 of the tip relay causes closing relay CR to be energized over a circuit extending from the battery bus-bar B′ through the winding of said relay CR, closed contact 197 of relay TR and closed contact 198 of relay RG to ground. The consequent actuation of relay CR opens its contact 194 to interrupt the circuit of the flip-flop relay FF and thereby discontinue the application of ringing current. The closing of its contact 199 completes a locking circuit for itself which may be traced from the winding of said relay through said closed contact 199 and closed contact 198 of relay RG to ground. The closing of contact 200 of this relay completes a part of a release circuit including the right-hand winding of the release magnet RM^3, but this circuit is not completed at this time because of the previous opening of contact 201 of tip relay TR. The movement of contact 202 of tip relay TR to its alternate position connects the multiple contacts 63 of the second selectors having access to this connector to ground through resistance coil 203. This resistance is included because of the multiple arrangement of the release circuits hereinafter referred to. Prior to the movement of contact 202 to its alternate position, the left-hand winding of release magnet RM^3 is connected to local conductor 223 via contact 204 of primary off-normal switch PO^3 and contact 205 of secondary off-normal switch SO^3, the purpose of which will be explained later. By means of contacts 183—184, the secondary wipers 70 and 71 are disconnected during their selecting movements; but upon the energization of closing relay CR, the normally disconnected portions of the strands P^6 and S^6 are united and the circuit is thereby completed between the calling and called substations. The response of the called party is also instrumental in actuating the printing magnet 145 associated with the line selector Q, and also in collecting the token deposited in the slot mechanism 81 of the calling party. It will, of course, be understood that in practice it is not usually considered necessary to record a completed connection against a line whose subscribers are equipped with nickel-in-slot service. It will, however, also be understood that although the only subscriber's line shown in full in Fig. 1 is equipped with slot service mechanism there may be other lines belonging to the same calling group not thus equipped. Thus, some, or all, of the lines of any calling group may be individual, as one-party lines, having limited or measured service. In such cases, the record given by the printing magnet 145 is highly desirable. Again, there may be certain groups of calling lines in which all subscribers are provided with slot service in which case not only the printing magnet but the entire recording device X may be omitted from the selector switches. The description, however, with respect to Fig.

1 will include the use of party lines equipped with coin box service.

From the circuit previously traced through impedance coil 189 to the primary side of the heavily marked circuit and thence through the called sub-station and back over the secondary side of the heavily marked circuit through the tip relay TR, it will be seen that as soon as relay CR has operated to close contact 184, there will be a flow of current through the reversing relay RV, which may be traced from the battery bus-bar B′, through the winding of said relay, closed contact 206 of secondary relay S′R, alternate contact 153, thence over the secondary side of the heavily marked circuit, joining with the current supply through the impedance coil 189, cut-in over the called line and back through the tip relay TR to ground. The resulting energization of reversing relay RV, by reason of the cross connections 207—208, disconnects primary relay P′R from primary strand P^2 and connects it to secondary strand S^2, and similarly disconnects secondary relay S′R from strand S^2 and connects it to strand P^2. Thus the supply of current from the batteries *b*—*b′* to the calling station M′ is reversed and the polarized relay 82 at said station is thereby operated to throw the upper end of the arm 95 to the left to collect the token by allowing it to pass through the right-hand opening into a suitable receptacle provided for the purpose. The energization of relay RV further, by closing its contact 209 to ground, completes a circuit for printing magnet 145 which actuates its hammer 144 to apply the proper impression to the recording strip 143 and to, upon its release, move said strip to a new position. Thus it will be seen that the token deposited by the calling party, in case slot service be employed, is not collected, or the record of the call, in case measured service be employed, is not completed, until the called party has responded to the call.

With the parties thus connected, conversation may be carried on. At this time, transmission current will be supplied from the batteries *b*—*b′* to the calling party's transmitter, and from the battery B, via battery bus-bar B′, to the called party's transmitter, the latter connection being, as before indicated, through the impedance coil 189 and reversing relay RV in multiple to the secondary side of the circuit, and through tip relay TR to the primary side of the circuit.

The called line may be busy either because it has already been selected by some other line or because it has initiated a call or is in the process of initiating one. Under the former assumption, the multiply connected test contacts 75 of the connectors will be connected to battery B through relay RG as already traced. Under the assumption that the called line is busy, because it has just started to initiate a call, that is, while its line relay LR is still energized, the said testing contact 75 would be connected to battery via the alternate contact 106 of said operated line relay as previously traced. Under the assumption that the called line is busy because it has initiated a call and the connection has been established far enough to cause the release of its line relay LR, the said testing contacts 75 would be connected to battery B via the normal contact 106 of said line relay LR as previously traced. Thus, in all cases, when the called-for line is busy, the testing contacts 75 are connected to battery. Therefore, the final secondary impulse transmitted to the connector momentarily energizes the busy relay BR as previously described; but said relay does not now return to normal upon the release of relay R, but is held up by reason of the maintaining circuit previously traced from battery through the secondary wiper 72, primary wiper 66, closed contact 186, alternate contact 187 and the left-hand winding of relay BR to ground. This maintaining circuit is established prior to the breaking of contact 180 which causes the release of relay R. The closing of its contact 181 will not now be instrumental in energizing the relay RG, since its energizing circuit is now open at normal contact 187. On the other hand, by reason of the continuous closure of contact 210 of relay BR, a characteristic busy signal is transmitted to the calling party through the agency of a primary circuit extending from bus-bar B′ and including interrupter 211 and a winding of induction coil 212, in association with a secondary circuit including the other winding of said coil 212, the condenser 213, closed contact 210, alternate contact 179 of off-normal switch SO^3, thence over the secondary side of the heavily marked circuit, through the transmitter, receiver and condenser at the calling substation, back over the primary side of the heavily marked circuit to such ground connections as may be found thereon, such as that through the primary relay P′R. Due to the characteristic signal produced in the secondary circuit, due to the interruptions caused by interrupter 211 in the primary circuit, the calling party will understand that the desired line is not available to him and will restore his receiver to its hook. In such event, the token at the calling station, which has up to this time remained in engagement with the upper end of the arm 95, will be returned into the socket of the slot mechanism, and the talking circuit will remain uncompleted at contacts 183—184 of the relay CR.

Release.—This leads naturally to the consideration of the release of the various switches employed in establishing the connection. Assuming that the connection has

been completed between the sub-station M′ and a similarly equipped substation on the called line connecting with the conductors 85—86 at the right of the diagram, as heretofore explained, and assuming that conversation has been carried on between these stations, then, whenever the calling party at substation M′ hangs up his receiver, whether before or after the called party hangs up his, all the switches, except the connector W, will be released and restored to normal as a result of his action; likewise, when the called party hangs up his receiver, whether it be before or after the calling party hangs up his, the connector W will be released. Thus, after conversation, the restoration of the calling party's receiver controls the release of the line, first and second selectors; and the restoration of the called party's receiver controls the release of the connector. Now, if it be assumed that the line circuit of a calling line has been extended through to the line of a desired subscriber, and the latter is found to be busy, or does not answer, then, when the calling party restores his receiver to its hook, all the switches, including the connector W, will be released and restored to normal. Likewise, if at any time, in the process of extending the calling subscriber's circuit, such subscriber 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. It will be remembered that in this form of the invention, the restoration of the switches to normal is brought about by a step-by-step advance of the wipers until they reach their normal positions.

Considering these release operations more in detail, it will be remembered that during conversation, the relays P′R and S′R 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 are thereupon de-energized, thereby allowing their contacts 129—130 to close. By the closing of these contacts, a release circuit for the release magnet RM of the line selector is completed. Relay SN has been previously operated by current from battery B, bus-bar B′, said relay SN and closed contact 131 of the secondary off-normal switch SO. The said relay establishes a locking-circuit for itself via its contact 131^2 and contact 131^3 of the primary off-normal switch PO, whereby the said relay, after having been once operated by the closing of contact 131, will remain operated until both the primary and secondary off-normal switches of the line selector Q have been restored to normal. The operation of said relay SN closed contact 131′ thereby completing the release circuit for the release magnet RM of the line selector as follows: battery bus-bar B′, through the winding of said release magnet RM, closed contacts 129—130 of relays S′R and P′R respectively and said closed contact 131′ to ground. The closing of this circuit energizes the release magnet RM and, by the closing of its contact 214, completes a locking circuit with parallel ground connections through the primary and secondary off-normal switches. This circuit may be traced from the winding of release magnet RM, through closed contact 214 to the point 215 and thence to ground either by way of closed contact 216 of off-normal switch PO or closed contact 217 of off-normal switch SO. Thus the release magnet is maintained energized until the switch has advanced to its normal position, thereby restoring the primary and secondary off-normal contacts to their normal positions. Due to the mechanical construction of the switch and to the relative distances which the wipers have to move to reach normal, in some instances the primary wipers and, in other instances, the secondary wipers, may reach their normal positions first, and consequently this double ground connection, through the primary and secondary off-normal switches, is provided to insure the maintenance of the release circuit until both sets of wipers have returned to normal. The movement of contact 122 of release magnet RM to its alternate position, completes a circuit for the secondary relay SR through said alternate contact 122 and closed contact 218 to ground, thereby energizing said relay to disconnect the switch wipers 26 and 27 during their advance movement to normal. The movement of contact 110 of release magnet RM to its alternate position likewise completes a circuit for primary relay PR via said alternate contact 110 and closed contact 120 of off-normal switch PO to ground. The result of the energization of both the primary and secondary relays PR and SR is to complete the energizing circuits for the primary and secondary magnets PM and SM respectively. As a result, the primary and secondary wipers are advanced until they reach their normal positions. During this advance, the local wiper 28 has its circuit open at normal contact 122 of release magnet RM until the secondary wiper 36 has reached normal. As soon as the primary wipers reach their normal position, the primary off-normal contact PO returns to normal and thereby cause the de-energization of primary relay PR with a consequent interruption of the circuit of the primary magnet PM. Likewise, as soon as the secondary wipers reach their normal position, the secondary off-normal contacts are restored to normal with a consequent de-energization of the secondary relay

SR and an interruption of the circuit of the secondary magnet SM, thereby leaving the secondary wipers in their normal positions. During the restoration of the line selector to normal, and in fact until its release magnet RM is restored to normal, the contact 23 of the master-switch is maintained grounded at contact 140, thereby maintaining the busy condition of the said selector until it has been completely restored to normal and becomes again available for use. The energization of relay SR interrupts, at normal contact 123—140^b, the maintaining circuit of cut-off relay CO, thus permitting its restoration to normal with a consequent restoration to normal of the calling subscriber's line and its associated apparatus and circuits.

The movement of contact 162 of release magnet RM of the line selector Q to its alternate position is instrumental in completing release circuits for the first and second selectors. Upon the closing of said contact, current is supplied from the battery bus-bar B′ through resistance lamp 140, alternate contact 162, conductor 161′ to contact 160 of relay SR′, thence there dividing, part going to ground via the winding of release magnet RM′ and closed contact 161 of offnormal switch PO′ and closed contact 219 of off-normal switch SO′, and part extending through primary wiper 42 of second selector U, engaged primary bank contact 45, secondary wiper 48, engaged secondary bank contact 51, conductor 170, normal contact 169 to point 220, there dividing, part going to ground through the winding of release magnet RM^2 of the second selector and closed contact 221 of off-normal switch PO^2 and closed contact 222 of off-normal switch SO^2, and part continuing via normal contact 168 of secondary relay SR^2 through primary wiper 54 of second selector V, engaged bank contact 57, secondary wiper 60, engaged bank contact 63, conductor 223, alternate contact 202 of tip relay TR through resistance 203 to ground. From this it will be seen that parallel circuits extend through release magnets RM′ and RM^2 and resistance 203. The parallel path through resistance 203 might be omitted as far as the release is concerned, but it is provided in order to establish a ground connection to the secondary bank contacts 63 of the second selectors having access to the particular connector W, thereby rendering the said connector busy to other selecting second selectors V, whenever the selectors have been released in advance of the said connector, as occurs when the calling party hangs up his receiver in advance of the called party hanging up his. The operation of release magnet RM′ closes a circuit for primary magnet PM′ which may be traced from the battery bus-bar B′ through the winding of said magnet, alternate contact 151 of release magnet RM′ and closed contact 224 of off-normal switch PO′ and interrupter 225 to ground. By means of the interrupter, which like the other interrupters shown in the system is preferably constantly rotated, the primary magnet PM′ is repeatedly energized and de-energized with the consequent advance of the primary wipers until they reach normal. As soon as this point is reached, the interrupter circuit is broken by the return of contact 224 of primary off-normal switch PO′ to normal. The energization of release magnet RM′ also results in energizing the secondary relay SR′. This circuit may be traced from the battery bus-bar B′ through the winding of said secondary relay SR′, through alternate contact 158 of release magnet RM′, the winding of said magnet and thence to ground either by way of primary off-normal contact 161 or secondary off-normal 219. The energization of secondary relay SR′ disconnects the line wipers during their advance to normal position and, at the same time, completes an energizing circuit for the secondary magnet SM′ which may be traced from the live pole of the generator bus-bar G′ through the winding of said magnet SM′, closed contact 156 of relay SR′, alternate contact 157 of release magnet RM′ and closed contact 226 of off-normal switch SO′ to ground. This circuit is maintained until the secondary wipers reach their normal position, at which time the secondary off-normal switch contacts return to normal thereby interrupting said circuit at contact 226, and, at the same time, (assuming that the primary wipers have already reached normal) interrupting the circuit of relay SR′ and release magnet RM′, thereby allowing them to return to normal. Relay RV is restored to normal by the operation of SR′. The circuit of wiper 42 is maintained open at alternate contact 158 during restoration to normal. Similarly, the energization of release magnet RM^2 of the second selector V results in closing a circuit for the primary magnet PM^2 which may be traced from the battery bus-bar B′ through the winding of said magnet, alternate contact 163 of magnet RM^2, closed contact 227 of off-normal switch PO^2 and interrupter 228 to ground. The closing of this circuit results in advancing the primary wipers to their normal position, at which time the primary off-normal switch PO^2 returns its contacts to normal, thereby interrupting the primary magnet circuit and preventing further movement of the primary wipers. The energization of release magnet RM^2 also completes an energizing circuit for the secondary relay SR^2 which includes the winding of said magnet RM^2. This circuit, as before, extends from battery bus-bar B′ through the winding of relay SR^2, alternate contact 167 of release magnet RM^2,

the winding of said magnet and to ground by way of primary off-normal contact 221 and secondary off-normal contact 222. The energization of secondary relay SR^2 disconnects the line wipers during their advance to normal and closes a circuit for secondary magnet SM^2 by way of closed contact 171, alternate contact 172 and secondary off-normal contact 229 to ground. The secondary wipers are thus advanced until they reach their normal positions at which time the secondary off-normal contact 229 interrupts the circuit for said secondary magnet, and further advance of the wipers is prevented. The return of both the off-normal contacts thus interrupts the circuits of the release magnet RM^2 and secondary relay SR^2 thereby allowing their contacts to return to normal. Although in this description I have first referred to the primary circuit and the return of the primary wipers to normal, yet it will be understood that the return of the sets of wipers is not always in that order, but, in many instances, as both start at the same time, the secondary wipers will reach normal before the primary wipers; in such event, the maintaining circuit for the release magnet will be continued through the primary off-normal contact. The circuit of wiper 54 is maintained open at alternate contact 167 during restoration to normal. Moreover, it will be observed that during restoration to normal, the second selector V and the link-circuit extending thereto, is rendered "busy" by the presence of ground on conductor 170 via alternate contact 169 of relay SR^2. Thus it will be seen that upon the restoration of the calling party's receiver to its hook, the line selector Q, first selector U and second selector V, which have been employed in the connection, are restored to normal. Moreover, the connector W, not yet released, is rendered "busy" by ground on conductor 223 via alternate contact 202 of tip relay TR and coil 203.

Considering, now, the result of the restoration of the called party's receiver to its hook, it will be observed that as soon as this is done, the circuit through the tip relay TR is interrupted at the switch-hook 76 at the called substation. The restoration of the tip relay contacts to normal immediately completed a circuit to ground for the release magnet RM^3 through the primary and secondary off-normal contacts. This circuit extends from the battery bus-bar B′, through the right-hand winding of release magnet RM^3, closed contact 200 of relay CR (which is held up at this time), closed contact 201 of relay TR, conductor 230, to ground via closed contact 204 of off-normal switch PO^3 and closed contact 205 of off-normal switch SO^3. The closing of this circuit energizes release magnet RM^3 and the latter, by closing its contact 231, completes a locking circuit for itself through the same grounded off-normal contacts 204 and 205. While the tip relay thus remains de-energized, and during the complete releasing operation of the connector, conductor 223, which leads to the secondary bank contacts of the second selectors V having access to this connector, is grounded via normal contact 202 of relay TR, the left-hand winding of release magnet RM^3, conductor 230 and said closed off-normal contacts 204 and 205. The closing of contact 232 of release magnet RM^3 completes an energizing circuit for the primary magnet PM^3 which may be traced from the generator bus-bar G′, through the upper winding of said magnet, closed contact 232 and closed contact 233 of off-normal switch PO^3 to ground. Due to the character of the current supplied over the generator bus-bar G′, the primary magnet PM^3 is repeatedly energized and de-energized with a resulting advance of the primary wipers to their normal position. As soon as this position is reached, the energizing circuit of primary magnet PM^3 is interrupted at primary off-normal contact 233, and the further advance of the primary wipers is prevented. At the same time, the closing of contact 234 of release magnet RM^3 closes a vibratory circuit or individual interrupter, for the secondary magnet SM^3 which may be traced from the battery bus-bar B′, through the winding of said relay, vibratory contacts 235, closed contact 234, and closed contact 236 of off-normal switch SO^3 to ground. Due to the vibratory or intermittent character of this circuit, the secondary magnet is repeatedly energized and de-energized to advance the secondary wipers to normal position. As soon as this position is reached, secondary off-normal switch SO^3 has its contacts returned to normal, thereby interrupting the vibratory circuit of the secondary magnet and preventing the further advance of the secondary wipers. As before, there is no definite sequence in the operation of the primary and secondary magnets, (both starting at the same time) and the primary magnet may have its operation discontinued before the secondary magnet in some instances, and in others the secondary magnet will have its circuit interrupted first. In either event, the release magnet circuit is maintained until both sets of wipers have been restored to normal.

It will be observed that the energization of release magnet RM^3 also opens contact 186 which, it will be remembered, is included in the circuit which holds up the relays RG and CO of the called line, during conversation. Consequently, these relays will be de-energized. The de-energization of relay RG results in the de-energization of relay CR, since, as previously shown, the latter relay is locked up over a circuit

including contact 198 of the former relay. Consequently, all the relays, wipers and other parts of the connector circuit are restored to normal. Likewise, the de-energization of cut-off relay CO restores its contacts to normal and places the called line again in its normal condition.

Assuming now that the called-for subscriber should first replace his telephone upon its hook, the connector W would be released in the manner above described and said connector would still be maintained "busy" because of the ground present on conductor 223 at contact 162 of the line selector Q as already described. Upon the hanging up by the calling party, switches Q, U and V would be restored as above described, thus leaving all switches normal.

It now remains to consider the effect of the calling party's restoring his receiver to its hook at various times prior to the completion of a conversational circuit. Thus, he may, after initiating a call, immediately restore the receiver to its hook. In such event, the line relay LR will be drawn up to close a circuit for relay 24 of the master-switch O and the master-switch will in turn be operated to complete a starting circuit for the connected line selector Q. The latter will thus be started in search of the calling line just as hereinbefore described at length. If the receiver, however, is immediately restored, the energization of group relay GR may be discontinued before the private wiper 29 engages the bank contact 33 corresponding to the group relay of the calling line. In such event, the primary wipers of the line selector will not be stopped by engagement with the contacts corresponding to the group relay, but will (assuming there be no other subscriber just initiating a call) continue their advance movement until they again reach normal, at which time the off-normal switch PO will return to normal, thus preventing the closing of the circuit through the secondary relay SR. Since this latter circuit is not closed, there will be no advance movement of the secondary wipers of the line selectors.

If, however, it should happen, that the receiver is not restored to its hook until after the primary wipers have completed their selecting movement and the secondary wipers have been set in operation, but that the receiver is then immediately restored to its hook, that is, is restored prior to the secondary wipers engaging the said calling line contacts, then the said secondary wipers would in like manner continue their advance movement until they be returned to normal. It will be apparent that if the secondary relay SR be energized, the bridge 126 will be closed and cause the initial energization of relays P′R and S′R as already described. Similarly, relay SN will be operated upon the first movement of the secondary wipers through contact 131 of secondary off-normal switch SO, and will lock itself up through contact 131^3 of the primary off-normal switch PO, as previously described. Therefore, should the secondary wipers return to normal without first selecting a line, as assumed, relay SN would still be held operated over its locking circuit including the primary off-normal switch, whereby the release circuit for magnet RM would, upon the dropping back of relay SR, be completed. Thus, because the wipers 34, 35, have returned to normal, the relays P′R and S′R of switch U will be de-energized upon the opening of the bridge 126, to close contacts 129, 130, thus completing the energizing circuit for release magnet RM via said contacts 129, 130, conductor 131^4 and contact 131′ as previously described, whereby said magnet RM locks itself up via primary off-normal switch contact 216 to effect the complete release of the primary wipers,—the secondary wipers having been already restored to normal. The purpose of relay SN and its locking circuit through said primary off-normal switch contact 131^3 is to secure the release of the primary wipers, as above described, under the unusual conditions when a calling subscriber replaces his telephone after starting the secondary wipers of switch Q but before they have selected his line. The said relay SN may be omitted and the conductor 131^4 brought directly to contact 131 of switch SO in case the next to the last bank contact points 37, 38, and 39 of the secondary segments of the line selector Q be left unconnected or open. This arrangement is shown in Fig. 2. With this arrangement the secondary wipers would be unable to return to normal when seeking a calling line without first stopping in engagement with said last set of contacts, because the absence of a ground on said last contact 39 (Fig. 1), would cause the de-energization of relay SR and thereby cause the de-energization of relays P′R and S′R (because their circuit would then be open at wipers 34, 35). The circuit for the release magnet RM would then be completed through the secondary off-normal switch contact 131 and the release of the entire switch would take place as hitherto described at length.

In case the calling line circuit be extended to the first selector U, or the second selector V, the releasing operation of these selectors and the line selector will be substantially the same as heretofore described, and, therefore, need not be repeated. In case, however, the calling line circuit has been extended to a busy called line, then the release of the connector is under the control of the calling party; and in such event, battery is supplied, in the manner previously traced, to conductor 223 of the connector,

from which point the circuit extends via normal contact 202 of tip relay TR, the left-hand winding of release magnet RM^3, conductor 230 to ground at both the primary off-normal contact 204 and the secondary off-normal contact 205. The initial energizing circuit for the release magnet RM^3, as before, results in completing the circuit of the locking or right-hand winding through the contact 231 of said relay, and the subsequent releasing operation is the same as heretofore described. Similarly, in case the called-for subscriber is idle but does not respond to his call, the releasing circuit will (upon the calling subscriber replacing his telephone upon its hook) be completed through the same left-hand winding of the releasing magnet RM^3 of the connector, thereby causing its operation and the complete release of the connector just as above pointed out with respect to a busy called line. It has already appeared that the reversing relay RV of the selector Q which controls the operation of the printing magnet 145 as well as the collection of the coin at the substation, can only be operated after relays TR and CR of the connector have operated in response to the removal of the telephone at the called station. It therefore follows that a coin will not be collected, nor a charge be made for either a "busy" call or for a "don't answer" call, but that, on the contrary, upon the replacement of the telephone at the calling station, the coin will be automatically restored through the left-hand opening, unless the calling subscriber has actually established a conversation circuit with the called subscriber.

Additional features.—In the practice of my invention, I may employ an individual interrupter, a common interrupter with an additional winding on the stepping magnet, or a vibratory interrupter interchangeably, and I do not wish to be restricted to the specific use of these instrumentalities shown.

In the diagram of the connector circuits, ringing generators g', g^2 and g^3 are shown in addition to ringing generator g. These generators are designed to supply ringing current of different frequencies to operate the call-bells at the various substations of a partly line, and each generator is intended for connection to a different group of connectors. Thus the generator g is connected to the connector whose circuits are shown in the diagram; and connections to other similar connector circuits are indicated by the additional lines extending from its active pole. Similarly, each of the other generators is connected to a group of connectors. This will be more fully explained hereinafter in connection with Fig. 4. Obviously, in the operation of party lines, other methods of selective ringing may be employed. The method illustrated is merely typical and is that disclosed in Patent No. 779,533, granted to W. W. Dean. It may be stated at this point that although four substations are shown in this diagram and the other diagrams of this application to indicate the party line, the system need not be limited to four parties on a line, but any desired number may be employed.

Another feature to which attention is directed is the employment of a condenser c, together with a switch s, in the strand S^6 associated with the connector. This is provided to care for a certain class of service in which the calling party, having either meter or slot equipment, will not be charged with the call. It will be seen that by throwing the switch s so as to bring the condenser c in circuit, the reversing relay RV will not be operated and consequently the token at the substation, where slot service is given, will not be collected, or the meter mechanism X, where measured service is given, will not be operated. It will of course be understood that, in the arrangement of the system, all so-called "dead-head" calls will be arranged to pass through certain definite connectors, whose circuits will be provided with the condenser c while the other connectors will have them omitted.

System of Fig. 2.

Apparatus.—In the diagram of Fig. 2, which is analogous to that of Fig. 1, the equipment employed differs essentially from that employed in the system of Fig. 1, in having switches of the second class—that is, switches of the one dimension type, preferably rotary, which are returned to normal position instead of being advanced step-by-step to normal position, as are the switches of Fig. 1. This difference in switch construction necessitates the employment of a return spring, or its equivalent, and a release magnet for the switch wipers. This results in the employment of somewhat different arrangement of circuits. In this figure, as in the preceding, a party line is represented, the line extending to the exchange via limbs P^8—S^8 from substations M^{11}, M^{12}, M^{13} and M^{14}; slot service, however, is omitted for the purpose of simplicity and the spring arrangement of the calling device 80 is somewhat modified. The line circuit arrangement, by which the line is connected to the multiple contacts of the connectors and line selectors, remains the same. The master-switch O is also of the same construction. Connection is completed between the subscribers' line P^8—S^8 at the left and a line at the right of the diagram through the agency of a line selector, first selector, second selector, and a connector, designated, respectively Q′, U′, V′ and W′. In part 1 of the diagram, the connectors for party line

service are indicated at W^{10}, W^{11}, W^{12} and W^{13}. In this system, the same proportioning of the switches may be employed as in the system of Fig. 1. In view of the similarity of this diagram to that of Fig. 1, it is believed that a full understanding of the system depicted therein will be understood by entering at once into a description of the operation of the system without further explanation as to the parts associated with each switch and their general operation, which is substantially the same as that of the switches of Fig. 1, except in the matter of release, as just pointed out.

Operation.—Assuming that a party at substation M^{11} on the line P^8—S^8 at the left desires to converse with a party at a substation on the line associated with extension conductors 85—86 at the right, and assuming that the number of the latter's telephone is 3333, then, as before, the calling party removes his receiver 77 from its hook 76; and if he finds the line not in use, the line relay LR and the relay 24 of the master-switch O operate in the manner heretofore described to complete a starting circuit for the line selector Q'. It will be apparent that if the line is in use, the relay LR will not be under the control of the party at substation M^{11} and consequently a line selector will not be operated. In this instance, the idle indicator of Fig. 1 is omitted and the calling party must rely upon hearing conversation over the line to determine the busy condition of the line. Obviously, in the case of an idle line, the removal of the calling party's receiver will be instrumental at all times in energizing the line relay to cause the consequent operation of an idle line selector. In this instance, the removal of the receiver completes a somewhat different bridge between the line limbs, due to the absence of the slot mechanism of the previous figure. This bridge extends from line limb P^8, through contacts 237—238, transmitter 79, switch-hook 76, impedance coil 239, contacts 240—241 to line limb S^8. Without repeating the operation by which the starting circuit through an idle line selector is completed, it will be sufficient to start at this point and trace said circuit from the battery bus-bar B', through the winding of primary relay PR^4, closed contact 242 of off-normal switch PO^4, bank contact 22 of the master-switch O, wiper 20, closed contact 103 and normal contact 107 to ground. The consequent energization of relay PR^4 results in establishing a circuit for primary magnet PM^4 from the generator bus-bar G', which, as before, supplies alternating, pulsating, or like current, through the winding of said relay and alternate contact 243 to ground. Upon the first movement of the primary wipers 244, 245, 246 and 247, associated with bank contacts 248, 249, 250 and 251 respectively, the primary off-normal switch PO^4 is actuated and the initial energizing circuit of relay PR^4 is interrupted, but a maintaining circuit for said relay has been established via closed contact 252 of said relay, primary wiper 247, engaged contact 251 and thence to ground so long as grounded contacts are engaged. As soon as an ungrounded contact is encountered, this circuit is interrupted and the further advance of the primary wipers discontinued, as heretofore described. Upon the return of contact 243 of relay PR^4 to normal, a circuit is completed for secondary relay SR^4 which may be traced from the battery bus-bar B', through the winding of relay SR^4, closed contact 253 of secondary off-normal switch SO^4, closed contact 254 of said off-normal switch PO^4 and normal contact 243 to ground. The energization of this relay SR^4 opens the strands P^{10}—S^{10} at contacts 124—125 and unites the right-hand portions thereof by a conductive bridge 126. The energization of the relay SR^4 also completes an actuating circuit for secondary magnet SM^4 which extends from the generator bus-bar G', through the winding of said magnet, normal contact 255 of release relay RR^4, and closed contact 256 of secondary relay SR^4 to ground. Upon the closing of this circuit, the advance of the secondary wipers 257, 258 and 259 over their co-operating contacts 260, 261 and 262, respectively, begins. Upon the first movement of these wipers, secondary off-normal switch SO^4, being actuated, interrupts the initial energizing circuit of the secondary relay SR^4, but a maintaining circuit is provided for such relay via normal contact 263 of release relay RR^4, alternate contact 264 of relay SR^4, primary wiper 246, engaged contact 250, secondary wiper 259 and contact 262 to ground, so long as the grounded contacts are encountered. As soon as an ungrounded contact is encountered by wiper 259, the circuit of relay SR^4 is interrupted with a consequent stopping of the secondary wipers in engagement with the contacts corresponding to ungrounded contact 262, which, as in the case of the line selector Q of Fig. 1, will be the contacts of the calling line.

As soon as the contact 125 of the secondary relay SR^4 is moved to its alternate position, thus closing the bridge 126 across the strands P^{10}—S^{10}, the relays P^2R and S^2R, contained together with the batteries b^2—b^3 in bridge of the same strands, are energized. Upon the return of contact 125 to normal, it will be seen that other circuits are already established for the relays P^2R and S^2R. One of these extends, as in the case of Fig. 1, momentarily through the winding of the cut-off relay and need not be traced. The closing of this circuit maintains the primary relay, P^2R temporarily energized and ener-

gizes the cut-off relay CO. The other circuit extends from the live, or positive, pole of battery b^3, through the winding of secondary relay S^2R, strand S^{10}, including contact 125, wiper 245, strand S^9, wiper 258, extension conductor 84, line limb S^8, contact 240—241, coil 239, switch-hook 76, transmitter 79, contact 237—238, line limb P^8, via normal contact 93 and coil 94 to the live, or negative pole of battery B prior to the operation of cut-off relay CO and immediately subsequent thereto to the live, or negative, pole of battery b^2 via alternate contact 93 and the path previously traced for the initial energization of the cut-off relay CO. Relays P^2R, S^2R are thus held energized to prevent the premature closing of the release circuit through release relay RR^4. The energization of the cut-off relay CO, as before, disconnects the line relay and battery and extends the calling line circuit through the line selector Q′ to the associated first selector U′. This circuit is conductively continuous to the condensers 266 and 267, located in the strands P^{10} and S^{10} respectively. As before, the energization of the cut-off relay, by closing its contact 105—132, completes a circuit which is instrumental in causing the master-switch to step its wipers around until they engage the bank contact corresponding to an idle line selector. The energization of the cut-off relay also, as before, provides a local maintaining circuit through resistance lamp 140, closed contact 268 of off-normal switch SO^4, contact 269—264, primary wiper 246, engaged contact 250, secondary wiper 259, engaged contact 262, conductor 104, contact 105—132 and the winding of cut-off relay to ground. The operation of the group relay GR and the master-switch O under the various conditions of service are the same as set forth heretofore in the description of the operation of the system of Fig. 1. In this form of the invention, it will be observed that the primary and secondary relays P^2R and S^2R are connected directly in bridge of the strands P^{10}—S^{10} without the intervention of a reversing relay such as is employed in the system of Fig. 1. Obviously, this relay might be employed in this system if required for the operation of any substation apparatus, meter mechanism, or the like.

The calling line circuit having now been extended to a first selector U′ in response to the removal of the receiver at the calling station, it remains, as before, for the calling party to extend his line-circuit through the first selector U′, a second selector V′ and a connector W′ to the desired called line, by operating his calling mechanism 80 in accordance with the number of the called party, which has been assumed to be 3332. The disk of the calling mechanism 80 is operated the same in this case as before, but the spring arrangement is somewhat different. In order to transmit three impulses corresponding to the thousands digit, the disk is moved in the direction of the arrow against the tension of its retractile spring until three teeth have passed below spring contact 270 and it is then allowed to return to normal, with the resulting three interruptions of the primary side of the circuit, following three similar groundings of the secondary side. This is brought about by contact 270 first engaging contact 237, thereby grounding the secondary side of the circuit, followed by a separation of contacts 237 and 238, thereby interrupting the primary side of the circuit. The purpose of grounding the secondary side in this manner is to continue the energization of relay S^2R while the primary side of the circuit is open. The interruptions of the primary side of the circuit are followed by a similar grounding of that side of the circuit and a single interruption of the secondary side of the circuit. This is brought about by grounded contact 271 and co-operating contacts 240 and 241, similarly arranged. The ground in this case similarly continues the energization of relay P^2R while the secondary side of the circuit is open. Thus the initial operation of the dial at the calling station, as before, causes three de-energizations of the primary relay P^2R followed by a single momentary de-energization of secondary relay S^2R. The effect of these de-energizations is to ground the primary side of the circuit at the right of condenser 266 three times, followed by a grounding of the secondary side of the circuit at the right of the condenser 267 once. This is brought about by primary relay contacts 272—273 and secondary relay contact 274. The three momentary grounds, occasioned by the primary relay P^2R, cause three complete energizations and de-energizations of the primary magnet PM^5 which controls the primary wipers 275, 276 and 277, co-operating with the bank contacts 278, 279 and 280 of the first selector U′, the circuit of the primary magnet PM^5 extending through closed contact 281 of off-normal switch SO^5 and the contacts of the primary and secondary relays. Upon the first movement of the primary wipers, primary off-normal contact PO^5 is closed to ground. The single grounding of the secondary side of the circuit energizes secondary relay SR^5 over a circuit including the winding of said relay, closed contact 282 of off-normal switch SO^5 and the contacts of relay P^2R and S^2R. The energization of this relay disconnects the selector wipers by opening contacts 283—284, and, by closing contact 285, completes a circuit for the secondary magnet SM^5 which also extends through

contact 286 of release relay RR^5. The single energization of the secondary magnet SM^5 advances the secondary wipers 287, 288 and 289 into engagement with the first set of bank contacts 290, 291 and 292, and actuates secondary off-normal switch SO^5. The actuation of the latter interrupts the initial circuit for secondary relay SR^5, but the latter, by actuating its contact 293, provides a maintaining path through normal contact 294 of release relay RR^5, alternate contact 293 of relay SR^5, primary wiper 277, engaged contact 280. secondary wiper 289 and engaged contact 292 to ground, so long as grounded contacts are encountered. Thus, as before, the circuit of secondary magnet SM^5 is maintained and the secondary wipers are stepped over the contacts until an ungrounded contact is encountered. As soon as this occurs, relay SR^5 is de-energized with the consequent closing of strands P^{10}—S^{10}, whereby the calling line circuit is extended, via strands P^{11}—S^{11} and P^{12}—S^{12}, to a second selector V of the third thousands group. The ground connection, by which the selected link-circuit P^{12}—S^{12} is guarded against selection by other first selectors, is provided over a path extending from such multiple contacts 292 through secondary wiper 289, primary contact 280, primary wiper 277, contact 293—295, conductor 296, contact 297 of release relay RR^4 to ground.

The next step in the operation consists in repeating the previous operation of the calling mechanism, which results in again grounding the primary side of the circuit three times, followed by a grounding of the secondary side of the circuit once. The operation of the second selector V′, thus connected, is substantially the same as that of the first selector U′. The circuit through the primary magnet PM^6 extends through closed contact 298 of off-normal switch SO^6 to the primary side of the circuit, and the secondary relay SR^6 is initially energized over a circuit through contact 299 of off-normal switch PO^6, and contact 300 of off-normal switch SO^6. The primary magnet PM^6 advances primary wipers 301, 302 and 303 over co-operating contacts 304, 305 and 306, respectively, and actuates off-normal switch PO^6. A maintaining circuit for secondary relay SR^6 extends via normal contact 307 of release relay RR^6, alternate contact 308 of secondary relay SR^6, primary wiper 303, engaged contact 306 and the private secondary wiper 311 to ground so long as grounded contacts are encountered. The secondary magnet SM^6 actuates the secondary wipers, which are designated 309, 310 and 311, and which co-operate with secondary bank contacts 312, 313 and 314 respectively. The energizing circuit for the secondary magnet includes the winding of said magnet, normal contact 315 of release relay RR^6 and closed contact 316 of relay SR^6, which contact is grounded. The secondary off-normal switch SO^6 is actuated, as before, upon the first step of the secondary wipers 309, 310 and 311. During the movement of the secondary wipers, they are disconnected at secondary relay contacts 317—318. Thus the second set of three impulses, followed by a single impulse, is instrumental in extending the calling line circuit through strands P^{13}—S^{13} and P^{14}—S^{14}, to a connector W of the third hundred of the third thousand, which connector has access to the desired called line. The selected link-circuit P^{14}—S^{14} is guarded against selection by other second selectors V′ by reason of the grounded connection extending from contact 314 of the selected second selector, through a multiple contact 314, a secondary wiper 311 of some other second selector V, an associated primary contact 306, and primary wiper 303, normal contact 308 of relay SR^6 of said other second selector, normal contact 319 of said relay, conductor 320, to contact 292 of the first selector U′ connected to said other second selector V′, and thence to ground as previously traced.

The next step in the operation consists in again repeating the previous operation of the calling mechanism, thereby transmitting the directive impulses corresponding to the tens digit of the called number. This results in grounding strand P^{14} three times, followed by a single grounding of strand S^{14}. The grounding of strand P^{14} three times causes three complete energizations and de-energizations of primary magnet PM^6 over a circuit extending from battery bus-bar B′, through the winding of said relay, closed contact 321 of off-normal switch SO^6, normal contact 322 of relay R′, through strand P^{14} to ground. These energizations of magnet PM^6 step the primary wipers 323, 324 and 325 to the third set of bank contacts 326, 327 and 328, respectively, and actuate primary off-normal switch PO^6. The actuation of the latter, by closing contact 329, completes a circuit from battery bus-bar B′, through the winding of relay R′, closed contact 329 and normal contact 330 to secondary strand S^{14}. Consequently, upon the grounding of said strand, relay R′ is momentarily energized; and upon such energization, closes a locking circuit for itself through its closed contact 331 and closed contact 332 of busy relay BR′ to ground.

The next and final step in the operation on the part of the calling party is to repeat the preceding operation, thereby again grounding strand P^{14} twice, followed by a grounding of strand S^{14} once. Each grounding of strand P^{14} completes a circuit through the winding of the secondary magnet SM^6, alternate contact 322 of relay R′,

strand P^{14} to ground. The closing of these circuit energizes magnet SM^6 twice and thereby advances secondary wipers 333, 334 and 335 to the second set of bank contacts 336, 337 and 338 respectively, which are bank contacts of the desired called line. Thus, up to the time that the secondary side of the circuit is about to receive its final impulse, the calling line circuit is extended to the called line, except that contacts 339 and 340 of closing relay CR′ have not been actuated to connect the normally disconnected portions of the strands P^{14} and S^{14}.

Called line idle.—If it be assumed that the called line is idle, then, as before, the multiple contacts 338 will be connected to ground. On the other hand, if said line is busy, said contacts will be connected to battery, as previously explained. Under the assumption, then, that the called line is idle, in which case the contact 338 of the engaged connector W is grounded, then the final grounding of strand S^{14} will momentarily energize busy relay BR′ over a circuit extending from battery bus-bar B′, through the right-hand winding of relay BR′, closed contact 341 of relay R′, alternate contact 330 of off-normal switch SO^6 and strand S^{14} to ground. The resulting energization of relay BR′ will close alternate contact 342 and open contact 332, thereby, in the latter case, interrupting the maintaining circuit of relay R′ and allowing its contacts to return to normal; and in the former case, connecting engaged contact 338 to ground through the left-hand winding of busy relay BR′. This latter circuit may be traced from contact 338, through secondary wiper 335, primary contact 328, primary wiper 325, normal contact 343 of release relay RR^6, alternate contact 342 and the left-hand winding of relay BR′ to ground. From this it will be seen that if battery is supplied to the contact 338, as would be the case if the called line were busy, then relay BR′ will be held up. Under the present assumptions, however, this it does not do, but immediately restores to normal and thereby completes a local circuit extending through the winding of ringing relay RG′ and the winding of cut-off relay CO of the called line. This circuit is substantially the same as the corresponding circuit of Fig. 1 and may be briefly outlined as including closed contact 344 of relay R′, contact 345 of off-normal switch SO^6, normal contact 342 of relay BR′, normal contact 343 of relay RR^6, primary wiper 325, secondary wiper 335, conductor 185, normal contact 106 of the line relay LR and the winding of cut-off relay CO. The resulting energization of cut-off relay CO operates, as before, to destroy the normal substation control of the line relay and to render the extension conductors of the called line continuous. The energization of ringing relay RG completes a circuit for the flip-flop relay FF′ through contacts 346—347 and interrupter 348. Its energization also connects contact 349 of relay CR′ to ground through contact 350; and at the same time, connects the secondary strand S^{14} through impedance coil 351 to battery bus-bar B′ via contact 352; and also connects the primary strand P^{14} to ground via contacts 353—354 of flip-flop relay FF′, contact 355 of relay RG′, through the winding of tip relay TR′. The momentary ground connection, occasioned in the operation of contacts 353 and 354 of relay FF′, is provided to care for the discharge of the substation condensers of the called lines, as previously explained. As before, the operation of the flip-flop relay FF′ alternately connects ringing generator *g* and tip relay TR′ to the primary, or tip, side of the circuit. As before, upon the response of the called party, by which a conductive bridge is completed between the line limbs at his station, the tip relay TR′ is energized; and as a result, closing relay CR′ is energized over a circuit including tip relay contact 356 and ringing relay contact 350. This circuit is at once replaced by a locking circuit extending through closing relay contact 349 and ringing relay contact 350. The energization of closing relay CR′ completes the talking circuit at contacts 339—340 and interrupts the flip-flop relay circuit at contact 347. Thus the calling and the called substations are connected and conversation may be carried on. At this time transmission current is supplied from batteries b^2—b^3 to the calling party's transmitter, and from battery bus-bar B′, via impedance coil 351 and tip relay TR′, to the called party's transmitter.

Called line busy.—Now, if it be assumed that the called line is busy, then, as soon as the secondary impulse is transmitted, and the busy relay BR′ is momentarily energized as a result thereof, the aforesaid circuit through the left hand winding of the said relay, being closed to battery, will maintain said relay energized; and by the closing of its contact 357, a characteristic busy signal will be transmitted to the called party through the agency of interrupter 358, induction coil 359 and condenser 360, in a manner which will be understood without tracing the circuits. In such event, the talking circuit between the connected stations will remain uncompleted at contacts 339—340 of relay CR′.

Release.—As in the case of the system disclosed in Fig. 1, the release of the various switches, after a complete connection has been established and conversation carried on, is controlled by the restoration of the calling and called parties' receivers to their hooks. Under these conditions, the line,

first and second selectors are under the control of the calling party, and the connector under the control of the called party. Under these assumptions, the restoration of the calling party's receiver to its hook interrupts the normal circuit through the primary and secondary relays P^2R and S^2R and thereby allows their contacts 265 and 361, respectively, to close a circuit for release relay RR^4 which may be traced from the battery bus-bar B′, through the winding of said relay, closed contacts 361—265, and closed contact 362 of off-normal switch SO^4 of the line selector, to ground. In order to hold up the release relay RR^4 through both primary and secondary off-normal contacts and independently of the contacts of relays P^2R and S^2R, connections are completed, upon its energization, through closed contact 363, closed contact 364 of off-normal switch PO^4 and normal contact 343 of relay PR^4 to ground, and from closed contact 363 through closed contact 365 of secondary off-normal switch SO^4 to ground. The energization of release relay RR^4 energizes secondary relay SR^4 over a circuit extending from battery bus-bar B′, through the winding of said relay and alternate contact 263 of relay RR^4 to ground. Thus during the release movement, the line selector wipers are disconnected. The movement of contact 255 of release relay RR^4 to its alternate position completes energizing circuits for the release magnets RM^4 and $R'M^4$ of the line selectors. These circuits extend from the battery bus-bar B′, through the windings of said release magnets in parallel, thence by way of alternate contact 255 of relay RR^4 and closed contact 256 of relay SR^4 to ground. As diagrammatically illustrated, all of the switches of this form of the invention are moved from normal against the tension of a retractile spring by means of a driving pawl, which is normally held out of engagement with the ratchet teeth, and a retaining pawl holds the wipers in the position to which they have been moved. The release magnets actuate these retaining pawls to free the ratchet wheels and thereby allow the wipers to return to normal under the action of their retractile springs. During the restoration of the line selector to normal and until the de-energization of release relay RR^4, the wiper 21 of the master-switch is grounded via closed contact 295′, thereby maintaining the busy condition of said selector until it is completely restored to normal. The energization of relay SR^4 at this time interrupts the cut-off relay circuit at contact 264—269, thereby permitting the restoration of the line circuit to normal. The release circuits of the first selector U′ and second selector V′ are similar to those of the line selector just traced. The energization of release relay RR^4 connects conductor 296, via alternate contact 297 and resistance lamp 140, to battery bus-bar B′, thereby supplying current for the actuation of the release of the selectors U′ and V′. From contact 295, in which conductor 296 terminates, battery is supplied over a circuit including contacts 293—366, the winding of release relay RR^5 and closed off-normal contact PO^5. From this same contact 295, battery is supplied through primary wiper 277, secondary wiper 289, conductor 320 to the point 367 and thence over a path including the winding of release relay RR^6 of second selector V′ and closed contact 368 of off-normal switch PO^6 to ground. The closing of these circuits results in the energizations of the release relays RR^5 and RR^6. The energization of the former, by the movement of its contact 294, closes a new circuit which extends from battery bus-bar B′, through the winding of secondary relay SR^5, alternate contact 294, winding of release relay RR^5 and to ground via primary off-normal contact PO^5 and closed contact 369 of off-normal switch SO^5. The corresponding circuit for release relay RR^6 extends from the battery bus-bar B′, through the winding of secondary relay SR^6, alternate contact 307, the winding of relay RR^6, to ground via closed contact 368 of off-normal switch PO^6 and closed contact 370 of off-normal switch SO^6. By the energization of secondary relays SR^5 and SR^6, the wipers of the first and second selectors U′ and V′, respectively, are disconnected. By the closing of contact 285 of secondary relay SR^5, an energizing circuit for release magnets RM^5 and $R'M^5$ of the first selector U′ are completed via alternate contact 286 of release relay RR^5 and closed contact 285 of secondary relay SR^5 to ground. The corresponding circuits for the release magnets RM^6 and $R'M^6$ of the second selector V′ extend through alternate contact 315 of release relay RR^6 and closed contact 316 of relay SR^6 to ground. The energizations of these release magnets, as in the case of the line selector Q′, withdraw the retaining pawls from engagement with the different ratchet wheels and allow the switch wipers to return to normal. In the case of any particular switch, the circuit of the release relay will be maintained until both sets of wipers are restored to normal. This is true, irrespective of the order in which the wipers reach normal, and is brought about by providing two connections for the release relays through both primary and secondary off-normal switches. Since the secondary and release relays are held up through these off-normal contacts, it follows that when both sets of switch wipers have been returned to normal, said relays will be de-energized, with a resulting return of their contacts to normal position, thus leaving all

the parts in the condition illustrated. During the restoration of the second selector V′ to normal, said selector and the link-circuit P^{12}—S^{12} are rendered "busy" by the presence of ground on conductor 320 via alternate contact 319 of relay SR^6. Similarly, during the restoration of the second selector V (Fig. 1) to normal, the second selector V and the link-circuit P^4—S^4 are rendered "busy" by the presence of ground on conductor 170 via alternate contact 169 of relay SR^2. Similarly, also, connector W′ (Fig. 2), not yet released, is rendered busy by ground on conductor 369 via alternate contact 377 of tip relay TR, and resistance coil 203, just as explained with reference to Fig. 1. Thus it is seen that after the completion of a conversational circuit, the restoration of the calling party's receiver to its hook releases the line, first and second selectors, and leaves the connector still "busy."

Considering, now, the result of the restoration of the called party's receiver to its hook, it will be observed that as soon as this is done, the circuit for the flow of battery current through the tip relay TR′ will be interrupted at the switch-hook of the called party. The restoration of the tip relay contacts to normal, as in the case of the connector W of Fig. 1, immediately completes a circuit for the release relay RR^6 through primary and secondary off-normal contacts. This circuit extends from battery bus-bar B′, through the right-hand winding of release relay RR^6, closed contact 371 of relay CR′, normal contact 372 of relay TR′, conductor 373, closed contact 374 of off-normal switch PO^6 to ground, and from conductor 373 through closed contact 375 of off-normal switch SO^6. The closing of this circuit energizes release relay RR^6, and the latter, by closing its contact 376, completes a locking circuit for itself through the same grounded off-normal contacts. While the tip relay thus remains de-energized, and during the release operation, conductor 369, which leads to the secondary bank contacts of the second selectors P′ having access to this connector, is grounded via normal contact 377 of relay TR′, the left-hand winding of release relay RR^6, conductor 373 and the same grounded off-normal contacts. The closing of grounded contact 378 completes an energizing circuit for release magnets RM^6 and $R'M^6$. The result of closing this circuit is to withdraw the retaining pawls and allow the switch wipers to return to normal, as before explained. Upon the return of said wipers to normal, primary and secondary off-normal switches PO^6 and SO^6 are returned to their normal positions, thereby interrupting the release relay circuit and allowing the contacts to return to normal. The energization of release relay RR^6, by opening contact 343, interrupts the circuit of relays RG′ and CO of the called line. The de-energization of relay RG′ results, as in the case of connector W of Fig. 1, in the de-energization of relay CR′, since the latter is held up over a circuit including contact 350 of relay RG′. Consequently, all the relays, wipers and other parts of the connector circuit are restored to normal. Likewise, the de-energization of the cut-off relay CO, as before, restores its contacts to normal and places the line in condition for the establishment of another connection.

Assuming now that the called-for subscriber should first replace his receiver, then the connector W′ would be released in the manner above described and said connector would still be maintained "busy" because of the ground on conductor 369 at contact 297 of the line selector Q′ as already described. Upon the hanging up by the calling party, switches Q′, U′ and V′ would each be restored as above described, thus leaving all switches normal.

It now remains to consider the effect of the calling party's restoring his receiver to its hook at various times prior to the completion of a conversational circuit. The effect of the calling party's removing his receiver and then immediately restoring it prior to the selection of the sub-group by the primary wipers of the line selector Q′, would be to cause said wipers to continue their motion until they reached the last set of primary bank contacts. Said last set is, however, whether the switch be circular, arcuate or linear, preferably left open and disconnected from any of the secondary wipers of said switch. In other words, the said switch is preferably provided with a sufficient number of primary bank points so that in addition to the normal point there may be ten other points corresponding to the ten sets of secondary wipers and an additional dead point. Should said primary wipers rotate to the last set of contacts without finding a sub-group containing a subscriber just initiating a call, then the primary relay PR^4 would be released just as hitherto described and cause the energization of secondary relay SR^4 to start the advance of the secondary wipers. It is apparent, however, that the said relay SR^4 would be released as soon as the secondary wipers had made their first step, thus completing the circuit through the release relay RR^4 over the circuit hitherto traced and including closed contacts 361 and 265 of relays S^2R and P^2R respectively, and closed contact 362 of secondary off-normal switch SO^4, whereby the line selector Q′ and calling line circuit would be completely restored as hitherto described at length. Should, however, the calling party replace his telephone upon its hook subsequent to the pri-

mary wipers of the line selector Q′, selecting the sub-group, but prior to the selection of his line by the secondary wipers of said line selector, then the said secondary wipers would continue in their motion until they reach the last set of bank contacts. Said last set are, however, also, whether the switch be circular, arcuate or linear, preferably left open and disconnected from all lines. In other words, said switch is preferably provided with twelve sets of secondary bank contacts, the first set being the zero position and the twelfth set being a dead position. Should, therefore, said secondary wipers rotate to said last set of contacts without finding a line just initiating a call, the secondary relay SR^4 would, as usual, be released, thus completing the energizing circuit for release relay RR^4 and causing the complete release of the said line selector Q′ and calling line, as hitherto described. Although I have described the line selecting switch as having preferably twelve primary bank contacts for each primary wiper and twelve secondary bank contacts for each secondary wiper, so that the said switch will accommodate one hundred telephone lines, yet it is apparent that if it be desired to include less than one hundred lines in each group of calling lines, the number of bank contacts may be proportionally decreased. In case the calling line circuit be extended to the first selector U′, or the second selector V′, the releasing operation of these selectors and the line selector would be the same as heretofore described. In case, however, the calling line circuit has been extended to a busy called line, then the release of the connector W′ is also under the control of the calling party. In such event, battery current, which is supplied to the point 367 in the circuits of second selector V′, flows also through the release relay RR^6 of the connector over a path extending from point 367, through normal contact 308 of secondary relay SR^6, primary wiper 303 of selector V′, secondary wiper 311 of said selector, conductor 369, normal contact 377 of relay TR′, the left-hand winding of release relay RR^6, conductor 373 and off-normal contacts 374 and 375 to ground. This initial energizing circuit for the release relay RR^6, as before, results in immediately completing the locking circuit through its right-hand winding and contact 376 of said relay, whereby the complete restoration of said connector is obtained as heretofore described at length. Similarly, in case the called subscriber does not respond, the hanging up by the calling subscriber will cause a complete release of all of the switches, the battery circuit being extended, just as in the case of a "busy" line, over conductor 369 and through the left-hand winding of the release relay RR^6, whereby the connector W′ will be also restored to normal.

Party line features.—The same party line features exist in this form of the invention as in the form illustrated in Fig. 1, and the generators g, g', g^2 and g^3 are intended to be operated in the same manner.

System of Fig. 3.

Apparatus.—In the diagram of Fig. 3, which is somewhat analogous to that of the preceding figures, switches of the third class are employed. It will be remembered that these switches are operated to advance their wipers first in a primary direction to a desired group of bank contacts, and then in a secondary direction over the contacts of said group, and that they are released by retractile springs or their equivalents. Due to this different switch construction, a modified arrangement of circuits must be employed for each of the switches. In the diagram, as in each of the preceding diagrams, a party line is represented at the left by the line limbs P^{16}—S^{16}, extending from substations M^{21}, M^{22}, M^{23} and M^{24} to the exchange. In this diagram, the same substation equipment is shown as in the diagram of Fig. 2, but the calling apparatus 80 has the spring arrangement of that of Fig. 1. The line circuit arrangement and the arrangement of the master-switch circuits are the same as those heretofore described. Connection is completed between the subscriber's line P^{16}—S^{16} at the left and the line at the right of the diagram associated with the extension conductors 85, 86, 185, at the right of the diagram, through the agency of a line selector, a first selector, a second selector and a connector, designated, respectively, Q^2, U^2, V^2 and W^2. In part 1, of the diagram, the connectors for party line service are indicated at W^{20}, W^{21}, W^{22}, and W^{23}. With this preliminary outline of the apparatus employed, it is believed that a full understanding of this form of the invention will be had from a consideration of its operation.

Operation.—Assuming that a party at substation M^{21} on the line P^{16}—S^{16} at the left desires to converse with a party at a substation on the line associated with extension conductors 85, 86, 185 at the right, and assuming, as in Fig. 1, that the number of the latter's telephone is 3333, then, as before, the calling party removes his receiver from its hook and operates the calling apparatus in the same manner as in the operation of each of the previously described systems. As explained in connection with the statement of operation of the system of Fig. 2, if the calling party's line is idle, the removal of his receiver will cause the operation of line relay LR and master-

switch relay 24, and a starting circuit will be thereby completed for the idle line selector Q^2 associated with the master-switch contacts then engaged. Starting at this point with a more detailed statement of the operation, this starting circuit extends from the battery bus-bar B′, through the winding of primary relay PR^7, closed contact 379 of off-normal switch PO^7, master-switch contact 22, wiper 20, and closed contacts 103—107 of relays 24 and 25, respectively, to ground. The consequent energization of primary relay PR^7 results in establishing a circuit for the primary magnet PM^7 from generator bus-bar G′, which, as before supplies alternating, pulsating, or like current, through the winding of said magnet and alternate contacts 380 of relay PR^7 to ground. Upon the first movement in a primary direction of the switch wipers 381, 382, 383 and 384, associated with the bank contacts 385, 386, 387 and 388, respectively, the primary off-normal switch PO^7 is actuated and the intial energizing circuit of primary relay PR^7 is interrupted, but a maintaining circuit for said relay has been established via closed contact 389 of said relay, wiper 384, engaged contact 388 and thence to ground via normal contacts 102 of group relays GR so long as contacts 388, thus grounded, are encountered. As soon as an ungrounded contact is encountered, this circuit is interrupted and the further advance of the wipers 381, 382, 383 and 384 in a primary direction is discontinued. From the previous description, it will be remembered that the group relay GR, corresponding to the group which contains the calling line, is energized upon the initiation of a call. Consequently the wiper 384 will advance over the contacts 388 until that contact, corresponding to the group containing the calling line, is encountered. The wiper 384, by reason of the mechanical construction of the switch, partakes of the primary movement only, while the remaining wipers 381, 382 and 383 partake of both the primary and secondary movements, but engage contacts 385, 386 and 387 only on the secondary movement. Consequently, each of the latter wipers is moved, during the advance of the wiper 384, in juxtaposition with a group of bank contacts in which contacts, corresponding to the calling lines, are located. Upon the return of contact 380 of relay PR^7 to normal, a circuit is completed for secondary relay SR^7 which may be traced from the battery bus-bar B′, through the winding of said relay, closed contact 390 of off-normal switch SO^7, closed contact 391 of off-normal switch PO^7, and normal contact 380 to ground. The resulting energization of relay SR^7 opens the strands P^{17}—S^{17} at contacts 392 and 393 and unites the right-hand portions thereof by the conductive bridge 126. The energization of relay SR^7 also completes a circuit for secondary magnet SM^7 which extends from the generator bus-bar G′, through the winding of said magnet, normal contact 394 of release relay RR^7, and closed contact 395 of relay SR^7 to ground. Upon the closing of this circuit, due to the character of the current supplied and the construction of the switch, the wipers 381, 382 and 383 begin their movement in the secondary direction. At the beginning of this movement, the secondary off-normal switch SO^7 is actuated and thereby interrupts the initial energizing circuit of secondary relay SR^7, but not until after a maintaining circuit is provided for such relay via normal contact 396 of release relay RR^7, alternate contact 397 of relay SR^7, wiper 383, engaged contact 387 to ground via conductor 104, normal contact 105 of cut-off relay CO, and normal contact 99 of line relay LR, so long as this ground connection exists. It will be remembered, however, that this ground connection is interrupted for the contact 387 corresponding to the calling line. Consequently, the advance of the wipers 381, 382 and 383 will be discontinued when the wiper 383 engages the contact 387 corresponding to the calling line. In this event, the extension conductors 83—84 of the calling line will be connected via wipers 381 and 382 to the link-circuit strands P^{17}—S^{17}. The switch is stopped in its secondary movement, as just described, for the reason that the circuit of the secondary relay SR^7 is interrupted and, as a result, said relay is de-energized and thereby interrupts the circuit of the secondary magnet SM^7.

As soon as the contact 393 of the secondary relay SR^7 is moved to its alternate position by the energization of said relay, thus closing the bridge 126 across the strands P^{17}—S^{17}, the relays P^3R and S^3R, contained together with the batteries b^4—b^5 in bridge of the same strands, are energized. Upon the return of contact 393 to normal, due to the deenergization of relay SR^7 upon the selection of the calling line, other circuits are found to have been established for the relays P^3R and S^3R. One of these momentarily extends, as in the case of Figs. 1 and 2, through the winding of primary relay P^3R and the cut-off relay CO of the calling line and need not be traced. The closing of this circuit maintains the primary relay P^3R temporarily energized and energizes the cut-off relay CO. The other circuit extends from the live, or positive, pole of battery b^5 over the secondary side of the circuit to the calling substation, through said station and back over the primary line limb P^{16} to contact 93 of cut-off relay CO and thence to the live, or negative, pole of battery B via normal contact 93 and coil 94 prior to the operation of the cut-off relay and immediately subse-

quent thereto to the negative pole of battery b^4, as in the case of Figs. 1 and 2. The energization of the cut-off relay CO, as before, disconnects the line relay and battery and unites the line limb P^{16} and extension conductor 83, thereby extending the calling line circuit through the line selector Q^2 to the associated first selector U^2. This circuit is conductively continuous to the condensers 399 and 400, located in the strands P^{17} and S^{17}, respectively, and is completed at said selector through the relays P^3R and S^3R and batteries b^4—b^5, as above traced. As before, also, the energization of the cut-off relay CO, by closing its contact 105—132, completes a circuit which is instrumental in causing the master-switch to step its wipers around until they engage bank contacts corresponding to an idle line selector Q^2. The energization of the cut-off relay also, as before, supplants its initial energizing circuit by a local circuit through resistance lamp 140, closed contact 401 of off-normal switch SO^7, contact 402—397 of relay SR^7, wiper 383, engaged contact 387, conductor 104, said contact 105—132 of cut-off relay CO, and the winding of said relay to ground. In this form of the invention, as in Fig. 2, no reversing relay is employed. The operation of the group relay GR and the master-switch O is the same as heretofore described.

The calling line circuit having now been extended to a first selector U^2 in response to the removal of the receiver at the calling station, it remains to consider the operations of the switches in response to the operations of the calling apparatus at the calling station. This mechanism, as in previous cases, de-energizes the relay P^3R a number of times, depending upon the extent of movement of the mechanism, and this is followed by a single de-energization of the secondary relay S^3R. In transmitting the number 3333, the first operation of the calling apparatus then causes three distinct de-energizations of relay P^3R, followed by a single de-energization of relay S^3R. The effect of these de-energizations, as before, is to successively ground the primary and secondary sides of the circuit at the right of the interposed condensers, here the condensers 399 and 400. These grounds are applied through the agency of contacts 403—404 of relay P^3R and contact 405 of relay S^3R. The three momentary grounds, occasioned by the primary relay P^3R, cause three complete energizations and de-energizations of the primary magnet PM^8 of the first selector U^2. This magnet controls the operation of wipers 406, 407 and 408, which co-operate with bank contacts 409, 410 and 411, respectively. The circuit of primary magnet PM^8 extends from battery bus-bar B′, through the winding of said magnet, closed contact 403 of relay P^3R, and alternate contact 405 of relay S^3R to ground. On the first movement of said wipers in a primary direction, the primary off-normal contact PO^8 is actuated. The following single grounding of the secondary side of the circuit energizes secondary relay SR^8 over a circuit including the winding of said relay, closed contact 413 of off-normal switch SO^8, closed contact 404 of relay P^3R, and normal contact 405 of relay S^3R to ground. The energization of this relay disconnects the wipers 406—407 by opening contacts 414—415 and, by closing contact 416, completes a circuit for the secondary magnet SM^8, which extends from the generator bus-bar G′, through the winding of said magnet, normal contact 417 of release relay RR^8 and closed contact 416 of relay SR^8 to ground. Due to the character of the current supplied to the secondary magnet, and due to the construction of the switch, the closing of the circuit of said magnet causes it to move the wipers 406, 407 and 408 in a secondary direction over the associated bank contacts, the first step advancing said wipers into engagement with the first set of bank contacts. Upon the first step in a secondary direction, secondary off-normal switch SO^8 is moved to open position, thereby interrupting the initial energizing circuit of secondary relay SR^8. The latter in the meantime has, however, been provided with a maintaining circuit which extends from the winding of said relay, through normal contact 418 of release relay RR^8, alternate contact 419 of secondary relay SR^8, wiper 408, and engaged contact 411 to ground, so long as a grounded contact is encountered. Thus, the wipers 406 and 407 are moved into engagement with contacts in which an idle link circuit P^{18}—S^{18} terminates, thereby extending the calling line circuit through to an idle second selector of the third thousands group. As soon as the selection of the idle link-circuit occurs, relay SR^8 is de-energized and its contacts 414—415 unite the previously separated portions of the strands P^{17}—S^{17}. The ground connection to the contact 411, by which the selected link-circuit is guarded against selection by another first selector, may be traced from wiper 408, through contact 419—482 of relay SR^8, and normal contact 481 of relay RR^7 to ground.

As a result of again transmitting three primary impulses, followed by a single impulse, from the calling station, which results in grounding the primary strand P^{18} three times, followed by a single grounding of the secondary strand S^{18}, the connected second selector V^2 is operated to extend the calling line circuit to a connector W^2 of the third hundreds group of the third thousand. The operation of this second selector is substantially the same as that of the first selector U^2. The circuit through the primary mag-

net PM^9 extends through closed contact 424 of off-normal switch SO^9, to the primary strand P^{18}; and the secondary relay SR^9 is initially energized over a circuit through contact 425 of off-normal switch PO^9 and contact 426 of off-normal switch SO^9 to secondary strand S^{18}. Primary magnet PM^9 advances the wipers 427, 428 and 429 in a primary direction to the third group of bank contacts and actuates primary off-normal switch PO^9. These bank contacts are designated, respectively, 430, 431 and 432. The energization of secondary relay SR^9 completes a circuit for secondary magnet SM^9 extending from generator bus-bar G', through the winding of said magnet, normal contact 433 of release relay RR^9, closed contact 434 of relay SR^9 to ground. Due to the construction of the switch and the character of the current supplied over this circuit, the secondary magnet SM^9 causes the wipers 427, 428 and 429 to advance over the contacts 430, 431 and 432, in a secondary direction, until they encounter contacts of an idle link-circuit P^{19}—S^{19}. Upon the initial movement of the wipers in a secondary direction, off-normal switch SO^9 is actuated and the initial energizing circuit of relay SR^9 is interrupted; but before this occurs, a maintaining circuit for secondary relay SR^9 is completed via normal contact 435 of relay RR^9, alternate contact 436 of relay SR^9, wiper 429, the first contact 432 and thence to ground if said contact be that corresponding to a busy link-circuit. Thus, as before, the secondary movement of the wipers is continued until they rest upon the contacts of an idle link-circuit. As soon as this occurs, secondary relay SR^9 is de-energized and, by restoring its contacts 437 and 438, which have been open during the secondary movement of the wipers, the calling line circuit is extended through to a connector W^2 having access to the called line. The ground connection with multiple contacts 432, which protects the selected link-circuit P^{19}—S^{19} from selection by other second selectors having access thereto, is provided over a path including wiper 429, normal contacts 436 and 422 of relay SR^9, conductor 421, bank contacts 411 and wiper 408 of selector S^2 to ground at normal contact 481 as already traced. From the ground connections traced both from contacts 411 of first selector U^2 and from contacts 432 of second selector V^2, it will be apparent that the maintaining circuits for the relays SR^8 and SR^9 are maintained during the selective operation by multiple contacts and similar ground connections thereto at other busy switches in the system.

The next step in the operation consists in again repeating the previous operation of the calling mechanism, thereby transmitting the directive impulses corresponding to the tens digit of the called line. This results in grounding strand P^{19} three times, followed by a single grounding of strand S^{19}. The grounding of strand P^{19} three times causes three distinct energizations and de-energizations of primary magnet PM^{10} over a circuit extending from battery bus-bar B', through the winding of said magnet, closed contact 443 of off-normal switch SO^{10}, normal contact 444 of relay R^2 to said strand P^{19} and ground. These energizations of primary magnet PM^{10}, due to the construction of the switch, advance the wipers 445, 446 and 447 to the third group of bank contacts 448, 449 and 450, respectively, and actuate off-normal switch PO^{10}. The actuation of the latter by closing contact 451, extends a circuit from battery bus-bar B', through the winding of relay R^2, normal contact 452, closed contact 451 of said off-normal switch PO^{10} and normal contact 453 of off-normal switch SO^{10}, to the secondary strand S^{19}. Consequently, upon the grounding of said strand, relay R^2 is energized; and upon such energization, closes a locking circuit for itself through alternate contact 452 and closed contact 454 of busy relay BR^2 to ground. The locking circuit is closed prior to the opening of the initial energizing circuit at normal contact 452, the same as in the case of relay R of Fig. 1.

The next and final step in the operation on the part of the calling party is to repeat the preceding operation, thereby again grounding strand P^{19} three times, followed by a grounding of the strand S^{19} once. Each ground of the strand P^{19} completes a circuit from battery bus-bar B', through the winding of secondary magnet SM^{10}, alternate contact 444 of relay R^2 to said strand P^{19}. Magnet SM^{10} is thereby operated to step wipers 445, 446 and 447 to the third set of bank contacts 448, 449 and 450 in the previously selected third group, which are bank contacts of the desired called line. Thus, up to the time that the secondary side of the circuit is about to receive its final impulse, the calling line circuit is extended through to the called line, except at contacts 455 and 456 of closing relay CR^2.

Called line idle.—If it be assumed that the called line is busy, then the multiple contacts 450 will be connected to battery, as previously explained. On the other hand, if said line is idle, said contacts will be connected to ground. Under the given assumptions, then, the final grounding of the strand S^{19} will momentarily energize busy relay BR^2 over a circuit extending from battery bus-bar B', through the right-hand winding of said relay BR^2, closed contact 457 of relay R^2, alternate contact 453 of off-normal switch SO^{10} and strand S^{19} to ground. The resulting energization of relay BR^2 will move contact 458 to its alternate position and open contact 454. By the

opening of the latter, the maintaining circuit of relay R^2 is interrupted and the contacts of said relay return to normal. The movement of contact 458 to its alternate position at this time performs no useful function, since the contact 450 of the called line, under the assumption that the line is idle, is grounded. However, it will be apparent that if it were connected to battery, as is the case when the line is busy, then relay BR^2 would be held up over a circuit extending through the wiper 447, normal contact 459 of relay RR^{10}, alternate contact 458 of relay BR^2, and the left-hand winding of said relay to ground. Under the present assumptions of an idle line, however, this is not the case, but the relay BR^2, upon having its initial energizing circuit broken, immediately restores its contacts to normal and thereby completes a local circuit through the windings of ringing relay RG^2 and cut-off relay CO of the called line. This circuit is the same as heretofore traced but, for convenience, may be outlined as including normal contact 460, closed contact 461, normal contact 458 of relay BR^2, normal contact 459 of release relay RR^{10}, wiper 447, engaged contact 450, conductor 185, normal contact 106 of line relay LR, and the winding of cut-off relay CO. The resulting energization of cut-off relay CO operates, as before, to interrupt the normal line relay and battery connections and to complete the talking circuit through the extension conductors of the called line. The energization of the ringing relay RG^2 completes a circuit for flip-flop relay FF^2 through contact 462 of relay RG^2, contact 463 of relay CR^2 and interrupter 464. Its energization also connects contact 465 of relay CR^2 to ground through contact 466; at the same time, it connects the secondary strand S^{19} to battery bus-bar B′ through impedance coil 467 and closed contact 468, and also connects the primary strand P^{19} to ground via contacts 469—470 of flip-flop relay FF^2, contact 471 of relay RG^2, and the winding of tip relay TR^2. The momentary ground connection, occasioned by the operation of flip-flop relay contacts 469—470, is provided to care for the discharge of the substation condensers of called lines, as previously explained. As before, the operation of the flip-flop relay alternately connects ringing generator g and tip relay TR^2 to the primary, or tip, side of the circuit. As before, upon the response of the called party, by which a conductive bridge is completed between the line limbs at the called station, tip relay TR^2 is energized. As a result of the energization of said relay, closing relay CR^2 is energized over a circuit including tip relay contact 472 and ringing relay contact 466. This circuit is at once replaced by a locking circuit including contacts 465 and 466. The energization of closing relay CR^2 completes the talking circuit at the contacts 455—456 and interrupts the flip-flop relay circuit at contact 463. Thus the calling and called substations are connected and conversation may be carried on. At this time, transmission current is supplied to the calling station from batteries b^4—b^5, and to the called station from battery B, via bus-bar B′ and impedance coil 467 to one side of the circuit; and from the opposite or grounded pole of the battery, through tip relay TR^2, to the other side of the circuit.

Called line busy.—Now, if it be assumed that the called line is busy, then as soon as the final secondary impulse is transmitted and the busy relay BR^2 is momentarily energized as a result thereof, the aforesaid circuit through the left-hand winding of said relay will be closed to battery and said relay thereby energized. The resulting continued energization of relay BR^2 will maintain its contact 473 closed, thereby transmitting a busy signal to the calling party through the agency of condenser 474, induction coil 475 and interrupter 476 in the same manner as heretofore explained.

Release.—As in the case of the other forms of the invention, the release of the various switches, after a complete connection has been established, as a result of the response of the called party, is occasioned by the restoration of the calling and called parties' receivers to their hooks. Under these conditions, the line, first and second selectors are under the control of the calling party, and the connector under the control of the called party. Thus upon the restoration of the calling party's receiver to its hook, the normal circuit through the primary and secondary relays P^3R and S^3R is interrupted and, by the return of their contacts 398 and 477, respectively, a circuit for release relay RR^7 is closed. This circuit may be more fully traced as extending from bus-bar B′, through the winding of said relay, closed contacts 477—398, and closed contact 478 of off-normal switch SO^7 to ground. The resulting energization of release relay RR^7, by closing its contact 479, completes a locking circuit through its winding, which is independent of the contacts of relays P^3R and S^3R and of off-normal switch SO^7. This circuit extends from closed contact 479, through closed contact 480 of off-normal switch PO^7 and normal contact 380 of primary relay PR^7. The energization of release relay RR^7 also closes a circuit for secondary relay SR^7, which may be traced from the battery bus-bar B′, through the winding of said relay, and alternate contact 396 of relay RR^7 to ground. As a result of the energization of relay SR^7, the wipers 381 and 382 of the line selector are disconnected during the releasing movement. Similarly,

the circuit of wiper 383 is left open at contact 396 of relay RR^7. The energization of release relay RR^7 and secondary relay SR^7 completes an energizing circuit for release magnet RM^7, which may be traced from the battery bus-bar B', through the winding of said magnet, alternate contact 394, of release relay RR^7, closed contact 395 of secondary relay SR^7 to ground. Due to the construction of the switch, the energization of the release magnet RM^7 frees the switch wipers and allows them to retrace their motion and return to normal under the tension of their retractile springs. Upon the completion of the return of the secondary movement of the wipers, off-normal switch SO^7 is restored to normal; and upon the complete restoration of the switch wipers, off-normal switch PO^7 is restored to normal. Thus the circuit for release relay RR^7 is interrupted only when the wipers return to normal whereupon the contacts of said relay are restored to normal, with a resulting de-energization of relay SR^7 and the restoration of its contacts to normal. Thus all the parts of the line selector are restored to their normal positions. During the release of the line selector and until the de-energization of release relay RR^7, the wiper 21 of the master-switch O is maintained grounded at contact 480' of relay RR^7, thereby maintaining the busy condition of said selector until it is restored to normal and rendered available for use.

The release circuits of the first selector U^2 and second selector V^2 are similar to those of the line selector illustrated. The energization of release relay RR^7, by moving its contact 481 to its alternate position, closes a circuit for the release of the first selector U^2 and second selector V^2. This circuit extends from battery bus-bar B', through resistance lamp 140, alternate contact 481 of release relay RR^7, to contact 482 and thence, by parallel paths, to ground through release relays RR^8 and RR^9 of said selectors. The path through relay RR^8 extends from contact 482, through contacts 419—420, winding of release relay RR^8 and closed off-normal contact PO^8 to ground. The path through release relay RR^9 extends from contact 482, through contact 419, wiper 408, engaged contact 411, conductor 421, normal contact 422 of relay SR^9, winding of release relay RR^9 and closed contact 423 of off-normal switch PO^9 to ground. A third path, in shunt with the two said relays, extends from point 422' via normal contact 436 of relay SR^9, wiper 429, conductor 439, alternate contact 440 and resistance coil 441 to ground. The said coil is provided for purposes to be later explained. The energization of release relay RR^8 closes a circuit from the battery bus-bar B', through the winding of secondary relay SR^8 alternate contact 418 of release relay RR^8, the winding of said relay, through closed off-normal contact PO^8 to ground. A corresponding circuit for the second selector V^2 extends from the battery bus-bar B', through the winding of secondary relay SR^9, alternate contact 435 of relay RR^9, the winding of said relay, closed contact 423 of off-normal switch PO^9. By the energization of the secondary relays SR^8 and SR^9, the wipers of the first and second selectors U^2 and V^2, respectively, are disconnected during the releasing operation. By the energization of release relay RR^8, a circuit is completed from battery bus-bar B', through release magnet RM^8, alternate contact 417 of relay RR^8, closed contact 416 of relay SR^8, and a corresponding circuit for the release magnet RM^9 extends from battery bus-bar B', through the winding of said magnet, alternate contact 433 of relay RR^9, closed contact 434 of relay SR^9, to ground. The energization of the release magnets RM^8 and RM^9, as in the case of the line selector Q^2, causes the wipers of their respective switches to return to normal under the retractile force of their return springs. In like manner, the secondary and primary off-normal switches are restored to normal. Since the release relays are maintained energized by a circuit extending through the primary off-normal switches, it will be clear that a positive and complete releasing operation will be obtained in each case. During the restoration of the second selector to normal (as well as at all other times when the secondary relay SR^9 is energized) said selector (and consequently the link-circuit P^{18}, S^{18}) is rendered "busy" by the presence of ground on conductor 421 via alternate contact 422 of said relay SR^9. Also the connector W^2, not yet released, is rendered busy by ground on conductor 439 via alternate contact 440 of tip relay TR^2 and resistance coil 441. Thus it is seen that after the completion of the conversational circuit, the restoration of the calling party's receiver to its hook releases the line, first and second selectors.

Considering, now, the restoration of the called party's receiver to its hook, it will be observed that as soon as this is done, the circuit for the flow of battery current through the tip relay TR^2 is interrupted at the switch-hook of the called party. The restoration of the tip relay contacts, as in the case of the connectors of Figs. 1 and 2, immediately completes a circuit for the release relay RR^{10}, which may be traced from the battery bus-bar B', through the right-hand winding of release relay RR^{10}, closed contact 483 of closing relay CR^2, closed contact 484 of tip relay TR^2, and closed contact 442 of off-normal switch PO^{10} to ground. The closing of this circuit energizes the release relay RR^{10}, and the latter, by closing its

contact 485, completes a locking circuit for itself through the same grounded off-normal contact. The closing of grounded contact 486 of relay RR^{10} completes an energizing circuit through release magnet RM^{10}. The latter, as in the case of the line, first and second selectors, Q^2, U^2 and V^2, frees the switch wipers for restoration to normal under the actuation of their return springs. As before, also, the off-normal switches PO^{10} and SO^{10} are restored to normal at the same time. The energization of release relay RR^{10}, by opening contact 459, interrupts the local circuit including relays RG^2 and CO and thereby causes the de-energization of said relays and the consequent de-energization of closing relay CR^2, and the restoration of all the connector circuit parts and line circuit parts to normal. During the restoration of said connector, the wipers 445 and 446 are maintained open at contacts 455, 456, respectively of relay CR^2 and wiper 447 is maintained open at normal contact 459 of relay RR^{10}. Also the connector is held busy during restoration by ground on conductor 439 via normal contact 440 of tip relay TR^2, left-hand winding of relay RR^{10} and primary off-normal contact 442.

It now remains to consider the effect of the calling party's restoring his receiver to its hook at various times prior to the completion of a conversational circuit. Thus he may, after initiating a call, immediately restore the receiver to its hook. In such event, the line relay LR will be drawn up to close a circuit for relay 24 of the master-switch O, and the master-switch will be in turn operated to complete a starting circuit for the connected line selector Q^2. The latter will thus be started in search of a calling line. If the receiver, however, is immediately restored, the grounding of group relay GR may be discontinued before the private wiper 384 engages the bank contact 388 corresponding to the group relay of the calling line. In such event, the wipers of the line selector will not be stopped when they have reached the group of bank contacts in which those of the calling line are located, but will be stepped in a primary direction beyond the last group of connected bank contacts. This will leave the wiper 384 on open circuit and will thus cause a de-energization of relay PR^7. This will result, as before explained, in energizing secondary relay SR^7, which, by momentarily closing the energizing circuit of secondary magnet SM^7, will advance the wipers 381, 382 and 383 one step in a secondary direction. This single step will leave the wiper 383 on open circuit; and since this first step also causes the actuation of secondary off-normal switch SO^7, the secondary relay SR^7 will be de-energized and the further advance of the switch wipers discontinued. This will result in leaving the talking wipers 381 and 382 on open circuit and consequently, as soon as bridge 126 is broken by the return of the secondary relay contacts, there will be no energizing circuit for the primary and secondary relays P^3R and S^3R which control the circuit of release relay RR^7, as previously explained. Consequently, this release circuit will be closed and the regular releasing operation, previously explained, will ensue. Similarly, in case the calling subscriber should replace his receiver after the primary wiper 380 had selected the subgroup but prior to the selection of his line by the wiper 383, then the secondary movement would continue until said wiper 383 reached the last (or unconnected) point 388′, whereupon the secondary relay SR^7 would be released thus again leaving relays P^3R and S^3R on open circuit, to secure the release of the switch as above described.

In case the calling line circuit has been extended to the first selector U^2, or the second selector V^2, the releasing operation of these selectors and the line selector will be the same as that heretofore described.

If, however, the calling line circuit has been extended to a busy called line, then the release of the connector also is under the control of the calling party; and in such event, battery current is supplied, during the release of the first and second selectors, to point 422′ at selector V^2, as previously traced. From this point, then, current for the release of the connector will flow through normal contact 436 of relay SR^9, wiper 429, engaged contact 432, conductor 439, normal contact 440 of tip relay TR^2, the left-hand winding of release relay RR^{10}, and closed contact 442 of off-normal switch PO^{10} to ground. The closing of this circuit, with the consequent energization of release relay RR^{10}, results in closing a locking circuit for its right-hand winding via its contact 485 and closed contact 442, as previously traced. The releasing operation, resulting from the energization of this release relay, is the same as heretofore described. Similarly, in case the called subscriber does not answer, the connector will also be released by the hanging up of the calling subscriber, the releasing circuit being the same as above described for a "busy" subscriber.

This diagram also shows a plurality of ringing generators g, g', g^2 and g^3, for use in the same manner as those of the previously described connectors.

Connections between switches.

In order to explain fully and clearly the arrangement of connections between switches, heretofore referred to, by which it is possible for any subscriber to obtain connection with any second selector in the exchange, and in order to make clear the general ar-

rangement of connections of a complete automatic telephone exchange system without extending the diagram of such a system beyond the reasonable bounds of a patent drawing, I have employed a diagram, shown in Fig. 4, of a complete telephone exchange system having a limited number of lines instead of employing a diagram of a small portion of an automatic telephone exchange system having a large number of lines. It has been fairly easy to accomplish this by reason of the fact that the system of the type to which the invention relates is preferably a decimal system; that is, a system based on the number 10 as a unit. Consequently, by employing some smaller number as a unit it is possible to greatly reduce the size of a diagram, while still retaining the same principles of interconnection and interrelation. In preparing the diagram of Fig. 4, I have used the number 3 instead of the number 10 and in this way a system having eighty-one subscribers' lines, twenty-seven line selectors, twenty-seven first selectors, twenty-seven second selectors, and twenty-seven connectors has been developed as representative of a system employing ten thousand lines, one thousand line selectors, one thousand first selectors, one thousand second selectors and one thousand connectors. In the diagram also, switches having three rows of three contacts each are employed instead of switches having ten rows of ten contacts each. Thus the numbers 1, 3, 9, 27 and 81 of the diagram correspond respectively to the numbers 1, 10, 100, 1,000 and 10,000 of a ten thousand line exchange. In the latter system, the number of the subscribers' lines are made up by combining, in combinations of four, all the ten characters of the arithmetical notation, giving numbers from 0001 to 9999 (although not in this order) and in the system of the diagram, the numbers of the subscribers' lines are similarly made up by combining (likewise in combinations of four), three digits, viz: 1, 2 and 3, thus giving the eighty-one numbers, set out at the right of the diagram.

With this preliminary explanation of the relation of the diagram to a ten thousand line exchange, the diagram may be considered more in detail. The line selectors, first selectors, second selectors and connectors are shown in rows and are respectively designated Q, U, V and W in accordance with the designations of the corresponding switches of Fig. 1. This same diagram applies equally well to the systems of Figs. 2 and 3, but in such event it will be understood that the letters Q, U, V and W take the place of the same letters with their exponents as employed in said Figs. 2 and 3. The eighty-one (corresponding to ten thousand) subscribers' lines are divided into nine (corresponding to one hundred) groups of nine (corresponding to one hundred) lines each, as indicated at the left of the diagram where they are connected to the line selectors Q, and, as indicated, at the right of the diagram where they are connected to the connectors W. The grouping of the lines for the latter connection should be such as to include the lines whose numbers are those given adjacent to each group. The grouping for the former connections need not be in accordance with a definite numbering of the lines. This is true for the reason that the connections with called lines are brought about by the operation of connectors in exact accordance with directive impulses transmitted from the calling station, while the connections with calling lines are dependent upon the changed condition of the line selector contacts corresponding to said lines and not upon definite directive impulses. Obviously then any calling subscriber's line may be connected to the bank contacts of any group of three (corresponding to ten) line selectors Q. From the numbering of the subscribers' lines at the right of Fig. 4, it will be seen that three (corresponding to ten) of the nine (corresponding to one hundred) line groups, which may be termed "minor" groups, constitute one major group of twenty-seven (corresponding to one thousand) lines and that there are three (corresponding to ten) such groups. In a ten thousand line exchange, these groups may be referred to as a given hundred in a given thousand, as the sixth hundred of the first thousand, the third hundred in the tenth or "0th" thousand, etc. For convenience, the twenty-seven (corresponding to one thousand) switches of each class may be similarly divided into three (corresponding to ten) major groups of nine (corresponding to one hundred) switches each, and each of these major groups may again be divided into three (corresponding to ten) minor groups of three (corresponding to ten) switches each. Thus a minor group of connectors (W) corresponds to and is capable of connecting to the lines of a minor line group.

Referring now to the connections between the line selectors Q and first selectors U, it will be observed that each line selector is paired with a first selector. An inspection will also show that connections extend from each minor group of line selectors to one first selector in each major group of first selectors. Thus, in the specific instance of the first three line selectors Q, which constitute the first minor group of the first major group of line selectors, a conductor m unites the wipers of the first line selector Q in that group to the first first selector U in the first major group of first selectors, a conductor n unites the second line selector in that same group to the first first selector in the second major group of first selectors, and

a conductor *o* unites the third line selector in the same group to the first first selector in the third major group of first selectors. It will also be observed that the connections are between minor groups of the same order. In other words, the first minor group of any major group of line selectors has its switches connected to the switches of first minor groups of different major groups of first selectors, the second major group to the second and so on. Thus the conductors *m*, *n*, *o*, run from the line selectors of the first minor group of the first major group of line selectors, to first selectors U of the first minor group of the first, second, and third major groups of first selectors, respectively. As to the connections between the first selectors U and the second selectors V, it will be observed that connections are made between the major groups of the same order, and that each second selector is multiply connected to bank contacts of all first selectors of the corresponding major group of first selectors. Thus each second selector V has its wiper multiply connected to nine (corresponding to one hundred) first selector bank contacts. Moreover, it will be observed that the first minor group of second selectors has its switches connected to the first row bank contacts of the associated major group of first selectors, the second to the second, and so on; and that the order of connection among the contacts of each row is changed upon passing from one minor group to another. Thus in the diagram, the first second selector V, which is the first switch of the first minor group of the first major group of second selectors, is connected to the first bank contacts of the first minor group of first selectors, to the second contacts of the second minor group, and to the third contacts of the third minor group. Thus the order of rotation for the first second selector V is 1—2—3. The corresponding order for the next second selector is 2—3—1 and for the third second selector 3—1—2. This will all be apparent from an inspection of the drawing. The same order of rotation of 1—2—3, 2—3—1 and 3—1—2, exists in the connection of the second selectors of the second minor group to the second row contacts of the first selectors, and of the second selectors of the third minor group to the third row contacts of the first selector contacts. Thus are the first and second selectors of the first major groups connected. The first and second selectors of each of the remaining major groups are similarly connected. By this method of rotation among the contacts of each row, the work of the second selectors is more evenly divided than if such method were not employed. This is true whether the master-switches O do, or do not, return to normal upon the selection of the calling line. This will be clear after an inspection of the diagram, from which it will be seen that, starting with any given row of first selector bank contacts, any of the switches of the first minor group of said first selectors, will attempt connection with the second selectors of the first minor group in the order 1—2—3, while in the case of the second minor group of first selectors, the order will be 2—3—1 and in the case of the third minor group, 3—1—2. This is true for each of the other minor groups of second selectors.

In case the master-switches O do restore to normal upon the selection of a calling line (instead of advancing to the next idle line selector as is the case in the embodiments of my invention shown in Figs. 1, 2 and 3), then, the rotation, above described between the bank contacts of the first selectors and the wipers of the second selectors, becomes very important in securing an approximately uniform use of the second selectors. Moreover, even if the said master-switches O, do not restore to normal upon the selection of the calling line (as is the case in the embodiments of my invention illustrated in Figs. 1, 2 and 3), then, also, the rotation of connections between the bank contacts of the first selectors and the wipers of the second selectors, still has a value in securing a more uniform use of the various second selectors, as above pointed out. I do not, however, desire to be limited to the particular rotation of contacts illustrated in Fig. 4, because it is apparent that numerous other rotations of contact connections may be made and yet secure the advantages of the particular rotation illustrated in the said Fig. 4; all such rotations being equivalents with respect to securing, as nearly as possible, uniform use of the switches.

Referring now to the connections between the second selectors V and the connectors W, it will be observed that the connectors of each major group are connected to the bank contacts of second selectors of a minor group of each major group of second selectors, the minor groups corresponding in order to the order of the connector major groups. Thus, connectors of the first major group are connected to second selectors of the first minor groups, connectors of the second major group to second selectors of the second minor groups, and so on. In this interconnection there is preferably no rotation but the order of connection is regular, as illustrated.

From the above it will be apparent that any calling line may obtain access through its line selectors Q to any major group of first selectors U and thence to any second selector V and connector W. Thus a maximum number of chances for completing a desired connection is obtained.

From a consideration of the relation of the connectors and the trunks connecting therewith, made plain by the diagram of Fig. 4, it will be apparent that the number of connectors W allotted to a given group of one hundred called lines may be made greater or less than ten depending upon the service requirements. For example, the lines of a certain group of one hundred lines may be so frequently called for as to require provisions for establishing fifteen simultaneous connections thereto. Fifteen connectors W would therefore be provided. Five of said connectors (say the first five) would then be preferably connected to one hundred second selectors V just as hitherto described, the second five would be connected to the remaining five points on each alternate one of the same second selectors while the last five would be connected to the remaining five points of the remaining fifty of said second selectors, thereby providing access to one-third of said fifteen connectors W from one hundred second selectors and providing access to the remaining two-thirds from fifty each of said one hundred second selectors. It is apparent that if more than ten connectors be required there are innumerable orders in which they may be connected to the corresponding second selector bank contacts, but the one example given above is sufficient to illustrate fully the principle employed.

In the case of party lines upon which a plurality of selectively signalled subscribers' stations may be located as illustrated in Figs. 1, 2 and 3, the connectors may be arranged also in a variety of ways. As an example, I will assume that the one hundred lines connected to the first minor groups of the first major group of connectors be reserved for four party selectively signalled subscribers' stations. Then the connectors forming the second, third and fourth minor groups of the same major group, I would reserve for and connect to the same one hundred lines. Thus, referring to Figure 4, the one hundred (represented by nine) lines connected to the first minor group of connectors W would be the same lines as those connected to the second, third and fourth minor group connectors of the same major group. This will be clear when it is stated that the four subscribers upon a given line would have numbers differing only in the hundreds place. Thus, subscribers 1111, 1211, 1311 and 1411 would be on the same line; also subscribers 1100, 1200, 1300 and 1400 would all be on a second line, etc. At the left hand portion of Fig. 1, part 1, the four minor groups of connectors are indicated respectively at W, W′, W^2 and W^3 and it will be understood that the generators g, g', g^2, g^3 (Fig. 1, part 4) of different frequencies are respectively connected into circuit with the said connectors W, W′, W^2 and W^3, so as to signal selectively and respectively the subscribers' stations M′, M^2, M^3 and M^4 which may be considered to be numbered 1111, 1211, 1311 and 1411, respectively. Should now the entire number (ten) of connectors be retained in each of these four minor groups of connectors, it is apparent that there would be provided a total of forty connectors for this particular group of one hundred lines. Unless a very large number of calls were to be expected for the subscribers on this group of one hundred lines, fewer connectors in each or any of these four minor groups could be employed, say, seven. In such event, the last three line bank contacts on each second selector V, corresponding to the omitted connectors, would not be used. It is, of course, obvious that individual lines may, if desired, be included in the same minor group or groups reserved for party lines but that in so doing the bell of each such subscriber must be capable of responding to the particular frequency given by the ringing generator connected to the particular group of connectors capable of connecting with the line. It is also obvious that as many groups of lines as desired may be reserved for party line work.

Referring now to the number of line selectors and first selectors provided for any group of calling lines, it is apparent that should a certain group of one hundred calling lines initiate more than the average number of calls, and more than could be properly handled by ten line selectors Q and their associated ten first selectors U, then certain of the busiest lines would be transposed by means of the distributing apparatus DB, and other less busy calling lines substituted, whereby, as previously described, the number of calls initiated could be maintained fairly constant in all groups. Should, however, more than ten line selectors be required for a group of calling lines, then additional ones may be added (as well as the corresponding number of line selectors) without increasing the number of second selectors V. As an example, I will assume that a certain minor group of one hundred calling lines requires fifteen line selectors Q (and fifteen first selectors U) to provide for fifteen co-existing calls. The ten already present first selectors U for said group of one hundred lines are distributed among the ten major groups of said first selectors, one in each group. The added five first selectors may be placed respectively in each alternate major group and preferably in the same minor groups containing the already present first selectors. The bank contacts of each added first selector would then preferably be wired to the correspond-

ingly numbered bank contacts of the already present first selector in the same minor group, whereby double access could be had to the second selectors V in each alternate major group. It is obvious that other distributions could be as readily employed. In all cases the added line selectors Q would have their bank contacts multiply connected to the calling lines in the same manner as the already present line selectors Q.

Although in my general discussion I have assumed that a sufficient number of second selectors and a sufficient number of connectors would always be provided to furnish facilities for the maximum uses of such switches, yet it is obvious that should all trunks be found busy at the time when either a first selector or a second selector might be searching for an idle trunk, then the secondary wipers of the seeking switch would, in the system of Fig. 1, rotate to the next normal position, and the said switch, upon the restoration of the receiver to its hook switch by the calling subscriber, would be restored just as hitherto described. Similarly, in the case of Fig. 2, preferably assuming (especially in case a circular switch be employed) that the last line contact points of a series be left dead, as hitherto explained, the release would also be effected should all trunks be found busy. Similarly, in the case of Fig. 3, where two motion switches are employed, should all trunks be found busy, then, as hitherto described, the restoration would be effected upon the hanging up of the calling subscriber. In fact, whatever style of switches be employed, it is obvious that even if all trunks be found busy, my invention provides means for restoring all switches to normal upon the calling subscriber replacing his receiver.

Switch construction.

Obviously in the practice of the various forms of the invention heretofore described, many different switch constructions may be employed to perform the switching operations therein indicated. As previously noted, the circuits of Fig. 1 are devised for use with switches of the first class which, it will be remembered, are of the rotary type having a step-by-step release; likewise, the circuits of Fig. 2 are devised for use with switches of the second class which are rectilinear, arcuate or circular in form and provided with a spring, or equivalent, release; and the circuits of Fig. 3 are devised for use with switches of the third class, having primary and secondary movements and provided with a spring, or equivalent, release.

Switches of the first class.—A preferred switch construction for this class of switches is illustrated in its mechanical form in Figs. 5 and 6 and the diagrams of Figs. 8 to 11, inclusive, disclose the arrangement of its bank contacts. This construction is applicable to the several selectors Q, U, V and the connector W but, for convenience in describing, the illustration may be deemed to be that of a line selector Q. The switch consists essentially of primary and secondary wipers mounted on concentric shafts, independent mechanism for operating said wipers, and co-operating primary and secondary bank contacts arranged in an annular bank, concentric with said shafts. The frame, which supports these parts, comprises a circular top plate 487 and a similar bottom plate 488. The contact bank is composed of sets of individual and strip contacts, of the character illustrated in Figs. 8 to 11, inclusive, arranged with intervening insulation 489. The various parts forming the contact bank are preferably held in place by screws 490 which extend through the top plate 487 and the insulation 489 into threaded engagement with the bottom plate 488 The primary shaft 115 is journaled at one end in the center of the base plate 488 and at its opposite end in a bridge 491 forming part of the top plate 487 and provided with oppositely extending stops 492—493 which project respectively into the planes of the primary and secondary ratchet wheels 114—114′ so as to co-operate with the primary and secondary driving pawls 113—113′ respectively. These pawls are spring pressed against their respective ratchet wheels and are carried upon similarly shaped armatures 112—112′ of the primary and secondary magnets PM and SM respectively. The armatures 112—112′ are normally held in retracted position by springs 494—494′ respectively. The return movement of the armature 112 is limited by stop 495 while its advance movement is limited by the engagement of pawl 113 with the stop 492. A like construction is provided for armature 112′ of the secondary magnet SM. In each instance, the stroke of either armature is such as to advance the corresponding ratchet wheel one tooth upon each energization of the magnet. The advance of the ratchet wheel is limited at the end of each stroke by the pawl locking its engaged tooth by reason of the inclination given to the stop. Thus it will be seen that upon the operation of primary magnet PM, ratchet wheel 114 and shaft 115 will be actuated, and upon a like operation of secondary magnet SM, ratchet wheel 114′ and shaft 115′ will be actuated. The shaft 115 is provided with a hub 496 which is rigidly secured to it and which carries a set of wipers whose outer ends co-act with two rows of bank contacts. These wipers and bank contacts constitute the primary portion of the switch. As shown in Fig. 8, there are preferably ten primary wipers, each normally bridging a

pair of independently insulated bank contacts. Four of the wipers designated 26, 27, 28, 29, correspond to the similarly designated primary wipers of the diagram, and, as there shown, co-operate with bank contacts 30, 31, 32, and 33 respectively. In the diagram, conductors are shown permanently connected to these wipers, but the preferred construction is that shown in Fig. 6 and diagrammatically illustrated in Fig. 8, wherein the conductors are connected to plates such as 26′, 27′, 28′, and 29′ instead of to the wipers 26, 27, 28, 29, and the electrical connections between these plates and the associated bank contacts are accomplished by the bridging action of the associated wiper. As indicated in the diagram, the wipers 28 and 29 in passing over the bank contacts 32—33 bridge the space between adjacent contacts. In the diagram this is indicated by a wiper having a broadened end, while in the actual switch construction it is accomplished by providing bank contacts of a greater width than those where this bridging action is not required. Obviously, the method of the diagram might equally be employed in the switch construction. The remaining wipers of this primary group are used together with the associated bank contacts as primary off-normal switches. It will be seen that this can readily be done since normally any given wiper bridged a pair of contacts, and when moved from normal, breaks said connection at once and bridges a second set of contacts. Thus, as indicated, in Fig. 8, upon the first movement of the primary wipers, wiper 497 moves out of engagement with its normally engaged bank contacts and into engagement with contact strip 120 and its mate. This action corresponds exactly to the operation of normally closed contact 108 and normally open contact 120 described while considering Fig. 1. Similarly, wipers 498 and 113^{10}, when moved from normal, bridge respectively contact 216 and its mate, and contact 113^{3} and its mate. The remaining wipers shown in the diagram are not employed in the case of the line selector Q, but it will be apparent that they may be employed wherever a large number of primary off-normal contacts are necessary, as in a connector. In such event, connections will be made with the different sets of associated bank contacts, as required by the operation of the system.

The secondary shaft 115′, as previously noted, carries the secondary ratchet wheel 114′ and said wheel in turn carries the several sets (in the present instance, four) of secondary wipers which co-operate with the rows of secondary contacts forming part of the contact bank. The secondary wipers are insulated from the ratchet wheel 114′ by switch insulation 499. The secondary bank contacts include two sets of rows arranged like the segment illustrated in Fig. 9, one set of rows arranged like the segment of Fig. 10, and one set of rows arranged like the segment of Fig. 11. The arrangement of Fig. 9 is that of the line contacts; the arrangement of Fig. 10 that of the private or local contacts; and the arrangement of Fig. 11 that of off-normal contacts. As in the case of the primary portion of the switch, the wipers bridge the contacts of adjacent rows. Thus, as shown in Fig. 9, the line wiper, say wiper 34, normally bridges independently insulated open contacts and when moved from normal connects line contact, say contact 37, with the conducting strip 34′ to which permanent electrical connection is made instead of to the wiper as illustrated in Fig. 1. Similarly, private wiper 36, normally resting upon independently insulated contacts, co-operates with individual contacts 39 and contact strip 36′. In like manner, also, the wipers of Fig. 11 co-operate with the secondary off-normal contacts 119, 140^{a}, 131, 217, 218. Upon inspection of Fig. 11, it will be seen that upon the first step of the wipers, contact 119 will be broken while contacts 140^{a}, 131, 217, and 218 will be closed as required by the operation of the system of Fig. 1, previously explained.

As shown, the primary portion of the switch includes two line wipers, two private or local wipers, and six off-normal switch wipers, each with its associated segment of bank contacts; and the secondary porton includes ten primary line wipers, ten secondary line wipers, ten private or local wipers, and ten off-normal switch wipers. Thus there is a secondary wiper 34 corresponding to each of the primary bank contacts 30, a like wiper corresponding to each primary contact 31, a wiper 36 corresponding to each primary contact 32 and a sufficient number of off-normal contacts to care for all the required off-normal contacts, in fact, exceed in number those required.

In operation, it will be apparent that the primary wipers are stepped over their associated bank contacts until those bank contacts corresponding to the secondary wipers having access to the contacts of the calling line are encountered. This, as explained heretofore, is occasioned by the operation of the primary magnet PM. As soon as the proper secondary wiper is selected, the operation of the secondary magnet SM steps all the secondary wipers over their bank contacts until the contacts corresponding to the calling line are encountered whereupon further movement is prevented. At the time of release, as previously explained, the primary and secondary wipers are both independently advanced by the repeated energizations and de-energizations of their actuating magnets PM and SM until the wipers

reach the position indicated in Figs. 8, 9, 10 and 11. When this position is reached, a further advance of the wipers is discontinued and the wipers are left in condition for a new operation. It will be noted that with this construction, the wipers are advanced upon each operation through one-tenth of a complete rotation. Obviously the number of wipers and the corresponding segments might be varied according to the requirements of any given case or at the will of the constructor.

Obviously, in using the switch just described as a first selector, a second selector, or a connector, there would be no occasion to connect up the second set of private or local contacts and the off-normal contacts; both primary and secondary, would be connected up as indicated in the diagram.

Switches of the second class.—In switches of the second class, the spring release presents a considerable variation in the arrangement of the bank contacts from the circular arrangement of the switches of the first class. However, I have chosen to illustrate, largely for the sake of brevity, a switch of the second class having substantially the same structural arrangement as the switch shown in Figs. 5 and 6. In this instance, the primary and secondary magnets are designated PM^4 and SM^4 to correspond to the designation of the corresponding parts of line selector Q′ of Fig. 2. In this instance, ratchet wheels 114—114′ need be provided only with a sufficient number of teeth to step the wipers over their associated bank contacts, which, in the present case, are distributed over one-tenth of the circumference of the switch. In this instance too, they must be provided with additional teeth for the engagement of the retaining pawls 499′—499^2 which are pivotally secured to the bridge 491 of the top plate 487 and are yieldingly held in engaging position by spiral springs 500—501 acting between the pawls and a fixed portion of the switch frame. The armature 501′ of the release magnet RM^4 which is yieldingly held in retracted position, projects so as to engage the tails of the pawls 499′—499^2 when said armature is attracted, then, as previously described, upon the energization of release magnet RM^4, the retaining pawls are withdrawn from engaging position and the ratchet wheels 114—114′ together with the attached wipers are instantly returned to normal through the agency of spiral retractile springs 502—503 actuating between said ratchet wheels and a fixed point, such as the bridge 491 of the switch frame. Obviously, the retractile springs might be otherwise located.

From the previous description of the operation of the first and second selectors and connector of Fig. 2, it will be apparent that this same switch construction may be employed for each of the switches in the same manner that the switch construction of Figs. 5 and 6 may be employed for the corresponding switches of Fig. 1.

Meter mechanism construction.—In Figs. 12 and 13, I have illustrated a switch of the first class such as is shown in Figs. 5 and 6, provided with an arrangement of type wheels and co-operating mechanism for carrying out the functions of the mechanism X of Fig. 1. In this instance, the primary and secondary ratchet wheels 114—114′ are separated somewhat more than in Figs. 5 and 6, and gear wheels 504 and 505 are interposed in the space thus provided; gear wheel 504 being secured to ratchet wheel 114, and gear-wheel 505 to ratchet wheel 114′. The gear-wheels 504 and 505 mesh respectively with gear-wheels 506 and 507 carried by concentric shafts 509 and 508 respectively. The latter are suitably journaled in the top plate 487 of the switch frame and carry at their upper ends type wheels 511 and 510 respectively. Wheel 510, thus, is moved in accordance with the movement of secondary ratchet wheel 114′ and wheel 511 is moved in accordance with the movement of the primary ratchet wheel 114. A strip 512, of paper, or other suitable material, for recording impressions obtained from type wheels 510—511, is arranged to be wound from spool 513, suitably journaled on the switch frame, over guiding rollers 514 and 515 to a spool 516 also journaled on the switch frame. The guiding rollers 514—515 are journaled upon suitable projections of the top plate 487 of the switch, and are located so as to bring the recording strip 512 into close proximity to the type wheels 510—511. At the point of nearest approach of the recording strip to the type wheels and located on the opposite side of the strip from said wheels, is a yieldingly supporting hammer 144 which is adapted to be thrown against the adjacent portion of the strip 512 to press it into engagement with the types on the wheels 510—511 which, at the time of operation, are directly opposite the engaging portion of the hammer. The hammer is actuated by the printing magnet 145 through the agency of its armature 517 and by reason of its spring support, it only makes a momentary engagement even though the armature be held attracted. In order to move the recording strip 512 so as to bring a fresh portion of the strip opposite the hammer 144 after each operation, the armature 517 is provided with a driving pawl 518 which is normally held by gravity, or its equivalent, in engagement with a ratchet wheel 519 secured to the spool 516. With this arrangement, the retraction of the armature 517 rotates the spool 516 far enough to move the

strip 512 the required distance. Any suitable inking device for applying ink on the type wheels 510—511 may be employed. From this description and what has preceded, it will be apparent that upon each selecting operation of a line selector, definite types will be brought opposite the hammer 144 and a definite impression will be made upon the recording strip. It will be at once apparent that the impressions thus made may be, if desired, the numbers of the calling lines, or at least, numbers by which the calling lines may be identified. In this way, an exact record is kept on the recording strip 512 of all completed connections which have been made, except in cases where such record is not desired.

Switches of the third class.—Figs. 14 to 18, inclusive, illustrate a switch of the third class, which may be assumed to be a line selector Q^2 of Fig. 3. A suitable frame 520 supports the switch mechanism, which includes primary magnet PM^7, secondary magnet SM^7 and release magnet RM^7, in association with wipers 381—382—383, co-operating with bank contacts 385—386—387, which are arranged in a bank 521 with their free ends adapted for the attachment of suitable conductors 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 contact sets each. In the present instance, ten rows of ten sets of contacts each are illustrated. The set of wipers 381—382—383, are pivoted at the center of rotation of the spherical surface formed by the inner ends of the bank contacts. The pivotal support for the wipers is provided with a pivot 522 located near the lower end of rotary shaft 523, carried by the frame 520. These wipers are rotatable with the shaft 523 in a horizontal or primary direction, and, in addition, may be rotated vertically about their pivot 522 through the agency of an additional longitudinally movable shaft 524 having a broad strip 525 at its lower end which engages a transverse slot in disk 526 which, in turn, is rotatable in a bearing formed at the rear end of the member 527 which carries the wipers. Thus, by rotating the shaft 523, the wipers may be given their primary movement to the desired group, or row, of bank contacts, and by subsequently giving the shaft 524 a longitudinal movement, the wipers may move to the desired bank contacts in the selected group. The strip 525 on the shaft 524 is sufficiently broad to engage the slot in the disk 526, no matter what the position of the wipers may be. In addition to the wipers and bank contacts thus provided, the fixed contacts 388 are arranged in a row below the fixed contacts 385—386—387 in the arc of a circle and in a position to have their inner ends engaged by the wiper 384 carried by, and insulated from the shaft 523. As will be apparent, the wiper 384 is capable of a horizontal, or primary, movement only and therefore does not partake of the secondary movement of the wipers 381—382—383. The mechanism associated with the primary magnet PM^7 by which the shaft 523 is given its primary or rotary movement, comprises an actuating pawl 528, carried by the armature 529, adapted to engage the teeth of a ratchet wheel 530 rigidly secured to the shaft 523 and adapted to step it around upon the successive energizations and de-energizations of the primary magnet PM^7. The forward movement of the pawl 528 is limited by the bevelled stop 531, secured to a portion of the frame 520. Return movement of the pawl is limited by an adjustable stop 532, also carried by the frame 520 and adapted to engage the pawl 528 so as to throw its engaging end outward away from the teeth of the ratchet wheel 530. A spring 533, carried by the armature 529, bears against a portion of the pawl 528 and tends to force it into its engaging position. The armature 529 is normally held in its retracted position by means of a leaf spring 534, carried by the magnet frame. The shaft 523 is retained in its various positions by a retaining pawl 535, pivoted upon the frame 520 and normally pressed into engaging position by a spring 536. The pawl 535 is provided with a tail 537 which is adapted to be engaged by the armature 538 of the release magnet RM^7, 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 523 is surrounded by a coiled retractile spring 539 which is placed under increased tension by the movement of the wipers from normal and co-acts between the frame 520 and the shaft to return said shaft and wipers to normal when they are freed. The upper end of the shaft is also provided with two lateral projections 540 and 541. The former of these normally rests against the fixed stop 542, while the latter carries an upwardly projecting pin 543. The pin 543 co-operates with contacts of the primary off-normal switch PO^7 and when in a normal position, holds its contacts against their inherent tension, in the position illustrated, but as soon as moved from normal, the contacts freely move under their own spring action to their alternate positions.

The secondary magnet SM^7 through the agency of its armature 544, actuating pawl 545 and ratchet teeth 546 on the shaft 524, steps the latter downwardly to carry the contact ends of the wipers to their various engaging positions. The downward

movement of the pawl 545 is limited by a bevelled stop 547, carried by the magnet frame, while a similar square stop 548 moves the pawl out of engaging position as soon as the former returns to normal. The pawl is moved into its engaging position by a leaf spring 549, carried by the armature 544; and a similar spring 550 carried by the magnet frame, moves the armature to its retracted position. A suitable retaining pawl 551 engages teeth 552 upon the shaft 524 to hold it in its different operating positions. The shaft 524 is also provided with a suitable spline 553 which, after the first movement of the shaft, engages the teeth of the ratchet wheel 530 to lock the shaft 523 against rotation. The retaining pawl 551 is pivotally secured to a bracket 554, carried by the upper portion of the switch frame 520, and is normally pressed into engaging position by a suitable spring 555, coiled about its pivot. The free end of the retaining pawl 551 is connected by a link 556 to the free end of the primary retaining pawl 551. A pin and slot connection between the link 556 and pawl 551, enables the latter to move freely as the shaft 524 is moved downward but causes it to be moved out of engaging position whenever the release magnet is energized. The secondary shaft 524 is restored to normal through the agency of a coiled tension spring 557, secured at one end to a portion of the frame 520 and at the other end to one end of a lever 558 which is pivoted at an intermediate point to a projection 559 extending outward from the upper portion of the frame 520. The end of the lever 558 opposite to that to which the spring 557 is attached is connected by a pin and slot connection with the shaft 524. Thus, it will be seen that upon each energization of the release magnet RM^7, the retaining pawls 535 and 551 are moved out of engaging position and the shafts 523 and 524 are returned to their normal positions. Since the shaft 523 has its ratchet wheel 530 engaged with the spline 553, it cannot begin its return movement until shaft 524 has moved the wipers beyond the first set of bank contacts, the spline 553 being so positioned with reference to the ratchet wheel 530 and being of such a length as to bring about this result. The contacts of the secondary off-normal switches SO^7 are normally held against their spring tension in the position illustrated in part 1, of Fig. 3 through the agency of a projection 560, carried at the upper end of the shaft 524.

In the case of the first and second selectors U^2 and V^2, a switch of the same construction as the line selector may be employed, but in each instance there would be no functions for the wiper 384 and its associated bank contacts 388 and therefore, this would ordinarily be omitted and in each instance, the proper arrangement of primary and secondary off-normal switch contacts would supplant those provided for the line selector. In each instance, the off-normal switch arrangements of the corresponding portion of the diagram of Fig. 3 would be followed. In the case of the connector, the same switch construction may also be employed. In such case, the wiper 384 and its contacts 388 would also be omitted. The primary and secondary off-normal switch contacts would also be replaced by a number corresponding to the contacts of the corresponding parts in the diagram of Fig. 3.

From the above description, it will be seen that the switches of each class are comparatively simple in construction, requiring only primary, secondary and release magnets together with simple mechanical parts.

Master-switch construction.—The master-switch O of the several diagrams which controls the operation of the various line selectors, may also be constructed in various forms, but I preferably employ a construction of the character illustrated in Figs. 19 and 20. As therein indicated, the fixed contacts 22—23 are located in a bank 561, preferably arcuate in form, and have their inner ends arranged concentrically to the shaft 139 which carries the wipers 20—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, the motor magnet MM, but does not necessarily include the control relays 24—25. The latter may be mounted at any desired point. The wipers are suitably insulated from each other and their supporting shaft 139 which is journaled in the frame 562 which also supports the contact bank 561. The shaft 139 carries a pivoted wheel 138 which is rigidly mounted thereon and adapted to be rotated in response to the movements of the pawls 137—137′, carried by the irregularly shaped armature 136 rotatably supported upon the shaft 139 and co-operating with the pawls 137—137′ 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 568—569 of the frame 562. Each of the pawls 137—137′ is spring pressed into engaging position, while the armature itself is restored to its retracted position by means of a leaf spring 570 which, at one end engages said armature, and at the other end is fixed to the projection 568 of the frame. The movement of the armature 136 is limited by the pawls 137—137′ engaging the stops 571 and 572 respectively, carried upon the contact bank 561. The pawl 137′ is also adapted to ride upon the pin 573 secured adjacent to the stop 572. In the operation of the switch, upon the energization of motor magnet MM, its armature is attracted and thereby the pawl 137 is advanced until it engages stop 571. During its advance movement, pawl 137′ rides upon pin 573 and thereby moves its end out of engagement with the teeth of the wheel 138. Upon the return movement of the armature, the pawl 137′ drops into the next notch in the toothed wheel and comes up into engagement with stop 572. With the parts in the position illustrated, or when the the armature 136 has been moved far enough to bring pawl 137 into engagement with stop 571, 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 137 is not advanced a complete step, the pawl upon return, due to the proportioning of the parts, will engage a notch in the wheel 138 and return the wheel and the wipers to their previously occupied position. Thus, it is impossible to leave the wipers in other than a position in exact registry with the set of bank contacts.

Slot mechanism.—Obviously, many different forms of slot mechanism may be employed in the system of Fig. 1. In Fig. 21, I have illustrated one such form. In this construction, the mechanism is enclosed in a suitable casing 573 provided with a slot 574 for the deposit of the token. The slot is provided with two outlets, one of which permits the return of the token into the socket 575 located on the outside of one wall of the casing 573 so as to allow of the removal of the token by the calling party. The other path, as in the diagram, leads in the opposite direction and through it the token is deposited in the casing 573 whenever the mechanism is operated to collect the token. The polarized magnet 82 is suitably supported within the casing 573 in proximity to the switch-hook 76 which cooperates with a set of contacts 574 to change the substation circuits in the manner previously described. In the preferred construction, the armature arm 95 of the diagram is replaced by a pivoted stop arm 95^a, an armature 95^b and a connecting link 95^c. Upon the removal of the receiver from the switch-hook 76, it has its outer end raised by the leaf spring 575 and thereby moves arm 95^a to its intermediate position to retain the deposited token as previously explained. The movement of armature 95^b which accompanies this movement of arm 95^a does not continue far enough to cause the spring 600 to contact with spring 97. This contact occurs when magnet 82 is energized in a direction so as to collect the token. In such case, alternate contact 97 is made and immediately thereafter normal contact 97 is broken as will be evident from the contact arrangement. Similarly, contact 98 is so located with reference to the slot 574 that upon the deposit of a token, it will be moved from its normal to its alternate position as will be apparent.

In practicing my invention, it will be at once apparent from the above disclosure that many other alterations and modifications than those heretofore suggested may be made not only in the mechanical construction of the various parts but also in many of the circuit arrangements, without departing from the spirit and scope of the invention. I, therefore, do not wish to be limited to the specific matter disclosed but aim to cover by the terms of the appended claims all such alterations and modifications.

I claim—

1. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts some of which have primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; an initial energizing circuit for said primary relay including primary off-normal switch contacts; a maintaining circuit for said primary relay including one of said movable contacts; a release magnet; an initial energizing circuit for said secondary relay including primary and secondary off-normal switch-contacts and contacts of said primary relay; a maintaining circuit for said secondary relay including contacts of said secondary relay, contacts of said release magnet and another of said movable contacts, means for establishing a condition such as to cause the interruption of said maintaining circuits at predetermined points in the respective movements of said movable contacts; and means operated upon the energization of said release magnet to restore said switch parts to normal.

2. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts some of which have primary and secondary movements; primary and secondary relays for control-

ling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; talking strands including certain of said movable contacts and contacts of said secondary relay; an initial energizing circuit for said primary relay including primary off-normal switch contacts, a maintaining circuit for said primary relay including another of said movable contacts; a release magnet; an initial energizing circuit for said secondary relay including primary and secondary off-normal switch contacts and contacts of said primary relay; a maintaining circuit for said secondary relay including contacts of said secondary relay, contacts of said release magnet and another of said movable contacts, means for establishing a condition such as to cause the interruption of said maintaining circuits at predetermined points in the respective movements of said movable contacts; and means operated upon the energization of said release magnet to restore said switch parts to normal.

3. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively; means for energizing said relays so as to cause said movable contacts to move to predetermined points; release means for restoring said switch parts to normal; and a release circuit for said release means including certain of said secondary off-normal switch contacts.

4. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively, means for energizing said relays so as to cause said movable contacts to move to predetermined points; means for restoring said switch parts to normal when released; a magnet for releasing said switch; a control circuit for said release magnet including certain of said secondary off-normal switch contacts; and means controlled over the connected telephone line for closing said release circuit.

5. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively; means for energizing said relays so as to cause said movable contacts to move to predetermined points; means for restoring said switch parts to normal when released, a magnet for releasing said switch; a release relay for controlling the energization of said release magnet; an energizing circuit for said release relay including certain of said secondary off-normal switch contacts; and means controlled over the connected telephone line for closing said energizing circuit.

6. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively; talking strands including certain of said movable contacts and contacts of said secondary relay; means for energizing said primary relay so as to cause said contacts to move a predetermined distance in a primary direction; means for energizing said secondary relay so as to cause said contacts to move a predetermined distance in a secondary direction and maintaining said talking strands open during such movement; means for restoring said switch parts to normal; a release circuit for said release means including certain of said secondary off-normal switch contacts; and means for energizing said secondary relay during a portion of the return movement of the switch, to open said talking strands.

7. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively; talking strands including certain of said movable contacts and contacts of said secondary relay; means for energizing said primary relay so as to cause said contacts to move a predetermined distance in a primary direction; means for energizing said secondary relay so as to cause said contacts to move a predetermined distance in a secondary direction and maintaining said talking strands open during such movement; means for restoring said switch parts to normal when released; a magnet for releasing said switch; a control circuit for said re-

lease magnet including certain of said secondary off-normal switch contacts; means controlled over the connected telephone line for closing said release circuit; and means for energizing said secondary relay during a portion of the return movement of the switch, to open said talking strands.

8. A telephone exchange system comprising a telephone line; a line selecting switch including movable contacts having primary and secondary movements; primary and secondary relays for controlling said primary and secondary movements respectively; primary and secondary off-normal switch contacts actuated upon said primary and secondary switch movements respectively; talking strands including certain of said movable contacts and contacts of said secondary relay; means for energizing said primary relay so as to cause said contacts to move a predetermined distance in a primary direction; means for energizing said secondary relay so as to cause said contacts to move a predetermined distance in a secondary direction and maintaining said talking strands open during such movement; means for restoring said switch parts to normal when released; a magnet for releasing said switch; a release relay for controlling the energization of said release magnet; an energizing circuit for said release relay including certain of said secondary off-normal switch contacts; means controlled over the connected telephone line for closing said energizing circuit; and means for energizing said secondary relay during a portion of the return movement of the switch, to open said talking strands.

9. A telephone exchange system comprising a telephone line extending from a subscriber to the exchange; a selecting switch for extending the circuit of said line, including movable contacts having primary and secondary movements; off-normal switch contacts actuated upon said secondary movement; a primary magnet for causing said primary movement; an energizing circuit for said primary magnet including certain of said secondary off-normal switch contacts; and a relay under the control of the subscriber to make and break said energizing circuit, whereby said switch contacts are given their primary movement.

10. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor, including movable contacts having primary and secondary movements; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; a secondary magnet for causing said secondary movement; an initial control circuit for said secondary magnet including primary and secondary off-normal switch contacts; and a subsequent control circuit for said secondary magnet including one of said movable contacts.

11. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor, including movable contacts having primary and secondary movements; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; a secondary magnet for causing said secondary movement; an initial control circuit for said secondary magnet including primary and secondary off-normal switch contacts; a release magnet; and a subsequent control circuit for said secondary magnet including contacts of said release magnet and one of said movable contacts.

12. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor, including movable contacts having primary and secondary movements; a secondary magnet for causing said secondary movement; a secondary relay for controlling said secondary magnet; talking strands including certain of said movable contacts and contacts of said secondary relay; a release magnet, an energizing circuit for said secondary relay including contacts of said release magnet and another of said movable contacts.

13. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor including movable contacts having primary and secondary movements; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; a secondary magnet for causing said secondary movement; a secondary relay for controlling said secondary magnet; talking strands including certain of said movable contacts and contacts of said secondary relay; an initial energizing circuit for said secondary relay including certain of said primary and secondary off-normal switch contacts; and a maintaining circuit for said secondary relay including another of said movable contacts.

14. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor including movable contacts having primary and secondary movements; primary and secondary off-normal switch contacts actuated upon said primary and secondary movements respectively; a secondary magnet for causing said secondary movement; a secondary relay for controlling said secondary magnet; talking strands including certain of said movable contacts and contacts of said secondary relay; an initial energizing circuit for said secondary relay including certain of said primary and secondary off-normal switch contacts; and a maintaining circuit for said secondary relay including

another of said movable contacts; a release magnet; and a maintaining circuit for said secondary relay including contacts of said release magnet and another of said movable contacts.

15. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor, including movable contacts having primary and secondary movements; a secondary relay; a release relay; and a secondary magnet for causing said secondary movement of said movable contacts, having its winding in a circuit including normally closed contacts of said release relay and normally open contacts of said secondary relay.

16. A telephone exchange system comprising a conductor; a selecting switch for establishing connection with said conductor, including movable contacts having primary and secondary movements; primary off-normal switch contacts closed upon the first primary movement of said movable contacts; secondary off-normal switch contacts opened upon the first secondary movement of said movable contacts; a relay, talking strands including certain of said movable contacts and normally closed contacts of said relay; means for moving said movable contacts to predetermined points; means including a release magnet for restoring said switch parts to normal; a release relay for controlling said release magnet; means for energizing said release relay; an energizing circuit for said first mentioned relay closed in response to such energization of said release relay through actuated primary off-normal switch contacts and contacts of said release relay; and means for restoring said primary off-normal switch contacts to normal at the end of the return movement of said movable contacts, whereby said energizing circuit is interrupted and said talking strands thus closed.

17. A telephone exchange system comprising a telephone line, talking conductors for extending the circuit of said line, a cut-off relay for varying the connections of said line, means for initially energizing said relay over a circuit including a portion of one of said talking strands, and means for shifting the circuit of said relay from that including said talking strand to a local conductor.

18. A telephone exchange system comprising a telephone line, associated automatic switches and link-circuits for extending the circuit of said line, means for grounding the limbs of said telephone line to operate said switches, a normal ground connection on said line, a relay for removing said ground connection to render said line free for the operation of said switch operating grounding means, means for initially energizing said relay over a portion of a talking strand of one of said link-circuits, and means for subsequently shifting the circuit of said relay to a local conductor.

19. A telephone exchange system comprising a telephone line, associated automatic switches and link-circuits for extending the circuit of said line, a non-numerical switch and a relay energizable over the two sides of said line in series for connecting said line to said switches, relays bridged across the line and adapted to be energized at a definite point in the operation of said switches, a release circuit for certain of said switches controlled by said relays, and means for maintaining said relays energized so as to prevent the completion of said release circuit.

20. A telephone exchange system comprising a subscriber's telephone line, associated automatic switches and link-circuits for extending the circuit of said line, a non-numerical switch and a relay energizable over the two sides of said line in series for connecting said line to said switches, relays bridged across the line and adapted to be energized at a definite point in the operation of said switches, a release circuit for certain of said switches controlled by said relays, and means under the control of the subscriber for maintaining said relays energized so as to prevent the completion of said release circuit.

21. A telephone exchange system comprising a subscriber's telephone line, substation equipment including control mechanism, and contacts, automatic progressively movable switch mechanism at the exchange for connecting lines and operated responsive to the opening of a subscribers' line circuit to automatically release said switch mechanism, and means for preventing the operation of said switch mechanism until said control mechanism has been operated in a definite way to bridge said contacts across the said subscriber's telephone line.

22. A telephone exchange system comprising telephone lines, a central source of energy, a plurality of associated automatic switches and link-circuits for uniting said lines in the establishment of a conversational circuit, means for connecting said source of energy to said conversational circuit for supplying talking current, a release relay for controlling the release of each of said switches, means for including a plurality of said relays in parallel branches of an energizing circuit to cause the release of the switches controlled by them, audible means operable over a subscriber's line for advising said subscriber when he may initiate a call.

23. A telephone exchange system comprising a telephone line and associated automatic switch mechanism for service in extending the circuit of said line, said mechanism including only passive and active main

contacts, said mechanism being adapted for primary and secondary adjustment, primary and secondary off-normal contacts, magnets and connected mechanism for operating said active contacts, relays, and suitable electrical connections.

24. A telephone exchange system comprising a telephone line, a line selecting switch including a plurality of contact groups, contacts of said line included in one of said groups, movable contact makers for said switch, one set for each of said groups, an auxiliary selecting switch having a contact maker capable of selecting any set of said first-mentioned contact makers, a line relay individual to said line and operable by current thereover, and electrically controlled adjusting means for said switches, operative responsive to said relay, to cause said auxiliary switch to select the set of contact makers for the contact group including the contacts of said line, and for causing said set to select said contacts of said line.

25. A telephone exchange system comprising telephone lines, multiple calling contacts for said lines arranged in a plurality of groups at the exchange, a selecting switch having a movable contact, one for each of said groups, an additional movable contact common to said groups, line relays one for each of said lines, and electrically controlled adjusting means for said movable contacts serving on operation of any line's relay to cause the movable contact for the respective group to select the contacts of the line whose relay is operated, and also to cause said additional contact to select the movable contact that selects the line.

26. A telephone system comprising telephone lines, multiple contacts therefor at the exchange arranged in superposed groups, a selecting switch at the exchange including superposed traveling contacts, one for each group, means for simultaneously moving said traveling contacts along the multiple contacts of their groups, line relays one for each of said telephone lines, and circuit connections controlled by the line relay of a line to render said means effective to adjust the traveling contact for the group, including said line, to connection with said line.

27. A telephone system comprising telephone lines, multiple contacts therefor at the exchange arranged in superposed groups, a selecting switch at the exchange including superposed traveling contacts, one for each group, means for simultaneously moving said traveling contacts along the multiple contacts of their groups, line relays one for each of said telephone lines, circuit connections controlled by the line relay of a line to render said means effective to adjust the traveling contact for the group, including said line, to connection with said line, and means for causing further travel of said contacts in the original direction to a normal point.

28. A telephone system including a telephone line, a line relay therefor responsive to currents controlled at the substation, multiple contacts for said line normally unselectable in character, means controlled by said relay when operated to render said contacts selectable, a line selector adapted when started responsive to currents controlled at the substation to automatically select said contacts, switch contacts included in said line selector adapted to form part of the talking circuit for said line, an additional switch contact for said selector, a cut-off relay for said line, an initial circuit established for said relay on selection of said line including a talking contact of said line selector, and a maintaining circuit therefor excluding said talking contact and including said additional contact.

29. The combination with a telephone line, of a line relay therefor, a cut-off relay for said line having switch contacts controlling the circuit of said line relay, a multiple contact for said line normally in circuit with the winding of said cut-off relay, another multiple contact for said line normally disconnected from said winding, a connection terminal adapted to be applied to said multiple contacts, means for initially energizing said cut-off relay on application of said terminal over a circuit including a switch contact of said connection terminal and said first multiple contact, and means controlled by said cut-off relay for establishing a maintaining circuit for said relay excluding said first multiple contact and including said other multiple contact, substantially as described.

30. In a telephone system, the combination with a telephone line, a normally at rest automatic switch, a plurality of directively operable switches extending connection from said line to said automatic switch, means operable over said telephone line for advising the subscriber that he may operate said switches to connect his line to said automatic switch, a release conductor separate from the talking circuit extending conductively through all said switches, a release controlling magnet for each of said switches connected with said conductor, a source of current, and means for applying the same to said conductor to energize said magnets.

31. A telephone system including a telephone line, a selective switch in connection therewith, a plurality of other selective switches co-operating with said first-mentioned switch in extending the talking circuit of said line through contacts of a plurality of said switches, means for giving the subscriber an audible signal to advise him that he may operate said switches to

connect his line to said selective switch, and a release conductor separate from the talking circuit conductively extending to all of said switches.

32. A telephone system comprising calling and called subscribers' lines, a plurality of link-circuits, a plurality of automatic switches for linking said link-circuits and lines together to complete a talking circuit, means for giving the subscriber an audible signal to advise him that he may operate said automatic switches, and a release conductor separate from the talking circuit conductively extending to all of said switches.

33. A telephone system comprising calling and called subscribers' lines, a plurality of link-circuits, a plurality of automatic switches for linking said link-circuits and lines together to complete a talking circuit, means for giving the subscriber an audible signal to advise him that said switches may be operated to complete said talking circuit, a release conductor separate from the talking circuit conductively extending to all of said switches, release magnets for said switches connected to said conductor, and means for applying current to said conductor to energize said magnets.

34. A telephone system comprising a telephone line, a trunk, a line selector and a trunk selector, means for advancing said selectors to connecting positions, release means for restoring said selectors to normal, a control relay for disconnecting the wipers of said trunk selector during their release movement, and a release magnet for controlling said release means and the actuation of said control relay.

35. A telephone system comprising a telephone line, a trunk, a line selector and a trunk selector, means for advancing said selectors to connecting positions, release means for restoring said selectors to normal, control relays for disconnecting the wipers of said selectors during their release movement, and a release magnet for controlling said release means and the actuation of said control relays.

36. A telephone system comprising a telephone line, a trunk, a line selector and a trunk selector, means for advancing and releasing the wipers of said selectors, a control relay for disconnecting the wipers of one of said selectors during its release movement, and a release magnet for controlling the release of said other selector and the actuation of said control relay.

37. A telephone system comprising a telephone line, a trunk, a line selector and a trunk selector, means for advancing and releasing the wipers of said selectors, a control relay for disconnecting the wipers of said trunk selector during its release movement, and a release magnet for controlling the release of said line selector and the actuation of said control relay.

38. A telephone system comprising telephone lines, link-circuits and two automatic switches for use in uniting calling and called lines, means for advancing and releasing the wipers of said switches, a control relay for disconnecting the wipers of one of said switches during its release movement, and a release magnet for controlling said release means and the actuation of said control relay.

39. A telephone system comprising telephone lines, link-circuits and two automatic switches for use in uniting calling and called lines, means for advancing said switches to connecting positions, release means for restoring said switches to normal, control relays for disconnecting the wipers of said switches during their release movement, and a release magnet for controlling said release means and the actuation of said control relays.

40. A telephone system comprising telephone lines, link-circuits and two automatic switches for use in uniting calling and called lines, means for advancing and releasing the wipers of said switches, a control relay for disconnecting the wipers of one of said switches during its release movement, and a release magnet for controlling the release of said other switch and the actuation of said control relay.

41. In an automatic telephone system, a progressively movable switching mechanism comprising a normally inoperative motor magnet, having a circuit provided with two sets of contacts and separate devices controlling the motor magnet which operate conjointly to simultaneously open one set of contacts and close the other, one of said devices being adapted to close the contacts controlled by it while the other device holds its contacts closed, a source of current supply and a telephone instrument circuit and means for transmitting impulses of current thereover to operate the devices controlling the motor magnet, and an audible signal for advising the subscriber of said telephone instrument when said switching mechanism is in condition to be operated.

42. A subscriber's line a progressively movable mechanism comprising a normally inoperative motor device and electromagnetic mechanism for controlling its movement in unision with successive current impulses of given frequency, means for first rendering the motor device operative and secondly causing it to respond to said controlling mechanism only during the transmission of such impulses and means for producing the latter, and means transmitted

over the subscriber's line to advise the subscriber when said mechanism is in condition to be operated.

43. The combination with a normally open operative circuit an impulse transmitter arranged therein and a progressively movable mechanism comprising a normally inoperative motor magnet, means operable over said circuit to advise the subscriber when said impulse transmitter may be operated, of a switching relay adapted to render the motor magnet capable of operation when the operating circuit is closed, another switching relay responding to impulses of current transmitted over the operating circuit, said relay being adapted to effect the actuation of the motor magnet in unison with said impulses.

44. In a telephone system, a subscriber's line, a common battery connector having a release magnet, means for advising the subscriber when he may connect said line to said connector, and a plurality of relays adapted to remain energized while the connector is in use, to prevent the energizing of said magnet and the release of the connector, substantially as set forth.

45. A telephone exchange system comprising a telephone line extending from a central office to a distant point, a source of current in circuit with said line, manually controlled means at said distant point for interrupting the circuit of the line, audible means for advising said subscriber when said manually controlled means may be operated, other telephone lines, an electrically controlled switch at the central office for establishing connection betwen said line and said other lines, active contacts for said switch constituting terminals for said line, passive contacts for said switch constituting terminals for said other lines, restoring means for said switch, means responsive to short interruptions of the circuit of said line for causing a primary operation of said switch, and means responsive after connection is established with a desired line whereby a long interruption of the circuit of said line will cause a secondary operation of said switch.

46. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, said bridges including a battery connected in series therein, the combination of a suitable calling telephone line, audible means for advising the subscriber on said line when said switches may be operated, a two-wire called telephone line, means including a repeater and an automatic switch controlled thereby for extending connection from the calling line to the called line, a common battery for supplying talking current to the called line, the said calling telephone line being provided with a calling mechanism at the substation thereof for controlling the two sides of the line in series, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

47. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, said bridges including a battery connected in series therein, the combination of a suitable calling telephone line, audible means operable over said line for indicating when said switches may be operated, a two-wire called telephone line, means including a repeater and an automatic switch controlled thereby for extending connection from the calling line to the called line, a common battery for supplying talking current to the calling line, the said calling telephone line being provided with a calling mechanism at the substation thereof for controlling the two sides of the line in series, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

48. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, said bridges including a battery connected in series therein, the combination of a two-wire calling telephone line, audible means operable over said line for indicating when said switches may be operated, a suitable called telephone line, means including a repeater and an automatic switch controlled thereby for extending connection from the calling line to the called line, a common battery for supplying talking current to the called line, the said two-wire telephone line being provided with a calling mechanism at the substation thereof for controlling the two sides of the line in series, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

49. In a telephone system, means for setting up a talking circuit between a calling and a called subscriber's line, a connector switch for seizing the called line controlled over two sides of the talking circuit in series, means controlled by the calling subscriber for releasing said switch, and means for preventing a calling subscriber from releasing said switch.

In witness whereof, I hereunto subscribe my name this 7th day of February, 1908.

FRANCIS W. DUNBAR.