Dec. 1, 1925. 1,563,347

A. H. DYSON

AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907. 13 Sheets-Sheet 1

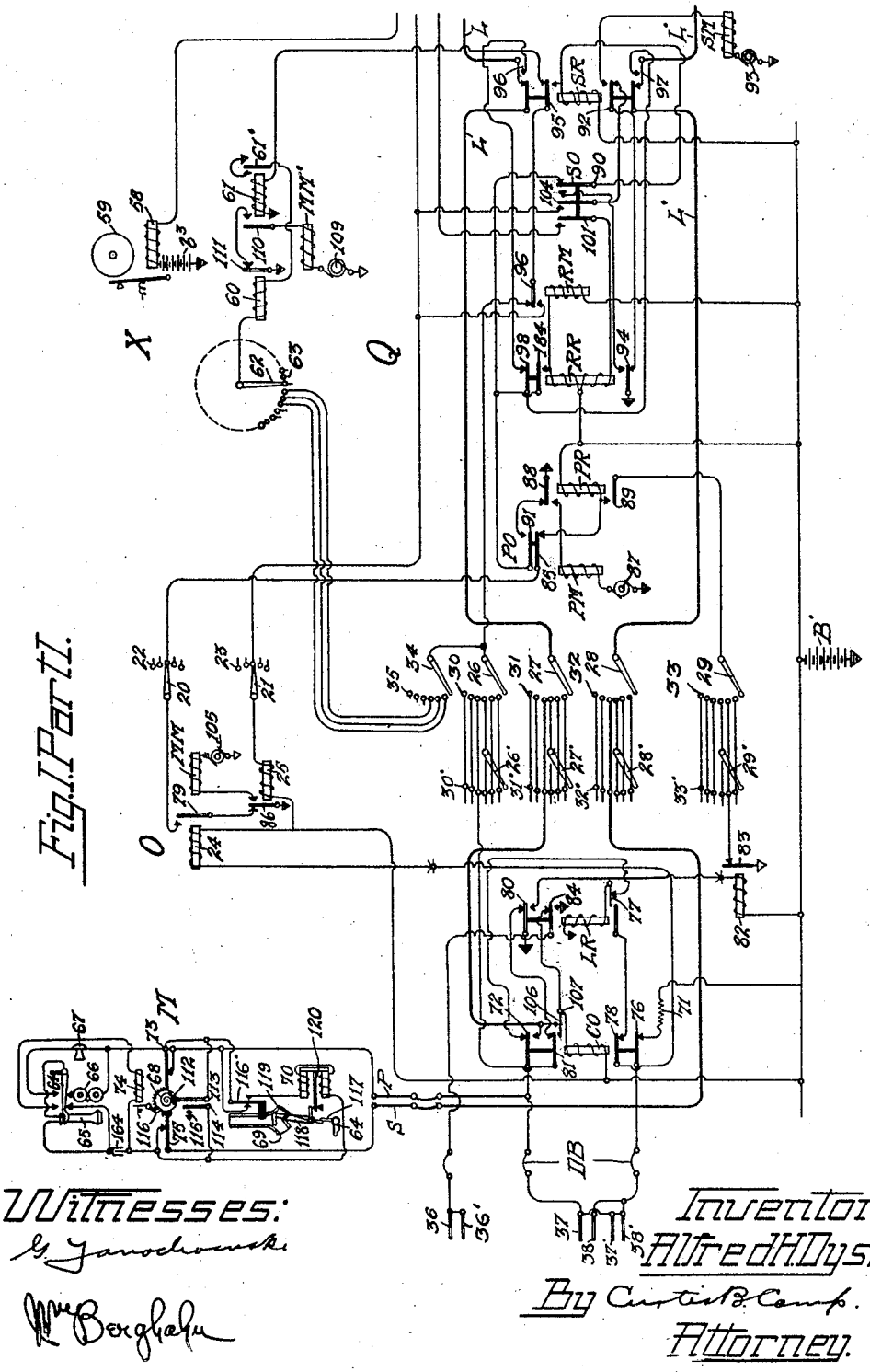

Fig. 1 Part II.

Witnesses:
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Wm. Berghahn

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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 2

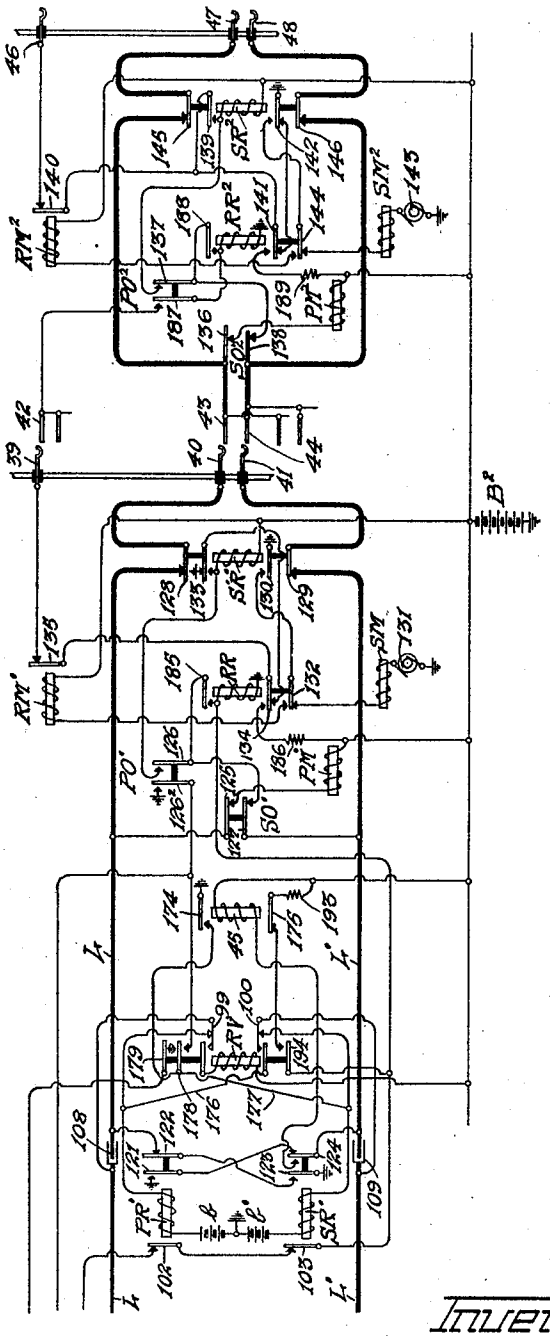

Fig. II Part 2.

Witnesses:
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1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 3

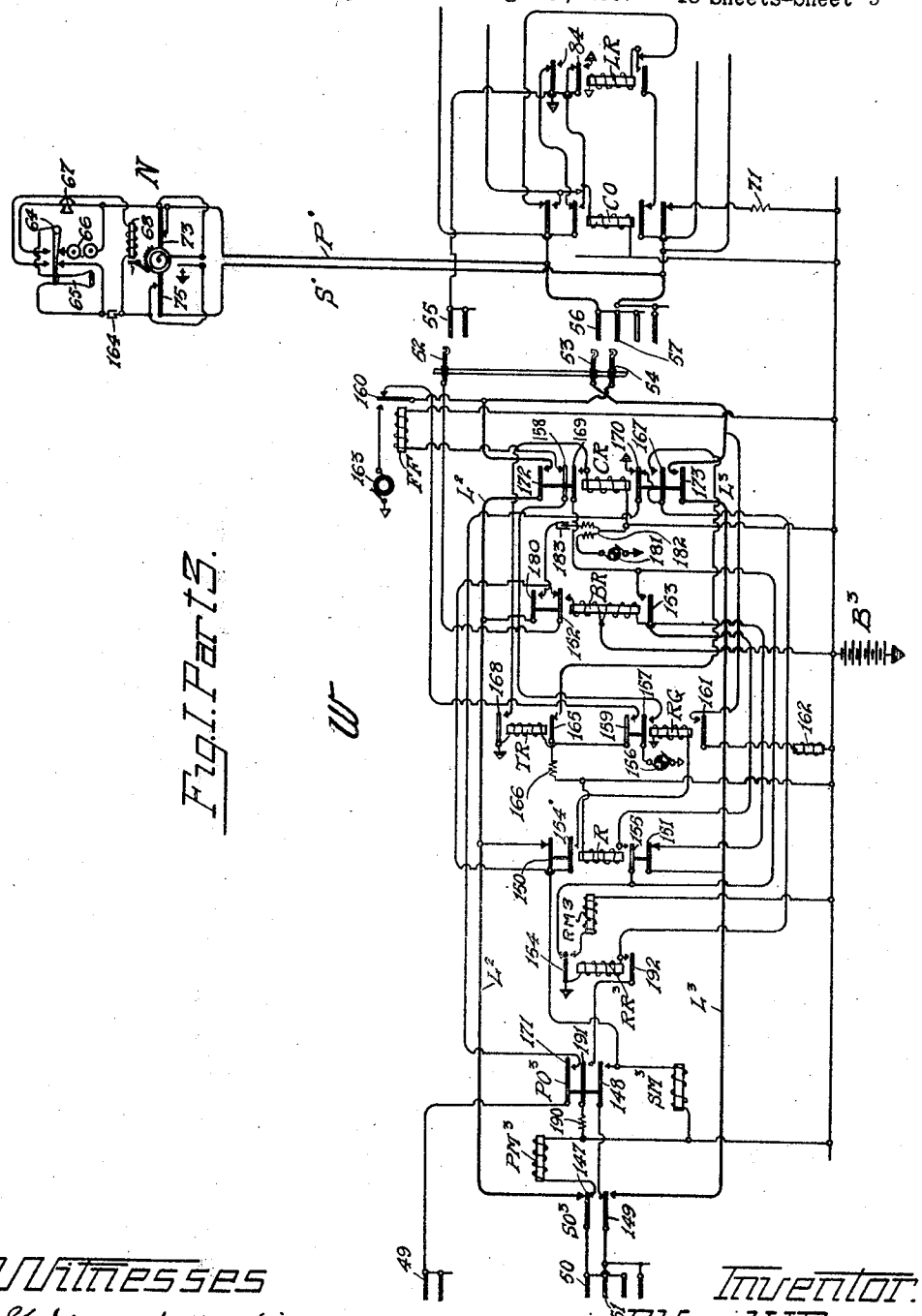

Fig. 1. Parts.

Witnesses

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1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 4

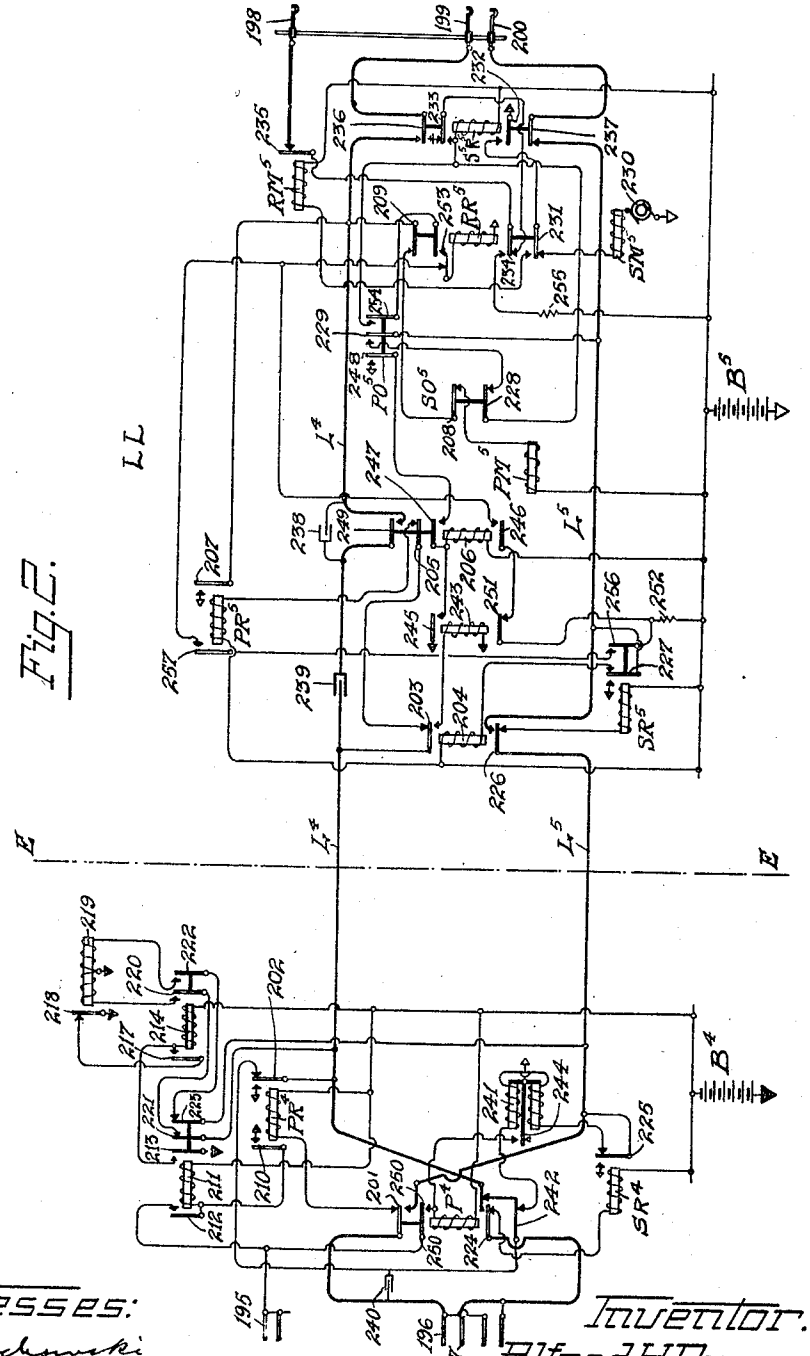

Fig. 2.

Witnesses:
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 5

Fig. 3.

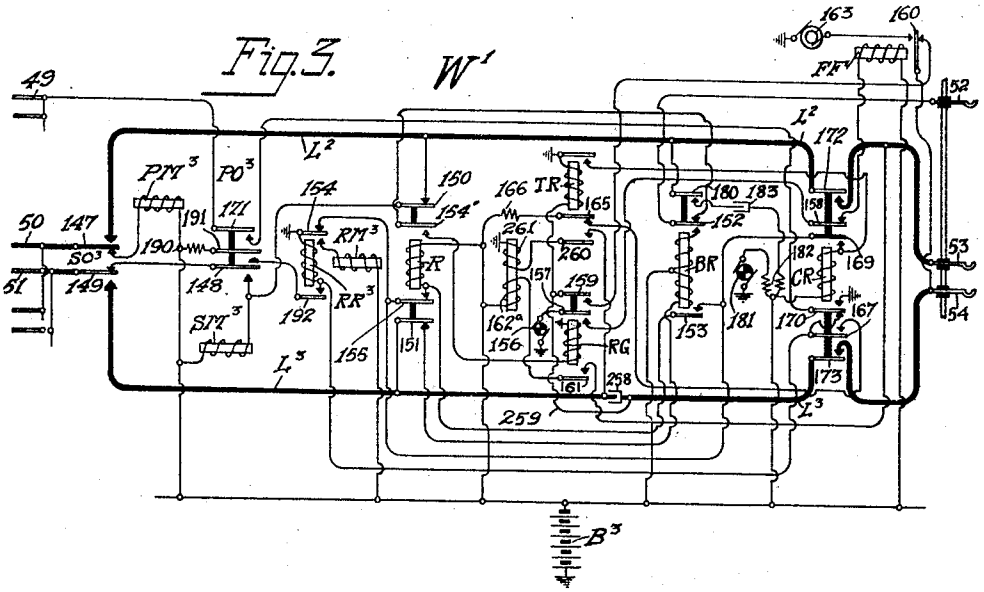
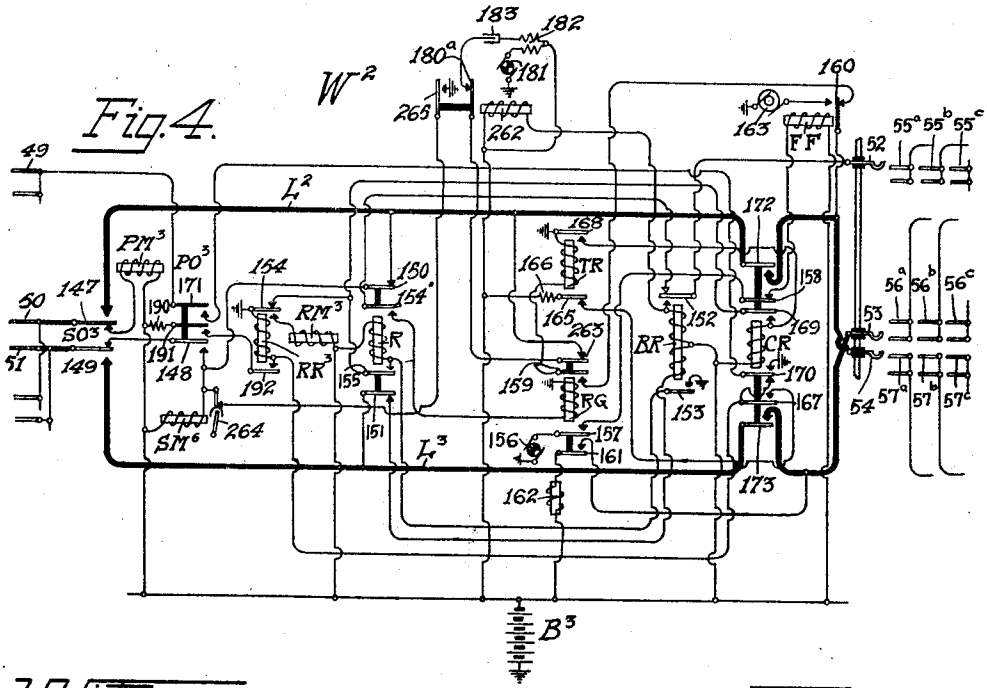


Fig. 4.



Witnesses:
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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 6

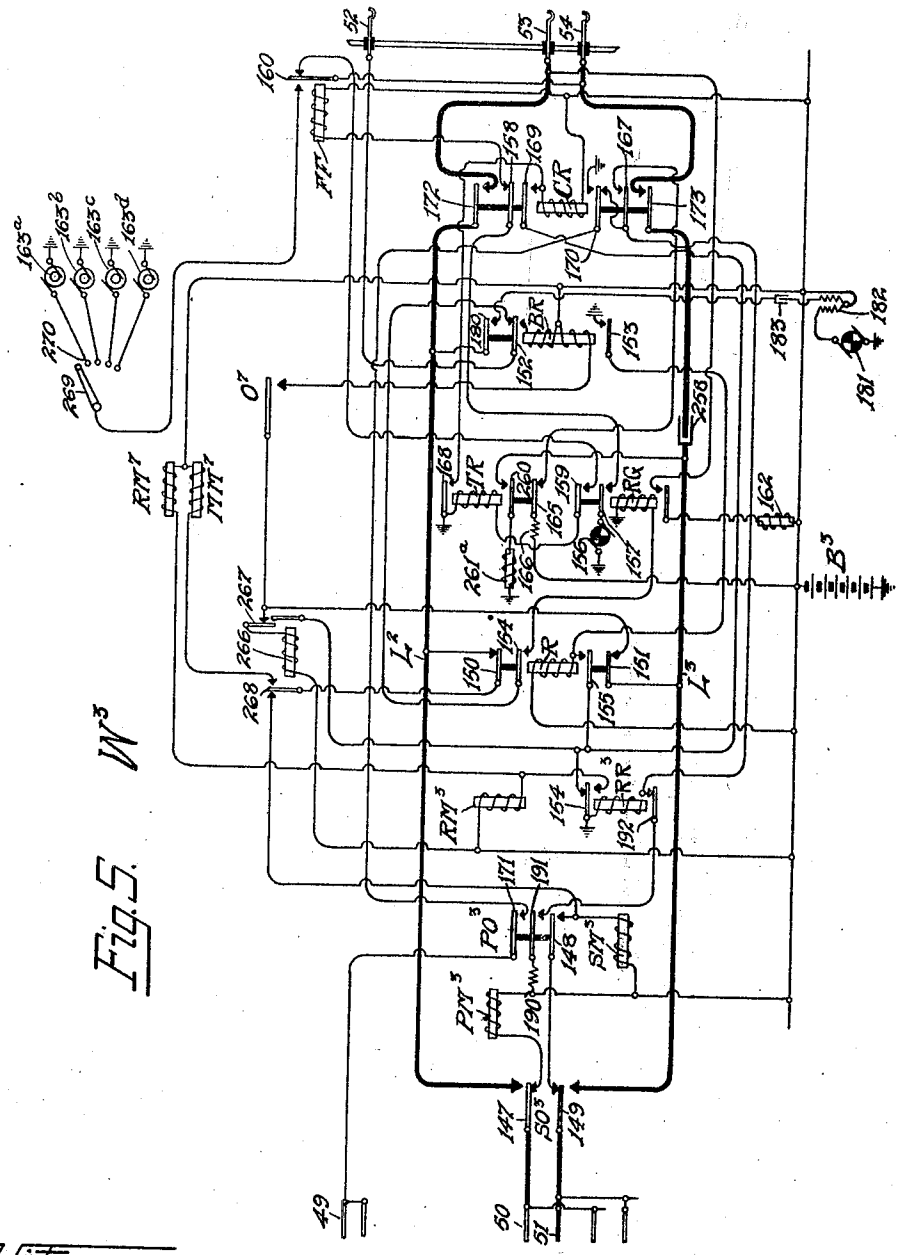

Fig. 5.

Witnesses:
G. Yanochowski.
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 7

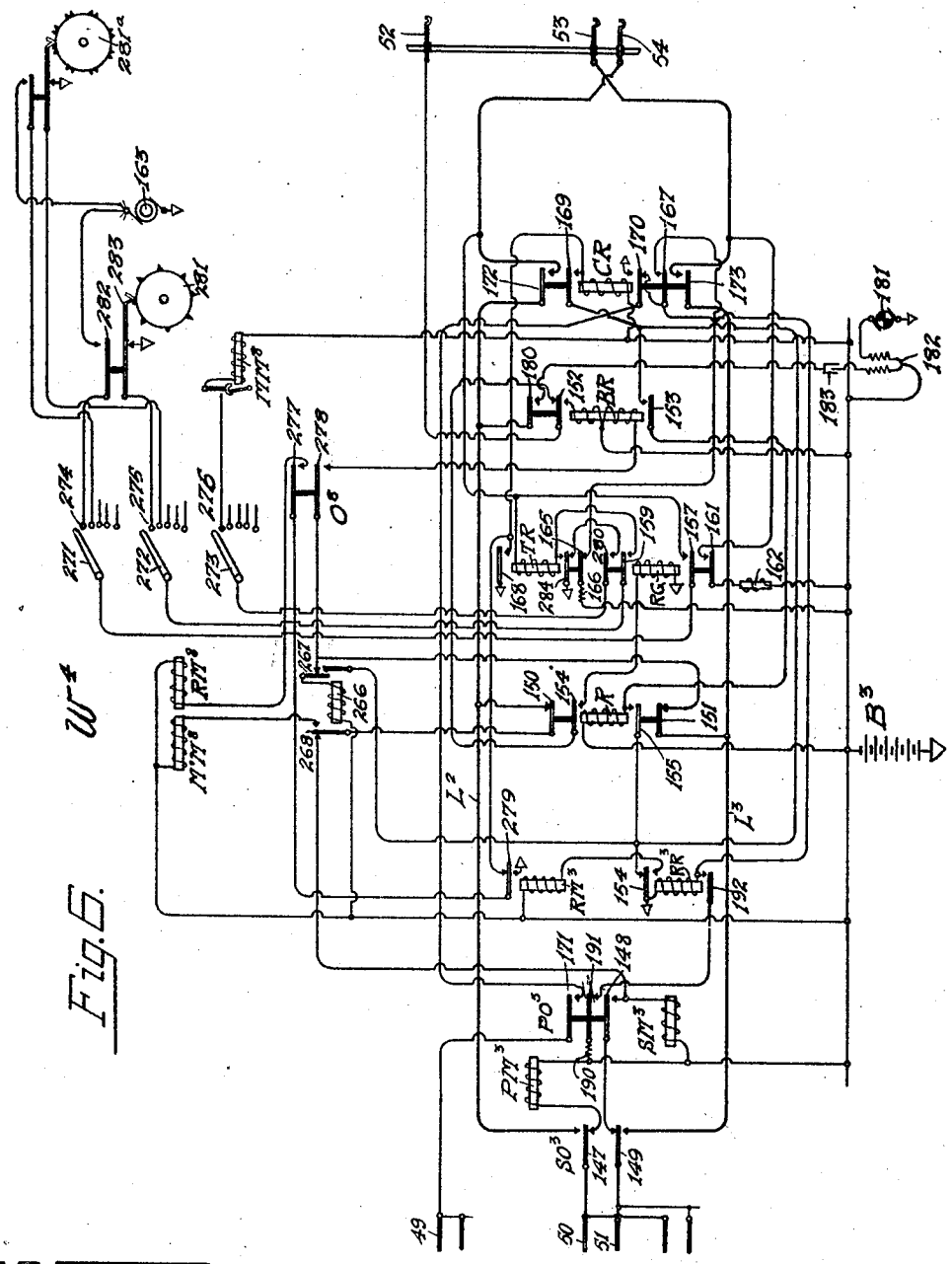

Fig. 6.

Witnesses:
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1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 8

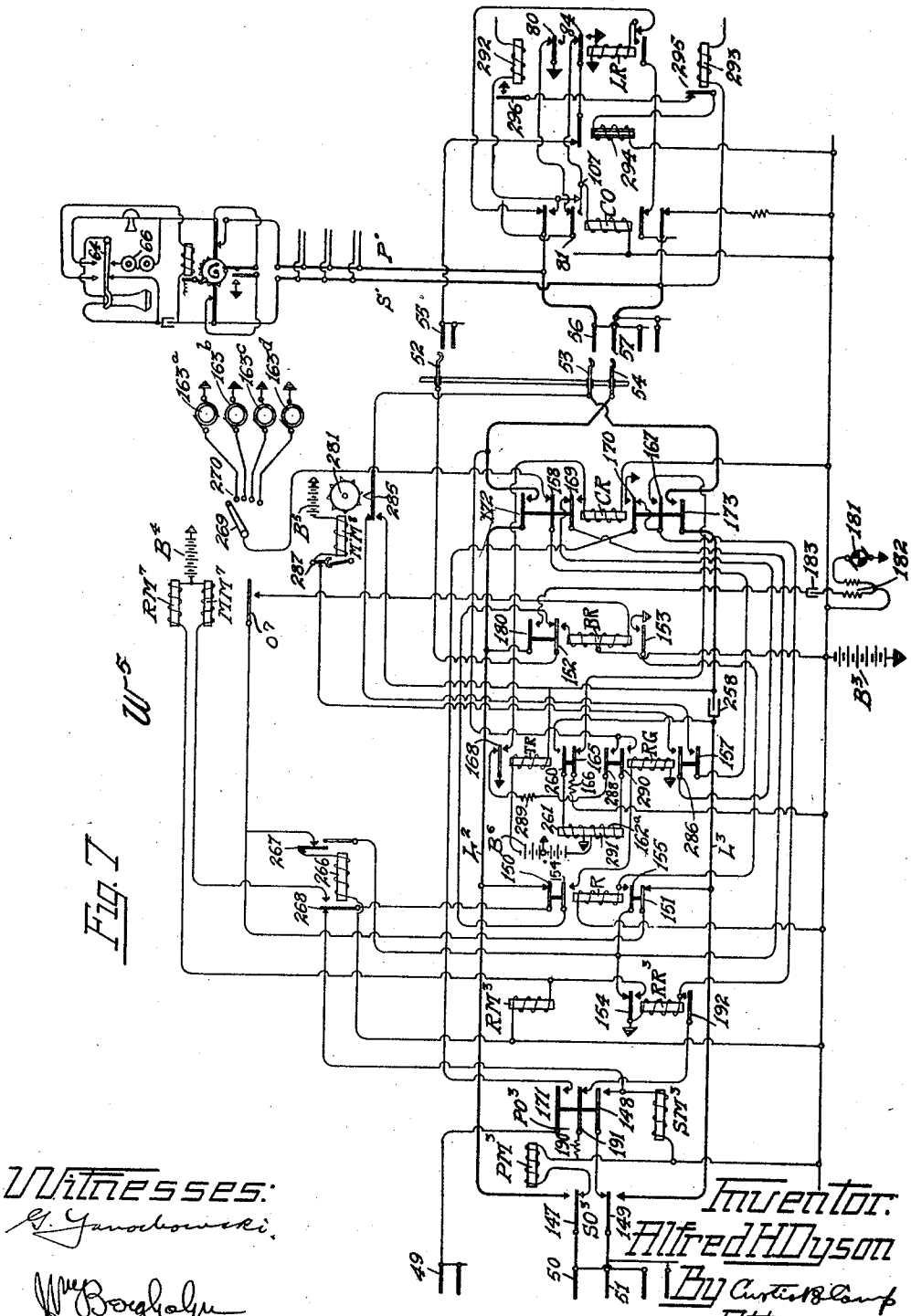

Fig. 7

Witnesses:
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 9

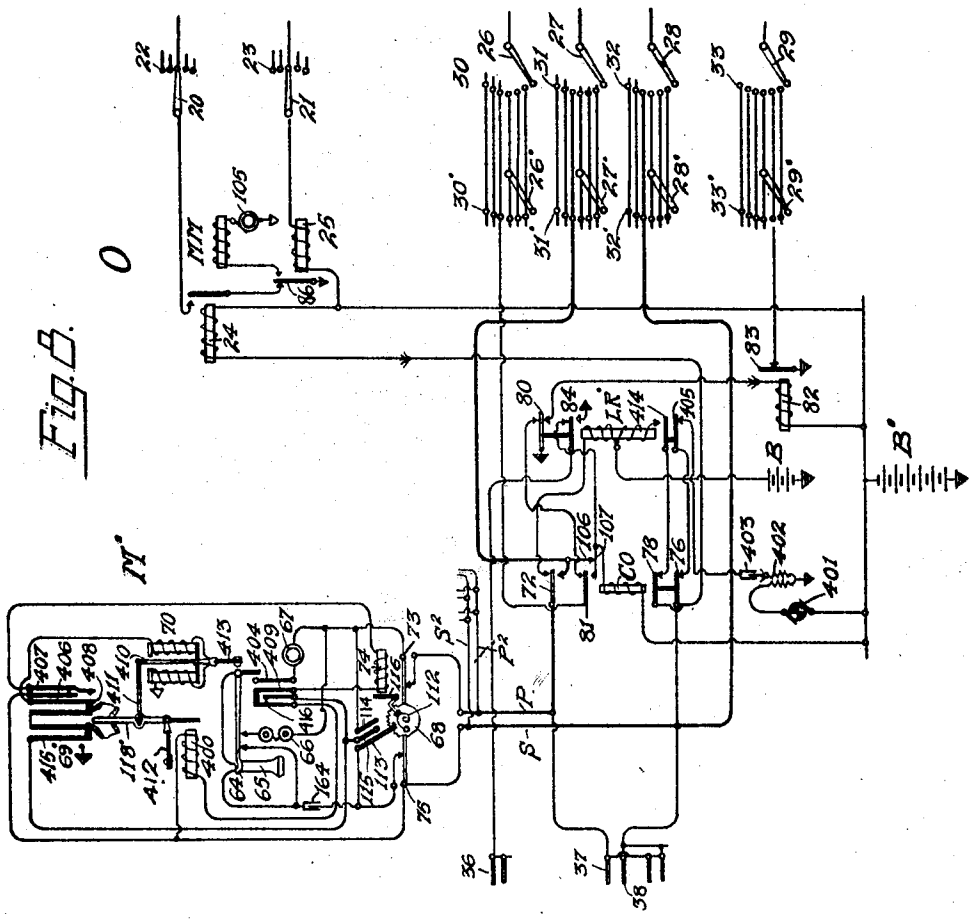

Fig. 8.

Witnesses:
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W. M. Berghaln

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Dec. 1, 1925. 1,563,347

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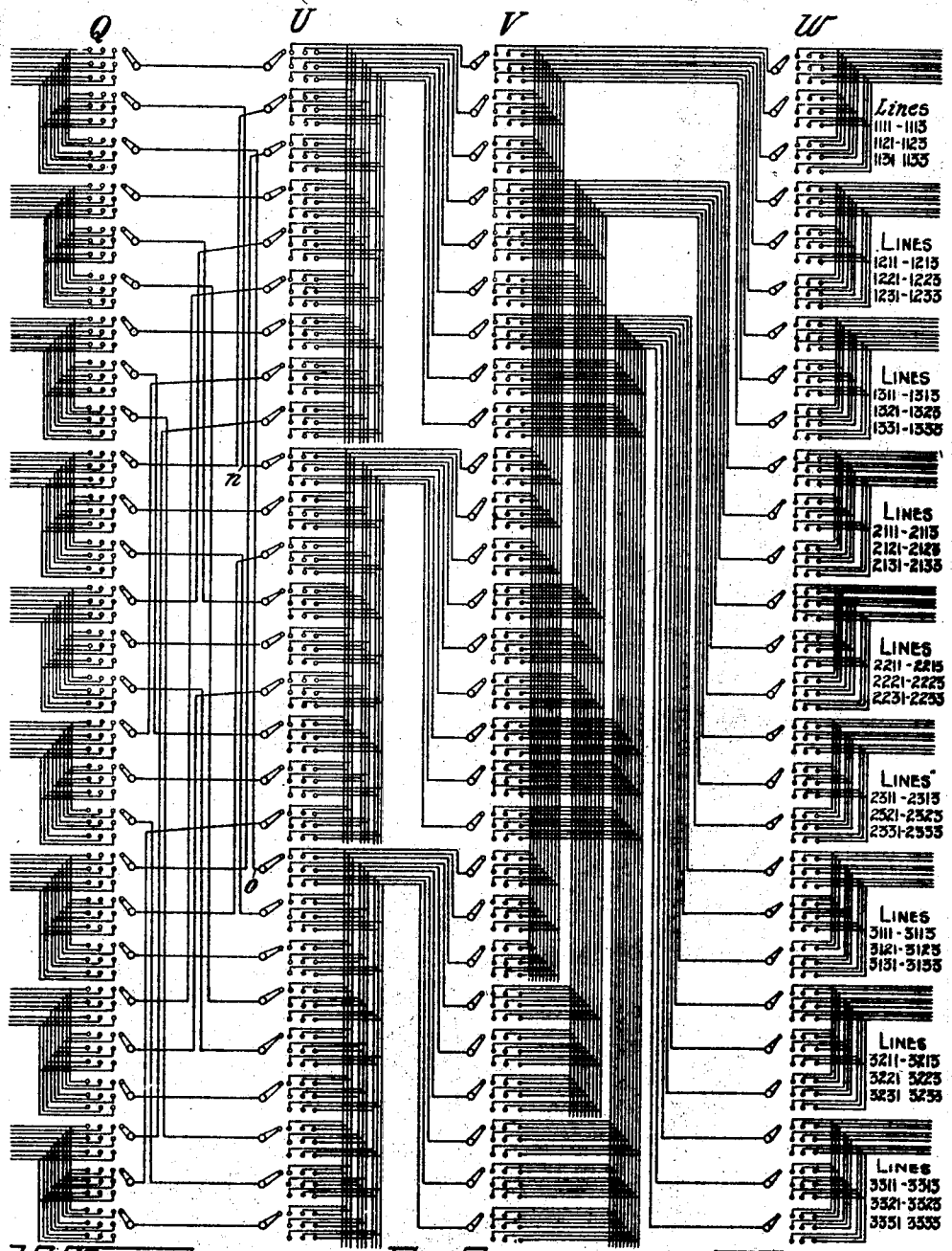
AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 10



Witnesses:
G. Ganschowski.
W. Berghaln

Fig. 9

Inventor:
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 11

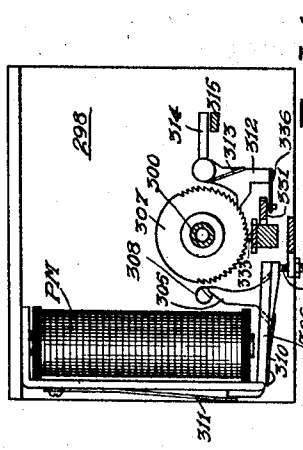

Fig. 14.

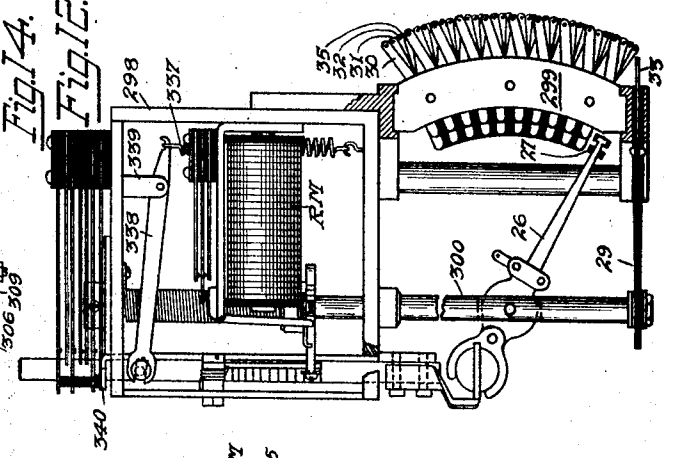

Fig. 12.

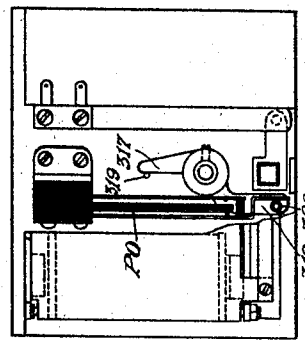

Fig. 13.

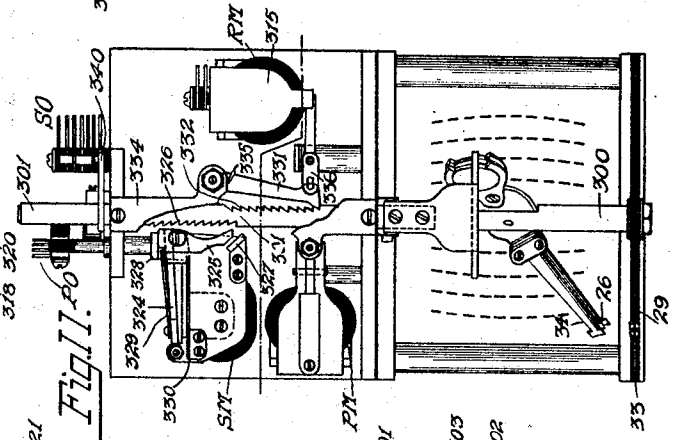

Fig. 11.

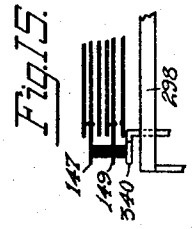

Fig. 15.

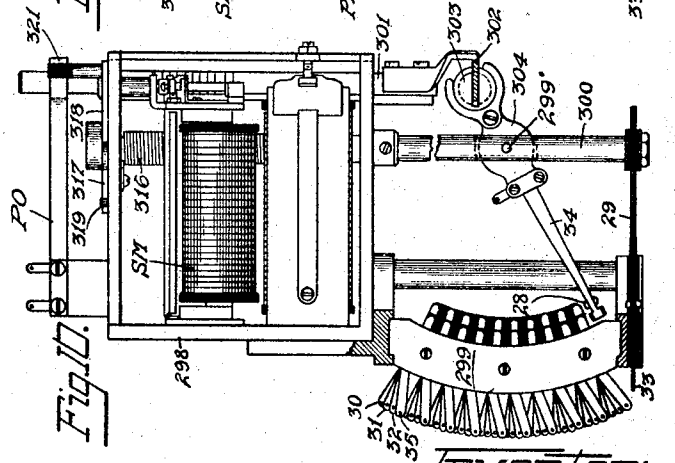

Fig. 10.

Witnesses:
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 12

Fig. 16.

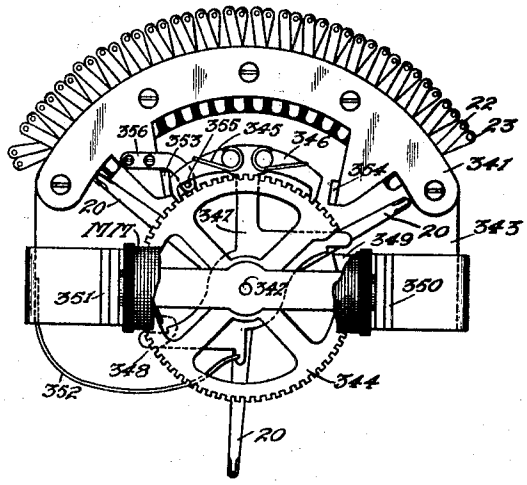


Fig. 17.

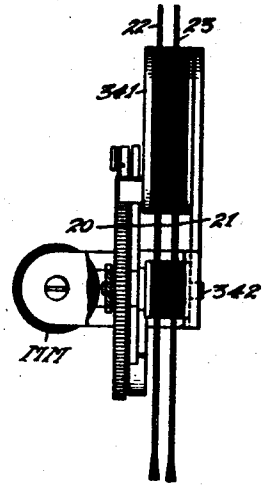


Fig. 18.

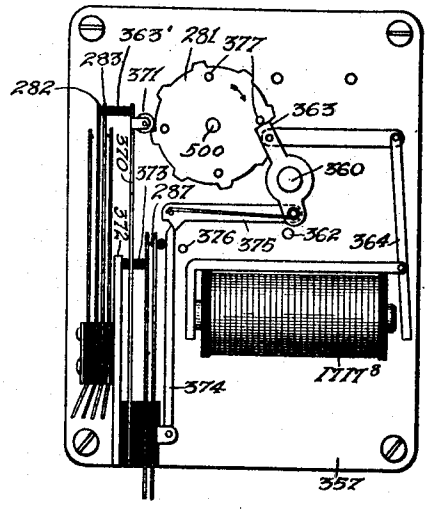
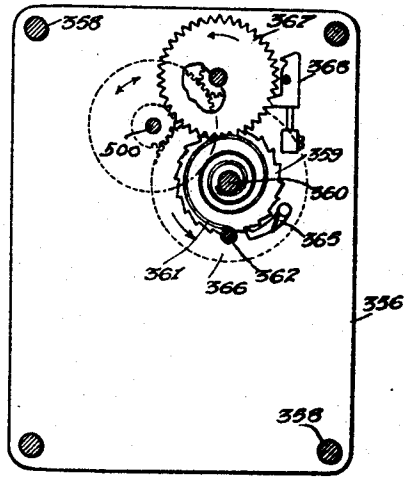


Fig. 19.



Witnesses:
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Dec. 1, 1925. 1,563,347

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AUTOMATIC TELEPHONE SYSTEM

Original Filed Aug. 19, 1907 13 Sheets-Sheet 13

Fig. 20.

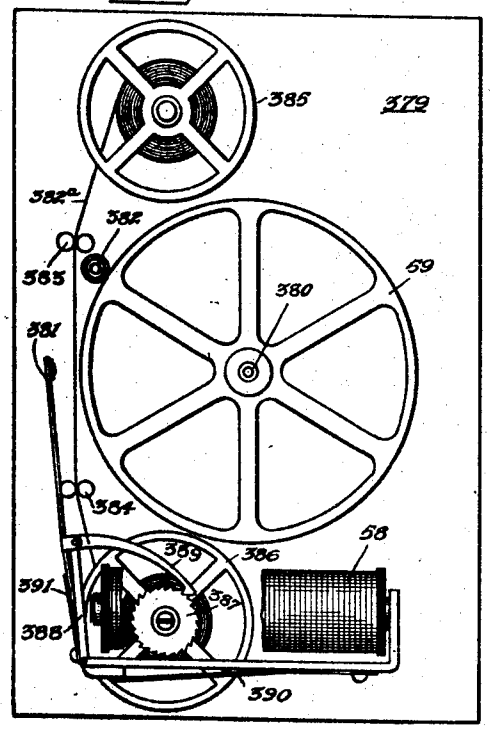
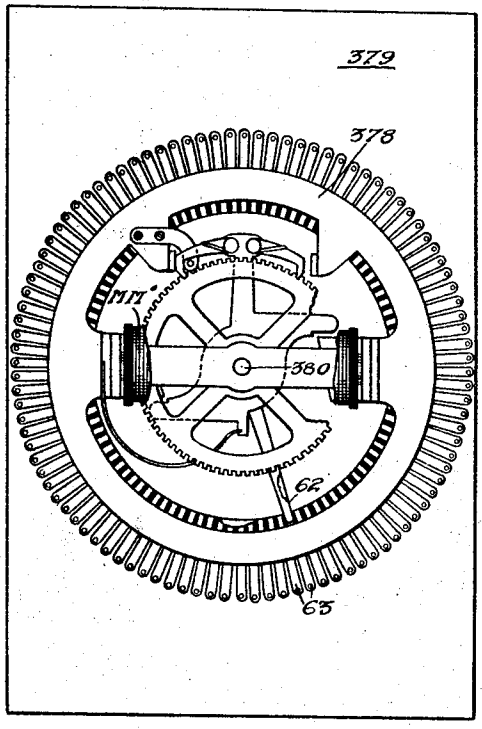


Fig. 21.



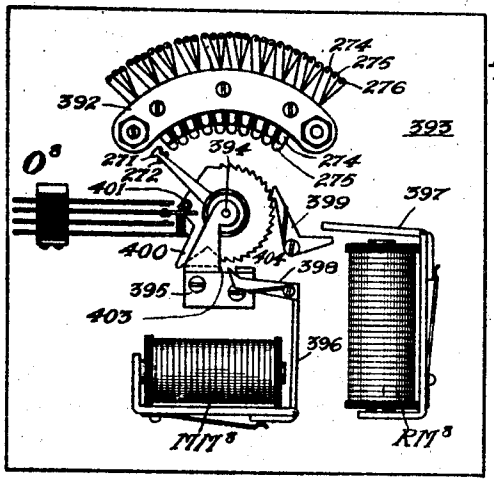


Fig. 22.

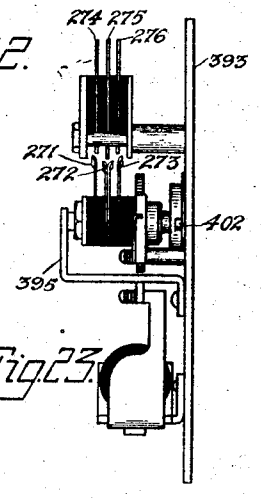


Fig. 23.

Witnesses:
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Patented Dec. 1, 1925. 1,563,347

UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

Original application filed August 19, 1907, Serial No. 389,180. Patent No. 1,257,283, dated February 19, 1918. Divided and this application filed March 2, 1917. Serial No. 152,045.

To all whom it may concern:

Be it known that I, ALFRED H. DYSON, a citizen of the United States, residing at Montclair, in the county of Essex and State of New Jersey, 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 that type in which the well known "selector" and "connector" switches of the two dimension type of the art are employed in conjunction with similarly constructed "line selectors" controlled by "master switches". In such systems the movable contacts, or wipers, of the two dimension switch are associated with a large number of fixed, or passive, contacts arranged in a bank and the wipers are first given a movement in one direction 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. The connections among the different switches will be best understood by discussing a particular case. Thus if one hundred point switches be employed in a ten thousand line exchange system arranged on a basis of ten per cent trunking, there would be one hundred master-switches, one thousand line selectors, one thousand first selectors, one thousand second selectors, and one thousand connectors; each subscriber's line would be multipled to ten line selectors and ten connectors; the lines selectors and first selectors would be united in pairs without multipling; the wipers of the second selectors would be multipled to the bank contacts of one hundred first selectors and the wipers of each connector would be multipled to the bank contacts of one hundred second selectors. Obviously with different assumptions, values differing from the above would be used, but this specific example will suffice to indicate the character of the system to which my invention belongs. The present application is a divisional application of my application for Letters Patent, Serial No. 389,180, filed August 19, 1907, Patent No. 1,257,283, Feb. 19, 1918.

Another object of my invention is to devise a novel arrangement by which the different parties on a party-line may be selectively signalled by means of code ringing apparatus. I have devised a novel circuit arrangement, operating in conjunction with a ringing machine having different impulse wheels arranged to make and break the ringing generator current according to the code selected.

A further object of my invention is to provide means for insuring that the signalled substation will receive the full selected code, that is, that the signal for the called substation will always begin at the beginning of the code ring.

Another object of the invention is to extend this simplification of structures to all commercial adaptations of the straight automatic system so as to include trunking between exchange, "nickel-in-the-slot" service, measured service, party line service of different kinds, as well as unlimited service.

Still another object of the invention is to devise a novel arrangement of electrical connections between the switches whereby the chances of the calling line finding an idle trunk through which to extend its circuits are greatly increased.

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 drawing, and the scope of the invention will be particularly pointed out in the appended claims.

Before referring to the drawings, it may be noted that in developing the invention along the lines indicated, many features have been devised which are capable of use in other relations than those herein indicated and in various telephone systems including manual systems and semi-automatic systems as well as straight automatic systems.

Referring to the drawings, Fig. 1, which is the principal figure and includes parts 1, 2 and 3, illustrates diagrammatically an automatic telephone system embodying cer-

tain features of the present invention; Fig. 2 illustrates a trunking circuit provided with a repeater and designed to connect exchanges located at some distance from each other; Figs. 3 and 4 illustrate modified connector circuits, the latter being arranged to automatically select one of a number of trunks running to a given private exchange, or to a group of telephones having a single calling number; Figs. 5, 6 and 7 illustrate connector circuits designed for use with party lines, the latter illustrating in addition a four-party subscribers' line; Fig. 8 illustrates a modified "slot" service substation and line circuit; Fig. 9 illustrates a novel method of interconnecting and trunking between switches by which the chances of a calling party obtaining a desired connection are increased; Figs. 10, 11 and 12 are elevations of a line selector viewed from different sides, the switch being also typical of the other selectors and the connectors employed in the system; Fig. 13 is a plan view of said switch; Fig. 14 is a sectional plan of a portion of the same taken on a plane indicated by the line 14—14 of Fig. 11; Fig. 15 is a detail view of certain connector off-normal contacts; Figs. 16 and 17 are front and side elevations of a master-switch employed in the control of the line selectors; Figs. 18 and 19 are front and sectional elevations, respectively, of a ringing machine employed in connection with certain of the party line circuits; Figs. 20 and 21 are front and rear elevations, respectively, of meter mechanism employed for measured service; and Figs. 22 and 23 are front and side elevations respectively, of a ringing switch employed for party line use. Throughout these views like characters refer to like parts.

Main System.

Apparatus.

Referring to the drawing, and more particularly for the present to Fig. 1, which may be considered the main diagram, M at the left of the diagram designates a subscriber's station provided with "slot" equipment and united to the main exchange by the line limbs P and S which terminate in multiple contacts of line connectors and line selectors. At the opposite end of the diagram, N designates a subscriber's equipment which is not designed for "slot" service and which is similarly united by line limbs P^1—S^1 to the exchange and the line limbs are similarly connected to the multiple contacts of connectors and line selectors. Connection is obtained between the line at the left and the line at the right through the agency of a master-switch O, a line selector Q, a first selector U, a second selector V and a connector W. Assuming that the selectors and connectors employed in establishing this connection are provided with one hundred bank contacts, and assuming that there are ten thousand lines in the exchange arranged on a basis of ten per cent trunking, then, the number of switches and their multiple arrangement heretofore outlined will exist. In such case there would be 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 of one hundred, and ten line selecting switches would be assigned to each group, thus enabling each line to be multipled to the corresponding bank contacts on ten different line selectors. Each group of line selectors would be under the control of one master-switch, having a pair of bank contacts assigned to each line selector. Each subscriber's line would also be multipled to the corresponding bank contacts of ten connectors. In the diagram, only two of the ten sets of multiple contacts of the line selectors and connectors are illustrated, while but five pairs of bank contacts of the master-switch are shown. The movable contacts, or wipers, of each line selecting switch Q are tied to the corresponding wipers of a first selector U, thus providing one thousand direct connections between the one thousand line selectors and the one thousand first selectors. The wipers of the second selectors are multiply connected to the bank contacts of the first selectors, and since there are a thousand of each of these switches, the wipers of each second selector are connected to the corresponding contacts of one hundred first selectors. Similarly, the wipers of each of the thousand connectors are connected to the corresponding contacts of one hundred second selectors. As previously indicated, this apportionment of values may be varied at will to suit the exigencies of any particular case.

In the operation of the parts in establishing connection between substations M and N, the calling party at substation M removes his receiver from its hook and thereby, through the agency of the master-switch O sets an idle line selector Q in operation to automatically seek out and establish connection with his line, thus extending the calling line circuit to the first selector U paired with the actuated line selector Q. The calling party then, by means of his calling mechanism, transmits a number of impulses corresponding to the digits of the number of the subscriber wanted. The first series of these impulses operates the connected first selector U so as to cause it to pick out an idle second selector V associated with the thousand group to which

the called line belongs. Thus, if the number of the calling party were two thousand some odd, the first set of two impulses would move the wipers of the first selector to the second group of its bank contacts and would then automatically move the wipers over the contacts in this bank until an idle contact was encountered, thereby extending the circuit of the calling party to an idle second selector in the second thousand group. The second series of impulses would similarly operate the second selector V to pick out and establish connection with a connector associated with the hundreds group to which the called line belongs. Thus if three impulses were transmitted over the circuit, the second selector V would move its wipers to the third group of its bank contacts and the wipers would then automatically move over the contacts in this bank until an idle one was selected, thereby extending the circuit of the calling line to a connector having access to the called line. The third series of impulses would cause the connector to move its wipers to that group of ten contacts in which the contacts of the called line were included, and the final series of impulses would cause the wiper to move over the contacts in this group until the contacts corresponding to the called line were encountered, thus completing the 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 a circuit through the master-switch O upon the initiation of a call, and a cut-off relay CO which is used to destroy the normal substation control of the line relay and to otherwise vary the line connections.

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

The line selector includes the wipers 26, 27, 28 and 29 co-operating with bank contacts 30, 31, 32, 33 and, where the meter mechanism X is used, with an additional wiper 34 co-operating with bank contacts 35 as will appear from Figs. 9 to 13 inclusive, described more fully hereinafter. Wipers 26, 27, 28 and 34 partake of the two movements of the switch, that is, the primary and secondary movements, while wiper 29 partakes only of the primary movement. The primary movement of the wipers is brought about by primary magnet PM controlled by a primary relay PR, and its secondary movement is similarly brought about by a secondary magnet SM controlled by a secondary relay SR, while the release of the switch, which permits it to return to its normal position, is brought about by a release magnet RM controlled by a release relay RR. The switch is also provided with primary and secondary off-normal contacts PO and SO which are operated respectively upon the first primary and the first secondary movements of the switch. Although each subscriber's line is multiply connected to ten line selectors and ten connectors, two such multiple connections only are shown in the drawing wherein bank contacts 30^1, 31^1, 32^1 and 33^1 and co-operating wipers 26^1, 27^1, 28^1, and 29^1 belong to a second line selector and contacts 36, 36^1, 37, 37^1, 38 and 38^1 are bank contacts of two connectors.

The first selector U includes the wipers 39, 40, 41 which co-operate with bank contacts 42, 43, 44 in response to the operation of the primary magnet PM^1, controlled by the primary relay PR^1, and the secondary magnet SM^1, controlled by the secondary relays SR^1 and S^1R^1. The wipers in this case all partake of the primary and secondary movements and the switch is released through the operation of the release magnet RM^1 and the release relay RR^1. The primary off-normal contacts PO^1 and secondary off-normal contacts SO^1 here, as before are operated upon the first primary and secondary movements of the wipers respectively. The circuit associated with this selector also includes a reversing relay RV for reversing the direction of current supplied to the calling line and an associated relay 45, all of which will be more fully understood from the subsequent description.

The second selector V comprises wipers 46, 47, 48 which co-operate with bank contacts 49, 50, 51 in the same manner as the first selector U. In this case, the corresponding relay, magnets and off-normal contacts are designated by corresponding reference characters having the exponent 2 instead of 1.

The connector W is provided with wipers 52, 53, 54 co-operating with bank contacts 55, 56, 57 and in this instance as before, they partake of both primary and secondary movements in response to the operations of the primary magnet PM^2 and the secondary magnet SM^2, respectively, and return to normal upon the operation of release relay RR^2 and release magnet RM^2. In this instance, the primary off-normal switch contacts are designated PO^2 and the secondary off-normal switch contacts SO^2. In addition to these parts, the circuit is provided with a busy relay BR, a ringing relay RG, a control relay R, a tip relay TR, a "flip-flop" relay FF, and a closing relay CR, all of which co-operate in the manner hereinafter more fully set forth.

As in the case of the line P—S, the line P^1—S^1 is provided with a cut-off relay CO and a line relay LR.

In this figure I have also illustrated mechanism for recording the completed connection over each calling line. One of these mechanisms is associated with each line selector O and comprises a printing magnet 58, a type wheel 59, actuated by a motor magnet MM¹ controlled by relays 60, 61 and wiper 62 rotated with the type wheel 59 and co-operating with bank contacts 63 of which there is a number equal to the number of contacts 35 on the line selectors.

The equipment at substation M includes the usual switch hook 64, receiver 65, call-bell 66, transmitter 67, calling mechanism 68, and "slot" mechanism 69 including a polarized relay 70. The equipment at substation N differs from that at substation M by omitting the "slot" mechanism 69.

Obviously, the various subscribers' lines entering the exchange will be distributed through the agency of a distributing board which I have indicated at the points designated D—B. Many different methods of distributing may be employed, but I preferably distribute the line limbs and the connections with the three sets of connector contacts, as clearly illustrated in the drawing.

Operation.

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

Assuming that a party at substation M desires to converse with a party at substation N and assuming that the number of the latter's telephone is 3456, then the calling party first removes his receiver 65 from its hook 64 and thereby establishes a circuit which may be traced from the live, or negative, pole of the battery B¹ through resistance 71, closed contact 76 of cut-off relay CO, line limb S, closed contact 75, the winding of lock controlling magnet 74, switch-hook 64, transmitter 67, closed contact 73, line limb P, normal contact 72 of cut-off relay CO, normal contact 77 of line relay LR, and the winding of said relay to the grounded or return side of the battery. The resulting movement of the contact 77 to its alternate position closes a new energizing circuit for the line relay LR which may be traced from the live, or negative, pole of the battery B¹ through the wniding of relay 24 of the master-switch O, closed contact 78 of cut-off relay CO and alternate contact 77 of line relay LR through the winding of said relay to ground. The closing of this circuit continues the energization of the line relay and actuates relay 24 so as to close its contact 79 to complete a starting circuit for one of the line selectors Q, as will be hereinafter explained. The movement of contact 80 of line relay LR, removes the normal ground connection from the contacts 30—30¹ corresponding to the calling line, this ground connection normally existing through normal contact 81 of cut-off relay CO and normal contact 80 of line relay LR. In addition to the removal of this ground which establishes that condition which will cause the line selector wipers to stop in engagement with the contacts of the line after they have been moved to the desired group, the actuated contact 80 of the line relay, grounds the winding of relay 82, which, upon being energized, opens its contact 83 to remove the normal ground from those contacts 33—33¹, etc., which correspond to the group of contacts in which those of the calling line are located, thereby establishing that condition which will cause the line selector to stop its primary movement at the proper group of bank contacts. The contact 84 of the line relay upon being attracted, destroys the normal battery connection through the winding of the cut-off relay CO to the contacts 36—36¹, etc., of the connectors to which the line P—S is connected, and substitutes a ground connection therefor. As will be hereinafter explained, the normal battery connection to these contacts permits connection to be made to the line P—S as a called line, while the ground connection renders the said line busy to incoming calls.

The master-switch wipers 20—21 are brought, after each operation of a line selector Q, into engagement with contacts 22—23 assigned to an idle line selector as will be hereinafter explained. Thus, as soon as relay 24 is energized, a starting circuit for such line selector is completed by the closing of battery B¹ through the winding of primary relay PR, primary off-normal contact 85, contacts 22—20, closed contact 79, and normal contact 86 to ground, thus energizing primary relay PR to actuate its contacts and thereby complete a circuit from the live pole of the alternating current generator 87 through the winding of primary magnet PM and alternate contact 88 of primary relay PR to ground, thus causing the wipers 26, 27, 28, 29 and 34 to move in a primary direction. The said group relay 82 has its winding connected to a plurality of alternate contacts 80, as indicated by the symbol ⅄ (which sign serves throughout the drawing to indicate a common connecting point), on as many different line relays LR. Thus, in the example chosen, there would be one hundred line relays and ten group relays for a group of one hundred calling lines. Each group

relay would then be connected to ten different line relays. Each of the ten bank contacts 33 therefore corresponds to a different sub-group of ten calling lines. Since the primary off-normal contacts PO are actuated upon the first primary movement of the switch wipers, the initial energizing circuit of the primary relay PR is interrupted, but in the meantime the closing of contact 89 of said relay has completed a new path through wiper 29 which is maintained so long as said wiper engages grounded contacts 33. The end of the wiper 29 is preferably made broad enough to bridge adjacent contacts so that it will not pass out of engagement with one contact before engaging with the next, thus insuring a circuit at all times except when an ungrounded contact 33 is engaged. It should also be noted that although the wiper 29 is normally out of engagement with contact 33, it engages said contact at the time the primary off-normal contact 85 breaks, thus insuring a suitable circuit for the relay PR until the wipers have been moved to that group of bank contacts which included the contacts assigned to the calling line. Just as soon as this group of contacts is reached, the primary movement of the switch wipers will be discontinued and the contacts 88—89 of relay PR will return to normal. The return of contact 88 will immediately energize the secondary relay SR over a circuit extending from the live pole of battery B^1 through the winding of said relay, a secondary off-normal contact 90, primary off-normal contact 91, which is closed at this time, and closed contact 88 to ground. The movement of contact 92 of relay SR to its alternate position, will at once close an energizing circuit for the secondary magnet SM extending from the live pole of the alternating current generator 93 through the winding of the secondary magnet, alternate contact 92, and normal contact 94 of release relay RR to ground. The resulting repeated energizations and de-energizations of the secondary magnet will cause the switch wipers 26, 27, 28 and 34 to move in a secondary direction over the contacts 30, 31, 32 and 35, respectively, of that group of bank contacts including the contacts of the calling line. Since upon the first secondary movement the contacts of the secondary off-normal switch SO are actuated, the initial energizing circuit of the relay SR will be interrupted but in the meantime the closing of its contact 95 will provide a new path through normal contact 96 of release magnet RM to wiper 26, and thence to ground so long as said wiper engages a grounded contact 30. It will be noted in this case as in the case of wiper 29 that the end of the wiper is preferably made broad enough to bridge the space between adjacent contacts and that although normally out of engagement with the nearest bank contact, it will engage said contact by the time the secondary off-normal contacts are moved from normal. Thus, the secondary movement of the switch wipers will continue until wiper 26 engages an ungrounded contact. Since the contact 30 corresponding to the calling line has been ungrounded as previously pointed out, the wipers will be stopped in engagement with the contacts corresponding to said line. Since other subscribers' lines are multiply connected to contacts over which the wipers 27—28 pass during this secondary movement, and since conversation may be going on over a connection including said contacts, the relay SR is arranged to electrically disconnect the wipers 27—28 from other parts during this secondary movement. This is brought about by contacts 96^1—97, which in their normal positions, join the adjacent portions of the strands or conductors L—L^1, but when actuated, separate them, thus disconnecting the said wipers from other parts. Thus, as soon as the wiper 26 engages an ungrounded contact 30, the relay SR is de-energized and the contacts 92, 95, 96^1, 97 return to their normal positions thereby discontinuing the further secondary movements of the wipers and restoring the normal connections of the wipers 27—28. The contacts 96^1—97 of relay SR when in their alternate positions connect the right-hand portions of the strands L—L^1 by a bridge which includes alternate contact 96^1, closed contact 98 of release relay RR and alternate contact 97. The same portions of the strands L—L^1 are united by a bridge including normal contacts 99—100 of reverse relay RV, windings of primary and secondary relays PR^1 and SR^1 and batteries b—b^1. These batteries being arranged in series, supply current over a circuit including both of these bridges and thereby energize relays PR^1 and SR^1 to actuate their contacts. This prevents the possible closing of the release circuit (when the secondary off-normal contacts SO are actuated) from battery B^1 through the winding of release relay RR, closed contact 101, contacts 102—103 of relays PR^1 and SR^1 and the winding of release relay RR^1 of the first selector U to ground.

The restoration of the contact 92 to normal, since the contact 104 of the secondary off-normal switch SO is now closed, immediately completes a circuit which is instrumental in causing the movement of the master-switch O to engage contacts of an idle line selector. This circuit extends from ground at contact 94 of release relay RR through said normal contact 92, closed contact 104, contacts 23—21 of the master-switch, and winding of relay 25 to the live

pole of battery B^1, thus energizing said relay to move its contact 86 to its alternate position and thereby close an energizing circuit for the motor magnet MM which includes the alternating current generator 105. Due to the mechanical relation of the parts, the energization and de-energization of this magnet will step the wipers 20—21 into engagement with the next pair of bank contacts. If the line selector corresponding to this pair is in use, there exists a ground at one point or another, as will be explained, on the corresponding contact 23 which will maintain the relay 25 energized and thereby maintain the circuit for the motor magnet. As soon, however, as an ungrounded contact 23 is encountered, this energizing circuit for relay 25 will be interrupted. Contact 23 corresponding to a busy line selector will always be grounded, while that corresponding to an idle line selector will be ungrounded, thus insuring the stopping of the master-switch with its wipers in engagement with contacts corresponding to an idle line selector. The ground connection with the contact 23 may exist over the path just traced including contacts 104, 92, 94, or by way of alternate contact 96, alternate contact 95, closed contact 90, closed contact 91 and alternate contact 88 to ground. Or the said ground may be maintained through the off-normal contact 126^2 of the primary off-normal switch PO^1 of the first selector U, or at other times through closed contact 178 of the reversing relay RV and closed contact 174 of relay 45.

As soon as the secondary relay SR of the line selector has been de-energized, and the adjacent portions of the conducting strands L—L^1 united, there are at once established circuits for the primary and secondary relays PR^1 and SR^1 in lieu of that previously traced through the alternate contacts 96^1—97 of relay SR. Thus a circuit extends from the live, or negative, pole of battery B^1 through the winding of the cut-off relay CO, contact 106—107 of said relay, bank contacts 31, wiper 27, strand L, normal contact 99 of reversing relay RV, winding of primary relay PR^1 to the live, or positive, pole of grounded battery *b*. At the same time, a circuit is completed from the live, or negative, pole of battery b^1 through the winding of secondary relay SR^1, normal contact 100 of reversing relay RV, strand L^1 including contact 97, wiper 28, contact 32, line limb S, via normal contact 76 and coil 71 to the negative pole of battery B^1 prior to the operation of cut-off relay CO and immediately subsequent thereto, over line limb S, contact 75, lock magnet 74, switch-hook 64, transmitter 67, contact 73, line limb P, including alternate contact 72 of cut-off relay CO, contact 31, wiper 27, link strand L, including contact 96^1, normal contact 99 of reversing relay RV, the winding of primary relay PR^1 to the positive pole of battery *b*. The closing of these circuits maintains the relays PR^1 and SR^1 energized, and in addition energizes the cut-off relay CO and the lock-controlling magnet 74 associated with the calling line. The movement of contact 72 of the cut-off relay to its alternate position continues line limb P to contacts 31—31^1 and interrupts the initial energizing circuit of the line relay LR and thus destroys the normal substation control of said relay. The opening of its contact 78 likewise interrupts the circuit established through relay 24 of the master-switch and the line relay. The opening of contact 76 interrupts the normal connection of battery B^1 to the line limb S. The subscriber's circuit is thus completed over the heavily marked lines to the sections of the strands L—L^1 lying beyond the condensers 108—109. The movement of contact 81 interrupts the path for current over the strand L through the cut-off relay CO, but before said circuit is interrupted, a new circuit is provided for the cut-off relay CO, which extends from battery B^1 through the winding of cut-off relay, contacts 107, 81, engaged contact 30, wiper 26, normal contacts 96 and 95, and winding of relay 61 of the meter mechanism X, to ground. Thus, the cut-off relay CO is maintained energized. The guarding circuit to ground for the line selector contacts 30, 30^1, etc., and for the connector contacts 36, 36^1, etc., is now furnished through said relay 61 as follows:—from contacts 36 via normal contact 84, alternate contact 81 and said contacts 30, 30^1, etc., and thence to ground through said relay 61 over the circuit previously traced for holding the cut-off relay CO energized. Upon closing this circuit the meter mechanism X is set in operation to move its wiper 62 and the rigidly connected type wheel 59 to that position corresponding to the calling line P—S. This is brought about by the energization of relay 61, which completes a circuit for the motor magnet MM^1 extending from the live pole of the alternating current generator 109 through the winding of said motor magnet, closed contact 110 of relay 61 and closed contact 111 of relay 60 to ground. The wiper 62 is thus moved over the bank contacts 63 which are equal in number to the line selector bank contact 35. These contacts are preferably arranged in a circle so that the wiper 62 need have but a simple rotary motion. Corresponding contacts 35 and 63 are electrically connected and since wipers 34 and 26 are connected, there exists at this time a potential at the contact 63 corresponding to the calling line, which will be above that of ground and, consequently, as soon as wiper 62 in its movement engages this contact 63, a circuit will be completed

from contact 63, through wiper 62, winding of relay 60 and closed contact 61^1 of relay 61 to ground, whereby relay 60 will be energized and its contact 111 opened to thereby interrupt the circuit of the motor magnet MM^1 and thus discontinue further movement of the wiper. By means of contact 61^1, the ground connection with wiper 62, and thence to contacts 63, 35 and 30 of the particular switch in use, is removed upon the release of the switch and subsequent improper operation, due to the presence of such a ground, is thereby prevented. From this it will be seen that the wiper 62 and the type wheel 59 are moved to a definite position corresponding to that of the calling line and left in that position. As will appear more fully hereinafter, as soon as the desired connection with the line P^1—S^1 is complete, the printing magnet 58 will be energized and there will be placed on a recording sheet a type impression corresponding to the calling line, as for example, the number of the calling line. The disconnection, and consequent de-energization, of line relay LR causes the release of the group relay 82 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 82 will restore the ground via contact 83 to bank contact 33 and to the 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 such relay 24 will prevent the starting of another line selector when the master-switch steps its wipers 20—21 around to engage the bank contacts corresponding to the next idle line selector.

With the parts in this position, then it remains for the calling party to operate his calling mechanism 68 to send the necessary impulses to extend his circuit to that of the called line. The calling mechanism is diagrammatically represented by a disk having a number of teeth adapted to engage a spring 73 to cause it to break contact upon the return of the disk due to its return spring 112, and a single tooth similarly cooperating with contact spring 75 to cause it to open its contact after the contact 73 has completed its interruptions. The disk is also provided with a pin which engages a spring contact 113 to hold it out of engagement with a similar spring contact 114 and a grounded contact 115. The disk is normally locked by means of a hook 116 arranged to engage a notch in the disk and normally held in engaging position by a spring and moved out of engaging position by the energizations of the magnet 74. In operation, the disk is moved against the tension of the return spring until a definite number of teeth have passed below the spring 73, and is then allowed to return to normal with the resulting breaking of contacts 73 and 75. Were substation M equipped in the same manner as substation N, that is without the slot mechanism 69, the calling party would now be free to operate his dial to send the necessary impulses. In the present instance, however, any break which might be made by contact 73 would be bridged by normal contact 116^1 of the "slot" mechanism so that there would be no resulting interruption of the line limb P as would be necessary to cause the operation of the connected first selector; consequently it is necessary for the calling party to deposit a "nickel" or other token in the slot of the slot mechanism 69. When this is done, the contact 116^1 is forced by the token to its alternate position. This is accomplished in the present instance by having a suitable projection from the contact 116^1 extend into the slot. As indicated upon the lower portion of the substation diagram, the pivoted end of the switch-hook is provided with an upward projection 117 which engages the lower end of a pivoted arm 118 which is adapted to be moved in the slot in order to determine the disposal of the token. When the receiver 65 is first removed from its hook, the projection 117 allows the arm 118 to move to an intermediate position under the pressure of a spring 119 carried by the arm 118 and bearing against the armature 120 of the polarized relay 70, which in normal position bears against a fixed stop. In case the connection is completed, the polarized relay is energized by a reversal of current, caused by the operation of the reversing relay RV, to throw the upper end of the arm 118 to the left to collect the token by allowing it to pass downward through the right-hand outlet of the slot, into a suitable receptacle. In case the desired connection is not completed, the token is returned upon the restoration of the receiver to its hook which forces the arm 118 to the right to the position indicated in the diagram, thereby allowing the token to pass out of the left-hand outlet of the slot into a suitable holder from which it may be taken by the calling party.

Assuming now that the calling party has deposited his token and thereby interrupted a bridge about the contact 73, he will be at liberty to operate his calling mechanism in accordance with the number of the tele-

phone with which connection is desired which has been assumed to be No. 3456. The calling party will therefore now rotate his dial far enough to bring three teeth below the contact 73 and will then release the same to allow it to return to its normal position and he will follow this operation by similar operations in which he will rotate the dial sufficiently to bring, next, four teeth, then five teeth, and then six teeth, below the spring contact 73. Considering only the effect of the first operation, it will be noted that as soon as the dial is removed from normal, contact spring 73 will be grounded through contacts 113—114—115; and while this ground remains, the primary relay PR^1 will be energized from the battery *b* over the strand L, line limb P, through contact 73 to this ground at the substation, while secondary relay SR^1 will be energized from battery b^1 over the strand L^1, line limb S, and contact 75 to this same ground. Consequently, the three resulting breaks and makes of the contact 73 will cause three de-energizations of the primary relay PR^1, and the single following break and make of the contact 75 will cause a single de-energization of the secondary relay SR^1. An inspection of the contacts 121, 122, 123, 124 of the primary and secondary relays PR^1 and SR^1 will show that the three de-energizations of the primary relay PR^1 will cause the section of the strand L to the right of the condenser 108 to be grounded three times, while the single de-energization of the secondary relay SR^1 will cause the section of the strand L^1 to the right of condenser 109 to be grounded once. While relays PR^1 and SR^1 are energized, these sections of the strands are not grounded by reason of the open contact 122 in one case, and the open contact 124 in the other. From this, it will be seen that the passage of each tooth past the contact 73 has the effect of producing a momentary ground upon the section of the strand L to the right of condenser 108, and each movement of the single tooth past contact 75 has the effect of producing a single momentary ground upon the section of the strand L^1 to the right of condenser 109. Thus the grounding of the strand L three times has the effect of producing three distinct energizations of the primary magnet PM^1 of the first selector, the circuit being from the live pole of the battery B^2 through the winding of said magnet, closed contact 125 of the secondary off-normal switch SO^1 and strand L to ground. These three energizations will cause the wipers 39, 40, 41, to move to the third group of bank contacts 42, 43, 44. Upon the first movement in this direction, the primary off-normal contacts PO^1 will be closed. Consequently, upon the subsequent grounding of strand L^1, secondary relay S^1R^1 will be energized over a circuit extending from the live pole of the battery B^2 through the winding of said relay, closed primary off-normal contact 126, closed secondary off-normal contact 127 and strand L^1 to ground. The energization of relay S^1R^1 will open its contacts 128—129 to disconnect the wipers 40—41 to prevent interference with possible conversation over multiply connected bank contacts in the manner heretofore pointed out in describing the line selector. The closing of contact 130 of relay S^1R^1 will energize secondary magnet SM^1 by closing a circuit extending from the live pole of alternating current generator 131 through the winding of said magnet, normal contact 132 of release relay RR^1 and closed contact 130 of relay S^1R^1 to ground. Due to the mechanical relation of the parts, the repeated energizations and de-energizations of the secondary magnet will cause the wipers to move in their secondary direction. Upon their first step in this direction, secondary off-normal contacts SO^1 will be opened, thus interrupting previous circuits for the primary magnet PM^1 and the secondary relay S^1R^1. In the meantime, the movement of contact 133 to its alternate position provides a substitute energizing circuit for relay S^1R^1 which extends via said contact, normal contact 134 of release relay RR^1 and closed contact 135 of release magnet RM^1 to wiper 39 and thence to ground so long as said wiper engages grounded contacts 42. In this case, as in the case of wipers 26 and 29, the end of the wiper is made sufficiently broad to engage a new contact 42 before disengaging a previous contact 42. In case the encountered contact 42 is that of a busy second selector V, its ground connection will extend over a wiper 39 of another first selector, through its closed contact 135 and normal contacts 134—133. This secondary movement of the selector will continue until an ungrounded contact 42 is encountered, whereupon the selector will stop. As soon as this happens, relay S^1R^1 will be de-energized with a resulting connection of the wipers 40—41 to the strands L—L^1, a resulting interruption of the secondary magnet circuit, and the restoration of ground to the wiper 39 and to multiply connected bank contacts 42, thus rendering the selected second selector busy to other seeking first selectors. Thus, by this operation of the calling mechanism, the circuit of the calling line is extended to a second selector of the third thousand group.

The next step in the operation consists in operating the calling device to first ground the strand L four times, following this by a single grounding of the strand L^1 through the agency of the primary and secondary relays PR^1 and SR^1, as heretofore. The operation of the second selector in response

to these impulses is substantially the same as that of the first selector just described. The grounding of the strand L four times causes four distinct energizations of the primary magnet PM^2 to cause the wipers 46, 47, 48 to advance to the fourth group of bank contacts 49, 50, 51, and the single grounding of the strand L^1, through the agency of the secondary relay SR^2 and secondary magnet SM^2, starts the wipers over the contacts in this group of bank contacts, and this secondary movement of the wipers is continued until an idle contact is encountered. The circuit for the primary magnet extends from the live pole of battery B^2 through the winding of said magnet, secondary off-normal contact 136, contacts 43—40, 128, and strand L to ground via contacts 122—123. The initial energizing circuit for the secondary relay SR^2 extends from the live pole of the battery B^2 through the winding of said relay, closed primary off-normal contact 137 (closed upon the first primary movement of the switch), and closed secondary off-normal contact 138, contacts 44—41, 129, and strand L^1 to ground via contact 124—121. A maintaining circuit is then established for the relay SR^2 by way of its closed contact 139, closed contact 140 of release magnet RM^2 to wiper 46 and contact 49 to ground as long as grounded contacts are encountered. The ground connection, as in the case of the first selector, is obtained by way of a multiple contact 49, a wiper 46 of some other second selector V engaging said contact, closed contact 140 and normal contacts 141—142 of said other second selector. The circuit of the secondary magnet similarly runs from the live pole of an alternating current generator 143, through the winding of said magnet, normal contact 144 of release relay RR^2 and alternate contact 142 to ground. The wipers 47—48 are also disconnected during the secondary movement by contacts 145—146 of the secondary relay SR^2. Thus, as a result of the transmission of the four impulses, the circuit of the calling line is extending to a connector having access to the fourth hundred group of the third thousand subscribers' lines.

The next step in the operation consists in grounding the strand L five times, followed by a single grounding of the strand L^1, through the agency of the primary and secondary relays PR^2 and SR^2 as before. The grounding of the strand L five times causes five distinct energizations of the primary magnet PM^3 which, due to the mechanical construction of the parts, causes the connected wipers 52, 53, 54, to be moved to the fifth group of bank contacts 55, 56, 57. The energizing circuit for the primary magnet extends from the live pole of the battery B^2 through the winding of said magnet, contact 147 of the secondary off-normal switch SO^3, contacts 50—47, closed contact 145, contacts 43—40, closed contact 128 and strand L to ground. On the first primary movement, as usual, the primary off-normal contacts PO^3 are closed and consequently upon the single grounding of the strand L^1, a circuit is completed through the winding of secondary magnet SM^3, which may be traced from the live pole of battery B^3, through the winding of said magnet, contact 148 of the primary off-normal switch PO^3, contact 149 of the secondary off-normal switch SO^3, contacts 51—48, closed contact 146, contacts 44—41, closed contact 129 and strand L^1 to ground. In the construction of the connector, the wipers are located two steps distant from the first set of bank contacts, and the resulting single momentary energization of secondary magnet SM^3 is instrumental in stepping these wipers one step nearer the said bank contacts; and, due to the spacing of the contacts of the secondary off-normal switch SO^3, this first secondary step of the wipers causes contact 147 of off-normal switch SO^3 to move to its alternate position and causes contact 149 of said switch to move out of engagement with its normal contact, but not into engagement with its alternate contact, the latter movement being performed by the next secondary step of the wipers.

The next step in the operation consists in grounding the strand L six times, followed by a single grounding of the strand L^1. Due to the position of the contact 147, the grounding of the strand L six times causes six distinct energizations of the secondary magnet SM^3 over a circuit extending from the live pole of battery B^3 through the winding of said magnet, closed contact 150 of relay R, alternate contact 147, contacts 50—47, and so on over the heavily marked path to ground at strand L. The first energization of the magnet SM^3 steps the wipers into engagement with the first set of bank contacts in the desired group and moves contact 149 to its alternate position. The six distinct energizations therefore move the wipers into engagement with the sixth set of bank contacts in the particular selected group and these are the bank contacts of the line S^1P^1. Thus a complete connection is established from the substation M over the heavily marked circuit to the substation N, except that the strands L^2—L^3 are interrupted at the relay CR which I may term a "closing" relay.

Called line idle.

It will be noted that the above connection is completed without the application of the final ground to the strand L^1. When this is applied, a circuit is completed through the lower winding of the relay BR, which, for

convenience, I may term a "busy" relay because part of its function is to apply the "busy" signal to the calling line. The energizing circuit for this relay extends from the live pole of the battery B^3 through the lower winding of said relay, closed contact 151 of relay R, alternate contact 149, contacts 51—48 and thence over the lower heavily marked path to strand L^1 and ground. This energization of the relay BR is momentary only. If it be assumed that the called line S^1 P^1 is idle, then there will be a potential at the contacts 55 equal to that of battery B^3, due to the connection of the cut-off relay and normal contact 84 of the line relay, and consequently the movement of contact 152 of relay BR to its alternate position will not be instrumental in maintaining said relay energized, since battery opposes battery over the resulting circuit. However, a circuit will be completed from the live pole of battery B^3 through the winding of relay R, momentarily closed contact 153 of relay BR and normal contact 154 of released relay RR^3 to ground. The energization of relay R will open contacts 150 and 151 to disconnect the secondary magnet SM^3 and the lower winding of relay BR from strands L^2—L^3 respectively. At the same time, it will close contacts 154^1—155, by the latter completing a locking circuit through the same grounded contact 154 of the release relay, and, by the former, completing a circuit for relay RG, which I may term a "ringing" relay because of its control over the application of ringing current to the called line. This circuit may be traced from the live pole of the battery B^3 through the winding of cut-off relay CO, normal contact 84 of line relay LR, contacts 55—52, normal contact 152 of relay BR, closed contact 154^1 of relay R, and the winding of ringing relay RG to ground. At this point, it may be noted that where the "slot" mechanism is omitted at the substation, as is the case at substation N, there is no need of a battery corresponding to battery B^1 of the calling line, and the line instead may be normally connected to the battery B^3 corresponding to the battery B^1 of the calling line. The energization of this relay will close a circuit extending from ground through closed contact 157, closed contact 158 of relay CR, winding of "flip-flop" relay FF to the live pole of the battery B^3. By the closing of contact 159 of "ringing" relay RG, a connection is completed from wiper 54 through contact 160 of flip-flop relay FF, closed contact 159 and winding of tip relay TR to ground. The closing of contact 161 of relay RG completes a connection between the live pole of battery B^3 and wiper 53, which includes an impedance coil 162. Due to the presence of the interrupter 156 in the circuit of the flip-flop relay FF, said relay is repeatedly energized and de-energized; and due to the connection of its contacts, alternately connects the tip relay TR and the ringing generator 163 to the wiper 54. Thus intermittently, ringing current is supplied over a circuit extending from the live pole of the generator 163 through alternate contact 160, wiper 54, contact 57, line limb S^1, closed contact 75, condenser 164, switch-hook 64, call-bell 66, closed contact 73, line limb P^1, contact 56, wiper 53, closed contact 161, impedance coil 162 to the live pole of battery B^3. Thus ringing current is intermittently applied to actuate the call-bell 66. As soon as the called party responds by removing his receiver from its hook, he completes a path for battery current through his substation and thereby a current flows from the live pole of the battery B^3 through impedance coil 162, closed contact 161, wiper 53, contact 56, line limb P^1, through the substation, line limb S^1, contact 56, wiper 54 and whenever contact 160 comes into its normal position through said contact, closed contact 159 and winding of tip relay TR to ground. The relay TR is thus energized upon the response of the called party. The resultant opening of its contact 165 prevents a possible circuit through protective resistance 166, contact 167 of relay CR and the winding of release relay RR^3 as soon as relay CR is energized in the subsequent operation. This energization of relay CR is brought about through the other contact 168 of relay TR which closes an energizing circuit for said relay extending from the live pole of the battery B^3 through the relay winding and closed contact 168 to ground. In order that the relay CR may remain energized independently of subsequent manipulations of the called-for party's switch-hook, it is provided with a locking circuit which extends through its contact 169 and normal contact 154 of release relay RR^3. By means of contact 170 of relay CR, a ground connection is provided for the bank contact 49 of the associated second selector. While the relay CR remains de-energized, this path extends from contact 49, through contact 171 of primary off-normal switch PO^3, normal contact 170 and winding of release relay RR^3 to ground. While relay CR remains energized, this ground connection extends directly to ground through its contact 170. By means of the contacts 172 and 173 of relay CR, the wipers 53—54 are disconnected during their selecting movements; and upon the energization of said relay, the talking strands are finally completed at this point.

The response of the called party is also instrumental in operating the printing magnet 58 associated with the line selector and also in collecting the token deposited in the slot mechanism 69 of the calling

party. From the circuit previously traced through impedance coil 162 of the called line and the line limbs, and tip relay TR, it will be seen that as soon as the called party removes his receiver and the relay CR has operated to close its contact 173, there will be a flow of current through the relay 45 associated with reverse relay RV, which may be traced from the live pole of the battery B^2, through the winding of relay 45, alternate contact 124 of relay SR^1 strand L^1, over the lower heavily marked path to strand L^3, thence through wiper 53, contact 56, line limb P^1, through the substation, line limb S^1, contact 57, wiper 54, normal contact 160 of relay FF, closed contact 159 of relay RG, and winding of tip relay TR to ground. Relay 45 will thus be energized and, by closing its contact 174, will cause the energization of reverse relay RV, the circuit for said relay extending from the live pole of the battery B^2, through the winding of said relay and closed contact 174 to ground. The opening of contact 175 of relay 45 will prevent a possible release circuit through release relay RR^1 when the reversing relay RV is energized. As is clear from the cross-connections 176—177, the energization of relay RV disconnects relay PR^1 from strand L and connects it to strand L^1 and similarly disconnects relay SR^1 from strand L^1 and connects it to strand L. Thus the supply of current from the batteries b—b^1 to the substation M is reversed and the polarized relay at the substation is thereby operated in the manner previously described to collect the coin deposited in the slot. As pointed out heretofore, the ground connection with the contact 23 of the master-switch O is obtained through a contact 178 of the reversing relay RV. This relay is also preferably provided with a contact 179 which is adapted to ground one terminal of the printing magnet 58 which is included in circuit with a battery b^3, thereby operating the printing mechanism in the manner heretofore described. Thus it will be seen that the token deposited by the calling party in case slot service is employed, or the record of the call in case measured service is intended, are not completed until the called party has responded to the call.

At this point it may be noted that in case the meter mechanism X is not to be employed, preferably the contact 179 of the reverse relay would be omitted, alternate contact 95 of secondary relay SR of the line selector would be directly to ground instead of to ground through the relay 61, and the wiper 34 would be disconnected from the wiper 26 or wholly omitted, together with the bank contacts 35, from the switch structure. It will also 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-the-slot service. moreover, 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, or one party, lines having limited or measured service. In such cases, the record given by the meter mechanism X is highly desirable. Again there may be certain groups of lines in which all subscribers are provided with slot service; in such case the meter mechanism X may be omitted.

With the parties thus connected, transmission current will be supplied from the batteries b—b^1 to the calling party's transmitter; and to the called party's transmitter from the battery B^3, the latter connection being, as before indicated, from the live pole of the battery through inpedance coil 162 to one side of the circuit, and from the grounded pole of the battery through tip relay TR to the other side of the circuit.

Called line busy.

Now, if it be assumed that the called line is busy by reason of some other connection having been established therewith, then as previously noted, the test contacts 55 would be connected directly to ground. In such event, the final secondary impulse transmitted to the connector would, as before, result in momentarily energizing the relay BR; but said relay would not be allowed to return to normal, but would be held up by reason of the completion of the circuit through the live pole of the battery B^3 through its upper winding, closed contact 152, wiper 52 and contact 55 to ground. In such event, the relay R would be energized as before by reason of the closure of contact 153, but it would not in turn cause the energization of relay RG, since the energizing circuit for this magnet must include normal contact 152. On the other hand, by reason of the closure of contact 180 of relay BR, a busy signal is transmitted to the calling party through the agency of a primary circuit including interrupter 181, one winding of the induction coil 182, and the battery B^3, in association with a secondary circuit including the other winding of said induction coil, a condenser 183, closed contact 180, the upper heavily marked path including line limb P, the receiver and condenser at the substation, line limb S, and the lower heavily marked path to such ground connections as may be found thereon. Due to the characteristic signal produced by the induction in the secondary circuit, the calling party will understand that the de-

sired line is not available to him and will hang up his receiver.

Release.

This leads naturally to the consideration of the release of the various switches employed in establishing a connection. Assuming that the connection has been completed between the substations M and N and conversation has been carried on between these stations, if the calling party at station M first hangs up his receiver, all the switches will be released and restored to normal except the connector W; if then the called party at station N hangs up his receiver, this connector will be released. If, on the other hand, the called party first hangs up his receiver then the first selector U, second selector V and connector W will be released; then as soon as the calling party restores his receiver, the line selector Q will be released. Again, if it be assumed that the line circuit of a calling line has been extended through to the desired called line and the latter is found to be busy, then if the calling party restores his receiver to its hook all the switches will be released and restored to normal. Likewise if at any time in the process of extending the calling subscriber's circuit, he decides not to complete the call, he may restore his receiver to its hook and thereby release all the switches which have thus far been operated and they will be restored to normal.

Considering these releasing operations more in detail, it will be remembered that during conversation the relays PR^1 and SR^1 are maintained continuously energized over the calling line circuit. The restoration of the calling party's receiver to its hook interrupts this energizing circuit and these relays become de-energized, thereby allowing their contacts 102—103 to close, thus completing a release circuit which may be traced from the live pole of battery B^1 through the lower winding of release relay RR, closed contact 101 of secondary off-normal switch SO, said closed contacts 102—103, and the winding of release relay RR^1 of the first selector U to ground. The closing of this circuit energizes both release relays RR and RR^1. The former by closing its contact 134 completes a locking circuit extending through its upper winding, closed contact 91 of the primary off-normal switch PO and normal contact 88 to ground. This connection to ground from the contact 184 also causes the energization of release magnet RM which, due to the mechanical construction of the parts, releases the switch wipers and other parts and allows them to return to normal under the action of its returning springs. In order that the wipers 27 and 28 may be disconnected from other parts while returning over bank contacts 31 and 32 multiply connected to other switches, the relay SR is energized during this return movement. This energizing circuit extends from the live pole of battery B^1 through the winding of said relay, alternate contact 90 and alternate contact 94 of release relay RR to ground. The locking circuit of the release relay RR is maintained until the primary off-normal contact 91 is opened upon the return of the switch to normal. The energizing circuit of relay SR is also maintained until the wipers have completed their return movement in a secondary direction. At this time the circuit is interrupted at contact 90 of the secondary off-normal switch SO. Alternate contact 96 of the release magnet RM is instrumental in placing a ground upon the associated master-switch bank contact 23 to cause the operation of the master-switch in case the release relay RR and release magnet RM are energized upon the line selector selecting the calling line, which would occur if the calling party hung up his receiver before the line seleecor had completed the selection.

The energization of release relay RR^1 of the first selector U, by closing its contact 185, completes a circuit from the live pole of battery B^2 through the winding of relay S^1R^1, closed contact 126 of the primary off-normal switch PO^1, closed contact 185, and winding of release relay RR^1 to ground, thereby maintaining the release relay RR^1 energized, and energizing the secondary relay S^1R^1. The energizing of these relays closes a circuit for the release magnet RM^1 which extends from the live pole of battery B^2 through the winding of said magnet, alternate contact 132 and closed contact 130 to ground. The structure of the parts is such that the energization of this magnet releases the switch and allows its parts to return to normal. The energization of relays S^1R^1 also disconnects the wipers 40—41 during their return movement. The circuit for the relays RR^1 and S^1R^1 is interrupted by primary off-normal contact 126 when the switch has reached its normal position. The release of the first selector U is relayed to the second selector V by the closing of alternate contact 134 over a circuit which extends from the live pole of battery B^2 through protective resistance 186, alternate contact 134, closed contact 135, wiper 39, bank contact 42, closed contact 187 of primary off-normal switch PO^2 of the second selector V and winding of release relay RR^2 of said selector to ground. This circuit is momentary only being interrupted by contact 135 upon the energization of release magnet RM^1.

The energization of release relay RR^2 completes a circuit which may be traced from the live pole of battery B^2 through the winding of secondary relay SR^2, closed primary off-

normal contact 137, closed contact 188 of relay RR^2 through the winding of said relay to ground, thereby maintaining the release relay energized and energizing relay SR^2. The joint energization of these relays, as in the case of the first selector U, completes an energizing circuit for the release magnet RM^2 which may be traced from the live pole of battery B^2 through the winding of said magnet and alternate contacts 144 and 142 to ground. The energization of release magnet, as before, causes the restoration of the switch parts to normal and during this return movement, the energization of the secondary relay SR^2 maintains the wipers disconnected. Upon the return of the switch parts to normal, the contacts of the primary off-normal switch PO^2 are opened and the previously traced circuit of the relays SR^2 and RR^2 interrupted. As before, the release of the second selector V closes a circuit which may be traced from the live pole of battery B^2 through protective resistance 189, alternate contact 141 of relay RR^2, closed contact 140 of release magnet RM^2, wiper 46, bank contact 49, closed contact 171 of primary off-normal switch PO^3, alternate contact 170 to ground. Under the assumption that the calling party has first hung up his receiver, the completion of this circuit does not cause the release of connector W. This release will not occur until the called party at substation N restores his receiver to its hook. Thus it will be seen that if the calling party restores his receiver before the called party, the switches Q, U and V will be restored to normal. Now when the called party hangs up his receiver he will interrupt the circuit over the line limbs by which the tip relay TR was maintained energized, and at once a release circuit will be closed from the live pole of battery B^3 through protective resistance 166, closed contact 165 of relay TR, closed contact 167, through the winding of release relay RR^3 to ground, thereby energizing said relay to cause it to close alternate contact 154 and thereby energize release magnet RM^3, which, due to the mechanical construction of the parts, releases the switch parts and allows them to return to normal. Since during the conversation, relays R and CR were locked up over a circuit including normal contact 154, it will be seen that these relays will be de-energized upon the energization of release relay RR^3, and furthermore, since the cut-off relay CO of the called line and the relay RG are held up over a circuit including contact 154^1 of relay R, this circuit will be interrupted and the cut-off relay and said magnet de-energized and the associated contacts allowed to return to normal. Likewise the return of the wipers to normal will cause a restoration of the primary and secondary off-normal contacts PO^3 and SO^3 to their normal positions. It may also be noted that the de-energization of relay CR is instrumental in interrupting the energizing circuit of the release relay RR^3. Thus all the connector parts are restored to normal.

Now, if it be assumed that the called for line S^1P^1 be busy, then the restoration of the calling party's receiver to its hook will cause a release of the switches Q, U, and V by the closing of the circuits in the manner just described. From the previous description it will be remembered that when the desired called line is busy, the relays BR and R are locked up, the former over a circuit including the wiper 52 and the latter over a circuit including normal contact 154 of release relay RR^3. Under these conditions then the relaying action of the second selector V will not be impotent, as in the case just considered, but a circuit will be completed by the energization of its relay RR^2 which, as before, will extend from the live pole of battery B^2 through protective resistance 189, alternate contact 141, closed contact 140, wiper 46, bank contact 49, closed contact 171 of primary off-normal switch PO^3, and thence, instead of direct to ground, through normal contact 170 and the winding of release relay RR^3 to ground. Thus the release relay is energized with the consequent energization of release magnet RM^3 and restoration of the switch parts, as heretofore described. To give time for this restoration, the release relay RR^3 is locked up over a circuit extending from the live pole of battery B^3 through protective resistance 190, closed contact 191 of primary off-normal switch PO^3, closed contact 192 of release relay RR^3 and the winding of said relay to ground.

Now consider the case in which the called, instead of the calling, party first restores his receiver to its hook. In such event, as heretofore, the circuit of the called line is broken with the consequent de-energization of the tip relay TR, and the connector W is released by the closing of its circuits in the manner heretofore fully described. At this point it will be remembered that the reversing relay RV, by which the polarized relay 70 of the slot mechanism at the calling station M was actuated, is maintained energized during conversation by the continued energization of relay 45 whose energizing circuit extends over one side of the heavily marked circuit, out over one limb of the called line and back over the other, and thence to ground through tip relay TR. Consequently when the called party restores his receiver to its hook, the relay 45 is de-energized. Thus a circuit for the release relay RR^1 is completed. This circuit extends from the live pole of battery

B^2 through protective resistance 193, closed contact 175 of relay 45, closed contact 194 of relay RV, and winding of release relay RR^1 to ground. The energization of this relay is instrumental in causing the release of the first selector U with the subsequent release of the second selector V in the manner heretofore fully described. From this it will be seen that if the called party first restores his receiver to its hook, all the switches employed in the connection are restored to normal except the line selector. This, however, is restored to normal as soon as the calling party interrupts his line circuit by restoring his receiver to its hook. This, as before described, causes the closing of contacts 102 and 103 by relays PR^1 and SR^1 with the consequent energization of release relay RR of the line selector. This as before described, is instrumental in returning the parts of the line selector to normal.

It remains now to consider the effect of the calling party's restoring his receiver to its hook at various times prior to the completion of a connection. Thus for example, if he immediately restores his receiver after having removed it, the effect will be to cause an idle line selector to select the calling party's line and then immediately release and restore all parts to normal. From the previous description it will be seen that the closing of the calling line circuit by the removal of the receiver initially energizes the line relay LR and that this line relay is then locked up over a local circuit independent of the manipulation of the switch hook at the substation. Consequently the conditions which determine the operation of an idle line selector are maintained until such selection is accomplished. As soon as this takes place, however, the primary and secondary relay PR^1 and SR^1 will not be energized, as before described, over the calling line circuit since the immediate restoration of the receiver to its hook has interrupted the energizing circuit for these relays. It therefore follows that as soon as the actuated line selector has established connection with the calling party, it is immediately released in the manner heretofore described by the closing of the release circuit extending from the live pole of battery B^1 through the lower winding of release relay RR, closed contact 101 of secondary off-normal switch SO, closed contacts 102 and 103 of relays PR^1 and SR^1 and the winding of release relay RR^1 to ground. As before indicated, at this time the necessary ground connection to the contact 23 of the master-switch O for causing the operation of the master-switch extends through alternate contact 96 and either to ground through normal contact 95 and relay 61, or to ground through alternate contacts 95, 90 and 94. Thus the master-switch is operated in the manner heretofore described to bring its wipers into engagement with bank contacts corresponding to an idle line selector. From this it will be seen that the removal of the calling party's receiver always extends the calling line circuit through to a first selector U, and the restoration of the receiver either before this connection has been completed, or after it has been completed and before operating the calling apparatus, is instrumental in releasing the parts and placing them in condition for subsequent operation.

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

Trunking Between Exchanges.

For the purpose of trunking between exchanges, I preferably employ the circuit arrangement illustrated in Fig. 2 which is to be considered in connection with the diagram of Fig. 1. Trunking circuits of this character may be employed between the second selectors V and connectors W, or between the first selectors U and the second selectors V. In the former case, in order to complete the diagram, Fig. 2 should be placed between the parts 2 and 3 of Fig. 1; while in the latter case, Fig. 2 should be considered as interposed, in part 2 of Fig. 1, between the wipers 39, 40 and 41 and the associated bank contacts 42, 43 and 44 of the first selector U, thus bringing wiper 39, 40 and 41 into co-operation with the bank contacts 195, 196 and 197, and the wipers 198, 199 and 200 of the selector U^1 into co-operation with the bank contacts 42, 43 and 44. With this latter arrangement, the selector U becomes practically a trunk selector and will be referred to as such in the description of these trunking circuits, while the switch U^1 becomes the first selector, leaving V a second selector as before, co-operating with the connector W. With this latter arrangement, it is possible to interconnect, on the assumptions of hundred point switches and ten per cent trunking heretofore assumed, ten exchanges of ten thousand lines each. In such event as before, the lines of each exchange would be divided into one hundred groups of one

hundred lines each and ten line selectors would be assigned to each group, thus providing one thousand line selectors. There would also be one thousand trunk selectors, one thousand first selectors, one thousand second selectors and one thousand connectors. The trunks from the trunk selectors at each exchange would extend to first selectors at its own and every other exchange. Thus, preferably the first row or group of bank contacts of each trunk selector would be assigned to trunks running to the first exchange, the second row or group to trunks running to the second exchange, the third row or group to trunks running to the third exchange, and so on throughout the ten exchanges. Obviously a similar arrangement could be provided for interconnecting the selectors in case the trunking circuits were arranged between the switches V and W. With the arrangement outlined, it will also be apparent that connection may be made with exchanges having less than ten thousand lines. In such event, if any exchange has less than one thousand lines, one set of selectors could be omitted completely from such exchange. By thus omitting, say, the second selectors, the wipers of the connectors would be multiply connected directly to the bank contacts of the first selectors.

Referring more particularly to the diagram of Fig. 2, the apparatus to the left of the dot and dash line E—E will ordinarily be located at one exchange, while that to the right of said line will be located at another exchange, usually located at some distance from the first, and conversation and the necessary signaling operations will be carried on by the use of the two trunks L^4—L^5 only. The switch mechanism U^1 at the right of the diagram includes in addition to the wipers 198, 199 and 200, heretofore referred to, the usual primary magnet PM^5, the secondary magnet SM^5 primary off-normal switch PO^5, secondary off-normal switch SO^5, secondary relay S^5R^5, release relay RR^5 and release magnet RM^5 all of which co-operate in the manner heretofore presented in describing the selectors U and V. The remaining apparatus includes merely simple mechanism which is diagrammatically illustrated and its functions will be understood from the description of the operation of the circuits.

Operation.

Considering the complete diagram of Fig. 1 with the trunking circuit of Fig. 2 interposed between the switches U and V as heretofore described, the operation of the trunking circuits will now be considered. Assuming that the calling party removed his receiver from its hook and thereby extended his line circuit to include the trunk selector U, it will be necessary for him to operate his dial mechanism five times instead of four, as heretofore described, in order to complete his connection with the desired called line. The first set of impulses will be instrumental in causing the trunk selector U to move its wipers to that group or row of bank contacts having access, over connected trunks, to the exchange in which the desired called line terminates. Subsequent impulses will successively operate the first selector U^1 second selector V and the connector W of the selected exchange, in the same manner as the four sets of impulse operated the first selector, second selector and connector as heretofore described. Considering this operation more in detail and assuming that the calling party has removed his receiver and transmitted his first set of impulses and is about to transmit the second set of impulses, then, under this assumption, the wipers 39, 40 and 41 of the trunk selector U will be in engagement with the bank contacts 195, 196 and 197 associated with the trunks L^4—L^5 which extend to be desired exchange. Now assuming that the calling party is calling the same number in the selected exchange as before, then the second set of impulses will successively ground the trunk L of the trunk selector U three times followed by a single grounding of the strand L^1. These impulses will be repeated over the trunks L^4 and L^5 to the selected exchange, there to cause the first selector U^1 to step its wipers 198, 199 and 200 to the third group of bank contacts 42, 43 and 44. Each ground placed upon the trunk L will complete a circuit extending from the live pole of battery B^4 through the winding of primary relay PR^4, normal contact 201, bank contact 196, wiper 40 to the trunk L, and thence to ground. Thus each grounding of the trunk L will cause a momentary energization of the relay PR^4 which in turn by its contact 202 will momentarily ground the trunk L^4 thereby completing a circuit which may be traced from said trunk through normal contact 203 of the relay 204, closed contact 205 of relay 206 and winding of primary relay PR^5 to the live pole of battery B^5. This will in turn momentarily energize primary relay PR^5, which, through its contact 207, will complete a circuit for the primary magnet PM^5 which may be traced from the live pole of battery B^5 through the winding of said magnet, closed contact 208 of off-normal switch SO^5, closed contact 209 of release relay RR^5 and closed contact 207 to ground. Thus it will be seen that each ground placed upon the trunk L causes a momentary energization of the primary magnet PM^5 which causes a corresponding advance of the wipers of the switch U^1.

Before considering the effect of the ground placed on the trunk L^1, it should be noted that the energization of relay PR^4 closes its contact 210 to thereby energize relay 211, which in turn closes its contact 212 to thereby establish a locking circuit extending through bank contact 195, wiper 39, closed contact 135, normal contacts 134 and 133, to ground. The energization of relay 211 by closing its contact 213 completes an energizing circuit for relay 214 which in turn is locked up over a circuit including its closed contact 217 and closed contact 218 of relay 219. Relay 219 has a double winding which is grounded at its center and connected between the trunks L^4—L^5 by way of contacts 220 and 221 on the one hand, and contacts 222 and 223 on the other. The single grounding of the trunk L^1 following the groundings of the trunk L, completes an energizing circuit for the secondary relay SR^4 which may be traced from the live pole of battery B^4 through the winding of said relay, normal contact 224, contact 197, wiper 41, and strand L^1, to ground. The resulting single energization of the secondary relay SR^4 moves its contact 225 to its alternate position thereby connecting trunk L^5 to ground. This grounding of the trunk L^5 completes an energizing circuit for the secondary relay SR^5 which may be traced from the live pole of battery B^5 through the winding of said relay, normal contact 226, trunk L^5, to ground. The energization of the relay SR^5 similarly grounds that portion of the trunk L^5 to the right of contact 226 through the agency of its contact 227, and an energizing circuit for the secondary relay S^5R^5 is thereby completed over a path which may be traced from the live pole of battery B^5 through the winding of said relay, closed contact 228 of off-normal switch SO^5, closed contact 229 of off-normal switch PO^5 to trunk L^5 and ground. Thus it will be seen that the single grounding of the trunk L^1 causes an initial energization of secondary relay S^5R^5 which is instrumental in closing a circuit for the secondary magnet SM^5 which includes the alternating current generator 230, normal contact 231 of release relay RR^5 and closed contact 232 of relay S^5R^5. The resulting repeated energizations and de-energizations of secondary magnet SM^5 cause the wipers of the switch U^1 to move in a secondary direction over the contacts of that group to which the wipers have been moved by the primary magnet PM^5. Upon the first secondary movement, the secondary off-normal contacts SO^5 are opened and the initial energizing circuit of the relay S^5R^5 is replaced by a circuit including alternate contact 233 of said relay, normal contact 234 of the release relay, closed contact 235 of release magnet RM^5 and wiper 198 to ground, so long as said wiper engages a grounded contact which it will continue to do until an idle selector V is found. When such a selector is encountered, the circuit of the relay S^5R^5 will be opened and in turn will open the circuit of the secondary magnet SM^5 and thereby discontinue the further secondary movement of the wipers 198, 199, 200 in the same manner heretofore explained in describing the operation of the switches U and V. During the secondary movement of the wipers they are disconnected by means of the contacts 236 and 237 of relay S^5R^5. Thus far the circuit of the calling line has been extended through the trunk selector and the trunks L^4L^5 to the first selector U^1.

The next step in the operation consists in transmitting four impulses over the primary side of the circuit followed by a single secondary impulse. As before, the primary impulses are repeated by means of the relays PR^4 and PR^5, but in this instance the energizations of relay PR^5 do not complete a circuit through the primary magnet PM^5 of the first selector U^1 as before, but instead completed a circuit through the primary magnet PM^2 of the second selector V which may be traced from the live pole of battery B^2 through the winding of said magnet, closed contact 136 of the off-normal switch SO^2, bank contact 43, wiper 199, closed contact 236 and closed contact 207 of relay PR^5 to ground. The subsequent secondary impulse is similarly repeated by means of the secondary relays SR^4 and SR^5 but in this instance, the movement of contact 227 of relay SR^5 to its grounded position does not complete a circuit through relay S^5R^5 of the first selector U^1 but instead completes a circuit through the corresponding relay SR^2 of the second selector V which may be traced from the live pole of battery B^2 through the winding of said relay, closed contact 137 of off-normal switch PO^2, closed contact 138 of off-normal switch SO^2, bank contact 44, wiper 200, closed contact 237, trunk L^5 and alternate contact 227 of relay SR^5 to ground. Thus the repeated primary and secondary impulses are instrumental in operating the second selector V in the manner heretofore described. Likewise the primary and secondary impulses which operate the connector W are repeated by means of the relays PR^4 and PR^5 in the case of the primary impulses, and relays SR^4 and SR^5 in the case of the secondary impulses.

Now if it be assumed that the line with which the connector W establishes connection is busy, then the apparatus of the trunking circuit will not be further actuated until the calling party hangs up his receiver and the parts are released, as will

be hereinafter more fully explained. A path for the current which produces the busy signal, however, will be provided back from the connector over the trunk L^4 including condensers 238 and 239, normal contact 202 of primary relay PR^4 and condenser 240 and thence to the calling line as before, returning to the grounds on the other side of the circuit, which grounds include that from the contact 197 through normal contact 224 of relay P^4 of relay SR^4 and battery B^4.

Now if the called line is found idle, then upon the called party removing his receiver from its hook, it will be remembered that he completes a circuit from the wiper 53 out over the line limb P^1 and back over line limb S^1, through wiper 54, normal contact 160, closed contact 159 and winding of the tip relay TR to ground, thus effectually connecting the wiper 53 to ground. As before, current is supplied to this wiper from the live pole of battery B^3 through impedance coil 162 and closed contact 161 of relay RG, but in addition, current is supplied to the same wiper from the live pole of battery B^5 through the winding of relay 204, normal contact 227, trunk L^5 including closed contact 237, wiper 200, bank contact 44, closed contact 146, wiper 48, bank contact 51, alternate contact 149 and closed contact 173. The relay 204 is thereby energized by the consequent connecting of the sections of the trunk L^5. As soon as these trunking sections are united, a circuit is completed through the polarized relay 241 which may be traced from the live pole of battery B^5 through the winding of relay 204, normal contact 227 of relay SR^5 to trunk L^5 as before, part of the current flowing to ground through the called substation as before, and a part over the trunk L^5, through normal contact 225 of relay SR^4, the windings of polarized relay 241, closed contact 242 of relay P^4, normal contact 202 of relay PR^4, trunk L^4, alternate contact 203 of relay 204, winding of relay 243 to ground. The closing of this circuit causes a movement of contact 244 of polarized relay 241 to its closed position and, in addition, the closing of contact 245 of relay 243. The closing of the latter contact causes the energization of relay 206 with the consequent closing of its contact 246 forming part of the release circuit, and the closing of a locking circuit extending through its contact 247 and closed contact 248 of off-normal switch PO^5, thus locking the relay 206 up through a primary off-normal switch contact. The opening of contact 205 disconnects the primary relay PR^5 from the trunk L^4, while the opening of contact 226 of relay 204 similarly disconnects the winding of secondary relay SR^5 from the trunk L^5. The closing of contact 249 of relay 206 unites the sections of the trunk L^4. On the other hand, the closing of the contact 244 of the polarized relay 241 completes an energizing circuit for relay P^4 which is immediately replaced by a locking circuit including closed contact 250, bank contact 195, wiper 39 and thence to ground. The resulting opening of contact 242 thereupon interrupts the circuit of the polarized relay 241. The completion of the trunk L^5 by joining its normally disconnected sections provides a path for current for the relay 45 which controls the reversing relay RV and as before, this relay is operated to supply reversed current to the calling station for the purpose heretofore mentioned.

Release.

If at the end of conversation it be assumed that the calling party first hangs up his receiver, then the release of the line selector Q and trunk selector U will be brought about in the manner heretofore described, and the connection of the wiper 39 to ground will be momentarily interrupted, thereby interrupting the locking circuit of relays P^4 and 211, the de-energization of the former restoring its contacts to normal, and the de-energization of the latter connecting the relay 219 in bridge of the trunks L^4L^5, thus grounding each trunk through a winding of said relay 219. As a result of this, current flows from the live pole of battery B^5 through the winding of relay 204, normal contact 227, trunk L^5, closed contacts 223 and 222 and the right hand winding of relay 219 to ground. This causes relay 219 to open its contact 218 and thereby interrupt the locking circuit of relay 214 which is provided with a copper shell for the purpose of causing its slow de-energization and consequently its slow release. By this means the grounds applied to the trunks L^4L^5 are maintained a sufficient length of time to enable a proper operation of the mechanism at the distant exchange. At this point its may be observed that the relay 243, after being initially energized over the circuit including the polarized relay 241, is maintained energized over a circuit extending from the live pole of battery B^2, through the winding of relay 45, alternate contact 124 of relay SR^1, trunk L^1, wiper 41, contact 197, alternate contact 224 of relay P^4, trunk L^4, alternate contact 203 of relay 204 and winding of relay 243 to ground. So long as this relay remains energized, the release circuit for the selector U^1 is maintained opened at the contact 251 of said relay. In view of the maintaining circuit for the relay 243 extending through the wipers of the trunk selector U, it will be apparent that as soon as said selector is released, this maintaining circuit will be interrupted and

the release circuit for the first selector U^1 will be closed at the contact 251. This circuit may be traced from the live pole of battery B^5 through protective resistance 252, closed contacts 251—246, normal contact 253 of release relay RR^5 and through the winding of said relay to ground. The resulting energization of the release relay closes an energizing circuit for the release magnet RM^5 which includes alternate contact 231 of said relay and closed contact 232 of the secondary relay S^5R^5. The energization of the release relay closes alternate contact 253 which thereupon establishes an energizing circuit which extends from the live pole of battery B^5 through the winding of relay S^5R^5, closed contact 254 of off-normal switch PO^5, alternate contact 253 and winding of release relay RR^5 to ground, thereby disconnecting the wipers 199 and 200 and maintaining the release relay energized until the switch parts are restored to normal in the manner heretofore described in connection with the description of the operation of the other selectors. As in other cases, the wiper 198 is momentarily connected to the live pole of battery B^5 by way of closed contact 235, alternate contact 234 and protective resistance 255. This circuit is interrupted upon the energization of release magnet RM^5, but its duration is of sufficient length to cause the energization of the release relay RR^2 of the second selector V, thus causing a restoration of the parts of this circuit to normal but without causing the release of the connector W. Thus, as before, the hanging up of the calling party's receiver restores all the apparatus to normal except the connector associated with the called line. This connector is subsequently restored upon the restoration of the called party's receiver to its hook in the manner heretofore described.

Now if it be assumed that at the end of conversation the called, instead of the calling party first hangs up his receiver, then, as previously described, the ground connection from the wiper 53 over the called line and through the winding of tip relay TR will be interrupted and at once release circuits for the trunk selector U, the first selector V and the connector W will be closed. The latter as previously traced extends from the live pole of battery B^3 through protective resistance 166, closed contacts 165 and 167 and winding of release relay RR^3 to ground. The releasing operation which follows the closing of this circuit has been described heretofore. The release circuit of the trunk selector U is completed as the result of the de-energization of relay 45 which is held up during conversation over the called line. This circuit includes protective resistance 193, closed contacts 175 and 194 and the winding of release relay RR^1 and, together with the consequent releasing operation of the trunk selector U, has been described heretofore. The release circuit of the first selector U^1 is closed by reason of the de-energization of relay 204 which, as previously noted, is also held up during conversation over the called line. The de-energization of this relay interrupts the previously traced maintaining circuit of relay 243 at contact 203. The resulting closing of contact 251 of relay 243 completes the release circuit for the release relay RR^5 of the selector U^1 and causes the restoration of its parts in the manner heretofore described. The release of the first selector U^1 is instrumental in causing the subsequent release of the second selector V, as heretofore described. Thus the restoration of the called party's receiver to its hook restores all the mechanism to normal except the line selector connected to the calling line. This is subsequently released upon the restoration of the calling party's receiver to its hook, in the manner heretofore described.

Now if it be assumed that the calling party has extended his line circuit through to the trunks L^4—L^5 and then restores his receiver to its hook, then, as before, the release of the trunk selector U will interrupt the locking circuit of relay 211 at bank contact 195 and the trunks L^4—L^5 will be grounded through the windings of relay 219 respectively. Since at this time the relay 204 has not yet been operated (it being remembered that it is operated only upon the response of the called party) a circuit will be completed from the live pole of battery B^5 through the winding of secondary relay SR^5, trunk L^5, closed contacts 223 and 222 and winding of relay 219 to ground. Likewise a path will be completed from the live pole of the same battery through winding of primary relay PR^5, closed contact 205, normal contact 203, trunk L^4, closed contacts 221 and 220 and a winding of relay 219 to ground. The result of the closing of these circuits will be to energize relay 219 to open its contact 218 and thereby de-energize relay 214, thus interrupting the connections between trunks and the windings of the relay 219. Since under the assumption no switches to the right of the line E—E have been operated, the resulting energization of the primary relay PR^5 and secondary relay SR^5 will perform no useful function, but, without their energization, the switch parts are restored to their normal positions. If now it be assumed that the calling party has extended his circuit far enough to cause the operation of the selector U^1 and then releases by restoring his receiver to its hook, then the simultaneous energization of the primary relay PR^5 and secondary relay SR^5, just de-

scribed, will provide a new release circuit for the release relay RR^5 of the selector U^1. The former release circuit cannot be closed at this time because relay 204, which controls the energization of relay 206, is not energized until the called party responds by removing his receiver from its hook. The new release circuit extends from the live pole of battery B^5 through protective resistance 252, closed contact 256 of relay SR^5, closed contact 257 of relay PR^5, normal contact 253 of relay RR^5 and the winding of said relay to ground. The result of the energization of release relay RR^5 is the restoration of the switch parts to normal in the manner heretofore described. If the connection has been extended far enough to cause the operation of the second selector V, its release will follow the release of the first selector U^1 in the manner heretofore set forth.

Connector W^1

In Fig. 3 of the accompanying drawings, I have illustrated a modified connector circuit which differs from that of the connector W of Fig. 1 in having (1) its strands L^2—L^3 connected to wipers 53—54 respectively instead of to wipers 54—53 respectively; (2) a condenser 258 interposed in the strand L^3; (3) a connection 259 from contact 159 to the portion of the strand L^3 lying between condenser 258 and contact 173 of relay CR; (4) a connection extending from that portion of the strand L^3 to the left of condenser 258, through normally open contact 260 and winding of impedance coil 261 to ground; and (5) a connection between the live pole of the battery B^3 and contact 161 of ringing relay RG which includes the winding 162^a wound upon the same core as the winding 261 and corresponding to the impedance coil 162 of the connector W. The operation of these circuits is substantially the same as that of the circuits of connector W except in certain particulars which will now be described. As before, relays R and RG are held up upon the establishment of connection with an idle called line and the flip-flop relay FF is intermittently energized to apply ringing current to the called line, and, during the non-ringing intervals, to connect the wiper 54 through normal contact 160, closed contact 159 and winding of tip relay TR to ground. Upon the response of the called party, tip relay TR is therefore energized and in turn energizes the closing relay CR, as before. In addition, the closing of contact 260 of tip relay TR connects the portion of strand L^3 to the left of condenser 258 to ground through impedance winding 261. Thereupon, relay 45, associated with the reversing relay RV, is energized and maintained energized so long as the tip relay is held up. Thus the relay 45, as before, is held up during conversation, but in this instance over a circuit extending directly from strand L^3 to ground through a contact of the tip relay instead of to ground over the called line and through the winding of the tip relay. During conversation, talking current is supplied to the called party from the battery B^3 through impedance winding 162^a and closed contact 161 to one side of the circuit, and from the grounded pole of the battery B^3 through the winding of the tip relay TR and conductor 259 to the other side of the circuit. Thus by means of the conductor 259, current is supplied to one side of the circuit without passing through relay contacts 159 and 160, thereby decreasing the number of relay contacts in the transmission circuit. The parts of the connector W^1, which are the same as those of the connector W, are designated by like characters. Consequently the description of the circuits of the connector W heretofore given may be read equally well upon the circuits of the connector W^1 except as heretofore pointed out.

Connector W^2.

In Fig. 4 of the accompanying drawings, I have illustrated a modified connector circuit which is designed for use in cases where a number of lines extend to a private branch exchange or to telephones having the same telephone number and usually located at one place, such as in a suit of offices. The circuits are so arranged that the connector will operate to pick out the first idle line running to the subscriber, and if none of the lines are idle, a "busy" signal will be returned to the calling party. This circuit differs from that of connector W principally in having a relay 262 which is held up whenever the connector connects with a busy line and thereby completes a vibratory circuit for the secondary magnet SM^6 to cause a further advance of the switch wipers in a secondary direction. This relay is also instrumental in applying the so-called busy-back signal to the calling line. By referring more particularly to Fig. 4, it will be seen that this circuit differs from that of the connector W in having a connection through this relay 262 extending from battery to the upper winding of the busy relay BR, in having a busy back circuit including an additional contact 263 on the ringing relay RG, and in providing the secondary relay SM^6 with vibratory contacts 264 and a connection to ground extending through contact 265 of relay 262. In this instance also the initial energizing circuit for the relay R extends to ground immediately after passing through contact 153 of relay BR instead of extending through contact 154 of the release relay RR^3 to ground. In the operation of the connector, if the first line

encountered is busy, the operation of the various relays and associated parts is the same as heretofore described. If, on the other hand, the first set of bank contacts 55^a, 56^a, 57^a, is found to be that of an engaged line, then, as previously pointed out, there will be a ground connection to the contact 55^a, and as soon as wiper 52 engages said contact, the final secondary impulse coming over the strand L^3 will be instrumental in momentarily energizing relay BR, and when energized, it will be held up through its contact 152, wiper 52 and grounded contact 55^a. This ground connection will also complete a circuit for the relay 262 which may be traced from the live pole of battery B^3 through the winding of said relay, alternate contact 152, wiper 52 and grounded contact 55^a. The resulting energization of relay 262 will interrupt the secondary circuit over which the busy back signal is transmitted at its contact 180^a. Furthermore, the energization of this relay will complete the vibratory circuit for the secondary magnet SM^6 and cause the same to advance the wipers into engagement with the next set of bank contacts 55^b, 56^b, 57^b. If now it be assumed that the line corresponding to this set of contacts is idle, then, as previously explained, there will be a connection from contact 55^b to battery. Consequently as soon as wiper 52 engages contact 55^a, relays BR and 262 will be de-energized. The de-energization of the latter will interrupt the vibratory circuit of the secondary magnet and close the busy back circuit at contact 180^a, but in the meantime, the return of contact 152 of relay BR will complete a circuit for ringing relay RG, which upon being energized, will interrupt the busy back circuit at contact 263. Consequently no busy back signal will be transmitted, but on the other hand, a circuit for flip-flop relay FF will be closed and a signal transmitted to the called station as heretofore, with a like operation of the apparatus upon the response of the called party. Now if it be assumed that the second set of contacts 55^b, 56^b, 57^b are those of a busy line, then the relays BR and 262 will not be de-energized and consequently, the vibratory circuit of the secondary magnet SM^6 will be maintained and the wipers consequently moved into engagement with the next set of bank contacts 55^c, 56^c, 57^c. If it be assumed that in the present instance there are but two lines running to the one office and having the same number, then the set of contacts 55^c, 56^c, 57^c, will be dead, that is, neither connected to ground or battery. Consequently, upon the engagement of wiper 52 with contact 55^c, the relays BR and 262 will be de-energized with the resulting return of their contacts to normal. This as before, will stop the further secondary movement of the wipers, will close busy back circuit at contact 180^a, but will not be instrumental in energizing the ringing relay RG, since to do this it is necessary that the engaged bank contact be connected to battery. Therefore, the busy back circuit through contact 263 of relay RG will be maintained. This circuit may be traced from ground to battery B^3, secondary winding of repeating coil 182, condenser 183, closed contacts 180^a and 263 to the strand L^2, thence over the primary side of the circuit through the substation and back over the secondary side of the circuit to the various grounds existing thereon, as traced before in connection with the description of the circuits of the connector W. The releasing operation is the same as that of connector W and need not be repeated.

Party line connector W^3.

In Fig. 5 of the accompanying drawings, I have illustrated a connector circuit which is designed for use with subscribers' lines having a plurality of substations located thereon. The general operation of this connector is the same as that of the others, previously described, but in addition, it is associated with a so-called party line ringing switch which is actuated in response to impulses transmitted from the calling station to connect a source of ringing current suitable to actuate the call-bell of the desired substation on the line. In the present instance I have illustrated four generators 163^a, 163^b, 163^c, 163^d which are designed to supply alternating current of different frequencies to the called line and the line in turn is provided with four call-bells or other signal devices which will respond to the current transmitted from the generators respectively, that is one call-bell will respond to current from the generator 163^a only, and another will respond to current from the generator 163^b only, and so on. Any preferred system of selective ringing may be employed and the one I have illustrated is merely typical and corresponds to that disclosed in Patent No. 779,533, granted January 10, 1905, to William W. Dean. For the purpose of actuating the party line switch to connect the proper generator and circuit, the calling party transmits other impulses in addition to the usual impulses by which the calling line circuit is extended to the called line.

Referring in detail to the operation of the circuits of this connector, the primary and secondary movements are accomplished in the manner heretofore described by repeated energizations and de-energizations of the primary and secondary magnets PM^3 and SM^3. In this instance, however, the secondary impulse which, in other cases causes the energization of relay BR, causes

a momentary energization of relay 266 over a circuit extending from strand L^5 through closed contact 151, normal contact 267 of relay 266 and the winding of said relay to the live pole of the battery B^3. The resulting energization of relay 266, by means of a make-before-break contact, interrupts this initial energizing circuit and replaces it by a circuit extending from the live pole of battery B^3 through the winding of said relay, alternate contact 267, and normal contact 154 of relay RR^3 to ground. The "party-selecting" impulses which must now follow, include a certain number of primary impulses followed by a single secondary impulse. If it be assumed that the party whose call-bell responds to current from the generator 163^a is wanted, then, according to the present diagram, the party selecting impulse would include a single primary impulse followed by a single secondary impulse. The single primary impulse is transmitted over a circuit extending from ground to strand L^2, thence via closed contact 150 of relay R, alternating contact 268 of relay 266 and winding of motor magnet MM^7 of the party line switch to the live pole of the battery B^3. Due to the mechanical construction of the parts hereinafter described, the single energization and de-energization of the motor magnet MM^7 will cause the wiper 269 to step into engagement with bank contact 270 corresponding to generator 163^a. The party line switch is provided with an off-normal switch O^7 which is closed upon the first movement of the wiper 269 from normal. The following secondary impulse, constituting a part of the party-selecting impulses, will extend from ground to the strand L^3 and thence by a closed contact 151 of relay R, closed off-normal switch O^7 and the lower winding of relay BR to the live pole of battery B^3. This secondary impulse is thus instrumental in energizing the relay BR which will be locked up in case a busy line is encountered, or immediately released in case the encountered line is idle. The operations following this energization of the relay BR including release are the same as heretofore described and therefore need not be repeated, except to state that the energization of release relay RR^3, in addition to closing an energizing circuit for the release magnet RM^5 of the connector, closes a like circuit for the release magnet RM^7 of the party line ringing switch and thereby causes the restoration of that switch to normal, as more fully explained hereinafter. It will be noted however, that the contact 160 of relay FF now intermittently applies ringing current from the selected generator instead of always from the same generator as in the previously described circuits.

In the diagram of this connector, it will also be observed that a condenser 258 is interposed in the strand L^3 and that the relay 45 associated with the reversing relay RV is held up during conversation through a tap extending from said strand through closed contact 260 of tip relay TR and impedance coil 261^a, the same as in the circuits of the connector W^1 previously described.

Party line connector W^4.

In Fig. 6 of the accompanying drawings, I have illustrated a second party line connector circuit designed for use in a system in which the different parties on the line are to be selectively signalled by means of a code including any desired sequence of long or short rings or a combination of both. The general arrangement of this connector circuit has the same characteristic as those heretofore described and differs essentially from the circuit of connector W^3 illustrated in Fig. 5, by having a party line ringing switch provided with a plurality of wipers and sets of bank contacts arranged to cut in ringing machines having different impulse wheels each arranged to make and break a ringing generator according to the code signal that is to be transmitted. The mechanism of the party line ringing switch, which is diagrammatically shown in Fig. 6, is fully illustrated in Figs. 18 and 19 and will be more fully hereinafter described. Due to the arrangement of this party line switch, the flip-flop relay FF of the previous diagram is omitted and the relays TR and RG are provided with additional contacts.

Referring to the operation, the same method of transmitting additional impulses for the purpose of selecting the desired party are to be employed as in the case of connector W^5. As in that case the secondary impulse which ordinarily would operate the relay BR, is transmitted through normal contact 267 of relay 266 and the winding of said relay to the live pole of battery B^3. The resulting energization of relay 266 interrupts the connection of the secondary magnet SM^3 with the strand L^2, replaces it by a connection through motor magnet M^1 M^3 of the party line switch and provides a locking circuit for said relay. The subsequent primary selecting impulses are thereupon transmitted, as before, through the motor magnet M^1 M^3 to cause a step-by-step movement of the wipers 271, 272, 273, over their associated bank contacts 274, 275, 276. Upon the first movement of these wipers from normal contacts 277 and 278 of off-normal switch O^8 are closed. Consequently the secondary impulse is transmitted over a circuit including strand L^3, closed contact 151 of relay R, closed contact 278 of switch O^8, the lower winding of relay BR and battery. Thus the

relay BR is energized, as before, to cause the subsequent operation of other parts. If the line selected is busy, as before, the relay BR will be locked up over wiper 52 and the busy back signal will be transmitted to the calling party. Upon the subsequent release of the connector, due to the calling party hanging up his receiver, contact 279 of release magnet RM^3 will be grounded and thereby a release circuit completed for the release magnet RM^8 for the party line switch, which will thereupon be restored to normal. In case the selected line is found to be idle, the energization of relay BR, which will be momentary, will cause the operation of relays R and RG as before explained. The energization of relay RG will connect wiper 54 of the connector directly with wiper 271 of the party line switch. Similarly, the closing of contact 159 of relay RG will connect the same wiper of the connector through the winding of tip relay TR to the wiper 272 of the party line switch. The closing of contact 280 of relay RG will ground wiper 273 of the party line switch. Now assuming that the wipers 271, 272, 273 have been moved to the first set of contacts 274, 275, 276, then, as soon as wiper 273 is grounded, a vibratory circuit is completed for the connected motor magnet MM^8 which is designed to cause the rotation of its impulse wheel 281. This impulse wheel controls contacts 282 and 283 which make and break contact between the contact 274 and the generator 163 on the one hand and contact 275 and ground on the other. These contacts are so positioned that at the instant ground is removed from contact 275, the generator is connected to contact 274. The impulse wheel 281 may be provided with teeth arranged in any desired order for the purpose of actuating the contacts 282 and 283 according to a predetermined code. In this instance, the impulse wheel 281 which is associated with the first set of bank contacts is provided with evenly spaced teeth and consequently will transmit a single impulse at regular intervals whereas impulse wheel 281^a associated with another set of contacts 274, 275, 276 is arranged to transmit two impulses at regular intervals. This results, in the former case, in a repetition of single "rings" at the substations on the connected line, and in the latter case, in the repetition of double "rings". Obviously, other arrangements of teeth may be employed, and it should be understood that the illustration is merely typical. The impulse wheel 281 is so positioned that whenever the motor magnet MM^8 is actuated to rotate the said impulse wheel, the code signal transmitted from the ringing generator 163 to the called substation is always started at the beginning of a code. This insures that the proper code shall be transmitted to the called substation, thus insuring against the splitting up of the different distinctive code signals, preventing false code rings. This method of obtaining this positive action of the impulse wheel to insure the code ring being started at the beginning of a code will be more fully hereinafter described in connection with the description of Figs. 18 and 19. From the circuits traced, it will be seen that whenever ringing current is applied to the wiper 54, and thence over the called line, a possible circuit through tip relay TR is interrupted, while whenever the latter circuit is closed, ringing generator 163 is disconnected. In this case, it will be observed that this is obtained without the employment of the flip-flop relay FF of the prior diagram, but as before, upon the response of the called party the circuit through tip relay TR will be completed and the energization of said relay will interrupt the vibratory circuits of motor magnet MM^8 at contact 284 and by the same contact, said relay TR will be locked up. By the closing of contact 168 of relay TR, a release circuit for the party line switch will also be completed from the live pole of battery B^3 through the winding of release magnet RM^8, closed contact 277 of switch O^8, normal contact 279 of release magnet RM^3 and closed contact 168 of relay TR to ground. Thus, as soon as the called party responds, the party line switch is released.

Party line connector W^5.

In Fig. 7 of the accompanying drawing, I have illustrated a third party line connector circuit which embodies certain of the features of the other two party line connector circuits, and which is arranged so that a calling party may establish a connection with his own line and signal another party on said line. The general arrangement of this connector circuit is the same as those heretofore described, including the usual primary magnet PM^3, secondary magnet SM^3, release relay RR^3, release magnet RM^3, and relays R, BR, CR, RG and TR. This circuit also includes the party line ringing switch of the connector W^3, shown in Fig. 5, and the ringing machine of connector W^4, shown in Fig. 6.

In this figure, I have also illustrated a modified line circuit arrangement which differs from those line circuits previously described, in having three additional relays which co-operate to remove the busy connection from the bank contact 55 of the calling party's line whereby a party may select his own line and signal another subscriber, located thereon.

In the operation of this circuit, that sec-

ondary impulse which precedes the party selecting impulses, as before explained, will be transmitted through relay 266 which will be at once locked up, and thus establish a connection between strand L^2 and the live pole of the battery B^4 through the winding of motor magnet MM^7 of the party line switch. Obviously the battery B^4 may be replaced by battery B^3. Following this, the primary party-selecting impulses, as before, are transmitted through the motor magnet MM^7 and it is actuated thereby to close off-normal switch O^7 and advance wiper 269 into engagement with the desired bank contact 270 which includes the desired ringing generator in circuit. The final secondary impulse now actuates relay BR over a circuit including off-normal swith O^7 and closed contact 151 of relay R. Assuming that connection is desired with a party line other than that of the calling party, then, as before, if the line is busy, there will be a connection between bank contact 55, corresponding to said line, and ground, which will be instrumental in locking up relay BR and applying the busy back signal to the line to signal the calling party that the desired called line is in use, all as heretofore explained. If the line wanted is found to be idle, then there will exist a connection between bank contact 55 and battery which will be instrumental in energizing relay RG in the manner heretofore described. The closing of contact 157 of relay RG will complete a circuit which may be traced from the included ringing generator through wiper 269 of the party line switch, closed contact 158 of relay CR, closed contact 157 of relay RG, normal contact 285 to the wiper 53. The closing of contact 286 of relay RG completes a vibratory circuit for the motor magnet M^1M^8 which may be traced from the live pole of battery B^5, which may be one and the same as battery B^3, through the winding of said motor magnet, its vibratory contacts 287, closed contact 286, normal contact 169 of relay CR and normal contact 154 of release relay RR^3 to ground. The closing of this circuit sets the impulse wheel 281 in operation to intermittently interrupt the connection from the ringing generator heretofore traced, and to alternately complete a connection through tip relay TR. The ringing circuit which includes the connection between wiper 53 and the ringing generator, extends out over the line limb P^1 of the calling line, through the call-bells 66 at the substations, back over the line limb S^1 through wiper 54 and thence to ground by way of closed contact 288, resistance 289 and normal contact 168 of relay TR. The bell of the desired party will thereupon be rung. As soon as the called party responds, a path for battery current is completed through the hook switch 64 between the line limbs S^1P^1 and, consequently as soon as contact 285 is moved to its alternating position by the impulse wheel 281, a circuit may be traced from the live, or negative, pole of the battery B^6, through the winding of tip relay TR, alternating contact 285, wiper 53, out over the line, through the substation, back through wiper 54, closed contact 290 of relay RG and winding 291 of an impedance coil to the live, or positive, pole of the battery B^7 whose negative pole is grounded and connected to the positive pole of the battery B^6. The closing of this circuit energizes the tip relay TR to cause the subsequent energization of closing relay CR, in the manner heretofore explained. The energization of the latter relay interrupts the ringing circuit at contact 158, and the vibratory circuit of motor magnet M^1M^8 at contact 169. The resulting closing of contact 173 of the relay CR also completes a connection from one terminal of the tip relay winding to wiper 53 which takes the place of the initial path between these points through alternating contact 285. Thus the tip relay is held up so long as the called party keeps his receiver off his hook, and transmission current is supplied from the battery B^6—B^7 to the called line. At the end of conversation, the connector is released the same as heretofore described.

Now if it be assumed that a calling party desired to converse with another party located on his own line, then he completes a connection through the connector as before, to his own line by transmitting the proper impulses and follows this with the necessary party-selecting impulses. It will be noted that in so doing, he has energized relays 292 and 293 which are included in circuit with the primary and secondary relays PR^1 and SR^1 which, it will be remembered, are included in a closed circuit except at such times as the calling party opens the line circuit by the manipulations of his calling apparatus. Relays 292 and 293 control a circuit through the winding of a third relay 294 which may be traced from the live pole of the battery B^3 through the winding of relay 294, contact 295 of relay 293 and contact 296 of relay 292. The relay 294 has a contact 297 included between the bank contact 55 and contact 84 of the line relay LR. Since the relays 292 and 293 are included in circuits with primary relay PR^1 and secondary relay SR^1 respectively, it follows that each time the latter relays are de-energized, the former will also be de-energized. The de-energization of relay 292 however, will not be instrumental in causing an energization of relay 294. On the other hand, each de-energization of relay 293, while relay 292 remains energized, will cause a correspond-

ing energization of relay 294 with a resultant opening of the normal connection extending from bank contact 55. From this it will be seen when the connector wipers 52, 53, 54 have engaged the bank contacts 55, 56, 57 coresponding to the calling line (now also the called line), and the final secondary impulse has been transmitted from the calling line, the ground connection to bank contact 55, which serves to guard it against selection, is removed at the same time that relay BR is energized. This follows since the same secondary impulse energizes both relays BR and 294. Consequently, the movement of contact 152 of relay BR to its alternate position will not lock up relay BR and thereby cause a busy signal to be transmitted to the calling line, but on the other hand, said relay will be immediately de-energized, and at the same time, the energizing circuit of relay 294 will be interrupted. Since, as will be apparent from the previous description, the cut-off relay CO has been energized by this time and is held up over a circuit including its contacts 107 and 81 extending to ground, then, as soon as relays BR and 294 are de-energized, a new path for current will be provided through cut-off relay CO to ground via normal contact 84 of line relay LR, closed contact 297 of relay 294, bank contact 55, wiper 52, normal contact 152 of relay BR, closed contact 154 of relay R and winding of relay RG. This will at once be recognized as the circuit which energizes relay RG which controls the application of ringing current to the line. Now since the calling party has selected the ringing generator which will actuate the call-bell of the desired called party on his line, it will be apparent that, because the calling party has his receiver off its hook, there will be established an energizing circuit for the tip relay TR as soon as contact 285 has been moved to its alternate position. This circuit has been previously traced. Since the closing of relay RG completes a vibratory circuit for motor magnet M^1M^8, and since this circuit is not interrupted until relay CR has been energized as the result of the energization of relay TR, it will be apparent that said motor magnet will be completely energized at least once. As will appear more fully hereinafter, the mechanical construction of the parts associated with this motor magnet is such that this single energization will store up sufficient energy in the actuating spring of the mechanism to cause it to apply ringing current to the line a sufficient length of time to properly signal the desired party. In this case, the restoration of the various switches to normal follows only when both parties have restored their receivers to their switch hooks. When this is done, the releasing operation is the same as that heretofore described and therefore, need not be repeated. In this connection, it may also be noted that the party line switch is also released upon the release of the connector.

Modified slot service equipment.

In Fig. 8 of the accompanying drawing, I have illustrated a substation and line circuit similar to that shown in part 1 of Fig. 1, but differing in certain respects which will be pointed out. The substation equipment at M^1, as before, includes the switch-hook 64, receiver 65, call-bell 66, transmitter 67, calling device 68 and slot mechanism 69^1, including polarized relay 70. The calling device 68, as before, includes an impulse-wheel associated with spring contacts 73—75, off-normal contacts 113, 114, 115, a lock 116 for holding the impulse-wheel against rotation, and a magnet 74 for controlling said lock. The substation equipment includes an additional magnet 400 for controlling the arm 118^1 of the slot mechanism 69^1. The substation equipment is designed for use on either individual or party lines, and in the drawing the branch conductors S^2—P^2 are used to indicate connections to a second equipment on the line S—P.

The line circuit differs from that illustrated in part 1 of Fig. 1 in being provided with an interrupter 401 associated with an induction coil 402 and a condenser 403, and arranged so as to transmit a characteristic signal to the calling party whenever the line is idle, as an indication to him that it is free for his call. The master-switch O and the line selecting contacts, shown in this figure, are the same as those shown in part 1 of Fig. 1. The parts heretofore mentioned are connected up differently from the corresponding parts in Fig. 1, as will be best apparent from the following description of the operation of this portion of the system which, for this purpose, may be considered as replacing the equipment of substation M and the calling line circuit in Fig. 1.

Assuming that a party at substation M^1 desires to make a call, he will proceed in very much the same manner as heretofore stated in describing the operation of the circuits of Fig. 1. His first act is to remove the receiver from its hook and place the receiver to his ear to see if the line is in condition for making a call. If the line is in such condition, a characteristic signal will be transmitted from the interrupter 401. The primary circuit of this interrupter leads from the battery B^1, through the interrupter and the primary winding of the induction coil 402 to the grounded side of the battery. The inductively related secondary circuit extends from ground through the secondary winding of induction coil 402, condenser 403,

normal contact 405 of relay LR¹, normal contact 76 of cut-off relay CO, line limb S, closed contact 75, condenser 164, receiver 65, switch-hook 64, contact 404, transmitter 67, closed contact 73, line limb P, normal contact 72 of cut-off relay CO, upper winding of line relay LR¹, and battery B to ground. If the line is in use, the secondary circuit, just traced, will be interrupted either at contact 76 of the cut-off relay, or contact 405 of the line relay LR¹, and the calling party will get no signal, indicating a busy condition of the line. If, however, he receives such indication, he must deposit his token in the slot of the mechanism 69¹ before it will be possible for him to start a line selector to establish connection with his line. This is true for the reason that until such deposit is made, there will be no circuit for the line relay LR¹. Obviously, if the line is not a party line this idle indicating means need not be employed and the calling party need not listen before depositing his coin or token. As soon as the token is deposited, contacts 406 and 407 are disengaged and contacts 407 and 408 engaged, thereby completing a circuit for the line relay LR¹, which may be traced from the live, or positive, pole of the battery B, through the upper winding of said relay LR¹ normal contact 72 of the cut-off relay, line limb P, closed contact 73, transmitter 67, contacts 404—409, winding of control magnet 74, contacts 407—408, and the winding of polarized relay 70 to ground. The direction of current flow through the polarized relay windings at this time is such that its armature 410 is moved to the right. This movement, because of the pin and slot connection between the link 411 and the arm 118¹, does not actuate said arm, but allows it to remain in its intermediate position where it is yieldingly held by the leaf-spring 412. At this point, it may be noted that a similar leaf-spring 413 normally holds the armature 410 of the polarized relay in its intermediate position. The energization of the line relay LR¹ operates the master-switch O and establishes those conditions necessary to cause the line selector to stop in engagement with the contacts of the calling line in the manner heretofore described. In the present instance, however, the locking circuit through the relay 24 of the master-switch and the line relay extends from the live, or negative, pole of the battery B¹, through the winding of relay 24, closed contact 78 of the cut-off relay CO, closed contact 414 of the line relay LR¹, the lower winding of said relay to the live, or positive, pole of the battery B. The closing of the line relay circuit also energizes the lock controlling magnet 74 at the substation sufficiently to cause it to move the lock 116 out of engaging position with the impulse-wheel of the calling device and thereby leaves it free for subsequent operation. Although the calling device is thus released for operation at the same time that the line selector is started, yet there will ordinarily be sufficient time elapse from the time of depositing the token to the time of operating the calling device to enable the line selector to complete its selecting operation before the calling device can be operated. However, if desired, the arrangement of Fig. 1 may be employed so as to prevent the operation of the lock controlling magnet 74 until after the calling line has been selected. The operation of selecting the calling line and extending its circuit to a first selector U is the same as that heretofore described and therefore need not be repeated. From the previous description, it will be remembered that the primary and secondary relays PR¹ and SR¹ are normally held up over a circuit extending over the calling line and through the calling substation. In the present instance, a maintaining circuit for the primary relay PR¹ only is maintained, except when the impulse-wheel of the calling device 68 is off-normal, at which time a circuit for the secondary relay SR¹ is also established. The circuit for the primary relay may be traced from the live pole of the battery *b* through the winding of relay PR¹, normal contact 99 of the reversing relay RV, the upper heavily marked path, line limb P, closed contact 73, transmitter 67, contacts 404—409, winding of lock controlling magnet 74, contacts 407—408 and the winding of polarized relay 70 to ground. As soon as the impulse-wheel of the calling device is moved from normal, contacts 113, 114, 115 are closed and the two sides of the line are thereby connected to ground through closed contact 415 of the slot mechanism 69¹. Thus as soon as the calling device is operated, secondary relay SR¹ is drawn up. The making and breaking of the circuit of the secondary relay at this time causes no ill effects in the operation of the system, since the secondary impulses transmitted by the relay SR¹ are not effective except when following impulses transmitted by the primary relay PR¹ in the regular operation. As before, the impulses are transmitted from the primary and secondary relays PR¹ and SR¹ by interrupting the energizing circuits for these relays extending through the contacts 73 and 75 of the calling device at the calling station. The operation of extending the calling line circuit to a called line by the successive operations of the calling device is the same as heretofore described. If the called line is found to be busy, the busy back signal is transmitted as before and passes through the receiver at the substation by way of transmitter 67, contact 404, receiver

65 and condenser 164. In case the called line is idle, the reversing relay RV is operated as before described, and the direction of current supply to the calling line is reversed. This reversal of current flow causes the polarized relay 70 to throw its armature 410 to the left and thereby rock the upper end of the arm 118[1] to the left to allow the token to escape through the right-hand portion of the slot into a suitable receptacle. At this point, it may be observed that in case the called line is busy, the restoration of the receiver to its hook completes a circuit for magnet 400 which moves the upper end of the arm 118[1] to the right and thereby allows the token to escape through the left branch of the slot into a holder from which it may be removed by the calling party. The circuit for the magnet 400 may be traced from the live pole of the battery b^1, through the secondary relay SR^1, normal contact 100 of relay RV, the lower heavily marked path, line limb S, winding of magnet 400, closed contact 416 and closed contact 415 to ground. Thus the token may be collected or returned, according to the idle or busy condition of the called party and, in the former case only, upon the response of the said called party.

In case the party at substation M^1 is a called party, ringing current will be transmitted over his line and through this substation by way of closed contact 73, call-bell 66, switch-hook 64, condenser 164 and closed contact 75. Upon his response to the call, the line limbs of the called line will be conductively united by a path extending from line limb P, through closed contact 73, transmitter 67, contacts 404—409, winding of magnet 74, contacts 406—407 to line limb S. The completion of this conductive bridge at the called station operates the tip relay TR of the connector and other parts in the manner heretofore described. In case substation M^1 is on a party line, selective ringing of the character heretofore referred to, or of other suitable type will of course be employed.

Connections between switches.

In order to explain fully and clearly the arrangements 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 arrangement 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. 9, of a complete telephone 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 inherently 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 the diagram, while still retaining the same principles of interconnection and interrelation. In preparing the diagram of Fig. 9, 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 the 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 3, 9, 27, and 81 of the diagram correspond to the numbers 10, 100, 1000 and 10,000 of a so-called ten thousand line exchange. In the latter system, the numbers 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 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, namely 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 itself may be considered 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 to Fig. 1. 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 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 the 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 di-

rective 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 such lines and not upon definite directive impulses Obviously then, a given subscriber's line may be connected to any three (corresponding to ten) bank contacts of any three (corresponding to ten) line selectors Q. From the numbering of the subscribers' lines at the right of Fig. 9, 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 of the tenth of "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 again divided into three (corresponding to ten) minor groups of three (corresponding to ten) switches each. Thus a minor switch group corresponds, and is assigned for connection to, each minor line group.

Referring now to the connections between the line selectors Q and the 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 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 switch connected to the switches of first minor groups of different major groups of first selectors, the second to the second, and so on. Thus the conductors *m*, *n* *o*, run from line selectors of the first minor group of the first major group of line selectors to first selectors U of the first minor groups of the first, second and third major groups of first selectors, respectively.

As to the connections between the first selectors U and 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 the 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 of 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 in passing from switch to switch in the same minor group. 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 contact of the first switch, the second contact of the second switch, and the third contact of the third switch of the three switches constituting each minor group. Thus the order of rotation of connection for said first second selector is 1—2—3 for each of the three minor groups of first selectors U. 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. Thus are the first and second selectors of the first major group 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 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, the first switches of the several minor groups will attempt connection with the second selectors of the first minor group in the order 1—2—3, while the second first selectors of said minor groups will attempt connection in the order 3—1—2 and the third switches of said groups in the order 2—3—1. This is true for each of the other minor groups of second selectors. From the above it is believed that this method of rotation may be readily applied to hundred point switches for use in exchanges having a larger number

of lines than diagrammatically illustrated in Fig. 4.

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 group 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 selector 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 the desired connection is obtained.

Switch construction.

Obviously in the practice of the telephone system and its modifications heretofore described, many different mechanical constructions may be employed for performing the switching functions therein indicated. In Figs. 10 to 23 inclusive, I have illustrated certain forms of switching mechanism which may be employed to perform these switching functions.

Referring first to Figs. 10 to 14 inclusive, which illustrate the mechanical arrangements of the parts of the line selector Q, 298 designates a suitable supporting frame for the switch mechanism which includes a primary magnet PM, secondary magnet SM and release against RM in association with wipers 26, 27, 28 and 34 co-operating with bank contacts 30, 31, 32 and 35, which are arranged in the bank 299 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 contacts each. In the present instance, ten rows of ten sets of contacts each are illustrated. The set of wipers 26, 27, 28 and 34 are pivoted at the center of rotation of the spherical surface formed by the inner ends of the contacts. The pivotal support for the wipers is provided by a pivot 299[1] located near the lower end of rotary shaft 300, carried by the frame 298. These wipers are rotatable with the shaft 300 in a horizontal or primary direction, and in addition may be rotated vertically about their pivot 299[1] through the agency of an additional longitudinally movable shaft 301 having a broad strip 302 at its lower end which engages a transverse slot in the disk 303 which is rotatably mounted in a bearing formed at the rear end of the member 304 which carries the wipers. Thus by rotating the shaft 300, the wipers may be given their primary movement to the desired group, or row, of bank contacts, and by subsequently giving the shaft 301 a longitudinal movement, the wipers may be moved to the desired bank contact in the selected group. The strip 302 on the shaft 301 is sufficiently broad to engage the slot in the disk 303, no matter what the position of the wipers may be. In addition to the wipers and bank contacts thus provided, the fixed contacts 33 are arranged in a row at the lower side of the bank contacts 30, 31, 32 and 35 in the arc of a circle in a position to have their inner ends engaged by the wiper 29, carried by and insulated from, the shaft 300. As will be apparent, the wiper 29 is capable of a horizontal, or primary, movement only, and therefore does not partake of the secondary movement of the wipers 26, 27, 28 and 34. The mechanism associated with the primary magnet PM, by which the shaft 300 is given its primary or rotary movement comprises an actuating pawl 305, carried by the armature 306, adapted to engage the teeth of a ratchet wheel 307, rigidly secured to the shaft 300 and adapted to step it around upon successive energizations and de-energizations of the primary magnet PM. The forward movement of the pawl 305 is limited by the bevelled stop 308 secured to a portion of the frame 298. The return movement of the pawl is limited by an adjustable stop 309, also carried by the frame 298 and adapted to engage the pawl 305 so as to throw its engaging end outward away from the teeth of the ratchet wheel 307. A spring 310 carried by the armature 306 bears against a portion of the pawl 305 and tends to force it into its engaging position. The armature 306 is normally held in its retracted position by means of a leaf spring 311 carried by the magnet frame. The shaft 300 is retained in its various positions by the retaining pawl 312, pivoted upon the frame 298 and normally pressed into engaging position by a spring 313. The pawl 312 is provided with a tail 314 which is adapted to be engaged by the armature 315 of the release magnet RM upon the energization of the latter. When the release magnet is thus energized, the retaining pawl is therefore moved out of retaining position. The upper end of the shaft 300 is surrounded by a coiled retracting spring 316 which is placed under tension by the movement of the wipers from normal and co-acts between the frame 298 and the shaft. The upper end of the

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

From the above it will be seen that the switch mechanism is free from the complicated mechanical arrangements referred to heretofore, and that all the necessary movements of the wipers and off-normal switches are obtained by means of a primary magnet, a secondary magnet and a release magnet.

In the case of the first and second selectors U and V, a switch of the same construction as the line selector just described, may be employed, but in each instance there would be no function for the wipers 28—34 and their associated bank contacts 33—35, and therefore, these 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, the off-normal switch arrangement in the case of each selector corresponding to the diagrammatic illustration of the same parts in Fig. 1.

In the case of the connector, the same switch may be also be employed with slight modifications. In such case, the wipers 29—34 and their contacts 33—35 should be omitted as before; the terminal piece 302 should be secured to the shaft 301 a little higher so as to bring the contacting ends of the wipers two steps distant from the nearest set of bank contacts; the primary off-normal switch contacts should be replaced by a proper number of off-normal spring contacts and the secondary off-normal contacts should be replaced by those illustrated in Fig. 15 wherein the projection 340 controls the movement of contacts 147 and 149. As previously explained when considering Fig. 1, contact 147 moves to its alternate position upon the first downward step of the shaft 301, while the contact 149 moves from its normal position upon the first downward step of said shaft, but does not move to its alternate position until the shaft has taken a second step. This is brought about by properly spacing the spring contacts co-operating with contacts 147 and 149 as illustrated in Fig. 15. It will be noted that the co-operating contacts below contacts 147 and 149 in said figure are located different distances away from said contacts. In other words, the contact below contact 149 is two steps distant from contact 149, while that below 147 is only one step distant from said contact. Consequently upon the first downward step of the shaft 301, contact 147 will

move from its normal to its alternate position, while contact 149 will break its normal contact but will not move to its alternate position until said shaft has made a second step.

The master-switch by which the various line selectors U are controlled, may also take various forms but is preferably constructed along the lines indicated in the Figs. 16 and 17. As therein indicated, the fixed contacts 22 and 23 are located in a bank 341, preferably arcuate in form, and have their inner ends arranged concentrically to the shaft 342 which carries the wipers 20 and 21 whose outer ends are adapted to engage the inner ends of the bank contacts. The latter are suitably insulated from each other and their outer ends are arranged for connection to conductors adapted to extend to the various line selectors. Although in the diagram but a single set of wipers and bank contacts is shown, I preferably employ three sets of wipers in association with bank contacts which embrace one hundred and twenty degrees of the arc of a circle. This is clearly the quivalent 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 and 25. The wipers are suitably insulated from each other and their supporting shaft 342 which is journaled in the frame 343 which also supports contact bank 341. The shaft 342 carries a toothed wheel 344 which is rigidly mounted thereon and adapted to be rotated in response to the movements of the pawls 345 and 346, carried by an irregularly shaped armature 347 rotatably supported upon the shaft 342 and co-operating with the poles 348 and 349 of the motor magnet MM. These pole pieces are angular in form and one leg of each is secured to the end of the magnet core which, together with the pole pieces, is located between the upward projections 350 and 351 of the frame 343. Each of the pawls 345 and 346 is spring pressed into engaging position while the armature itself is restored to its retracted position by means of a leaf spring 352, which at one end engages said armature and at the other end is fixed to the projection 351 of the frame. The movement of the armature 347 is limited by the pawls 345 and 346 engaging the stops 353 and 354 respectively, carried upon the contact bank 341. The pawl 345 is also adapted to ride upon the pin 355 carried upon a strip 356 secured adjacent to the stop 353. In the operation of the switch, upon the energization of motor magnet MM, its armature is attracted and thereby the pawl 346 is advanced until it engages stop 354. During this advance movement, pawl 345 rides upon pin 355 and thereby moves its end out of engagement with the teeth of the wheel 344. Upon the return movement of the armature, the pawl 345 drops into the next notch in the toothed wheel and comes up into engagement with stop 353. With the parts in the position illustrated or when the armature 347 has been moved far enough to bring pawl 346 into engagement with stop 354, one of the sets of wipers 20—21 will be exactly over the center of the corresponding bank contacts 22—23. If the energization of the motor magnet MM is such that the pawl 346 is not advanced a complete step, the pawl 345 upon return, due to the proportioning of the parts, will engage a notch in the wheel 344 and 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 a set of bank contacts.

A ringing-machine of the type previously referred to in the description of Figs. 6 and 7, for use in party line installations is disclosed in its mechanical form in Figs. 18 and 19, wherein 356 and 357 designate supporting plates spaced by connecting pins 358. As previously indicated, this mechanism includes a motor magnet MM^8 for storing energy in a spring which will rotate an impulse wheel 281 to actuate certain contacts controlled thereby, together with contacts for providing a vibratory circuit for the motor magnet. The motor magnet is suitably supported upon a plate 357, while the impulse wheel 281 is journaled between plates 356 and 357 and has its shaft operatively connected through a train of gearing with a ratchet wheel 359 which is fixed upon the shaft 360. A spiral spring 361 is coiled about the shaft 360 and is secured at one end to said shaft, and at its other end to a post 362 extending inward from the plate 357. A crank 363 is secured to the shaft 360 and linked to the armature 364 of the motor magnet MM^8. Upon the attraction of this armature, the crank 363 is moved to rotate the shaft 360 which places the spring 361 under tension and rotates the ratchet wheel 359 far enough to allow the pawl 365 to engage the next tooth in the ratchet wheel. This pawl is carried by a wheel 366 in the train between the shaft 500 in the shaft of the impulse wheel 281. An escapement wheel 367 and a pallet 368 are associated with this train to permit only a gradual unwinding of spring 361, thereby producing a retarded movement of the impulse wheel 281. From this it will be seen that the time consumed by the unwinding of the spring 361 greatly exceeds that consumed by its winding, and, as a result, the rotation of the impulse wheel 281, and the consequent application of ringing current, may continue

some time after the existence of the circuit conditions which occasioned the operation. Owing to the fact that the impulse cam 281 always comes to rest in one of its normal positions, due to one of the pins 377 which are carried by the cam 281 engaging the crank 363, it will be readily apparent that when the cam 281 is started from one of its normal positions the ringing of the called subscriber will start at the beginning of the selected code and not in the middle or at the end of the code as would otherwise occur if some provision were not made to start the ringing device from one of its normal positions.

The contacts actuated by the impulse wheel, shown in Fig. 18, are the contacts 282 and 283 of the circuit arrangement illustrated in Fig. 6, but obviously any other set of spring contacts might be employed. To get circuit connections equivalent to those of the contact 285 actuated by impulse wheel 281 in Fig. 7, it is only necessary to electrically connect the contacts 282 and 283 of Fig. 18. The contacts 282 and 283 are permanently united by an insulating strip 363[1] which is secured to a spring 370 provided with an anti-friction roller 371 which rests against the periphery of the impulse wheel 281. Contact 283 is normally closed while contact 282 is normally open and they remain in these positions while the roller 371 engages those portions of the wheel 281 between its teeth. Upon the roller's engaging a tooth, contact 282 is closed and 283 opened. The spring 370 is rigidly supported at its fixed end by any suitable means to the frame of the mechanism. In the present instance, a rigid arm 372 extends parallel to the spring 370 and supports it near its center through the agency of an insulating member 373 which also engages one of the contacts 287 which are included in the vibratory circuit of the motor magnet MM[s]. These contacts are closed in the position of the mechanism shown, but are adapted to be actuated by member 374 pivotally supported at one end and co-operating with a spring pressed arm 375 at its other end. The arm 375 is pivotally secured to the lower end of crank 363 mounted upon the shaft 360. The free end of the arm 375 is provided with a triangular shaped cam face which bears against the bevelled end of the arm 374. In operation, upon the energization of motor magnet MM[s], armature 364 is attracted and arm 375 is moved toward the left until the sharp end of the cam passes over the knife edge formed by the bevels at the end of the arm 374, whereupon the said arm is thrown to the right against the stop 376 and the spring contacts 287, which are included in the energizing circuit of motor magnet MM[s], are opened. Thus the circuit of the motor magnet is interrupted by the arm 375 being moved to the right. During this movement the cam face again co-operates with the knife edge formed at the end of the arm 374 and the latter is moved quickly to the left to again close the energizing circuit of the motor magnet at contacts 287. The co-operating sharp edges formed upon the members 374 and 375 are so positioned that the member 374 is thrown to its alternating positions just before the armature 364 reaches the end of its stroke in each direction. By this construction also a quick positive movement is given to the spring contacts. The upper end of the crank 363 co-operates with a series of stops 377 carried upon the impulse wheel 281 and so positioned as to enable the impulse wheel to rotate a definite portion of a complete revolution after once being started. Thus in operation, a momentary energization of motor magnet MM[s] releases the impulse wheel 281, and stores energy in the motor spring 361 which thereupon, through the train of gearing, actuates the impulse wheel until the next stop 377 engages the end of the crank 363. Repeated energizations maintain a practically continuous rotation of the impulse wheel.

The apparatus illustrated in Figs. 18 and 19 is shown in normal position, that is, the upper end of the crank arm 363 engages one of the stop pins 377 of the impulse wheel 281. Now, upon the actuation of motor magnet MM[s], the armature 364 is actuated to cause the link connecting the armature 364 and crank 363 to rotate the said crank 363 to disengage a pin 377, thus allowing the wheel 281 to rotate. The impulse wheel in conjunction with the springs interrupts the ringing current according to a predetermined code. The impulse wheel 281 is thus rotated continuously due to the intermittent operation of magnet MM[s]. The crank 363, after each de-energization of magnet MM[s], engages a stop pin 377, and should the subscriber at the called substation remove his receiver during the ringing period the wheel would continue to rotate until the crank 363 engages a pin 377. The circuit of magnet MM[s] is opened upon the response of the called substation. This always places the interrupter wheel in a position so that upon another energization of magnet MM[s], due to another selective operation of a calling substation, the impulse wheel 281 is released to cause the interruption of ringing current according to the selected code and always at the beginning of a code.

Meter mechanism, such as is diagrammatically illustrated at X in Fig. 1, is shown in its mechanical form in Figs. 20 and 21. This mechanism includes a switch, of the type illustrated in Figs. 16 and 17 and heretofore described, associated with a type

wheel, a recording strip, an impression hammer and means for actuating said strip and hammer. The switch mechanism includes a series of bank contacts 63, equal in number to the bank contacts 35 of the line selector Q, arranged in a bank 378 mounted upon a suitable base plate 379 and, in the present instance, extending completely around the circumference of a circle. These contacts are adapted to be engaged by a double wiper 62 mounted upon a shaft 380, suitably journaled in the base plate 379. The wiper 62 is actuated, in the present instance, through the agency of the motor magnet MM^1 in the same manner as the wipers 20 and 21 are actuated in the case of the master-switch illustrated in Figs. 16 and 17 and heretofore described. Therefore a description of this structure need not be repeated. The shaft 380 also carries the type wheel 59 preferably located on the opposite side of the base plate 379 from the switch bank 378. This wheel is adapted to carry a number of types on its periphery and these types are of such size and are so located that upon each movement of the wiper 62 from one bank contact 63 to the next, a new type will be brought opposite the type hammer 381, thus, since each bank contact represents a subscriber's line, there will be one type for each subscriber's line. An inking roller 382 co-operates with the types on the type wheel 59 to apply ink to their surface just before they reach the hammer 381. The recording strip 382^a, which may be composed of paper or other suitable material, is guided between guide rollers 383 and 384 into close proximity to the periphery of the type wheel 359 at a point directly opposite the hammer 381 into a second roll mounted upon the holder 386. The printing magnet 58 is carried upon the base plate 379 at a point adjacent to the holder 386 and by means of interconnecting mechanism, rotates said holder far enough to bring a clean portion of the recording strip opposite the hammer 381 whenever it is completely energized and de-energized. For this purpose, holder 386 is provided with a ratchet wheel 387 which is adapted to be rotated one step upon each return movement of the armature 388. This operation is brought about through the agency of an actuating pawl 389 and a return spring 390 mounted upon the printing magnet frame. The hammer 381 is pivoted to the free end of the armature 388 and is yieldingly held by a spring 391. By means of the latter spring, upon each attraction of the armature 388, the upper end of the hammer 381 is free to strike against the recording strip 382^a hard enough to produce a type impression on the strip and then to fly back out of engagement with the strip even though the armature be held attracted. Thus, upon each attraction of the armature, the hammer 381 produces an impression of the recording strip 382^a; and upon the retraction of the armature, the pawl 389 advances the holder 386 one step, thereby bringing a fresh portion of the recording strip 382^a in position for the subsequent impression.

A party line ringing switch of the type diagrammatically illustrated in Figs. 5, 6 and 7, is shown in a preferred mechanical form in Figs. 22 and 23. The particular form illustrated is that corresponding to the ringing switch shown in Fig. 6, therein three wipers 271, 272 and 273 co-operate with three sets of bank contacts 274, 275 and 276. These co-operating fixed contacts are preferably arranged in a bank 392, suitably supported on the base plate 393. The wipers are suitably mounted upon, and insulated from, a shaft 394 and journaled between a bracket 395 and the base plate 393. The motor magnet MM^s and the release magnet RM^s are suitably supported upon the base plate 393, and their armatures 396 and 397 co-operate with the actuating and retaining pawls 398 and 399 respectively, to control the movement of the shaft 394 through the agency of the ratchet wheel 400. The off-normal switch contacts O^s are also suitably mounted upon the base plate 393 and are normally held open by means of an insulating pin 401 carried by the ratchet wheel 400. The driving pawl 398 rotates the wipers against the tension of a return spring 402 coiled about the shaft 393 and co-acting between it and the said base plate. The forward end of the driving pawl 398 is limited in its advanced movement by means of the edge 403 of the bracket 395 and is carried out of engagement with the ratchet wheel upon its return movement by a projection 404 on said bracket. Thus upon each energization and de-energization of motor magnet MM^s, the wipers are advanced one step and are retained in their advanced position by the retaining pawl 399. The switch is free to return to its normal position upon the energization of release magnet RM^s whose armature engages the tail of the retaining pawl 399 and moves it out of engaging position with the ratchet wheel 400. Obviously, this ringing machine may be used in the circuits of Fig. 5, but in such case two sets of wipers and bank contacts and certain off-normal switch contacts may be omitted. The diagram of Fig. 5 clearly shows what parts of the structure should be retained.

In practicing my invention, it will be apparent that many alterations and modifications may be made not only in the mechanical construction of the various switching elements entering into the system, but also in many of the circuit arrange-

ments, without departing from the spirit and scope of my invention. Thus, obviously, in many instances, batteries diagrammatically illustrated as separate and distinct may be one and the same. It will also be apparent that where, in the description, I have referred to alternating current generators as supplying the current for actuating the switches, pulsating, or other intermittent, current may be sent from an interrupter, or a suitable generator, to perform the same function. Likewise, the "slot" mechanism, meter mechanism, and other elements of the system and its modifications may be readily omitted, as will be apparent to those skilled in this art. In view of these many changes which may be made within the scope of the invention, I have sought to use such terms in the appended claims as will fully cover them.

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

1. In a telephone system, a party-line, a plurality of substations on said line, means for automatically predetermining a code signal, means for signaling said stations according to said predetermined code and automatic means to insure that the code is always applied to the line at the beginning.

2. In a telephone system, a party-line, a plurality of signals on said line at the substations, a source of ringing current, automatically-controlled means for connecting said ringing current with the line, means for then operating said signals according to a predetermined code and automatic means to insure that the code is always applied to the line at the beginning.

3. In a telephone system, a party-line, a plurality of substations on said line, means including one or more automatic switches for extending a connection to said line, means for automatically signaling said substations on said line according to a predetermined code and automatic means to insure that the code is always applied to the line at the beginning.

4. In a telephone system, a party-line, a plurality of signals on said line at the substations, means including one or more automatic switches for extending a connection to said line, a source of ringing current, automatically-controlled means for connecting said ringing current with the line so as to operate said signals according to a predetermined code and automatic means to insure that the code is always applied to the line at the beginning.

5. In a telephone system, a plurality of subscribers' lines, means including one or more automatic switches for extending a connection between a calling and a called subscriber's line, a calling device for controlling said automatic switches, a source of ringing current, a step-by-step switch, means for controlling said step-by-step switch by said calling device, means controlled by said switch for automatically applying ringing current to the called line according to a predetermined code and automatic means to insure that the code is always applied to the line at the beginning.

6. In a telephone system, a line, a plurality of signals associated with said line, a plurality of code senders for operating said signals, electrically controlled means for selecting any one of said code senders and for applying it to the line to send the code signal thereover to operate said signals, and automatic means for controlling the senders to insure that the code signal begins at the beginning.

7. In a telephone system, a plurality of lines, a plurality of signals associated with each of said lines, a plurality of code senders for operating said signals, electrically controlled means for selecting any one of said lines and for selecting any one of said senders for applying the sender to the line to send a code signal thereover to operate the signals on said line, and automatic means for controlling the senders to insure that the code begins at the beginning.

8. In a telephone system, a party line, a plurality of substations on said line, electrically controlled means for signalling said stations according to a predetermined code, and automatic means for insuring that the code is delivered to the line from the beginning.

9. In a telephone system, a party line, a plurality of signals on said line at the substations, a source of ringing current, automatic controlling means for connecting said ringing current with said line to operate said signals according to a predetermined code, and automatic means for insuring that the code is delivered to the line from the beginning.

10. A telephone system including a polystation telephone line, a plurality of signals on said line, automatic switching means for extending a connection to said line, a source of ringing current, means including a plurality of interrupters for connecting said source to the line so as to operate the said signals according to predetermined codes, and automatic means for insuring that the codes are delivered to the line from the beginning.

11. A telephone system, including a polystation telephone line, an automatic switch for extending connection to said line, an auxiliary switch for automatically predetermining a code signal, means for operating the said switches to establish connection with the said line and for signaling the desired substation upon said line, and automatic means for insuring that the code is delivered to the line from the beginning.

12. A telephone system including multistation telephone lines, automatic switching mechanism having contact makers for interconnecting said lines, a source of signaling current, a plurality of interrupters for connecting said source of current through certain of the contact makers to code ring the desired substations upon the multistation lines, and automatic means for controlling the interrupters to insure that the codes start at the beginning.

13. A telephone system including a party telephone line, automatic trunking means for establishing a connection with said line, code ringing apparatus for signaling the desired substation upon said line, means for operating said automatic trunking means and said code ringing apparatus, and means for insuring that the code ringing apparatus applies ringing current to the line at the start of the code.

14. A telephone system including a polystation telephone line, means including automatic switches for extending connection to said line, means for automatically signaling the substations on said line according to a predetermined code, and automatic means for insuring that the codes are delivered to the line from the beginning.

15. A telephone system including a polystation telephone line, a plurality of signals upon said line at the substations, means including automatic switches for extending connections to said line, a source of signaling current, automatically controlled means for connecting said signaling current with the line so as to operate said signals according to a predetermined code, and automatic means to insure that the code is always applied to the line at the beginning.

16. In a telephone system, a party line, a plurality of substations on said line, means for automatically predetermining the code signal, means for signaling said station according to said predetermined code, and automatic means for controlling the apparatus to insure that the code starts at the beginning thereof.

17. In a telephone system, a plurality of lines, a switch adapted to operate at different levels, means in said switch for selecting a level in accordance with a certain digit of the called number, means in said switch for then causing the operation thereof in the selected level in accordance with another digit of said number, means in said switch for then automatically continuing the operation until an idle line is found, automatic means for supplying the selected line with current, and means controlled over two sides of the calling line in series for freeing said switch from said calling line.

18. In a telephone system, a common battery switch, a plurality of line terminals divided into contact levels, said switch provided with a shaft, means in said switch for operating said shaft to elect a contact level, a rotary magnet, means for first energizing said magnet by a plurality of impulses from the calling substation, means for then automatically energizing said magnet after said shaft has reached a certain point, and means controlled over two sides of said calling line in series for controlling said switch.

19. In a telephone exchange system, the combination with a line switching device carrying one group of line terminals and a second group of line terminals any one of which will serve the purpose of the calling line, of a moving contact member for said switching device, automatic means for moving said member to any of said line terminals of said first group or the first terminal of said second group, means actuated in case the first terminal of said second group is busy for stepping said member to a terminal of an idle line in said second group, and means controlled over two sides of said calling line in series for controlling said switch.

20. In a telephone exchange system, the combination with a telephone line extending from a substation to a central office, of a connecting circuit at the central office, a connection switch for uniting said connecting circuit with the telephone line, a line switching device carrying terminals for one set of lines in the exchange, a second set of lines any one of which will serve the purpose of the calling subscriber leading to terminals of said device, a contact arm for said mechanism adapted to move over said terminals to unite said connecting circuit with said terminals, automatically operated mechanism for advancing said arm over said terminals and over said second set of terminals until an idle line is reached, a busy signal, means actuated in case all of said second set of lines are busy for applying said busy signal to said connecting circuit, and means controlled over the two sides of said calling line in series for freeing said calling line from said connection switch.

21. In a telephone system, a plurality of subscribers' lines divided into groups and sub-groups, an automatic switch having one controlled movement to select a predetermined group, a second controlled movement to select a predetermined sub-group and a third automatic selecting movement to connect with an idle line in a selected sub-group, a calling line over which said switch may be controlled, and means controlled over the two sides of the calling line in series for disconnecting said calling line from said switch.

22. In a telephone system, a plurality of subscribers' lines divided into groups and sub-groups, an automatic switch having one

movement to select groups, a second movement to select sub-groups, and a third movement to connect with a line in a selected sub-group, common battery means for supplying talking current to said lines, a calling line over which said switch may be controlled, and means controlled over the two sides of said calling line in series for disconnecting said line from said switch.

23. In a telephone system, a plurality of subscribers' lines divided into groups and sub-groups, an automatic switch having one controlled movement to select a predetermined group, a second controlled movement to select a predetermined sub-group and a third automatic selecting movement to connect with an idle line in a selected sub-group, common battery means for supplying talking current to said lines, a calling line over which said switch may be controlled, and means controlled over the two sides of said calling line in series for disconnecting said line from said switch.

24. In a telephone system, the combination of a line, a switch associated with said line, a group of telephone lines and a terminal for each line in said switch, a test circuit for each line, means operated over the lines of said group for establishing a guarding potential to said test circuits for making lines in said group busy, automatic means for operating said switch to find the group of lines, automatic means for causing the operaton of said switch to select the first idle one of said lines, a common battery, coils associated with said switch to control the flow of talking current from said battery to the called telephone line, and means controlled over the two sides of the calling subscriber's line in series and over said called line for freeing said lines from said switch.

25. In a telephone system, the combination of a line, a switch associated with said line, a group of telephone lines a substation for each line and a terminal for each line in said switch, means controlled from the substations for making lines in said group busy, automatic means for operating said switch to find the group of lines, automatic means for causing the operation of said switch to select the first idle one of said lines, a common battery, coils associated with said switch to control the flow of talking current from said battery to the called substation, and means controlled over the two sides of the calling subscriber's line in series and over said called line for freeing said lines from said switch.

26. In a telephone system, a plurality of subscribers' lines, any one of which will serve the purpose of the calling subscriber, means controlled by one of said subscribers and including an automatic switch for automatically selecting an idle line for the calling subscriber, means associated with said automatic switch for supplying talking current to a subscriber's station, and means controlled over the two sides of said calling subscriber's line in series for freeing said line from said automatic switch.

27. In a telephone system, a plurality of subscribers' lines, any one of which will serve the purpose of the calling subscriber, means controlled by a plurality of subscribers and including an automatic switch for automatically selecting an idle line for the calling subscriber, means associated with said automatic switch for supplying talking current to a subscriber's station, and means controlled over the two sides of said calling subscriber's line in series for freeing said line from said automatic switch.

28. In a telephone system, a line, a switch for said line, a group of lines terminating in said switch, a second group of lines terminating in said switch, means for operating said switch over the said first line to establish connection with any one of the lines in the first group exclusively as a result of a numerical operation of the switch, means for operating said switch over said first line for establishing connection with some one of the lines in the second group involving a non-numerical operation of the switch, the operation of said means controlled from lines in said second group, and release means controlled over the two sides of said first line in series.

29. In a telephone system, a calling line, a switch associated with said line, one group of lines terminating in said switch, a second group of lines terminating in said switch, means responsive to numerical operations for establishing connection with any one of the lines in the first group, automatic means responsive to non-numerical operations to establish connection with lines in the second group, said automatic means controlled from lines in the second group, and means controlled over two sides of said calling line in series for freeing said line from said switch.

30. In a telephone system, a group of lines, a second group of lines, a switch having terminals for said lines, numerical automatic operating means for finding either group and for finding a line in the first group after the first group is found and non-numerical means for finding a line in the second group after the second group is found, movable switching means individual to the lines of the said second group for making said lines busy, said automatic non-numerical means controlled from said movable switching means for operating said switch to select the first idle one of said lines of the second group, a common battery, means associated with said switch for controlling the flow of current for talking from

said battery to said lines when found, means controlled over a calling line for actuating said switch, and means controlled over the two sides of said calling line in series for freeing said calling line from said switch.

31. In a telephone system a plurality of lines, automatic means for selecting the first idle line including a switch having means responsive to the last digit in the number of the called line, having one motion to select groups and another motion to automatically select the first idle line in the selected group, a common battery, automatic means for closing connection to supply talking current to a subscriber's station, a calling subscriber's line over which said switch may be controlled, said means controllable over the two sides of said calling subscriber's line in series for freeing said line from said switch.

32. In a telephone system, the combination of a plurality of lines, automatic means for selecting and extending connection to idle lines including a switch having means responsive to the last digit in the number of the called line, said switch having one motion to select groups and another motion to automatically select the first idle line in the selected group, means for signaling a called subscriber, a source of current, means for connecting the source of current to the automatic selected line, and automatic means for releasing, and means controlled over the two sides of the calling line in series for freeing said calling line from said switch.

33. In a telephone system, a plurality of lines any one of which will serve the purpose of a calling subscriber, means including an automatic switch having equipment responsive to the last digit in the number of the called line for automatically selecting an idle line for the calling subscriber, said switch having one motion to select groups and another motion to automatically select the first idle line in the selected group, means for automatically supplying talking current to a subscriber's station, automatic means for connecting said calling line to said switch, and means controlled over the two sides of said calling line in series for controlling said automatic means.

34. In a telephone system, a common battery automatic switch having means responsive to the last digit in the number of the called line and having provisions for selecting the first idle one of a number of lines common to a single subscriber, means for feeding talking current to any called line thus automatically selected, a calling line, automatic means for connecting said calling line to said automatic switch, and means controlled over the two sides of said calling line in series for controlling said automatic means.

35. In a telephone system, an automatic switch, automatic means for trunking a calling subscriber into connection with said automatic switch, said switch having means responsive to the last digit in the number of the called line and having provisions for automatically selecting the first idle one of a number of lines common to a single subscriber in combination with means for supplying talking current to any called line thus automatically selected, and means controlled over the two sides of the calling line in series for controlling said automatic means.

36. In a telephone system, the combination of a plurality of lines, automatic means for selecting and extending connection to idle lines, said means responsive to the last digit in the number of a called line, means for signaling a called line, a source of current, means associated with the line selecting means for connecting the source of current to the automatically selected line, automatic means for releasing, and means controlled over two sides of the calling line in series for freeing said calling line from said automatic means.

37. In a telephone system, the combination of a plurality of lines, a telephone receiver for each line, a switch, automatic means for causing the operation of said switch to select any idle one of said lines, means individual to each line for operatively associating each receiver with its line, a common battery, a relay allotted to said switch and controlling the flow of talking current from said battery to the selected line, means for effecting said current to effect said receiver for talking, an automatic switch for connecting the calling line to said first switch, and means controlled over two sides of said calling line in series for controlling said automatic switch.

38. In a telephone system, a plurality of lines, fixed terminals of said lines arranged in groups and sub-groups, an automatic switch provided with a movable terminal co-operating with said fixed terminals, directly controlled means for causing successive operations of said movable terminal to select a group and sub-group of fixed terminals, automatic means for then operating the said movable terminal to select an idle fixed terminal in the selected sub-group, a calling subscriber's line over which said automatic switch is operated, and means controlled over the two sides of the calling line in series for freeing said calling line from said switch.

39. In a telephone system, a calling subscriber's telephone, a line individual thereto, the combination of a plurality of telephone lines running to the same substation, telephones on said lines, an automatic switch provided with means for extending connec-

tion from said calling line to any one of said telephone lines, automatic means for causing the operation of said switch to select the first idle one of said lines, a common battery, relays allotter to said switch and controlling the flow of talking current from said battery to the called telephone line, and a circuit over which the said switching means is controlled comprising the two sides of said subscriber's line circuit in series.

40. In a telephone system, a connector, a relay, trunk lines leading from said connector, a calling substation, a line circuit individual thereto, means for transmitting current over said line circuit to said relay to operate said connector in accordance with the last two digits of the called number, said relay being maintained energized during conversation over a circuit including the two sides of said line circuit in series, a receiver switch hook, a switch at said telephone directly controlled by said hook, said switch included in the circuit of said relay, said connector provided with means for automatically selecting an idle trunk line, and means for transmitting a busy-signal over said line circuit if all the trunk lines are busy.

41. In a telephone system, a line, a line circuit individual thereto, an automatic switch controllable over the two sides of said line circuit in series, a rotary magnet therefor controlled in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts for controlling said operation, and means for energizing said rotary magnet when connection is made with a grounded contact of said bank.

42. In a telephone system, a connector, a relay, trunk lines leading therefrom, a line circuit, means for transmitting current over said line circuit to operate said connector through the medium of said relay in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy-signal over said metallic circuit if all the trunk lines are busy, and means at the central station including said relay for supplying talking current over said line circuit, said relay remaining energized during conversation over a circuit including the two sides of said line circuit in series.

43. In a telephone system, a line circuit, a step-by-step mechanism, a plurality of lines, means including a relay operable over said line circuit for controlling said mechanism to select a certain called line, means whereby said mechanism is operative to automatically select an idle one of said lines, and means at the central station including said relay for supplying talking current over said line circuit.

44. In a telephone system, a line circuit, an automatic switch, a rotary magnet therefor controlled over said line circuit in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts, means for energizing said rotary magnet when connection is made with a grounded contact of said bank, means at the central station for supplying talking current over said line circuit, and a relay held energized during conversation for controlling said switch.

45. In a telephone system, trunk lines, a line circuit, means for transmitting calling current over said circuit, means responsive to said current to select an idle trunk line, and means for transmitting a busy signal if all the trunk lines are busy, a relay for operating said second means, and means for supplying talking current through the said relay to said line, said relay remaining energized during conversation to prevent release.

46. In a telephone system, telephone lines, trunk lines, a connector, a line circuit, means for transmitting calling current over two sides of said circuit to operate said connector, said connector having mechanism operative under substation control to find a called telephone line, a relay allotted to said connector for supplying talking current to the called telephone line, means whereby said connector is operative to automatically select an idle trunk line, means for insuring a busy signal if the called telephone line is busy, means for insuring a like signal if all the trunk lines are busy, and means controlled over the two sides of said line circuit in series controlling the release of said connector.

47. In a telephone system, a connector, trunk lines leading therefrom, a line circuit, means for transmitting current over two sides of said circuit to operate said connector in accordance with the last two digits of the called number, said connector provided with means for automatically selecting an idle trunk line, means for transmitting a busy signal over said circuit if all the trunk lines are busy, a relay for operating said connector, and means for supplying talking current through a winding of said relay, said relay held energized during conversation.

48. In a telephone system, a plurality of lines, a line circuit, mechanism controllable over two sides of said line circuit for automatically selecting an idle line, said mechanism including a relay held energized during conversation, a source of busy signaling current, and means whereby if all the lines are found busy the said mechanism

is propelled beyond all of said lines without releasing said mechanism and a busy signal transmitted to a calling subscriber to indicate that all the lines are busy.

49. In a telephone system, a line circuit, a step-by-step mechanism, a plurality of lines divided into two groups, means including a relay whereby said mechanism is controllable to select a certain called line from one group, means whereby said mechanism is operative to automatically select an idle one of the lines in the other group, and means for supplying talking current to said line circuit through a winding of said relay, said relay held energized during conversation.

50. In a telephone system, a line circuit, an automatic switch controlled over two sides of said line circuit in series, one or more grounded private bank contacts and a non-grounded private bank contact for said switch for controlling said switch, means under the control of a subscriber for moving said switch over certain of said grounded contacts, means for automatically moving said switch over other of said grounded contacts, a relay included in said line circuit, and means for supplying talking current through a winding of said relay.

51. In a telephone system, a line circuit, an automatic switch, a relay therefor, a rotary magnet therefor controlled in accordance with the last digit of the called number, a plurality of grounded and non-grounded bank contacts, means for energizing said rotary magnet when connection is made with a grounded contact of said bank, and means at the central station for supplying talking current through a winding of said relay and over said circuit.

52. In a telephone exchange system, the combination with subscribers' telephones, a line individual to each telephone, a line switching device having line terminals and a group of trunk terminals, of a moving contact member for said switching device, automatic means for stepping said member to any of said line terminals or the first trunk terminal of said group, means actuated in case said first trunk is busy for stepping said member to a terminal of an idle trunk line, said switching device controlled over a circuit including both sides of any one of said lines in series, said circuit passing through the subscriber's telephone instrument.

Signed by me at New York in the county of New York, and State of New York.

ALFRED H. DYSON.