G. E. MUELLER.

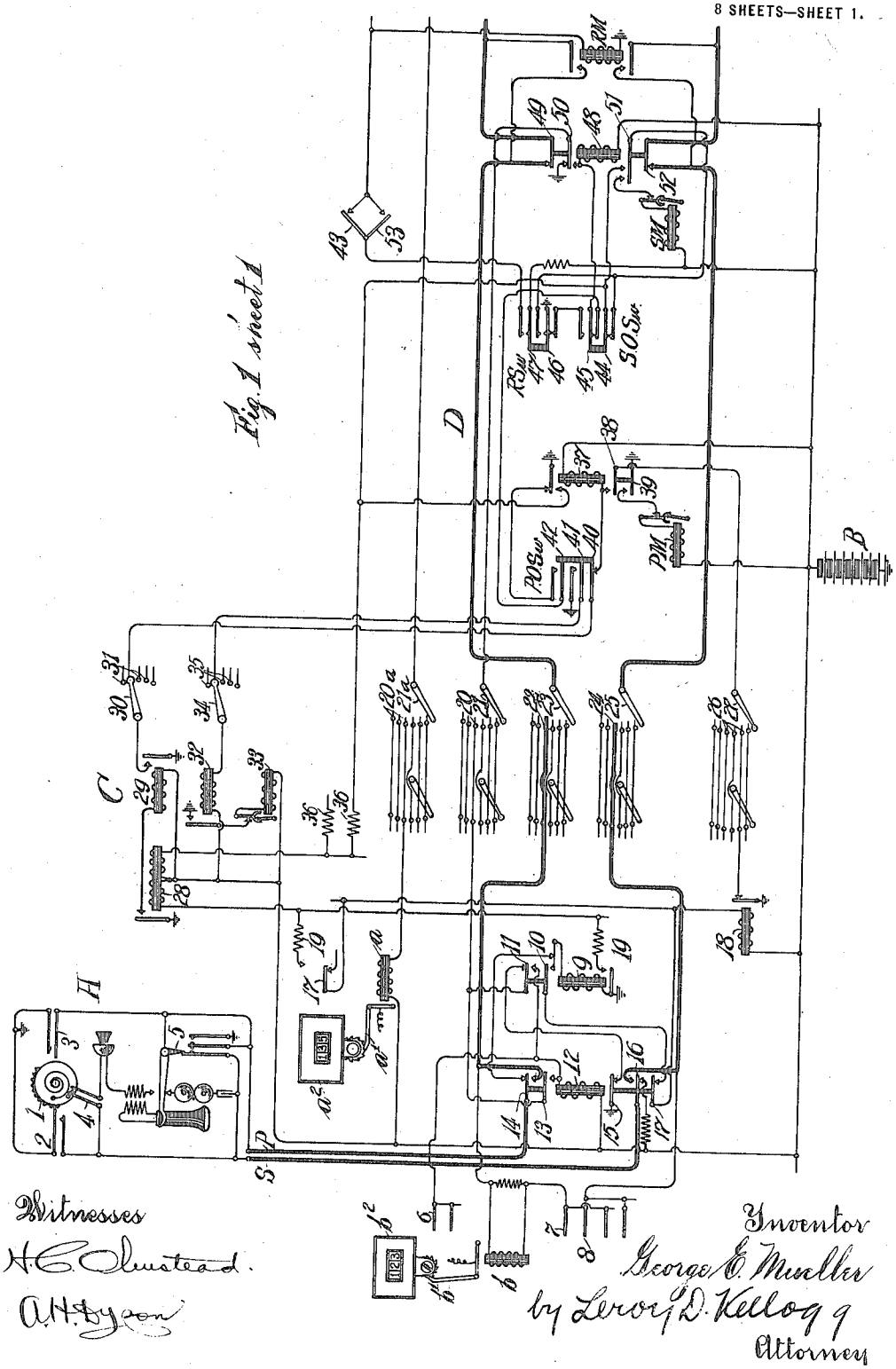
TELEPHONE CALL REGISTER AND SYSTEM.

APPLICATION FILED NOV. 19, 1906.

1,193,179.

Patented Aug. 1, 1916.

8 SHEETS—SHEET 1.



Witnesses

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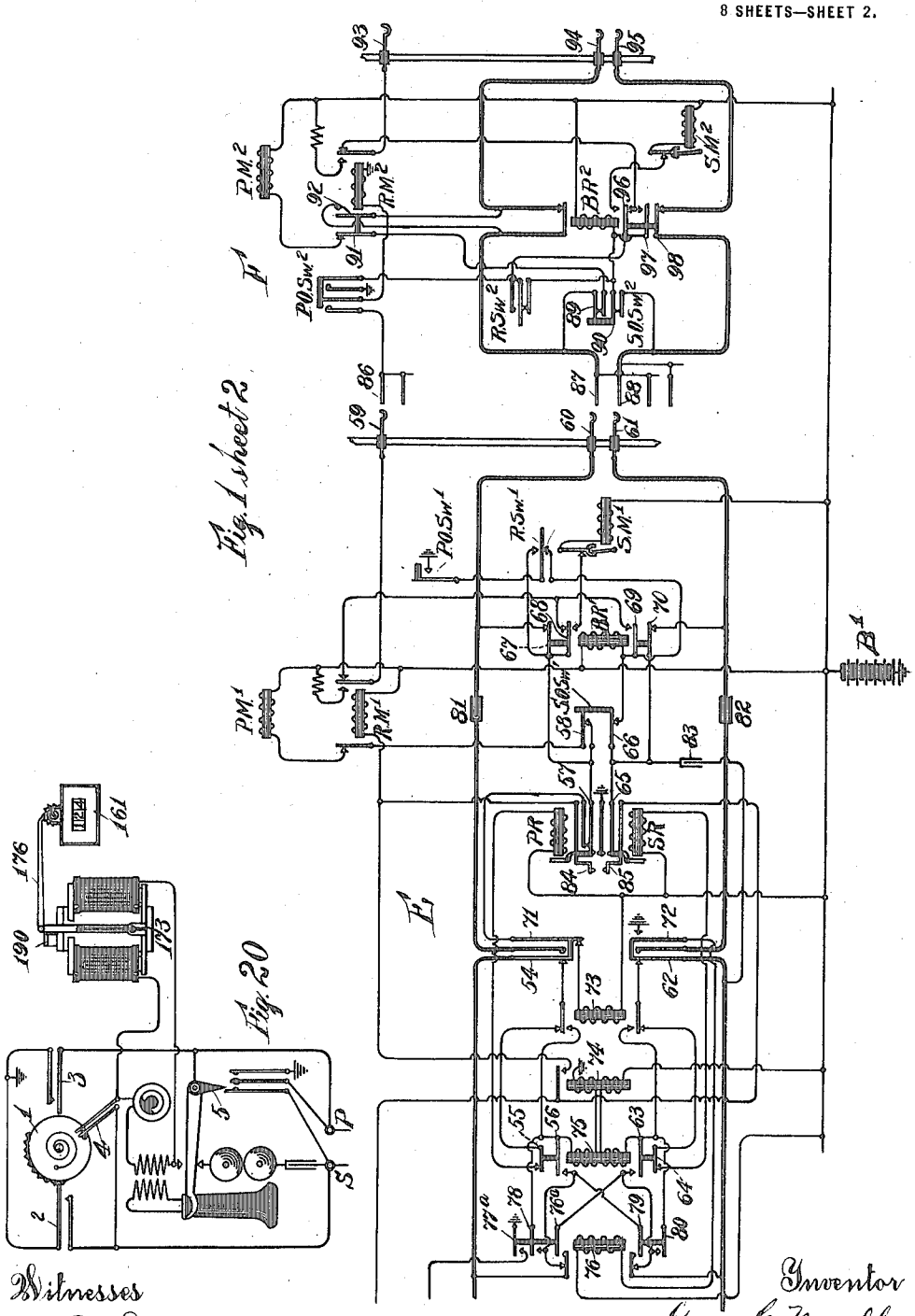

Witnesses

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8 SHEETS—SHEET 3.

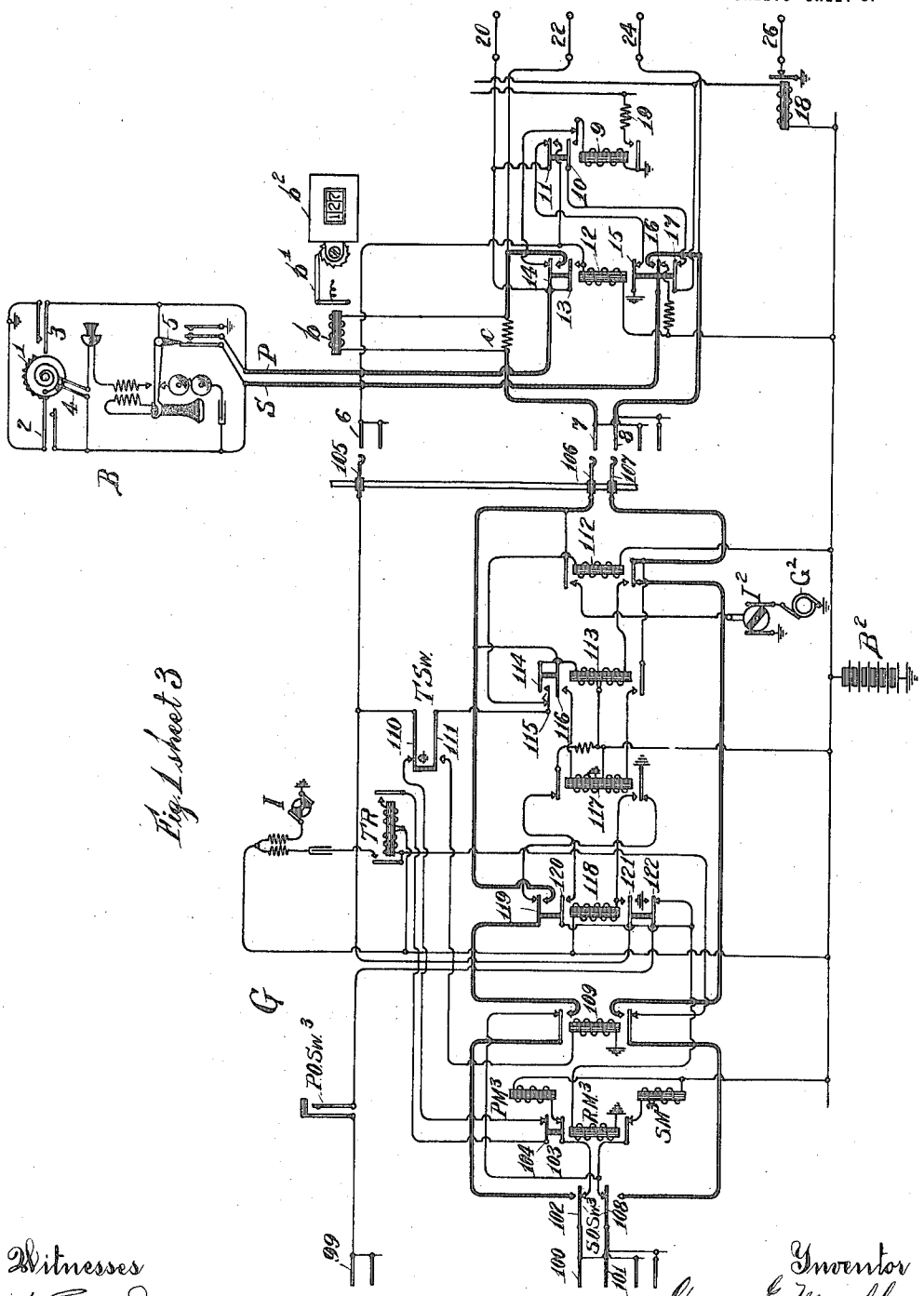

Fig. 1 sheet 3

Witnesses

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8 SHEETS—SHEET 4.

Fig. 2

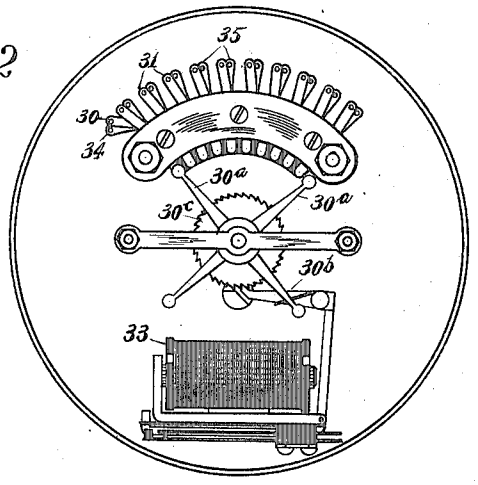


Fig. 3

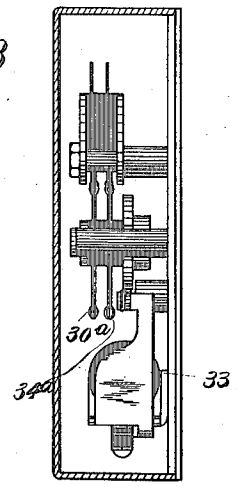


Fig. 4

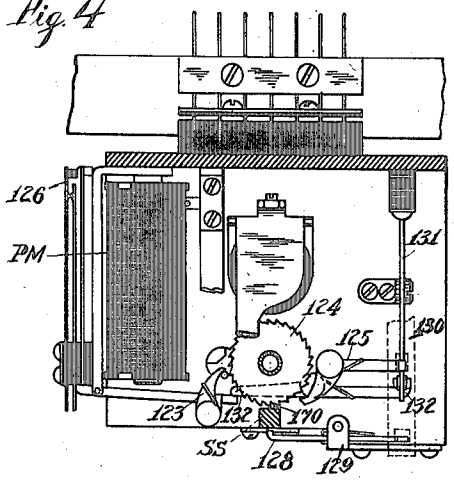


Fig. 5

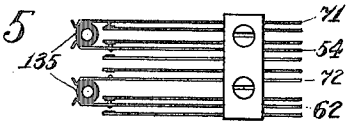


Fig. 6

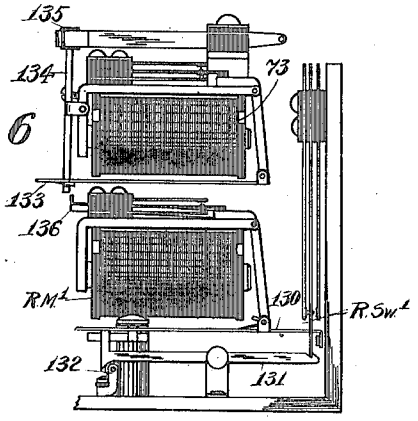


Fig. 8

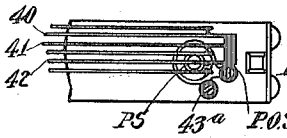
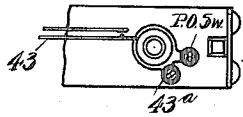


Fig. 7



Witnesses

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8 SHEETS—SHEET 5.

Fig. 11

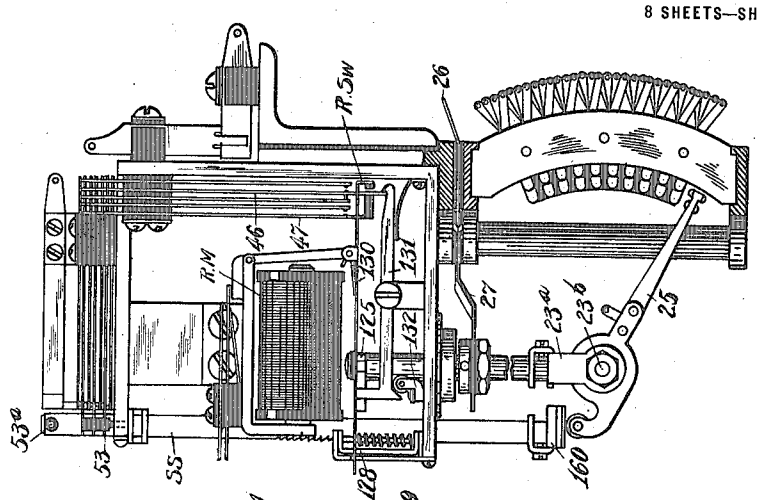


Fig. 10

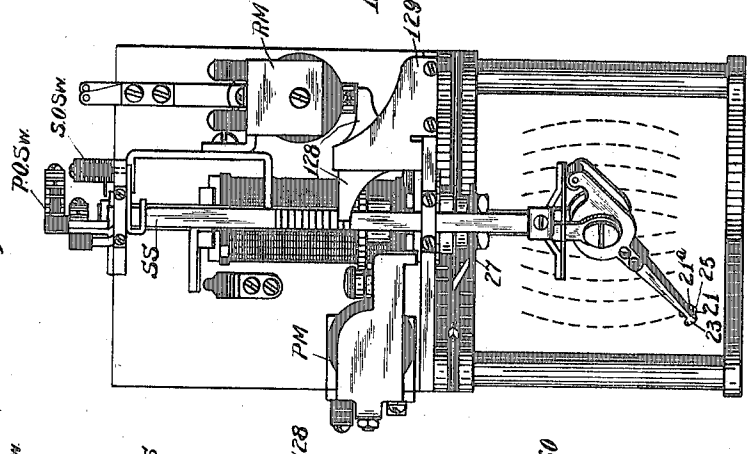
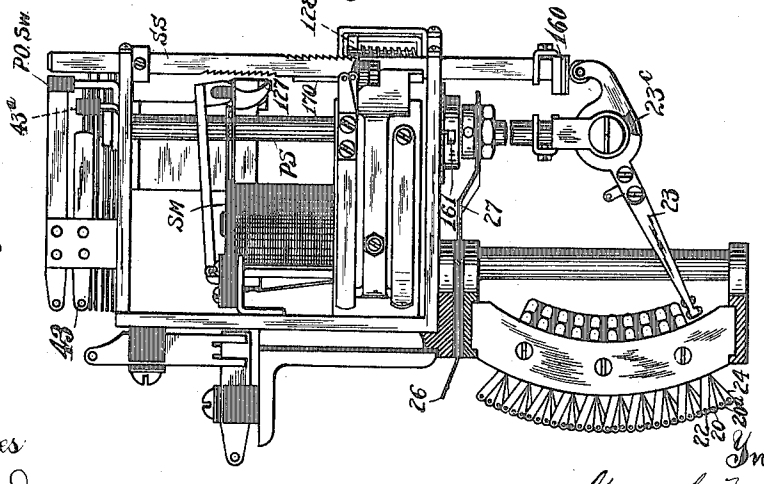


Fig. 9



Witnesses

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8 SHEETS—SHEET 6.

Fig. 14

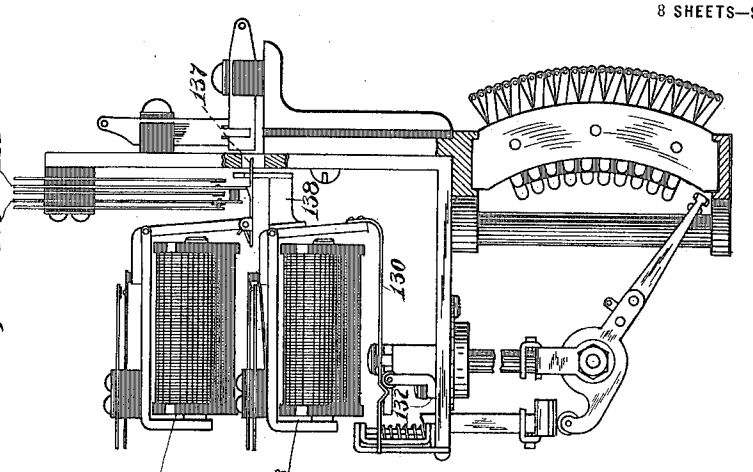


Fig. 13

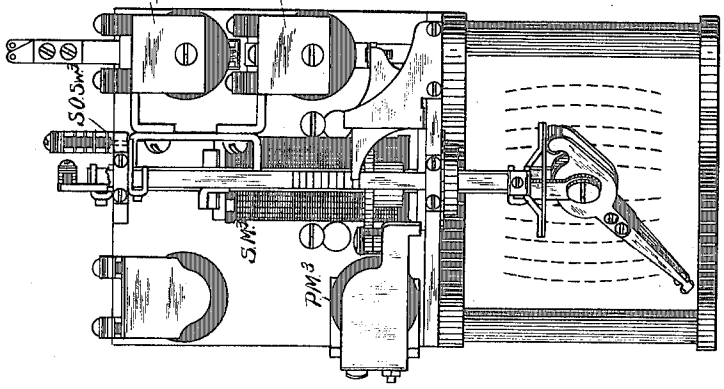
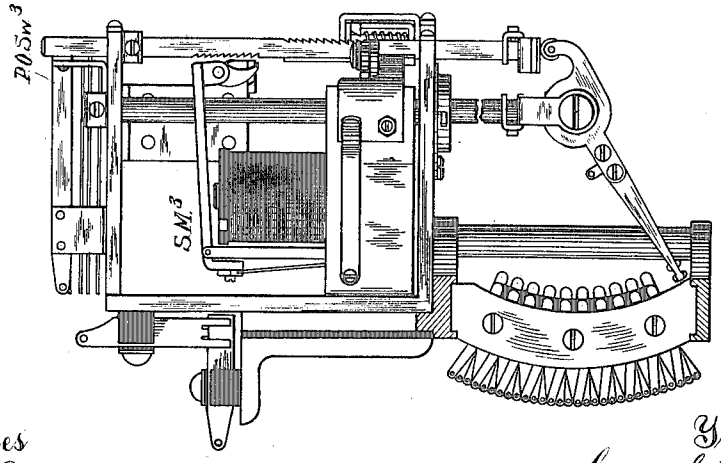


Fig. 12



Witnesses

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8 SHEETS—SHEET 7.

Fig. 15

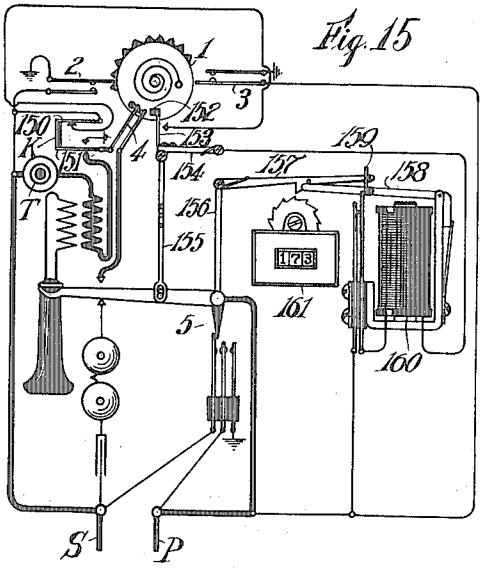


Fig. 16

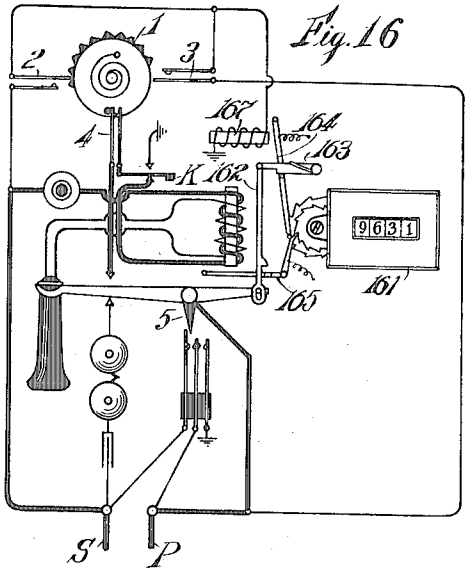
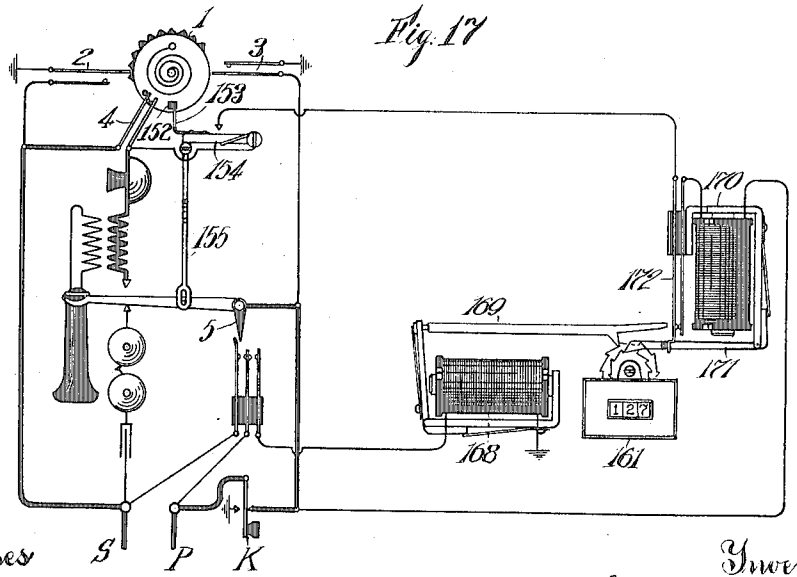


Fig. 17



Witnesses

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8 SHEETS—SHEET 8.

Fig. 18

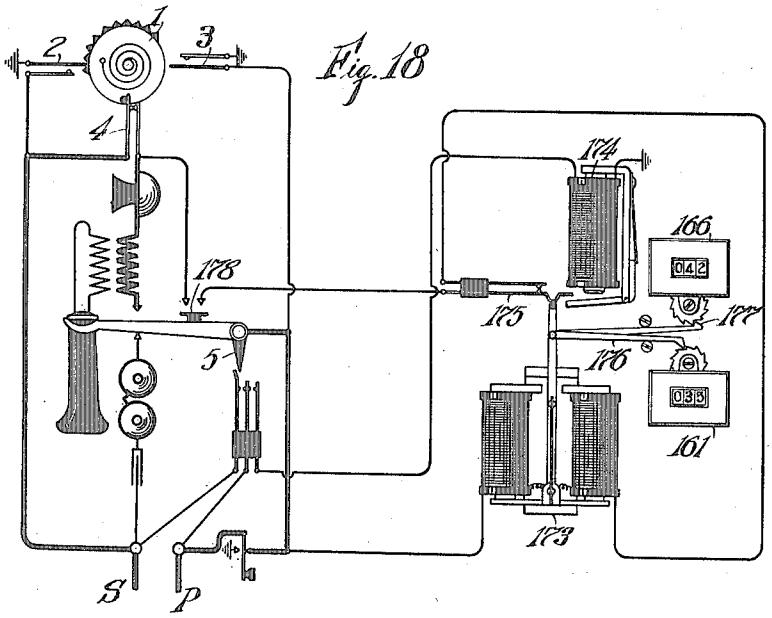
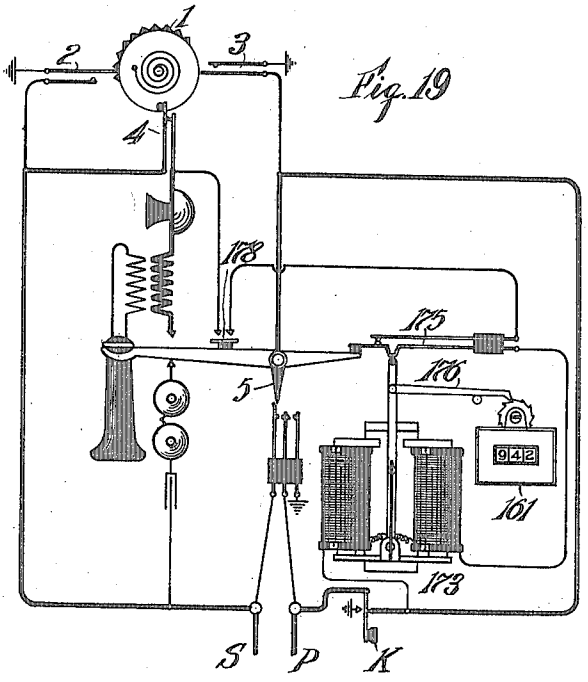


Fig. 19



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UNITED STATES PATENT OFFICE.

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

TELEPHONE-CALL REGISTER AND SYSTEM.

1,193,179. Specification of Letters Patent. Patented Aug. 1, 1916.

Application filed November 19, 1906. Serial No. 344,114.

To all whom it may concern:

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

My invention relates more particularly to automatic telephone systems having a central source of current from which subscribers' transmitters are energized for talking, but is in its broader aspects not to be limited to its employment in connection with such systems.

In the accompanying drawings, I have illustrated structures for registering the number of telephone calls capable of employment in connection with various telephone systems, as for instance, such a system as that illustrated in the patent to Alfred H. Dyson, telephone pay-station devices, No. 830,653, issued September 11, 1906, and also in connection with the telephone system more particularly hereinafter shown and described; the more particular object of my invention being to produce a call register system wherein the calls are automatically registered without the assistance of a central office operator.

Referring to the drawings, Figure 1, consisting of Sheets 1, 2 and 3, illustrates the circuits of an automatic common battery telephone system arranged in accordance with my invention; Figs. 2 and 3 show front and side views of a master-switch; Fig. 4 is a top sectional view of a line selector; Figs. 5 and 6 illustrate circuit-changing mechanism of a first selector; Figs. 7 and 8 illustrate, respectively, an over-run switch and a primary off-normal switch for the line selector; Figs. 9, 10 and 11 are, respectively, left, front and right elevations of a line selector; Figs. 12, 13 and 14 are similar views of a connector; and Figs. 15, 16, 17, 18, 19 and 20 illustrate various embodiments of my invention shown in connection with automatic telephone substation circuits and apparatus.

I shall first describe the automatic telephone system herein shown, which in itself I do not claim as my invention, and shall thereafter point out the various features of my invention as relating thereto and to the system of the patent above mentioned.

Referring first to Fig. 1, the system there illustrated may be considered as a ten thousand line system. Assuming such to be the case, each subscriber's line, such as those of substations A and B, extends to the exchange and is there provided with its individual passive multiple line contacts 20^a—20—22—24, appearing with those of ninety-nine other lines in the contact banks of ten line selectors, such as D. Inasmuch as ten thousand lines are assumed, there will have to be in all one hundred such groups of lines, each with its ten line selectors, making a total of one thousand such selectors. Each such line selector has permanent connection with a particular first selector such as E, which is automatically brought under the control of currents to be sent over the calling line by the operation of the line selector D. The first selector, by its adjustable wipers, gives the calling subscriber access to one hundred second selectors, there being ten of these representing each one thousand lines of the exchange. Contacts of the second selector engaged by the first selectors are, of course, multiplied in the usual manner to a large number of first selector contact banks and would ordinarily be multiplied one hundred times or to one hundred such banks.

Responsive to currents transmitted over the calling line by the subscriber, the first selector is caused to select the group of second selectors corresponding to the one thousands digit of the called number; the first selector then automatically selects the first idle second selector of the selected group, placing it under the control of the calling line.

The second selector, by its wipers, gives access to one hundred connectors divided in tens groups of ten switches each, the switches of each group being adapted to select out any particular line of a one hundred line group of subscribers to which the switches of the group are assigned. The contact terminals of the connector are, of course, multiplied a large number of times and would ordinarily be multiplied in the present system one hundred times or to each second selector of a one thousand line group. The second selector, operating responsive to currents controlled at the calling substation, selects the group of connectors desired, and then the idle connector, thereby placing it under the control of the calling substation.

The connector, by its wipers, has access

to contacts forming multiple terminals of subscribers' lines forming a one hundred line group, said contacts being multiplied ten times to appear in the contact banks of ten connectors.

In an ordinarily busy exchange of ten thousand lines, one thousand line selectors with their one thousand first selectors, one thousand second selectors, and one thousand connectors, would be adequate to handle the business of the exchange.

As above indicated, line selector D, by means of its wipers, has access to one hundred sets of multiple contacts 20^a—20—22—24, forming terminals of a group of one hundred subscribers' lines. The contacts of these lines are preferably arranged in ten groups of ten contact sets each, the motion of the wipers of switch D being first in a primary direction in one plane to select a group of contacts, and then in a secondary direction in another plane to select the calling line of the group. Each group of ten lines, therefore, has a common or group contact 27 controlled by a common relay 18, which contact the wiper 27 engages. The said wiper 27 controls the primary movement of the switch D, the line wipers 21^a—21—23—25 moving along with the said wiper 27. When the wiper 27 reaches a group contact 26 belonging to a group of lines among which a calling line is included, the primary movement of all the wipers is arrested and the line wipers 21^a—21—23—25 then initiate their secondary movements to select the individual contacts 20^a—20—22—24 of the calling line, wiper 27 remaining quiescent at this time and not partaking of the secondary movement.

As before stated, each group of one hundred calling lines has associated with it ten line selectors D, so that the contacts 20^a—20—22—24 of each line and the group contact 26 of each group are multiplied ten times, once to each such line selector bank. When the calling subscriber removes his receiver, he causes a line selector to start into operation to seek out his line and thereby connect the first selector with said line. This is effected through the agency of the master-switch C to whose relay 28 each calling line is enabled to transmit current by means of the switch contacts of its line relay 9. The said master-switch, when operated at the initiation of a call as above indicated, causes an idle selector to start its operation. The line selector then re-acts upon the master-switch in such manner that its wipers 30—34 move away from the switch contacts 31—35 of the line selector which they start, and then keep up an independent progressive movement over terminals 31—35 of busy line selectors until they reach terminals of an idle one, when the said wipers come to rest. The detailed relation of the different parts to one another will be best understood through the narrative of operation.

Assuming that subscriber A is to be connected with subscriber B whose telephone number will be assumed to be 3456; subscriber A first removes his receiver, thereby completing a conductive bridge of limbs P and S by the usual elevation of the hook lever. Relay 9 is energized by current from ground therethrough, normal armature contact 14, over limb P, through hook lever and transmitter at station A, limb S, normal armature contact 16, to battery B. Armature 10 is thereby attracted to engage its switch contact (immediately thereafter breaking the normal contact of said switch contact whereby substation control of relay 9 is removed) to complete a locking circuit for said relay, established from ground therethrough, contact 10, contact 17, relay 18, to battery. Relay 18 attracts its armature to remove ground from the multiple group contact 26 at each line selector of the ten. Armature 11 disengages its normal contact to remove ground from each of the individual private contacts 20 of the line at the ten line selectors, and the said armature engages its alternate contact, operatively connecting relay 12 with the contact 20. The lower armature of relay 9, engaging its contact completes a circuit from ground through resistance 19, the left-hand winding of master-switch relay 28 to battery, causing said relay to attract its armature and complete an energizing circuit of relay 29, which latter attracts its armature and causes a flow of current as follows: from ground at its armature, through contacts 30—31, contact 40, at an idle line selector D (wiper 30, when resting, always engages contact 31 of an idle line selector as hereafter explained), through relay 37 of said line selector to battery. Relay 37 attracts its upper armature and closes circuit from ground, through resistance 36, right-hand winding of relay 28 to battery, whereby the armature of relay 28 is allowed to fall back because the said relay is differentially wound and resistances 36 and 19 are equal. It is apparent that relay 29 is thereon immediately deënergized and its armature retracted. Armature 39 of relay 37 is attracted, closing circuit through vibratory primary magnet PM, which, becoming energized, advances wiper 27 to engage the first group contact 26, wipers 21^a—21—23—25 moving opposite the contacts of the first group, but not engaging any contacts. Relay 37 has attracted its armature 38; and if the first group contact 26 engaged is in its normal condition (no line in the group then calling), the said contact will be grounded at the armature of group relay 18, and locking circuit is completed for relay 37 from battery, through said relay, attracted armature 38, contact 27—26 to ground via arma-

ture of the first group relay 18. As armature 39 thus continues attracted, magnet PM is, on the retraction of its vibratory armature, again energized and moves wiper 27 to engage the second group contact. If this contact has its normal ground at the second group relay 18, relay 37 will continue energized and the preceding process is repeated; wiper 27 engaging the third group contact 26; and so on until the group contact of a calling line—that of subscriber A—is found whose ground has been removed by the previously described operation of relay 18. No locking circuit for relay 37 is then completed, and its armatures are retracted, the armature 39 preventing further operation of primary magnet PM whereby wiper 27 rests engaging group contact 26 of the ten line group including line A, while line wipers 21^a—21—23—25 have moved along with wiper 27 to such a position that they are adjacent to the group of contacts including a line contact set of subscriber A.

On the first primary movement of the wipers, contacts 40—41—42 of the primary off-normal switch P. O. Sw. were shifted to their alternate positions, contact 40 opening the original energizing circuit of relay 37. Contact 41 completes a circuit from ground, through contacts 35—34, relay 32 to battery B, causing relay 32 to attract its armature, whereby circuit is completed for magnet 33 of the master-switch, which, by its energization, advances wipers 30—34 a step to engage contacts 31—35, respectively, of the next line selector, it being understood that the said wipers have in front of them ten contacts 31 and ten contacts 35, belonging in pairs to ten line selectors. If the contact 35 now engaged by wiper 34 belong to a busy line selector—that is, one in which spring 41 has been shifted—relay 32 will continue energized by current from this second line selector via its shifted spring 41; magnet 33 will step wipers 30—34 one step farther, when the above process will be repeated if that line selector is in use; and so on until wiper 34 engages contact 35 of an idle line selector, when its contact 41 will be as shown at D, namely, on open circuit, whereupon relay 32 will become deënergized, preventing further operation of magnet 33, and wipers 30—34 of the master-switch will remain on the contacts of an idle line selector waiting for another call to come in.

Returning now to primary off-normal switch contact 42, its shifting operatively connects the winding of relay 48 with the normal contact of the upper armature of relay 37, so that on the deënergization of said relay, occurring as before described, circuit is completed from ground at said upper armature, through contact 42, normal contact 45, relay 48 to battery B. Relay 48 is thereby energized to initiate the secondary movement of wipers 21—23—25 by means of its armature 51 which closes circuit from battery, through secondary magnet SM, armature contact 51, to ground through alternate contact of switch spring 46; springs 46—47 of the release switch R. Sw. having been previously shifted on the first energization of the primary magnet PM. Wipers 21^a—21—23—25 engage contacts 20^a—20—22—24 respectively, belonging to the first line of the group. When it is at normal—that is, when the subscriber is not making a call—its multiple contact 20 will be grounded by way of the normal contacts 11—15 of its relays 9—12; hence, armature 50 of relay 48 being at this time attracted, a locking circuit will be closed from grounded contact 20, wiper 21, attracted armature 50, relay 48 to battery; and armature 51 continuing attracted, secondary magnet SM will, on the retraction of its armature, become again energized, moving wipers 21^a—21—23—25 to engage contacts 20^a—20—22—24 of the second line of the group. If this line is not calling, its contact 20 will be grounded and relay 48 will continue to be locked as before described, a third deënergization and energization of secondary magnet SM resulting, advancing the wipers the third secondary movement, and so until contact 20 of the line of subscriber A is reached, which contact, on account of the attracted condition of armature 11 of relay 9, is ungrounded, whereby locking circuit of relay 48 is destroyed, its armature retracted, opening circuit of secondary magnet SM and preventing further movement of wipers 21^a—21—23—25 which remain in engagement with the multiple contacts of the calling line; wiper 21^a then operatively connecting register magnet *a* with the contact of armature 77^a of E. Armatures 49 and 52 were held attracted during the secondary movement of the wipers in order that wipers 23—25, which were then wiping over line contacts of the various lines, might be insulated, so that no disturbance of existing conversations could occur. Upon the deënergization of the relay 48, they will, of course, be retracted to extend wipers 23—25 to connection with the circuits of the first selector E. Contact 50, upon the deënergization of the relay, by falling back to engage its normal grounded contact, completes a circuit from grounded contact 50, contact 21—20 and alternate contact 11, cut-off relay 12 to battery B, energizing the said relay 12 which, by the operation of its armature 13, completes a locking circuit for itself to the same ground at contact 50, while armature 14 completes a circuit from limb P through to wiper 23. Armature 15 removes the ground from the

normal contact of armature 11 of relay 9, thereby preventing a permanent locking of relay 12 which would otherwise occur when a connector engaged contact 6 of the line. Armature 16 in its operation opens the normal connection of battery B to limb S and completes the circuit of said line limb through to wiper 25, while armature 17 opens the previously extending series circuit through relays 9 and 18, causing the deenergization of both of them and the retraction of their armatures—that of relay 18 again grounding group contact 26. Since ground at armature 50 of relay 48 is now connected to the private contact 20 individual to the line, its multiples are now non-selectable by any other line selector.

The secondary off-normal switch S. O. Sw. contacts 44—45 were shifted at the first energization of the secondary magnet SM, spring 45 interrupting the original energizing circuit for relay 48, while spring 44 interrupts the neutralizing circuit including resistance 36, and said spring 45, by engaging its alternate contact, operatively associates relay 48 with the normal contact of release switch spring 46 for use in the restoration of the line selector, as hereafter described.

It will be observed that upon the retraction of the armature of relay 37, which in its attracted position originally completed the neutralizing circuit for relay 28, a new path for continuing such neutralization had been completed by the shifting of switch spring 46 occurring on the first actuation of primary magnet PM; the new neutralizing circuit extending from the ground of said switch spring 46, its alternate contact, normal contact of switch spring 44, and resistance 36. This circuit is of course broken on the first energization of secondary magnet SM by the shifting of spring 44, but before that occurred, a third circuit was completed from ground at switch spring 46, its alternate contact, attracted armature 51 of relay 48, and resistance 36. This last circuit continued until the deënergization of relay 48, when the circuit of resistance 36 in the right-hand winding of relay 28 is opened at contact 51; but simultaneously with the opening of this circuit, relay 12 was operated and relay 9 deënergized, the retraction of the lower armature of the latter opening the circuit through the left-hand winding of relay 28. Thus, it will be observed that from the time the line selector starts, armature of relay 28 will remain retracted as far as line A and switch D are concerned, first because of the neutralized condition of the relay windings continuing until selection of the line, and thereafter because of the practically simultaneous opening of the neutralizing circuits of its windings. Thus an untoward attraction of its armature is prevented which, should it occur or exist after wipers 30—34 have reached contacts 31—35 of an idle line selector, would cause the initial operation of said selector to no avail, as there would be no calling line for it to make connection with.

The relation of the master-switch to the line selectors and the calling lines which it serves is such that as many line selectors will be started to seek out calling lines as calls come into the exchange, and no more, except in certain rarely occurring instances. It will be observed that if three calls were to come in simultaneously, the resulting energization of the three relays 9 of the lines will cause three resistances 19 to be connected in circuit with the left-hand winding of relay 28, causing a greater current to flow therethrough than in the case of a single call. The starting of the first line selector, throwing only one resistance 36 into circuit with the right-hand winding, will neutralize one only of these resistances 19; therefore, the armature of relay 28 will continue attracted, and as soon as the wipers 30—34 reach contacts 31—35 of the next idle line selector, this switch will also be started; there will then be two windings 36 in circuit with the right-hand winding of relay 28, but, there being three windings in circuit with the left-hand winding, its armature will continue attracted; and when wipers 30—34 reach the third idle line selector, this one will also be started in search of the third line. As soon as this switch starts, however, a third winding 36 will be included in circuit with the right-hand winding of relay 28. The three windings 36 will effectively neutralize the three windings 19, the armature of relay 28 will be retracted, and when wipers 30—34 engage contacts of a fourth idle line selector, this switch will not be started.

The amount of time required for the operation of the line selector to connect with the calling line is exceedingly small, requiring (as will be more fully understood when the mechanical features of the switches are described hereinafter) a maximum of thirty step-by-step movements under the most unfavorable condition, the switches being of such character that this number of steps can be performed in less than a second of time.

Subscriber A, desiring his line to be connected with the line 3456, now operates the calling device to transmit three impulses of current by rotating the said device clock-wise until three of its insulated teeth have passed below spring 3 and then releasing it whereon its associated spring turns the dial in the opposite direction, the three insulated teeth each causing spring 3 to engage and disengage its contact once. With the return of the dial to normal, its insulated tooth at the ex-

treme left causes spring 2 to engage its associated contact a single time, thereby sending one impulse of current over limb S, but not until the last tooth at the right has sent the last impulse over limb P. While the dial is at any other than at normal position, the pin shown thereon is brought to such position that tension is removed from spring 4 which then disengages its associated contact, temporarily conductively disuniting the two line limbs P and S at that point in order that impulses may be sent over the line limbs separately. The operation of the dial, as described, sends three impulses of current from ground at the substation, through spring 3 and its contact, over limb P of the line, through attracted armature 14, contact 22—23, armature 49, contact 54 at switch E, upper armature of relay 73, contact 55, through the winding of primary relay PR to battery, causing energizations and deënergizations of said relay whose thrice attracted armature causes three impulses to flow from ground, through armature spring 57 and its alternate contact, contact 58, primary magnet PM′, to battery. The three resulting energizations of PM′ move the first selector switch wipers 59—60—61 to positions adjacent to the third group of second selector contacts, terminals of second selectors belonging to the third thousand lines including those from 3000 to 3999. With the first primary movement of the wipers, the primary off-normal switch (P. O. Sw.′) contact and the release switch (R. Sw.′) contact are shifted to their alternate positions preparatory to the energization of the secondary magnet SM′.

With the return of the dial to normal, an impulse flows from ground at the substation, through spring 2 and its contact, over limb S of the line, through attracted armature 16, contact 24—25, contact 52, through contact 62 at switch E, lower armature of relay 73, contact 64, winding of secondary relay SR, to battery, causing the attraction and release of said relay's armature and a flow of current from ground, through spring 65 and its alternate contact, contact 66 and busy relay BR′, to battery. Contacts 67—70 are attracted to disconnect wipers 60—61 from battery while wiping over contacts of busy second selectors; armature 68 is attracted to close circuit from ground, through the primary off-normal switch P. O. Sw.′, the alternate contact of the release switch R. Sw.′, alternate contact 68, secondary magnet SM′, to battery. The secondary magnet, having a vibratory circuit, attracts and releases its armature, the operation being effective to move wipers 59—60—61 into engagement with contacts 86—87—88 of the first second selector of the group. With the first secondary movement of the wipers, the secondary off-normal switch (S. O. Sw.′) contacts 58—66 are shifted to operatively disconnect the windings of the primary magnet PM′ and of the busy relay BR′ from switch springs 57 and 65 respectively. If the second selector mentioned is idle, it will be in the condition shown in Fig. 1. Contact 86 being on open circuit, busy relay BR′ becomes deënergized, armature 68 opens the circuit of magnet SM′, and the wipers rest in engagement with the contacts of the first second selector; armatures 67—70 by their retraction render the said second selector responsive to current to be transmitted by relays PR and SR.

Armature 68, in engaging its normal contact, places direct ground through the primary off-normal switch (P. O. Sw.′) and release switch (R. Sw.′) contacts, normal contact 68, right-hand armature of RM′, and wiper 59 upon contact 86 of the second selector and its multiples to render the said second selector busy. It will, therefore, result that should the wipers of another first selector now be brought to engage multiples of contacts 86—87—88 of the first second selector switch F, busy relay BR′ of this other first selector then energized will have its circuit continued in this condition by current flowing from grounded contact 86 to its multiple engaged, the right armature contact of RM′, through attracted armature 69 of its busy relay BR′, through said relay to battery. The relay will, therefore, continue to be energized. Secondary magnet SM′, by the retraction of its armature, will have its circuit closed and become energized and deënergized a second time, moving the wipers 59—60—61 to engage the contacts of the second second-selector of the group. If this be in use, another locking circuit for busy relay BR′ will be established as the preceding one is broken; SM′ advances the wipers a third step, and so on until contacts of an idle second selector are reached, when, owing to the insulated condition of its contact 86, the deënergizing of BR′ ensues, preventing further operation of SM′, and the wipers come to rest.

Returning to the connection being established, subscriber A now operates dial 1 to transmit four impulses of current through relay PR over the above traced path, which said relay is operated four times, transmitting four current impulses from ground, through alternate contact 57, normal contact 67, contacts 60—87, normal contact 89, normal contact 91, primary magnet PM^2, to battery, causing four energizations of the said primary magnet. The said magnet thereby moves wipers 93—94—95 of the second selector adjacent to a group of contacts, terminals of connectors belonging to the fourth one hundred group of subscribers' lines of the third thousand, this including lines from 3400 to 3499. With the first

movement of the wipers, the primary off-normal switch springs P. O. Sw.^{2} are shifted to their alternate positions and also the spring of the release switch R. Sw.^{2}.

With the return of the dial to normal, a single impulse flows from ground at the substation, through relay SR over the before-traced path, said relay being energized and deënergized to transmit a current impulse from ground, through spring 65 and its alternate contact, through normal contact 70, contact 61—88, contact 90, busy relay BR^2, to battery, energizing the said relay. Its upper armature and armature 98 place wipers 94 and 95 on open circuit, while armature 96 completes circuit from ground at the primary off-normal switch P. O. Sw^2, through the alternate release switch (R. Sw.^{2}) contact, attracted armature 96 and the winding of the secondary magnet SM^2 to battery, causing the energization of said magnet, which is effective to cause wipers 93—94—95 to engage contacts 99—100—101 of the first connector of the selected group. If contact 99 belongs to an idle connector, it will be on open circuit as shown at G in Fig. 1. No locking circuit for relay BR^2 will result from the attraction of armature 97, and the armature of said relay falls back; the upper armature and armature 98 operatively connecting the circuits of the connector with relays PR and SR, rendering the connector controllable from substation A, while armature 96 opens the circuit of secondary magnet SM^2, leaving the wipers in engagement with the terminals of the first connector of the group; and, by the engagement of its alternate contact, said armature 96 places dead ground from the primary off-normal switch spring, alternate contact of release switch R. Sw.^{2}, normal contact 96, normal contact of the right armature of release magnet RM^2, contact 93—99 upon the multiples of the said contact 99 appearing at the other second selector banks, so that if another second selector F has its wiper 93 brought to engagement with a multiple of contact 99, its relay BR^2 will be locked by current from grounded contact 99 via alternate contact 97; secondary magnet SM^2 then advances the wipers to engage contacts, terminals of the second connector of the group. If this contact 99 belongs to an idle connector, the second selector will stop its secondary movement and the contact 99 will be rendered busy, as described in connection with the second selector F, so that a third second selector seeking a connector in the same group will select the third connector of a group, and so on. With the first secondary movement of the wipers 93—94—95, springs 89—90 of the secondary off-normal switch S. O. Sw.^{2} are shifted to operatively disconnect primary magnet PM^2 and busy relay BR^2 from relays PR and SR. Subscriber A now operates dial 1, transmitting five impulses of current from ground at the substation, through relay PR, causing five actuations thereof which are effective to transmit five impulses of current from ground, through alternate contact 57, contacts 67, 60—87, 94—100, normal contact 102, contact 103, through primary magnet PM^3 at the connector G to battery. Five resulting actuations of said magnet are effective to move wipers 105—106—107 to positions adjacent to a group of ten contact sets in their banks, forming terminals of the fifth group of the one hundred lines which the connector serves—namely, terminals of lines from 3451 to 3459 inclusive, followed by terminals of line 3450, it being understood that zero is represented by ten current impulses. With the first primary movement of the wipers, primary off-normal switch spring P. O. Sw.^{3} is shifted to operatively connect contact 99, via normal contact 122, with the winding of the release magnet RM^3 to place the same under control of the calling subscriber, as will be hereinafter more fully explained.

With the return of dial 1 to normal, a single impulse is transmitted after the last of the five preceding ones from ground, over limb S, through relay SR, traversing a before-traced path, actuating relay SR a single time, whose armature is effective to transmit a single current impulse as follows: from ground, contacts 65—70—61—88—98—95—101, normal contact 108, lower armature of magnet RM^3, through secondary magnet SM^3 to battery. The secondary magnet SM^3 is thereby actuated a single time, moving wipers 105—106—107 one step nearer the selected contact group, it being understood that the normal positions of the wipers of a connector are such that after any primary adjustment, they are two steps distant from the first contacts of the group selected.

With the first secondary movement of the wipers, springs 102—108 of the secondary off-normal switch S. O. Sw.^{3} are shifted; 102 to engage its alternate contact, while 108 is shifted only sufficiently to disengage its normal contact; a second step of the wipers being required to shift it sufficiently to engage its alternate contact. Subscriber A now operates dial 1 to transmit six current impulses from ground at the substation through primary relay PR, causing six actuations thereof and six current impulses to be transmitted from ground via spring 57, over the before-traced path, contact 102, the impulses then passing via alternate contact 102, normal switch contact of upper armature of relay 109, lower armature of magnet RM^3, secondary magnet SM^3 to battery. The first resulting actuation of secondary magnet SM^3 moves wipers 105—106—107,

now on their normal open circuit, to engage contacts 6—7—8 of the first line of the group, or line 3451; and with this movement, the complete shifting of secondary off-normal switch spring 108 is accomplished. The succeeding five actuations of SM^3 are effective only to move wipers 105—106—107 successive steps, the sixth actuation causing them to engage contacts 6—7—8, multiple terminals of the called line 3456 belonging to subscriber B.

After the transmission of the last of the six impulses, a single impulse is, in the usual manner, caused to flow from ground at the substation over limb S to secondary relay SR, whose actuation transmits an impulse from ground, through contact 65, over the before-traced path to contact 108, thence via its alternate contact and the normal contact of the lower armature of relay 109, through the left-hand winding of test relay TR to battery, causing the said relay to attract its armature. Let it be first assumed that the called line B is idle, in which case, as shown, contact 6 is connected to battery B^2 through the winding of cut-off relay 12, there being no ground connection to the said contact except through battery. The attraction of the right-hand armature of test relay TR connected its right-hand winding from battery, through said attracted armature, normal contact 104, normal contact 110, wiper 105 to contact 6; but since this contact is already connected to battery, upon the cessation of the impulse transmitted by secondary relay SR, test relay TR is deënergized, its armatures falling back, this being effective to shift springs 110—111 of the test switch T. Sw. The shifting of spring 110 connects ground to wiper 105, contact 6 and its multiples, completing circuit through cut-off relay 12 of called line B, to battery. The resulting attraction of armatures 14—16 complete the circuit over limbs P and S of the called-for line to contacts 7—8. That of 14 also disconnects line relay 9 from limb P of the line, so that when the called subscriber B removes his receiver, the act is ineffective to operate relay 9 which would otherwise cause a line selector to select his line. The placing of ground, just described, upon contact 6 and its multiples from spring 110 renders the called line busy with respect to other connectors as will be hereafter more fully explained; ground from contact 6 being also connected via armature 13 to contacts 20 of the called line, keeping them unselectable in character.

The shifting of test switch (T. Sw.) spring 111 completes circuit through relay 109 from ground, spring 111, contact 115, ringing relay 112, to battery B^2. On the resulting attraction of the armatures of relay 109, a circuit is completed from ground through normal contact of the lower armature of relay 117, normal contact 119, attracted armature of relay 109, alternate contact 102, contacts 100—94, 87—60, contact 67, normal contact 57, contact 71, magnet 73 to battery, causing the energization of said magnet 73 whose attracted armatures complete a bridge of battery B′ in the line of subscriber A from ground through upper windings of relays 74—75, attracted upper armature of relay 73, contact 54, to the left over the heavily marked conductor, contact 62, attracted lower armature of relay 73, lower windings of relays 75—74 to battery. Differentially connected relay 74 is not energized, the flow in its two windings being equal, but cumulatively connected relay 75 attracts its armatures, of which 56 and 63 complete parallel paths from ground and battery to limbs P and S respectively, while contacts 55 and 64 disconnect relays PR and SR from the talking circuit.

Having explained the effect of the shifting of spring 111 at G with respect to the first selector, I will now describe its effect with respect to the called line. Its shifting energizes ringing relay 112 over a before-traced circuit, and the attracted armatures of said relay cause alternating current to flow from generator G^2, upper armature of relay 112, contact 106—7, relay *b* and non-inductive resistance *c* in parallel, alternate contact 14, limb P of the line of B, normal hook-switch contact, bell and condenser, limb S, alternate contact 16, contact 8—107, attracted lower armature of relay 112, lower winding of relay 113 through battery B^2. The interrupter I^2 is provided in the circuit of generator G^2, so arranged as to periodically connect the said generator in and out of circuit with said line in the well-known manner. It will be observed, however, that the brushes of I^2 are so arranged that at all times during the ringing, ground is connected to limb P of the rung line either through generator or the grounded brush of the interrupter.

It should be observed that the characters of relays 113 and *b* are such that the flow of generator current through the substation condenser does not actuate the relays. As soon, however, as the called subscriber answers the call by removing his receiver, the substation hook lever engages its alternate contact, completing a conductively continuous circuit from ground through generator G^2 or interrupter I^2, as the case may be, to limb P over the before-traced path for ringing current, the alternate contact of the hook lever and through the transmitter, returning over the limb S and thence over the before-traced path and the lower winding of relay 113 to battery B^2. Current flowing over this conductive circuit energizes relay *b* and relay 113, whose attracted armature 114 first completes, by engaging spring 115, a

locking circuit including serially the already energized relay 109 and the upper winding of relay 113, causing both relays to remain energized, the said armature immediately thereafter breaking the normal contact 115, thereby effecting the deënergization of ringing relay 112 and the immediate exclusion of generator G^2 from connection with the called line. The attraction of the lower armature and armature 116 of relay 113 bridges relay 117 across the called-for line, which relay is immediately energized by current flowing over said line. The lower armature of relay 117 disengages its normal contact whereby the before-traced circuit through magnet 73 at E is interrupted and the said magnet is deënergized, the consequent retraction of its armature shifting springs 54—71 and 62—72 to their alternate positions. The deënergization of relay 73 does not effect the continued energization of relay 75 on account of the parallel path of current, before indicated, through said relay. Springs 54 and 62, in disengaging their normal contacts, prevent relays PR and SR from again being connected to the calling line by the retraction of the armatures of 73; and in engaging their alternate contacts, said springs 54—62 complete the talking circuit of switch E. Spring 72, in engaging its alternate contact, completes a path for energizing relay 76, which relay, by the attraction of its armatures 76^a and 79 to engage their associated contact springs, thereafter breaking the normal contacts of said springs, reverses the connections of battery B to the calling line, causing a reverse flow of current thereover through the substation. The attraction of armature 77^a completes circuit through register magnet *a*, causing it to attract its armature to bring pawl *a'* into engagement with the next tooth of its associated ratchet, in order that on the deënergization of magnet *a* and the retraction of its armature, pawl *a'* may advance the ratchet a step, causing a completed call to be recorded against the line of A as a calling line upon the associated counter a^2.

Returning now to relay 117 at G, having explained the effect of the lower armature of said relay in disengaging its normal contact, it will be observed that the said armature, engaging its alternate contact, completes a circuit from ground through relay 118; said relay 118, by the attraction of armature 121, establishing a locking circuit for itself through switch spring 110 of the test switch T. Sw., to ground. Armature 119 completes the talking circuit to wiper 106; armature 120 closes a break in the circuit of release magnet RM^3; while armature 122, in leaving its normal contact, removes the previously existing control of release magnet RM^3 from the calling substation, and by engaging its alternate contact, places an independent ground upon contact 99 and its multiples, so that the connector is now rendered unselectable by any other second selector until both subscribers have replaced their receivers. The two subscribers A and B are now in conversation, circuit being traced from substation A to substation B by means of the heavily marked conductors and condensers 81—82 through the exchange, talking battery being supplied to the calling line through the impedances of relays 74—75, and to the called line through the impedances of relay 117 at the connector.

When the subscribers have finished their conversation, they replace their receivers upon the hook levers; the act of subscriber B in so doing restores the connector G to normal, while the act of subscriber A in so doing restores line selector D, first selector E and second selector F to normal. When subscriber B replaces his receiver, the operation of arm 5 of the hook lever upon its associated contact springs momentarily grounds limbs P and S in the usual manner, but this operation is not used to cause the release at the called substation. The replacing of the receiver causes the hook lever to disengage its alternate contact, opening circuit through relay 117, held energized by current over the line during conversation. The upper armature of relay 117 then falls back and completes a circuit through release magnet RM^3 from ground, through contact 120 of relay 118, upper armature contact of relay 117 to battery, effecting the energization of the release magnet whose armature is thus attracted, shifts the switch springs 110—111 to normal, opening the circuit of relays 109—113—118, causing their deënergizations. The deënergization of relay 118 opened the circuit of release magnet RM^3 whose armature thereupon is retracted and wipers 105—106—107 allowed to return to normal, their restoration causing on its completion the shifting to normal of the primary off-normal switch P. O. $Sw.^3$, the secondary off-normal switch springs S. O. $Sw.^3$ being restored at the time the wipers have been restored as to their secondary movements. As soon as the conductive circuit is opened at substation B, magnet *b* is deënergized; and the armature of said magnet, previously attracted on the energization of the magnet to cause pawl *b'* to engage the next tooth of its adjacent ratchet, is now retracted, causing said pawl *b'* to advance its ratchet a step and thereby count one completed call upon register b^2 against line B as a called line.

When the calling subscriber replaces his receiver, arm 5 temporarily grounds limbs P and S of the line, the grounding of limb S short circuiting the upper winding of differential release relay 74; and current continuing through the lower winding of

said relay to ground at the substation, its armature is attracted to complete circuit through release magnet RM at switch D; from ground, attracted armature of relay 74, release magnet RM′ of switch E to battery. The energization of magnet RM′ shifts springs 54—71 and 62—72 to normal, the shifting of spring 72 deënergizing magnet 76, whose retracted armature 77^a opens circuit through magnet a, so that its retracted armature effects a thrust of pawl a' to turn its ratchet a step and record a call on counter a^2. The attracted right-hand armature of release magnet RM′ closes circuit through release magnet RM^2 at second selector F, from ground through the shifted primary off-normal switch (P. O. Sw.^{2}) contact, contact 86—59, attracted armature of RM′ to battery. The release magnets of all the switches D, E and F are now energized and their energizations shift to normal the various release switches R. Sw., R. Sw.′, and R. Sw.^{2}; the shifting of said switches causing, respectively, the energizations of relays 48, BR′ and BR^2, whereby the wipers of the various switches are disconnected from battery and so held during the release of the switches. In the restoration of the hook lever at substation A, arm 5 in passing from the top of its associated contact spring removes ground from the two limbs of the line and the armature of relay 74 returns to normal, deënergizing release magnets RM and RM′, the deënergization of RM′ opening the circuit of RM^2. The deënergizations of the various release magnets RM, RM′ and RM^2 cause the restoration of the wipers of the various switches with which they are associated. When the switches have reached normal as to their secondary movements, the secondary off-normal switches S. O. Sw., S. O. Sw.′ and S. O. Sw.^{2} are restored; when the wipers have been restored as to their primary movements, the primary off-normal switches P. O. Sw., P. O. Sw.′ and P. O. Sw.^{2} are restored. The restoration of the primary off-normal switches respectively cause the deënergizations of relays 48, BR′ and BR^2, reëstablishing the normal connections of the wipers. It should be noted that the armatures of RM, when attracted, keep the line limbs P—S connected to the windings of relay 74, while the energization of relay 48 by armature 50 holds relay 12 energized.

Assuming now that, at the time wipers 105—106—107 came to rest engaging contacts 6—7—8 of the called line, this line was a busy line. In such case, ground will be connected to contact 6 and its multiples via the shifted test switch (T. Sw.) contact 110 of another connector (if the busy line be a called line), or via armature 13 pertaining to the busy line, its contact 20, wiper 21 of a line selector then connected thereto, to ground through contact 50 at the said line selector (if the busy line be a calling line). In either case, upon the energization of the test relay TR at switch G, as before described, the said relay, instead of being thereon deënergized, will have its armatures locked in their attracted positions by current from grounded contact 6, wiper 105, normal contact 110, contact 104, right armature of relay TR, its right winding to battery. The test switch contacts therefore remain at normal and a busy signal is transmitted to the calling subscriber from interrupter I through the induction coil and condenser, left armature of relay TR, normal contact of lower armature of relay 109, to the left over the talking circuit indicated by heavy lines, to switch E, via normal contact 70, condenser 83, to the left over the heavily marked talking conductor, limb S of the line of A, through the transmitter and the primary of the induction coil, causing an audible signal in the receiver, returning over limb P, to the right over the upper talking conductor, normal contact 54, normal contact of relay 73, armature 55, relay PR through battery B′. The calling subscriber, in response to this signal, replaces his receiver, momentarily grounding the two limbs of his line. Inasmuch as relay 73 has not been energized, relays PR and SR are still operatively connected to line limbs P and S respectively and they are therefore, on the grounding of the line limbs, both simultaneously energized to close contact 84—85. Circuit is then completed from ground at release magnet RM of the line selector, contact 85—84, release magnet RM′ of the first selector to battery. RM′ attracts its armature, closing circuit from ground at release magnet RM^2 of second selector F, through alternate contact of primary off-normal switch P. O. Sw.^{2}, contact 86—59, attracted armature of RM′ to battery. The attracted armature of RM^2 closes circuit from ground through RM^3 at the connector, normal contact 122, the shifted contact of primary off-normal switch P. O. Sw.^{3}, contact 99—93, attracted armature of RM^2 to battery. The armatures of all the release magnets are now attracted; and when ground is removed from the two line limbs at substation A, the resulting deënergization of relays PR and SR allows contact 84—85 to be opened, deënergizing RM and RM′; the deënergization of the latter deënergizing RM^2; the deënergization of RM^2 deënergizing RM^3; and each switch is restored as its release magnet RM, RM′, etc., is deënergized. Thus it is seen that until the called subscriber answers the call, the release of the connector remains under the control of the calling subscriber; the instrumentality controlled by the called

subscriber for removing the calling subscriber's control of RM[3] consists of armature spring 122 of relay 118, which, when actuated, by disengaging its normal contact, opens a contact in the circuit of RM[3] and thereafter puts the second busy potential upon contact 99, as before described.

From the release operations already described, it is apparent that as soon as the line selector has selected his line, the calling subscriber may, by grounding the two line limbs simultaneously, cause the closure of contact 85—84, which will be effective to release whatever switches are connected to his line, so that, whatever stage of completing a connection may have been reached, the release of all switches so far operated may be secured.

It may sometimes happen that a line selector will overrun on its primary or secondary movement through accident or certain rarely occurring combinations of circumstances. To take care of these occurrences, I have provided the two switch springs 43 and 53; the former being so related to the switch mechanism that, if the switch shall make an eleventh primary movement, the contact 43 will be closed; while if the switch makes an eleventh step in its secondary movement, the contact of 53 will be closed. In either case, a circuit will be completed from ground through the release magnet RM, contact 43 or 53, as the case may be, alternate contact 47 of the release switch R. Sw. to battery, energizing release magnet RM, upon whose energization the release switch R. Sw. will be shifted to normal, spring 47 then opening the circuit of release magnet RM, whose deënergization causes the restoration of the line selector.

Referring now to the mechanical drawings, as shown in Fig. 2, a preferred form of the master-switch, the contacts 31 and 35 are the terminals of the line selectors, while the contacts 30 and 34 extend around under the respective rows of contacts 31 and 35; the wipers 30[a] and 34[a] (Figs. 2 and 3) having in themselves no circuit connections, being employed only to successively cross the individual contacts 31 and 35 to the respective common contacts 30 and 34, leading (as shown in Fig. 1) to the armatures of relays 29 and to relay 32. The said wipers 30[a] and 34[a] are fastened to a rotatable ratchet 30[c] adapted to be driven, step by step, by the armature-actuated pawl 30[b] of magnet 33, the magnet being provided with an interrupter actuated by its armature, as shown.

A line selector (Figs. 4, 7, 8 to 11 inclusive) comprises essentially ten group contacts 26 and a group wiper 27 making primary movements only, a contact bank including one hundred sets of contacts 20[a]—22—20—24, arranged in ten groups of ten sets of contacts each, a set of wipers 21[a]—23—25—21, capable of primary movements to select a group and secondary movements in an intersecting plane to select a contact set of a group, a primary off-normal switch P. O. Sw. comprising switch springs shifted on the first primary movement of the wipers, a secondary off-normal switch S. O. Sw. comprising switch springs shifted on the first secondary movement of the wipers, a release switch R. Sw. comprising springs shifted on the first primary movement of the wipers, a primary over-run switch shifted when an eleventh primary movement takes place and a secondary over-run switch shifted when an eleventh secondary movement takes place.

A sectional view of a bank seen from the left is given in Fig. 9 and a front view in Fig. 10, a contact set 20[a]—22—20—24 (Fig. 9) being indicated by a single short line in Fig. 10. The one hundred sets of contacts, as indicated in Fig. 10, are arranged as if projecting through the inner surface of a section of a hollow sphere.

In their primary movements, the wipers 21[a]—23—25—21 are rotated step-by-step from left to right, each step bringing them opposite a different group or upright section of ten contact sets; and in their secondary movements, the wipers are rotated step-by-step upward over the contact sets of the selected row, successively engaging them.

The wipers are pivoted at 23[b] to a bearing 23[a], clamped to a rotatable primary shaft PS suitably journaled to the main frame; while a rearwardly extending portion of the wipers, provided with a roller, engages a broad piece 160 fastened to the secondary shaft SS, the secondary movements of the wiper ends being effected by the downward movement of shaft SS, piece 160 rotating the wipers about the pivot at 23[b].

A suitable spring 161 is fastened to the primary shaft PS against whose tension it is turned, while spring 23[c] is fastened to the wipers against whose tension the secondary movements are performed. These springs serve, when the switch (by the withdrawal of the retaining detents hereafter described) is released, to restore the primary and secondary shafts and consequently the wipers.

The auxiliary or group selecting wiper 27 is fastened to the primary shaft, being solely controlled thereby, and has its row of group contacts 26.

The primary off-normal switch P. O. Sw. comprises an arm fastened to the primary shaft and provided with a stud of insulating material, as best shown in the top view (Fig. 8), holding springs 42—41—40 in their normal positions, shaft PS under the

influence of spring 161 pressing the stud against spring 42. The first step of the shaft, which is clockwise, moves the stud away from spring 42 and the three springs 42—41—40, by their own tension, are shifted to their alternate position.

The operation of the primary over-run switch will be understood from an inspection of Fig. 7, wherein shaft PS is at normal. The movement of the shaft in the operation of the switch is clockwise, and stud 43^a on the eleventh clockwise step of shaft PS comes against and presses the spring 43 of the primary over-run switch to engage its alternate contact.

The secondary off-normal switch is best shown at S. O. Sw. in Fig. 10, comprising an arm clamped to secondary shaft SS extending to the right to hold, in its normal raised position, a stud of insulating material extending through the switch frame and engaging the secondary off-normal switch springs 44 and 45. With the first step of secondary shaft SS, downward in direction, the arm of the secondary off-normal switch is brought downwardly so that springs 44 and 45 press the stud down and engage their alternate contacts.

The secondary over-run switch comprises the stud 53^a fastened to secondary shaft SS and so placed that on the eleventh secondary movement it engages spring 53 and presses it into engagement with its associated contact.

For rotating the primary shaft PS, a circular ratchet 124 (Fig. 4) is provided, adapted to be turned step by step by the armature-driven pawl 123 of primary magnet PM, whose vibratory circuit-breaker is indicated at 126.

As well shown in Fig. 9, the secondary shaft SS has cut on its inner surface a ratchet adapted to be engaged by the armature-driven pawl 127 of secondary magnet SM, by successive thrusts of which the shaft may be moved downwardly. The secondary magnet has, like the primary magnet, its armature-actuated circuit-breaker.

A pivoted retaining detent is provided for each shaft, that of the primary shaft being indicated at 125 of Fig. 4, and that of the secondary shaft at 128 (Figs. 4 and 11). These detents have rearwardly extending portions normally engaged by orifices in release arm 130 (Figs. 4 and 11) and are by said arm normally held away from their respective ratchets. On the first actuation of primary magnet PM, its armature effects movement of the pivoted member 132 (see Fig. 4) whose roller end (see Fig. 11) tilts pivoted arm 131 to lift arm 130 to disengage detents 125 and 128 when their associated springs move them to engage their ratchets. They then serve to hold their respective shafts against back movement, keeping them in whatever position they may be placed by the primary or secondary magnets.

The release switch springs 46 and 47 (Fig. 11) are held in their normal positions by a hook at one end of arm 131. The first actuation of primary magnet PM, by operating arm 132, tilts the right end of arm 131 down, spring 46 is released and the two springs 46 and 47 by their tension move to engage their alternate contacts.

The release magnet RM has (as best shown in Fig. 11) a pivoted arm 130 whose left end an associated spring tends to depress. On attraction of the armature of RM, arm 130 is drawn to the left, two orifices therein (shown in the top view, Fig. 4) slipping over the rearwardly extending portions of detents 125 and 128. At the same time, the button of insulating material on the right end of arm 130 restores springs 46 and 47 by engaging spring 46 to move it to be caught and held by the hook of arm 131. When magnet RM is now deënergized, its retracted armature draws arm 130 to the right, which, keeping its hold on detents 125 and 128, moves them away from their shaft ratchets so that the shafts are now free to be restored, shaft SS by spring 23^c fastened to the wipers, and shaft PS by spring 161.

A spline 170 (Figs. 4 and 9) is provided on the secondary shaft engaging, with the first movement thereof, any adjacent tooth of ratchet 124 to hold the primary shaft against return movement, to the end that on the restoration of the shafts as described, the secondary shaft may be first completely restored clearing the wipers from the bank, whereon spline 170 releases the primary shaft and permits its restoration.

The primary and secondary off-normal switches are of course restored by the respective shafts when they reach normal, the restoration of the secondary one occurring first.

Recapitulating the principal operations; the first actuation of primary magnet PM rotates the wipers a step, shifts the primary off-normal switch, releases the primary and secondary shaft detents and shifts the release switch. Subsequent actuations of said magnet serve only to advance the wipers successive primary steps until a possible eleventh step, when the over-run switch is shifted. The first actuation of secondary magnet SM advances the line wipers a secondary step, shifts the secondary off-normal switch, and interlocks spline 170 with ratchet 124. Additional actuations of said magnet merely advance the line wipers additional secondary steps until a possible eleventh step when the secondary over-run switch will be shifted. The release magnet when energized shifts the release switch to

normal, and when deënergized withdraws the shaft detents, restoring the switch.

The mechanism of the first selector is, in general, similar to that of the line selector. The vibratory interrupter of the primary magnet and the group selecting wiper and contacts are omitted.

The primary off-normal, secondary off-normal and release switches are controlled in a manner similar to those of the line selector, and the adjustment of the line wipers is mechanically similar. The spring combinations of the various off-normal and release switches correspond, of course, to those indicated at E in Fig. 1.

In Figs. 5 and 6 is shown the mechanism associated with the first selector for shifting springs 71—54 and 72—62, described in connection with Fig. 1. Said springs are mounted as indicated in Fig. 5, the view showing the springs at normal. The two insulated studs 135 are drawn to the left to shift the springs, and when they are freed the tension of the springs restores the studs and springs. The studs 135 are fastened to an arm 134 (Fig. 6) pivoted as shown, and having a small projection on its lower extremity adapted to be engaged by the hook of arm 133 when the armature of magnet 73 is attracted. When said magnet is thereafter deënergized on the response of the called subscriber, its retracted armature causes arm 133 to draw the lower portion of member 134 to the right, whereby studs 135 move to the left to shift their springs.

The operation of release magnet RM′ is similar to that of magnet RM of the line selector, except that its armature carries an arm 136 adapted, when the armature is attracted, to engage and lift hooked arm 133 free of member 134, thus allowing the restoration of studs 135.

It will be remembered that the shifting of spring 72 (see Fig. 1) energizes relay 76, whose energization causes that of the magnet *a*. The latter should preferably not be operated when a calling subscriber has connected his line with an idle called line and fails to secure an answer, as it is desired that answered calls only be recorded. Under such circumstances, magnet 73 is energized as soon as connection is made with the called line, and its deënergization follows when the calling subscriber replaces his receiver, causing the energization of release magnet RM′, which, by shifting spring R. Sw.′, energizes relay BR′ whose armature opens the circuit of magnet 73. The previous energization of 73 has caused arm 133 to engage member 134 (see Fig. 6). The energization of magnet RM′, preceding the deënergization of magnet 73, is effective to cause arm 136 to lift arm 133 free so that the deënergization of magnet 73 (occurring while magnet RM′ remains energized) is ineffective to move member 134; spring 72 and the other associated springs remaining at normal, whereby an improper operation of magnet *a* is avoided.

The second selector is mechanically similar to the first selector, except that magnet 73 is not employed, the various off-normal and release spring combinations being arranged as indicated at F in Fig. 1.

The connector shown in Figs. 12–13–14 inclusive is generally similar to the first selector. No vibratory circuit-breaker of the secondary magnet SM^3 is provided, and the position of the wipers with respect to the contact bank is such that two secondary steps are required to cause the wipers to engage the first contact set of a selected row for the purposes hereinbefore indicated.

The mechanism of test relay TR is best shown in Fig. 14. The test switch springs 110—111 are preferably vertically disposed and arm 137, carried by the armature of relay TR, has a raised portion adapted, when the armature is attracted, to clear spring 111, the spring associated with arm 137 then causing the upraise to engage said spring 111. On the deënergization of relay TR, the springs 111 and 110 are of course shifted by arm 137 for the purposes hereinbefore indicated. When release magnet RM^3 attracts its armature, piece 138 fastened thereto draws arm 137 down so that its upraise frees spring 111 and the two springs 110—111 by their tension return to normal. Moreover it will be observed that when test relay TR is locked because the switch wipers have engaged terminals of a busy line, the energization of the release magnet RM^3 (occurring when the calling subscriber replaces his receiver) will be effective by piece 138 to withdraw arm 137 from engagement with spring 111 so that the springs remain unshifted.

From the foregoing, it is seen that the counter a^2 of a line is operated to register only when the line (as a calling line) has completed a call and secured an answer; and that if the called line be busy or, being idle, an answer is not secured, means are provided whereby the operation of counter a^2 is prevented. Also counter b^2 is operated to register a call only when a response is made from the called substation. If the called line be busy and another subscriber tries to establish connection therewith, magnet *b* will not be affected, since wipers 106—107 of the other connector remain on open circuit, due to the failure of springs 110—111 to shift. It will also be noted, by referring to magnet *b* associated with the line of A, that when the line of A is used as a calling line, no actuation of magnet *b* is caused in the process of completing the connection through to the called line, inas-

much as the only circuit possible through magnet *b* is by way of terminal contact 7 and no circuit is completed thereover in establishing the call; while, after the call has been initiated, no connector caused by another subscriber to bring its wipers 106—107 to engage contacts 7—8 can affect the operation of magnet *b* of the calling line because of the fact that, owing to the busy condition of contact 6 of the calling line, the line wipers 106—107 of said connector continue on their normal open circuit. It is thus seen that counters a^2 and b^2 will together register all conversations taking place over the line, and at the same time, distinguish between those conversations in which the subscriber takes part as a calling subscriber and those in which the subscriber takes part as a called subscriber.

Referring now to Fig. 15, which is an arrangement more particularly adapted for use and connection to the system of Patent No. 830,653, before referred to; it includes the calling device 1, operating in a manner similar to that described in connection with substation A of Fig. 1. The magnet 160 is provided, having its circuit normally open at 153, which contact is adapted to be closed as soon as (after the removal of the receiver from the hook lever, and the hook lever has risen to its alternate position) calling device 1 has been operated and has returned to normal. When the hook lever rises, the pin thereon is brought upward in the orifice shown in arm 155, so that as soon as the subscriber begins to rotate dial 1 from left to right, the insulating piece 152 frees the top of spring 153, whereupon the spring, associated with the right pivoted end of arm 154, lifts said arm 154, spring 153, and arm 155 upward, so that when the calling device returns to normal, piece 152 presses against contact 153 to close the circuit of magnet 160, bridging the winding of said magnet 160 across the two line limbs P and S. It will be noted, however, that each time dial 1 is operated, piece 152 will relieve tension on spring 153 which then disengages its contact, to again close the said contact when the dial reaches normal, after transmitting a set of impulses, whereby limbs P and S are kept conductively disunited during the operation of the device.

The feed hook lever, in rotating about its pivot, tilts arm 156 to the right, which arm carries with it pawl 157, so that the tooth of said pawl is brought over an adjacent tooth of the operating ratchet of counter 161, while the pin upon the end of pawl 157 is brought to the right to free spring 159. The spring 150, associated with the ringing key K, is provided in the circuit of magnet 160 in order that when the key K is shifted after the transmission of the last set of impulses for the purpose of applying ground to limb P of the line to energize the ringing relay (as is described in connection with the patent cited), the circuit of magnet 160 may be opened at contact 150 to prevent current finding a path over grounded spring 151, spring 4, magnet 160, via contact 153 and over limb S of the line to battery at the exchange, which would cause a premature operation of magnet 160. The calling subscriber, having released key K, again closes a conductive bridge of the line limbs P and S for the talking circuit as indicated in the heavy lines, and the parallel path through magnet 160. When the called subscriber answers the call, the battery 70, associated with switch C of the patent cited, is brought in bridge of the line limbs P and S, the current passing over the talking circuit at Fig. 15 and in parallel through magnet 160, which thereupon attracts its armature 158 so that its stud of insulating material is brought down below the elbow in spring 159, which spring, by its tension, then disengages its associated spring, and by means of the said elbow engages the stud of 158 and holds the armature in its attracted or depressed position. The described movement of spring 159 opens its circuit of magnet 160 so that its winding is disconnected from the substation talking circuit during conversation. The downward movement of the left end of armature 158 brings it out of supporting relation to the pin at the middle of pawl 157, and the said pawl by its associated spring is brought down to engage the tooth of the ratchet opposite which it had been brought by the operation of arm 156, as described; and in this position, said pawl remains while the conversation is in progress. The replacing of the receiver, at the conclusion of conversation, restores the hook lever to normal, simultaneously grounding limbs P and S for a moment, as before described; and arm 156, being then tilted back to its normal position, draws with it pawl 157, turning its ratchet a step to record a call upon counter 161, and thereafter as it moves said pawl 157, brings the pin upon its end to engage spring 159 and draw it to engage its associated contact; the said movement of spring 159 also frees the stud upon armature 158 so that the armature is free to be restored to normal by its associated spring, lifting pawl 157 out of engagement with the ratchet. The downward movement of the hook lever also draws arm 155 and spring 153 to a position where the top end of spring 153 is below piece 152 on dial 1. The spring then disengages its contact, assuming its normal position with respect to piece 152. It is thus seen that the operation of magnet 160 does not actually record the call, but by its mechanical parts, brings pawl 157 to a position with respect to the operating ratchet of the call counter such that when the calling sub-

scriber frees the line by replacing his receiver, his act mechanically operates the counter 161.

When a call is received at the substation (Fig. 15), the called subscriber of course does not operate his calling device at all; the circuit of magnet 160 remains when at contact 152; and as armature 158 remains at normal during conversation, its left end holds pawl 157 away from the ratchet, and the replacing of the receiver at the conclusion of conversation has no effect upon counter 161.

Referring now to Fig. 16, wherein the primary winding of the substation induction coil is employed as an energizing winding of a magnet for operating the call counter; the armature 164 of magnet 167 normally engages a ratchet fastened to the operating ratchet of counter 161 and renders movement of the same impossible. The magnet 167 has its winding connected in circuit with the ground employed for transmitting switching impulses so that, by the transmission of the first impulse, when the substation mechanism is used for calling purposes, the armature 164 is attracted to disengage its associated ratchet and is then locked in its attracted position by the off-set of arm 163, which arm is then rotated downwardly by the spring fastened about its pivot; the removal of the receiver from the hook lever prior to the operation of the calling device 1 having brought the pin upon its right extension downwardly with respect to the orifice in arm 162. The key K is so arranged that when operated for ringing purposes, the primary winding of the induction coil is excluded from circuit with line limb P. When, however, key K has been restored and response of the called subscriber made as described in connection with the patent cited, battery is placed in bridge of the calling line; and the primary winding of the induction coil, acting as a magnet winding, attracts armature 165 whose associated pawl turns the counting rack of register 161 one step and registers a call. In its attraction, armature 165 engages the projection upon arm 162 and lifts the said arm to turn piece 163 about its pivot, freeing armature 164 which is then retracted to engage the retaining ratchet before described. It is thus seen that in the structure of Fig. 16, the act of the called subscriber in answering the call, which bridges battery across the calling line, in itself registers the call against the calling line. The replacing of the receiver at the conclusion of conversation opens the circuit of the primary winding, whereupon armature 165 is retracted and its pawl engages a tooth of the counting ratchet adjacent to that operated by it in recording the call, so that the mechanism is now ready for further use. When the substation at Fig. 16 is used as a called substation, there is of course no occasion for turning the dial 1, and magnet 167 remains inert, armature 164 therefore continuing in its locking relation with its associated ratchet so that when, on response of the called subscriber, current flows through the primary winding of the induction coil, the attraction force of the coil upon armature 165 is ineffective, armature 164 by its continuing engagement with the retaining ratchet preventing any operation of the counting ratchet.

In Fig. 17, the substation hook lever is provided with an arm 155, as in Fig. 15, the arrangement of arm 154 being such that it completes a circuit for magnet 170 as soon as piece 152, on the actuation of the calling device 1, frees spring 153, and the connection remains closed at this point until the replacing of the receiver. Spring 4 serves to conductively disunite the line limbs while the device is being operated. When the called subscriber answers the call, the system of the patent cited being employed, the inclusion of the central source of current in bridge of limbs P and S of the substation (Fig. 17) completes a circuit through key K, magnet 170, spring 172 and its contact, arm 154 and its contact, to spring 4, returning over limb S (a parallel path existing through the transmitter), energizing magnet 170 whose armature 171 is attracted to disengage the retaining ratchet of counter 161, the pin of said armature being brought above the elbow of spring 172, whereupon said spring, by its tension, disengages its contact, opening the circuit of magnet 170, and at the same time engages the stud upon armature 171 to hold the said armature in its raised position. When, now, at the conclusion of conversation, the calling subscriber replaces his receiver, arm 5 momentarily connects its three associated springs together and to ground through magnet 168, over which ground the current then flows to release the central office mechanism. Magnet 168 is thereby actuated and attracts its armature, effecting a thrust of the pawl 169, which first moves the actuating ratchet of counter 161 a step and thereafter mechanically engages spring 172 to press it to engage its contact and release armature 171 which falls back into the retaining position. As arm 5 reaches normal, circuit is of course broken through magnet 168 and pawl 169 is retracted to engage the next tooth of the actuating ratchet. The described closing of contact 172 would cause a second energization of magnet 170, except that contact 154 is open when the receiver is replaced. When the substation (illustrated in Fig. 17) is used as a called substation, no actuation of magnet 170 can occur because dial 1 is not operated and

contact 153 remains open; hence, when the called subscriber replaces his receiver, the attractive effect of magnet 168 upon its armature is ineffective to cause pawl 159 to register a call, because armature 171 has remained in engagement with the retaining ratchet of the counter.

In Fig. 18, I have shown a substation arrangement provided with two call counters, counter 161 being adapted to register the number of conversations held over the line as a calling line, while 166 registers the number of conversations held over the line as a called-for line. The polarized magnet 173 is provided, so arranged that when the receiver is removed from the hook lever, its windings are bridged across limbs P and S of the line by the conductive piece 178. When the line is used as a calling line, the flow of current caused over the line limbs on the response of the called subscriber flows via key K, said magnet 173, contacts 175—178, in a direction to tilt the armature of the magnet to the right so that pawl 176 turns the operating ratchet of counter 161 to register a call against the line as a calling line. The described movement of the armature brings the insulating stud upon its extremity to the right of the depressed portion of spring 175, so that the said spring is freed to disengage its contact, disconnecting the magnet 173 from limb S of the talking circuit, while the depressed portion locks the armature of said magnet in its shifted position. When, at the conclusion of conversation, the calling subscriber replaces his receiver, the release springs actuated by arm 5 close circuit through magnet 174, whose attracted armature then lifts spring 175 up to engage its contact; and magnet 173 then having no current, its armature is caused, by its associated spring, to assume its normal position. The pawl 177 is provided with a stop so arranged that the tilting of the armature of the magnet to the right, as described, and its subsequent return brings the pawl 177 back into engagement with the same tooth of the operating ratchet of counter 166, as was originally engaged by it. For the purpose of providing a flow of current in the opposite direction through magnet 173, when the substation (Fig. 18) is employed as a called substation, the system of the cited patent requires that the lower winding of relay 67 be connected to the grounded side of battery 125, while the upper winding of said relay should be connected to the ungrounded side of said battery. Under these circumstances, when the called subscriber answers a call, current will flow through magnet 173 in a direction to tilt its armature to the left, and pawl 177 will rotate the operating ratchet of counter 166 a step to record a call against the line as a called line. The armature is held in its tilted position by spring 175 until the called subscriber replaces his receiver and the armature of magnet 174 lifts spring 175, as just described, when armature 173 returns to normal, and pawl 177 to engage an adjacent tooth of its ratchet. On said return, pawl 176 engages the same tooth that was previously engaged by it.

Fig. 19 shows a modification of the structure of Fig. 18, wherein the calling line counter 161 is alone associated with the calling line. The action of the armature of magnet 173 is similar to that described in connection with Fig. 18, being tilted to the right at the beginning of conversation, when the line is a calling line, to register a call; and tilted to the left at the beginning of conversation, when the line is a called line, in each case opening the circuit of magnet 173 and disconnecting it from limb S of the talking circuit. The actuation of spring 175 to allow the restoration of the armature of magnate 173 to normal is effected, when the subscriber replaces his receiver, by an arm of the hook lever extending to the right to engage, by an insulating piece, the end of spring 175. The tilting of the armature of magnet 173 to the right registers the call, while the tilting of said armature to the left merely opens the circuit of magnet 173.

The structures of Figs. 15 to 19, inclusive, are not adapted for use without change in connection with the precise circuits illustrated in Fig. 1, particularly because of the line-selecting provision made in said Fig. 1 and the consequent provision of a line relay bridge from the central office battery to the two sides of the subscriber's line. Were the line-selecting feature omitted and the two limbs P—S of the subscribers' lines tied directly to the talking conductors of first selectors individual to the lines, a substation arrangement, such as that shown in Fig. 15 for example, would be employed with the system. In such case, however, the counter at the substation would record each call where the called line was found idle, irrespective of whether a response was secured, but would not record calls where the called line was found busy. This will be apparent from a consideration of the fact that whenever a connector in the system of Fig. 1 connects to an idle called line, the deenergization of its test relay TR will result in the operation of the relay 73 at E, and battery will be bridged across the calling line.

In Fig. 20, I show a structure similar to that of Fig. 19 in its general aspects, which is particularly adapted for employment in connection with the system shown in Fig. 1. In connection with such a system, the counter 161 registers the number of conversations taking place over the line with which

it is associated as a calling line. It will be noted in connection with Fig. 1 that when subscriber A removes his receiver, live battery was connected to limb S of the line, while ground was connected to limb P; also, that after the calling line is connected with the called line, and prior to a response of the called subscriber, similar poles of the central source would be connected to the corresponding sides of his line. Referring now to Fig. 20, under the just mentioned circumstances, the flow of current over limb P through the hook lever and its alternate contact, through the primary winding of the induction coil and the transmitter, spring 4 to limb S, (current also flowing in a parallel path through magnet 173), will be in a direction to tend to throw the armature of the polarized magnet 173 to the left, but movement thereof is prevented by the stop 190. When, however, the called subscriber responds, the resulting actuation of magnet 76 at E in Fig. 1 reverses the direction of the current flow over the calling line, it then being in a direction to tilt armature magnet 173 to the right, whereby pawl 176 turns the actuating ratchet of counter 161 a step to register a call. The winding of magnet 173 is connected to substation talking circuit during conversation, its armature being held in a tilted position until the called subscriber, by replacing his receiver, opens the circuit of said magnet, when the armature is restored, pawl 176 engaging the next tooth of its ratchet. By referring to Fig. 1, Sheet 3, it will be noted that the talking battery supplied to a line when conversation is taking place thereover as a called line, from the active side of battery B^2, through the lower winding of relay 117, is connected to limb S of the line and the grounded side of said battery, through the upper winding of said relay 117, to limb P of the line. The flow of current is then in a direction to tend to tilt the armature of magnet 173 to the left so that, when a conversation takes place over a line having at its substation the arrangement of Fig. 20, as a called line, no effect is produced upon counter 161. The counter of Fig. 20 is to be employed in coöperative relation with the central office counters associated with lines to indicate calls initiated thereover, thus affording the subscriber a check upon the account rendered him for service by the operating company. By such employment, a complete unitary register system for commercial service is secured.

It is not my intention to limit myself to the precise structures herein described and shown, nor to the employment of my invention in connection with automatic telephone systems only, but

What I claim is:—

1. A telephone exchange system comprising telephone lines, selective switches automatically operated to select the calling lines, a call register individual to a telephone line and mechanism for recording thereon against said line the number of calls originating thereover to which responses are secured.

2. A telephone system comprising telephone lines, selective switches automatically operated to select the calling lines, call register mechanism individual to a telephone line, means for recording on said mechanism the number of conversations for which said line is used and for distinguishing the number of times said line is so used as a calling line.

3. A telephone system including a calling line and a called line switched to connection, automatic switches included in said connection, a central source of current having its opposite poles connected to the two limbs of said calling line, means operated by the response of the called subscriber to reverse the connections of said source to the calling line, and a call register individual to said calling line operated responsive thereto to register a call.

4. A telephone system including telephone lines, selective switches automatically operated to select the calling line, a call register individual to said line, an electromagnet therefor, contact wipers for said selective switches, means for causing a flow of current over a contact wiper to operate said electromagnet, and mechanism controlled by said electromagnet to record a call on said register.

5. A telephone system including telephone lines, selective switches automatically operated to select the calling line, a call register individual to said line, an electromagnet therefor, contact wipers for said selective switches, means for causing a flow of current over a contact wiper to operate said electromagnet, mechanism controlled by said electromagnet to record a call on said register, and means for preventing the recording thereof unless a response is secured.

6. A telephone system including a calling line and a called line, means including automatic switches for connecting said lines, a central source of current in bridge of the calling line, a call register individual to the calling line, means at the exchange for reversing the connections of said source to the calling line when the called subscriber responds and apparatus effective on said reversal to record a call on said register.

7. A telephone system including a telephone line, other telephone lines, selective switches at the exchange adapted to be operated responsive to currents over said line to connect said line with any one of said other telephone lines, a source of current having its opposite poles normally in connection with the two limbs of said line, means for reversing the connections of said

source, and a call register individual to said line operating responsive to said reversal to record a call.

8. An automatic telephone system including telephone lines, a calling line, a call register at the substation telephone of said line, a control magnet for said register, a control circuit for said magnet having two control points, one normally closed and the other normally open, switch-hook mechanism at the substation to close said normally open control point to place said magnet in operative relation with said line, selective switches at the exchange adapted to be operated in response to currents controlled at the substation to complete connection with a called line, a relay at the exchange, a central source of current, means for operating said relay effective on the response of the called subscriber to complete said control circuit to operate said magnet, and means responsive to such operation to render said register effective to record a call.

9. An automatic telephone system including telephone lines, a calling line, call register mechanism individual thereto, selective switches at the exchange for operation responsive to directive currents over said line to complete connection to the called line, line selectors at the exchange adapted to automatically connect with the calling line on initiation of a call to operatively associate said line with selective switches, a relay at the exchange sensitive to current over the called line controlled by the called subscriber after connection is made to his line, and a central source of current and means controlled by said relay for causing a current flow from said source over the calling line to render said register mechanism effective to record a call.

10. An automatic telephone system including telephone lines, a calling line, call register mechanism individual thereto, selective switches at the exchange for operation responsive to directive currents over said line to complete connection to the called line, line selectors at the exchange adapted to automatically connect with the calling line on initiation of a call to operatively associate said line with selective switches, a relay at the exchange sensitive to current over the called line controlled by the called subscriber after connection is made to his line, a central source of current, a polarized magnet for said register, and means controlled by said relay for causing a current flow from said source over the calling line in a particular direction to operate said magnet to render said register mechanism effective to record a call.

11. An automatic telephone system including telephone lines, a calling line, selective switches at the exchange for operation responsive to directive currents over said line to complete connection to the called line, line selectors at the exchange adapted to automatically connect with the calling line on initiation of a call to operatively associate said line with selective switches, call register mechanism at the called substation, a polarized operating magnet therefor, and means for causing a flow of current over the called line on the response of the subscriber in a particular direction to operate said magnet to render said register mechanism ineffective to record a call, and means for operating said magnet to record a call when its line is connected as a calling line.

12. A telephone system including a calling line, and a called line, electrically controlled selective switches at the exchange connecting said lines, an energized electromagnet at the exchange, means controlled by the response of the called subscriber for deënergizing said magnet, a call register individual to the calling line, and means for operating said register to record a call against said line responsive to the deënergization of said magnet caused by the called subscriber.

13. A telephone system including a calling line and a called line, electrically controlled selective switches at the exchange connecting said lines, an energized electromagnet at the exchange, means controlled by the response of the called subscriber for deënergizing said magnet, a call register individual to the calling line, means for operating said register to record a call against said line responsive to the deënergizing of said magnet caused by the called subscriber, mechanism controlled by the calling subscriber until response is secured adapted to deënergize said magnet, and apparatus for preventing operation of said register on deënergization of said magnet caused by the calling subscriber.

14. A telephone system including a calling line and a called line, electrically controlled selective switches at the exchange connecting said lines, a central source of current having its opposite poles connected to the calling line, an energized electromagnet at the exchange, means controlled by the response of the called subscriber to deënergize said magnet to cause a reversal of the connections of said poles to the calling line, a call register individual to the calling line, and mechanism operating only when said connections are reversed to record a call upon said register.

15. A telephone system including a calling line and a called line, electrically controlled selective switches at the exchange connecting said lines, a central source of current having its opposite poles connected to the calling line, an energized electromagnet at the exchange, means controlled by the response of the called subscriber to de-

energize said magnet to cause a reversal of the connections of said poles to the calling line, a call register individual to the calling line, mechanism operating only when said connections are reversed to record a call upon said register, apparatus controlled by the calling subscriber until response is made adapted to deënergize said magnet, and means for preventing the reversal of said connections on deënergization of said magnet caused by the calling subscriber.

16. A telephone system including telephone lines, a link-circuit at the exchange for interconnecting said lines, an automatic selective switch individual to said link-circuit and operative to connect it with a calling line on removal of the receiver at the sub-station, a call register for said line, a contact wiper for said switch, and means for causing a flow of current thereover to render said register effective for recording a call.

17. In a telephone system, the combination with telephone lines, of electrically operated selective switches, means for adjusting said switches to connection with said lines, a call recording circuit, and a contact wiper in one of said selective switches solely for forming part of said circuit.

18. In a telephone system, the combination with telephone lines, of electrically operated selective switches, means for adjusting said switches to connection with said lines, a call recording circuit, a contact wiper in one of said selective switches solely for forming part of said circuit, and means for operating said recording circuit controlled by the called subscriber.

19. In a telephone system, the combination with telephone lines, of electrically operated selective switches, means for adjusting said switches to connection with said lines when calling, directive switches for extending the selective switch to the called lines, contact wipers in said selective switches adapted to form parts of a talking circuit, and a contact wiper in one of said switches separate from the talking circuit adapted to form part of a recording circuit.

20. In a telephone system, the combination with telephone lines, of electrically operated selective switches, means for adjusting said switches to connection with said lines when calling, directive switches for extending the selective switch to the called lines, contact wipers in said selective switches adapted to form parts of a talking circuit, a contact wiper in one of said switches separate from the talking circuit adapted to form part of a recording circuit, and means for operating said recording circuit controlled by the called subscriber.

21. A telephone system comprising telephone lines, selective switches operatively related to said lines and responsive to the initial closure of the line circuit when calling to automatically extend the circuit thereof, call register mechanism individual to each telephone line, means controlled over the telephone lines for recording on each mechanism the number of conversations for which its line is used and for distinguishing the number of times each line is so used as a calling line.

22. A telephone system including a calling line and a called line adapted to be united into a conversational circuit, automatic switches for inclusion in said circuit, a central source of current having its opposite poles connected to the two limbs of said calling line, means for reversing the connections of said source to the calling line, and a call register individual to said calling line operated responsive thereto to register a call.

23. A telephone system including telephone lines, a calling line, call register mechanism individual to said line, "selector" and "connector" switches at the exchange responsive to directive currents over said line to extend the circuit of said line, selective switches for uniting said line to said selector switches automatically upon the initiation of a call over said calling line, a relay at the exchange sensitive to current over the called line controlled by the called subscriber after connection is made to his line, and a central source of current and means controlled by said relay for causing a current flow from said source over the calling line to render said register mechanism effective to record calls.

24. A telephone system including telephone lines, a calling line, call register mechanism individual to said line, "selector" and "connector" switches at the exchange responsive to directive currents over said line to extend the circuit of said line, selective switches for uniting said line to said "selector" switches automatically upon the initiation of a call over said calling line, a relay at the exchange sensitive to current over the called line controlled by the called subscriber after connection is made to his line, a central source of current, a polarized magnet for said register mechanism, and means controlled by said relay for causing a current flow from said source over the calling line in a particular direction to operate said magnet to render said register mechanism effective to record a call.

25. A telephone system including telephone lines, a calling line, "selector" and "connector" switches at the exchange responsive to directive currents over said line to extend the circuit of said line, selective switches for uniting said line to said "selector" switches automatically upon the

initiation of a call over said calling line, call register mechanism at the called substation, a polarized operating magnet therefor, and means for causing a flow of current over the called line on the response of the subscriber in a particular direction to operate said magnet to render said register mechanism ineffective to record a call and means for operating said magnet to record a call when its line is connected as a calling line.

26. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a magnet controlling said register normally not in operative relation with said line, a switch-hook and impulse transmitter at the substation jointly operative to place said magnet in operative relation with said line, and means for operating said magnet to render said register effective to record a call.

27. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a magnet controlling said register normally not in operative relation with said line, a switch-hook and impulse transmitter at the substation jointly operative to place said magnet in operative relation with said line, selective switches at the exchange adapted to be operated responsive to currents controlled at the substation to complete connection with a called line, and means for operating said magnet to render said register effective to record a call.

28. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a magnet controlling said register normally not in operative relation with said line, a switch-hook and impulse transmitter at the substation jointly operative to place said magnet in operative relation with said line, selective switches at the exchange adapted to be operated responsive to currents controlled at the substation to complete connection with a called line, a relay at the exchange, a central source of current and means for operating said relay to operate said magnet to render said register effective to record a call.

29. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a switch-hook and impulse transmitter at the substation, a circuit for said call register, contacts controlled by said switch hook and impulse transmitter for normally rendering said calling register inoperative whereby said contacts must be operated to include said register in said circuit, and means controlled by the response of a called subscriber to render said register effective to record a call.

30. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a switch-hook and impulse transmitter at the substation jointly controlling said call register, selective switches at the exchange adapted to be operated responsive to currents controlled at the substation by said impulse transmitter to complete connection with a called line, and means controlled by the response of a called subscriber to render said register effective to record a call.

31. A telephone system including telephone lines, a calling line, a call register at the substation of said line, a switch-hook and impulse transmitter at the substation jointly controlling said register, selective switches at the exchange adapted to be operated responsive to currents controlled at the substation by said impulse transmitter to complete connection with a called line, a relay at the exchange, a central source of current, and means for operating said relay effective upon the response of the called subscriber to operate said magnet to render said register effective to record a call.

32. A telephone system comprising telephone lines, service meter magnets at the substations of said lines placed in a closed electrical circuit upon the removal of each receiver thereat, automatic link circuit apparatus for interchangeably connecting said lines into conversational circuits, means for operating a magnet when its line is calling and means to prevent operation of a magnet when its line is called.

33. A telephone system comprising telephone lines, directively operated switches and means for operating them for extending the circuit of said lines, automatic switches for connecting said lines and directive switches upon initiation of calls over said lines, call register mechanism individual to a telephone line, means included in said switches for causing the operation of said mechanism to record the number of conversations for which said line is used and for distinguishing the number of times said line is used as a calling line.

34. A telephone system comprising telephone lines, directively operated switches and means for operating them for extending the circuit of said lines, automatic switches for interconnecting said lines and directive switches upon initiation of calls over said lines, call register mechanism individual to a telephone line, and means for operating said mechanism through such an extended circuit to record a call for each completed connection.

35. A telephone system including telephone lines, substations connected thereto, automatic link circuit apparatus for interconnecting said lines, register magnets and circuit connections at the substations whereby they are connected in closed circuit with the line each time the receiver is removed, means for au-

tomatically operating said magnets to register a call when said lines are calling and means to prevent operation of said magnets when the magnets are connected in circuit with the line in response to a call.

36. A telephone system comprising telephone lines, selective switches operatively related to said lines, call register mechanism individual to the telephone lines, including a pair of meter magnets, means including said switches for establishing a conversational circuit including a pair of talking conductors between said lines, circuit connections whereby one of said register magnets is included in the talking circuit of a line when called, a local circuit for operating the other one of the pairs of magnets when a line is calling whereby the number of conversations for which a line is used is registered on said mechanism and means for distinguishing the number of times said line is used as a calling line.

37. A telephone system including a calling line and a called line switched to connection, automatic link circuit apparatus included in said connection, a central source of current having its opposite poles connected to the two limbs of said calling line, means operated by the response of the called subscriber to reverse the connections of said source to the calling line, and a call register associated with the substation of the calling line operated responsive thereto to register a call.

38. A telephone system comprising telephone lines, selective switches operatively related to said lines, means for operating said switches for interconnecting said lines, call register mechanism associated with the substation of each telephone line, means operating over an established connection for recording on said mechanism the number of conversations for which said line is used, and for distinguishing the number of times said line is so used as a calling line.

39. A telephone system including a calling line and a called line switched to connection at the exchange, automatic switches included in said connection, a central source of current having its opposite poles connected to two limbs of said calling line, means for reversing the connections of said source to the calling line, and a call register at the substation of the calling line operated responsive to said reversal to register a call.

40. A telephone system comprising telephone lines, directive switches for extending the circuits thereof, automatic switches for connecting a calling line to an idle one of said directive switches, means for operating said directive switches to extend a connected calling line to a called line, call register mechanism individual to the substation of the calling telephone line, means operating over an established connection for recording on said mechanism the number of conversations for which said line is used, and for distinguishing the number of times it is so used as a calling line.

41. A telephone system comprising telephone lines, selective switches operatively related to said lines and responsive to the initial closure of the line when calling to automatically extend the circuit thereof, link circuits for thereafter extending the calling to a called line, call register mechanism located at the substation of said telephone line, means operating over an established connection for recording on said mechanism the number of conversations for which said line is used, and for distinguishing the number of times said line is so used as a called line.

42. In a telephone system, a calling and a called subscriber's line, a call registering device associated with said calling subscriber's line, automatic switch mechanism including directively controlled progressively movable automatic switches for connecting said lines in conversational circuit, a pair of wipers included in the conversational circuit extending between the lines, a third wiper separate from the conversational circuit, and a circuit extending through the said third wiper for operating the said call registering device.

43. In a telephone system the combination of a pair of connected telephone lines, a call registering device associated with one of said lines, directively controlled progressively movable automatic switches for establishing said connection, wipers for said switch mechanism included in the talking circuit, a third wiper for said switch mechanism separate from the talking circuit, and means for closing an operating circuit through the said third wiper for operating the said call registering device.

44. In a telephone system, a calling subscriber's line provided with a call registering device, a called subscriber's line, directively controlled step-by-step automatic switches controlled from said calling subscriber's line for completing a conversational circuit with the said called subscriber's line, a wiper for said automatic switch mechanism separate from said conversational circuit, and means controlled by the response of the called subscriber for closing a circuit through said wiper to operate said call registering device.

45. In a telephone system, a calling and a called subscriber's line, a polarized relay associated with said calling line for operating a call registering device, automatic switch mechanism for completing connection between said lines, a battery associated with said switch mechanism having its opposite

poles connected to said calling subscriber's line, and means controlled by the response of the called subscriber for reversing the connection of the said battery to the calling subscriber's line for causing the operation of the said polarized relay.

46. In a telephone system, a calling subscriber's line provided with a substation, a polarized relay associated with said substation, a call registering device controlled by said polarized relay for checking the number of established connections over said calling line, a source of current having its opposite poles connected to said calling line, and means for reversing the connection of said source to the said calling line whereby said polarized relay is operated.

In witness whereof, I hereunto subscribe my name this 15 day of November, A. D., 1906.

GEORGE E. MUELLER.

Witnesses:

H. C. OLMSTEAD,

THOMAS H. FERGUSON.