A. H. DYSON.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED JAN. 8, 1909.

959,485.

Patented May 31, 1910.

5 SHEETS—SHEET 1.

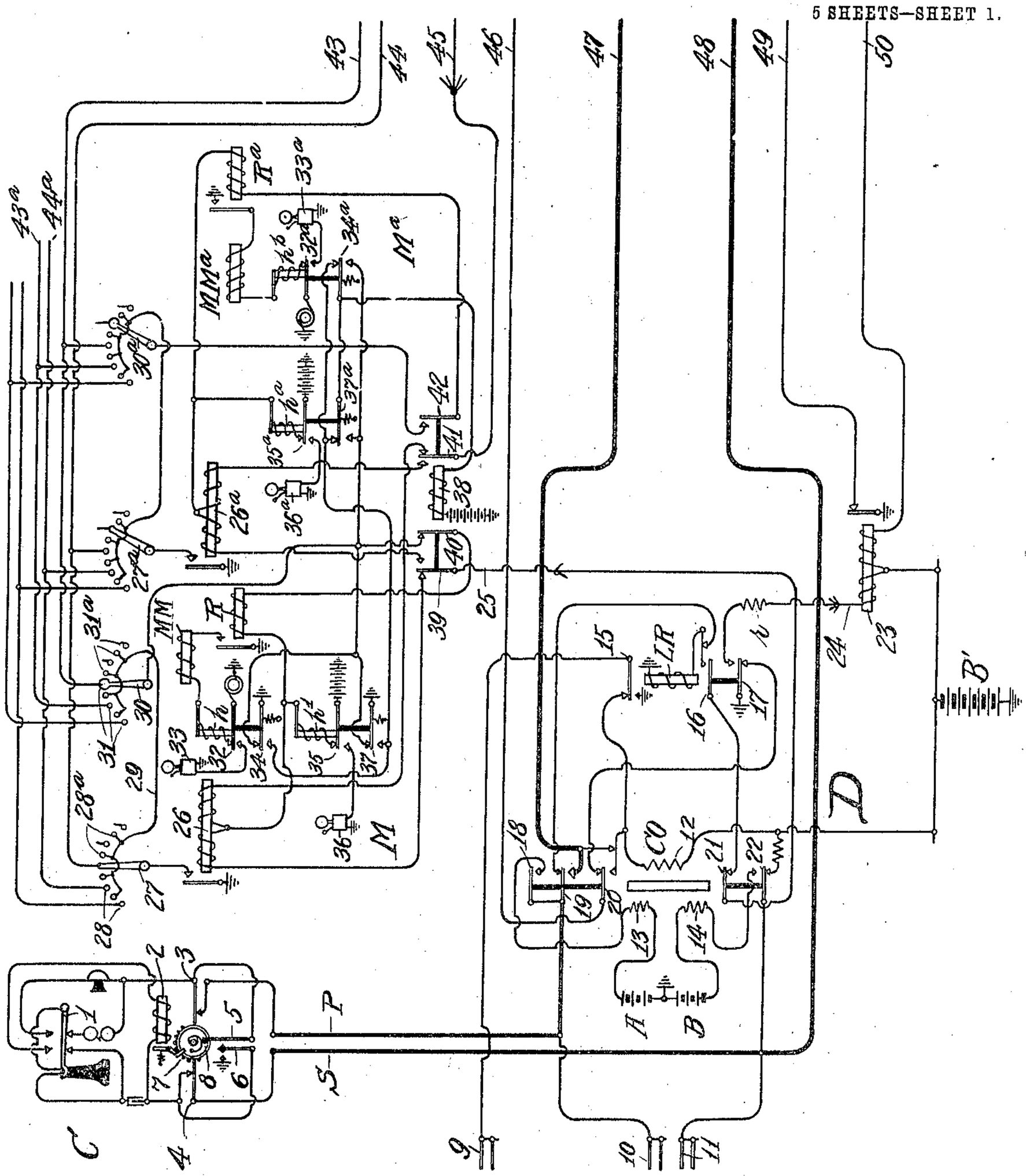

Fig. 1 part 1

Witnesses

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5 SHEETS—SHEET 2.

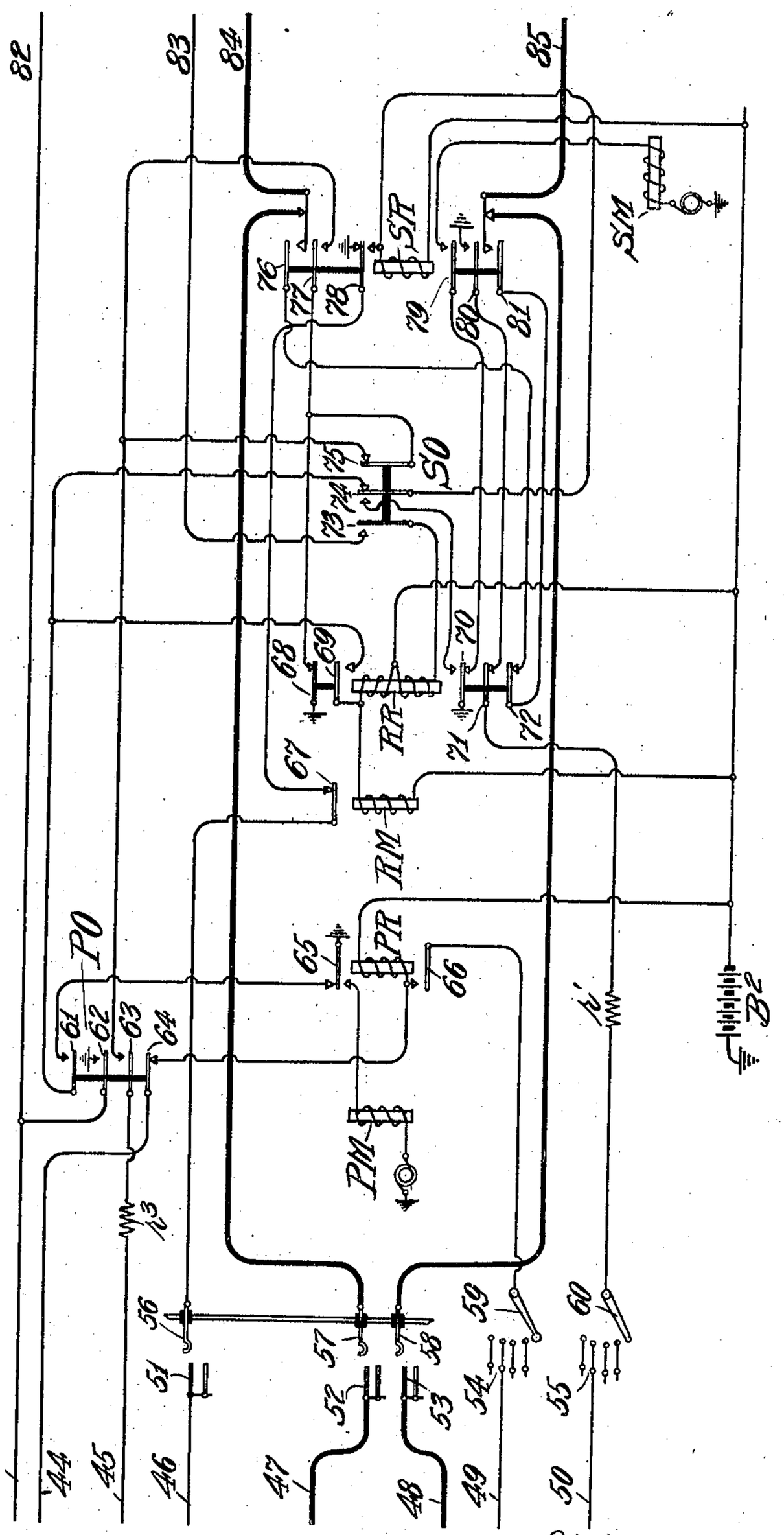

Fig. 1 part 2

Witnesses

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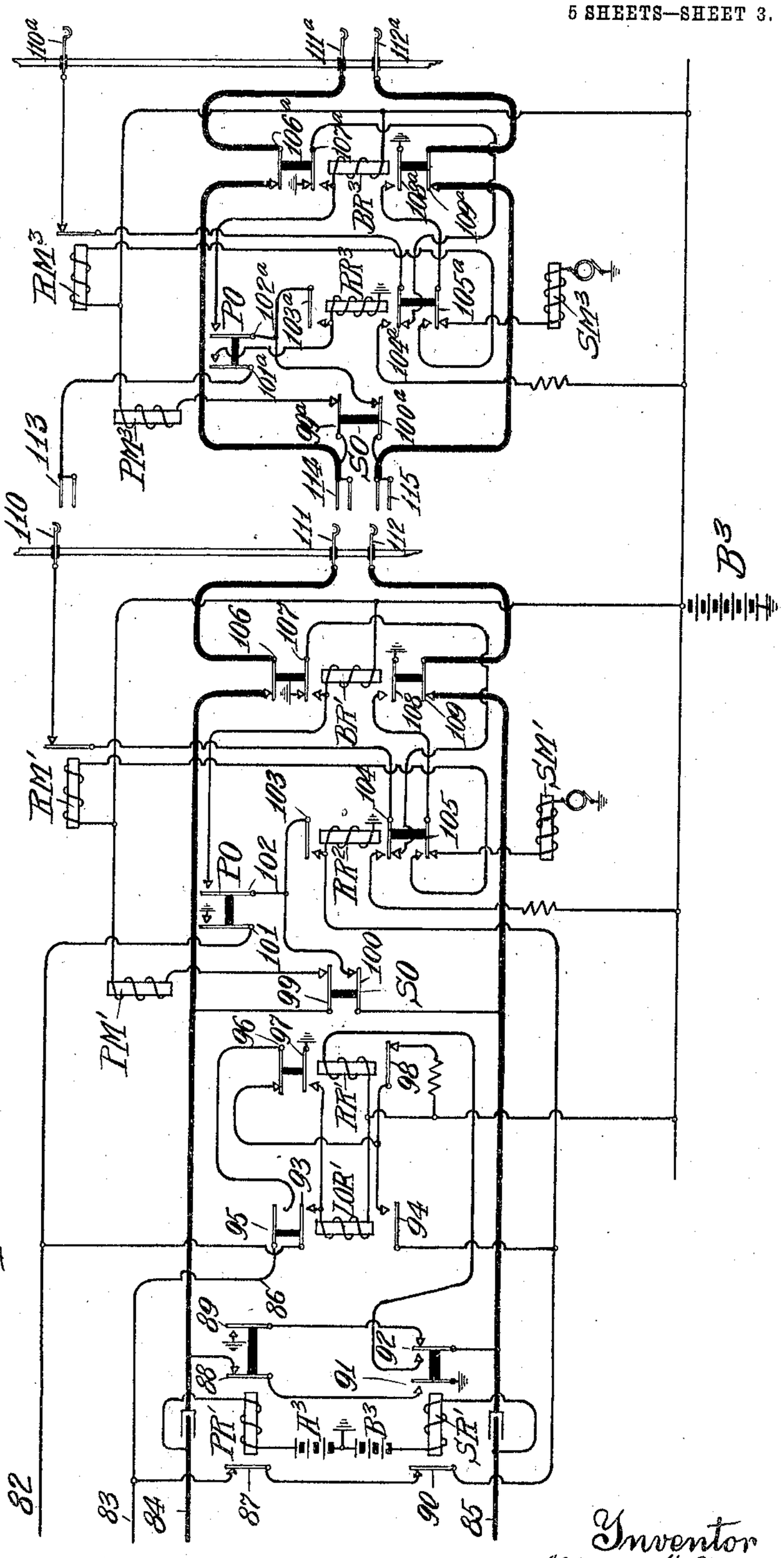
5 SHEETS—SHEET 3.



Witnesses

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5 SHEETS—SHEET 4.

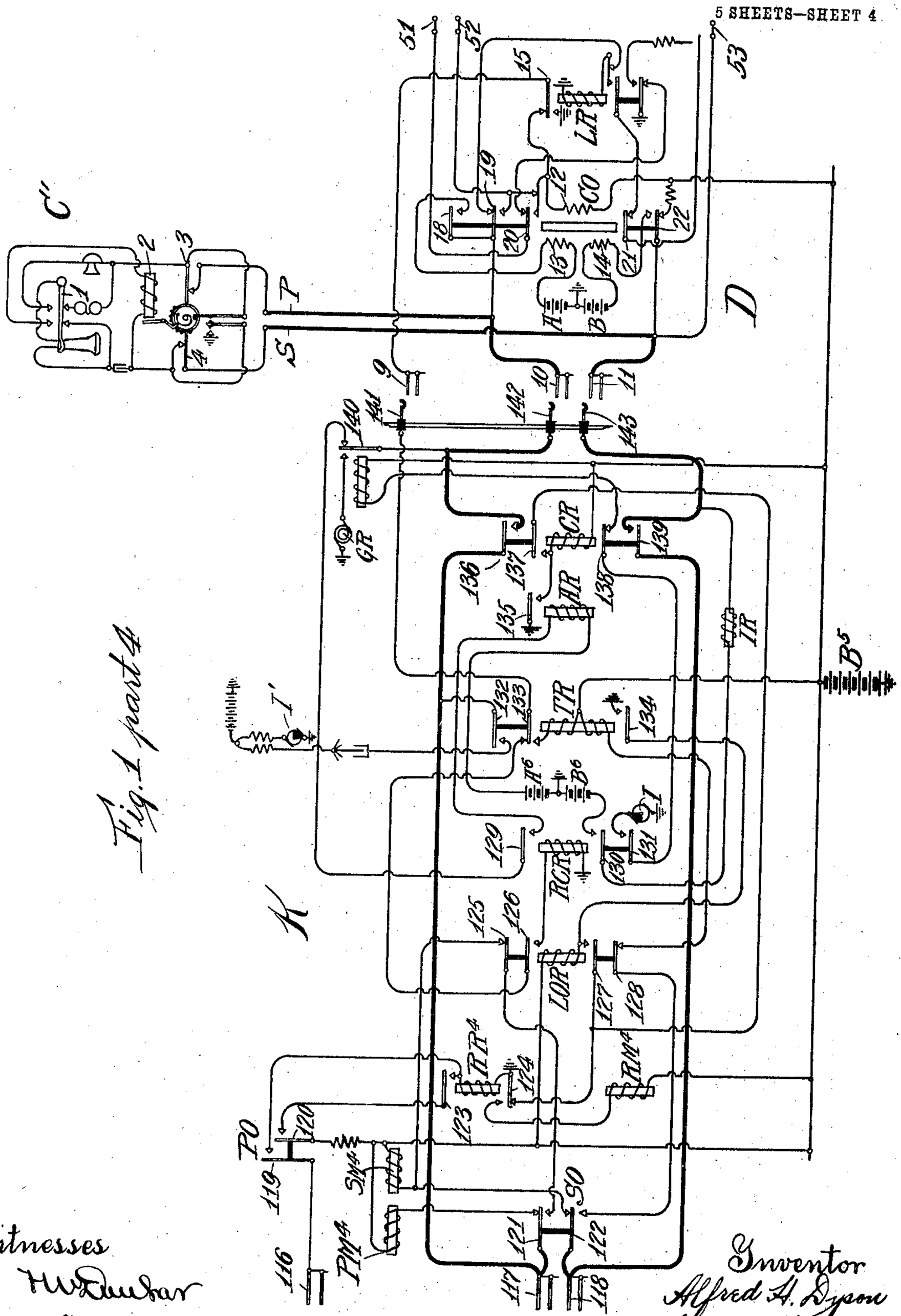

Fig. 1 part 4

Witnesses

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5 SHEETS—SHEET 5.

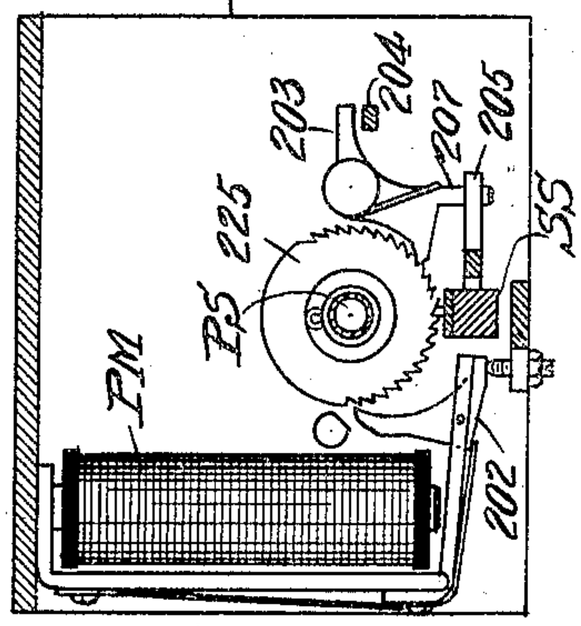
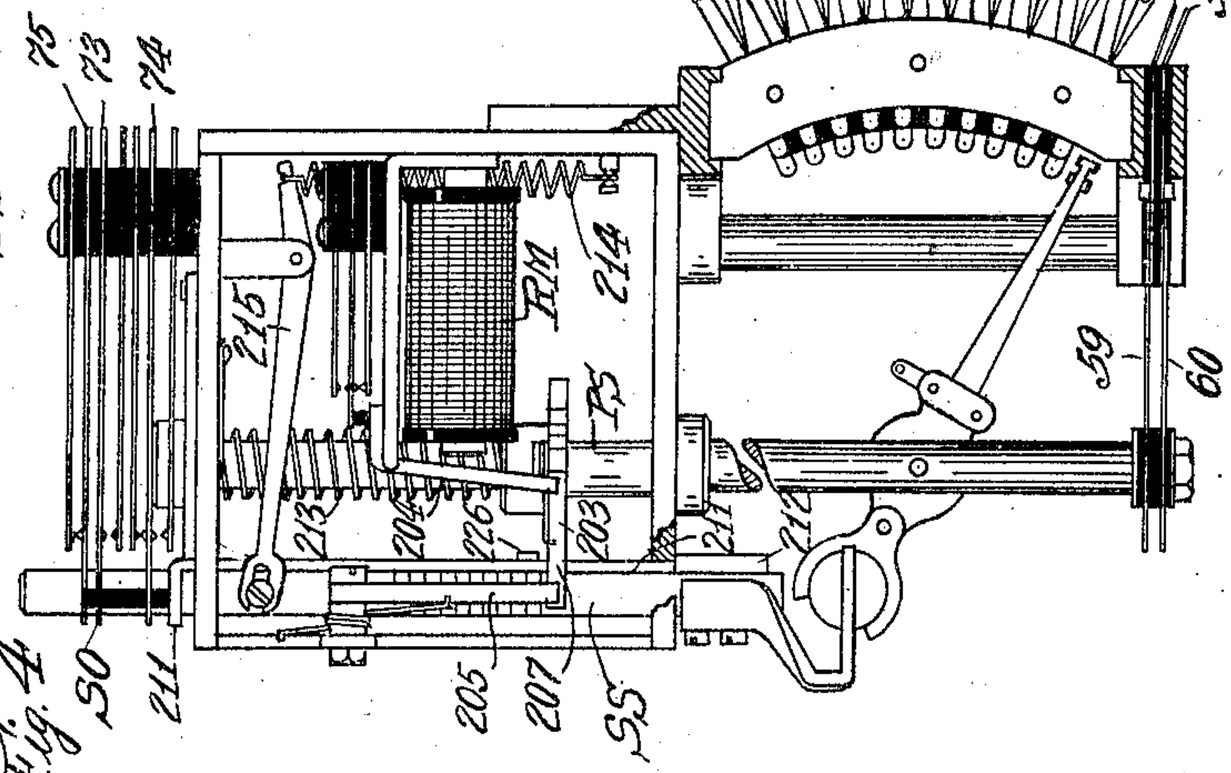


Fig. 4



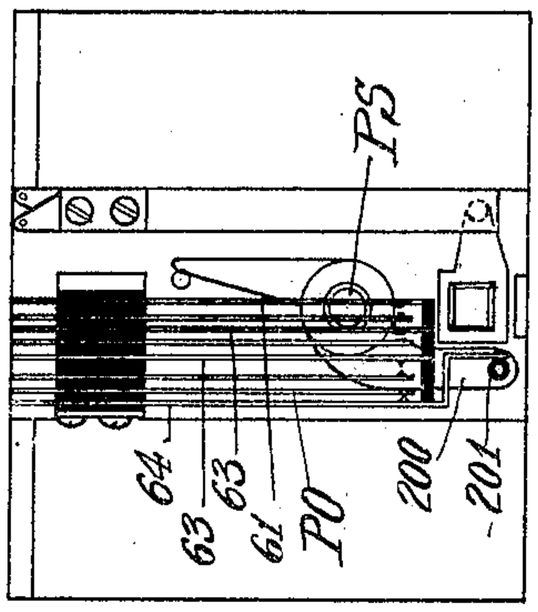


Fig. 5

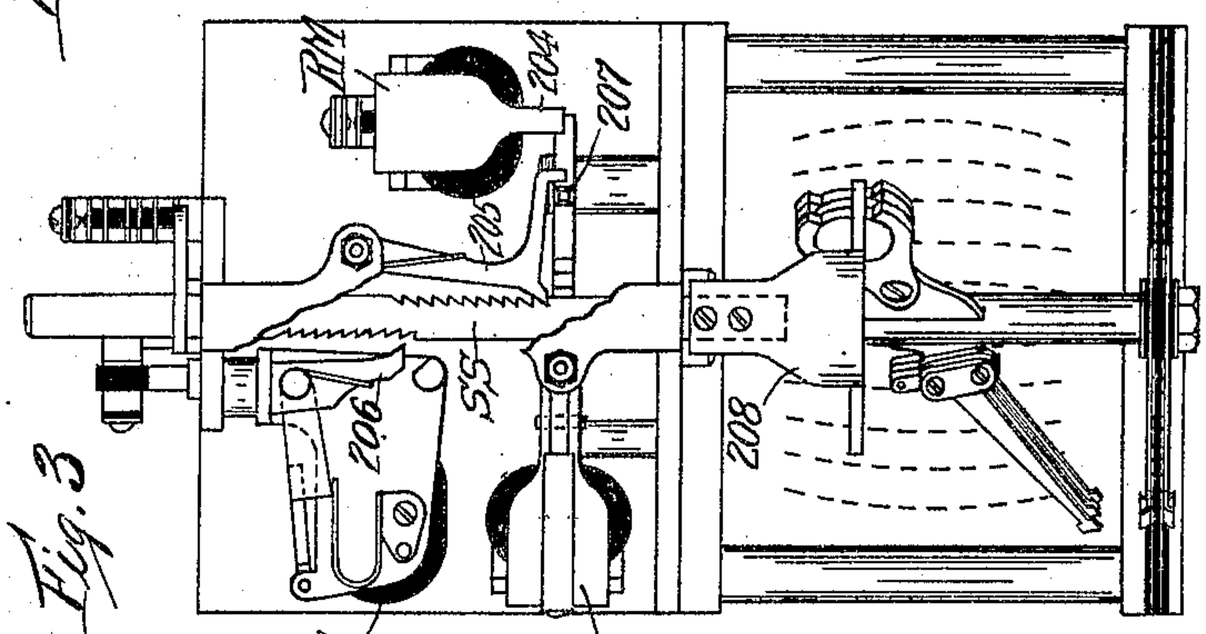


Fig. 3

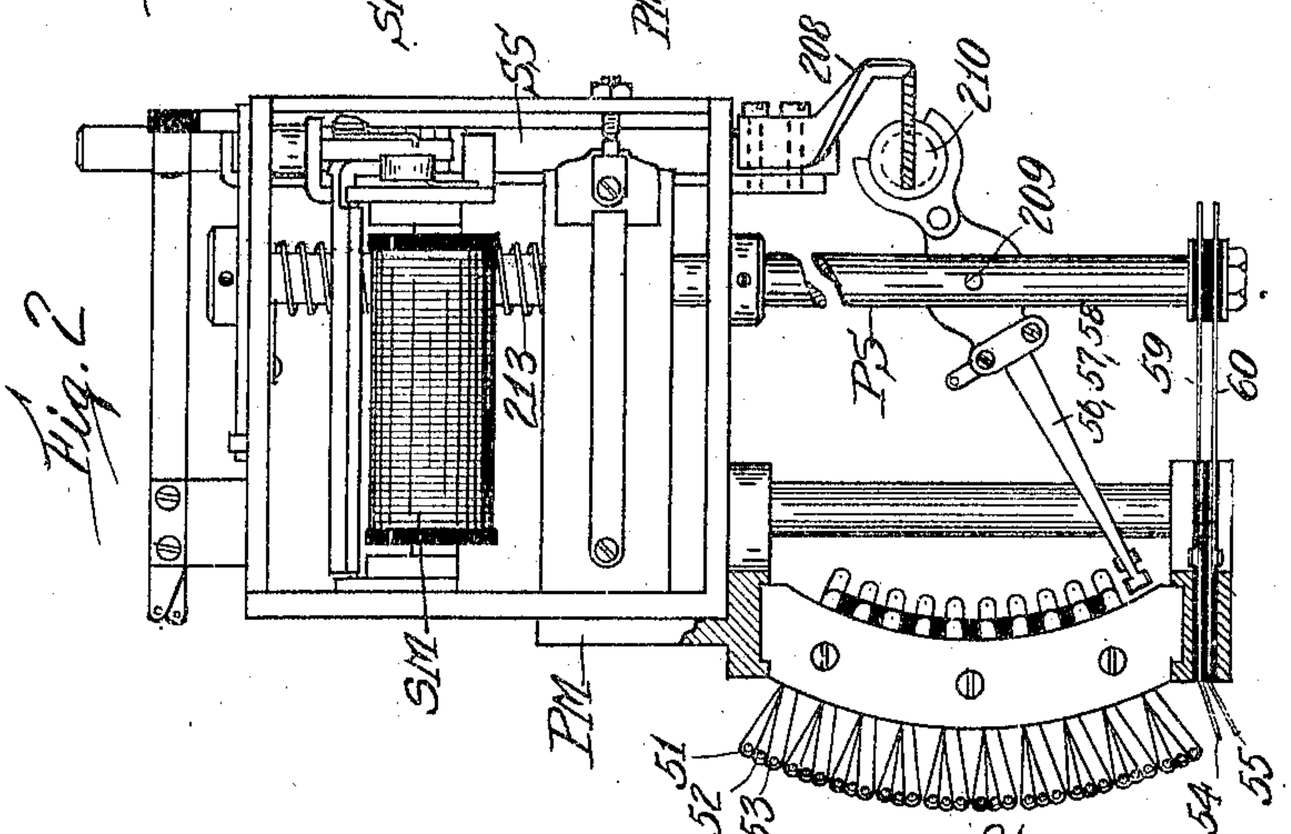


Fig. 2

Witnesses

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

959,485. Specification of Letters Patent. Patented May 31, 1910.

Application filed January 8, 1909. Serial No. 471,314.

To all whom it may concern:

Be it known that I, ALFRED H. DYSON, residing in Chicago, Cook county, Illinois, have invented new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention has special reference to telephone systems wherein the lines are divided into groups and a number of line selectors are employed for each group to select calling lines as soon as they initiate calls. In such systems, the line selectors are preferably not constantly operating mechanisms and a starting conductor is used common to the lines of a group and its selectors to start an idle line selector when a call is initiated.

An object of the present invention is to provide improved means for controlling the starting circuit. It will be seen that the starting means is a very important element in such systems, since it is common to a group of lines and all the lines must rely upon it. If such a starting conductor should for some reason be placed out of service, no calls from the line group which it serves could be successfully made until the trouble was ascertained and the starting circuit again put in service. By the present invention, a plurality of starting circuits are provided with mechanism such that, should one circuit be disabled, another will automatically, or without the aid of an attendant, be connected into operative relation with the lines and the line selectors.

Another object of the invention is to provide means in an automatic telephone system, employing line selectors to select calling lines, whereby it may be rendered feasible, when at the conclusion of conversation the subscriber replaces his receiver, to release all the selectors employed in the connection. In telephone systems where automatic mechanism is employed to interchangeably associate first selectors with calling lines by the removals of the receivers at calling substations, if one subscriber were to release all selectors by replacing his receiver, while the other subscriber, for example, forgot to replace his receiver, the result would be, were not special means provided to prevent it, that the line, whose receiver was left off the hook, would be automatically connected with a first selector and such first selector would accordingly be unavailable for further use until the receiver was replaced at the connected line. By the present invention, means are provided to prevent the re-connection of a line, at whose substation the receiver is left removed, and consequently from being connected with a first selector when all the selectors employed in the connection are restored. In the present case, this is accomplished by locking the cut-off relays of the lines over the line circuits, so that, as long as a line circuit remains closed after the cut-off relay has once operated, the normal battery connection to the line will remain open, thereby preventing the switching operations, necessary to connect a calling line with a first selector, from taking place.

Another object of the invention is to provide improved means for preventing more than one line selector from causing its wipers to enter the group of contacts containing contacts of a single calling line.

These and other features of the invention will be more specifically referred to in the following description of the drawings and will be specifically pointed out in the appended claims.

In the drawings, Figure 1, consisting of parts 1 to 4, illustrates in diagrammatic form an organization of automatic telephone circuits arranged to show one practical way of putting the present invention into service; Figs. 2, 3 and 4 are, respectively, left, front and side elevations of a selector mechanism adapted for employment in connection with the circuits of Fig. 1; Fig. 5 is a top view showing a detail of the primary off-normal switch combination of said selector; and Fig. 6 shows a detail of the

primary magnet and the associated parts of the selector. Figs. 2 to 6 inclusive, as well as Fig. 1, are, to a certain extent, diagrammatic.

Referring first to Fig. 1, whose sheets are to be placed in consecutive order from left to right, I show at C and C′ two substations, each associated by line limbs P, S with its individual line circuit D at the exchange; and at M and M[a] I have shown duplicate master-switch circuits; at E, the circuits of a line selector; at F, those of a first selector; at H, those of a second selector; and at K, the circuits of a connector. Assuming a system of ten thousand subscribers, there would be ten thousand substations like C and C′, each with its line. The subscribers' lines may be divided into groups of one hundred, both as calling and as called lines. The called multiple terminals 9, 10 and 11 will appear in the banks of a suitable number of connectors K and are there preferably arranged in ten subgroups of ten contact sets each, according to the tens value of the lines. The individual calling multiple terminals, 51, 52, 53, of one hundred lines are grouped together in subgroups of ten contact sets each and are multipled to the banks of a suitable number of line selectors, say, ten, each such line selector, as E, having wipers 56, 57, 58, adapted for automatic adjustment when a call is initiated to first select the sub-group including the calling line, and thereafter the individual terminals of the calling line out of the sub-group. Each sub-group of ten lines has a pair of group contacts 54 and 55 which are multipled throughout the line selectors of the ten-line group.

Each line selector E is, according to the illustrated arrangement, permanently linked to a particular first selector F, so that there will be as many first selectors as there are line selectors. Each first selector F has before its wipers 110, 111, 112, a hundred multipled contact sets 113, 114, 115 of second selectors H, which contact sets are arranged in ten groups of ten contact sets each, according to the thousands to which the second selectors are assigned, all in the usual manner. A first selector F has its wipers first directively adjusted to select a group of second selectors of the wanted thousand, whereafter the first selector is automatically operated to pick out the contact set of an idle second selector of the group. The second selectors H have before their wipers 110[a], 111[a], 112[a], one hundred multiple contact sets 116, 117, 118, of connectors assigned for connections to the different hundreds of the thousand which the second selector serves. There may be ten connectors for each hundred and the multiple contacts 116, 117, 118 of the connectors for each hundred will form a separate group before the wipers of a second selector. A second selector is in the usual manner directly adjusted to select the group of connector contacts wanted, whereafter the wipers are automatically adjusted to select an idle contact set out of the group. Before the wipers 141, 142, 143 of a connector K, are multiple contacts 9, 10, 11, of the one hundred lines which it serves, said contacts being grouped according to the tens value of the lines, as before indicated. The wipers of the connector are first primarily adjusted responsive to directive impulses to select the sub-group of contact sets containing the set of a called line, and thereafter secondarily adjusted responsive to like impulses to select the individual contact set of the called line, all in the usual way.

Each subscriber's line, as C, in addition to the calling and called multiple terminals before referred to, has its line relay LR for operation when a call is initiated to influence a master-switch M to start a line selector, E, to alter the electrical condition of the individual calling multiple terminals 51, 52, 53, to render them selectable; and also to alter the electrical condition of the group terminals 54 to render them selectable. In addition, an operated line relay grounds the multiple private called contacts 9 of the line at the connectors to render them busy. The cut-off relay CO includes armature switches to deënergize the line relay and has an energizing winding 12 energized in response to the selection of the line by a line selector, and locking windings 13, 14, with the batteries A, B, bridged between them. The master-switch M may include mechanically the customary rotary shaft with a rotary ratchet and a magnet M having the usual armature-actuated pawl to drive the ratchet and shaft. To the latter, the wipers 27 and 30 are rigidly fastened and are rotated in response to actuations of the magnet M. Before the wiper 27, are a set of contacts 28, each connected by a wire 44 with one of the line selectors E of the group, the wires 44 being those over which starting impulses are transmitted to the line selectors. Before the wiper 30, are contacts 31, each connected by a wire 43 to a different line selector, the wires 43 being employed to render the contact set 28, 31 of a line selector busy at the master-switch. Between the contacts 28, are placed the contacts 28[a], connected together and also connected by a wire 29 with the contacts 31[a] before the wiper 30, which contacts 31[a] are placed between the contacts 31. The wipers 27 and 30 are preferably always operated in the same direction of rotation, no restoring mechanism being necessary, and in practice the contacts 28, 28[a], may form a circle about the axis of rotation of wiper 37, while contacts 31, 31[a] also form a circle about the axis of rotation of the wiper 30. The mas-

ter-switch relay 26, when energized, grounds the wiper 27 to start a line selector and said relay 26 is common to the one hundred lines of the calling line group, being so rendered by the common conductor 25 having one hundred branches, one to each line relay of such line group.

Referring to the group relay 23 controlling by its armature the selectable condition of the group contacts 54, each relay 23 of a sub-group of ten lines is common to the sub-group, being so rendered by a conductor 24 having ten branches, one to each line relay of its sub-group.

The remaining circuit connections will be best understood from the following description of operation, wherein it is assumed that the line C is to be connected for conversation with the line C′, whose number may be assumed to be 2345, it being assumed that at the time substation C initiates the call, the apparatus is in the normal condition—that illustrated in Fig. 1. Subscriber C removes his receiver, whereupon hook-lever 1 engages its upper contacts and closes a circuit of battery B′ over the calling line, extending through normal contact 22, limb S, contact 4, the magnet impedance 2, the transmitter, returning through contact 3, limb P, normal contact 19, line relay LR, to ground. Armature 15 is then attracted to ground the called contacts 9 at the connectors, rendering them busy. Armature 17 disconnects ground from multipled private contacts 51 of the line selectors and energizes the group relay 23 whose armature removes ground from wire 49 and so from the group contacts 54 at the line selectors, rendering them selectable. By armature 16, relay LR is disconnected from the line and locks in series with the left winding of master-switch relay 26, the circuit being traced through heat-coil h', normal contact 35 to battery. The attracted armature of relay 26 grounds the starting wiper 27 of master-switch M, circuit being traced through the engaged contact 28, wire 44, normal contact 64, primary relay PR, to battery B^2. Relay PR energizes and its armature 65 completes a circuit for alternating current traversing the winding of magnet PM, whose resulting actuations drive wipers 56 to 60, inclusive, in a primary direction, each actuation bringing the wipers 56, 57, 58 below a different group of contacts 51, 52, 53, and wipers 59, 60 to engage a successive set of contacts 54, 55. On the first primary step, the PO contacts are shifted to their alternate positions, the shifting of contact 64 opening the initial energizing circuit of relay PR, so that thereafter said relay depends for its continued energization upon a circuit extending through attracted armature 66, through group wiper 59, and to grounds over successively engaged group contacts 54 of non-calling sub-groups. Relay PR will accordingly remain energized and magnet PM will receive successive actuations as wiper 59 is stepped along, until said wiper engages the group contact 54 of the sub-group containing the calling line, at which time, because of the energization of group relay 23, the encountered group contact 54 will be on open circuit, relay PR will deënergize, and actuations of magnet PM will cease, at which time all the wipers will come to rest, the wipers 59 and 60 engaging the group contacts 54 and 55, respectively, of the selected sub-group.

The retracted armature 65 closes circuit through contact 61, normal contact 74, through secondary relay SR to battery B^2, which relay energizes and, by armature 79, closes a circuit for alternating current through secondary magnet SM, which is alternately energized and deënergized, stepping the wipers 56, 57, 58, in a secondary direction to engage successive contact sets 51, 52, 53 of lines of the selected sub-group, the wipers 59, 60 at this time remaining stationary. On the first secondary step, the initial energizing circuit of relay SR is opened at contact 74, because of the shifting from normal of the secondary off-normal, SO, switch contacts on the first secondary step of the line selector. Thus the relay SR thereafter depends for energizing current upon a circuit extending through its attracted armature 78, through contact 67, to wiper 56 and to grounds at successively engaged individual private multiple contacts 51 of non-calling lines of the selected sub-group. As soon as wiper 56 engages the contact 51 of the calling line, such contact will be ungrounded, because the line relay of such line is operated. Relay SR deenergizes and its retracted armature 79 opens the energizing circuit of secondary magnet SM so that said magnet remains inert, the wipers 56, 57, 58 accordingly resting engaging the contact set 51, 52, 53 of the calling line.

As soon as the relay SR first operated, its armatures 76 and 81 bridged the wires 84 and 85 so that the relays PR′ and SR′ at F energized. When relay SR deënergized, the relay PR′, because of the make-before-break arrangement at 76, had a substitute circuit completed from battery A^3, over wire 84, contact 57—52, normal contact at 20, winding 12, to battery B′. Relay CO accordingly energizes and, by its armature 19, extends the circuit of relay PR′ over limb P, through contact 3, upper contacts at 1, magnet 2, contact 4, limb S, wire 48, contact 53—58, and wire 85 through relay SR′ to battery B^3. These shiftings in the circuit of relay PR′ occur without its armatures retracting. The attraction of armature 20 of relay CO locks the relay to ground through wire 46,

contact 51—56, and contacts 67 and 78. The opening of contact 21 deënergizes relay LR and the left winding of relay 26. On the retraction of armature 15, the grounded armature 20 is connected to multiple contacts 9 at the connectors continuing the calling line busy. The private contacts 51 of the calling line at the line selectors are rendered unselectable, as soon as the line is selected, by the ground at armature 78, and so continue while the connection exists.

Returning now to the starting of the line selector E, the shifting of primary off-normal contact 63 on the first step closed a circuit from ground at 68, through normal contact 75, resistance r^3 (the common wire 45 having ten branches, one to each line selector served by master-switch M) and through the right winding of relay 26 to battery through heat-coil h'. The windings of relay 26 are opposed and the resistances of relay LR and of r^3 are so proportioned that the core of relay 26 is substantially neutral and its armature immediately retracts, ungrounding the starting wiper 27. During the secondary travel of line selector E under the influence of relay SR, the neutralizing circuit through the right winding of relay 26 is continued closed at armature 77 of relay SR. When the line selector E has completed its selection, the opening of contact 77 to deënergize the right winding of relay 26, and the opening of contact 21 to deenergize the left winding thereof, will occur nearly simultaneously and the armature of said relay may remain unattracted, or it may momentarily attract.

On the first step of selector E, the closure of contact 62 causes a flow of current over wire 43, through the engaged contact 31, the wiper 30, contact 40, the master-switch relay R to battery, operating said relay, whose attracted armature closes a circuit for alternating current through the motor magnet MM, which steps the wipers 27, 30, rotarily step by step. Obviously, as long as the wiper 30 is engaging successive grounded contacts, relay R will remain operated and the magnet MM will continue to drive the switch wipers. If the neutralizing of the core of relay 26 fails to occur soon enough to unground the wiper 27 before the master-switch wipers make their first step to engage a contact set 28^a, 31^a, the relay R will continue operated and the master-switch wipers will engage the next contact set 28, 31; and if this contact set is that of an idle line selector, the master-switch will come to rest, since relay R will become deënergized, its circuit being opened at contact 62 of the idle line selector, and the wipers of the master-switch M will rest engaging contacts of such line selector, ready to start the same. Should it by chance happen that the opening of contact 21 and that of contact 77 occur, one long enough after the other to cause the momentary attraction of the armature of the relay 26, and if the wipers have come to rest engaging a contact set 28^a, 31^a, the only effect will be to initiate a stepping forward of the said wipers to engage the next contact set 28, 31. If this is an idle set, the wipers will come to rest, as the attraction of the armature of relay 26 is momentary only, and ground will be removed from wiper 27 by the time the wipers move one step. If, as will often occur, wipers 27, 30 make only one step when contact 62 of a started line selector is closed, thus resting engaging a contact set 28^a, 31^a, it may happen that, should the armature of relay 26 momentarily attract, circuit will be closed through the relay R too short a time to permit of a step of the master-switch wipers. It will be understood that by adjusting the various relays involved, the openings of contacts 77 and 21 can be caused to occur so close together that the armature of relay 26 will not attract when a line is selected. The present arrangement avoids the necessity of very close adjustment in this regard.

As soon as line selector E initiated secondary travel, the attraction of armature 80 of relay SR closed a circuit through contact 71, the resistance r', contact 60—55, wire 50, through the right winding of relay 23 to battery B'. The windings of relay 23 being now opposed and the resistances r and r' being so proportioned that said windings now substantially neutralize the core of the relay 23, its armature is retracted, so that on the secondary travel of the line selector, the multiple group contacts 54 are unselectable. By this arrangement, should two line selectors be started and reach their group contacts 54 of the same group, one immediately after the other, only one of them will move its wipers into that sub-group of line contacts, unless indeed there be two calling lines in said sub-group. In such case, the inclusion of one resistance r' in circuit with the right winding of relay 23 will not deenergize said relay, since the fact that two lines are calling, which have contact sets in said group, will have caused the inclusion of two parallel resistances r in the circuit of the left winding of relay 23; and until both line selectors have started to move their wipers into that sub-group of contacts, there will be a preponderating current flow in the left winding of relay 23. It will also be observed that if a second calling line initiates a call before a first calling line has been selected by a line selector, the initiation of the second call will cause the re-operation of the master-switch relay 26 to cause it to start another line selector, since the operation of the second line relay will include its winding in a branch of the circuit of the left winding of relay 26 and greater current will flow in

said winding than that flowing in the right winding of the relay. The starting of the second line selector will of course include a second resistance r^3 in circuit with the right winding of relay 26 and then the relay will be neutral. Thus if several lines were to initiate simultaneous calls, the relay 26 would remain operated until as many line selectors had been started as there were calling lines. Because of the circuit before traced through substation C, the magnet 2 is now energized and its attracted armature has withdrawn the retaining pawl from the dial 7 so that the same is now operable by hand. To transmit the called number 2345, subscriber C first rotates dial 7 clockwise until two insulating teeth are below the spring 3, and then replaces it, whereupon the dial is spring-restored in a reverse clockwise direction, the two teeth causing two momentary breaks at contact 3, whereafter a tooth at the extreme left of dial 7 causes one momentary break at contact 4. A stud 8 is mounted on the dial so that when the dial is in other than normal position, the stud is moved free of the spring 5 and the springs 5, 6 are by their tension connected together and to ground. The springs 3, 4 are therefore both grounded as long as the dial is off normal; and while two openings are being produced at contact 3, each of which will deenergize momentarily relay PR′, the relay SR′ will remain operated by current over limb S and through contacts 4, 6 to ground. Conversely, when contact 4 is opened as before described, it will deënergize the relay SR′, but the contact 3 will be closed and the relay PR′ will remain energized by current over limb P and through contacts 3 and 5—6 to ground.

The two deënergizations of relay PR′ transmit two current impulses from ground through contacts 91, 88, 99, magnet PM′ to battery, and two primary steps of first selector F are caused, the wipers 110, 111 and 112 being adjusted adjacent to the second group of second selector contacts, terminals of second selectors assigned to the second thousand. On the subsequent deënergization of relay SR′, a current impulse is transmitted from ground through contact 89, normal contact 92, contact 100, contact 102 of the primary off-normal switch which was closed on the first primary step, and through relay BR′ to battery, operating said relay whose armature 107 connects its winding through normal contact 104 with the private wiper 110. Armature 108 closes a circuit for alternating current through secondary magnet SM′ and said magnet steps the wipers 110, 111, 112 step by step to engage successive contact sets of the selected group. Until that of an idle second selector is reached, the wiper 110 will engage successively grounded contacts 113 and the relay BR′ will remain energized. As soon, however, as the wiper 110 engages the contact 113 of an idle second selector, such contact will be disconnected from ground and relay BR′ will deënergize, the opening of contact 108 preventing further actuations of magnet SM′ so that the wipers of switch F will remain engaging the contacts of the selected second selector. The closing of normal contact 107 will have connected ground through wiper 110 to the contacts 113 thus selected, rendering them busy. The secondary off-normal contacts 99, 100 were shifted on the first secondary step of the first selector F so that magnets PM′ and BR′ were disconnected from the upper and lower talking conductors, which, throughout the drawings, are indicated by heavily marked lines. The subscriber C now actuates his dial 7 until three teeth are below spring 3, and releases said dial. As a result, three deënergizations of relay PR′ transmit three impulses through contacts 91, 88, 106, 111—114, and primary magnet PM^3 to battery, causing three primary steps of second selector H to select the third group of connectors of its thousand, being those assigned to lines 2300 to 2399. The following deënergization of relay SR′ transmits a current impulse from ground, through contact 89, normal contact 92, contacts 109, 112—115, 100^a, 102^a and relay BR^3, and said relay initiates and controls secondary travel of second selector H to select contacts of an idle connector in the same manner that relay BR′ controls the travel of first selector F, the detail of operation of second selector H being apparent from that given for the first selector, like parts at H and F being given like reference characters with different exponents. Subscriber C now actuates his dial until four teeth are brought below spring 3, and releases it. Four resulting deënergizations of relay PR′ transmit four current impulses through contacts 111—114, 111^a, 117, 121 and magnet PM^4 to battery, causing four actuations of said magnet and four primary steps of the wipers 141, 142, 143, to select the fourth group of called line contact sets 9, 10, 11, comprising contacts of lines 2341 to 2349 inclusive, followed by those of line 2340, zero being ten impulses. A following deënergization of relay SR′ will transmit a current impulse through contacts 112—115, 112^a—118, normal contact 122, secondary magnet SM^4 to battery, which magnet will cause one secondary step of the wipers 141, 142, 143, toward the edge of the contact bank, but said wipers do not, at the conclusion of this step, engage the first contact set of the group, since the normal position of the wipers of a connector, after their primary adjustment, is always two secondary steps distant from the first contact set of the selected group. By this first step, however,

the secondary off-normal contacts 121, 122 are shifted,—121 to engage its alternate contact, while 122 is shifted sufficiently to disengage its normal contact, but not to engage its alternate contact, the latter occurring only on the second secondary step of the connector. The calling subscriber C now actuates his dial until five teeth are brought below spring 3, and releases it. The resulting five deënergizations of relay PR′ transmit five current impulses over the before-traced path through contact 117, thence through alternate contact 121, normal contact 125, magnet SM^4 to battery, and said magnet causes five additional secondary steps of the wipers 141, 142, 143, the fifth step bringing them to engage the contacts 9, 10, 11 of the called line C′, No. 2345. Thereafter a deënergization of relay SR′ transmits a current impulse over the before-traced path through contact 118, thence through alternate contact 122, normal contact 128 and lower winding of test relay TR to battery B^5. Relay TR operates and its armature 134 actuates the locking relay LOR, said relay, by armature 127, locking to ground at 124. The test relay TR now proceeds to test the called line, and if said line be found idle, the ringing generator will be connected to the called line to signal the substation. If the line be busy, the ringing generator will remain excluded and the busy interrupter I′ will be connected with the calling line, at whose substation the subscriber will hear the busy signal and will replace his receiver to disconnect the central office apparatus.

Assuming first the called line to be idle, its multiple contacts 9 will be in the condition shown, connected to the active side of battery B^5, through contact 15 of relay LR and winding 12. The engaging wiper 141 is, on the attraction of armature 133 of relay TR, also connected to the active side of the battery B^5. Thus as soon as the attraction of armature 128 of relay LOR opens the circuit of the lower winding of the relay TR, said relay deënergizes, since the two ends of its upper winding are connected to the active side of battery B^5 and said relay TR deënergizes. As soon as this occurs, a circuit is completed from ground through ringing control relay RCR, contacts 126, 133, 141—9, 15, winding 12 of relay CO of the called line to battery B^5, and relays CO and RCR both operate, the former, by its armature 20, connecting the ground through relay RCR to the private contacts 51 of the called line at the line selectors, so rendering them busy. The interrupter I, a constantly rotating device, will now alternately energize and deënergize the generator relay GR, whose armature 140 alternately connects and disconnects the ringing generator with and from the called line, causing its substation bell to periodically sound in the well-known manner. When the called subscriber removes his receiver, hook-lever 1 closes a conductive circuit through the substation; and as soon as armature 140 is retracted, a circuit is completed as follows: from the active side of battery A^6, through answering relay AR, contact 129, normal contact 140, contact 142—10, limb P, contact 3, the transmitter and upper hook-switch contacts, impedance 2, contact 4, limb S, contact 11—143, inductive resistance IR, attracted armature 130, to battery B^6. This flow of current energizes the transmitter at substation C′ for talking and operates relay AR, whose armature 135 actuates closing relay CR which, by armature 137, locks to ground at contact 124. Armature 138 opens the circuit of relay GR so that it remains deënergized, ringing current accordingly remaining excluded from the called line. Armatures 136 and 139 complete the talking circuit at the connector and the two subscribers are now in conversation over a circuit traced from substation C and over the heavily marked conductors to substation C′, the calling and called portions of the talking circuit being united inductively by the condensers at F.

It will be seen that when the called subscriber answers and contacts 136, 139 are closed, positive battery at A^6 is, over the called subscriber's line, connected over a return circuit traced through contacts 118—112^a, 115—112, and alternate contact 92 and relay RR′ with the negative battery B^3, so that the relay RR′ is held energized during conversation by current passing over the called line. On the operation of relay RR′, its armature 97 energizes locking relay LOR′ which, by armature 93, locks to ground at 101 and over wire 82, to ground at 62.

As before stated, when either subscriber replaces his receiver, all the central office switches are restored to normal. Assuming that subscriber C replaces his first, the opening of alternate contacts at 1 will deënergize, simultaneously for the first time, relays PR′ and SR′ and armatures 87 and 90 are simultaneously retracted to close the release circuit 83. Current will then flow from ground through release relay RR^2 at F, contacts 90, 87, wire 83, contact 73, lower winding of relay RR at E, to battery B^2, and both said relays energize. Relay RR at E, by armature 69, actuates release magnet RM by current through contacts 61 and 65 and said magnet withdraws the retaining pawls of line selector E and its wipers and off-normal contacts are automatically restored to normal. Relay RR, by armature 69, has locked to ground in parallel with release magnet RM, and until the wipers are fully restored, at which time the primary off-normal PO

contacts are shifted back to normal, relay RR and magnet RM will both remain actuated. During restoration, the talking wipers 57, 58 are held on open circuit, since armature 70 maintains relay SR operated until the wipers are free of the contact bank, as hereafter explained.

Relay RR² at F, by armature 103, locks itself in series with relay BR′, and magnet RM′ is energized by current from ground through contact 108, alternate contact 105, and the winding of said magnet to battery, the magnet being then effective to withdraw the retaining pawls of first selector F, whose wipers will be automatically restored, at which time the opening of primary off-normal contact 102 deënergizes relays RR² and BR′. Before magnet RM′ can attract its armature, however, a current impulse will pass from battery B³, through alternate contact 104, contact 110—113, contact 101ª, release relay RR³ of second selector H, which relay, by armature 103ª, locks in series with busy relay BR³. Current will then flow from ground through alternate contacts 108ª, 105ª, release magnet RM³ to battery, and said magnet withdraws the retaining pawls of second selector H, causing its wipers to be restored to normal, at which time the opening of contact 101ª will deënergize relays RR³ and BR³. Before magnet RM³ can attract its armature, however, an impulse of current flows from battery B³, through alternate contact 104ª, contact 110ª—116, 119, release relay RR⁴ to ground, which relay, by armature 123, locks itself and, by armature 124, actuates release magnet RM⁴ which withdraws the retaining pawls of connector K, whose wipers 141, 142, 143 thereupon restore to normal, at which time the opening of contact 120 of course deenergizes the release relay RR⁴. It will be observed that on the attraction of armature 124, the circuits of relays LOR and CR are opened and said relays deënergize. Although the wipers 141, 142, 143 have now been restored to normal and accordingly disconnected from the contacts 9, 10, 11, and it is assumed that called subscriber C′ has not yet replaced his receiver, the cut-off relay CO of his line will still remain energized, said relay being locked by current over a path traced as follows: from the active side of battery A, through winding 13, alternate contact 18, limb P, to the raised hook-lever 1, returning over limb S, alternate contact 22, and through winding 14 to the active side of battery B. The line relay LR can accordingly not be energized. When the called subscriber C′ replaces his receiver, the opening of a conductive circuit at the substation deënergizes windings 13, 14, the armatures of relay CO retract, and should the subscriber now remove his receiver, his line relay LR will operate and cause his line to be selected by a line selector.

Were the called subscriber C′ to replace his receiver before the calling subscriber C, the opening of the conductive circuit at substation C′ will deënergize answering relay AR at K and relay RR′ at F. On the deenergization of the latter relay, circuit is completed as follows: from ground through release relay RR², closed contact 94, normal contact 96, attracted armature 95 and over wire 83 and contact 73, lower winding of release relay RR to battery B². The energization of these relays causes the restoration to normal of all the central office apparatus in the way just described. If it be assumed that the subscriber C still has his receiver removed, his relay CO will remain operated, although line selector E has been disconnected therefrom, because of the circuit through the locking windings 13 and 14, traced through alternate contacts 18 and 22.

Let it now be assumed that at the time the connector K made connection with the called line, said line was busy. In such case, the private contacts 9 would be grounded in one of the several ways heretofore mentioned; and on its initial operation, the relay TR would be locked by current flowing from battery B⁵, through the upper winding of said relay, alternate contact 133, contact 141—9, and to ground. Busy interrupter I′ would remain connected to the upper talking conductor at connector K and the calling subscriber C would hear the busy signal in his receiver. He would accordingly replace his receiver, deënergizing relays PR′ and SR′ and the central office apparatus would all be restored to normal.

Returning now to the master-switches M and Mª, let it be assumed that the idle line selector, for which the relay 26 closed a starting circuit, failed to operate and start to select the calling line. In such case, the contact 63 would remain open and current would continue flowing from ground through line relay LR, over wire 25, left winding of relay 26 and through heat-coil *h′* to battery. This current would continue until the heat-coil blew, the heat-coils being proportioned to blow after a definite time, the contact 35 being then released to engage the alternate contact, the release of contact 37, linked to 35, being simultaneously shifted to engage its alternate contact. On the closure of alternate contact 35, the bell 36 will sound to advise the central office attendant that the master-switch M is in trouble, while the closure of contact 37 will close a circuit extending through normal contact 34ª to energize the relay 38, whose armatures then cut out the master-switch M and operatively associate the circuits of master-switch Mª with the common conductor 25 extending to the line relays, and with the

conductors extending to the line selectors. Thus if the line selector fails to start, the alternate master-switch is automatically cut into service and the other master-switch is automatically cut out. Furthermore, should any line relay hold its armature attracted an undue length of time, or should the armature "stick" after the relay had its circuit opened, the heat-coil will blow and the attendant will be notified of trouble.

Suppose the line selector E starts and for some reason sticks at some point in its operation without completing its selection; it will be obvious that current will continue to flow through both windings of relay 26 and the heat-coil h' will blow and in this case also cause the connection in circuit of the substitute master-switch and of the alarm bell. Furthermore, should the relay R get out of order or have its circuit closed with the result that its armature stayed continuously attracted, thus causing magnet MM to continuously rotate the wipers 27 and 30, the generator impulses will, after a certain length of time, blow the heat-coil h, at which time alternate contacts 32 and 34 will automatically close, the closing of 32 causing the bell 33 to sound, while the closure of 34 energizes the relay 38 which operatively connects in circuit the substitute master-switch M^a. It will of course be the duty of the attendant, as soon as either bell sounds, to ascertain the trouble as speedily as possible and replace the blown heat-coil with a new one, thus again cutting into circuit the regular-service master-switch M. The master-switch M^a has heat-coils h^a and h^b similar to the coils h and h' of M, so that if, what would be a very rare occurrence, both master-switches should be disabled, the fact would be at once advertised to the central office attendant. It will be observed that the wire connected to the wiper 30 of master-switch M is connected to alternate contacts 37 and 34 so that, if the heat-coil were to blow, the contact of the line selector engaged by wiper 30 will be rendered busy before the wiper 30^a. Thus a disabled line selector, or a contact on which the disabled master-switch M rests, will be incapable of selection by the alternate master-switch when it is cut into circuit.

Referring to the mechanical drawings, Figs. 2 to 6, the one hundred contact sets 51, 52, 53, which comprise the main switch bank, are arranged in ten vertically extending groups of ten contact sets each, being mounted before the wipers 56, 57, 58, as shown in Fig. 3, as if extending through the inner surface of a section of a hollow sphere. Said wipers 56, 57, 58 are given their primary adjustment by being rotated step by step from left to right beneath the lower edge of the contact bank as viewed in Fig. 3, each step bringing them beneath a different group of contact sets. Their secondary adjustment is effected by moving the wiper ends adjacent to the bank upward, each secondary step causing them to engage a different contact set. As shown in Fig. 2, the wipers are supported by a primary shaft PS and extend through said shaft, being pivoted at 209. The rearward extending portion of the wiper mounting is provided with a bearing engaging the slotted wheel members 210, free to rotate in the bearing. Engaging the slots, is an angular piece 208 fastened to secondary shaft SS and sufficiently broad so that it remains in engagement with the slots after any primary adjustment of the wipers. The group contacts 54, 55 are mounted below the contact bank and their associated group wipers 59 and 60 are rigidly fastened to the primary shaft PS and partake only of the primary movements of the switch. For rotating the shaft PS and thus effecting the primary adjustments of the wipers, a primary ratchet 225 is rigidly attached to the shaft PS, as shown in Fig. 6. The driving pawl 202, adapted for actuation by the armature of primary magnet PM, is arranged on successive actuations to engage successive teeth of the ratchet 225 and so drive the ratchet, the primary shaft, and the wipers 56 to 60, inclusive, rotarily step by step. The primary adjustment of the switch is effected against the tension of the spring 213 shown in Fig. 4; and to prevent back movement, the primary retaining pawl 203 is provided. After the primary adjustment is completed, actuations of secondary magnet SM will effect successive thrusts of its armature controlled pawl 206, which, engaging successive teeth of an associated ratchet cut in secondary shaft SS, drives said shaft downward step by step, the secondary retaining pawl 205 holding the shaft SS against back movement after each step, which would otherwise occur under the influence of the spring 214 linked to the secondary shaft SS by the lever 215, whose long arm loosely engages a screw inserted in the shaft SS. Each downward step of shaft SS moves the piece 208 a step downward and the contact ends of the wipers 56, 57, 58 are moved upward to engage successive contact sets of the selected group.

In Fig. 5, the piece 200 is shown fastened to the shaft PS and carrying a stud 201, which normally engages an angular extension of the primary off-normal spring 64, to which the other springs 61, 62, 63 are linked by insulating studs. On the first rotary step of shaft PS, the stud 201 frees the spring 64 and the primary off-normal springs are moved by their tension to their alternate positions. As shown in Fig. 4, an angular piece 211 normally holds in its raised position an insulating spacer connected to the secondary off-normal springs 73, 74, 75. A

piece 212, fastened to secondary shaft SS, normally holds the arm 211, which extends parallel with shaft SS, in its raised position. On the first downward step of shaft SS, the piece 212 clears the piece 211, which then drops down, allowing the springs 73, 74, 75 to be moved by their tension to their alternate positions. The piece 211 is provided with a tooth 226, adapted when the piece 211 drops down, as described, to engage any adjacent tooth of the primary ratchet 225 to render ineffective the tension of the spring 213 while the secondary shaft SS is being restored to normal, as hereafter described.

To restore the described mechanism to normal, it is only necessary to energize the release magnet RM, whose armature 204 then engages a rearwardly extending portion of the primary retaining pawl 203 and rotates said pawl to free the primary ratchet 225. The pawl 203 has a projection 207 interlocking with the secondary retaining pawl 205, so that the described movement of the primary retaining pawl 203 serves to also withdraw the secondary retaining pawl. Thereupon the spring 214 is effective to raise the shaft SS upward until the piece 212 raises the piece 211, whereby the secondary off-normal contacts are restored, and abuts upon the lower surface of the switch frame. Until this occurs, the tooth 226 remains in engagement with the tooth of the primary ratchet 225. When the secondary shaft reaches normal, however, at which time the wipers are below the lower edge of the contact bank, the tooth 226 disengages ratchet 225 and the spring 213 is effective to rotate the primary shaft and the wipers of the switch back to normal, at which time the stud 201 (Fig. 5) restores the primary off-normal contacts.

The switch just described, which is specifically arranged to perform the functions of line selector E, may also serve for first selector F, second selector H, and connector K. For these latter uses, however, the group contacts and group wipers are not required; and in the case of the connector, the wipers will be so adjusted with respect to the lower edge of the contact bank as to be two steps distant from the first contact set of the selected group after the primary adjustment is completed, as already referred to in connection with the circuits.

The various battery symbols, shown as having the same pole grounded, may be a single source of current if preferred, and the various generator symbols, shown in connection with the switch driving magnets, may be a single source.

Obviously, the different features of the invention may be altered by the skill of the engineer so as to be rendered adaptable to systems other than those of the specific character herein described, and the appended claims are intended to be of scope sufficient to cover such alterations and modifications.

I claim as my invention:—

1. In a telephone system, the combination with an organization comprising telephone lines, and a circuit adapted to be influenced responsive to current over any of said lines, of a second like circuit and a switch automatically operated responsive to trouble in said organization to substitute said second circuit for said first-mentioned circuit in said organization.

2. In a telephone system, the combination with an organization comprising telephone lines, selectors, a starting circuit operable responsive to current over said lines and mechanism sensitive to the electrical condition of said circuit to connect said selectors interchangeably with said lines, of a second starting circuit, and a switch automatically operated responsive to trouble in said organization to substitute said second circuit for said first-mentioned circuit in said organization.

3. In a telephone system, the combination with selectors and means for starting the same, of a starting circuit operatively associated with said selectors, a second starting circuit, and means responsive to disabling of the first starting circuit to automatically connect into operative relation with said selectors said second circuit.

4. In a telephone system, the combination with selectors, of a conductor for starting the same, means for interchangeably associating said conductor with different selectors, a second starting conductor not in operative relation with said selectors, and apparatus responsive to an abnormal condition of said means for automatically connecting said second conductor into operative relation with said selectors.

5. In a telephone system, the combination with selectors, of a conductor for distributively starting the same and operatively associated therewith, a second conductor for distributively starting said selectors and inoperatively associated therewith, means for altering the electrical condition of said first conductor in order to start a connected selector, and an automatic switch operated responsive to failure of said connected selector to start to operatively dissociate said first conductor from said selectors and operatively associate said second conductor therewith.

6. In a telephone system, the combination with selectors, of a conductor for distributively starting the same and operatively associated therewith, a second conductor for distributively starting said selectors and inoperatively associated therewith, means for altering the electrical condition of said first conductor in order to start a connected selector, and means responsive to a failure of

said connected selector to properly perform its functions serving to operatively dissociate said first conductor from said selectors and operatively associate said second conductor therewith.

7. A telephone organization including telephone lines, line selectors to select said lines, a master-switch common to said selectors and lines operable responsive to current over a line to start an idle selector, a second master-switch, and automatic means responsive to trouble in said organization to substitute said second master-switch for said first switch.

8. A telephone organization including telephone lines, line selectors to select said lines, a master-switch common to said selectors and lines operable responsive to current over a line to start an idle selector, a second master-switch, a relay associated with the first master-switch adapted to initiate travel of a line selector, and means responsive to an abnormally prolonged flow of current through said relay to operatively connect said second master-switch in circuit.

9. A telephone organization including telephone lines, line selectors to select said lines, a master-switch common to said selectors and lines operable responsive to current over a line to start an idle selector, a second master-switch, a magnet for adjusting said first master-switch, and means automatically operated responsive to abnormally prolonged actuation of said magnet to operatively connect said second master-switch in circuit.

10. In a telephone system, the combination with an organization comprising telephone lines and a circuit adapted to be influenced responsive to current over a line, of a second like circuit, a heat-controlled contact, and means responsive to a prolonged flow of current to change the connection of said contact to substitute said second circuit for said first-mentioned circuit in said organization.

11. A telephone system including telephone lines, selectors, a starting circuit operable responsive to current over a line to initiate travel of a selector to select said line, a second starting circuit and a heat-controlled contact automatically operated responsive to the presence of trouble to operatively connect into circuit said second circuit.

12. In a telephone system, the combination with selectors, of a starting circuit operatively associated with said selectors, a second starting circuit, and a heat-controlled contact actuated responsive to disabling of the first starting circuit to automatically connect into operative relation with said selectors said second starting circuit.

13. In a telephone system, the combination with selectors, of a conductor for starting the same, means for interchangeably associating said conductor with different selectors, a second starting conductor not in operative relation with said selector, a heat-controlled contact adapted to have its connection changed responsive to an abnormally prolonged current flow, and a switch automatically operated by the changing of the connections of said contact to connect said second conductor to operative relation with said selectors.

14. A telephone system including selectors, means for distributively starting said selectors, a second means for starting said selectors normally in inoperative relation therewith, apparatus for causing a current flow in said first means for the purpose of starting a connected selector, said current flow continuing upon failure of said connected selector to start, a heat-controlled contact adapted to be actuated responsive to an abnormally prolonged continuation of said current flow, said contact serving when actuated to operatively associate said second means with said selectors.

15. A telephone system including selectors, a conductor for distributively starting the same and operatively associated therewith, a second conductor for distributively starting said selectors and inoperatively associated therewith, means for causing a current flow over said first conductor for the purpose of starting a connected selector, a heat-controlled contact, means for actuating said contact responsive to an abnormal continuation of said current flow due to a failure of said connected selector to properly perform its functions, and switch connections controlled by the actuation of said contact serving to operatively dissociate said first conductor from said selectors and operatively associate said second conductor therewith.

16. A telephone system including selectors, a conductor for distributively starting the same and operatively associated therewith, a second conductor for distributively starting said selectors and inoperatively associated therewith, means for causing a current flow over said first conductor for the purpose of starting a connected selector, a heat-controlled contact, means for actuating said contact responsive to an abnormal continuation of said current flow due to a failure of said connected selector to properly perform its functions, an electromagnet adapted to have its electrical condition changed responsive to the actuation of said contact, and contacts controlled by said magnet shifted responsive to a change in its electrical condition to operatively associate said second conductor with said selectors.

17. In a telephone system, the combination with terminal contacts arranged in groups, a selector for selecting a group and then a

contact of the group, a common or group contact for each said group, means for altering the electrical condition of a group contact to cause selection of its group by a selector, and means responsive to initial travel of the selector to select a contact of the selected group to render the group contact unselectable.

18. In a telephone system, the combination with terminal contacts arranged in groups, a selector for selecting a group and then a contact of the group, a common or group contact for each said group, means for altering the electrical condition of a group contact to cause selection of its group by a selector, and apparatus actuated by the selector on initiation of its travel over contacts of the selected group to render the group contact again unselectable.

19. In a telephone system, the combination with terminal contacts arranged in groups, a selector for selecting a group and then a contact of the group, a common or group contact for each said group, means for altering the electrical character of an individual contact, means for altering the electrical character of the respective group contact, and means controlled by an operated selector for first restoring the electrical character of the group contact and then the electrical character of the individual contact.

20. In a telephone system, the combination with terminal contacts arranged in groups, a selector for selecting a group and then a contact of the group, a common or group contact for each said group, means for altering the electrical character of an individual contact, means for altering the electrical character of the respective group contact, means controlled by an operated selector for first restoring the electrical character of the group contact and then the electrical character of the individual contact, and means rendering the selector ineffective to restore the electrical condition of the group contact when more than one individual contact of the same group have their electrical characters altered.

21. In a telephone system, the combination with normally unselectable individual terminal contacts arranged in groups, selecting mechanisms for selecting a group and then a contact of the group, a common or group contact for each said group, said group contacts being also normally unselectable, means for each individual contact for rendering it selectable, said means also being adapted to render the respective group contact selectable, and apparatus operated by a selecting mechanism for rendering the group contact unselectable and thereafter the associated individual contact.

22. In a telephone system, the combination with normally unselectable individual terminal contacts arranged in groups, selecting mechanisms for selecting a group and then a contact of the group, a common or group contact for each said group, said group contacts being also normally unselectable, means for each individual contact for rendering it selectable, said means also being adapted to render the respective group contact selectable, apparatus operated by a selecting mechanism for rendering the group contact unselectable and thereafter the associated individual contact effective by the operation of the means of a second individual contact of the same group to render ineffective the operation of said first-mentioned apparatus.

23. A telephone system including a telephone line, selective mechanism to select said line, a starting circuit responsive to current over the line to initiate travel of said mechanism to select said line, means independent of said line's circuit for disconnecting said mechanism from said line, and apparatus including a relay held energized by current over said line to prevent reoperation of the starting circuit on disconnection.

24. A telephone system including a telephone line having multiple terminals, selective mechanism to select said terminals, means for altering the normal electrical condition of said contacts to render them selectable by said mechanism, means effective by connection of said mechanism with said terminals to render them unselectable, apparatus independent of said telephone line to disconnect said mechanism from said terminals, and means controlled by current flowing over said telephone line serving to continue said contacts unselectable after disconnection of said mechanism.

25. A telephone system including a telephone line, an electromagnet individual to said line, link-circuits, automatic mechanism for interchangeably connecting said line with an idle link-circuit, and means controlled by said mechanism in its operation to include a winding of said magnet and said telephone line in circuit.

26. A telephone system including a telephone line, link-circuits, means normally adapted for operation responsive to currents over said line to automatically cause connection of an idle link-circuit to said line, a cut-off relay coöperating with said means, a circuit for operating said cut-off relay on connection of a link-circuit with said line, and a contact controlled by said cut-off relay when energized to connect its winding with said line to hold said relay energized by current over said line after said link-circuit is disconnected therefrom.

27. A telephone system including telephone lines, line selectors for selecting said lines, a line relay normally controllable responsive to current over a telephone line to

initiate travel of a line selector to select the line, a cut-off relay serving to deënergize said line relay on selection of said line, means for initially energizing said cut-off relay over a local circuit and thereupon locking said relay over said telephone line whereby, after disconnection of said selector from said line, said cut-off relay maintains said line relay disconnected while current flows in said telephone line.

In witness whereof, I hereunto subscribe my name this 6th day of January, 1909.

ALFRED H. DYSON.

Witnesses:

THOMAS H. FERGUSON,

CAROLYN WEBER.