

June 12, 1923.

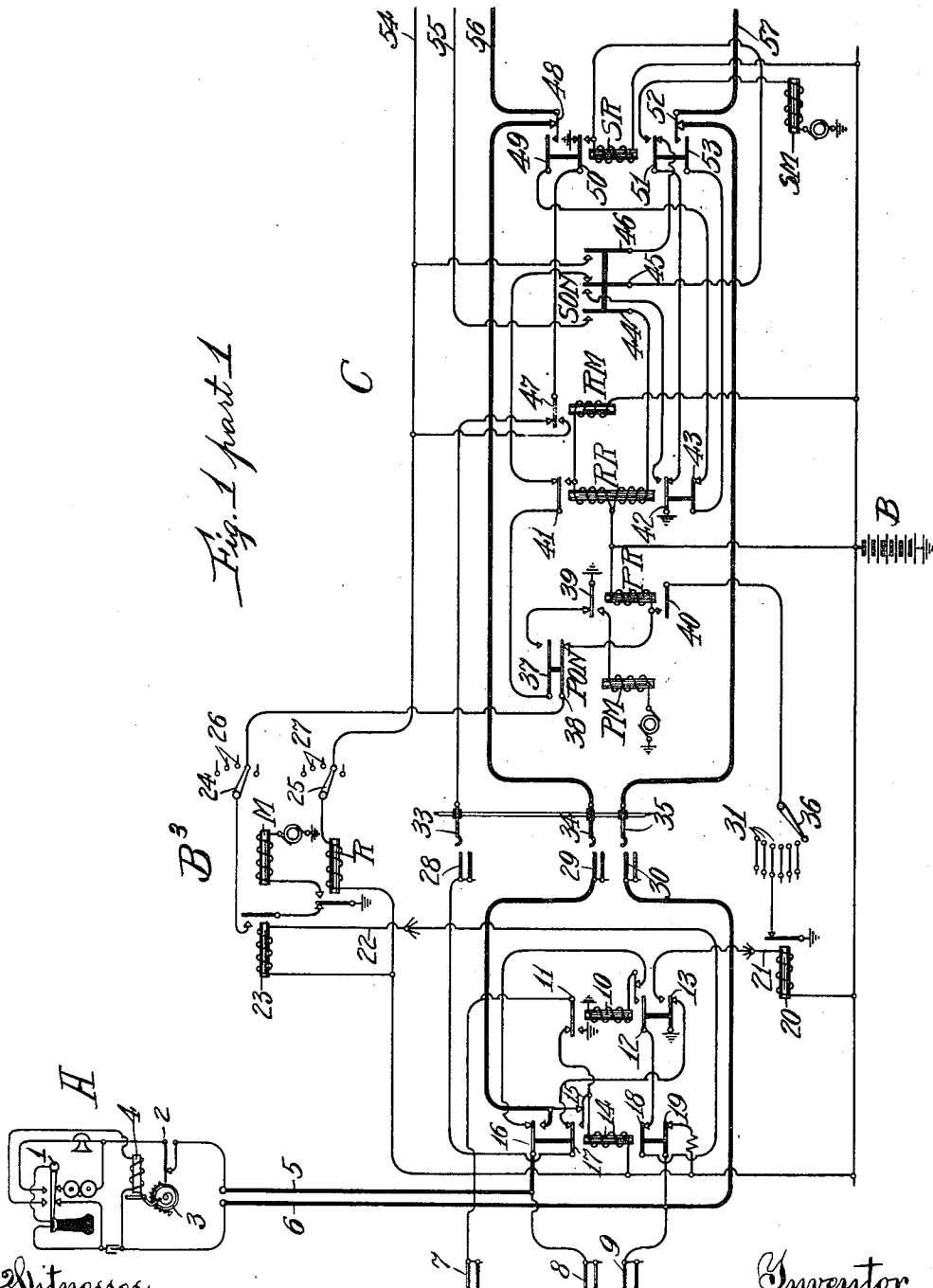
1,458,907

G. E. MUELLER

AUTOMATIC TELEPHONE SYSTEM

Filed June 25, 1908

4 Sheets-Sheet 1



Witnesses
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Inventor
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4 Sheets-Sheet 2

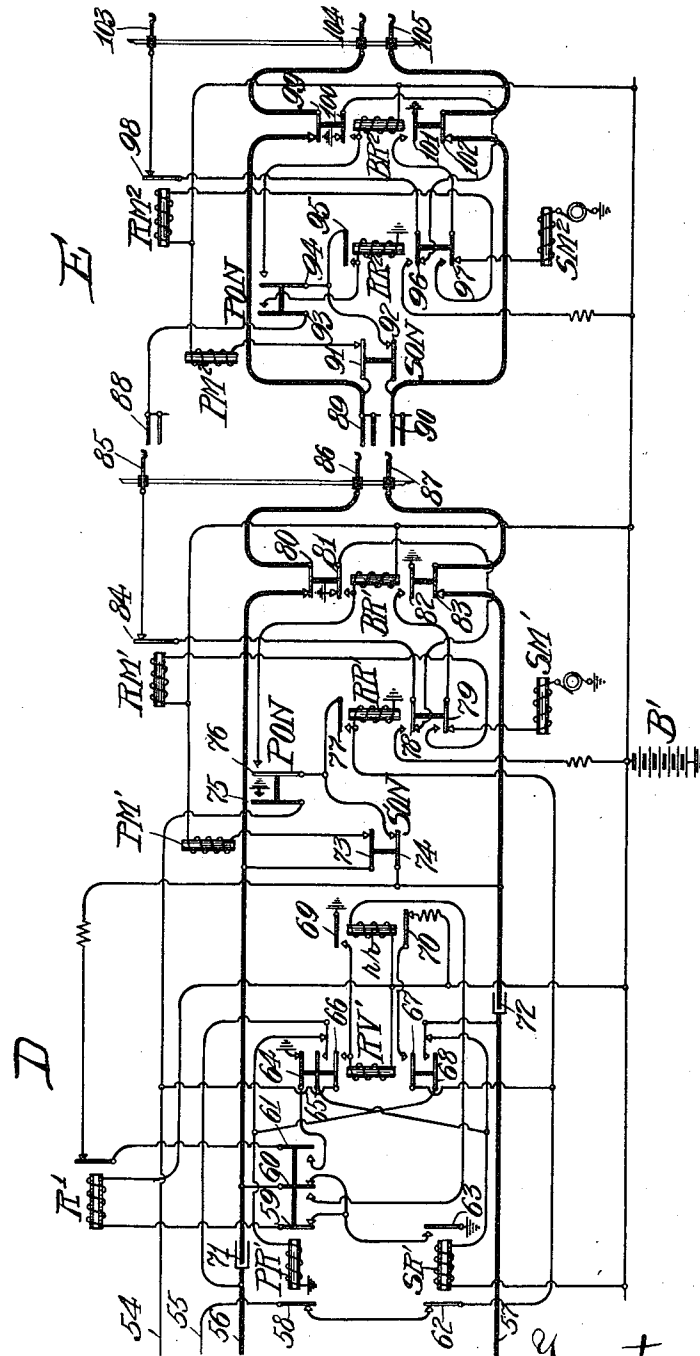


Fig. 1 part 2

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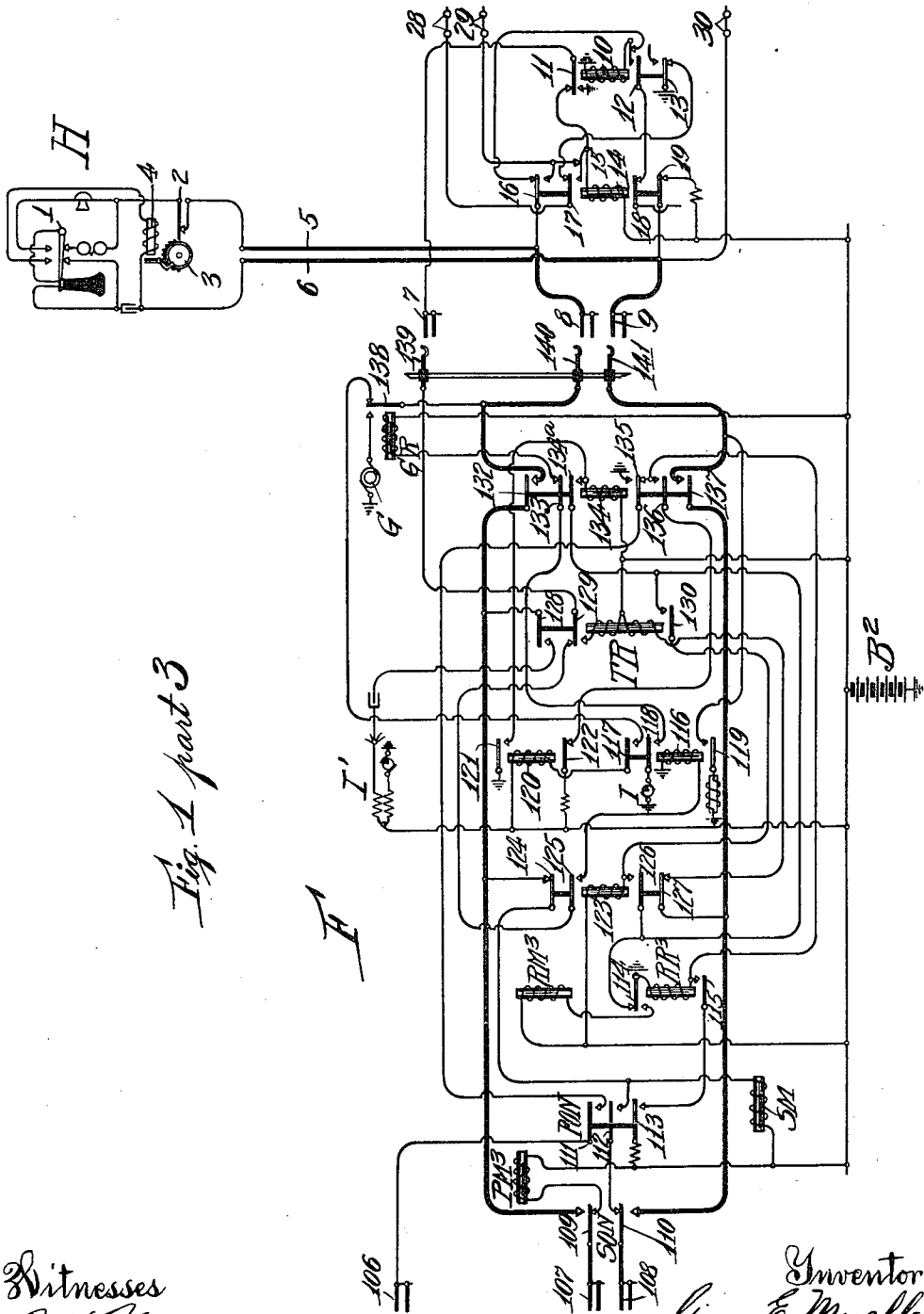
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AUTOMATIC TELEPHONE SYSTEM

Filed June 25, 1908

4 Sheets-Sheet 3



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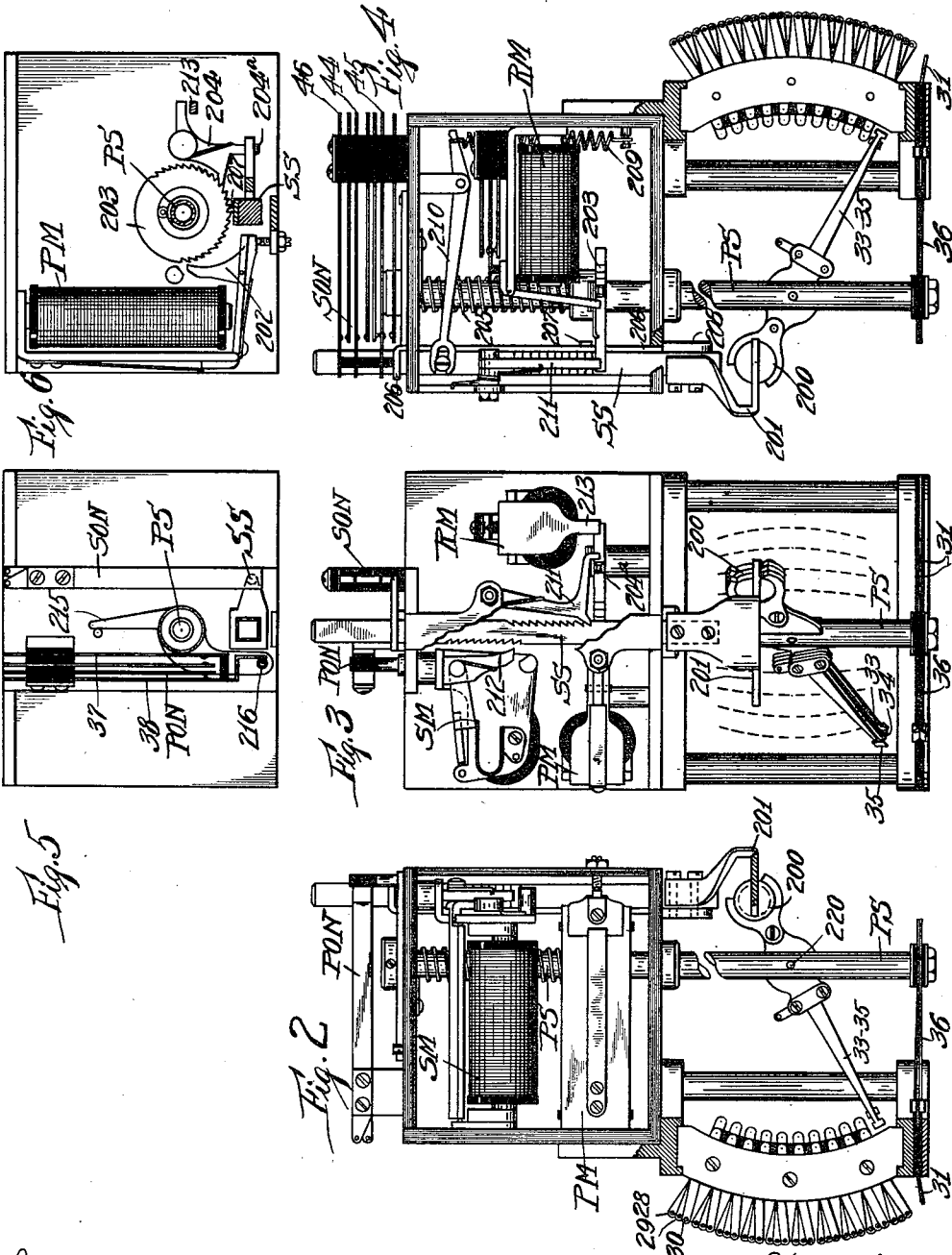
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AUTOMATIC TELEPHONE SYSTEM

Filed June 25, 1908

4 Sheets-Sheet 4



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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.

AUTOMATIC TELEPHONE SYSTEM.

Application filed June 25, 1908. Serial No. 440,309.

To all whom it may concern:

Be it known that I, GEORGE E. MUELLER, residing in Aurora, county of Kane, State of Illinois, have invented new and useful
5 Improvements in Automatic Telephone Systems, of which the following is a specification.

Generally speaking, the invention is capable of employment in both automatic and
10 semi-automatic telephony, although I have preferred to illustrate the same in connection with a system of the former class.

An object of the present invention is to secure an improved arrangement of circuits
15 of selective switches for use in connection with calling devices which operate only to interrupt a single circuit; that is to say, devices which produce changes in a single circuit as distinguished from those which produce changes in two circuits, as, for example,
20 by grounding alternately the two wires of a conductor pair. In practicing the invention, I avail myself of the fact that, by well known means, one electromagnet, or relay,
25 may be rendered relatively slow, in comparison with another, to release its armature. In the system as arranged, I make use of primary and secondary impulses, the former serving to adjust a switch directive-
30 tively, and the latter, following the directive adjustment, serves to prepare the switch mechanism for transmission of the next set of directive impulses. The directive impulses are transmitted by a relay which
35 quickly releases and attracts its armatures, while the secondary impulse is transmitted by a relay relatively slow to release its armatures, which has become energized and maintains its armatures attracted, although
40 its circuit is intermittently interrupted, while the first-mentioned relay is being operated.

I am aware that quick and slow releasing relays have heretofore been employed in
45 automatic telephone systems and I do not claim the feature as broadly novel, but do claim the structure employing such relays as generally indicated above and as hereinafter more specifically described and pointed
50 out.

Referring to the drawings, I have illustrated in Fig. 1, comprising parts 1, 2 and 3, a circuit of an automatic telephone system embodying the invention; Figs. 2, 3 and 4

are elevations of a selective switch which
65 may be employed in connection with the circuit diagram; Fig. 5 illustrates the primary off-normal combination of said switch; and Fig. 6 illustrates its primary magnet and the mechanism associated therewith.

Referring first to Fig. 1, whose parts are to be adjacently disposed in numerical order, the calling automatic substation is illustrated at A, and the called automatic substation at H. The system, as illustrated,
65 is arranged for ten thousand lines as maximum, and accordingly, first selectors D to select the thousands, second selectors E to select the hundreds, and connectors F to select the tens and units, are provided.
70 The lines, as called lines, are divided into groups of one hundred, and each such group may have, say, ten connectors F assigned for connections to its lines. Multiple called contacts 7, 8, 9, for each line are provided,
75 appearing with those of the other ninety-nine lines of the group in the banks of each of the ten connectors. The contact sets of the called lines at the connectors are preferably
80 arranged in ten groups of ten contact sets each, according to the tens values of the numbers of the lines, and adjustments of the wipers 139, 140, 141, of the connectors are made in one plane to select the tens
85 group, whereafter secondary adjustments are produced in another plane to select the units, i. e., the contact set of the called line. The one hundred connectors F, of the ten
90 groups of called lines of the same thousands value, have each their stationary multiple contact sets 106, 107, 108, appearing before the wipers 103, 104, 105, of one hundred second
95 selectors E, the said contact sets being arranged in groups, so that the sets of the ten connectors for a given one hundred lines form one group. Thus the wipers 103, 104,
100 105, of a second selector E are adjusted in one plane to select the group of contact sets of the one hundred wanted, and then adjusted in an intersecting plane to select the contact set of an idle connector. On the usual
105 ten per cent trunking basis, there will be one hundred second selectors E for each thousand, and each second selector will have stationary contacts 88, 29, 90, multiplied to, say, one hundred first selectors D. Each such first selector D will have before its wipers ten groups of ten contact sets each,

the sets of each group being connected to second selectors E, assigned to a different thousand, so that also in the case of the first selector D, primary adjustments of the wipers are made in one plane to select the group of the wanted thousand, and thereafter, secondary adjustments in an intersecting plane to select the contact set of an idle switch.

The first selectors D are preferably not individual to calling lines, but each one has paired with it a line selector C whose wipers 33, 34, 35 are adapted to select multiple contacts of any one of one hundred calling lines; each line, as a calling line, is provided with multiple contacts 28, 29, 30, which may appear along with similar contact sets of ninety-nine other lines in the banks of a suitable number of line selectors C, say ten. The multiple calling contact sets are preferably arranged in ten groups of ten contact sets each and the travel of the line selector C will be first in one plane to select the sub-group of the calling line, and then in another plane to select the contact set of such line out of the sub-group. Each such sub-group of ten lines is provided with a multiple group contact 31 which appears in each of the line selectors serving the one hundred line group. The line selectors C are not constantly traveling devices, but are so arranged that when any line of the group initiates a call, a starting device B³ is operated to initiate travel of an idle line selector which thereupon, by means of the group wiper 36, seeks out the group contact 31 of the sub-group containing the calling line. On the primary travel of the line selector, which is controlled by the group wiper 36, the wipers 33, 34, 35, move along with said group wiper 36 and are so brought adjacent to the group of contacts 28, 29, 30, among which those of the calling line are included. After the primary adjustment of line selector C, under the control of wiper 36, secondary adjustments are produced in which the wipers 33, 34, 35 move under control of wiper 33 in an intersecting plane, until they reach the contact set of the calling line. During the secondary travel, the wiper 36 remains stationary engaging the group contact selected.

Each subscriber's line, such as A and H, is provided with a line relay 10 which is adapted for operation on the initiation of a call at the substation of its line to render the multiple called contacts of the line 7, 8, 9, busy at the connectors; to render the multiple calling contacts 28, 29, 30, at the line selectors C selectable; to operate the master switch relay 23 to start an idle line selector C; and finally, to operate a common or group relay 20 whose armature will then remove a normal ground connection

from the group contact 31 of the sub-group including the calling line to render the sub-group selectable. The master switch relay 23 is common to the entire one hundred lines of a calling line group being so made by the common conductor 22 which has one hundred branches, one to each line relay of the group. For each sub-group of ten calling lines, a group relay 20 is provided which is rendered common to the ten lines of its appropriate sub-group by means of the common conductor 21 which has ten branches, one extending to the line relay of each line of the sub-group. In addition to the line relay 10, each line is provided with an individual cut-off relay 14 which is so arranged in circuit as to be operated when connection is made to the line either as a calling line or as a called line, when the said cut-off relay will, in the well known manner, render the line relay 10 inoperable.

Assuming that the calling substation A desires to converse with the subscriber at substation H, whose number may be assumed to be 3456, the subscriber at A first removes his receiver, whereupon hook-lever 1 rises and completes a conductive bridge through the substation, giving rise to a flow of current from battery B, through contact 19, line limb 6, the impedance of magnet 4, the upper hook-switch contacts, returning through the transmitter, contact 2, line limb 5, normal contact 16, line relay 10 to ground. Said relay 10 operates and its armature 12 disconnects the relay from the line and establishes a locking circuit traced through contact 18, the common wire 22, and master switch relay 23 to battery. Armature 13 of relay 10 removes ground from the multiple contacts 28 at the line selectors C, altering their electrical condition to render them selectable, and said armature 13 further operates the group relay 20 by current over the common wire 21 to remove ground from the sub-group contacts 31, to render them selectable. Armature 11 connects ground to the multiple called contacts 7 at the connectors and renders them busy against incoming calls. Operated relay 23, at master switch B³, closes circuit from ground through armature of relay R, contact 24—26 (the wipers 24 and 25 of master switch B³ normally engaging contacts 26 and 27 of an idle line selector now assumed to be C), through contact 38 of the engaged idle line selector, and its primary relay PR to battery B. Operated relay PR, by armature 39, closes generator circuit for primary magnet PM which will step wipers 33, 34, 35, 36 on their primary travel, each step bringing the wipers to select the different sub-group of lines. Relay PR, by armature 40, is now connected to wiper 36 and said relay will continue operated by current flowing

through said armature 40, wiper 36 to ground at engaged multiple contacts 31 of the sub-groups not having a calling line, until wiper 36 engages the contact 31 of the sub-group of A. This contact will be ungrounded, as before described, and relay PR will therefore de-energize, the primary off-normal contacts 37 and 38 having been shifted on the first primary step of the switch C to disconnect the relay PR from its initially energizing circuit. Armature 39 now prevents further actuation of magnet PM and, by engaging its back contact, closes circuit through contacts 37, 41, 45, secondary relay SR to battery, and this relay, by armature 51, closes a generator circuit for secondary magnet SM extending to ground at normal contact 42, whereby secondary travel of line selector C is initiated. The relay SR, by armature 50, has connected its winding to the private wiper 33 which now engages successive contacts 28 of the lines of the selected sub-group. Relay SR will continue energized (and magnet SM will so produce successive secondary steps of switch C) until the wiper 33 engages the contact 28 of the calling line, since as long as wiper 33 is passing over successive contacts 28 of non-calling lines, successive locking circuits for relay SR will be established to grounds via contacts 17 and 13 of non-calling line circuits. When wiper 33 engages the contact 28 of line A, the fact that armature 13 of the line circuit of the calling line is attracted occasions a de-energization of relay SR, whose retracted armatures prevent further actuations of magnet SM so that the wipers 33, 34, 35 remain engaging the multiple contacts 28, 29, 30 of the calling line. On the first secondary step of line selector C, the secondary off-normal (SON) contacts 44, 45, 46 were all shifted, contact 45 then opening the initial energizing circuit of relay SR and rendering it solely dependent for current upon the wiper 33.

As soon as relay SR was operated, a circuit was closed from ground to relay PR' at D, normal contact at 65, wire 56, contact 48—49, normal contact 43, contact 53—52, wire 57, normal contact at 68 and relay SR' to battery B', whereby relays PR' and SR' are both energized. When relay SR at C allows its armatures to be retracted, a substitute circuit for relay PR' is extended via contacts 34—29, 15, cut-off relay 14 of the calling line, to battery B. Relay 14 energizes and, by armature 16, establishes a new substitute circuit for relay PR' extending out over line limb 5, through the conductive path at the substation, returning over line limb 6, contact 30—35, normal contact 52, normal contact at 68 and relay SR' to battery B'. By suitably adjusted make-before-break contacts, these shiftings of

the circuits of relays PR' and SR' occur without permitting the retractions of their armatures.

It will be observed that an armature-controlled pawl of magnet 4 at substation A normally engages the notch in the calling device 3 and prevents the same from being actuated by hand. At the instant the calling subscriber A first removes his receiver, magnet 4 momentarily energizes, but as soon as armature 12 of relay 10 disconnected ground from the line limb 5, said magnet 4 de-energized and calling device 3 remained locked until the operation of relay 14 extended ground through relay PR' to line limb 5, thus energizing the magnet 4 and rendering the dial 3 now operable by the subscriber at A.

It will be observed that the operation of relay 14, by the closure of contact 15—17, has now locked said relay 14 through contacts 28—33, 47, 50, to ground. Furthermore, armature 19 has disconnected battery B from line limb 6, and armature 18 has opened the locking circuit of relays 10 and 23, which both de-energize.

When relay SR de-energized, upon selection of the calling line as before described, circuit was completed from ground, through normal contacts 42 and 51, through contact 46, and to the left through contact 27—25, relay R to battery B. Operated relay R, by its armature, closes generator circuit for magnet M, which steps the wipers 24 and 25 rotarily over contact sets 26, 27, of the different line selectors C in search of contacts of an idle one. Until contacts of an idle one are reached, relay R will be continued energized by current to grounds through wiper 25 and successive contacts 27 of busy line selectors C. When, however, the contact 27 of an idle one is reached, such contact will be ungrounded, as an inspection of Fig. 1, Part 1, shows, relay R de-energizes and its armature prevents further actuation of magnet M, the wipers 24, 25, then remaining engaging the contacts 26, 27, of the line selector so selected. It will be understood that the master switch B³ may comprise mechanically a rotary shaft carrying wipers 24 and 25, and a ratchet wheel which the customary armature actuated pawl of magnet M may drive. The contact sets 26, 27, of which one set is provided for each line selector C, serving the one hundred lines to which the master switch B³ is individual, are preferably arranged to form a circle so that the wipers of switch B³ will always be engaging a contact set of one or another of the line selectors. It will be understood that by this arrangement no spring return for switch B³ is necessary, and that the wipers are always caused to travel in one direction of rotation.

The line selector C has now connected the relays PR' and SR' of the first selector D with the limbs of the calling line, and the calling device at A is now to be operated to produce the necessary directive adjustments of a first selector, a second selector, and a connector to establish connection to the called telephone.

To transmit the thousands digit 3 of the called subscriber's number 3456, the subscriber at A rotates dial 3 until three insulating teeth are brought below spring 2. When dial 3 is now released, its spring returns it to normal and three breaks in the conductive circuit of the substation are produced at contact 2. The breaks follow one another rapidly and will cause three de-energizations of the relay PR' whose armatures will be thrice retracted and attracted. During this, however, the relay SR' continues to hold its armatures attracted, said relay SR' being rendered slow to release its armatures when its circuit is broken, by any of the well known expedients of the art, such as a shell of copper about its core, or by a non-inductive shunt, or otherwise. On the first de-energization of relay PR', its armature 59 closed circuit from ground through attracted armature 63, the relay R', which like the relay SR' is slow to release its armature, and to battery B'. During the subsequent breaks and makes at substation A, the relay R' continues to hold its armature attracted. Each de-energization of relay PR' transmits a current impulse from ground through contact 63, normal contact 60, contact 73, primary magnet PM' to battery, and said magnet causes three primary steps of wipers 85, 86, 87, to select the group of multiple contact sets 88, 89, 90, of second selectors E assigned for connections to the third thousand. When, after the last break in the circuit at substation A, the dial 3 reaches normal, relay PR' will hold its armatures in their attracted positions and this will maintain contact at 59 open a sufficient length of time to cause the relay R' to allow its armature to be retracted, whereupon current will flow from ground, through contact 64, contact 61, armature of relay R', through secondary off-normal (SON) contact 74, primary off-normal (PON) contact 76, shifted, as was also 75, on the first step of switch D, through busy relay BR' to battery B'. Relay BR', by armature 82, closes generator circuit for secondary magnet SM', which steps the wipers of the switch D on their secondary travel in search of the contact set of an idle second selector E of the selected group. Magnet SM' will continue to receive actuation until relay BR' de-energizes, which will only occur when wiper 85 engages contact 88 of an idle second selector E, because as long as wiper 85 is passing over successive contacts 88 of busy second selec-

tors (which contacts will be grounded), successive locking circuits will be established for relay BR', through alternate contact 81, normal contacts 78, 84, to wiper 85 and to successive grounded contacts 88. The secondary off-normal (SON) contacts 73, 74, are opened on the first secondary step of switch D, whereby relay BR' is rendered solely dependent upon wiper 85 for current. When wiper 85 does strike contact 88 of an idle second selector which will be ungrounded, relay BR' de-energizes and its armature 82 prevents further actuation of magnet SM', whereby wipers 85, 86, 87, rest engaging the contacts 88, 89, 90, respectively, of the second selector selected, assumed to be E. Armature 81, in engaging its normal contact, has now connected ground to the wiper 85 and to the multiple contacts 88 of the selected switch E rendering it busy to other first selectors D having access to it.

The calling subscriber at A now actuates dial 3 to produce four short breaks in the line circuit, whereby four de-energizations of relay PR' are produced, while relay SR' remains operated. On the first de-energization of relay PR', circuit is closed through relay R', and said relay, as before, holds its armature attracted during the subsequent operations of relay PR' and until the calling device at substation A reaches normal, when a prolonged energization of relay PR' occurs. Each de-energization of relay PR' transmits a current impulse from ground through contact 63, normal contact 60, contacts 80, 86—89, 91, magnet PM², to battery B', and four actuations of magnet PM² step wipers 103, 104, 105, four primary steps to select the group comprising contact sets 106, 107, 108, of connectors F assigned to the lines of the fourth hundred of the third thousand. When, after this adjustment, the armature of relay R' retracts, current flows over a before-traced path through said armature, through contact 83, 87—90, 92, 94 (primary off-normal, PON, contacts 93, 94, having shifted on the first step of the switch E), through busy relay BR², to battery. Relay BR², by armature 101, closes generator circuit for secondary magnet SM², which steps the wipers 103, 104, 105 over the contact sets of the selected group to select a set connected to an idle connector, this selection occurring in a manner understood from the preceding description, the relay BR² having connected its winding by armature 100 with private wiper 103 and secondary off-normal (SON) contacts 91, 92, having been opened on the first secondary step. When the idle connector has been selected, ground from normal contact 100 will be connected to wiper 103 and the multiple contacts 106 of the selected connector to render it busy to other second selectors having access to it.

The calling subscriber A now operates his



calling device to produce five breaks in the conductive circuit of substation A, and this operation, in a manner obvious from what has preceded, will effect transmission of five impulses of current through contacts 86, 89, 99, 104—107, normal contact 109, primary magnet PM^3 to battery B^2 and the magnet PM^3 will then cause five primary steps of wipers 139, 140, 141, to select the fifth group of contact sets of called line terminals, which contact sets will be those of lines 3451 to 3459 inclusive, followed by the contacts of line number 3450, naught being ten impulses. After this, relay R' de-energizes and current flows as before through contact 87—90, thence through contacts 102, 105—108, normal contact 110, closed contact 112 (primary off-normal, PON, contacts 111, 112, 113, having been shifted on the first primary step of switch F), thence through magnet SM^3 to battery B^2 . The resulting actuation of magnet SM^3 produces a first secondary step of the switch wipers, but they are not moved sufficiently to engage the first contact set of the selected group, the mechanism of the connector being so arranged that, after primary adjustment, two secondary steps of the wipers are required to bring them to engage the first contact set. By the first step, however, the secondary off-normal (SON) contacts are shifted, 109 to engage its alternate contact, and 110 to disengage its normal contact, but not sufficiently to engage its alternate contact, which latter occurs only on the second secondary step of the switch F.

The subscriber at A now actuates his dial 3 to produce six breaks in the line circuit of the substation and six resulting de-energizations of relay PR' transmits current impulses as before through contacts 86—89, 104—107, thence through alternate contact 109, contact 124, secondary magnet SM^3 , to battery B^2 , whereby magnet SM^3 is caused to produce six additional secondary steps of the switch wipers, at the conclusion of which said wipers 139, 140, 141 will rest engaging contacts 7, 8, 9, of the called line 3456, to which is connected the substation H. After this, a continued energization of relay PR' will cause the armature of relay R' to fall back to transmit a current impulse from ground, through contacts 87—90, 105—108, alternate contact 110, normal contact 127, lower winding of test relay TR to battery B^2 . The test relay TR is thus energized and by its armature 129 connects its upper winding with private wiper 139 to test the called-for line. Immediately on the energization of relay TR, relay 123 energized by current through contact 130, and normal contact 114 to ground, whereupon armature 126 locks the said relay 123 to ground at said armature 114. The opening of contact 127 has now disconnected the relay TR from its initial energizing circuit and whether or not it con-

tinues operated will depend upon the electrical condition of the private or test contact 7 of the called line. If the called line is idle, the contact 7 will, as shown, be connected through normal contact 11 and cut-off relay 14 of the line circuit to the active side of battery B^2 , and since the winding of relay TR is also connected with the active side of said battery, the relay de-energizes and the following circuit changes are occasioned. Current flows from ground, through relay 116, through attracted armature 125, normal contact 129, contact 139—7, normal contact 11 and the cut-off relay 14 to battery B^2 . The relay 14 operates, and by closing the contact 15—17, connects ground traced through relay 116 at F to the multiple contacts 28 of the line of H at the line selectors, maintaining the called line busy there; while armature 16 disconnects the line relay 10 from the called line so that it will remain unoperated when the called subscriber removes his receiver.

Upon the operation of relay 116, the constantly operating interrupter I alternately energizes and de-energizes the relay GR by current from ground through said interrupter I, attracted armature 118, normal contact 133, to battery B through relay GR, and the armature 138 of said relay attracts and releases, alternately including and excluding the ringing generator G with, and from, circuit with the called substation. Whenever the armature 138 is attracted, the current from generator G passes through contact 140—8 over the called line through condenser and bell, ringing the latter, returning through contact 9—141, attracted armature 119 to ground. When the called subscriber answers the call and removes his receiver, the relay 120 energizes, as soon as armature 138 is engaging its normal contact, by current flowing from battery B^2 through said relay 120, contact 117, normal contact 138, contact 140—8, line limb 5, contact 2, through transmitter and raised hook-lever, magnet 4, line limb 6, contact 9—141, contact 119, and associated retardation coil to ground. This supplies current to the transmitter of the called substation for talking purposes. Attracted armature 121 of relay 120 operates relay 134 which, by armature 134^a, locks to ground at normal contact 114. Armatures 132 and 137 complete the talking circuit at H, the talking circuit being indicated throughout the circuit drawings by the heavily marked conductors. Armature 133 disconnects generator relay GR from interrupter I so that ringing current remains excluded from the called line. The armatures 135 and 136 shifted the connections of the release relay RR^3 at switch F so that from this time on, the connector F depends for its restoration upon circuit connections controlled at substation H. The

ground at armature 119 is, on the operation of relay 134, extended over the called line and through contacts 107—104, 89—86, alternate contact 60, to battery B' through the relay *rr*, which relay, by armature 69, operates the reversing relay RV' whose armature 66 establishes a locking circuit extending to the primary off-normal contact 75. On the actuation of relay RV', the connections of battery B' to the limbs 5, 6, of the calling line, is reversed and this reversal may be profitably employed for operating any of the polarized special service devices of the art. The attraction of armature 64 of relay RV' has removed the operating current from the lower talking conductor. The transmitter at the substation A is now energized for talking through the impedances of relays PR' and SR' and the talking circuit may be traced from substation A to substation H by the heavily marked conductors, the said circuit being inductively completed at switch D by the condensers 71 and 72.

When the subscribers finish their conversation, they replace their receivers upon the hook-switch and the central office mechanism is restored to normal. If the subscriber A first replaces his receiver, switches C, D and E will be restored, switch F remaining to be restored when subscriber H replaces his receiver. If subscriber H first hangs up his receiver, switches D, E and F will be restored, switch C remaining for subscriber A to restore.

Assuming the called subscriber H hangs up his receiver first, the hook-lever 1 opens the conductive circuit through the substation, relay 120 at F de-energizes, as does also the relay *rr* at D, which has been held energized by current over the called line. Referring first to F, the falling back of armature 122 operates release relay RR³ by current through alternate contact 136. Relay RR³, by armature 115, locks to battery through off-normal contact 113, and by armature 114, energizes release magnet RM³, which withdraws the retaining pawls of the connector F which then restores to normal, the primary off-normal (PON) and secondary off-normal (SON) contacts being also restored in the process. On the attraction of armature 114, relays 123 and 134 have their locking circuits opened and they de-energize. Armature 125, falling back, de-energizes relay 116 at F and the cut-off relay 14 at H so that the line circuit of H, as well as connector F, is at normal. On the de-energization of relay *rr* at D, circuit is closed from battery, through contact 70, contact 67, release relay RR', which, by armature 77, locks in series with busy relay BR'. Release magnet RM' now energizes by current through alternate contacts 79, 82, to ground and withdraws the retaining pawls of first selector D, whose wipers restore to normal, the primary and secondary off-normal contacts being also restored in the process. The opening of contact 76 de-energizes relays BR' and RR', and the de-energization of release magnet RM' necessarily follows. The relays PR' and SR' remain energized by current over the calling line A, and relay RV' remains locked by current over wire 54, through contacts 46, 51, 42, to ground. When relay RR' at D first operated, its armature 78 connected battery (before armature 84 of magnet RM' was attracted) through contact 85—88, contact 93, to ground through release relay RR² of switch E. Relay RR², by armature 95, locks in series with relay BR², whereupon energizing current for release magnet RM² flows through alternate contacts 97 and 101 to ground. The actuated magnet RM² withdraws the retaining pawls of switch E, and the switch wipers are restored, as are the primary and secondary off-normal switch contacts. The resulting opening of contact 94 de-energizes relays RR² (and thereby RM²) and BR², and the second selector E is at normal. When, now, the calling subscriber A replaces his receiver, the conductive circuit through the substation is interrupted and relays PR' and SR' are together de-energized for the first time since their initial operation, closing a circuit from ground through release relay RR', contacts 62, 58, wire 55, contact 44, lower winding of release relay RR, to battery B. Armature 42 operates relay SR during the release by current through alternate contact 45. Armature 41 of relay RR locks said relay to ground at normal contact 39 and connects the winding of release magnet RM over a branch circuit with said ground so that the magnet is actuated and withdraws the retaining pawls of the line selector C, which restores. The primary and secondary off-normal switches are also restored and the opening of contact 37 de-energizes relay RR and magnet RM. The opening of alternate contact 42 then de-energizes secondary relay SR and the line selector C is at normal, as is first selector D by the de-energizations of relays PR', SR' and RV', the latter having had its locking circuit, traced over wire 54, opened as soon as armature 42 was attracted. It will be observed that when line selector C is restoring, ground is maintained upon contact 27 of master switch B³, over a circuit traced through alternate contacts 47, 50, 45 and 42.

Had the calling subscriber A first replaced his receiver, the de-energization of relays PR' and SR' would have completed the before-traced path for current including the winding of relay RR', and the operation of this relay would have caused the restorations of switches D and E in the same manner that

they occurred when relay RR' was operated from substation H. Then, when the receiver would be replaced at substation H, the connector F' would be restored as before. Until this occurred, however, the multiple contacts 106, 107, 108, of the switch F at the second selector E would continue busy, since the multiple contact 106 would be connected to ground through alternate contacts 111, 135.

Returning now to the point when the test relay TR at F was energized by the transmission of the secondary impulse to test the called line, and assuming that at such time the called line was busy, then the multiple contacts 7 of the called line would have been connected to ground in one of the several ways heretofore indicated as possible; and on the attraction of armature 129 of TR, said relay would have continued energized, being locked to ground at the engaged contact 7 of the busy called line. The contact 128 would therefore remain closed and the busy signal from interrupter I' would be transmitted over the upper talking conductor, through the exchange to substation A, giving the usual audible busy signal in the receiver. The calling subscriber A will thereupon replace his receiver, and switches C, D and E will be restored in the manner before described. The continued energization of relay TR has prevented any of the relays 116, 120 and 134 from operating, and the release relay RR² remains connected, through normal contact 135 and contact 111, with the private contact 106. Thus, when, at the initiation of release of switch E, relay RR² operates, current flows from battery B', through alternate contact 96, normal contact 98 (before magnet RM² energizes), contact 103—106 to ground through relay RR³, which relay operates and restores the connector F in the manner before described. With respect to the line circuit of substation A, it is of course apparent that as soon as switch C starts to restore, cut-off relay 14 de-energizes and the line circuit is placed in its normal condition.

The switch structure diagrammatically shown in Figs. 2 to 6, inclusive, is more specifically a line selector C, although a similar structure may be employed in connection with the circuits shown at D, E and F of Fig. 1.

In Fig. 2, the main contact bank is shown in section, one group of ten contact sets being indicated as extending vertically. In Fig. 3, showing a front view of the contact bank, each set of three contacts is indicated by a single short line; and in this figure are illustrated the ten vertically extending groups of contact sets having their contact ends projecting as through the inner surface of a section of a hollow sphere. The contact wipers 33, 34, 35 have their contact

ends rotated step by step from left to right, each step bringing them below a different group of contact sets, whereafter said contact ends are rotated step by step upwardly to engage successive contact sets of the selected group. For the primary adjustment, to select the group, a rotary primary shaft PS is provided, through which the wipers 33 to 35 extend and are fastened by a pivoted bearing at 220. The group-selecting wiper 36 is rigidly attached at the base of shaft PS and its co-operating contacts 31 are arranged in a horizontally extending curved group below the main switch bank. The primary magnet PM, best shown in the sectional top view, Fig. 6, has an armature-actuated pawl 202 adapted, on actuations of said magnet, to engage successive teeth of the rotary ratchet 203, firmly attached to shaft PS, and so rotate shaft, ratchet and wipers step by step. A pivoted retaining pawl 204 is provided to engage the ratchet 203 and hold it against back movement during the primary adjustment of the switch. The wipers 33 to 35 have a rearwardly extending portion 200 provided with a suitable bearing engaging the broad piece 201, screwed to secondary shaft SS. When actuations of secondary magnet SM are produced, its armature-driven pawl 212 engages successive teeth of an associated ratchet of shaft SS and drives the shaft downwardly, whereby the piece 201 rotates the wiper ends upward about the pivot 220, moving them to engage successive contact sets of the selected group. As best shown in Fig. 3, the piece 201 is sufficiently broad so that it continued in engagement with the bearing of the piece 200, irrespective of the primary position to which the wipers may have been rotated. To hold the secondary shaft SS against back movement, a secondary retaining pawl 211 is provided to engage successive teeth of a ratchet cut in said shaft.

It is thus seen that by means of primary magnet PM and secondary magnet SM, the wipers 33, 34, 35 may be adjusted to select any group of contacts and then any contact set of the group.

To restore the switch, the release magnet RM is actuated, whose attracted armature 213 rotates the primary retaining pawl 204 about its pivot, which pawl, by an arm 204^a, withdraws the secondary retaining pawl 211 and the two shafts are then free to be restored. First the spring 209, engaging the short end of the pivoted rocker arm 210, whose distant end engages loosely a screw threaded to shaft SS, is effective to raise said shaft upward, whereby the wipers are rotated downwardly to free the contact bank. As soon as this occurs, the spring 205, one end of which is attached to the main switch frame and the other end to the primary shaft PS, is effective to rotate the primary

shaft reverse clockwise back to normal. The tension of spring 205 is ineffective while shaft SS is being restored, because of the piece 206 which extends parallel with the shaft SS and has a tooth 207 which engages some adjacent tooth of the rotary ratchet 203 at all times when the secondary shaft is in other than normal position. Thus on the first downward step of shaft SS, the piece 208, fastened thereto, disengages the piece 206 which drops down through the switch frame, the tooth 207 then engaging an adjacent tooth of the ratchet 203. When the secondary shaft SS, in its restoration, reaches normal, the piece 208 again raises the piece 206, disengaging the tooth 207 from ratchet 203. The piece 206 permits the secondary off-normal springs 44, 45, 46 to shift on the first secondary step of the switch and restores them to normal as the restoration of the secondary shaft is completed, in an obvious manner.

The primary off-normal switch arrangement indicated in Fig. 5, which is a top view of the selector, includes the piece 215, rigidly fastened to the primary shaft PS and having a stud 216 normally engaging the end of the primary off-normal spring 38 which is mechanically linked with the associated spring 37 by an insulating spacer. On the first rotary step of the shaft PS, stud 216 frees spring 38 and the two springs 37 and 38 assume their alternate positions. When shaft PS is subsequently rotated back to normal, stud 216 engages spring 38 and restores it and spring 37 to their normal circuit relations.

When the switch, indicated in Figs. 2 to 6, is employed in connection with the circuits indicated at D, E and F, the group wiper 36 and the group contact 31 may be omitted or left disconnected. When the switch mechanism is used for these other circuits, they will be provided with the particular primary and secondary off-normal switch combinations indicated in said circuits. When the switch mechanism is used for the purposes of the connector F, the normal relation of the contact ends of wipers 33 to 35 to the lower edge of the contact bank will be two secondary steps below.

It will thus be seen that I have devised a relatively simple circuit arrangement for operation in connection with a calling device which operates to open and close a single circuit only, and that I have embodied in the invention the feature of employing a single set of relays to be actuated by the substation currents in adjusting all the switches employed in a given connection, the relays of switch D operating as repeater relays to distribute the transmitted impulses among the various switches to properly adjust them.

The various battery symbols indicate a

single source of direct current, and the various generator symbols may also be a single source. I do not desire to be limited to the precise structures herein shown and described, but what I claim as my invention is:—

1. A selector for telephone systems comprising a metallic circuit, a pair of relays bridged to opposite sides of said circuit, one of said relays being relatively slow to release its armature, a second relay slow to release its armature jointly controlled by said first mentioned relays, and means for producing rapid intermittent interruptions in said circuit.

2. A selector for telephone systems comprising a metallic circuit, a first relay bridged to one side of said circuit, a second relay relatively slow to release its armature bridged to the opposite side of said circuit, a third relay slow to release its armature jointly controlled by said first and second relays, and means in said circuit for causing said first mentioned relay to rapidly vibrate its armature while said third relay holds its armature attracted.

3. A selector for telephone systems comprising a metallic circuit, a first relay bridged to one side of said circuit, a second relay relatively slow to release its armature bridged to the opposite side of said circuit, a third relay slow to release its armature jointly controlled by said first and second relays, means in said circuit for causing said first mentioned relay to rapidly vibrate its armature while said third relay holds its armature attracted, and means for adjusting said selector, responsive to said vibrated armature.

4. A selector for telephone systems comprising a metallic circuit, a first relay bridged to one side of said circuit, a second relay relatively slow to release its armature bridged to the opposite side of said circuit, a third relay slow to release its armature jointly controlled by said first and second relays, means in said circuit for causing said first mentioned relay to rapidly vibrate its armature while said third relay holds its armature attracted, means for adjusting said selector responsive to said vibrated armature, a switch controlled by said third relay operating responsive to cessation of the vibration, and means for adjusting said selector responsive to the operation of said switch.

5. An automatic telephone system including a selector having a metallic circuit, a first relay bridged to one side of said circuit, a second relay relatively slow to release its armature bridged to the opposite side of said circuit, a third relay slow to release its armature jointly controlled by said first and second relays, means in said circuit for causing said first mentioned relay to

rapidly vibrate its armature while said third relay holds its armature attracted, means for adjusting said selector, responsive to said vibrated armature, a switch controlled by said third relay operating responsive to cessation of the vibration, means for adjusting said selector responsive to the operation of said switch, an auxiliary selector and a connector adapted to be connected with said first mentioned selector, and means for operating said auxiliary selector and said connector by currents transmitted by said relays after said first-mentioned selector has operated.

6. An automatic telephone system including metallic circuit telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line finder switch normally associated with said relays for rendering said relays controllable by currents over the metallic circuit of calling lines interchangeably, selective switches of a plurality of classes, and means for successively operating selective switches, one of each class, by currents transmitted by said relays.

7. An automatic telephone system including metallic circuit telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line finder switch normally associated with said relays for rendering said relays controllable by currents over the metallic circuit of calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for connecting directly with called lines, an impulse controller at a calling station for controlling said relays, and circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line.

8. An automatic telephone system including telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line selecting switch for rendering said relays controllable by currents over calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for connecting directly with called lines, an impulse controller at a calling station for controlling said relays, circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line, and a switch adapted for actuation at the called station for restoring the directly operable switches employed in a connection.

9. An automatic telephone system including telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses,

a line selecting switch for rendering said relays controllable by currents over calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for connecting directly with called lines, an impulse controller at a calling station for controlling said relays, circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line, a switch adapted for actuation at the called station for restoring the directly operable switches employed in a connection, and means at the calling station for restoring said line selecting switch.

10. An automatic telephone system including metallic circuit telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line finder switch individual to said relays for rendering said relays controllable by currents over the metallic circuit of calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for connecting directly with called lines, an impulse controller at a calling station for controlling said relays, circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line, and a switch at the calling station adapted for actuation to restore said line selecting switch and the directly operable switches, other than the connector, used in a completed connection.

11. An automatic telephone system including metallic circuit telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line selecting switch for rendering said relays controllable by currents over the metallic circuit of calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for connecting directly with called lines, an impulse controller at a calling station for controlling said relays, circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line, and a switch at the called station for causing the release of the connector.

12. An automatic telephone system including metallic circuit telephone lines, a quick releasing relay to transmit primary impulses, a slow releasing relay to transmit secondary impulses, a line selecting switch for rendering said relays controllable by currents over the metallic circuit of calling lines interchangeably, directly operable switches of a plurality of classes including selectors and connectors, the latter for con-

necting directly with called lines, an impulse controller at a calling station for controlling said relays, circuit connections for successively operating said switches, one of each class, by currents transmitted by said relays to complete connection to the called line, a switch at the calling station adapted for actuation to restore said line selecting switch and the directly operable switches other than the connector, used in a completed connection, and a switch at the called station for causing the release of the connector.

13. An automatic telephone system including a selector and a telephone line connected thereto, a quick releasing relay and a slow releasing relay associated with said selector, both said relays being connected in the direct circuit of the telephone line, a third relay slow to release its armature controlled by said quick releasing relay, primary adjusting mechanism for said selector responsive to said quick releasing relay, secondary adjusting mechanism for said selector controlled by said third relay, and a release circuit controlled jointly by said two first-mentioned relays.

14. A selector for telephone systems comprising a metallic circuit, a pair of relays bridged to opposite sides of said circuit and energized by current over said metallic circuit, a circuit jointly controlled by said relays, means for rapidly interrupting said metallic circuit thereby interrupting the circuit of said relays, and means for maintaining one of said relays energized during said interruptions.

15. A selector for telephone systems comprising a metallic circuit, a pair of relays and a source of current in bridge of said circuit, said relays being energized by current from said source, means for rapidly and intermittently interrupting said metallic circuit thereby interrupting the circuit of said relays, means for maintaining one of said relays energized during said interruptions, electromagnetic means for adjusting said selector responsive to said interruptions, and a release circuit for said selector jointly controlled by said relays.

16. A selector for telephone systems having wipers adapted to receive primary and secondary adjustment, a metallic circuit, a pair of relays in bridge of said circuit, a source of current for energizing said relays, means for producing rapid intermittent interruptions of said metallic circuit thereby interrupting the circuit of said relays, means for maintaining the armature of one of said relays attracted while the other relay rapidly vibrates its armature responsive to said interruptions, electromagnetic means for giving said wipers a primary adjustment responsive to said vibrations, a slow relay jointly controlled by said relays and energized by current from said source, said

slow relay remaining energized while said relay is vibrating, and releasing its armature responsive to cessation of said vibrations, and means for giving said wiper a secondary adjustment, controlled by said slow relay upon said release of its armature.

17. A telephone system including a calling subscriber's line and a called subscriber's line, a first selector switch, a second selector switch and a connector switch, each of said switches having motion in one plane to select groups of lines and motion in another plane to select idle lines in the selected groups of lines, switch adjusting magnets for each of said switches, a quick-acting line relay and a pair of slow-acting relays for said first selector switch, a normally at rest switching device responsive to the removal of the receiver at the calling substation to connect said calling subscriber's line to said first selector switch, means responsive to current interruptions of the calling subscriber's metallic line circuit to operate said selector relays to directly transmit series of impulses to the switch adjusting magnets of the selector and connector switches to extend a connection from the calling subscriber's line to the called subscriber's line, a battery for supplying current to the calling subscriber's line for talking purposes, and means controlled by the called subscriber for reversing the flow of current over the calling subscriber's line.

18. A telephone system including a calling subscriber's telephone line and a called subscriber's telephone line, a first selector switch, a second selector switch and a connector switch, each of said switches having access to a plurality of groups of lines, switch adjusting magnets for each of said switches, a normally at rest progressively movable non-numerical finder switch responsive to the removal of the receiver at the calling substation to connect said calling line to said first selector switch, a quick-acting line relay and a pair of slow-acting relays individual to said first selector switch, means responsive to the connection of the calling subscriber's line to said first selector switch to energize said line relay and one of said slow-acting relays, a calling device for intermittently interrupting the calling subscriber's line whereby said other slow-acting relay is energized, and a series of impulses generated by the operation of said relays and transmitted directly to the switch adjusting magnets to operate said switches to cause them to extend the talking circuit of the calling subscriber's line to the called subscriber's line.

19. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling

the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay over the two sides of the metallic line in series, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and means controlled by the called subscriber for reversing the flow of current over the calling subscriber's line.

20. In a common battery system, subscribers' lines means for establishing a talking circuit between two of said lines, said means including trunks divided into groups, an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay over two sides of one of said lines in series, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and called subscriber controlled means for reversing the flow of current over the calling subscriber's line.

21. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including the two sides of a metallic line circuit in series for controlling said relay, the said energizing circuit including a ground connection controlled by said relay, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and called subscriber controlled means for reversing the flow of current over the calling subscriber's line.

22. In a common battery system, subscribers' lines, means for establishing a talking

circuit between two of said lines, said means including trunks divided into groups, an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including the two sides of the metallic line circuit in series for controlling the said relay, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, the said energizing circuit including a ground connection controlled by said relay, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and subscriber-controlled means for reversing the flow of current over the calling subscriber's line.

23. In a telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including a first selector common to a plurality of said lines provided with a line relay normally connected thereto, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, said impulses delivered over a circuit including the two sides of a calling line in series, a trunk line adapted to be seized by said first selector, an automatic switch having a progressively movable element, a magnet having an armature for driving said element, a circuit for said magnet extending over said trunk line and controlled by said relay after the first selector has seized said trunk, means independent of said selector for supplying talking current to any substation called through the medium thereof, and means for reversing the flow of current over said circuit including two sides of the calling subscriber's line in series.

24. In a telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic switch common to a plurality of said lines and provided with a line relay, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a circuit including the two sides of a portion of said talking circuit in series for controlling said relay, a trunk line adapted to be seized by said switch, another switch having wipers, a magnet for driving said wipers, a circuit for said magnet extending over said trunk line and controlled by said relay, a selector

also controllable by said relay, operative for switching in accordance with a digit of the called number, and means independent of said automatic switch for supplying talking current to any substation called through the medium thereof, and means for reversing the flow of current over the circuit called for including the two sides of a portion of the talking circuit in series.

25. In a telephone exchange repeater system, subscribers' lines, a plurality of trunks, a plurality of automatic switches, means for controlling the operation of said switches by a varying number of impulses corresponding to the digits of the called number, each switch provided with a propelling mechanism, an actuating magnet for operating said propelling mechanism, ground circuits including only one side of said trunks for energizing said magnets, a relay for successively controlling said circuits, means including the two sides of a calling line in series for controlling said relay, and means for reversing the flow of talking current over the calling subscriber's line when the called subscriber responds.

26. In a telephone exchange repeater system, subscribers' lines, the combination of a plurality of trunks, a plurality of automatic switches, means for controlling the operation of said switches by a varying number of impulses corresponding to the digits of the called number, each switch provided with a propelling mechanism, an actuating magnet for operating said propelling mechanism, ground circuits including only one side of said trunks for energizing said magnets, a relay for successively controlling said circuits, means including the two sides of a calling line in series for controlling said relay, means for automatically extending connection to said automatic switches, and means for reversing the flow of current over said control circuit of said relay.

27. In a telephone exchange repeater system, a plurality of trunks, a plurality of automatic switches, means for controlling the operation of said switches by a varying number of impulses corresponding to the digits of the called number, each switch provided with a propelling mechanism, an actuating magnet for directly operating said propelling mechanism, ground circuits including only one side of said trunks for energizing said magnets, a relay for successively controlling said circuits, means including two sides of a metallic line circuit in series for controlling said relay, means at the central station for supplying talking current over said metallic circuit, and means for reversing the flow of talking current over the metallic circuit.

28. In a telephone exchange repeater system having trunks divided into groups, the

combination of an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a ground circuit including only one side of a trunk for energizing said magnet, a relay for controlling said circuit, means including two sides of a metallic line circuit in series for controlling said relay, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, means at the central station for supplying talking current over said metallic circuit, and means included in said trunking switch for reversing the flow of talking current over said metallic circuit.

29. In a common battery telephone system subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including two sides of the talking circuit in series for controlling said relay, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and means for reversing the flow of talking current over the calling line.

30. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including two sides of the talking circuit in series for controlling said relay, an automatic switch mechanism allotted to and controlled by said relay, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and means controlled over the called subscriber's line for reversing the flow of talking current over the calling subscriber's line.

31. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic

step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including two sides of the talking circuit in series for controlling said relay, means for automatically extending connection to said automatic switch, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and means controlled by the response of the called subscriber for reversing the flow of talking current over the calling subscriber's line.

32. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including two sides of the talking circuit in series for controlling said relay, an automatic switch mechanism allotted to and controlled by said relay, the said energizing circuit including a ground connection controlled by said relay, instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines, and means controlled by the response of the called subscriber for reversing the flow of talking current over the calling subscriber's line.

33. In a telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic switch common to a plurality of said lines provided with a line relay, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a trunk line adapted to be seized by said switch, a switch having wipers, a magnet having an armature for driving said wipers, a circuit for said magnet extending over said trunk line and controlled by said relay, said relay controlled over two sides of the talking circuit in series, means independent of said automatic switch for supplying talking current to any substation called through the medium thereof, and means controlled by the response of the called subscriber for reversing the flow of talking current over the calling subscriber's line.

34. In a telephone system employing means for automatically disconnecting or cutting off an automatic switch from the conductors of the talking circuit, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to both calling and called subscribers, and means individual to the repeater for reversing the flow of talking current over the calling subscriber's line, and trunk-circuit-controlled releasing means for restoring the switch disconnected from the conductors of any talking circuit.

35. In a telephone system employing means for automatically disconnecting or cutting off an automatic switch from the conductors of the talking circuit, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to calling subscribers, and talking current reversing means individual to the repeaters, and trunk-circuit-controlled releasing means for restoring the switch disconnected from the conductors of any talking circuit.

36. In a telephone system employing means for automatically disconnecting or cutting off an automatic switch from the conductors of the talking circuit, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to calling subscribers, and talking current reversing means for said repeaters, and trunk-circuit-controlled releasing means for restoring the switch disconnected from the conductors of any talking circuit.

37. In a telephone system employing means for automatically disconnecting or cutting off an automatic switch from the conductors of the talking circuit, the combination of a talking circuit between calling and called subscribers, said talking circuit having a section normally disconnected from the subscribers' lines, an automatic switch controllable over portions of the two sides of said talking circuit in series, to ex-

tend connection in the direction of the called subscriber, a repeater in the talking circuit individual to said section for controlling the said automatic switch, said repeater being controllable over different portions of the two sides of said circuit in series, means at the central station for supplying current over portions of the said circuit to subscribers for talking purposes, and subscriber-controlled talking current reversing means for said repeater, and trunk-circuit-controlled releasing means for restoring the switch disconnected from the conductors of any talking circuit.

38. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, said bridges including a battery connected in series therein, the combination of a suitable calling telephone line, a two-wire called telephone line, means including a repeater and an automatic switch controlled thereby for extending connection from the calling line to the called line, a common battery for supplying talking current to the called line, circuits for connecting talking current to the calling line, the said calling telephone line being provided with a calling mechanism at the substation thereof for controlling the two sides of the line in series, subscriber-controlled electromagnetic means for reversing the flow of talking current over one of said lines, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

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

40. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, said bridges including a battery connected in series therein, the combination of a two-wire calling telephone line, a suitable called telephone line, means in-

cluding a repeater and an automatic switch controlled thereby for extending connection from the calling line to the called line, a common battery for supplying talking current to the called line, circuits for connecting talking current to the calling line, the said two-wire telephone line being provided with a calling mechanism at the substation thereof for controlling the two sides of the line in series, and means individual to the repeaters for reversing the flow of talking current, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

41. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to both calling and called subscribers, subscriber-controlled electromagnetic means for reversing the flow of talking current to the calling line, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

42. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to calling and called subscribers, subscriber-controlled means for reversing the flow of talking current over the calling line, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

43. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, the combination of subscribers' lines which are free from operating grounds outside of the exchange or central station, trunk lines provided with repeaters, means controllable over said subscribers' lines for automatically selecting idle repeaters, automatic switches controllable by said repeaters, means at the exchange or central station for supplying talking current to call-

ries, and current reversing means for said repeater for reversing the supply of talking current to the calling subscriber's line.

47. A telephone system including a calling subscriber's line, a called subscriber's line, automatic switches and an impulse repeater for establishing connection between said lines, a battery for supplying talking current to the calling subscriber's line, a battery supply circuit to the calling subscriber normally connected to and including the two sides of the calling subscriber's line in series, repeater means controlled by the called subscriber for reversing the flow of talking current over the calling subscriber's line.

48. A telephone system including a calling subscriber's line, a called subscriber's line, automatic switches operative over the two sides of said calling subscriber's line in series and an impulse repeater for establishing connection between said lines, relay mechanism for one of said automatic switches controlled by the called subscriber, relay mechanism for said repeater, talking current adapted to be connected over the two sides of the calling subscriber's line in series, and circuits controlled by said switch relay mechanism to actuate the repeater relay mechanism to reverse the flow of talking current over the calling subscriber's line.

49. A telephone system including subscribers' lines, automatic switches and impulse repeaters for interconnecting said subscribers' lines, a battery for supplying talking current over the two sides of a calling subscriber's line in series, said battery being normally connected to said subscriber's line and relay mechanism individual to the repeater for reversing the flow of talking current over the calling subscriber's line.

50. A telephone system including subscribers' lines, automatic switches and impulse repeaters for interconnecting said lines, said switches and repeaters being controlled over the two sides of a calling one of said lines in series, a battery, means for supplying current from said battery to one of said subscribers' lines for talking purposes, and means in said repeater for reversing the flow of talking current to said subscriber's line.

51. A telephone system including a calling subscriber's line and a called subscriber's line, automatic switches controlled over the two sides of one of said subscribers' lines in series for connecting said subscribers' lines, a battery for supplying talking current to one of said subscribers' lines, and mechanism for reversing the flow of talking current over the said subscriber's line.

52. A telephone system including a calling subscriber's line and a called subscriber's line, automatic switches controlled over the two sides of one of said subscribers' lines in series for connecting said subscribers', 130

44. In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, the combination of a talking circuit between calling and called subscribers, said talking circuit having a section normally disconnected from the subscribers' lines, an automatic switch controllable over portions of the two sides of said circuit in series, to extend connection in the direction of the called subscriber, a repeater in the talking circuit individual to said section for controlling the said automatic switch, said repeater being controllable over different portions of the two sides of said circuit in series, means at the central station for supplying current over portions of the said circuit to the called subscriber for talking purposes, battery supply means for furnishing current to the calling subscriber, means individual to the repeater for reversing the flow of talking current over the calling line, and means for automatically reducing the number of bridges across the conductors of any talking circuit during the establishment thereof.

35 45 In a telephone system employing relay bridges across the conductors of the talking circuit for controlling automatic switches, the combination of a talking circuit between calling and called subscribers, said talking circuit having a section normally disconnected from the subscribers' lines, an automatic switch controllable over portions of the two sides of said circuit in series, to extend connection in the direction of the called subscriber, a repeater in the talking circuit individual to said section for controlling the said automatic switch, said repeater being controllable over different portions of the two sides of said circuit in series, means at the central station for supplying current over portions of the said circuit to the calling subscriber for talking purposes, means individual to the repeater and controllable by the called subscriber for reversing the flow of talking current to the calling subscriber's line, and means for automatically reducing the number of bridges across the conductors of any talking circuit during establishment thereof.

46. A telephone system including a calling subscriber's line, a called subscriber's line, automatic switches and an impulse repeater for establishing connection between said lines, said switches and impulse repeater being controlled over the two sides of said calling subscriber's line in series, means for supplying talking current to the two sides of the calling subscriber's line in se-

lines, a battery, means for supplying talking current from said battery over the two sides of one of said subscribers' lines in series for talking purposes, a relay mechanism controlled by the response of the called subscriber for reversing the flow of talking current to the subscriber's line.

53. A telephone system including a calling subscriber's line and a called subscriber's line, automatic switches controlled over the two sides of one of said subscribers' lines in series for connecting said subscribers' lines, a battery for supplying talking current to one of said subscribers' lines, and relay mechanism controlled by the response of the called subscriber for reversing the flow of talking current to the subscriber's line.

54. A telephone system including a calling subscriber's line and a called subscriber's line, automatic step-by-step switching mechanism controlled over the two sides of the said calling subscriber's line for connecting said subscribers' lines in conversational circuit, a battery, means for supplying talking current from said battery to said calling subscriber's line, the battery supply circuit including the two sides of the calling subscriber's line in series, and mechanism controlled over one of said subscribers' lines for reversing the flow of talking current over the calling subscriber's line.

55. A telephone system including a calling subscriber's line and a called subscriber's line, a plurality of automatic switches and trunks for connecting said subscribers' lines, a battery, circuit connections normally including the two sides of said calling sub-

scriber's line in series and said battery, circuit connections for connecting said battery to the calling subscriber's line to furnish talking current thereto, said circuit connection including the two sides of the calling subscriber's line in series, and relay mechanism for reversing the flow of talking current over the calling subscriber's line.

56. A telephone system including a calling subscriber's line, a called subscriber's line, a non-numerical switch and numerical switches controlled over the two sides of a circuit in series for establishing connection between said lines, a battery, circuit connections for supplying talking current to one of said subscriber's lines, and relay mechanism controlled over the other subscriber's line for reversing the flow of talking current to said subscriber's line.

57. A telephone system including a calling subscriber's line, a called subscriber's line, automatic switches provided with quick and slow acting relays controllable over the two sides of the calling subscriber's line in series for establishing connection between said lines, a battery, circuit connections for supplying talking current to said calling subscriber's line, and relay mechanism controlled over the called subscriber's line for reversing the flow of talking current to said calling subscriber's line.

In witness whereof, I hereunto subscribe my name this 23rd day of June, 1908.

GEORGE E. MUELLER.

Witnesses:

F. SCHOENWOLF,
T. H. FERGUSON.