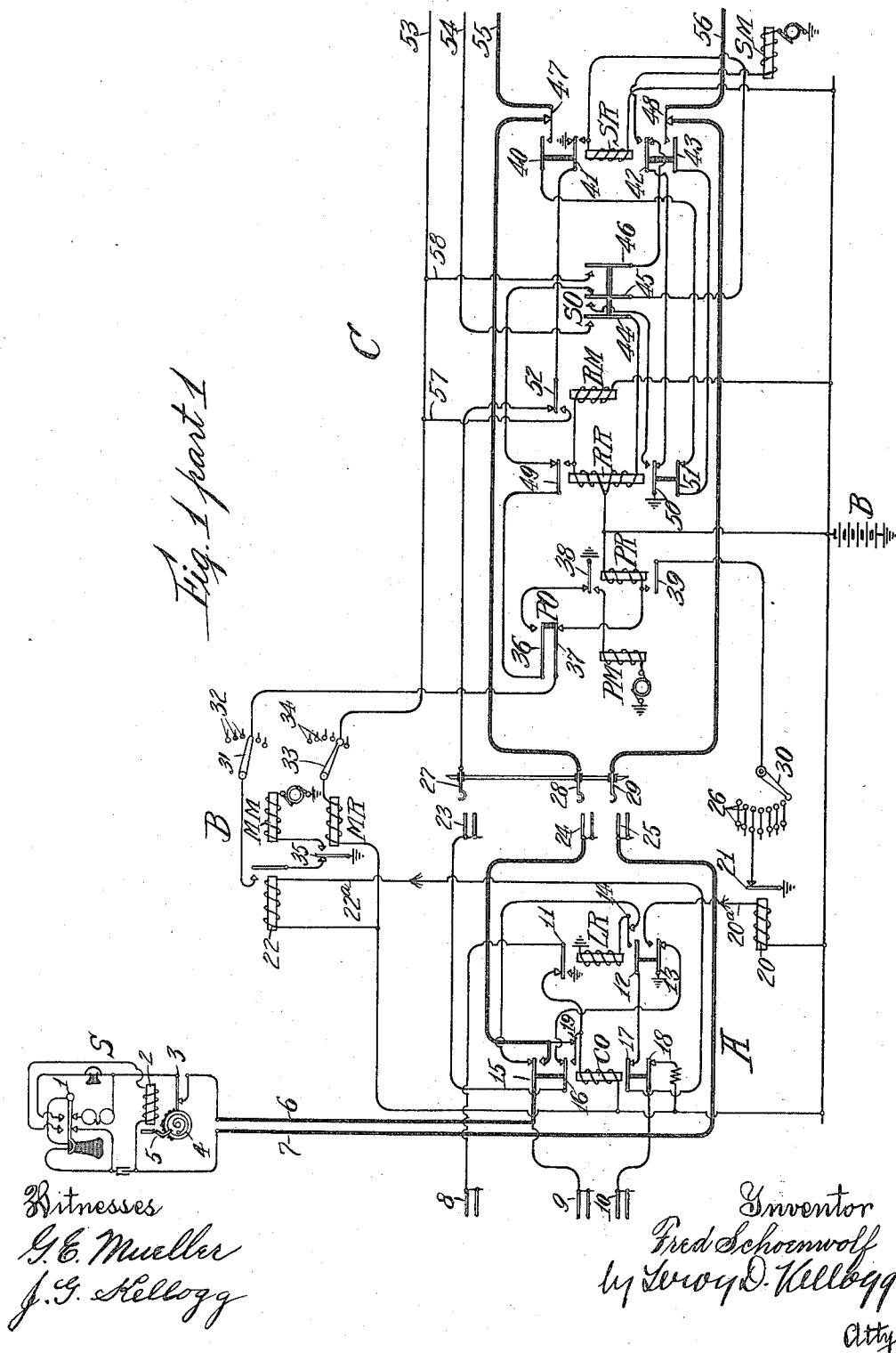


1,169,736.

F. SCHOENWOLF.
TELEPHONE EXCHANGE SYSTEM.
APPLICATION FILED DEC. 16, 1908.

Patented Jan. 25, 1916.

11 SHEETS—SHEET 1.



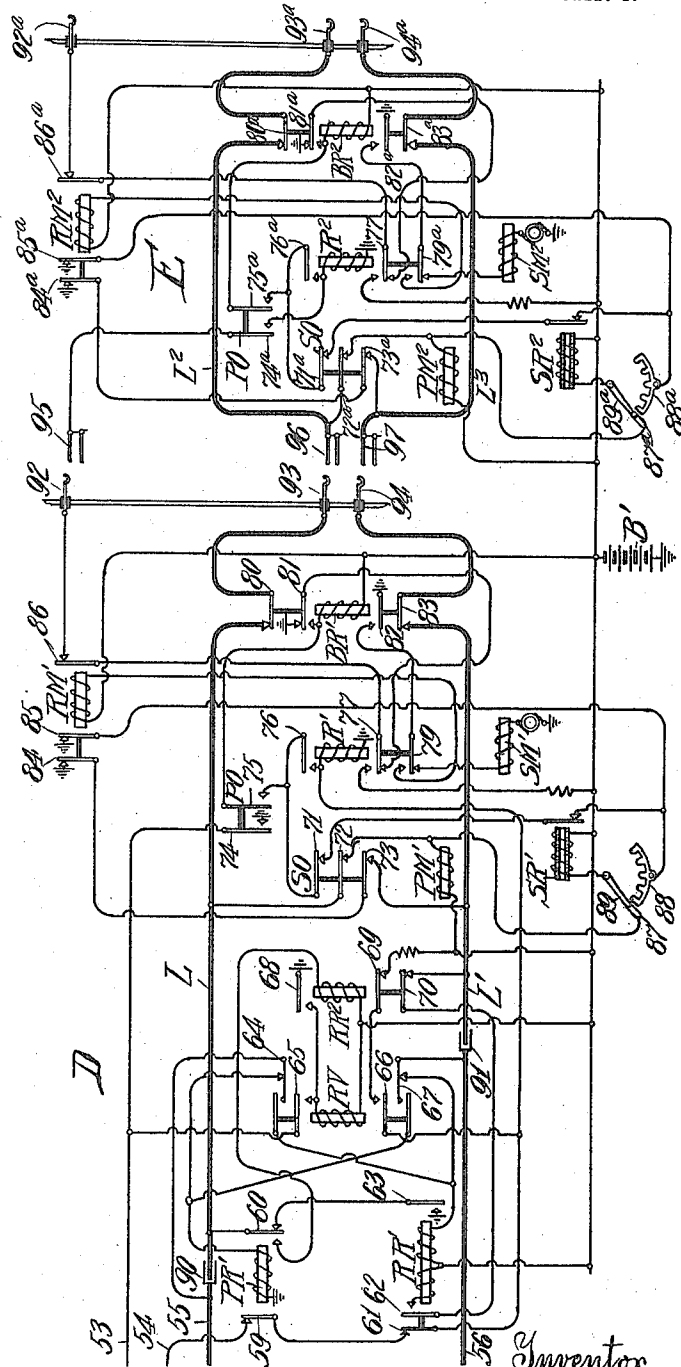
1,169,736.

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11 SHEETS—SHEET 2.

Fig 1 part 2



Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

F. SCHOENWOLF.
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11 SHEETS—SHEET 3.

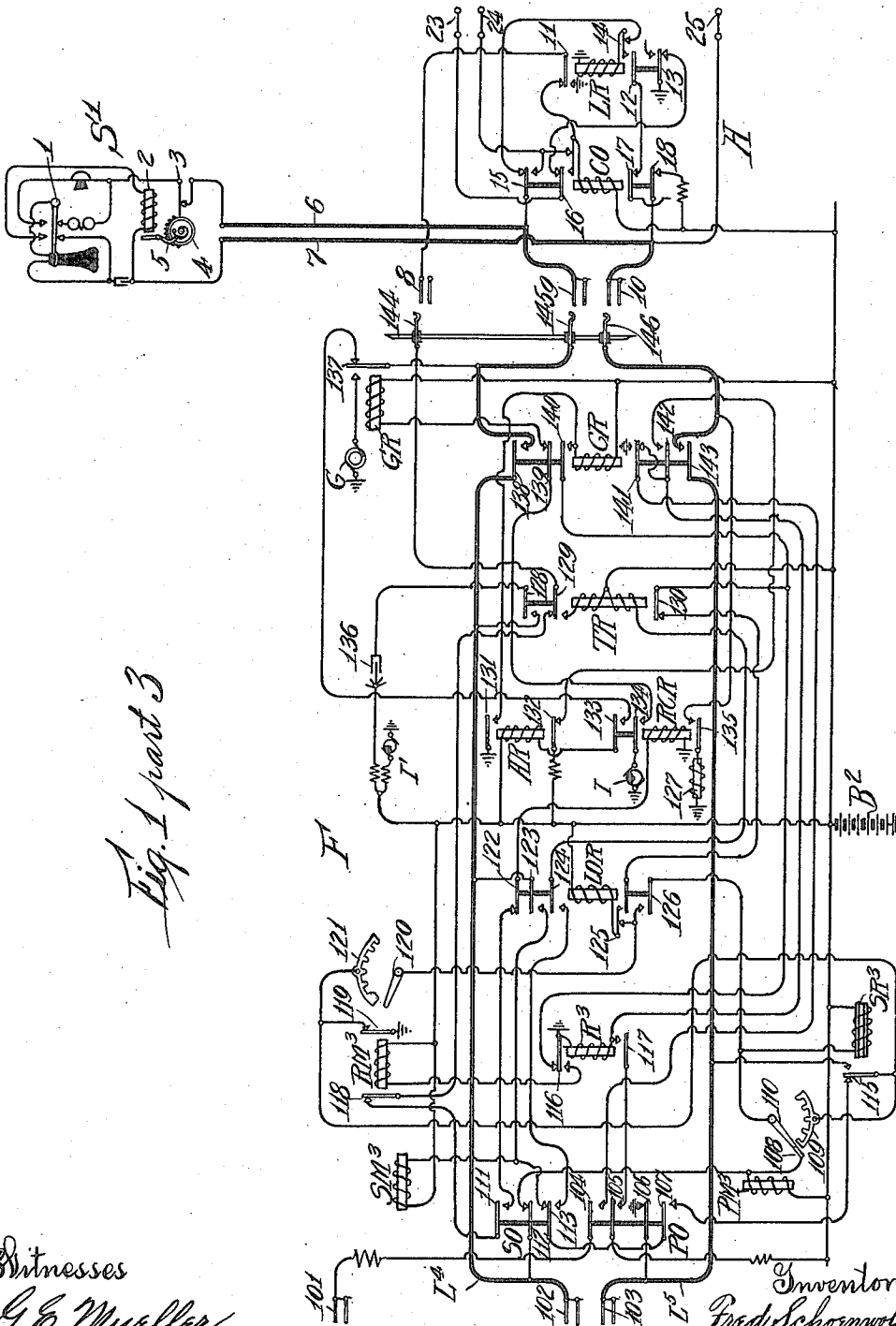


Fig. 1 part 3

Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty

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F. SCHOENWOLF.
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11 SHEETS—SHEET 4.

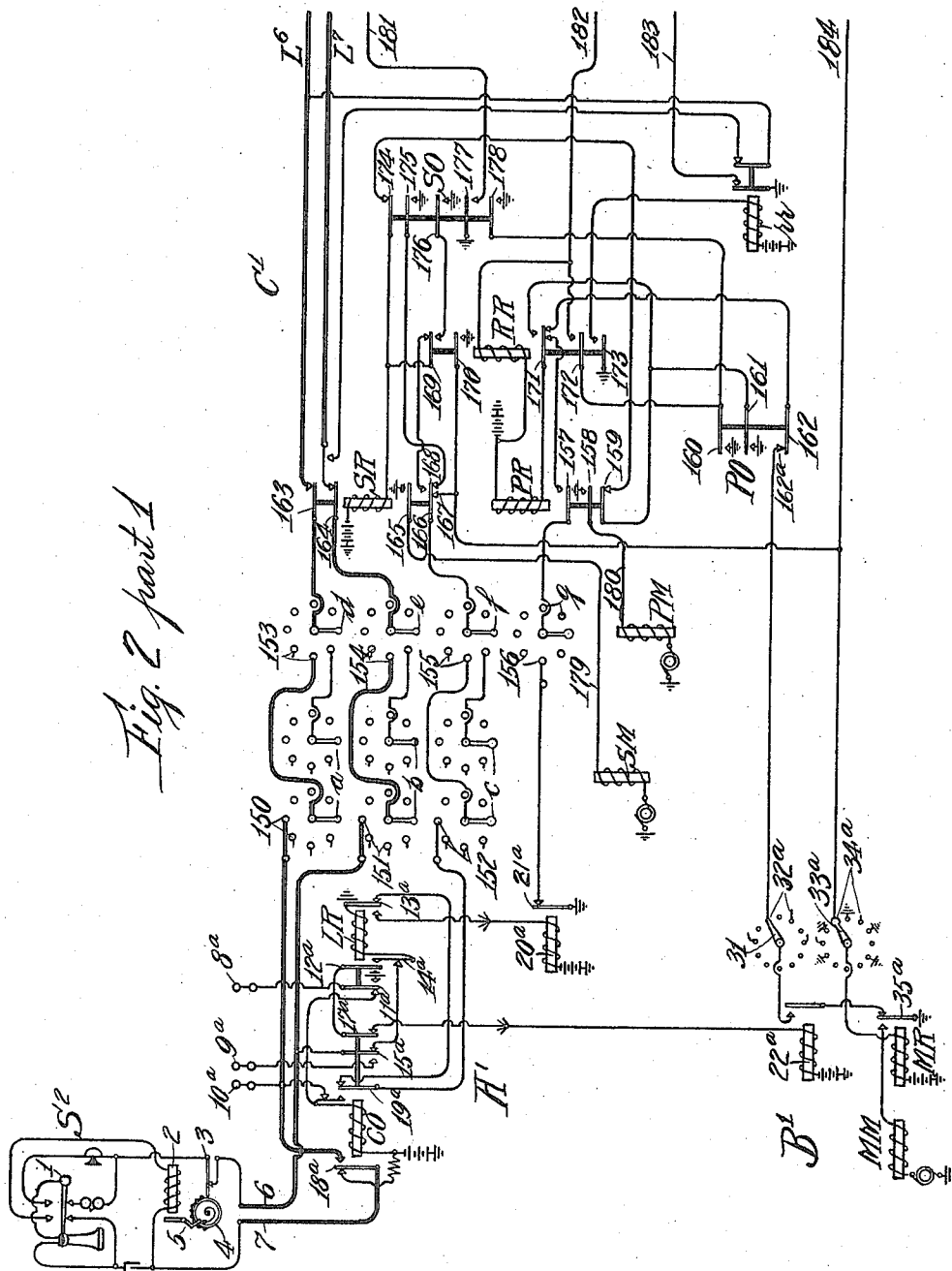


Fig. 2 part 1

Witnesses
G. E. Mueller
J. G. Kellogg

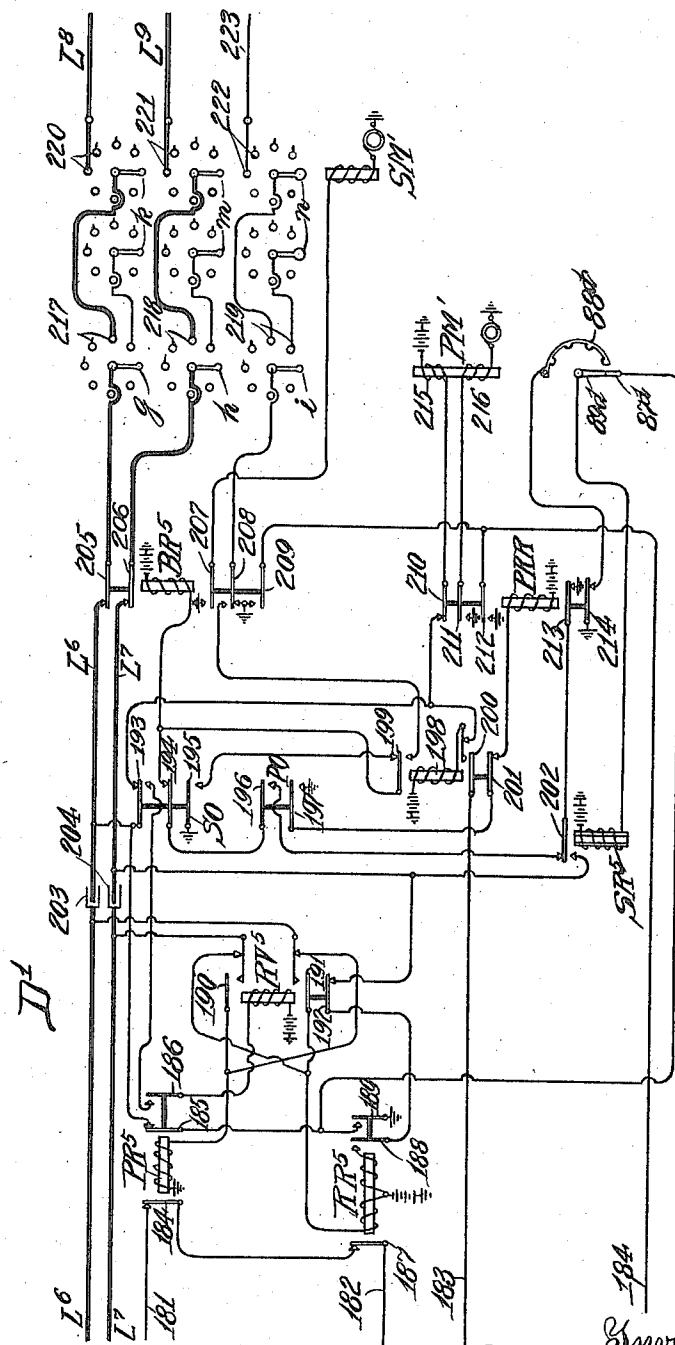
Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

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11 SHEETS—SHEET 5.

Fig. 2 part 2



Witnesses
G. E. Mueller
J. F. Kellogg

Inventor
Fred Schoenwolf
by Lloyd D. Kellogg
Atty

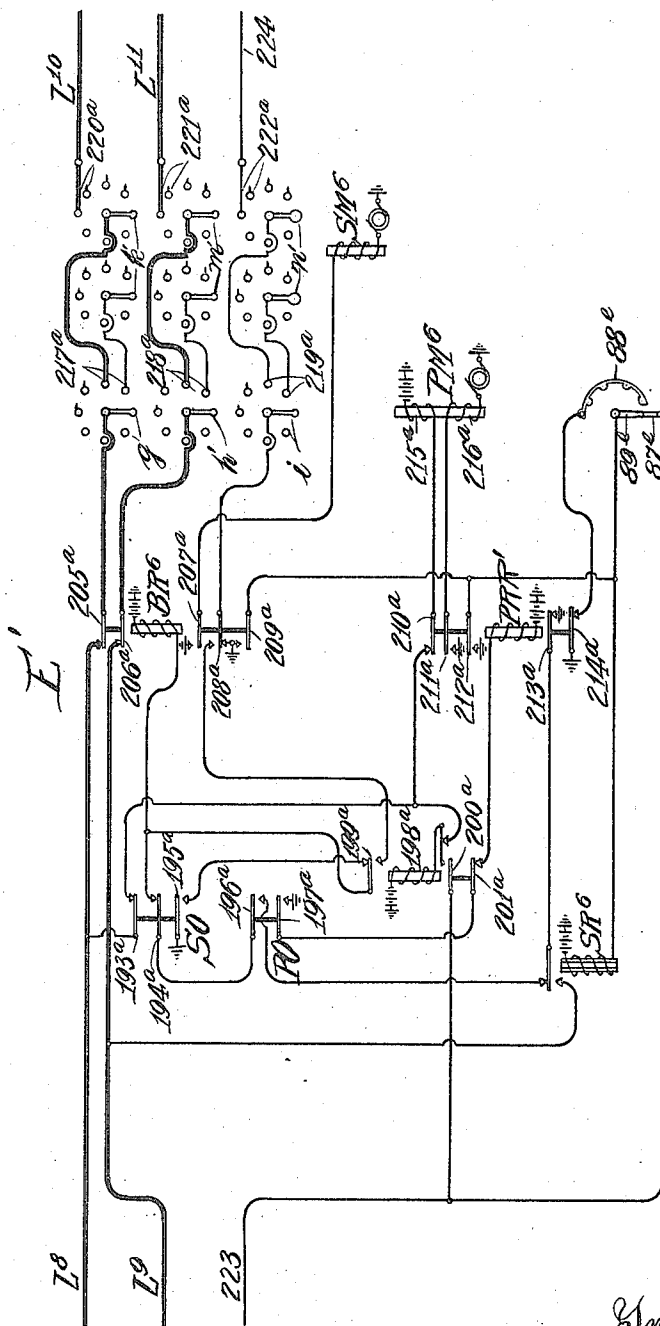
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11 SHEETS—SHEET 6.

Fig. 2 part 3



Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty

F. SCHOENWOLF.
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11 SHEETS—SHEET 7.

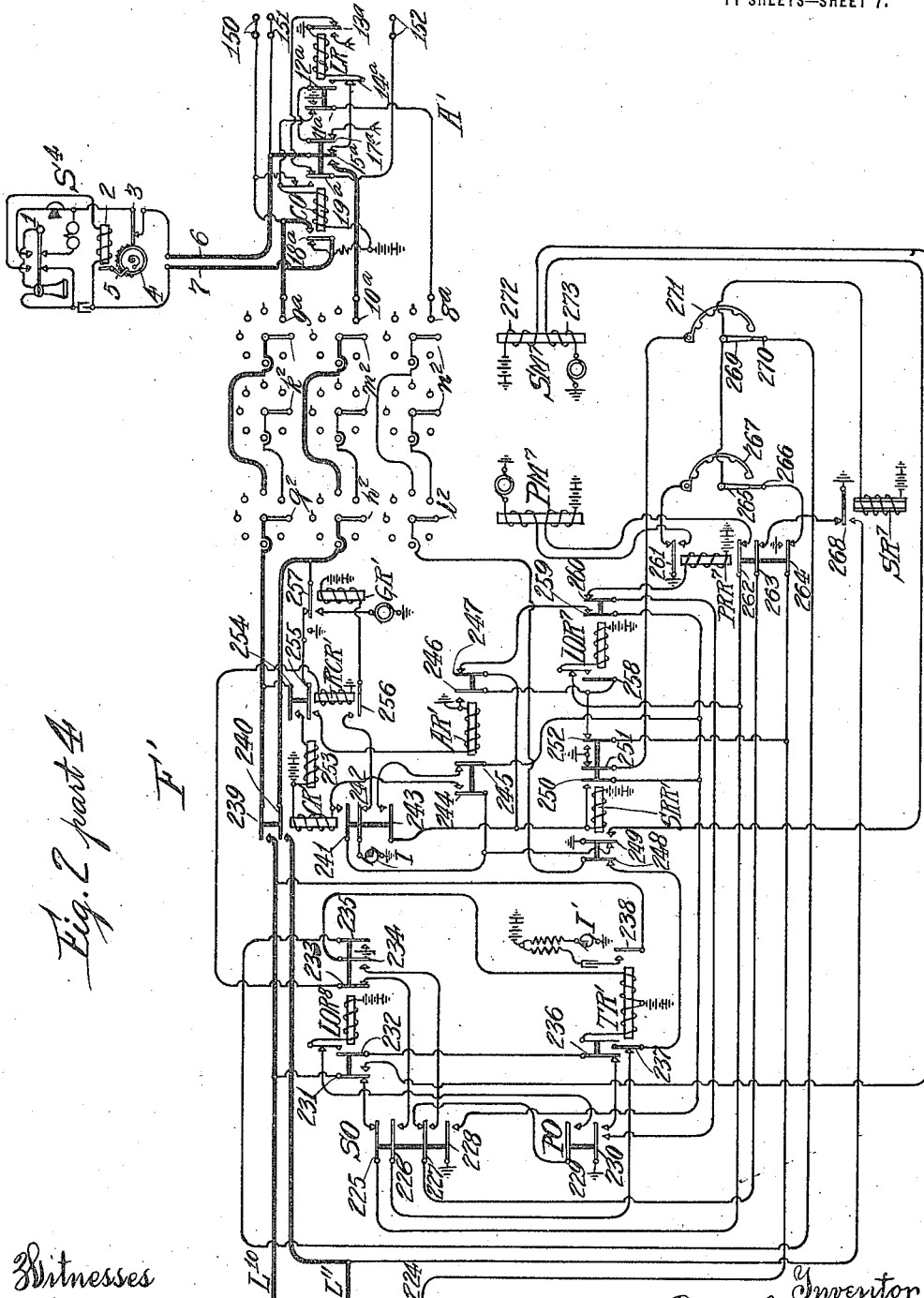


Fig. 2 part 4

F

Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty

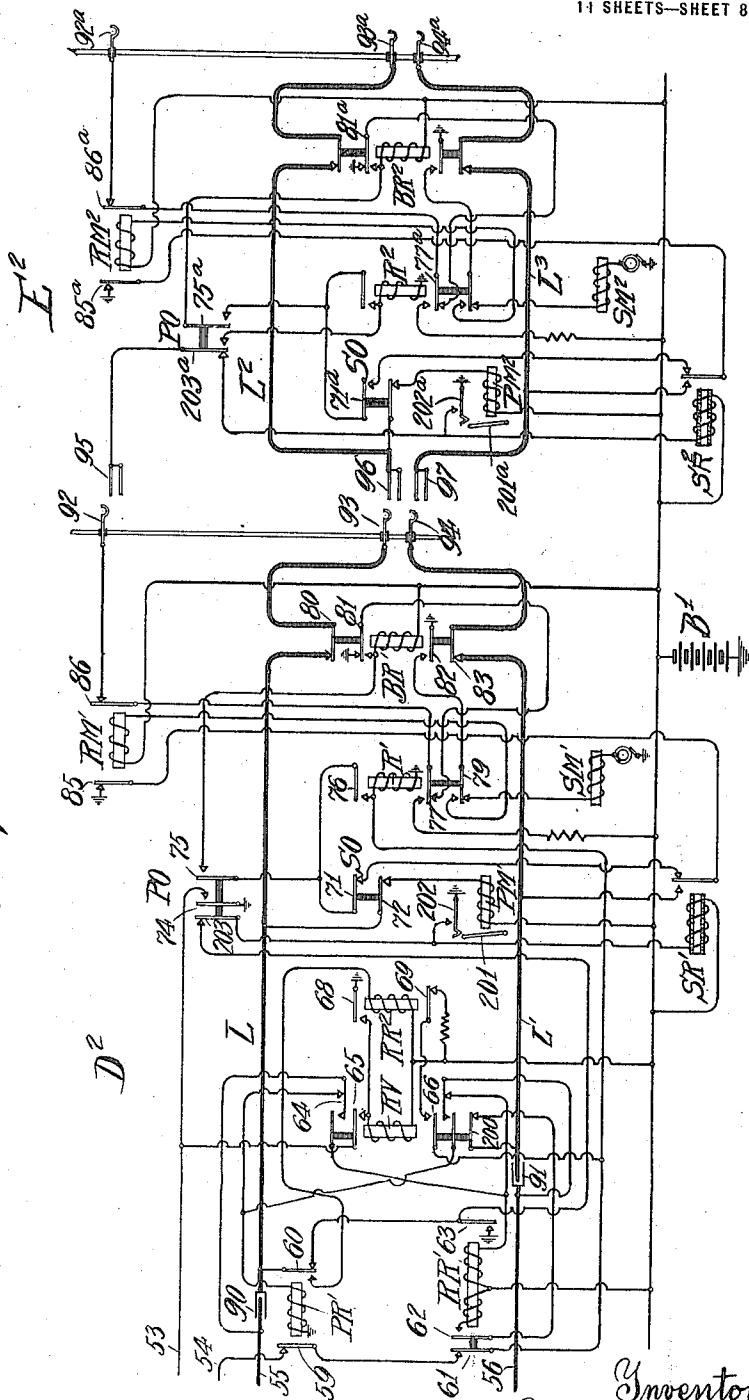
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APPLICATION FILED DEC. 16, 1908.

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11 SHEETS—SHEET 8.

Fig. 3 part 1



Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

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11 SHEETS—SHEET 9.

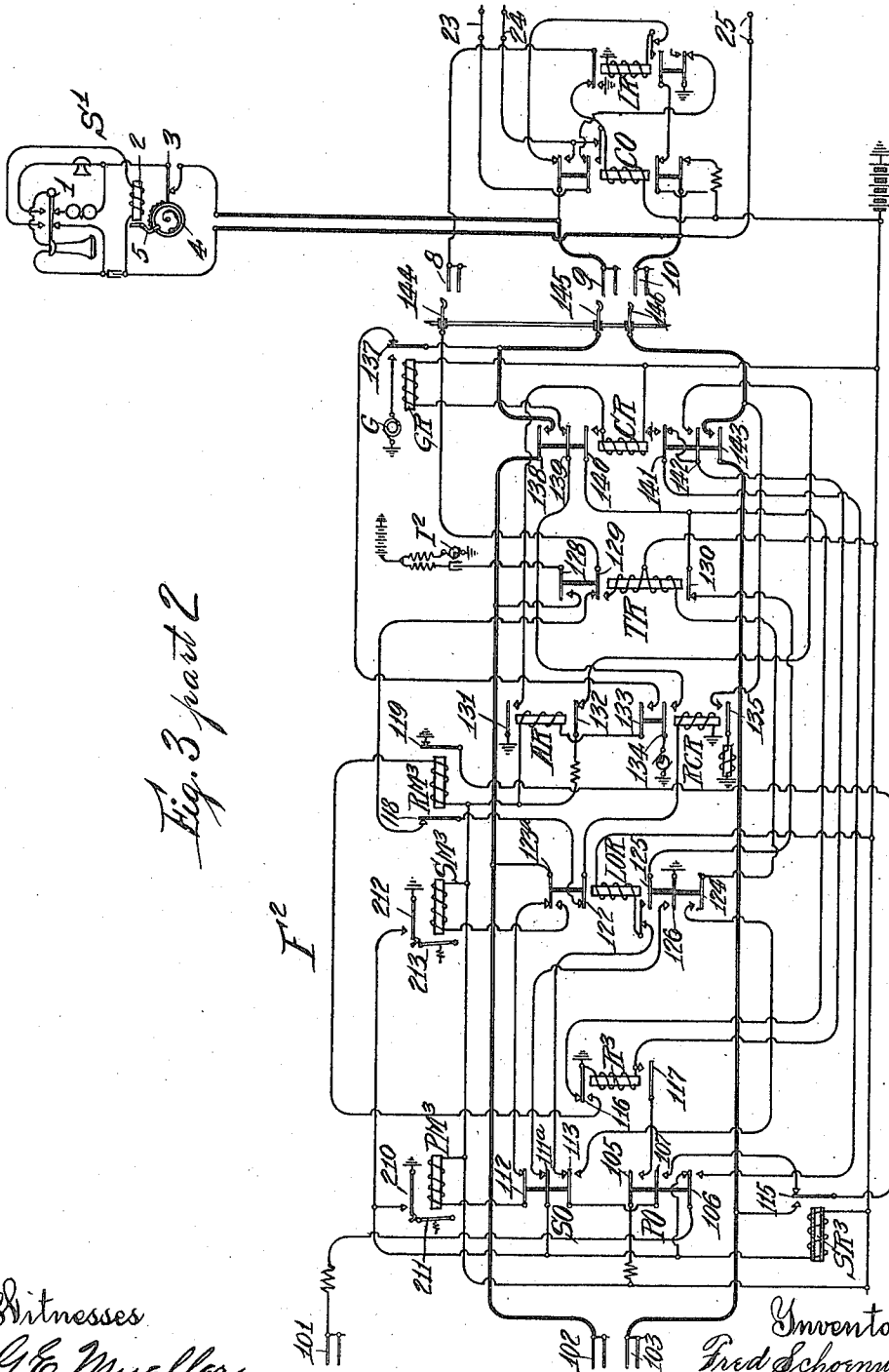


Fig. 3 part 2

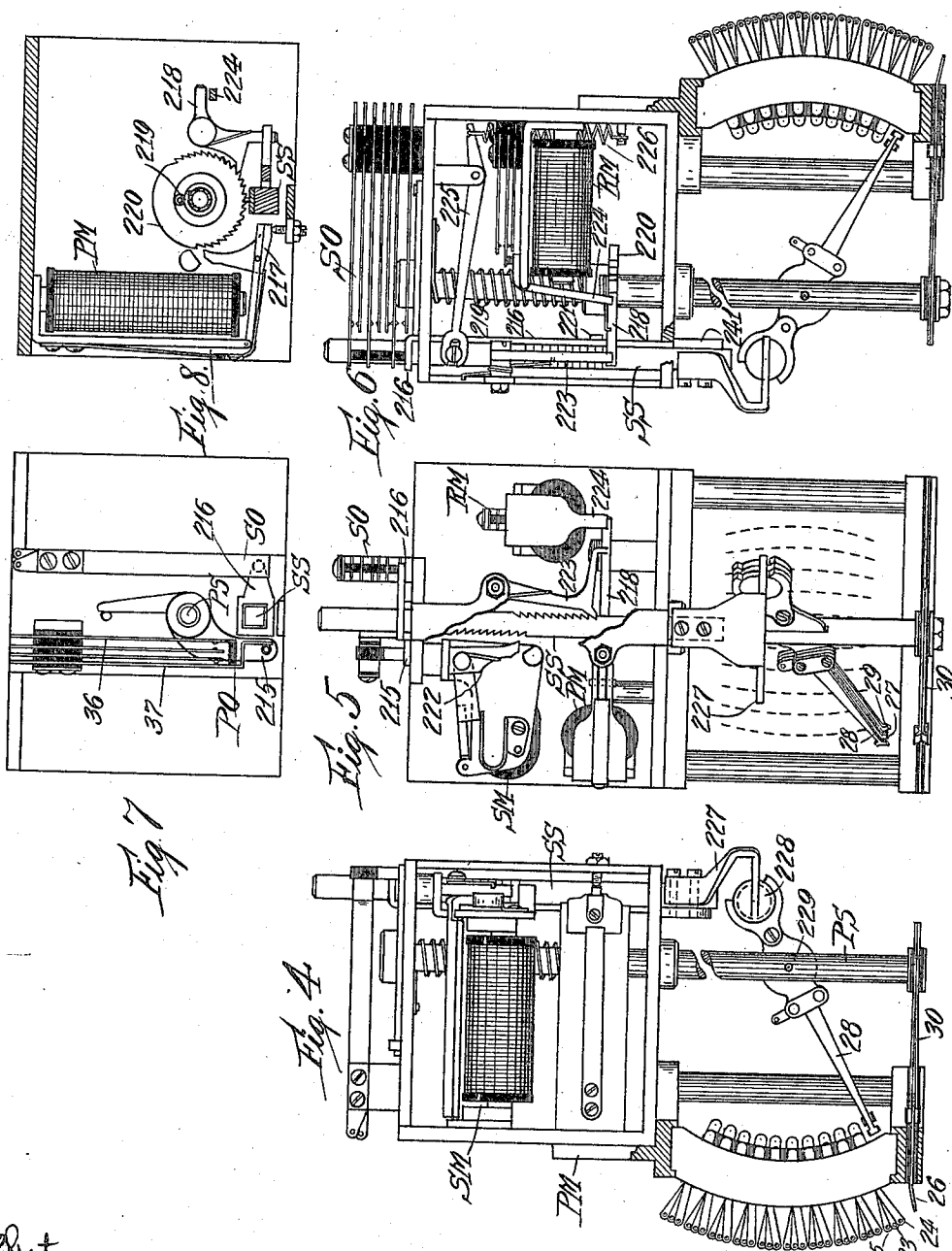
Witnesses
G. C. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

1,169,736.

F. SCHOENWOLF.
TELEPHONE EXCHANGE SYSTEM.
APPLICATION FILED DEC. 16, 1908.

Patented Jan. 25, 1916.
11 SHEETS—SHEET 10.



Witnesses
G. C. Mueller
J. G. Kellogg

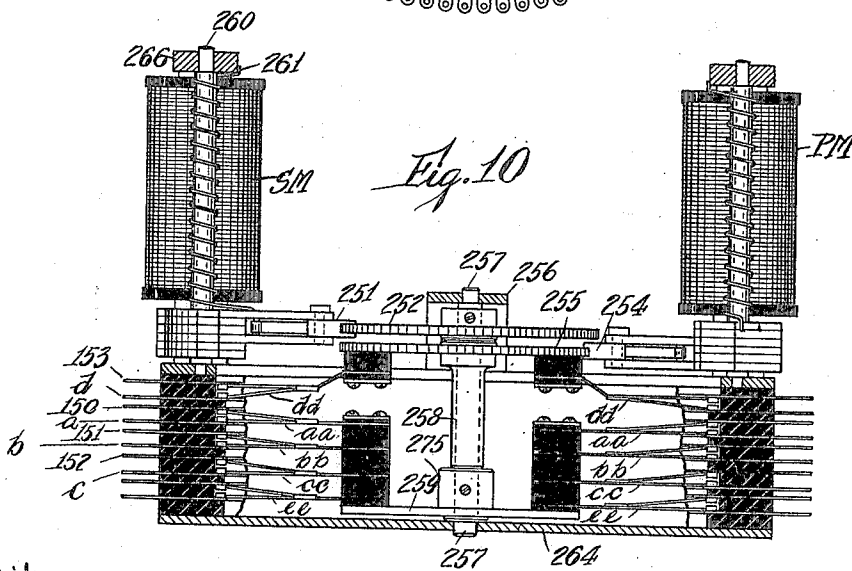
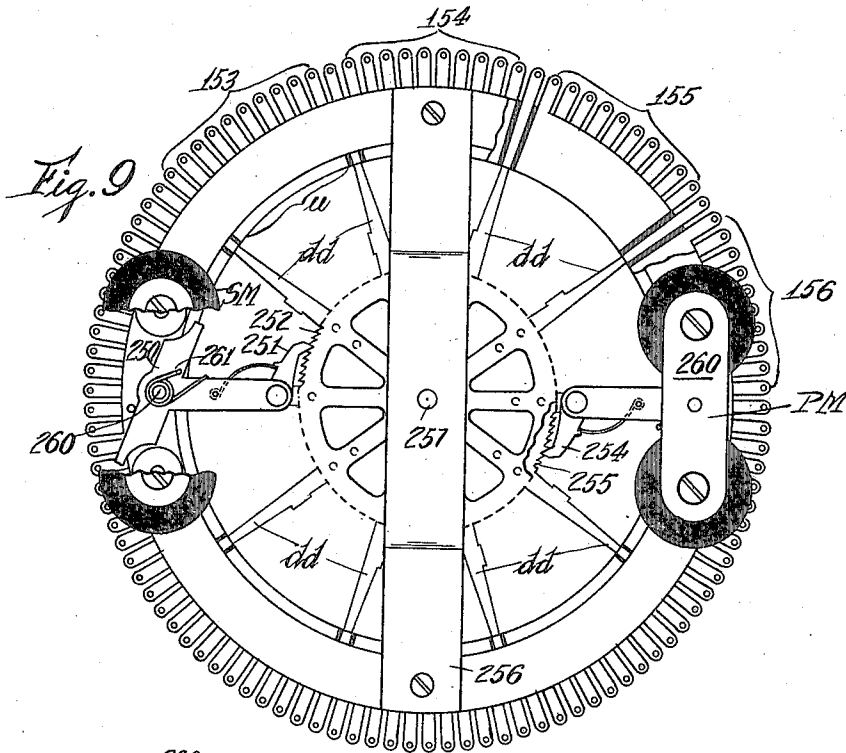
Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

1,169,736.

F. SCHOENWOLF.
TELEPHONE EXCHANGE SYSTEM.
APPLICATION FILED DEC. 16, 1908.

Patented Jan. 25, 1916.

11 SHEETS—SHEET 11.



Witnesses
G. E. Mueller
J. G. Kellogg

Inventor
Fred Schoenwolf
by Leroy D. Kellogg
Atty.

UNITED STATES PATENT OFFICE.

FRED SCHOENWOLF, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO
KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

TELEPHONE-EXCHANGE SYSTEM.

1,169,736.

Specification of Letters Patent.

Patented Jan. 25, 1916.

Application filed December 16, 1908. Serial No. 467,814.

To all whom it may concern:

Be it known that I, FRED SCHOENWOLF, residing in Chicago, county of Cook, and State of Illinois, have invented new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification.

My invention is adapted for use in connection with automatic or semi-automatic systems and I have illustrated it as embodied in systems of the former class.

More specifically, it has to do with what are often referred to as "two wire" systems, in that the signaling currents are transmitted by causing breaks in a metallic circuit so that the use of a third or common return conductor, now commonly employed to permit signaling over the two sides of a metallic circuit separately, is not required. I am aware that the systems of this general character have hitherto been proposed and the present invention is found in the manner in which the transmission of the signaling currents is effected over the various circuits, in the combination of the circuits with the selective devices employed, and in certain arrangements provided.

The object of the invention generally is to provide a simple and efficient structure of the character hereinbefore mentioned and more specific references will be made to the various features of the invention in connection with the detailed description, and in the claims.

Referring to the drawings, Parts 1, 2 and 3 of Fig. 1, when adjacently disposed, constitute a complete circuit diagram for an automatic telephone system embodying the invention. Parts 1, 2, 3 and 4 of Fig. 2, when adjacently disposed, constitute a second complete diagram illustrating an automatic telephone system embodying the invention, employing selector mechanisms of a character varying from those of Fig. 1. Fig. 3, Parts 1 and 2, when placed with Part 1 to the right of Fig. 1, Part 1, and Fig. 3, Part 2, to the right of Fig. 3, Part 1, constitute a third diagram showing a modified system embodying the invention. Figs. 4, 5 and 6 are, respectively, a left elevation, a front elevation and a right elevation of a selector for use with the circuits of Figs. 1 and 3. Fig. 7 shows off-normal combinations of said selector, and Fig. 8 primary adjusting mechanism thereof. Figs. 9 and

10 are respective top and side views of selector mechanism for the circuits of Fig. 2.

Referring first to Fig. 1, I show at S a calling substation and at S' a called substation, each provided with its appropriate line circuit A at the exchange, with which are associated the multiple called contacts 8, 9, 10, appearing in the banks of a suitable number of connectors, as F, in the usual manner, for use when the line is a called line. Similarly, the multiple calling contacts 23, 24, 25 are provided, appearing in the banks of a suitable number of line selectors at C, said last-mentioned contacts being for use when the line is a calling line. As calling lines, the lines are divided into groups of one hundred, and the contacts 23, 24, 25 of the lines of each hundred line group are multiplied before the wipers 27, 28, 29 of a suitable number of line selectors C, say, ten per hundred lines. At the line selectors, the said contacts 23, 24, 25 are preferably arranged in ten groups of ten contact sets each, primary movements of wipers 27, 28, 29 in one plane being first effected to seek out the group containing the contact set of a calling line, whereafter secondary movements are caused in a second and intersecting plane to seek out the individual contact set of the calling line. Each sub-group of ten lines of a hundred is provided with multiple common or group contacts 26 before a group-selecting wiper 30 at each line selector; and for each such sub-group of ten lines, a common relay 20 is provided, controlling, by its armature 21, the selectable condition of the multiple group contacts 26 of the sub-group of lines. Said relay 20 is rendered common to a sub-group of ten lines by the conductor 20^a having ten branches, one to each line relay LR of the lines of the sub-group.

The line selectors C of a hundred line group are normally at rest; and on initiation of a call from any line, a master-switch mechanism B is actuated to transmit a starting impulse to an idle line selector C which then seeks out the terminals of the calling line. The master-switch B is common to the one hundred lines of its particular group, being so rendered by the common conductor 22^a connected with a master-switch relay 22, said common conductor having one hundred branches, one extending to each line relay LR of the hundred lines. Each line selector

C is provided with a set of stationary contacts 32, 34 at master-switch B, and the wipers 31, 33 are adapted, by virtue of being mounted upon the customary rotary shaft
 5 provided with a rotary ratchet for receiving thrusts of an armature-controlled pawl of magnet MM, to be driven step by step over the contacts 32, 34, to seek out the contacts of an idle line selector C after the master-switch
 10 B has started a previously engaged line selector. As will more fully appear, the normal condition of wipers 31, 33 is one wherein they engage contacts 32, 34 of an idle line selector C. Thus assuming an exchange of
 15 ten thousand lines, there will be one hundred groups of one hundred calling lines each. Each such group will have its individual master-switch B and, say, ten line selectors C assigned to it, making a total of one thousand line selectors. Each line selector C in
 20 the present embodiment of the invention has associated with it a first selector D so that there will be, in all, one thousand first selectors. The function of a first selector is the
 25 usual one of being adjustable under substation control to select a group of multiple contact sets connected to second selectors assigned for connections to a particular group of lines, in the present case a thousand,
 30 whereafter its wipers 92, 93, 94 are automatically adjusted to select contacts of an idle second selector. The function of a second selector in the ten thousand system now assumed is to select a group of multiple contact
 35 sets, terminals of connectors of the wanted hundred, and then to select the individual terminal set of an idle connector. A connector is adjusted responsive to substation impulses to select a group of contact
 40 sets forming terminals of the lines of the tens group, containing the set of the wanted subscriber, and is then further adjusted responsive to an additional set of impulses to select the individual multiple terminals of
 45 the wanted line.

Assuming ten per cent. trunking facilities to be required, there will be one thousand second selectors E and one thousand connectors F. I contemplate employing usual
 50 and now well known arrangements of multiple contacts connected to second selectors before the wipers of the first selectors, and of the multiple contacts connected to the connectors before the wipers of the second
 55 selectors, and in view of the state of the art an extended reference to these well known matters will not be made. Referring now to the first selector D, the relay PR' is an impulse relay adapted to be controlled by
 60 interruptions caused in the line circuit at the substation of a calling line when such first selector has, by its associated line selector D, been connected with the calling line. Said relay PR' is the only relay of the first
 65 selector directly influenced by the directive

interruptions caused by the substation calling device, and said relay PR' controls, by suitable electrical and mechanical connections, the primary adjustment of wipers 92, 93, 94 of first selector D to select the required
 70 group of multiple contacts 95, 96, 97. To initiate the secondary travel of the wipers 92, 93, 94, a secondary relay SR' is provided, constructed so as to be slow to release its armature when its circuit is interrupted. Its
 75 winding is connected to the wiper 89, normally engaging the contact 87 and adapted to move over the contact projections of the bank segment 88, said wiper 89 accompanying the wipers 92, 93, 94 in their primary
 80 travel. As will be observed, the segment 88 is normally grounded at 85 and for each primary step of the switch wipers the wiper 89 passes over a contact projection of 88 into an open circuit relation, so that with
 85 successive steps of wipers 92, 93, 94, the wiper 89 is alternately grounded and ungrounded; and when the primary travel of the wipers ceases, the wiper 89 will be resting in one of its open circuit positions. As
 90 long as a substation calling device is operating, primary steps of wipers 92, 93, 94, 89 will be produced with rapidity such that the wiper 89 will not rest in one of its open circuit positions long enough to permit the
 95 armature of magnet SR' to retract. When, however, the calling device at the substation reaches normal and comes to rest, the wipers of first selector D, including 89, remain stationary an appreciable time, the armature
 100 of relay SR' presently retracts and closes a circuit which initiates the secondary travel of the first selector D to select an idle contact set of the selected group.

In the second selector E, the primary adjustment of wipers 92^a, 93^a, 94^a is also produced responsive to substation circuit
 105 interruptions acting on the primary relay PR' at first selector D. For second selector E, a secondary relay SR² is provided having 110 the associated wiper 89^a, the normal contact 87^a and the contact segment 88^a, the whole coöperating in a manner similar to that before outlined with respect to relay SR', and its elements 87, 88, 89, to initiate secondary
 115 travel of second selector E after the primary adjustment has been completed.

At the connector F, the circuit changes requisite to shift the impulse wire L⁴ from the primary magnet PM³ to the secondary
 120 magnet SM³ at the proper time are controlled by a secondary relay SR³ and an associated wiper 110, having normal contact 108 and the segment 109, in a manner evident from the preceding, it being under-
 125 stood that the wiper 110 travels with the connector wipers 144, 145, 146 during their primary adjustment. The same relay SR³ serves, when the secondary adjustment of the connector wipers is completed, to trans-
 130

mit the impulse necessary for the testing of the called-for line, said relay SR^a during secondary travel being controlled by the wiper 120 and the circuit connection extending through the segment 121. The wiper 120 travels with the wipers of the connector when they are stepped in their secondary direction. It will be observed that the so-called slow-release relays, which I have throughout the diagram designated by SR, receive their energizing current at all times over local circuits so that none of them are at any time dependent for current upon the limbs of the telephone line. This is a preferred arrangement for the reason that the circuits of these relays can always be provided of certain definite fixed resistances, it being well known that when relays of this character are placed in circuit with subscribers' lines of different resistances and capacities, their certain operations in the manner required cannot be absolutely relied upon.

Although I have illustrated the relays SR^a as provided with a copper shell about the cores to render them slow to release their armatures, it will be understood that I do not desire to be limited to the use of this method of construction for slowing up the retraction of the relay's armatures, since the use of secondary windings for the same purpose is well known, as well as other commonly employed expedients, any of which will be within the scope of the present invention.

To describe the system embodying the invention more in detail, and first referring to Fig. 1, the equipment at substation S includes the usual transmitter, receiver, condenser and call-bell, and the usual switch-hook 1, adapted in the present instance to be raised to cut out the call-bell and complete the talking circuit when the receiver is taken down. A calling device 4 is also provided having the locking pawl 5 fastened to the armature of the magnet 2, whose winding also serves as the substation impedance coil in the usual manner. The calling device 4 is represented diagrammatically as a rotary disk having teeth of insulating material and a notch engaged by the pawl 5. Said device 4 is for clockwise rotation by hand to bring a number of teeth, corresponding to the digit to be transmitted, below impulse spring 3, so that, when released, the associated spring returns the dial to the normal point, whereby breaks are produced at contact 3 in number corresponding to the number of teeth brought below said spring. Such breaks are employed for the directive adjustments of the first and second selectors and the connectors; and by successive actuations of dial 4, a calling subscriber is enabled to produce a number of sets of breaks in the circuit of line limb 6 to adjust the ex-

change apparatus to complete connection to the wanted called line.

At the exchange, the line relay LR is provided having the functions, when operated, of grounding the multiple called contacts 8 at the connectors to render them busy, to unground the multiple calling contacts 23 at the line selectors to render them selectable, to operate the group relay 20 to unground the multiple group contacts 26 to render them selectable, and to operate the master-switch relay 22 to start the line selector C whose contacts said master-switch engages. Thus on removal of the receiver at substation S, current flows from ground through LR, 14, 15, 6, 3, the upper contacts of hook-lever 1, 2, 7, 18, to battery B. Relay LR then operates and, by armature 12, disconnects itself from the line and locks through contact 17 and over common wire 22^a in series with relay 22, operating said relay which grounds the starting wiper 31. Armature 11 grounds the multiple contacts 8, while armature 13 ungrounds the private contacts 23 and operates the group relay 20 by current over the common conductor 20^a, so that the armature 21 ungrounds the multiple group contacts 26 of that sub-group of ten lines in which the calling line S has its contacts 23, 24, 25.

The line selector C includes the primary relay PR, adapted to be controlled by the group wiper 30, and said relay controls the primary magnet PM which causes the primary adjustments of the wipers to select the sub-group. Further, a secondary relay SR is provided adapted to be controlled by the individual private wiper 27, which relay controls the secondary magnet SM by which the secondary adjustments of the wipers 27, 28, 29 to select the individual contact set of a calling line out of a subgroup, are effected. The selector C also includes the primary off-normal (PO) switch contacts 36, 37, shifted from their normal position on the first primary movement of the wipers, and the secondary off-normal (SO) switch contacts 44, 45, 46, shifted from their normal position, shown, on the first secondary movement of the wipers. Said PO and SO contacts are restored to normal by the restoring operations of the wiper mechanism.

It will be seen that on the grounding of wiper 31 on the energization of relay 22 before mentioned, current will flow from ground through the engaged contact 32, contact 37, primary relay PR to battery B, and the operated relay PR attracts armature 39 to connect the relay's winding, the group wiper 30, and armature 38 to complete the generator circuit of primary magnet PM which receives an impulse to advance wipers 27, 28, 29, 30 a primary step, so that the group wiper 30 engages the first multiple group contact 26. This first step shifts con-

tacts 36, 37 to their alternate positions, the opening at 37 breaking the initial energizing circuit of relay PR so that it now depends for continued energization upon grounds encountered at successive group contacts 26 engaged by wiper 30. The multiple group contacts 26 of non-calling sub-groups will be grounded at the armatures 21 of the respective group relays 20 so that in the present case the wiper 30, moving from contact to contact, will maintain relay PR energized so that magnet PM receives successive current impulses until the fifth group contact 26 is encountered. As this pertains to the sub-group of the calling line S, whose group relay 20 is energized, it is ungrounded at attracted armature 21. Circuit through relay PR is opened and its armatures are retracted, whereof 38 prevents further impulses through magnet PM and the primary adjustment of the switch wipers ceases. During the primary adjustment, the wipers 27, 28, 29 move from right to left below the edge of their contact bank and do not engage any contacts. Circuit may now be traced from ground through normal contact 38, contacts 36, 49, 45, secondary relay SR to battery, which relay operates and, by armature 41, connects its winding through contact 52 with the individual private wiper 27. Armature 42 closes generator circuit through secondary magnet SM to ground at 50 and said magnet produces a first secondary step of wipers 27, 28, 29 upward to engage the first contact set 23, 24, 25 of the selected sub-group. This first step shifts the SO contacts 44, 45, 46 to their alternate positions, the shifting of contact 45 opening the initial energizing circuit of secondary relay SR which now depends for its continued energization upon grounds at contacts 23 of non-calling lines engaged by the wiper 27 as the wipers move step by step, engaging successive sets of contacts 23, 24, 25. The relay SR will thus continue energized and magnet SM will receive successive current impulses, each impulse causing a step of the switch wipers until wiper 27 engages the contact 23 of the line circuit of the line S. As this is ungrounded as before explained, the relay SR will de-energize as soon as wipers 27, 28, 29 reach the contacts 23, 24, 25 of said calling line, and the opening of alternate contact 42 prevents further actuation of secondary magnet SM so that the switch wipers remain in engagement with the contacts of the calling line.

To prevent premature closing of circuit through release wire 54, relays PR' and RR' at D are operated when relay SR at C first energizes by current from ground through PR' 64, 55, 47—40, 51, 43—48, 56, 67, RR' to battery, the relay RR', by armature 62, locking itself to ground through contacts 70, 73,

84. On the deenergization described of relay SR, the circuit of relay PR' is extended, or shifted, through normal contact 47, contact 28—24, contact 19, cut-off relay CO to battery B; and upon the consequent operation of said relay CO, the circuit of relay PR' extends through alternate contact 15 to line limb 6, through substation S, returning over line limb 7, contact 25—29, normal contact 48, and to battery through relay RR'. These extensions occur by virtue of the make-before-break spring combinations diagrammatically illustrated, without the armatures of relay PR' being permitted to be retracted.

It will be seen that when the subscriber first removes his receiver, the magnet 2 is momentarily energized in circuit with line relay LR and the calling device 4 is consequently unlocked. This is for a moment only, however, since as soon as relay LR is fully energized, it terminates temporarily, by the opening of normal contact 14, the flow of current over the line. Obviously, while the line selector is making its selection, no current flows over the line, but as soon as such selection is completed and the circuit of relay PR' is extended to the line conductors, the magnet 2 energizes and withdraws the pawl 5 so that the device 4 may be rotated by hand.

On the operation of cut-off relay CO, said relay locks through contacts 19—16, 23—27, 52 and 41 to ground. Its armature 17 de-energizes relays LR and 22; and on the retraction of armature 11 of relay LR, the ground already traced to contact 23 is extended to the multiple private contacts 8 at the connectors, continuing them busy. Armatures 15 and 18 have disconnected relay LR from the line so that it remains de-energized. On the retraction of armature 13, the group relay 20 deenergizes and its retracted armature restores the unselectable condition to the multiple contacts 26.

When relay SR first deenergized as before described, the ground at normal contact 50 was connected through normal contact 42 and the now closed contact 46 with the contact 34 of the particular line selector C at master-switch B, so that current flowed through the selecting wiper 33, motor relay MR to battery, and said relay energizes to close generator circuit through motor magnet MM via alternate contact 35. Said magnet drives wipers 31, 33 step by step over the contacts 32, 34, in search of the set of an idle line selector. Until such set is found, the wiper 33 will be engaging successive grounded contacts 34 and so hold the circuit of magnet MM closed. When, however, an idle contact set 32, 34 is encountered, the ungrounded condition of the contact 34 de-energizes relay MR and its retracted armature prevents further actuations of magnet

MM so that the wipers 31, 33 remain in engagement with the contact set of the selected idle line selector, ready to start it as soon as the initiation of another call causes the operation of relay 22. The contacts 32, 34 of the ten line selectors C may be arranged to form a complete circle so that the direction of travel of the wipers 31, 33 is always in the same direction. If desired, the construction may be such that each contact set 32, 34 appears a number of times in a circular bank, the bank then being built up of a number of segments having duplicate contact sets in them.

Relays PR' and RR' being now held up by current over the line, relay RR' having by its armature 62 further established a locking circuit for itself extending through contacts 70, 73 and 84, the subscriber at S actuates the dial 4 and releases it four times, each operation resulting in a number of openings at 3 corresponding to the units of one of the digits of the called number. Each actuation of dial 4 causes a corresponding number of deenergizations of relay PR', while the relay RR' continues energized because of its locking circuit. Assuming the called number to be 2345, the first set of breaks at 3, two in number, deenergizes relay PR' twice. The first retraction of its armatures transmits an impulse from ground through contact 63, normal contact 60, contact 72, through primary magnet PM', to battery and over a parallel path through normal control 87—89, secondary relay SR' to battery. The resulting actuation of magnet PM' brings wipers 92, 93, 94 adjacent to the first group of multiple second selector contacts, and the wiper 89 is moved over the first projection of segment 88 to a between-contact position so that the circuit of secondary relay SR' is open at wiper 89. The relay SR', being constructed to be slow to release its armature, is at this time prevented from releasing its armature because a second deenergization of relay PR' occurs quickly, whereby another actuation of magnet PM' is produced and the wipers 92, 93, 94 are moved adjacent to the second group of second selector contacts 95, 96, 97, assigned to the second thousand in the exchange. Wiper 89 moves simultaneously across a second contact projection of segment 88 into the next open circuit position. In this step, it makes contact with the second projection of 88 for a moment and, as the projections are grounded at normal contact 85, current is again passed through relay SR' before its armature has time to retract.

Since now the subscriber at S has to await the complete return of dial 4 to normal before selecting a new hold, and must then operate the device again, sufficient time elapses, while wiper 89 is on open circuit,

for the relay SR' to retract its armature and for the resulting selection of an idle contact set 95, 96, 97, out of the selected group to take place before another set of deenergizations of relay PR' begins. On the deenergization of relay SR', its retracted armature closes circuit from contact 85, through contact 71, contact 75 (said contact, along with 74, having been shifted on the first primary step) through busy relay BR' to battery B', energizing said relay, which, by armature 81, connects itself through normal contacts 77, 86 to wiper 92. Contact 82 completes a generator circuit for secondary magnet SM' which will be successively actuated as long as the relay BR' remains energized, each actuation of said magnet moving wipers 92, 93, 94 a secondary step to engage a different contact set 95, 96, 97, until the set of an idle second selector is encountered, wiper 89 at this time remaining at rest. The multiple private contacts 95 of busy second selectors E will be grounded, and as wiper 92 passes over such busy contacts, relay BR' will have successive locking circuits established through it and will remain energized. As soon as an idle—that is, ungrounded—contact 95 is engaged by wiper 92, relay BR' will necessarily deenergize, since the secondary off-normal, SO, contacts are shifted on the first secondary step, at which time the original energizing circuit of relay BR' is opened at 71. On the deenergization of relay BR', further actuations of magnet SM' are prevented and the wipers 92, 93, 94 remain engaging the contacts 95, 96, 97 of the selected idle second selector. The retraction of armature 81 immediately places ground on the private contacts 95, rendering the selected contact set busy to other first selectors D at which it may have multiples. During the secondary selection, the locking circuit of relay RR' is opened at contacts 73 and 83, so that the relay depends for its energizing upon current which will be flowing over the line circuit extending to S. As soon, however, as the talking circuit, indicated throughout the drawings by the heavily marked conductors, is reestablished at contacts 80 and 83 on the deenergization of BR', a locking circuit for relay RR' is extended through contact 83, contact 94—97, 73^a and to normal contact 84^a at second selector E.

The subscriber at S will now actuate dial 4 to cause three breaks at 3, resulting in three deenergizations of relay PR' and the transmission of three impulses from ground and at contact 63, over wire L, contact 80, contact 93—96, contact 72^a and in parallel through magnet PM² and secondary relay SR².

At E, the mechanism and circuits are

substantially like those of first selector D, and like parts at E have been given reference characters corresponding to those at D, except that exponents are added. The operations of the second selector E to select the third group of contact sets of connectors, those assigned for connections to lines 2300 to 2399 inclusive, the selection of an idle contact set 101, 102, 103, out of the group and the placing of a busy ground upon the private contacts 101 of the selected connector F, will be sufficiently plain from the description of the operation of the first selector. When the selection of an idle connector F has been completed, the wipers 92^a, 93^a, 94^a will be at rest engaging contacts 101, 102, 103 of the selected connector; and the relay RR' which, during the secondary selection by switch E, had its locking circuit opened and was energized by current over the closed calling line circuit, will have a locking circuit established extending through contacts 94—97, 94^a—103, to ground at 106. The subscriber at S now actuates the dial 4 to cause four breaks at 3 and four deenergizations of relay PR' occur. The resulting impulses from ground at 63 traverse contacts 93—96 and 93^a—102, contact 112 and magnet PM³ to battery, the four resulting actuations of said magnet causing four steps of wipers 144, 145, 146 to select the fourth group of multiple terminals 8, 9 and 10. A further effect of the actuations of magnet PM³ is to step wiper 110 across four contacts of segment 109 to a position between the fourth and fifth contact projections. The first impulse energizing magnet PM³, flowed in part through contact 108—110, relay SR³ to battery B², so that said relay became energized and, because of its slow release character, remained energized while the wiper 110 was making its steps across the contact projections of segment 109, which segment is grounded at normal contact 119. During the three breaks now being made at contact 3 at S, following the first one, a locking circuit for relay RR' is continued, extending as before to conductor L⁵ of switch F, but now completed through alternate contact 115 and to ground at 119.

After the fourth primary step of connector F, sufficient time will elapse before the subscriber at S can operate and release his calling device, for relay SR³ to deenergize (wiper 110 being on open circuit) and the following circuit changes are produced. The closure of normal contact 115 connects ground at 119 through contact 107 (the primary off-normal switches being shifted on the first primary step) through normal contact 113 and secondary magnet SM³ to battery, whereby a first secondary step of wipers 144, 145, 146 will be produced to bring them to a position adjacent to, but

not in contact with, the first contact set 8, 9, 10 of the selected group. To this end, the position of the wipers of the connector, after adjustment to select a group, is two steps distant from the first set of the selected group. By this first step, the secondary off-normal SO contacts are shifted, the change at contact 113 disconnecting magnet SM³ from armature 115. The first actuation of magnet SM³ mentioned also moves wiper 120 one step to engage the first contact projection of the segment 121, whereupon circuit was completed from ground at contact 119, through contact 121—120, normal contact at 125, and locking relay LOR to battery, which relay energizes and closes alternate contact 125, whereby said relay is locked through contacts 130 and 116 to ground. On the attraction of armature 126, ground through 119—120 is extended to the secondary relay SR³, which again energizes. When now the calling device at S is actuated to cause five breaks at 3 and five deenergizations of relay PR', five impulses will flow from ground at 63 over wires L, L², L⁴, through alternate contact 123 and secondary magnet SM³, causing five actuations thereof and five secondary steps of wipers 144, 145, 146, after which said wipers will rest engaging the multiple contacts 8, 9, 10, of line No. 2345, which extends to substation S'. During such secondary adjustment, wiper 120 travels and secondary relay SR³ is having its circuit alternately closed and broken at the contact projections of segment 121; and at the end of the last step, the wiper 120 will be between the fourth and fifth projections of the ring and the circuit of relay SR³ will be opened long enough so that its armature will retract. During the secondary adjustment of connector F, the relay RR' at D is held energized by a locking circuit extending through alternate contact 115 to ground at 119. On the present deenergization of relay SR³, the closure of normal contact 115 connects ground at 119 through alternate contacts 107, 113, 124, with the lower winding of test relay TR, momentarily energizing it. This circuit is, however, immediately broken, since the attraction of armature 130 of relay TR opens the locking circuit of relay LOR and contact 124 opens. By the attraction of armature 129 of relay TR, said relay is connected to wiper 144 now engaging multiple contact 8 of the called line, for the purpose of testing said line. If said line is idle—the condition illustrated in Fig. 1—battery B² is, through cut-off relay CO and normal contact 11, alone connected with contact 8; and since the upper winding of relay TR is also connected to battery B², said relay deenergizes and its armatures retract, the closure of normal contact 129 closing a circuit from ground through ringing con-

trol relay RCR, normal contact 122, con-
 tacts 111, 118, 129, 144—8, 11, cut-off relay
 CO, to battery B², energizing both said
 relays. The energized relay CO attracts its
 5 armatures, opening the normal battery con-
 nections of the called line, while the attrac-
 tion of armature 16 connects the ground,
 traced from relay RCR, to the multiple
 private contacts 23 at the line selectors, con-
 10 tinuing the called line unselectable there.
 The attracted armature 134 of relay RCR
 connects constantly rotating interrupter I
 through contact 139 with generator relay
 GR and battery; and as said interrupter re-
 15 volves, relay GR is alternately energized
 and deenergized, connecting and disconnect-
 ing ringing generator G with and from
 the called line to periodically ring its bell;
 the ringing current passing out over line
 20 limb 6, through condenser and bell at the sub-
 station, returning over line limb 7, contact
 10—146, and coil 127 to ground. When the
 called subscriber answers and the armature
 137 is retracted, the answering relay AR
 25 operates by current from battery B² through
 contact 133, normal contact 137, 145—9,
 over line limb 6, contact 3, transmitter and
 raised hook-lever at substation S', imped-
 ance 2, line limb 7, contact 10—146, contact
 30 135 to ground. Upon the operation of relay
 AR, armature 131 actuates closing relay CR,
 which, by armature 140, locks to ground at
 116 and, by armatures 138 and 143, com-
 pletes the talking circuit at the connector,
 35 whereby the ground traced through coil 127
 and over the limbs of the called line is ex-
 tended over wire L⁴ to the left, conductors
 L² and L, alternate contact 60, release relay
 RR² to battery, whereupon relay RR² en-
 40 ergizes and its armature 68 operates re-
 versing relay RV which, by armature 65,
 locks to ground over wire 53 and over a
 branch to ground at contact 74. By the at-
 traction of the armatures of relay RV, the
 45 connections of battery B' to the calling line
 are reversed, this reversal being useful when
 it is desired to employ any of the well
 known polarized auxiliary service devices
 in association with the calling line.
 50 The two subscribers S and S' are now in
 conversation, their transmitters being en-
 ergized by current transmitted from the cen-
 tral office through coils PR' and RR' for S
 and coils AR and 127 for S'. When they
 55 finish conversation, they replace their re-
 ceivers, opening the conductive circuits at
 the respective substations. If subscriber S
 does so first, all the switches are restored ex-
 cept connector F, which remains to be re-
 60 stored by subscriber S'. If subscriber S'
 hangs up his receiver first, all the switches
 are restored except line selector C, which re-
 mains to be restored by subscriber S. As-
 suming subscriber S to first replace his re-
 65 ceiver, the circuit through relays PR' and
 RR' will be opened and both relays will de-
 energize, since at this time there is no lock-
 ing circuit completed for relay RR'. On their
 deenergizations, their armatures retract and
 the release wire 54 has ground through 70
 relay R' at D connected to it and current will
 flow thereover through said relay R' and
 through contact 44 at C, traversing the lower
 winding of release relay RR, which relay
 will operate and, by armature 49, energize 75
 release magnet RM, which withdraws the
 retaining pawls of line selector C so that
 said selector automatically restores to nor-
 mal, the relay SR being held energized by
 current to ground at alternate contact 50 80
 during restoration so that the wipers 28 and
 29 will be on open circuit. On the restora-
 tion, the opening of the off-normal contacts
 will deenergize relays RR and SR and mag-
 net RM. When selector C begins to restore, 85
 the cut-off relay CO of line S will deener-
 gize and its line circuit A will be restored
 to normal. On the operation of relay R' at
 D, said relay, by armature 76, locked itself
 in series with busy relay BR', the joint op- 90
 eration of said relays, by closing alternate
 contacts 82 and 79, actuating the release
 magnet RM', on whose energization the first
 selector D restores to normal, whereby the
 opening of its off-normal contacts will de- 95
 energize the relays BR', RR', RV, and mag-
 net RM'. Before magnet RM' had time to
 energize, an impulse of current flowed from
 battery B' through alternate contact 77, con-
 tacts 86, 92—95, 74^a, relay R², and said relay 100
 energized, locking itself in series with relay
 BR², and the second selector E restores on
 the consequent actuation of release magnet
 RM² in the same manner that first selector
 D restores. When now subscriber S' re- 105
 places his receiver, the circuit of relay AR
 is opened; and on its deenergization, the clo-
 sure of contact 132 passes current from bat-
 tery B², via attracted armature 142, relay
 R³ to ground, which relay energizes and, by 110
 armature 116, actuates release magnet RM³
 which restores the connector F, the shifting
 to normal of whose off-normal contacts will
 deenergize the various relays. If subscriber
 S' were first to replace his receiver, con- 115
 nector F would be restored as just described.
 In the present case, the opening of the con-
 ductive circuit through the substation will
 deenergize the release relay RR² at D, on
 whose deenergization current from battery 120
 B' will flow, through normal contact 69,
 contact 66, relay R' to ground, operating
 said relay, which will result in the release
 and restoration to normal of first selector
 D and second selector E as before. The line 125
 selector C remains to be restored by sub-
 scriber S. Let it now be assumed that when
 connection was made therewith, the called
 line was busy. In such case, ground, traced
 through release control relay RCR of some 130

other connector F, will be connected to the multiple contacts 8, or ground at the line circuit A, or at some line selector C, which has already selected the line S, will be connected to said contact 8. In either case, the presence of ground upon the engaged contact 8 will cause the test relay TR to remain operated on its initial energization, whereby the busy interrupter I' will remain connected to the upper talking conductor via attracted armature 128, and the calling subscriber will receive the busy signal and will accordingly replace his receiver. When he does so, his act will deenergize relays PR' and RR', and switches C, D and E will all automatically restore, as before described. In the present instance, connector F also restores as follows: When relay R² at E energizes, its armature 77 will cause an impulse of current to flow from battery B' through contact 86^a before the magnet RM² has time to open said contact, thence through contact 92^a—101, contact 104, normal contact 141, relay R³ to ground, which relay will energize and will restore the connector F by closing circuit through release magnet RM³.

One feature of the present invention is found in the way the operated switch mechanisms are restored in case the calling subscriber replaces his receiver before all the sets of switching impulses are transmitted. Assuming the calling subscriber replaces his receiver before a line selector selects his line, the selection will take place nevertheless because line relay LR is locked. The relay RR' will have operated and will have locked to ground at 84. As soon as cut-off relay CO of the calling line energizes, the relay PR' will be deenergized, since no conductive circuit is extended for it through the substitution. On its deenergization, a single impulse will be transmitted through magnet PM' and first selector D will select its first group of terminals, whereupon relay SR' will retract its armature in an obvious manner and initiate secondary travel of first selector D by energizing relay BR'. On the first secondary step, the locking circuit of relay RR' will be opened; and since the substitution line circuit is also open now, relays PR' and RR' will have their armatures retracted simultaneously, whereby relay R' at D and RR at C will have their circuits closed through contact 59—61 so that the selectors C and D will both automatically release. Like release operations will occur if the calling subscriber replaces his receiver after his line has been selected, but before transmitting any impulses.

If the calling subscriber transmit the first set of impulses so that line selector D selects a second selector E of some group, and then replaces his receiver, the second selector E will make one primary step and then commence its secondary travel, whereupon the

locking circuit of relay RR' traced now through secondary off-normal contact 73^a, will be opened and relays RR' and PR' will have their armatures simultaneously retracted, the release of selectors C, D and E proceeding in a manner obvious from the preceding description.

If the calling subscriber were to transmit two impulse sets so that selectors D and E were caused to operate to connect through to a connector F, and then replace his receiver, obviously the connector F would make one primary step, whereafter the secondary relay SR² would be deenergized as before, whereon the opening of alternate contact 115 would deenergize relay RR' at D and the selectors C, D, E and F would release as in the case where the called line was found to be busy.

In Fig. 2, I have illustrated my invention, hereinbefore described, as applied to a system using a different class of mechanical switches; and as the operation of the telephone system as a whole, and the application of the features of the present invention is considerably like that before described, a brief reference to the said Fig. 2 will be sufficient. In Fig. 2, the arrangement of the substations S² and S⁴ are substantially like those in Fig. 1, although the line circuits A' are somewhat different. The lines as calling lines are in this case provided with multiple calling contacts 150, 151, 152, at a number of line selectors C', and with multiple called contacts 8^a, 9^a, 10^a, at a number of connectors F'. In addition to the switches of these classes, a first selector is indicated at D' and a second selector at E'. The arrangement of the selectors and the connectors, their general functions, and the trunk arrangements between them, are substantially like those of the classes of switches of like name in Fig. 1 and need not be more specifically referred to. In the mechanical switches employed for selectors and connectors in Fig. 2, each group of multiple terminal contacts is provided with a separate set of wipers. In Fig. 2, the selection of the group is effected by providing what may be called a primary set of wipers which has before it nonmultiple terminals, one set being connected with each of the sets of wipers which are assigned to the different groups of multiple terminals. Thus for example, in Fig. 2, Part 1, the line selector C' will comprise ten groups of multiple contact sets 150, 151, 152, each set having a separate wiper set *a*, *b*, *c*, of which two sets only are indicated. Each such wiper set is shown connected with short conductors with its individual contact set 153, 154, 155, before the primary wiper set *d*, *e*, *f*, of the line selector C'. In order to select the calling subgroup of lines, the wiper set *d*, *e*, *f*, and the group wiper *g* are clockwise rotated under the influence of primary magnet PM until 130

they engage the contact set 153, 154, 155, extending to the wiper set of the subgroup containing the calling line, at which time the wipers *g* will be engaging the multiple group contact 156 of that subgroup, which contact will be on open circuit and will accordingly stop the travel of the primary wipers. Then, under the influence of secondary magnet SM, all the sets of secondary wipers *a, b, c*, of all subgroups will be caused to travel over their associated contact sets. The wiper set previously selected by the primary wipers will be the only one not on open circuit, and, under the influence of its private wiper *c*, will select the individual contact set of the calling line. This method of selection of the group and then of contacts from the group, involving the use of a secondary wiper set for each group of contacts and a set of primary wipers to pick out the group by selecting the secondary wiper set for that group, is employed throughout the first selectors D', the second selectors E' and the connectors F'.

Assuming the calling subscriber S² desires to converse with subscriber S⁴, whose number will be assumed to be 2221, subscriber S² first removes his receiver, operating line relay LR whose armature 13^a ungrounds the private multiple contacts 152 and operates the group relay 20^a, which ungrounds the multiple group contacts 156. Armature 11^a places busy ground upon the private multiples 8^a at the connectors, while armature 12^a locks relay LR in series with the common master-switch relay 22^a to start an idle line selector C'. The attracted armature of relay 22^a closes circuit from ground at normal contact 35^a through starting wiper 31, contact 32^a of the engaged idle line selector, its primary off-normal contact 162, through contact 171, the relay PR to battery, actuating said relay PR, which closes an actuating circuit for magnet PM, under whose influence the primary wipers are rotated step by step. Armature 157 connects relay PR to the group primary wiper *g* so that as long as said wiper passes over group contacts 156 of non-calling sub-groups, it will establish successive locking circuits for the relay PR, holding said relay continuously energized. On the first step of the primary wipers, the primary off-normal PO contacts are shifted, whereby the opening of contact 162 renders relay PR entirely dependent upon the wiper *g*. As soon as said wiper engages the ungrounded group contact 156, relay PR accordingly deenergizes and operates secondary relay SR by current through contact 174—159 to ground at 161.

By armature 165, relay SR now completes an actuating circuit for secondary magnet SM which steps the wipers *a, b, c*, in search of the individual contact set of the calling line. Until the selected wiper *c* engages the

multiple contact 152 of an unselected calling line, relay SR will have successive locking circuits extended for it extending through normal contact 169, alternate contact 166, contact *f'*—155, and through wiper *c* to ground at successive engaged contacts 152. As soon, however, as wiper *c* engages the contact 152 of the calling line, the ungrounded condition of said contact will deenergize relay SR, whose armatures will retract, preventing further actuations of magnet SM, the conductors L⁶, L⁷ being at this time extended through to the talking contacts 150, 151 of the calling line. On the initial operation of relay SR, alternate contact 164 was closed to conductively bridge wires L⁶ and L⁷ and to operate relays PR⁵ and RR⁵ at D' before the secondary off-normal SO contacts were shifted, which shifting occurs on the first step of the secondary wipers, whereby contact 174 is opened to render relay SR solely dependent upon the circuit extended to the selected wiper *c*. By this means, a premature operation of release relay RR is prevented. On the retraction of armatures 163, 164, battery through relay PR⁵ is, through the first-mentioned contact, connected with cut-off relay CO of the line, which relay, by armature 19^a, locks over contact 152—*c*, 155—*f*, contact 166—168, to ground at contact 175, which ground now maintains contact 152 busy. Armature 18^a extends the circuit of relay PR⁵ over the calling line, through magnet 2, unlocking the calling device and returning over conductor L⁷ through relay RR⁵ without permitting any retraction of the armatures of said relay PR⁵. When relay RR⁵ first energized, its armature 189 operated the secondary relay SR⁵, whose attracted armature 202 closed the locking circuit for the relay RR⁵, extending through contact 192, to ground at 213. When now subscriber S² causes the first set of two breaks at contact 3, each deenergization of relay PR⁵ will transmit an impulse from ground through contacts 189, 185, 193, 210, and winding 215 to primary magnet PM', which magnet will drive primary wipers *g, h, i* and 89^a two counterclockwise steps. Although wiper 89^a at the conclusion of each step will have passed over one of the contact projections of the grounded ring 88^a and be on open circuit, the relay SR⁵, owing to its slow release character, will not deenergize until the completion of the second step whereby, during the transmission of the primary adjusting impulses, the relay RR⁵ has its locking circuit maintained closed. The first primary impulse flows in part through the locking relay 198 which, by armature 200, locks to ground over the wire 183 and, by armature 201, prevents premature operation of primary release relay PRR, which would otherwise energize when, on the first

primary step, the PO contacts 196, 197 shift.

At the conclusion of the two primary adjusting impulses, the wipers g , h and i will have selected the contacts 217, 218, 219, connected to wipers l , m , n , which have associated with them a group of multiple contact sets 220, 221, 222, connected to second selectors E' for the second thousand. After the second step of the primary wipers, the relay SR^5 remains on open circuit long enough to retract armature 202, whereby busy relay BR^5 is operated by current through contacts 194, 196, 202, 213. Said relay BR^5 by armature 207, closes the actuating circuit of secondary magnet SM' , which drives wipers l , m , n , in search of idle contacts. On the first step, the secondary off-normal SO contacts are shifted and relay BR^5 depends for its continued energization upon current through alternate contacts 199 and 203, through contact i —219, wiper n and to grounds encountered upon successive engaged contacts 222 of busy second selectors. As soon as the secondary wipers engage the contact set of an idle second selector, its multiple contact 222 will be ungrounded and relay BR^5 will be deenergized, preventing further actuation of secondary magnet SM' by retracting armature 207, while armature 203 grounds the wiper n and the multiple contacts 222, rendering the selected second selector busy.

The apparatus is now ready for the operation of second selector E' in response to the transmission of the second set of digit impulses from substation S^2 , the relay RR^5 having locked over wires L' and L^9 to ground through the attracted armature of secondary relay SR^6 and contact 213^a. Since the retraction of armature 208 at D' has energized secondary relay SR^6 at E' by current through contact 87^c. As the operating features of second selector E' are substantially like those of first selector D' , the parts at E' , corresponding to like parts at D' , have been given similar reference numbers with a different exponent, and the operation, whereby the primary wipers g' , h' , i' , of second selector E' are caused to select the second group of connector terminals 220^a, 221^a and 222^a, and the operation of the secondary wipers l' , m' , n' to thereafter select an idle contact set out of the group selected, will be obvious from the preceding, without more specific reference. At the conclusion of operation of second selector E' , the talking circuit, indicated throughout by the heavily marked conductors, will have been extended from the calling substation, over conductors L^{10} and L^{11} to the connector F' , assigned for connection to lines 2200 to 2299, and the ground at 208^a of E' will be connected through con-

tacts i' —219^a, n' —222^a, over wire 224, contacts 264, 266, 265, secondary relay SR^7 to battery whereby said relay operates and it establishes at its attracted armature a locking circuit for relay RR^5 extended over wires L^7 , L^9 and L^{11} . The first deenergization of relay PR^5 , now caused by the first of the two tens breaks caused at substation S^2 , will transmit the current impulse over wire L^{10} , normal contacts 231, 225, and in parallel through locking relay LOR^7 and the lower winding of primary magnet PM^7 . Said relay, by armature 258, locks to ground over the private wire 224 and disconnects itself from the wire L^{10} . The impulse transmitted by the second deenergization of primary relay PR^5 over wire LR^{10} only flows, however, through the lower winding of primary magnet PM^7 . Thus two primary steps of wipers g^2 , h^2 , i^2 and 265 will be produced, the primary wipers g^2 , h^2 , i^2 , selecting the wiper set l^2 , m^2 , n^2 , having before it the second group of called line terminals; while the wiper 265, in passing over the first two contact projections of the grounded ring 267, will not interrupt the circuit of relay SR^7 long enough to permit it to retract its armature. When, however, the adjustment of the primary wipers is completed, said circuit will be open long enough for relay SR^7 to deenergize, whereon the closure of normal contact 268 results in a flow of current through contacts 263, 227, 229, the PO contacts having shifted on the first step of the primary wipers, and through locking relay LOR^8 to battery, operating said relay which, by armature 232, locks to ground through contacts 236 and 230 and, by armature 231, shifts the connection of wire L^{10} from primary magnet PM^7 to secondary magnet SM^7 . Its armature 235 re-operates the secondary relay SR^7 so that relay RR^5 has its locking circuit again established preparative for the last actuation of the calling device at substation S^2 . A single break at substation S^2 in the line circuit deenergizes relay PR^5 once and an impulse is transmitted over wire L^{10} at F' , through alternate contact 231 and secondary magnet SM^7 to battery, actuating said magnet, which drives the secondary wipers l^2 , m^2 , n^2 to engage the multiple contact set 9^a, 10^a, 8^a of the called line S^4 .

While the secondary wipers are traveling, the wiper 269 will be passing over projections of the grounded ring 271 in such a way that relay SR^7 will remain operated until the secondary adjustment is completed. When this occurs, in the present case after one step of the secondary wipers, armature 268 retracts and closes a circuit through contacts 263, alternate contacts 227, 234, right winding of test relay TR^7 to battery, actuating said relay, whose armature 236 de-

energizes relay LOR³, while armature 237 connects the winding of test relay TR' with the private contact 8^a of the called line. If the line be idle, said contact 8^a is connected to the active side of battery, relay TR' de-energizes, and its armature 237 then connects battery through cut-off relay CO of the called line and contact 8^a via contacts 226 and 233 with ringing control relay RCR', said relay and cut-off relay CO both energizing. The closure of contact 256 connects interrupter I with generator relay GR' and the called line is rung as in the case of connector F. On the response of the called subscriber, answering relay AR' operates and energizes closing relay CR' by current through contacts 244 and 249, said relay locking by armature 241 and by armature 242, preventing ringing current from being further applied to the called line. On the operation of relay CR' and the closure of contacts 239, 240, the ground through answering relay AR' is, over the called line circuit S⁴, connected with battery through reversing relay RV⁵ at D' and said relay energizes and reverses the battery connections to the calling line.

The two subscribers S² and S⁴ are now in conversation, their transmitters being energized from the central battery. If, at the conclusion of conversation, subscriber S⁴ first replace his receiver, the answering relay AR' will deenergize and restore the connector F'. Thus, on the retraction of armature 245, current is closed from battery, through secondary release relay SRR', contact 243, armature 245 to ground at secondary off-normal contact 228, whereupon said secondary release relay locks, by armature 250, to ground at 228 and, by armature 249, closes the generator circuit of winding 273 of secondary magnet SM', which magnet will be actuated, driving the wipers k^2 , m^2 , n^2 in the original direction of travel to a normal point, at which time the opening of secondary off-normal contact 228 will deenergize relay SRR', whose retracted armatures will prevent further actuation of the winding 273 and the secondary wipers will rest at normal. Armature 252 has opened the locking circuit of relay LOR' and said relay deenergizes, its armature 260 closing a circuit for primary release relay PRR', extending to ground at primary off-normal contact 230. Said relay, by armature 261, closes a generator circuit for the upper winding of primary magnet PM' and said magnet will receive actuation until the primary wipers g^2 , h^2 , i^2 are rotated in the original direction of travel to a normal point, at which time the opening of contact 230 deenergizes relay PRR', whose armature 261 prevents further actuations of the primary magnet, and the primary wipers rest at normal. As soon as relay AR' deener-

gized and relay SRR' energized, the circuit of relay CR' opened and the relay deenergized. The opening of contact 248 of course deenergized cut-off relay CO and ringing control relay RCR', so that the connector F' and the called line circuit S⁴ are now both at normal. It will be seen that until both primary and secondary wipers of switch F' are restored, the private wire 224 will be held grounded either at alternate contact 252 or alternate contact 264 so that, until restoration is complete, the connector remains busy at the second selector. In the present system, the called subscriber releases the connector only. The other switches remain to be restored when the other subscriber replaces his receiver. If the calling subscriber has replaced his receiver in advance of the called subscriber, his act would deenergize the relays PR⁵ and RR⁵, since the relay RR⁵ is at this time entirely dependent for its current upon the calling line circuit, any possible locking circuit therefor being opened at contact 192. Current will now flow from ground through contact 177 at C', over wires 181 and 182, through release relay RR at C to battery, and said relay, by armature 172, locks to ground over two branches extending through contacts 160 and 178 respectively. Armature 171 energizes relay PR by current to ground at contact 161 and said relay remains operated, causing actuations of primary magnet PM until the primary wipers d , e , f , g reach a normal point, when the opening of the PO contacts will occur—that of 161, deenergizing relay PR, causing the primary wipers to rest. Armature 169 of relay RR operates secondary relay SR by current to ground at contact 176. Said relay remains energized, causing successive actuations of magnet SM, which drives secondary wipers a , b , c , around to a normal point, at which time the SO contacts are shifted to normal, the shifting of 176 deenergizing relay SR and thus preventing further travel of the secondary wipers.

Obviously, when both primary and secondary wipers are restored, relay RR deenergizes and the line selector is at normal. When relay RR first energizes, its armature 173 energizes relay rr , whereby wire 183 is ungrounded and the relay 198 at D' is deenergized. On the closure of contact 201, primary release relay PRR energizes by current through contact 197 and its armature 211 closes a generator circuit for winding 216 of magnet PM', which will receive actuations, driving the primary wipers to a normal point when the opening of contact 197 will deenergize relay PRR, whereupon the primary wipers come to rest. On the closure of normal contact 199, busy relay BR⁵ is energized and closes the generator circuit for secondary magnet SM' at 207, 180

whereby said magnet drives the secondary wipers around to a normal point. When the opening of contact 193 deenergizes relay BR⁵, the secondary wipers rest. As soon as armature 208 of relay BR⁵ is attracted, relay 198^a of the second selector E' was deenergized; and on the retraction of its armatures, the restoration to normal of selector E' proceeds in a manner obvious from the description of the release of selector D'.

I have not made specific reference to the operation of the motor mechanism of the master-switch B' of Fig. 2. Its travel and control is substantially like that of Fig. 1 and its operation is believed to be sufficiently apparent from an inspection of the circuits taken in connection with a description of their operation, hereinbefore given. If the called line had been found busy when test relay TR' energized, said relay would have locked to ground over the multiple contact 8^a and a busy signal from the interrupter I' would have been transmitted to the telephone of the calling subscriber. He would thereupon replace his receiver and the relays PR⁵ and RR⁵ would both deenergize, inasmuch as no locking circuit for relay RR⁵ would at this time exist, since the wire L¹¹ would be opened at contact 268. On the deenergization of said two relays, selectors C', D' and E' would release in the manner before described. On the energization of relay BR⁵ at E', wire 224 would be disconnected from ground and the locking circuit of relay LOR⁷ would be opened. On the deenergization of said relay, the secondary release relay SRR⁷ would operate by current through normal contacts 247, 259, to ground at 228, and the energized relay SRR⁷ would then cause the restoration of the secondary mechanism of the connector. The closure of normal contact 260 would operate primary release relay PRR⁷ by current to ground at contact 230; and on its energization, the primary mechanism of the connector F' would be restored.

Means enabling a calling subscriber to release the operated selectors at any time during the process of putting through a connection, are provided in Fig. 2. Thus, if he remove and then immediately replace his receiver, his line relay will operate and lock, selector C' will select his line, relays PR⁵ and RR⁵ being operated in the process by the closure of alternate contact 164 and relay SR⁵ will also energize, establishing the locking circuit for relay RR⁵. The selection of the calling line will result in the deenergization of relay PR⁵ and the transmission of an impulse causing one actuation of magnet PM' and the energization and locking of relay 198. At the conclusion of this first actuation of magnet PM', relay SR⁵ will deenergize and secondary travel of the first selector will be initiated. Since the line

circuit at S² is opened, the deenergization of relay SR⁵ in this case causes the relay RR⁵ to be deenergized, at which time the wires 181 and 182 will be bridged, resulting in the establishing of the release circuits for selectors C' and D', and they will automatically restore to normal. A like method of release occurs if the calling subscriber replaces his receiver after the line has been selected and before he actuates his calling device. If the calling subscriber has operated selector D' to select a group of second selectors E' and then an idle selector of the group, and then replaces his receiver, the act will result in an obvious manner in causing a single primary step of the mechanism at E' and the deenergization of the secondary relay SR⁵ to open the locking circuit of relay RR⁵ to deenergize it, and thus release connections for selectors C', D' and E' will be established in the manner apparent from the previous descriptions.

Supposing the calling subscriber S² has transmitted two sets of adjusting impulses so that a connection has been established through to the connector F', which, however, is still at normal. The replacing of the receiver at S² in this case deenergizes relay PR⁵ alone, the relay RR⁵ having a locking circuit extending through alternate contact 268 at F', the relay SR⁷ being now energized by current over private wire 224. The deenergization of relay PR⁵ transmits an impulse over wire L¹⁰ to energize locking relay LOR⁷, which locks, and to actuate the lower winding of primary magnet PM⁷, which causes one primary step of the wipers. At the conclusion of this step, secondary relay SR⁷ deenergizes, its armature 268 retracts, and because the line circuit at S² is open, relay RR⁵ deenergizes; and since relay PR⁵ is already deenergized, selectors C', D' and E' will restore in a manner obvious from the preceding. When in the present case the relay BR⁵ at E' energizes, ground is removed from the private wire 224 and locking relay LOR⁷ accordingly deenergizes, effecting the actuations of relays PRR⁷ and SRR⁷, which cause the restorations of the primary and secondary portions of the connector mechanism in a manner already described.

If the calling subscriber S² replace his receiver after having actuated his calling device a third time so that the primary adjustment of selector F' has been completed, the relay PR⁵ will first deenergize to cause a step of the secondary switch mechanism of connector F', the relay RR⁵ remaining momentarily energized because of a locking circuit extending over wire L¹¹ and to alternate contact 268 at F', since the relay SR⁷ is, at the initiation of release, energized by current through contact 269—270 and alternate contact 235 to ground.

The deenergization of relay PR^s transmits a current impulse over wire L^{10} , through alternate contact 231, and the upper winding of secondary magnet SM^7 , which magnet
 5 causes one step of the secondary switch mechanism, whereafter the relay SR^7 will deenergize, since the wiper 269 will then be on open circuit. The retracted armature 268 opens the locking circuit of relay RR^s ,
 10 which deenergizes, and the various switching mechanisms are restored in a manner similar to that described in the case of the called line found busy.

Placing now Fig. 3, Part 1, to the right of Fig. 1, Part 1, and Fig. 3, Part 2, to the right of Fig. 3, Part 1, a third complete diagram, showing circuits of a system-embodiment of the invention, is provided. In connection with this circuit diagram, selective
 20 switches of the class employed in connection with Fig. 1 are used, such switches having their wipers adjustable in one plane to select a group, and in an intersecting plane to select contacts of a group. In the system
 25 now under consideration, the secondary relay SR^7 is, like the secondary relay in Fig. 2, energized as soon as the secondary relay SR at the line selector energizes without waiting for the transmission of the first
 30 directive impulse, as in the case of Fig. 1. The said relay SR^7 , by its armature, closes the locking circuit for the relay RR^7 so as to hold it energized when the primary relay PR^7 is being energized and deenergized by
 35 the substation calling device operation. In Fig. 3, however, a wiper is not provided for controlling the circuit of relay SR^7 , but the primary magnet PM^7 directly controls a vibrating armature 201 which, each time
 40 said magnet energizes, passes over the bent portion of spring 202, momentarily closing contact in the winding of relay SR^7 at said point. Then, as said armature 201 completes its stroke, it will permit the contact 202 to
 45 open; and on the deenergization of magnet PM^7 , the armature 201 again falls back, operating the spring 202 to close its contact and then open it as the armature 201 reaches normal. In the previous systems herein
 50 described, it will be seen that the relays SR are required to maintain their armatures attracted during the entire time the respective magnets PM are having their armatures retracted and until the armatures begin to be again attracted. In the present
 55 case, on the contrary, the circuit of the secondary relay SR^7 , and the other secondary relays SR , are opened only for relatively short periods at the beginnings and ends
 60 of the strokes of the armatures of their controlling magnets when said magnets are operating responsive to the relay PR^7 , the advantage of the present arrangement being clear. To provide a smoothly operating de-
 65 vice, it will be understood that a roller may,

if desired, be provided upon the armature 201 to operate the spring 202, and so for the similar devices in other parts of Fig. 3.

The operation of the line selector C in selecting the calling line is as before described for Fig. 1. As soon as relay SR at C
 70 operates, wires 55 and 56 are bridged and relays PR^7 and RR^7 energize; the latter, by armature 63, closing a circuit traced through contact 203 and through relay SR^7 to bat-
 75 tery, actuating said relay, whose attracted armature completes the locking circuit for relay RR^7 extending through contact 200 and to ground at 85. Then, when the calling
 80 subscriber actuates his calling device to cause deenergization of relay PR^7 , the armature 60 will vibrate, while 63 will remain attracted, and each closure of normal contact 60 will actuate primary magnet PM^7 by cur-
 85 rent through SO contact 72. Elements 201 and 202 operate in the manner before indicated to maintain relay SR^7 energized until, when the calling device at S reaches normal, relay PR^7 holds its armature attracted, when
 90 the armature 201 will remain in its retracted position and relay SR^7 will have its circuit opened long enough to deenergize, since the initial energizing circuit of relay SR^7 opens
 95 on the first primary step at the PO contact 203. Its then retracted armature closes a circuit from ground at 85, through contacts 71 and 75, the PO contacts having closed on the
 100 first primary step, and through busy relay BR^7 to battery. The selection of an idle contact set 95, 96, 97, by the first selector D^2 , occurs under control of relay BR^7 in the
 105 manner described in connection with Fig. 1.

On a completed selection, the retracted armature 81 closes circuit from ground through
 110 contacts 77, 86, 92—95, 203^a and secondary relay SR^2 to battery, and said relay energizes, establishing a locking circuit for relay RR^7 extending from ground at contact 85^a
 115 and contact 94—97, and through contact 62. The second actuation of the calling device at substation S causes a set of deenergizations of relay PR^7 , which will transmit impulses
 120 through contact 93—96 and magnet PM^2 to battery, actuating said magnet to drive the wipers 92^a, 93^a, 94^a to select the group of connector terminals corresponding to the extent
 125 of actuation of the substation calling device. On the first primary step, the circuit of secondary relay SR^2 is opened at contact 203^a, but while the successive actuations of magnet PM^2 are continuing, the elements
 201^a and 202^a cooperate to rapidly close and open the circuit of relay SR^2 so that its
 130 armature cannot retract and relay RR^7 remains energized. When, however, the actuations of magnet PM^2 cease, relay SR^2 deenergizes and circuit is closed from ground at 85^a, through contacts 71^a, 75^a and busy relay BR^2 to battery, which relay operates and
 135 causes the wipers 92^a, 93^a, 94^a to select the

multiple contacts 101, 102, 103 of an idle connector F² in a manner obvious from the description given of the operation of second selector E in Fig. 1.

5 On the retraction of armature 81^a, circuit is closed through contacts 77^a, 86^a, 92^a—101, 106, relay SR³ to battery, whereby said relay energizes and its armature closes a locking circuit for relay RR' at D², extending
10 from ground at 119, over the lower talking conductor and through contact 200, through the locking contact 62. By this means relay RR' remains operated, while in response to the actuation of the calling device at S, relay PR' transmits adjusting impulses over
15 the upper talking conductor through contact 93^a—102, 123^a, 112, primary magnet PM³ to battery, to cause the primary adjustment of the wipers 144, 145, 146. On the first primary step, the PO contacts shift and the circuit of relay SR³ is opened at normal contact 106. By the cooperating parts 210, 211, however, of magnet PM³, relay SR³ has its circuit alternately opened and closed and
20 so holds its armature attracted until the primary directive impulses have all been transmitted to connector F². After the last primary step, however, contact 210 remains open long enough so that relay SR³ retracts its armature 115, thereby closing circuit from battery, through relay LOR, contacts 113, 107, 115, 119, to ground, said relay LOR then energizing and, by armature 125, locking itself to ground at 116. Armature 123^a
25 shifts the impulse wire from magnet PM³ to magnet SM³, while armature 126 now re-energizes relay SR³ by current through 111^a to reestablish the locking circuit for relay RR' at D². The fourth actuation of the calling device at substation S causes de-energizations of relay PR' to transmit directive impulses over the upper talking conductor to F², through alternate contact 123^a and magnet SM³, which magnet adjusts the
30 wipers 144, 145, 146, in their secondary travel to select the contact set of the called line. On the first secondary step, the SO contacts shift, the shifting of 111^a opening the energizing circuit of relay SR³, which
35 would deenergize were it not for the fact that, during the actuations of magnet SM³, the elements 213, 212 cooperate to alternately open and close the circuit of relay SR³.

When the calling device at S again
55 reaches normal, relay PR' will remain energized so that magnet SM³ remains inert and the circuit of relay SR³ is opened long enough so that its armature retracts to close circuit from 119, through contact 107, alternate contact 113, lower winding of relay TR to battery, whereupon said relay energizes and its armature 130 deenergizes the relay LOR by opening its locking circuit. From this point, the testing of the called line, the
60 ringing of the called subscriber, and the

operations involved in the response, proceed as described in connection with Fig. 1, the said response of course involving the energization of release relay RR² at D² and the operation of the reversing relay RV as in 70 Fig. 1.

When, at the conclusion of conversation, the called subscriber replaces his receiver, assuming he does so first, he energizes relay R³ at F² and relay R' at D² and the ener- 75 gizations of these relays result, as in Fig. 1, in the restorations to normal of the first selector, the second selector and the connector. Then when the calling subscriber replaces his receiver, he causes the release of line selector C in the following manner: It will be seen that on the release of first selector D² from the called substation S', the relays PR' and RR' will both continue energized under the assumption that the calling subscriber has 85 not yet hung up his receiver. Although first selector D² has restored, the associated relay RV will still be energized by current through attracted armature 65, to the left over wire 53, wire 58, and contacts 46, 42, 90 50, to ground. Contact 200 of relay RV will accordingly be opened so that no locking circuit can exist for relay RR'. For this reason, the replacing of the receiver at S will deenergize relays PR' and RR' and 95 their retracted armatures 59 and 61 will close a series circuit including relay R' at D² and RR at C; and on the energizations of these relays, the line selector C and the first selector D² will have their release mag- 100 nets operated in a manner apparent from the description of Fig. 1, whereby the line selector C will restore and the central office apparatus will be at normal. If the subscriber S had first replaced his receiver, line selector C and first selector D² would have their release mechanisms operated, as just mentioned. Before release magnet RM' had time to attract its armature, however, attracted armature 77 of relay R' would 110 transmit an impulse through contact 92—95, alternate contact 203^a, relay R² to ground, actuating said relay R², which would cause the restoration to normal of second selector E² in a manner like that given in connection with Fig. 1, the connector F² remaining to be restored from the called substation in the manner already mentioned. If the called line had been busy, the test relay TR at F² would have remained energized as in 120 Fig. 1, and the calling subscriber would have received the busy signal. In this case, of course, the relay AR at F² would not have operated and accordingly closing relay CR would have remained inert. Also, as in Fig. 125 1, the release relay RR² would have received no energizing current and relay RV would not have operated. At this time, both relays PR' and RR' at D² would be solely dependent for current upon the calling line circuit 130

and when the calling subscriber replaces his receiver, said relays deenergize, restoring to normal selectors C, D² and E², just as before described. Because relay CR at F² has remained unenergized, current will, as soon as relay R² at E² operates, flow through alternate contact 77, contacts 86^a, 92^a—101, alternate contact 106, normal contact 141, relay R³ to ground, operating said relay, which will of course restore connector F².

Suppose subscriber S replaces his receiver before operating at all his calling device 4. At this time, relay SR' at D² will be energized by current through contacts 63, 203; relay RR' being held energized over its locking circuit. Relay PR' alone deenergizes at first and actuates magnet PM' a single time, causing one primary step of selector D². By this step, contact 203 is opened and, at the conclusion of the step, magnet PM' will remain for a moment energized, contact 202 being then open. Secondary relay SR' accordingly retracts its armature, opening the locking circuit of relay RR' so that said relay deenergizes and the simultaneous closure of contacts 59 and 61 closes the release circuits of selectors C and D². If the subscriber S had actuated his calling device once so that selector D² had made connection to a selector E², the replacing of the receiver at S would cause the deenergization of relay PR', while relay RR' remained for the moment locked through contact 94—97, attracted armature of relay SR², to ground at 85^a. Retracted armature 60 would accordingly transmit one impulse through magnet PM², one primary step of selector E² would be made, opening contact 203^a, and since armature 201^a would continue attracted, the armature of relay SR² would fall back, opening the locking circuit of relay RR', on whose deenergization the release circuit of selectors C and D² will be closed and, in its release operation, the selector D² will cause the energization of relay R² as already described, and second selector E² will restore. If the subscriber S had actuated his calling device twice so that a connection has been extended through to connector F², and then replaced his receiver, relay PR' will deenergize while relay RR' remains locked by current over the lower talking conductor, through alternate contact 115, to ground. Accordingly, an impulse will be transmitted to magnet PM³ to cause one primary step of connector F², opening a circuit of relay SR³ at 106, whereafter the armature of magnet PM³ will remain attracted, leaving contact 210 open so that armature 115 restores to normal and relay RR' has its locking circuit opened. When this occurs, selectors C, D² and E² will of course restore, and connector F² will also be restored, as in the case where the called line was busy,

by an impulse transmitted through alternate contact 77^a on the energization of relay R², which impulse will flow over contact 92^a—101, alternate contact 106, normal contact 141, relay R³ to ground. If the calling subscriber transmits three sets of impulses and then hangs up his receiver, relay LOR will have operated when armature 115 retracted at the conclusion of the third impulse set and relay SR³ will have again energized by current through armature 126 and contact 111^a. Relay RR' will accordingly have had its locking circuit reestablished. Relay PR' will accordingly transmit an impulse over the upper talking conductor to F², to alternate contact 123^a and magnet SM³. Said magnet will cause one secondary step of the connector, opening the SO contacts, whereby circuit from armature 126 through relay SR³ is opened. Further, magnet SM³ will for the moment remain energized so that contact is open at 212, the circuit of relay SR³ remaining open long enough for armature 115 to retract. When this occurs, relay RR' deenergizes and the release circuits for selectors C, D², E² and F² are closed as in the last preceding case and all the switches restore to normal.

In the description of the circuit diagrams, I have indicated in a definite way the arrangement of the different parts, their relation to one another, and the way in which they operate so as to render the invention readily understood by one skilled in the art. It will be understood that I have not, however, attempted to mention all the functions of all parts, or in all cases to give the reasons for the particular circuit connections illustrated and described, as to do so would necessarily extend the description far beyond all reasonable limits.

Referring now to the mechanical Figs. 4 to 8 inclusive, the switch there shown may be regarded as a line selector C and, for convenience, reference characters corresponding to those in Fig. 1, Part 1, have been supplied to these mechanical figures. In Fig. 4, the contact bank is shown in section and one group of ten contact sets, each set comprising contacts 23, 24, 25, is illustrated. In the front view of the bank, shown in Fig. 5, each contact set 23, 24, 25, is represented by a single short dash and it is there apparent that the ten groups of ten contact sets each are mounted side by side, extending up and down, the contact bank as a whole presenting a surface as of the interior of a section of a sphere. The contact ends of wipers 27, 28, 29, normally rest, as shown in Fig. 5, to the left and below the edge of the contact bank. Rotary steps of said wipers from left to right are caused for the primary adjustment, each step bringing the wipers immediately below a different group of verti-

cally extending contact sets. The secondary travel of the wiper ends is caused by rotating the wipers about a bearing 229 in their supporting shaft PS, the wiper ends then moving upward, engaging with each secondary step a successive set of contacts 27, 28, 29, of the selected group. To cause the primary or left-to-right rotation of the wipers, the primary shaft PS, supporting them, has fastened to it a ratchet 220 (Fig. 8) adapted to be driven step by step by the armature-actuated pawl 217 of the primary magnet PM, a retaining pawl 218 being provided, spring-pressed against said ratchet to engage successive teeth thereof and prevent back movement under the influence of the spring 219. For causing the upward rotation of the wiper ends on their secondary travel, said wipers have a rearwardly extending bearing passing through shaft PS, provided with a roller bearing 228, engaged by the broad piece 227 screwed to a secondary shaft SS, said piece 227 being sufficiently broad so that, in whatever primary position the wipers may be rotated by actuation of magnet PM, the bearing 228 will still engage piece 227. Secondary magnet SM has an armature actuated pawl 222 adapted to engage successive teeth of an associated ratchet and shaft SS (Fig. 5); and on the opposite side of said shaft, another ratchet is provided, against which is a spring-pressed secondary retaining pawl 223 to retain the shaft against back movement under the influence of a spring 226, linked with shaft SS by the pivoted lever 225. Fastened to primary shaft PS, as indicated in Fig. 7, is a piece 215 having a stud of insulating material, normally engaging the primary off-normal PO spring 37, whereby said spring and spring 36 are held in their normal positions. On the first rotary step of shaft PS, said piece 215 is rotated to free the spring 37 sufficiently to allow the two springs, by their tension, to shift to their alternate positions. On the restoration of shaft PS to normal, the piece 215 will obviously be brought back to shift the springs 36, 37, to normal. The secondary off-normal arrangement is most clearly seen in Fig. 6, wherein the springs SO, linked by suitable studs of insulating material are held in their normal positions by the piece 216, angular in shape and extending downward through the frame of the switch, parallel with shaft SS, to be held in its raised or normal position by the piece 241 fastened on shaft SS. On the first downward step of the shaft, the piece 241 frees piece 216, which then drops down upon the top frame and the springs SO move to their alternate positions. To release the selector, release magnet RM is energized and its armature 224 engages a projection upon primary retaining pawl 218 and rotates said

pawl to free the primary ratchet 220. The pawl 218 has an extension extending to engage an arm of secondary retaining pawl 223 so that, on its actuation by armature 224, pawl 218 withdraws pawl 223 from its ratchet on shaft SS. The tension of spring 226 then avails to raise shaft SS up to normal by means of the lever 225 when the wiper ends free the contact bank and piece 241 lifts piece 216 to shift to normal the secondary off-normal contacts. The piece 216 carries the tooth 221, adapted to engage any opposite tooth of ratchet 220 on the first downward step of the secondary shaft. Until the secondary shaft reaches normal, raising piece 216 upward, the tooth 221 will remain engaging a tooth of ratchet 220 so that the tension of spring 219 is unavailing during the restoration of shaft SS. As soon, however, as, on the restoration of shaft SS, tooth 221 clears ratchet 220, spring 219 rotates shaft PS and the wipers back to normal, at which time the primary off-normal contacts are of course also shifted. The wiper 30 will be noted rigidly attached to shaft PS and arranged to move over the group contacts 26 horizontally located below the main contact bank. The wiper 30 of course partakes only of the primary adjustments of the switches.

The selectors illustrated in Figs. 4 to 8 may be employed for the first selector D and second selector E of Fig. 1. In such case, the wiper 30 may be provided with the contact arrangement diagrammatically shown at 88 at D and E, and by giving the wiper 30 suitable connections, as indicated at D, it may be employed to serve the function of the wiper 89 controlling the secondary relay SR. In Fig. 1, Part 3, a wiper arranged like 30 may obviously be used to perform the functions of wiper 110, while to secure the functions provided for by the segment 121 and wiper 120, a fourth primarily and secondarily adjustable wiper may be provided for the selector and each group of contact sets in the main switch bank may have associated with it a segment having projections like 121, over which the fourth wiper will move during the secondary adjustments of the selector. When the selector of Figs. 4 to 8 is used for the purposes of the connector, the normal position of the individual wipers of the bank will of course be two steps distant from the bank edge after its primary adjustment, as explained in connection with the circuits, but the first contact projection of the segment 121 will extend sufficiently so that, on the first secondary step of the wipers, the wiper 120 will engage it.

In Figs. 9 and 10, illustrating mechanically the form of selector adapted for use with the selector and connector circuits of Fig. 2, the mechanism as a whole may comprise a circular contact bank having one

hundred and ten contacts to complete the circuit, arranged in groups of ten, between groups single contacts being provided which may conveniently be called between-group contacts. Comparing the structure of Figs. 9 and 10 with the line selector C' of Fig. 2, it may first be stated that the wiper terminals, indicated in Fig. 2, are in the mechanical embodiment found in common strips extending along beneath their associated groups of contacts. The wiper members in the mechanical structure have no circuit connection in themselves, but serve only to cross successive individual contacts of a group to their respective common, whereby the functions represented by adjustable wipers, having circuit connections and associated stationary contacts, are produced.

Referring to Fig. 9, I have marked 153, 154, 155, 156, groups of line, private and group contacts, respectively, beneath which, respectively, will be the common strips representing the wipers *d*, *e*, *f* and *g* of Fig. 2. Rotatable about the center of the contact circle, are ten sets of wipers *dd*, radiating at equal angles and so arranged that if they are rotated eleven steps from any normal or between-group point, each contact 153, 154, 155 and 156 will have been crossed to its common strip and the wipers will, on the eleventh step, reach a between-group position, at which time all the contacts will be on open circuit. Thus, each time eleven steps of the wipers *dd* are caused, a complete operation and restoration to normal of the primary switch mechanism will be effected. It will be seen that for the space of six groups of ten contacts, as viewed in Fig. 9, the contacts are not required for the functions of selecting the sets of secondary wipers. The spaces occupied by these contacts may be conveniently employed by the use of suitable commons to provide the two make and one break off-normal contacts indicated at PO in Fig. 2, Part 1. Thus, for the contact 160, any one of the free groups of ten contacts may have its contacts connected together, or may have a common substituted for the ten contacts; and when one of the eleven-step operations of the switch is initiated, the first step will bring a pair of wipers to close the contact and it will remain closed until the eleventh step. So also for the contact 161 and, obviously, any pair of between-group contacts may be used for the break indicated at 162^a, 162.

In Fig. 10, the stationary secondary contacts 150, 151, 152, are placed one beneath the other in the same bank with the primary contacts. Each of the ten groups of ten contact sets 150, 151, 152, required for Fig. 2, will occupy a segment in the circular bank corresponding to the space occupied by a group of contacts, as 153 or 154 shown in Fig. 9. The wiper contacts will, in the me-

chanical structure of Fig. 10, be represented by the respective commons *a*, *b*, *c*, extending along underneath the contacts 150, 151, 152 of their respective groups. The mechanical secondary wiper members *aa*, *bb*, and *cc* serve only when they are rotated to cross the commons *a*, *b*, *c*, to successive contacts 150, 151, 152, of their groups. In the mechanical switch, there are provided ten sets of secondary wipers *aa*, *bb*, *cc* and *ee*, extending to equal angles with respect to the center of the bank, but not visible in Fig. 9, as their normal positions are between-group positions and there will be one set of such wipers underneath each wiper *dd*. When the secondary mechanism of the switch is operated, all the ten sets of wipers *aa* to *ee* will be caused to travel in a rotary direction step by step; and when they have moved eleven steps from one normal or between-group position, a complete cycle of operation of the secondary mechanism will have been completed, wherein each contact set 150, 151, 152 of all ten groups will have been connected to its respective contact *a*, *b*, *c*, and the secondary mechanism will again have reached, on the eleventh step, a normal or between-group relation. The fourth set of secondary wipers *ee* is employed for performing the secondary off-normal switch functions, as indicated at SO in Fig. 2. Obviously, for the "break" contact 174, a pair of between-group contacts, associated with wipers *ee*, will be used. For each of the "make" contacts 175, 176, 177, 178 of Fig. 2, a pair of commons may be provided associated with the wiper sets *ee* and extending from adjacent to one between-group contact to a point adjacent to the next, the space indicated by *u* in Fig. 9.

Having explained the contact and wiper arrangements of Figs. 9 and 10, it remains to refer to the means employed for driving the wipers. The contact bank is fastened to a circular back-plate 264, and across the top of the bank the bridge 256 extends. A shaft 257 is journaled to the bridge 256 and base-plate 264 and has rigidly fastened to it a hub 275 (Fig. 10) forming part of the circular plate 259 which supports the secondary wiper sets *aa*, *bb*, *cc* and *ee*, two of the latter only being shown. The shaft 257 has also rigidly fastened to it the secondary ratchet 252 provided with a suitable hub to facilitate its attachment. The primary ratchet 255, which carries the primary wipers *dd*, is provided with a supporting cylinder member 258 which is slipped over the secondary shaft 257 and is adapted to rotate freely about the same, the said cylinder piece 258 having suitable bearings in the upper and lower hubs fastened to shaft 257. The primary magnet PM and secondary magnet SM may be alike in construction and the magnet SM in Fig. 9 is shown with

some of its parts omitted to disclose the arrangement of the rocking armature 250, adapted to rock about the fixed post 260 and provided with a retracting spring 261, one end of which is fastened to the armature and the other to the bridge 266. The ends of the armature 250 extend adjacent to the lower core ends of the two electromagnets of magnet SM; and when said cores are magnetized, the armature 250 will be attracted to cause a thrust of the pawl 251 to drive the ratchet 252, controlling the secondary wipers *aa* to *ee*, a step. When magnet SM deenergizes, its cores become demagnetized and the spring 261 retracts the armature 250, when pawl 251 engages a different tooth of ratchet 252, ready to drive said ratchet and the secondary wipers another step on the next actuation of magnet SM. The magnet PM is preferably constructed exactly as magnet SM. Its armature will, however, carry the primary pawl 254, adapted to engage the ratchet 255, which controls the primary wipers *dd*, said pawl 254 being adapted to drive the ratchet 255 and the primary wipers step by step rotarily on successive actuations of magnet PM.

It is to be understood that the invention is not limited to the precise arrangements that I have herein shown and described and that the customary conventions employed in illustrations of the character provided are observed, such as the employment of a plurality of battery symbols at convenient points which may, if desired, be mechanically represented by a single source, and so with the various generator symbols. As is in fact shown by the various systems illustrated, the circuit arrangements of the invention are adapted to a considerable variation. The mechanical drawings are illustrative to an extent diagrammatically of convenient mechanisms for performing the circuit changes required by the specific diagrams illustrated. Obviously mechanical skill will suffice to provide mechanical structures different from those illustrated to perform the switching functions required.

I claim as my invention:—

1. A telephone system including a telephone line, a pair of relays connected with said telephone line, a selective switch, an armature for one of said relays serving to adjust said switch and adapted to vibrate responsive to circuit changes produced in said telephone line, a local maintaining circuit for the second relay held closed while said armature vibrates, an electromagnet provided with a slow release armature, and a circuit for said electromagnet closed and opened responsive to the vibration of said armature, said electromagnet holding said maintaining circuit closed while said armature vibrates.

2. A telephone system including a tele-

phone line, a pair of relays connected with said telephone line, a selective switch, an armature for one of said relays serving to adjust said switch and adapted to vibrate responsive to circuit changes produced in said telephone line, a local maintaining circuit for the second relay held closed while said armature vibrates, an electromagnet provided with a slow release armature, a circuit for said electromagnet closed and opened responsive to the vibration of said armature, said electromagnet holding said maintaining circuit closed while said armature vibrates and opened responsive to the cessation of vibration.

3. An automatic telephone system including a telephone line, a selective switch, a pair of relays connected in the circuit of said line for controlling said switch, one of said relays serving to control directive adjustment of said switch, mechanism for restoring said switch to normal controlled by said other relay, armature mechanism for said first relay adapted to be vibrated responsive to circuit changes produced in said telephone line, a local maintaining circuit for said second relay, a third relay slow to release its armature having its circuit in controllable relation with said first mentioned relay and unresponsive to successive vibrations of said armature, and a switch contact of said third relay included in said maintaining circuit.

4. An automatic telephone system including a telephone line, a selective switch, a pair of relays connected in the circuit of said line for controlling said switch, one of said relays serving to control directive adjustment of said switch, mechanism for restoring said switch to normal controlled by said other relay, armature mechanism for said first relay adapted to be vibrated responsive to circuit changes produced in said telephone line, a local maintaining circuit for said second relay, a third relay slow to release its armature having its circuit in controllable relation with said first mentioned relay and unresponsive to successive vibrations of said armature, a switch contact of said third relay included in said maintaining circuit, and means controlled by said third relay effective when said armature ceases to vibrate to open said maintaining circuit.

5. An automatic telephone system including a telephone line, a selective switch, a pair of relays connected in the circuit of said line for controlling said switch, one of said relays serving to control directive adjustment of said switch, mechanism for restoring said switch to normal controlled by said other relay, armature mechanism for said first relay adapted to be vibrated responsive to circuit changes produced in said telephone line, a local maintaining circuit for said second relay, a third relay slow to release its armature having its circuit in controllable rela-

tion with said first mentioned relay and unresponsive to successive vibrations of said armature, a switch contact of said third relay included in said maintaining circuit, means controlled by said third relay effective when said armature ceases to vibrate to open said maintaining circuit, secondary adjusting mechanism for said switch, and connections altered by said third relay when said armature ceases to vibrate to transmit an impulse to initiate operation of said mechanism.

6. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, and an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates.

7. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates, and circuit connections controlled by said first relay serving on cessation of vibration of said armature to deenergize said electromagnet whereby said maintaining circuit opens.

8. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates, circuit connections controlled by said first relay serving on cessation of vibration of said armature to deenergize said electromagnet whereby said maintaining circuit opens, and secondary adjustment mechanism for said selective switch responsive to deenergization of said electromagnet.

9. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an

armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates, circuit connections controlled by said first relay serving on cessation of vibration of said armature to deenergize said electromagnet whereby said maintaining circuit opens, and a release circuit having a contact controlled by said second relay.

10. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates, secondary adjusting mechanism for said selective switch responsive to deenergization of said electromagnet, and connections effective by the operation of said secondary mechanism to again establish a maintaining circuit for said second relay.

11. A telephone system including a telephone line, a pair of relays connected in the circuit of said line, a selective switch, an armature switch for one of said relays adapted to control adjustment of said selective switch, a calling device for said line serving to control said first relay to vibrate its armature, a maintaining circuit for the second relay, an electromagnet having a slow release armature in controllable circuit relation with said first relay and serving to hold said maintaining circuit closed while said armature vibrates, and a release circuit for said selective switch jointly controlled by said relays.

12. A telephone system including a telephone line, a pair of relays connected in circuit with said line, a selective switch, an armature for one of said relays adapted to be vibrated responsive to substation circuit changes controlling said relay, to adjust said switch, a primary switch adjusting magnet actuated to adjust said switch responsive to vibration of said armature, a third relay at the exchange having a slow release armature, a circuit for said third relay alternately opened and closed responsive to the actuations of said magnet while said third relay maintains its armature attracted, and a maintaining circuit for the

other relay of said pair, said maintaining circuit being completed over a front contact of said third relay whereby said second relay remains in closed circuit while said substation circuit changes are produced.

13. A telephone system including a telephone line, a pair of relays connected in circuit with said line, a selective switch, an armature for one of said relays adapted to be vibrated responsive to substation circuit changes controlling said relay, to adjust said switch, a primary switch adjusting magnet actuated to adjust said switch responsive to vibration of said armature, a third relay at the exchange having a slow release armature, a circuit for said third relay alternately opened and closed responsive to the actuations of said magnet while said third relay maintains its armature attracted, a maintaining circuit for the other relay of said pair, said maintaining circuit being completed over a front contact of said third relay whereby said second relay remains in closed circuit while said substation circuit changes are produced, and means whereby a prolonged opening or closing of the line circuit at the substation will deenergize said third relay to open said maintaining circuit.

14. A telephone system including a telephone line, a pair of relays connected in circuit with said line, a selective switch, an armature for one of said relays adapted to be vibrated responsive to substation circuit changes controlling said relay, to adjust said switch, a primary switch adjusting magnet actuated to adjust said switch responsive to vibration of said armature, a third relay at the exchange having a slow release armature, a circuit for said third relay alternately opened and closed responsive to the actuations of said magnet while said third relay maintains its armature attracted, a maintaining circuit for the other relay of said pair, said maintaining circuit being completed over a front contact of said third relay whereby said second relay remains in closed circuit while said substation circuit changes are produced, means whereby a prolonged opening or closing of the line circuit at the substation will deenergize said third relay to open said maintaining circuit, secondary adjusting means for said switch set in operation responsive to deenergization of said third relay, and circuit connections closed on completion of the operation of said secondary adjusting mechanism serving to close a substitute maintaining circuit for said second relay.

15. A telephone system including a telephone line, a pair of relays at the exchange connected in circuit with said line, a selective switch, an armature for one of said relays adapted to make forward and back strokes responsive to circuit changes con-

trolled at the substation of said line, a maintaining circuit for the second relay, a third relay having a slow release armature and adapted when energized to hold closed a contact in said maintaining circuit, mechanism controlling the circuit of said third relay responsive to vibrations of said armature, whereby each forward and back stroke of said armature is effective to open and close the circuit of said third relay, and means controlled by said third relay serving on a prolonged attraction or release of said armature to affect connections serving to open said local maintaining circuit.

16. A telephone system including a telephone line, a pair of relays at the exchange connected in circuit with said line, a selective switch, an armature for one of said relays adapted to make forward and back strokes responsive to circuit changes controlled at the substation of said line, a maintaining circuit for the second relay, a third relay having a slow release armature and adapted when energized to hold closed a contact in said maintaining circuit, mechanism controlling the circuit of said third relay responsive to vibrations of said armature, whereby each forward and back stroke of said armature is effective to open and close the circuit of said third relay, means controlled by said third relay serving on a prolonged attraction or release of said armature to affect connections serving to open said local maintaining circuit, and restoring means for said selective switch effective on simultaneous deenergization of said two first mentioned relays.

17. A telephone system including a telephone line, a pair of relays at the exchange connected in circuit with said line, a selective switch, an armature for one of said relays adapted to make forward and back strokes responsive to circuit changes controlled at the substation of said line, a maintaining circuit for the second relay, a third relay having a slow release armature and adapted when energized to hold closed a contact in said maintaining circuit, mechanism controlling the circuit of said third relay responsive to vibrations of said armature, whereby each forward stroke of said armature opens and closes the circuit of said third relay, and means controlled by said third relay effective on a prolonged attraction of said armature to open said maintaining circuit.

18. A telephone system including a telephone line, a pair of relays at the exchange connected in circuit with said line, a selective switch, an armature for one of said relays adapted to make forward and back strokes responsive to circuit changes controlled at the substation of said line, a maintaining circuit for the second relay, a third relay having a slow release armature and

adapted when energized to hold closed a contact in said maintaining circuit, mechanism controlling the circuit of said third relay responsive to vibrations of said armature, whereby each forward and back stroke of said armature opens and closes the circuit of said third relay, and means controlled by said third relay effective on a prolonged retraction of said armature to open said maintaining circuit.

19. A telephone system including a telephone line, a pair of relays at the exchange connected in circuit with said line, a selective switch, an armature for one of said relays adapted to make forward and back strokes responsive to circuit changes controlled at the substation of said line, a maintaining circuit for the second relay, a third relay having a slow release armature and adapted when energized to hold closed a contact in said maintaining circuit, mechanism controlling the circuit of said third relay responsive to vibrations of said armature, whereby each forward and back stroke of said armature is effective to open and close the circuit of said third relay, means controlled by said third relay serving on a prolonged attraction or release of said armature to effect connections serving to open said local maintaining circuit, restoring means for said selective switch effective on simultaneous deenergization of said two first mentioned relays, secondary adjusting mechanism for said switch, and a circuit for transmitting a secondary current impulse to said mechanism, said circuit having two normally open contacts, one adapted to be closed responsive to said first mentioned relay, and the other closed responsive to deenergization of said third relay.

20. A telephone system including a telephone line, a pair of relays energized by current over said telephone line, a selective switch, an armature for one of said relays serving to control adjustment of said switch and adapted to vibrate responsive to rapid interruptions of said telephone line, a local maintaining circuit for the second relay held closed while said armature vibrates, an electromagnet provided with a slow release armature, and a circuit for said electromagnet closed and opened responsive to the vibration of said armature, said electromagnet holding said maintaining circuit closed while said armature vibrates.

21. A telephone system including a telephone line, a pair of relays energized by current over said telephone line, a selective switch, an armature for one of said relays serving to control adjustment of said switch and adapted to vibrate responsive to rapid interruptions of said telephone line, a local maintaining circuit for the second relay held

closed while said armature vibrates, an electromagnet provided with a slow release armature, a circuit for said electromagnet closed and opened responsive to the vibration of said armature, said electromagnet holding said maintaining circuit closed while said armature vibrates and opened responsive to the cessation of vibration.

22. A telephone system comprising a subscriber's telephone line, an automatic selector switch for extending connections from said line, a quick-acting line relay responsive to current interruptions of said line circuit for adjusting said switch to a predetermined point, a slow-acting circuit changing relay responsive to the cessation of said interruptions for causing said switch to start from said predetermined point and select an idle trunk line, and a quick-acting release relay provided with means for preventing its deenergization during the said interruptions of the said line circuit for controlling a release circuit.

23. A telephone system comprising a two-conductor metallic telephone line, an automatic progressively-movable step-by-step switch for extending a connection from said telephone line, a quick-acting line relay responsive to current interruptions in said telephone line for operating said automatic switch to select a group of trunk lines, a slow-acting circuit changing relay responsive to a cessation of said current interruptions for controlling the automatic selection of an idle trunk in the selected group of trunks, a quick-acting release relay directly controlled over the said metallic line for controlling a release circuit, and means for preventing the deenergization of said quick-acting release relay during said interruptions.

24. A telephone system comprising a subscriber's line, an automatic switch for extending a connection from said line, a quick-acting line relay for said switch responsive to current interruptions in said line for controlling said switch to elect a group of trunk lines, a slow-acting circuit changing relay responsive to the cessation of said current interruptions for operating said switch to select an idle trunk in the elected group of trunks, a quick-acting release relay energized upon connection of said switch to the said line, and means controlled over the said line for deenergizing said quick-acting release relay to close a release circuit.

In witness whereof, I hereunto subscribe my name this 8th day of December, 1908.

FRED SCHOENWOLF.

Witnesses:

CAROLYN WEBER,
F. H. FERGUSON.