C. S. WINSTON.

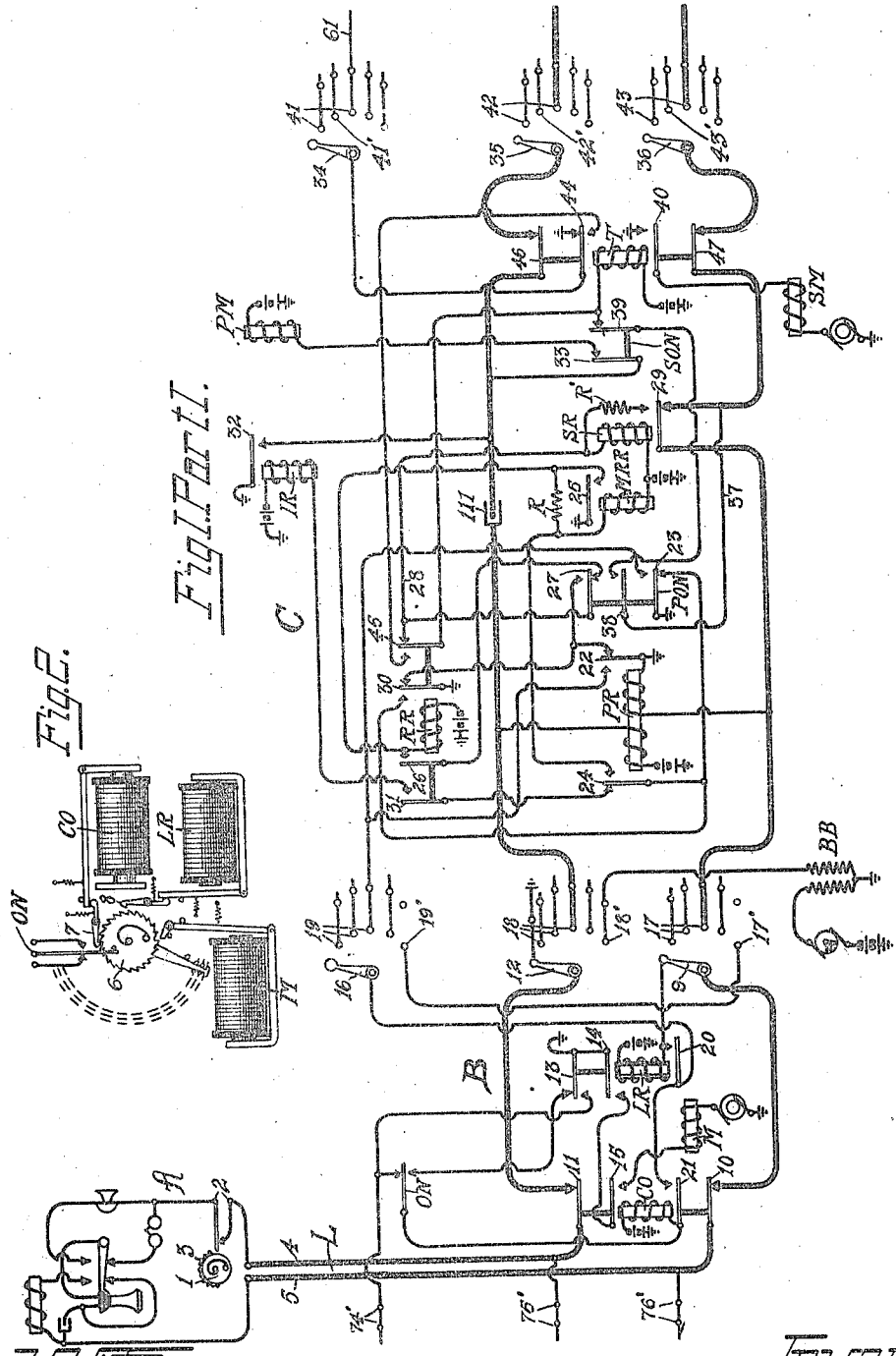
AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED AUG. 5, 1912.

1,197,989.

Patented Sept. 12, 1916.

3 SHEETS—SHEET 1.



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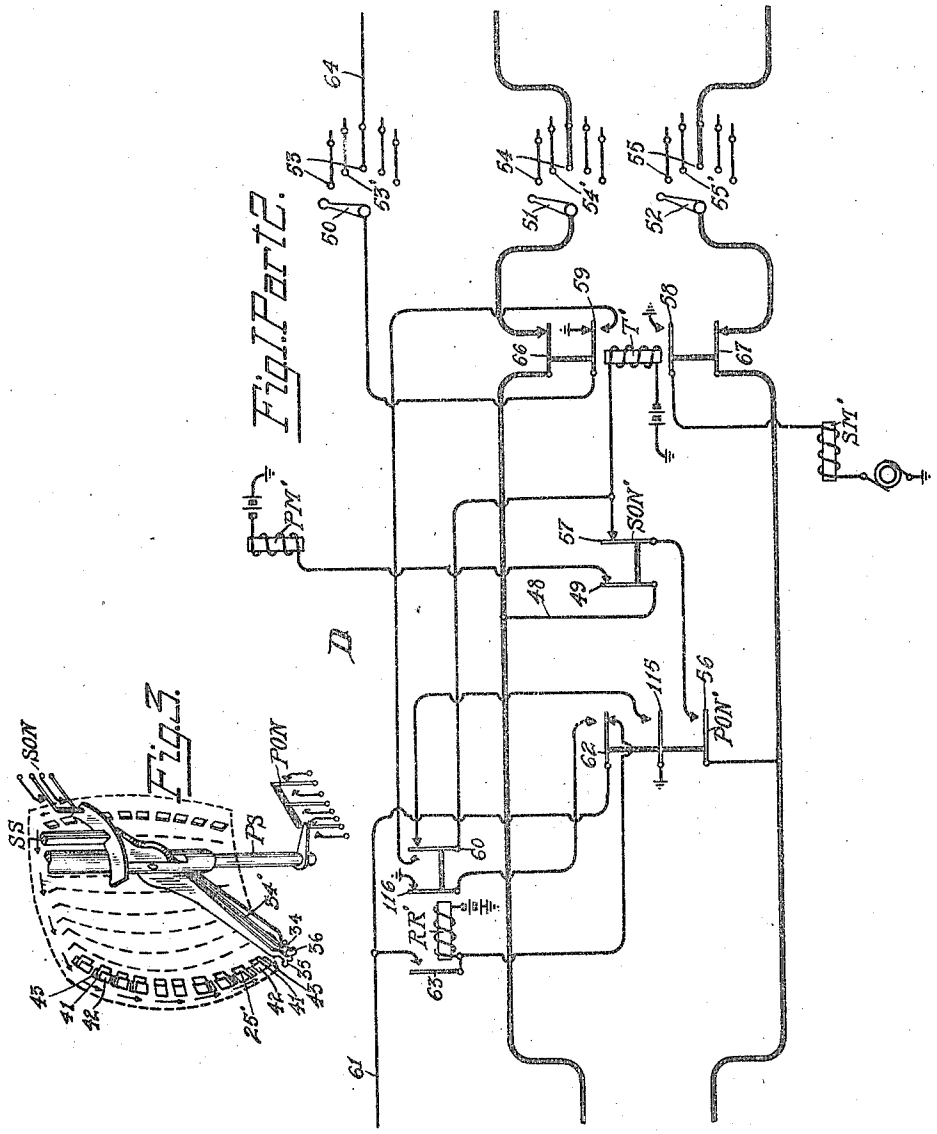

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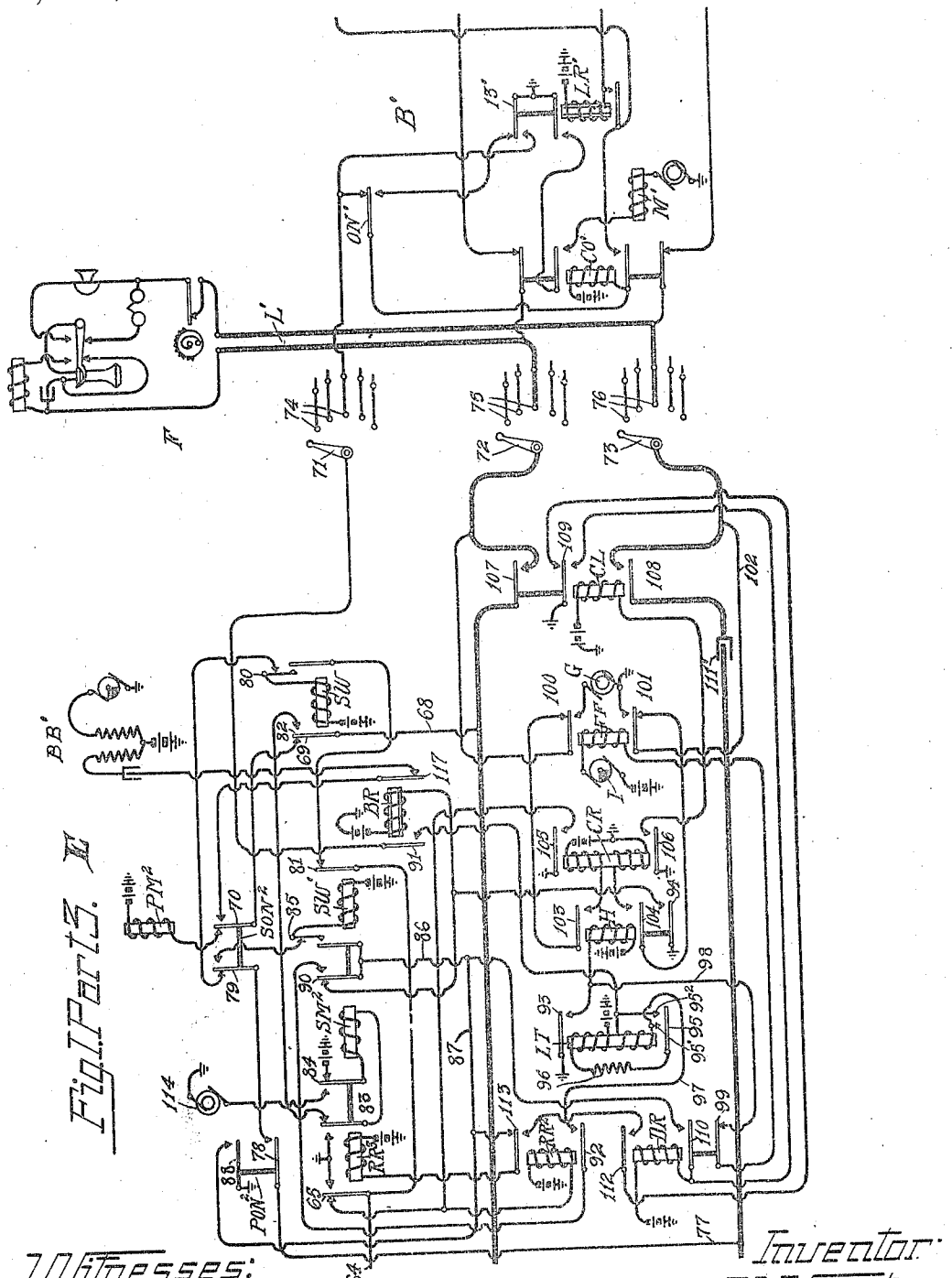

Fig. 1 Part 3.

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AUTOMATIC TELEPHONE SYSTEM.

1,197,989. Specification of Letters Patent. Patented Sept. 12, 1916.

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To all whom it may concern:

Be it known that I, CHARLES S. WINSTON, a citizen of the United States of America, residing in Chicago, county of Cook, State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates to telephone systems employing step-by-step automatic switches for making connection between subscribers' lines. The switches are of the well known type having preferably two directions of movement and comprise a bank of contacts and a movable wiper adapted to make connection therewith. The bank consists of groups of contacts, and the wiper is adapted to be moved first by directive impulses under the control of the subscriber to a desired group, and then moved automatically, and independently of the subscriber, to the first idle contact in the selected group. The movement of the wiper to the group of contacts is usually in one direction, and the movement to the idle contact in that group is usually in another direction of movement, but the particular construction of the switch is not important to my invention as any kind of switch may be employed that selects first a group of contacts, and then an idle contact in the selected group.

My invention is also of the two wire or metallic line type. That is, the impulses for operating the switches are sent over the two limbs of the telephone line in series, so that no ground connections are necessary at the subscribers' stations.

Heretofore in two wire automatic telephone systems it has been necessary to employ combinations of quick and slow relays for controlling the step-by-step switches. The slow acting relay in such prior systems had its circuit broken each time the quick acting or control relay received an impulse of current over the telephone line, but due to its construction it was not sufficiently deenergized to release its armature during the sending of said impulses. The retarded release in such slow acting relays was secured by providing a copper shell for the core of the relay, or a retarding winding therefor, either of which required special construction. This special construction in said sluggish relays was necessary to prevent the armature of said relays from dropping back while the impulses were being sent over the line to directively move the wipers of the switch to a group of contacts. After the directive impulses were sent in said prior systems, the circuit of the slow acting relay was interrupted by a second impulse or series of impulses, consisting of a long make, or a long break in the line circuit of sufficient duration to permit the slow acting relay to become deënergized and release its armature. The release of the armature of the slow acting relay closed the circuit of the secondary magnet to automatically move the wipers of the switch to an idle contact in the selected group.

In my invention I still employ the metallic line circuit without ground at the subscribers' station, sending the directive impulses over the two limbs of the telephone line in series, but I do not employ any combination of quick and slow acting relays to control the switches. For this reason it is only necessary in my system to send one series of impulses from the subscriber's line to control the switch in selecting an idle trunk, and this single series of impulses preferably are all of the same character or duration. It is not necessary, as in the quick and slow relay systems, to have impulses of different character, that is, quick impulses to operate the quick relay, and a long impulse or circuit condition to affect the slow relay. I am also enabled to have all of the relays for controlling the switches equally quick in action, without the addition of windings or sleeves to make them slow to respond in one direction.

In my system a relay which closes the circuit of the secondary magnet to move the wiper of the switch to an idle contact in the group after the directive impulses have been sent, may be of the same character and the same construction as the relay which operates over the telephone line in response to the directive impulses from the subscribers' station. Both of these relays are equally quick to attract their armatures and equally quick to release them when deprived of current. As stated, I therefore dispense with specially constructed relays designed to give a slow or sluggish action, and in addition to this saving of expense, and simplicity of manufacture, I am able to accomplish the result by a single series of

impulses sent over the subscriber's line, all of said impulses being of the same character or duration.

In the present embodiment of my invention, I accomplish these results by providing a high resistance path for the current flowing in the winding of the relay corresponding to the slow or sluggish relay in said prior systems. During the sending of the impulses to directively operate the switch, the circuit of said relay is not broken, or otherwise it would immediately release its armature, but instead of having its circuit broken as these impulses are being sent, as is the case in systems employing slow acting relays, the circuit of the corresponding relay in my system is closed through said high resistance during the intervals of said impulses, and sufficient current flows through said high resistance to energize the relay during said intervals. That is, two simultaneous paths are provided for the current that energizes said relay, one a high resistance and the other a low resistance path, and during the interval of time that the low resistance path is open (due to the transmission of impulses), the relay is held energized by current through its high resistance path but the instant that this path is opened the relay immediately deënergizes and allows its armature to fall back. The relay is not deprived of energizing current during the operation of the primary relay, and holds its armature attracted solely for this reason. The arrangement is such that sufficient current will not flow through the high resistance path to keep said relay energized for a longer time than during the interval between said impulses. Accordingly, after said impulses have been sent, and the group selected, there is not sufficient current flowing through the path containing said high resistance to keep the relay energized, and it accordingly releases its armature, closing the path for current through the test relay T which relay immediately energizes and closes a path for current through the secondary driving magnet, which moves the wipers to select an idle contact in the selected group.

For better understanding of my invention reference is had to the accompanying drawings in which all parts are shown in their normal position, and in which like reference characters indicate like parts, Figure 1 comprising parts 1, 2 and 3 illustrates an automatic telephone system embodying my invention; Fig. 2 illustrates diagrammatically a mechanism adapted for use with the line circuit B; Fig. 3 illustrates in perspective a diagrammatic view of a contact bank and wiper arrangement of the selector and connector switches.

Referring now to the system of Fig. 1, it illustrates a so-called 10,000 line system and I have shown only sufficient apparatus to connect a calling and called substation. In the preferred embodiment of my invention as here illustrated I employ line switches B, first selectors C, second selectors D and connectors E. Assuming a system of 10,000 lines, there would be 10,000 substations A each connected by line conductors L to a line switch B, and these switches B would be divided into groups of 100 each (grouped on a basis of 10% trunking), each group of 100 having access to 10 first selectors C, which are multiply connected to the terminals of their associated 100 line switches B. That is, each group of 100 line switches would be so wired to its corresponding group of 10 first selectors that each line in any group would have access to the entire ten first selectors, and could select the first first selector in the group that happened to be idle. There would then be 1000 first selectors C divided into groups of 10 each, and there would be 1000 second selectors divided in the same way, ten groups, ten in each group. Referring to Fig. 3, when the subscriber removes his telephone in initiating a call, his line switch would be started and automatically select the wiper or movable contact 34′ of the first idle selector in the group of ten to which his line had access. This wiper 34′ through the bank contacts 41, 42 and 43 would have access to the wipers of the second selector switches. Each vertical row 41, 42 and 43 of bank contacts indicated upon the first selector switch in Fig. 3 corresponds to one of said groups of ten second selectors. Accordingly, after the call was extended to a first selector, the subscriber would directively operate the wipers 34′ of said first selector by giving them a rotary motion to bring them opposite the vertical row of contacts thereof corresponding to the desired group of ten second selectors, and after reaching said row, the switch wipers would be automatically operated to select the first idle second selector in that group. There would be also 1000 connector switches arranged the same as the first and second selectors in ten groups of ten switches in each group. After connecting with the wiper of a second selector, the subscriber would directively operate said wiper to select the desired group of ten connectors, said groups corresponding to the vertical rows of bank contacts of Fig. 3, and after selecting said group by a rotary movement of the wipers 34′, the second selector would then be automatically operated to move its wipers in a vertical direction over the selected group of bank contacts, to select the first idle connector in that group.

The connector switches have access to 100 subscribers' lines, and the lines are connected multiply to the ten connectors con-

stituting the group at which said 100 lines terminate. The connector thus selected is then directively operated in both directions to select the desired line. For instance if No. 9846 was the number of the desired line, when the subscriber removed his receiver from the hook, his line switch would select an idle first selector, (from the group of ten selectors common to the group of 100 lines in which the calling subscriber's line is located). Having reached the wipers of the first selector, the subscriber would send nine impulses over his line to directively operate the wiper 34′ of said first selector (see Fig. 3) to bring them opposite the ninth vertical row of bank contacts upon the selector switch. This row of bank contacts would correspond to the thousand digit of the number wanted, or to the ninth group of ten second selector switches, and after thus selecting this ninth group by nine directive impulses, the first selector would be automatically operated to pick out the first idle second selector in that group. The subscriber would then send eight directive impulses corresponding to the hundred digit of the desired line, or to the eighth group of ten connector switches. These eight directive impulses would directively operate the wiper 34′ of the second selector (which would be the same in construction as the first selector of Fig. 3), to select the eighth group of ten connectors, which would be the group at which all subscribers' lines in the eighth hundred terminate. After selecting this eighth hundred group of connectors by the eight directive impulses, the second selector would be automatically operated, the same as in the first selector, to move its wipers into engagement with the first idle contact in that group, thus selecting the first idle connector switch therein.

As above stated, the ten connector switches of each group are multiply connected so that each connector of the group has access to any one of the 100 lines terminating thereat, the 100 contacts upon each connector representing 100 subscriber's lines. After selecting an idle connector, the subscriber would then directively operate the wipers of the said connector switch in both directions, sending four directive impulses to move the wipers in a rotary direction opposite the fourth row of vertical contacts shown in Fig. 3, which would correspond to the tens digit of the desired line, and would then send six directive impulses over the line to move the wipers in a vertical direction to the contact in said selected group corresponding to the units digit of the desired line, this contact being the line of the called subscriber.

The construction of the switches and the grouping thereof, as above described, as well as the operation of the wipers, first directively to a desired group, and then automatically to an idle contact in the selected group, are old and well known in the art, but have been set out in detail for a clearer understanding of my invention. It is to a new method of operating the first and second selectors in a two wire system, that my invention relates.

In prior two wire systems quick and slow relays were employed, the quick relay was vibrated by impulses over the line to move the wipers opposite the desired group of contacts (corresponding to the vertical rows of Fig. 3), and the slow relay was made sufficiently sluggish in action so that its armature did not drop back when its circuit was broken by the sending of said directive impulses. When the desired group was selected, however, the circuit of the sluggish relay was broken for a sufficient length of time to allow its armature to drop back, and this closed the circuit of the automatically operated driving magnet, to move the wipers over the selected group in search of an idle contact.

The development of the art at the present time demands a two wire or metallic line circuit without grounds at the subscriber's station, and said quick and slow relay systems are adapted to operate over such metallic lines. My invention consists of means for operating said switches over metallic line circuits without the necessity of using slow or sluggish acting relays. Instead of quick and slow acting relays for obtaining the movement of the wipers first to a desired group, and then to an idle contact in that group, I employ two quick acting relays, both of said relays being equally quick to attract and equally quick to release their armatures. Thus copper sleeves, coils, or other adjuncts to make the relays sluggish in action are dispensed with. One of these quick acting relays in my system is energized over the metallic line to directively operate the wipers to move them to the desired group of contacts, but during the vibrations of said relay while these selective impulses are being sent, the circuit of the second quick acting relay remains unbroken. Instead of breaking the circuit of said second relay it is preferably shifted, so that continuous current is supplied to said second relay to maintain it in an actuated condition, while the directive impulses are being sent through said first relay. If said second quick acting relay should be deprived of current for one instant while these directive impulses are being sent, its armature would drop back, and the wipers of the switch would be started automatically to select an idle contact, before the desired group of contacts had been reached.

In the present form of my invention, the maintaining of the armature of this second

quick acting relay, which corresponds to the sluggish relays in said prior systems) in attracted position, while the impulses are being sent from the subscribers' station, and while the other quick acting relay is vibrating in response thereto, is accomplished by providing two paths for the energizing current through its w nding, one of these paths being of low resistance and the other of high resistance, so that said relay is constantly supplied with energizing current, as will be more particularly pointed out in the following description. This arrangement not only simplifies the apparatus, but enables the switches to be operated by the sending of a single series of impulses from the subscribers' stations said impulses being of uniform duration. A plurality of series of impulses of unequal duration are not necessary.

Referring now more in detail to the apparatus and circuit arrangement preferably employed in this embodiment of my invention, substations A are of the well known Kellogg type having a calling device 1 with its interrupter contacts 2 connected in circuit with the line conductors, the impulse wheel 3, being so arranged that when advanced, its teeth will not interrupt the contacts 2 but upon being restored by its spring it will interrupt said contacts 2 according to the number of teeth on its periphery which were initially moved beyond said contacts. The line L comprising line conductors 4 and 5 extends from substation A to its line switch B.

Line switch B comprises a line relay LR, cut-off relay CO, motor magnet M, off-normal contacts ON, and a pair of line wipers 9 and 12 and coöperating contacts together with a test wiper 16 and coöperating contacts.

Fig. 2 illustrates diagrammatically a switch mechanism adapted to operate in connection with circuit B, like reference characters indicating corresponding parts. This switch comprises sets of bank contacts and coöperating wipers mounted upon a central shaft carrying a ratchet wheel 6 adapted to be driven by motor magnet M. It will be noted that two check pawls 7 and 8 are employed, pawl 7 being normally in engagement with ratchet 6 while pawl 8 is normally out of engagement with said ratchet. In the preferred operation of Fig. 2, which is in accordance with circuit B, upon initiation of a call by removal of the receiver from the switch hook, line relay LR is energized thus causing the associated pawl 8 to engage ratchet wheel 6 and thereafter cut-off relay CO is energized causing its associated ratchet 7 to disengage from ratchet wheel 6. Thereafter the motor magnet M advances the wipers over the contacts followed by the deënergization of CO, but LR is maintained energized so that both pawls 7 and 8 are engaging ratchet 6. To release switch B line relay LR is deënergized thus withdrawing pawl 8 from engagement with ratchet 6 and thereafter cut-off relay CO is again energized moving pawl 7 out of engagement with ratchet 6, allowing the wipers to be restored by a suitable spring. On the first step off-normal contacts ON assume their alternate position and are maintained thus until the wipers are restored whereby said contacts ON are again moved to their normal position. Other forms of line switch may be employed without in any way affecting the principle or operation of my invention.

In Fig. 3 I have illustrated diagrammatically the contact bank and wiper arrangement of one form of selector and connector switch that may be used with my invention, and for a more complete understanding of the switch structure reference is to be had to an application of William Kaisling for automatic switch for telephone systems, Serial No. 600,664, Patent No. 1,131,140, filed January 3rd, 1911.

Any form of switch adapted to select a group of contacts, and then an idle contact in the group, would be equally within my invention.

My preferred switch, referred to in the previous paragraph (see Fig. 3) in general comprises a bank of contacts (which I have indicated inclosed in dotted lines), made up of 100 sets of contacts, arranged in ten vertical groups, ten sets in each group. Each set consists of three contacts 41, 42 and 43, (which for clear illustration I have spread apart at the first set in Fig. 3, and which correspond to contacts 41, 42 and 43 in Fig. 1, Part 1, contacts 41′, 42′ and 43′ in said figure corresponding to the next set 25′ in Fig. 3). A set of wipers 34′ consisting of wipers 34, 35 and 36 are provided to wipe over the corresponding contacts in the vertical groups. (These wipers correspond to wipers 34, 35 and 36 in Fig. 1, Part 1).

A primary magnet (PM, Fig. 1, Part 1) is adapted to rotate the wipers through the medium of a primary shaft PS to bring them opposite one of the vertical groups of contacts. This group selecting movement is in response to directive impulses sent over the line from the subscribers' station. A secondary magnet (SM, Fig. 1, Part 1) is provided to step the wipers in a vertical direction through the medium of a secondary shaft SS to select an idle contact set in the selected group. This secondary movement to select an idle set of contacts in the selected group is accomplished automatically, without the aid of directive impulses from the subscribers' station. The switch construction is preferably such that the wipers are advanced against the tension of a pair

of so-called watch springs, one spring opposing each movement respectively.

To release the switch wipers, and restore them to normal position after connection with one of the sets of contacts in a group, the secondary magnet is again actuated to step the wipers beyond the last or top contact of that group, whereby they are automatically restored to normal by the springs referred to, the wipers in being restored taking the path indicated by arrows in Fig. 3. Thus, in the operation of the switch the contacting ends of the wipers travel in a primary direction (rotary) to select a group of contacts, then in a secondary direction (vertical) to select a contact in that group, and in the release of the wipers this secondary travel is continued until the contacting ends have passed beyond the last or top contact in the group, when they are automatically released as shown by the arrows to normal position.

A set of primary off-normal spring contacts PON are moved upon the first primary step of the switch while a set of secondary off-normal spring contacts SON are moved upon the first secondary step of the switch, being restored upon restoration of the wipers from their respective movements as will be clear from the diagram. It is to be understood that for a more detailed description of this switch, reference is to be had to the above identified application.

First selector C comprises, besides its wipers and bank contacts, a primary magnet PM, a secondary magnet SM, a primary relay PR adapted to be energized by current over a calling line upon connection made with said switch C, a main release relay MRR which is adapted to be energized responsive to the initial energization of relay PR, a release relay RR adapted to be energized responsive to the initial energization of MRR, and a secondary relay SR adapted to be energized following the energization of RR. An impulse relay IR is also provided being controlled by the primary relay PR and adapted to transmit directive impulses for causing an operation of the switches, while a test relay T is adapted to be energized to effect the secondary movement of switch C to cause a secondary travel thereof to select an idle set of contacts in the selected group.

Upon the initial energization of relay MRR a locking circuit for itself is provided through its contact 25 and high resistance R, so that when its initial energizing circuit is interrupted due to the vibration of relay PR, a maintaining circuit through this high resistance R is closed. The current flowing through the winding of MRR maintains its armature attracted while relay PR is vibrating in response to impulses over the telephone line, which cause the primary movement of the switch wipers. Relay SR operates on the same principle as relay MRR, as will be more particularly pointed out.

Second selector D (Fig. 1, Part 2) is preferably of the same construction as the first selector, and comprises wipers and suitable bank contacts, operating magnets PM^1, SM^1, a release relay RR^1, and test relay T^1. Off-normal switches PON^1 and SON^1 are also provided.

Connector switch E of the same construction, comprises, besides its wipers and coöperating contacts, off-normal switches PON^2 and SON^2, operating magnets PM^2, SM^2, release relays RR^2, RR^3, switching relays SW and SW^1, a line test relay LT, a relay H, controlled by relay LT, and maintained energized while LT is energized, a flip-flop or interrupter relay FF for intermittently connecting ringing generator G and the bridged control relay CR across the terminals of the called line, a disconnect relay DR for disconnecting the ringing current upon response of the called subscriber, a circuit closing relay CL also energized when a called subscriber responds and a busy relay BR for controlling the application of a busy signal from busy back BB^1.

The called line L^1, called sub-station F and associated line switch B^1 are similar to the calling line equipment, the similar parts being indicated by like reference characters but with the suffix prime.

Operation of Fig. 1.—Having described in general the apparatus and circuit arrangement in the preferred embodiment of my invention the operation of the system illustrated, in connecting a calling and called line, will now be described.

Assuming a subscriber at station A desires to connect with a subscriber at substation F whose telephone number we will assume is 2343, he will remove his receiver from its switch hook whereby a circuit for line relay LR is established from battery through the winding of LR, wiper 9, normal contact 10, line conductor 5, substation A, line conductor 4, normal contact 11, the wiper 12 to ground. Relay LR is thus energized closing its alternate contact 13 and establishing an energizing circuit for cut-off relay CO through normal contact ON. Relays LR and CO being energized, a circuit for motor magnet M is established through their alternate contacts 14 and 15 respectively, whereby said magnet M advances wipers 9, 12 and 16 into engagement with the first set of contacts 17, 18, 19, which, we will assume leads to a busy first selector C. Therefore, the test contact 19 thereof is grounded through primary off-normal contacts PON, said contacts being in their alternate position when the selector C is busy, and a locking circuit for relay LR and CO is therefore established which

may be traced from ground through PON contacts, wiper 16 and alternate contacts 20, 21 and the windings of relays LR and CO respectively. Relay CO thus maintains the circuit of driving magnet M closed notwithstanding the opening of the circuit at off-normal contacts ON at the first step of the switch. Magnet M now advances the wipers another step and in fact continues such advancement until the test wiper 16 reaches an idle test-contact 19 which we will assume is the third one leading to first selector C. Assuming this is idle, as stated, it would be ungrounded and therefore the locking circuit for relays LR and CO is interrupted, but relay LR being a slow relay maintains its armature attracted until a locking circuit from switch C is provided, which will be later described, but relay CO being a quick relay immediately releases its armature opening its contact 15 in the circuit of driving magnet M, thus rendering the switch wipers inert. As above stated L is one of a group of 100 lines that has access to a group of ten first selectors C, and thus the first idle selector C of the group is automatically selected by the removal of the receiver from the hook of any one of said group of 100 lines.

Due to the closing of normal contacts 10, 11 of relay CO, when it is deënergized, a circuit for the primary relay PR of the selector C is established over the calling line, which may be traced from battery through the left hand winding of PR, the upper heavily marked primary conductor, contact 18, wiper 12, normal contact 11, the calling line and substation, normal contact 10, wiper 9, the selected contact 17 and the right hand winding of PR to ground, causing its energization.

Upon the closing of alternate contact 22 of PR, the locking circuit above referred to for the slow-acting line relay LR is established, traced over contact 19, wiper 16, alternate contact 20, and the winding of LR to battery thus maintaining said relay energized until a release is desired. Also responsive to the energization of PR a circuit for MRR is established traced from ground at normal contact 23 of PON, alternate contact 24 and winding of MRR to battery causing its energization. Alternate contact 25 is thereby closed establishing a second circuit for MRR through the comparatively high resistance R. Also responsive to the closure of alternate contact 25, a circuit is established through the winding of release relay RR causing its energization whereby its alternate contact 26 is closed, establishing an energizing circuit for secondary relay SR traced from said grounded alternate contact 26, normal contact 27, conductor 28, and the winding of SR to battery causing its energization. Its alternate contact 29 is therefore closed establishing a second or maintaining circuit for secondary relay SR, through comparatively high resistance R^1 and right hand winding of PR to ground.

One path for current through relays MRR and SR is through the contacts of relay PR. The relays MRR and SR, both being quick acting, would therefore be deënergized and release their armatures while PR was operating to step the switch around to the desired group, if it were not for the second or maintaining path for current through the windings of these relays including the high resistance R and R^1 respectively. As the first path for these relays through the contacts of relay PR is broken by its vibration in response to impulses from the substation, the second or high resistance path being closed maintains them in energized position, so that the relays MRR and SR are not deënergized but hold their armatures attracted until sufficient impulses have been sent through PR to move the wipers of the switch to the desired group of contacts. The high resistance path, however, only furnishes sufficient current to energize the relays MRR and SR between the intervals or vibrations of relay PR, so that when the desired group of contacts is reached and relay PR ceases to vibrate, relay SR, being energized now solely over the high resistance path, releases its armature, resulting in the operation of secondary magnet SM to move the wipers of the switch to the first idle contact in the selected group. If SR should be deënergized or release its armature while relay PR was vibrating the desired group would not be selected, but the wipers would be started in a vertical movement to select an idle contact in some group, before the desired vertical group of contacts was reached. (See Fig. 3). It is thus apparent that second relay SR, while quick acting, and the same in construction in this respect as relay PR, maintains its armature attracted during the vibrations of the latter, not because of any retarding means added thereto, but because it is continuously supplied with energizing current during such vibrations. Instead of retarding means the relay SR and the other relays in my invention that correspond to the slow acting or sluggish relays in other systems, are provided with two separate paths for energizing current, in the present embodiment, one of these paths being a low resistance path and the other a comparatively high resistance path. Said secondary relays, such as SR in Fig. 1, are first energized over the low resistance path through contacts of relay PR, and when this low resistance path is interrupted by the vibrations of relay PR, the high resistance path being closed at this time, the said relays are held energized and kept in actuated condition by current flowing in this high resist-

contact 24 is closed causing an operation of impulse relay IR, the three operations thereof causing the transmission of three primary or directive impulses to the primary magnet PM^1 of the selected switch D. Responsive to the first of said deënergizations of PR, its normal contact 22 is again closed establishing an initial or low resistance energizing circuit for the secondary relay SR traced through alternate contact 27, conductor 28, and the winding of SR to battery. Relay SR again closes its maintaining contact 29 whereby a second or alternate circuit for relay SR is again closed through the high resistance R^1 and the right hand end winding of PR to ground as previously described. This second circuit for SR is effective to maintain its armature attracted while the primary impulses are coming from normal contact 22, but as previously described, upon the cessation of these primary impulses the flow of current through the second circuit alone is not sufficient to maintain its armature attracted whereby it restores effecting a secondary circuit change for switch D as will be described.

Referring now to the said three operations of relay PR, three impulses of current are transmitted, as previously, through the winding of relay IR via contact 24 of relay PR and contact 31 of relay RR. Said relay IR thus actuates its armature three times and transmits three impulses of current to the primary driving magnet of switch D, over a path traced from its alternate contact 32, normal contact 46, wiper 35, contact 42, the upper heavily marked primary conductor to conductor 48 of switch D, normal contact 49 and winding of PM^1 to battery resulting in three operations of said primary driving magnet. The wipers 50, 51, 52 of switch D therefore receive three primary steps to select the third group of contacts which are the contacts extending to connector switches in the third hundredths group of the selected thousands group, and which includes the line of the called substation F.

Upon the first primary step of switch D, the primary off-normal contact 56 is closed so that upon the said retraction of the armature of secondary relay SR, a secondary circuit is established traced from ground through the right end winding of PR, normal contacts 29, 47, wiper 36, contact 43, the lower heavily marked secondary conductor, alternate contact 56, normal contact 57 and the winding of test relay T^1 to battery. Relay T^1 is thus energized closing its alternate contact 58 whereby a circuit for magnet SM^1 is established causing it to step the wipers into engagement with the first set of contacts in the selected group. Assuming this first set of contacts lead to a busy connector E, its test contact 53 has a busy or ground potential connected thereto (as will be pointed out) so that a maintaining circuit for relay T^1 is established traced from said grounded contact 53, wiper 50, alternate contact 59, alternate contact 60 and the winding of T^1 to battery, its initial energizing circuit having been interrupted at normal contact 57 on the first secondary step of the switch. Magnet SM^1 therefore continues to advance the wipers until an idle set of contacts is reached which we will assume are the contacts shown connected to connector E, and there being no busy potential upon these contacts, the circuit for relay T^1 is interrupted causing its deënergization and the consequent interruption of the circuit for SM^1 whereby the wipers remain in engagement with the contacts leading to selected switch E.

Upon deënergization of T^1 its normal contact 59 is closed, placing a ground or busy potential upon the selected test contact 53 and its multiples rendering them unselectable. This ground connection also is effective to cause energization of relay RR^2 of switch E, its circuit being traced over test conductor 64, normal contact 65 and the winding of RR^2 to battery causing its energization. Upon said restoration of T^1 its normal contacts 66, 67 being again closed, the circuit from the calling line is extended through to the connector E.

The subscriber at A now operates his calling device to effect four operations of relay PR, this corresponding to the third or tens digit of the called line number, this resulting in the energization of secondary relay SR in a manner as before described and also causing four operations of impulse relay IR whereby four impulses of current are transmitted through primary magnet PM^2 of switch E. These impulses to magnet PM^2 are traced from ground at alternate contact 32 of impulse relay IR, normal contact 46, wiper 35, contact 42, normal contact 66, wiper 51, contact 54, conductor 68, normal contacts 69, 70 and the winding of PM^2 to battery causing four operations thereof and four primary steps of wipers 71, 72, 73 to select the fourth group of contacts 74, 75, 76, which is the group including the terminals of the wanted line. Following the said primary impulses the secondary relay SR restores its armature in the manner as before described, whereby a secondary circuit is established including switching relay SW of connector E. This circuit is traced from ground through the right end winding of PR along the lower heavily marked secondary conductor through switch D, conductor 77 extending from the secondary conductor of switch E, alternate contact 78 (which is now closed), normal contacts 79, 80 and the winding of switching relay SW to battery. This relay is therefore energized closing its

ance or maintaining path. In my invention, therefore, all specially constructed or slow acting secondary relays are dispensed with, quick acting relays of standard construction being used in lieu thereof, and by providing two paths of high and low resistance respectively for said relays, I keep them energized in the regular way to wit, by supplying steady and continuous current thereto, as said relay PR vibrates, the current in the high resistance path permitting said relays to release their armatures after the impulses have been sent, but coöperating with the low resistance path to keep said relays energized until that time, or during the sending of the directive impulses. The manner in which the above operations are effected will now be described in detail:

We now have relays PR, MRR, RR, and SR energized over the previously described paths. The subscriber at station A now operates calling device 1 to effect operations of impulse springs 2 corresponding in number to the first digit of the called substation number which is 2, and thus select the second vertical group of contacts (see Fig. 3). The first interruption of contacts 2 causes an interruption of the circuit for the primary relay PR, whereby its contacts momentarily restore to normal, the closure of normal contact 24 (which is now also grounded through alternate contact 30 of RR) closing a circuit for impulse relay IR traced through alternate contact 31 and the winding of IR to battery. Such an energizing circuit for relay IR is closed responsive to each deënergization of relay PR and upon each such operation of IR its alternate contact 32 is closed establishing a circuit through normal contact 33 and winding of magnet PM to battery causing an operation thereof, each such operation affecting a primary step of wipers 34, 35 and 36.

Referring now to the other contact 22 of relay PR, upon its first momentary restoration to normal, and as soon as alternate contact 27 of PON is closed, a low resistance circuit is closed through SR, traced from the ground at said normal contact 22, alternate contact 27, conductor 28 and the winding of SR to battery, such a circuit being closed each time the armature of PR is vibrated. Relay PR having operated two times, remains energized over the line circuit until the calling device is operated for the second time. Therefore, normal contact 22 is maintained interrupted, and the low resistance circuit of relay SR is opened to allow the retraction of the armature of secondary relay SR to start the secondary selecting operation of the wipers, this being brought about in the following manner: As soon as normal contact 29 of SR closes, a circuit for test relay T is established traced from ground through the right end winding of PR, normal contact 29, conductor 37, alternate contact 38, normal contact 39, and the winding of T to battery, causing its energization and the closing of its alternate contact 40, thus establishing an operating circuit for secondary magnet SM and its generator. The first impulse of current from the generator operates said magnet to step wipers 34, 35, and 36 into engagement with the first set of contacts 41, 42, 43 of the selected second group. Assuming the first set of contacts lead to a busy second selector D, the test contact 41 thereof will be grounded whereby a maintaining circuit for relay T is provided traced from the said grounded contact 41, wiper 34, alternate contact 44, alternate contact 45 and the winding of T to battery. As long as test wiper 34 is engaging a busy test contact 41, it will be seen that relay T remains energized, so that magnet SM continues to advance the wipers until an idle set of contacts is reached. Assuming the set of contacts shown as extending to second selector D are the first idle set in the group, no busy potential will be present at its test contact 41 so that the maintaining circuit for relay T is interrupted, causing its deënergization and the interruption of the circuit for SM, whereby the wipers 34, 35, 36 remain in engagement with the selected set of idle contacts.

In order to prevent interference with any established connections over which wipers 35, 36 may move during the trunk selecting operation of the switch, their circuit is interrupted at normal contacts 46, 47 of relay T. After the selection this relay deenergizes as stated and the circuit of the calling substation is extended to an idle second selector switch D in the thousand group, which includes the line of the called substation.

It will be noted that upon the first secondary step of switch C its secondary off-normal contacts SON move to their alternate position disconnecting magnet PM and interrupting the initial energizing circuit for relay T.

Upon deënergization of relay T, normal contact 44 is closed placing ground upon the multiple contacts 41 connected to wiper 34, whereby an energizing circuit for relay RR^1 of secondary selector D is established, traced over test conductor 61, normal contact 62, and the winding of RR^1 to battery, causing its energization, whereby its alternate contact 63 establishes a locking circuit for it. This ground potential at 44, placed upon multiple contacts 41 also renders them unselectable by any other first selector.

The subscriber at A now operates calling device 1 to effect three interruptions of the circuit for relay PR and responsive to each ensuing deënergization thereof its normal

alternate contact 80 and establishing a locking circuit for itself through normal contact 81 to grounded test conductor 64. Alternate contact 82 of relay SW is also closed thereby disconnecting the primary magnet PM^2 and connecting the secondary magnet SM^2 to the primary conductor.

The subscriber at A now operates his dial to cause three operations of primary relay PR, these operations corresponding in number to the last or units digit of the called line number, whereby three impulses are transmitted from impulse relay IR to switch E followed by the retraction of the armature of SR in a manner as previously described. The said last three impulses of current are traced over the previously described path including the upper or heavily marked primary conductor to conductor 68 of switch E, alternate contact 82, normal contact 83, the winding of SM^2 to battery at normal contact 84. The ensuing three operations of SM^2 are effective to step wipers 71, 72, 73 into engagement with the third set of contacts 74, 75, 76 which are the terminals of the called line.

Following the transmission of the last series of impulses, secondary relay SR retracts its armature in a manner as previously described to effect a secondary circuit change at switch E by the application of ground through the right end winding of relay PR to the secondary conductor of switch E. This ground connection then extends over conductor 77, switch E, alternate contacts 78, 79, normal contacts 85 and the winding of switching relay SW′ to battery causing its energization. Its alternate contact 85 is thereby closed establishing a locking circuit for itself over conductors 86, 87 to ground at alternate contact 88. Its normal contact 81 is also interrupted thereby interrupting the locking circuit for relay SW causing its deënergization. Also responsive to said energization of SW^1 its alternate contact 90 is closed to connect line test relay LT in circuit with the test contact 74 of the seized line. This circuit is traced from wiper 71, alternate contact 91 (relay BR having been energized over a circuit including normal contact 90 and alternate primary off-normal contact 88 upon the first off-normal step of the switch), the lower winding of LT, conductor 97, alternate contacts 92, 90, conductors 86, 87 to ground at alternate contact 88. Although the initial energizing circuit for BR is interrupted at normal contact 90 when SW^1 is energized, BR, being a slow-acting relay, maintains its contact 91 closed until a substitute energizing circuit for BR is established, providing the called-for line is idle, as will be described. Returning now to relay LT, it will be noted that its lower winding has its terminals connected between ground at alternate contact 91 and the wiper 71.

Up to this period the operation of switch E is the same whether connection has been made with an idle or a busy line but after this period the operation differs depending upon whether the called line is idle or busy.

Called line idle.—Assuming that the called line is idle there will be no ground or busy potential upon its test contact 74, as indicated in Fig. 1, part 3, so that upon wiper 71 making connection therewith and the circuit through the lower winding of relay LT closed by the closing of alternate contact 90 as described, an energizing circuit for LT is established over the said circuit including its lower winding, wiper 71, contact 74, ON^1 and the winding of CO^1 causing the energization of both relays LT and CO^1, the energization of CO^1 removing the substation control of its line switch B^1.

Upon energization of LT, its alternate contact 93 is closed causing the energization of relay H whose alternate contact 94 closes, reëstablishing an energizing circuit for relay BR thus maintaining its armature attracted. The closing of alternate contacts 95^1, 95^2, of relay LT shunts the lower winding thereof, but a maintaining circuit therefor is established from battery through its upper winding and the current reducing resistance 96, alternate contacts 95, 95^1, conductor 97, alternate contacts 92, 90, conductors 86, 87, to ground at alternate contact 88. This ground connection is also extended through alternate contacts 95^2, 91 and wiper 71 to the engaged terminal 74 maintaining a direct ground upon this terminal and its multiples and thus rendering the associated line unselectable by any other connector. Also, upon the closure of alternate contact 93 of LT, a path for current through relay FF is established including conductor 98, normal contact 99, the winding of FF and interrupter I to battery. By the operation of interrupter I, relay FF is periodically energized thereby operating its contacts 100, 101 to alternately connect generator G and control relay CR in bridge of the terminals 75, 76 of the called line. Upon each connection of current from ringing generator G the call bell at substation F is operated, the circuit therefor being traced from the upper terminal of generator G, alternate contact 100, wiper 72, terminal 75, over the line and through the condenser and call bell of station F, returning through terminal 76, wiper 73, conductor 102, alternate contact 101, to the lower terminal of generator G.

Upon each retraction of the armature of FF, relay CR is connected in bridge of the called line, this circuit being traced from battery through the upper winding thereof, alternate contact 103, normal contact 100, to

the terminal of the called line, while the other winding of CR is connected through alternate contact 104, normal contact 101, terminal 76 of the called line. Due to the condenser included in circuit at the substation F while the receiver is on its switch hook, there is no path for direct current for relay CR so that it does not energize until the called subscriber answers the call and removes his receiver from its switch hook thereby providing a path for direct current over the called line. Thus, when the subscriber at F removes his receiver in response to a call and upon the following deënergization of FF, a path for direct current through control relay CR is provided over the previously described path causing its energization. Therefore its alternate contact 105 is closed maintaining relay RR² energized as long as the receiver remains off the switch hook at substation F and relay CR thereby energized. This prevents the release of switch E until the called subscriber replaces the receiver.

Returning now to CR, the closure of its alternate contact 106 is effective to prevent another application of ringing current to the called line, also by the ensuing energization of relay CL causing the establishment of a talking circuit by the closing of alternate contacts 107, 108. Responsive to said energization of CL alternate contact 109 is closed establishing an energizing circuit for disconnect relay DR which closes its alternate contact 110 establishing a locking circuit for itself over conductor 87 to ground at alternate contact 88. Relay DR therefore interrupts its normal contact 99 rendering relay FF inert and preventing any further application of ringing current to the terminals of the called line. The two substations are now connected over a conversational circuit including the heavily marked primary and secondary conductors, a condenser 111 being interposed in the primary conductor at first selector C while a condenser 111¹ is interposed in the secondary conductor at connector E, these condensers being connected in circuit to prevent interference between the control circuits of the respective substations.

The talking battery for the calling substation is provided through the windings of relay PR, while talking battery for the called substation is provided through the winding of relay CR.

Release.—After the subscribers have finished conversation by replacing their receivers upon their respective switch hooks they may effect the release of the switches used in establishing the connection. The release of the switches is preferably controlled from both substations, that is, release of switches B, C and D is effected when the calling subscriber replaces the receiver while the release of the connector E is effected when the called subscriber replaces his receiver. This order of release may, of course, be varied.

Assuming now, that the subscriber at F replaces his receiver, the previously described circuit through relay CR is interrupted at the switch hook of station F whereby said relay restores. Due to the interruption of alternate contact 106 of CR, relay CL is restored closing its normal contact 109 and thereby establishing an energizing circuit for release relay RR³ through alternate contacts 112, 113. Relay RR³ is therefore energized interrupting the circuit for RR² causing its restoration, but relay RR³ is maintained energized through normal contact 113 of RR² and normal contact 88 to ground. The restoration of RR² and consequent interruption of its alternate contact 92 effects the restoration of relays LT and CO¹, and due to the interruption of alternate contact 93 of LT, relay H restores disconnecting relay CR from the wipers and by the interruption of its alternate contact 94 allows relay BR to deënergize.

Returning now to RR³, due to the closing of its alternate contacts 83, 84, magnet SM² is connected in circuit with the alternating current generator 114 whereby the wipers are advanced in a secondary direction as already described causing their restoration and the restoration of the off-normal contacts. As soon as contact 88 of PON² restores to normal, relays SW¹, RR³, and DR restore, as it will be remembered these relays were held energized over circuits including said grounded contact 88. Upon restoration of RR³ its normal contact 65 is again closed and as test conductor 64 may still be grounded from second selector D, RR² again becomes energized but this is only incidental and has no effect upon the switch at this time.

The cut-off relay CO¹ of switch B¹ having been restored, the line of substation F is available for use in establishing other connections.

Upon the subscriber at A replacing his receiver, the circuit for relay PR is interrupted causing its restoration and the interruption of its alternate contact 24. Although the interruption of alternate contact 24 opens the high voltage path for current through relay MRR, alternate contact 25 thereof being closed there is still a flow of current through the second of low voltage path including high resistance R, but this is not sufficient to maintain the armature of relay MRR attracted. Said armature therefore restores interrupting alternate contact 25 and thus allowing the release relay RR to restore.

Upon the closing of normal contact 45 of RR, a circuit for relay T is established

traced from battery through the winding of said relay, normal contact 45, alternate contact 27 normal contact 22 to ground. Relay T therefore closes its alternate contact 40 effecting an operating circuit for magnet SM whereby the wipers are advanced to effect their release in a manner as previously described, also causing the off-normal switches to be restored. Upon the interruption of alternate contact 27 of PON, the circuit for relay T is interrupted causing its deënergization and the interruption of the circuit for SM.

It will be noted that upon the closing of normal contact 22 and the release operation just described, ground is connected through alternate contact 27, conductor 28, and the winding of SR to battery causing the energization of SR, but this has no effect upon the release of switch C as relay SR again restores when the alternate contact 27 of PON is interrupted.

Another incidental operation may occur when the calling subscriber replaces his receiver for release purposes, this being an application of ground over the primary conductor. This is brought about in the following manner. Upon restoration of PR its normal contact 24 closes, and as relay RR maintains its armature in an attracted position for an instant after restoration of PR, ground will be connected through alternate contact 30 of RR, normal contact 24, alternate contact 31, and relay IR to battery, causing a momentary energization thereof and causing a short application of ground through its alternate contact 32 to the primary conductor. This incidental application of ground to the primary conductor in the present embodiment of my invention, is effective to cause a primary step of connector E (if said connector was released by the called subscriber before the calling subscriber replaces his receiver) but thereafter if said connector E is so operated, it is automatically restored. This incidental operation of connector E is brought about as follows: The ground impulse to the primary conductor follows a path over conductor 68 of switch E, normal contacts 69, 70 and PM^2, to battery, causing a primary step of the wipers 71, 72, 73, leaving the switch off-normal until released as will be described.

Returning now to switch C, upon the said releasing energization or operation of relay T, its normal contact 44 is interrupted disconnecting ground from test wiper 34 whereby the locking circuit for RR^1 of switch D is interrupted causing its restoration. A release circuit is thus closed for relay T^1 traced from ground at alternate contact 115 of PON^1, normal contact 60 through winding of T^1 to battery. Its alternate contact 58 is thereby closed establishing an energizing circuit for SM^1 whereby the wipers are advanced and the restoration of switch D effected in a manner as previously described. It will be noted that while switch D is restoring a ground or busy potential is connected to test conductor 61 due to the closing of normal contact 116 of relay RR^1, this being removed when alternate contact 62 of PON^1 is interrupted. Switch D having been restored is available for use in establishing other connections.

Now as to the restoration of switch B, this is effected upon restoration of switch C due to the interruption of alternate contact 23 of PON, this bringing about the restoration of relay LR which has been held energized through this alternate contact 23. Upon restoration of LR its normal contact 13 is closed connecting ground through alternate contact ON and the winding of CO to battery. Thus relay LR being deënergized and relay CO energized, both retaining pawls 7, 8 are disengaged from the ratchet 6 allowing the wipers to be restored. Upon restoration of contact ON the circuit for CO is interrupted causing its deënergization whereby switch B is at normal and available for use in extending other connections.

Connector E it will be remembered was incidentally stepped one point off normal, and relay RR^2 thereof was energized over the circuit including the grounded test conductor 64. But, upon the removal of this ground due to the interruption of normal contact 59 of relay T^1, switch D, relay RR^2 restores energizing relay RR^3 and causing a restoring operation of switch E from the incidental operation.

In the previous description of the release operation it was assumed that the subscriber at the called substation was the first to replace the receiver upon its switch hook. We will now trace the release operation under the assumption that the subscriber at the calling substation was the first to replace the receiver followed by the replacing of the receiver at the called substation. In such a case relay PR deënergizes upon replacing the receiver at substation A, causing a restoration of the switches C, B and D in a manner as previously described. In this instance the connector switch is not affected because its release relay RR^2 is energized over a path including grounded alternate contact 105 of relay CR, said relay CR being maintained energized over the calling line. Therefore, when the subscriber at substation F replaces his receiver, relay CR restores to normal followed by the deënergization of RR^2, while due to the interruption of alternate contact 106 of CR, relay CL restores. Responsive to the restoration of RR^2, relay RR^3 energizes closing a circuit through SM^2 whereby the wipers are automatically restored in a manner as previously described. Also, upon restoration of

RR², due to the interruption of its alternate contact 92, relays LT and CO¹ restore, the restoration of alternate contact 93 of LT causing the restoration of relay H followed by the restoration of BR as before described. Upon restoration of PON², relays DR and SW¹ are restored whereby the switch being at normal is available for further use in establishing other connections.

The restoration of CO¹ of line switch B¹ restores the substation control of its line switch whereby the line is free to be used in establishing other connections.

Called line busy.—In the previous description it was assumed that the called line was idle upon connection made therewith. It will now be assumed that said line is a busy line upon connection being made therewith, in which case its test terminal 74 will have a ground or busy potential connected thereto either from alternate contact 13¹ of switch B¹ if the line be calling, or from the grounded test wiper 71 connected to multiple of terminal 74 if the line be a called line.

It will be remembered that following the last secondary circuit change, relays RR², SW¹ and BR were in an energized condition and the closing of alternate contact 91 of relay BR had connected the lower winding of line test relay LR in circuit between ground at alternate contact 88 of PON² and test wiper 71 and terminal 74. It will be remembered also that upon connection with the idle line relay LR was energized, but in the present case there being ground or busy potential upon test terminal 74, no energizing circuit for LT of T is provided as both of its terminals are connected to ground, and it remains inert. Therefore, relay H is not energized so that slow-acting relay BR restores closing its normal contact 117 connecting busy back BB¹ through alternate contact 70 and normal contact 82 to the primary conductor. This busy tone follows a path back over the primary conductor and out through the receiver of the calling substation A then back over the lower heavily marked primary conductor through the right end winding of relay PR to ground. The subscriber at A in response to this signal knows that the wanted line is busy and therefore replaces his receiver upon its switchhook interrupting the circuit for relay PR. Upon restoration of relay PR, switches C, D, and B are restored in a manner as previously described, and in the present instance switch E being off-normal is also restored. This is brought about in the following manner. Upon the interruption of normal contact 59, relay T¹ of switch D, the energizing circuit for RR² is interrupted (relay CR not having been energized) causing restoration of RR² whereby its normal contact 113 is closed connecting ground from alternate contact 88 through the winding of RR³ to battery. Relay RR³ closes its alternate contacts 83, 84 establishing an operating circuit for SM² as before, whereby the wipers are advanced effecting the restoration of switch E in a manner as previously described. Upon interruption of alternate contact 88 relays RR³ and SW¹ are restored and switch E being at normal is available for use in establishing other connections.

In connection with line switch B, means are provided to indicate to the calling subscriber when such switch has not been able to find an idle trunk. For instance if all of the trunks leading from contacts 17, 18, 19 are busy, their test contacts 19 will be grounded causing the switch to step to the last set of contacts 17¹, 18¹, 19¹. There being no ground connected to terminal 19¹, relay CO immediately deënergizes but relay LR maintains its armature attracted due to its slow acting construction so that upon the closing of normal contacts 10, 11 of CO, a locking circuit for LR is established from ground through busy back BB, terminal 18¹, wiper 12 over the calling line, returning to wiper 9, contact 17¹, contact 19¹, wiper 16, alternate contact 20, and winding of LR to battery. A characteristic signal is thus transmitted from BB over the path just described whereby the subscriber at A receiving such signal knows that all of the trunks are busy and therefore replaces his receiver upon its switch hook. The circuit for LR being thus interrupted, it restores to normal closing an energizing circuit for CO as before, and relay LR being deënergized and CO energized, both retaining pawls 7, 8 are disengaged from ratchet wheel 6 and the wipers restore to normal. Upon restoration of ON, relay CO is deënergized.

Several alternating current generators are illustrated, these being used for effecting the operation of certain of the motor magnets, but it is to be understood that these generators may be all one and the same but have been shown in this manner to simplify the drawings. Also a number of batteries are shown in different parts of the drawings but it is to be understood that these may be one and the same batteries, and those terminals which are shown connected to ground, in practice would be connected to the grounded terminal of the battery.

While I have embodied my invention in what is known as a complete automatic telephone system, it is apparent that my invention is by no means limited to such a system and furthermore while I have embodied it in circuits for controlling switches of certain characteristics, my invention is not limited to such particular switches. Also many changes and modifications will be apparent, and therefore I do not desire to be limited to the structure as shown and de-

scribed but aim to cover all that which comes within the spirit and scope of the appended claims.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, a quick-acting release relay having an energizing circuit closed responsive to the initial energization of the primary relay and interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay, and means for closing it and holding it closed during the period of said interruptions of its first said circuit, and operating and release means for said switch controlled by said primary and release relays.

2. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, a quick-acting release relay having an energizing circuit closed responsive to the initial energization of the primary relay and interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay and means for closing it and holding it closed during the period of said interruptions of its first said circuit whereby its armature is maintained attracted during such interruptions, operating means for said switch responsive to said primary relay operations, release means for said switch rendered ineffective while said release relay has its armature attracted, and means for causing a prolonged interruption of said metallic circuit whereby said primary and release relays are restored and said release means rendered effective.

3. A telephone system comprising a metallic circuit telephone line, an automatic switch, a primary relay energized by current over said line and responsive to rapid interruptions of said metallic circuit, a quick-acting release relay having a high current value energizing circuit closed responsive to the initial energization of the primary relay and interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay and means for closing it and holding it closed during the period of said interruptions of its high current value circuit, and operating and release means for said switch controlled by said primary and release relays respectively.

4. A telephone system comprising a metallic circuit telephone line, an automatic switch, a primary relay energized by current over said line and responsive to rapid interruptions of said metallic circuit, a quick-acting release relay, means for closing an energizing circuit for said relay responsive to the initial energization of the primary relay and interrupting said circuit responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay and means for closing it and holding it closed during the period of said interruptions of its said first circuit, driving mechanism for said switch operated responsive to said primary relay operations, and release means for said switch jointly controlled by said primary and release relays.

5. A telephone system comprising a metallic telephone line, a primary relay energized by current over said line, an automatic switch, a quick-acting release relay energized responsive to said energization of the primary relay, said energizing circuit for the release relay being over a low resistance path, means for causing rapid interruptions of said metallic circuit to cause similar operations of said primary relay whereby said low resistance energizing circuit for the release relay is rapidly interrupted, a second comparatively high resistance energizing circuit of continuous flow for said release relay and means for closing it and holding it closed during the period of said interruptions of its said low resistance circuit, and operating and release means for said switch controlled by said primary and release relays respectively.

6. A telephone system comprising a metallic circuit telephone line, an automatic switch, a primary relay energized by current over said line and responsive to rapid interruptions of said metallic circuit, a quick-acting release relay having a low resistance energizing circuit closed responsive to the initial energization of the primary relay and interrupted responsive to said primary relay operations, a second comparatively high resistance energizing circuit of continuous flow for said release relay and means for closing it and holding it closed during the period of said interruptions of its low resistance circuit, and operating and release means for said switch controlled by said primary and release relays respectively.

7. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, primary driving mechanism for said switch responsive to said primary relay operations, a quick-acting secondary relay having an energizing circuit closed responsive to said primary relay and interrupted respon-

sive to said primary relay operations, a second energizing circuit of comparatively low current value and of continuous flow for said secondary relay and means for closing it and holding it closed during the period of said interruptions of its first said circuit whereby its armature is maintained attracted during such interruptions, said armature being retracted upon cessation of said primary relay operations to effect a secondary circuit change for said switch.

8. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, primary driving mechanism for said switch responsive to said operations of the primary relay, a quick-acting secondary relay having an energizing circuit closed responsive to said primary relay and interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and of continuous flow for said secondary relay and means for closing it and holding it closed during the period of said interruptions of its first said circuit whereby its armature is maintained attracted during such interruptions, said armature being retracted upon cessation of said primary relay operations whereby a secondary circuit change is effected, means for causing a secondary operation of said switch responsive to said secondary circuit change, and means for restoring said switch.

9. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, primary driving mechanism responsive to said primary relay operations, quick-acting release and secondary relays each having an energizing circuit periodically closed through contacts of said primary relay while operating, a second energizing circuit of comparatively low current value and continuous flow for each of said release and secondary relays and means for closing it and holding it closed during the period of said interruptions of their first said circuits, whereby said relays maintain their armatures attracted, said secondary relay being adapted to retract its armature upon cessation of said primary relay operations to effect a secondary circuit change for said switch, and release means controlled by said release relay.

10. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary quick-acting relay having the continuity of its circuit broken responsive to the rapid operations of said primary relay, and a low current value maintaining circuit for said secondary relay, said maintaining circuit being continuous and preventing the deënergization of said secondary relay during the period of operations of said primary relay.

11. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary quick-acting relay having two circuits, one of said circuits being of high current value and broken by the rapid operations of said primary relay, and the other circuit being of low current value and of continuous flow during the period of said operations, so that said secondary relay is maintained energized during said period.

12. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary quick-acting relay having two circuits, one of low resistance and the other of high resistance, the low resistance circuit being broken by the rapid operations of said primary relay, and the high resistance circuit being of continuous flow during the period of said operations, so that said secondary relay is not deenergized until after the primary relay has operated.

13. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary quick-acting relay having two circuits of different current values, one of said circuits being of sufficient value to energize said secondary relay but being broken responsive to the operations of said primary relay, and the other circuit being of continuous flow during the period of operation of said primary relay and insufficient value to energize said relay, but sufficient to maintain it energized during said broken periods in the first mentioned circuit.

14. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary quick-acting relay having two energizing circuits, one a vibrating energizing circuit responsive to the operations of said primary relay, and the other a continuously energizing circuit, said continuous circuit being only of sufficient

strength to maintain said secondary relay energized when assisted by said vibrating circuit.

15. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, means controlled by said primary relay for giving said switches a primary movement, a secondary quick-acting relay having a high resistance and a low resistance path for current, said low resistance path being interrupted responsive to the operations of said primary relay, but said high resistance path having current of continuous flow for maintaining said secondary relay energized during the period of said interruptions, and means operative when said secondary relay is deënergized for giving said switches a secondary movement.

16. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a quick-acting release relay having the continuity of a low resistance circuit thereof broken responsive to the rapid operations of said primary relay, and a high resistance maintaining circuit for said release relay, said maintaining circuit being of continuous flow and preventing the deenergization of said release relay during the operations of said primary relay.

17. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a quick-acting release relay having two circuits, one of said circuits being of low resistance and broken by the rapid operations of said primary relay, and the other circuit being of high resistance and of continuous flow during the period of said operations, so that said release relay is maintained energized during said period, and a release circuit for said switch controlled by said release relay.

18. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a quick-acting release relay having two circuits of different current values, one of said circuits being of sufficient value to energize said release relay but being broken responsive to the operations of said primary relay, and the other circuit being of continuous flow but of insufficient value to energize said relay, but sufficient to maintain it energized during said broken periods in the first mentioned circuit, and a release circuit for said switch controlled by said release relay.

19. A telephone system, including subscribers' metallic telephone lines, automatic switches for making connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a quick-acting release relay having two circuits, one a vibrating circuit responsive to the operations of said primary relay, and the other a continuous flow circuit, said continuous circuit being only of sufficient strength to maintain said release relay energized when assisted by said vibrating circuit, and a release circuit for said switch controlled by said release relay.

20. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, a quick acting release relay for said switch, means for closing an energizing circuit for said release relay, said circuit being rapidly interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay, and means for closing it and holding it closed during the period of said interruptions of its first circuit so as to maintain the armature of said release relay attracted, and operating and release means for said switch controlled by said primary and release relays.

21. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said metallic circuit and responsive to rapid interruptions thereof, a release relay, means for closing an energizing circuit for said release relay, said release relay having its said energizing circuit rapidly interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for said release relay, and means for closing it and holding it closed during the period of said interruptions of its first closed circuit whereby its armature is maintained attracted during such interruptions, operating means for said switch responsive to said primary relay operations, release means for said switch rendered ineffective while said release relay has its armature attracted, and means for causing a prolonged interruption of said metallic circuit whereby said primary and release relays are restored and said release means rendered effective.

22. A telephone system comprising a metallic circuit telephone line, an automatic switch associated therewith, a primary relay energized by current over said line and responsive to rapid interruptions of said

metallic circuit, a release relay, a high current value energizing circuit closed responsive to said primary relay and rapidly interrupted responsive to said primary relay operations, a second energizing circuit of comparatively low current value and of continuous flow for said release relay with means for closing it and holding it closed during the period of said interruptions of its high current value circuit, and operating and release means for said switch controlled by said primary and release relays respectively.

23. A telephone system including an automatic switch, a metallic control circuit for said switch including a primary relay energized by current over said circuit and responsive to rapid interruptions thereof, primary driving mechanism responsive to said primary relay operations, release and secondary relays, energizing circuits for said last two relays periodically closed responsive to said primary relay operations, a second energizing circuit of comparatively low current value and continuous flow for each of said release and secondary relays and means for closing and holding closed during the period of said interruptions of their first said circuits, whereby said relays maintain their armatures attracted, said secondary relay being adapted to retract its armature upon cessation of said primary relay operations to effect a secondary circuit change for said switch, means whereby a prolonged interruption of said control circuit causes the deënergization of said primary and release relays to cause the release of said switch.

24. A control circuit for automatic switches comprising a primary or impulse relay, a second relay, an energizing circuit for said second relay responsive to said primary relay whereby said second relay attracts its armature, means for rapidly interrupting the circuit of said primary relay whereby it interrupts said energizing circuit of the second relay accordingly, a second energizing circuit of continuous flow for said second relay of itself not sufficient to hold the armature thereof attracted, means for closing this second circuit and holding it closed during the period of interruptions of the first said circuit thereof whereby the armature of said second relay is maintained attracted during said interruptions, and circuits controlled by each of said relays respectively.

25. A control circuit for automatic switches comprising a primary or impulse relay, a second relay, a high current value energizing circuit for said second relay responsive to said primary relay whereby said second relay attracts its armature, means for rapidly interrupting the circuit of said primary relay whereby it interrupts said energizing circuit of said second relay accordingly, a low current-value energizing circuit of continuous flow for said second relay of itself not sufficient to hold the armature thereof attracted, means for closing this low current-value circuit and holding it closed during the period of interruptions of the high current-value circuit whereby the armature of said second relay is maintained attracted during said interruptions, and circuits controlled by each of said relays respectively.

26. A telephone system including subscribers' telephone lines, automatic switches of the two-motion type for completing connection between said lines, a primary relay responsive to rapid variations of current in the line of a calling subscriber, a secondary relay provided with two circuits one of low resistance and the other of high resistance, the low resistance circuit being broken by the rapid operations of the said primary relay and the high resistance circuit being of continuous flow during the period of said operations, means controlled by the operations of said primary relay for controlling one of the motions of said switches, and means controlled by the said secondary relay for controlling the second motion of said switches.

27. In a telephone system an automatic switch of the two-motion type for extending a connection from the line of a calling subscriber in the direction of the line of the called subscriber, a primary relay for said automatic switch responsive to current variations in the line of the calling subscriber, a secondary relay having two circuits one of low current consumption and the other of high current consumption, the low current path being interrupted by the operations of the said primary relay and the high current path being of continuous flow during the period of said operations of the primary relay, means controlled by the said primary relay to control one motion of said switch and automatic means controlled by the secondary relay for controlling the second operation of said switch.

28. In a telephone system a calling subscriber's line, an automatic switch accessible to said calling subscriber's line, said automatic switch being of the two-motion type and provided with means for operating the said switch in one direction to elect a group of trunk lines and means for operating the said switch in another direction to automatically select a trunk line in the elected group, a primary relay responsive to current variations in the calling subscriber's line for controlling the said first motion and a secondary relay for controlling the second motion of said switch the said secondary relay being provided with two circuits, one of low resistance and the other of high resistance, the low resistance circuit being

broken by the rapid operations of said primary relay and the high resistance circuit being of continuous flow during the period of said operations of the said primary relay.

29. A telephone system comprising a primary relay an energizing circuit therefor, an automatic switch, secondary and release relays, each of said last two relays having high and low current-value energizing circuits, the low current-value circuits being of continuous flow and not sufficient by themselves to hold the armatures of the relays attracted, means responsive to rapid operations of the primary relay to render the two said circuits of each relay effective so as to maintain their armatures attracted during the period of operations of the primary relay, to operate said switch.

Signed by me at Chicago, county of Cook, and State of Illinois, in the presence of two witnesses.

CHARLES S. WINSTON.

Witnesses:
M. R. ROCHFORD,
G. E. MUELLER.