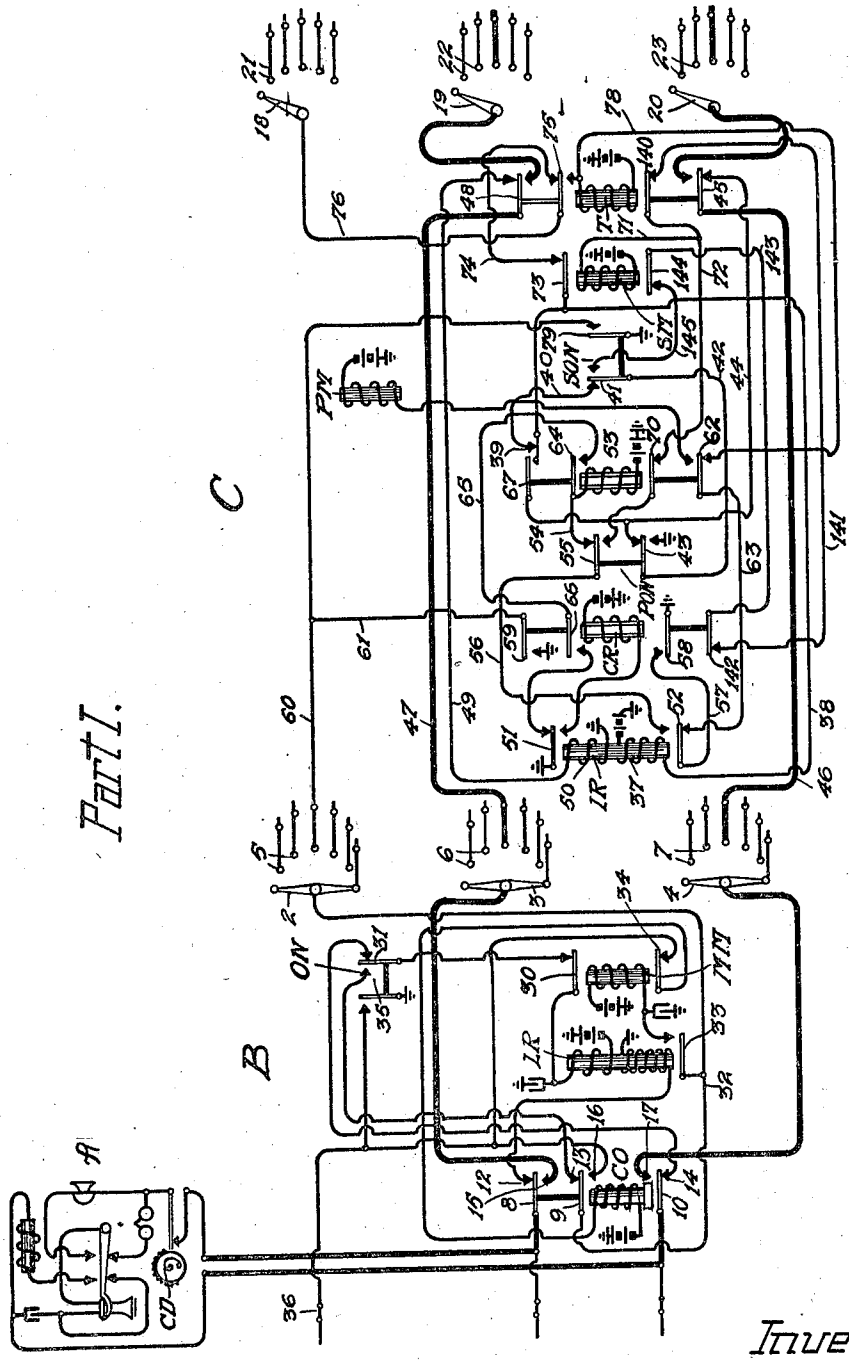
July 31, 1923. 1,463,164

H. H. IDE

TELEPHONE SYSTEM

Filed July 28, 1919 2 Sheets-Sheet 1



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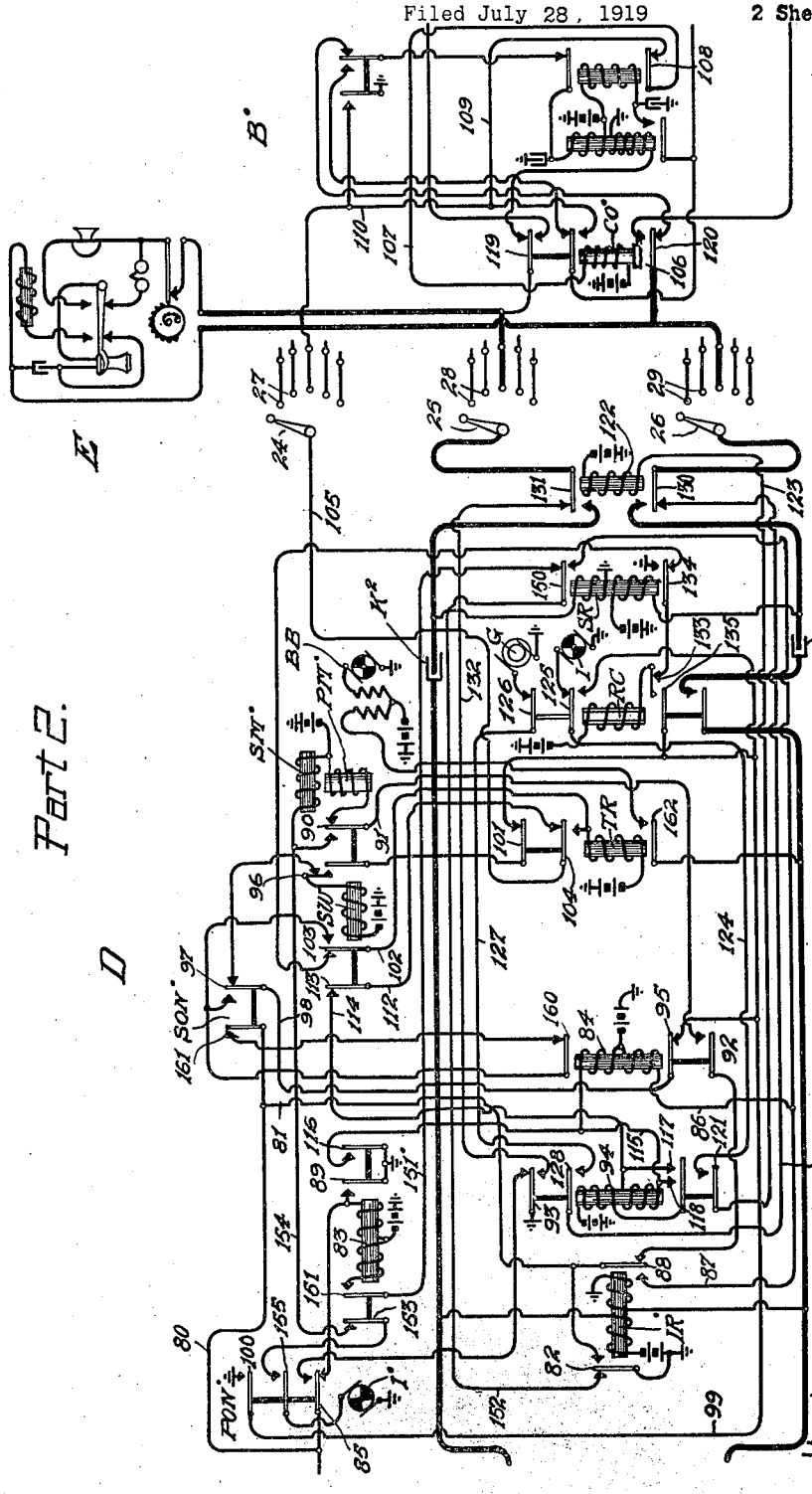

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Patented July 31, 1923. 1,463,164

UNITED STATES PATENT OFFICE.

HARRY H. IDE, OF LA GRANGE, ILLINOIS, ASSIGNOR TO KELLOGG SWITCHBOARD AND SUPPLY COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

TELEPHONE SYSTEM.

Application filed July 28, 1919. Serial No. 313,799.

To all whom it may concern:

Be it known that I, HARRY H. IDE, a citizen of the United States of America, residing in La Grange, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Telephone Systems, of which the following is a specification.

My invention relates to telephone systems of the two-wire or metallic line type in which the directively controlled switches at the exchange are operated responsive to a series of rapid interruptions of the subscribers' line circuits, and more particularly to a circuit arrangement adapted to operate in connection with a directively controlled switch.

A feature of my invention is the provision of an automatic numerical or selector switch for use in an automatic telephone system, which is provided with only four operating relays and the necessary operating magnets.

A further feature of my invention is the provision of a combined impulse and test relay. The relay, when its windings are serially connected, acts as an impulse relay and receives impulses from the calling device at a calling substation to actuate means to step the wipers of the switch in a primary direction to a desired group of contacts. When used as a test relay, after the termination of impulses, one winding is connected in a local circuit with the private test wiper through the contact of a secondary magnet for testing purposes, and by this arrangement I reduce the number of relays required to actuate a switch.

The novel features of my invention through the provision of which the above-mentioned and other advantageous results are obtained will be explained by reference to the accompanying drawings in which Parts 1 and 2 illustrate diagrammatically an automatic telephone system embodying my invention.

Referring now more particularly to the system as illustrated in the drawings, which comprises Parts 1 and 2, the substation A in Part 1 comprises the usual switch hook and substation equipment, and includes a calling device CD. The said substation A is connected by means of two line limbs, as shown, to a line switch B at the exchange. The line switch B is adapted upon the initiation of a call from the substation A to automatically connect with an idle first selector C as shown in Part 1. The subscriber at A by the use of the calling device CD in connection with the substation equipment may by its actuation operate the first selector C to extend the connection from the said substation A to an idle connector switch D. The subscriber at A then may by the further actuation of his calling device CD operate the connector switch D to connect to the terminals of the called line E. If the called line E is idle, ringing current is automatically applied to the terminals thereof to signal the subscriber thereat. Should the line of the called for subscriber be busy, a characteristic busy signal will be automatically transmitted back to the calling subscriber who may by replacing his receiver upon its switch hook release the switches which are used in extending his line to the line of the called for subscriber at substation E.

The switch B is diagrammatically illustrated and comprises a double wound line and test relay LR, a single wound cut off relay CO and a motor magnet MM. The line relay LR is adapted to be energized over the two sides of the subscriber's line in series. The cut off relay CO is adapted when energized to disconnect the subscriber's line circuit from the line relay LR and to connect the switch wipers to the subscriber's line circuit provided the line switch B is being used for calling purposes. Motor magnet MM is provided for stepping the switch shaft and wipers 2, 3 and 4 step by step over the bank contacts 5, 6, and 7. The switch wipers 2, 3 and 4 are adapted to always be rotated in the same direction and do not restore to normal, that is, the switch wipers do not have a normal position but remain in their antecedent progressive position when a connection is released. The wipers 2, 3 and 4 are double ended wipers and as one contact end of these wipers moves off the last contacts of their respective switch banks the other contacting ends thereof move into engagement with the first contacts of the switch banks. The off nor-

mal contacts ON are so arranged that when the line relay LR is energized they are moved to their off normal position, and are returned to their normal position by the energization of the cut off relay CO. That is, these off normal springs ON are so arranged that when the line relay LR is energized, the catch mechanism is operated to release the off normal springs ON to their operated position and upon the energization of the cut off relay CO, the springs are returned to their normal position in which position the catch mechanism is again brought into operation, to hold the off normal springs ON in their normal position. The switch shaft which carries the wipers 2, 3 and 4 is provided with a ratchet mechanism which is adapted to co-operate with the driving pawl controlled by the motor magnet MM to rotate the switch shaft and wipers in a clockwise direction.

A further mechanical arrangement is provided for the line switch and connects the line relay LR and cut off relay CO in such a manner that the armature of the cut off relay CO cannot be fully attracted unless the line relay LR has been energized first, that is, if the line relay LR has been energized the armature of the cut off relay CO may then be energized to move its switch contacts to their alternate positions into engagement with their alternate contacts. If the cut off relay CO is energized before the line relay LR is operated, the armature of the cut off relay CO is permitted to move only a sufficient distance that its contacts 8, 9 and 10 are moved from engagement with their back contacts 12, 13 and 14, respectively, but not into engagement with their front contacts 15, 16 and 17. This feature is provided so that when the substation A is called and the cut off relay CO energized, the subscriber's line is disconnected from the line relay LR of the switch B, but cannot be connected with the switch wipers 2, 3 and 4 of the switch. The line switch B just described is of the type shown in my co-pending application Serial No. 271,960 filed January 20, 1919. The mechanical switch structure of line switches B and B′ is of that type shown in my said copending application S. N. 271,960. Said copending application shows the mechanical construction of the switch and of the cut-off and line relays thereof. Reference is here made to said copending application for a more thorough understanding of the switch structure of line switches B and B′.

The circuits for the selector switch C and connector switch D are adapted to work with a switch structure similar to that shown in my Patent Number 1402936, granted January 10, 1922.

The first selector C comprises a combined impulse and interrupter relay IR which relay is energized and de-energized by impulses from the calling device CD at the calling substation A. The energization and de-energization of the relay IR brings about the actuation of the primary magnet PM to step the first selector switch wipers 18, 19 and 20 in a primary direction to a desired group of contacts. The secondary magnet SM is provided for the selector, which magnet automatically steps the wipers 18, 19 and 20 in a secondary direction over the contacts 21, 22 and 23 in the selected group to seek an idle set of contacts leading to a connector D. A switching relay T is also provided which when energized extends the connection of the calling substation A to the selected idle connector D. Primary off normal contacts PON are provided and assume their alternate position upon the first step of the wipers 18, 19 and 20 in a primary direction, and secondary off normal contacts SON are also provided which assume their alternate position upon the first step of the said wipers in a secondary direction.

The connector switch D is provided with an impulse relay IR′ responsive to the impulses of the calling device CD of the calling substation A, which relay IR′ brings about the actuation of the primary magnet PM′ to step the connector switch wipers 24, 25 and 26 in a primary direction to a certain group of contacts containing contacts of the called line E. A switch relay SW is provided which energizes upon the termination of the first set of impulses to connect the secondary magnet SM′ in circuit with the impulse relay IR′ to be actuated by the energization and de-energization thereof to step the connector switch wipers 24, 25 and 26 over the contacts 27, 28 and 29 in the selected group to the contacts of the called line E. A test relay TR is also provided which is actuated to test the busy or idle condition of the called subscriber's line. The said test relay TR operates to connect the busy back apparatus BB to the calling subscriber's line to notify the subscriber thereat of the busy condition of the called line E. A ringing control relay RC is also provided for intermittently applying ringing current to the called subscriber's line from the ringing generator G. A supervisory relay SR is shown which operates upon the response of the called subscriber at substation E, and prevents the further application of ringing current to the called line. Primary off normal contacts PON′ and secondary off normal contacts SON′ are provided, which contacts assume their alternate positions respectively upon the movement of the wipers 24, 25 and 26 in their primary and secondary off normal positions.

To the right of Part 2 I show a called substation E similar to the substation A, said substation E being connected to a line

switch B′ at the exchange similar to the line switch B.

Having described in general the structure of the switches and apparatus I will now describe more in detail the operation of the same.

Assuming that the subscriber at the substation A initiates a call, the removal of the receiver by the subscriber at the substation brings about the energization of the line relay LR of the line switch B, said circuit being traced from battery through the upper winding of the line relay LR, normal contact 30 of motor magnet MM, normal contact 31 of off normal contacts ON, normal contacts 14 and 10 of cut off relay CO through the calling substation A back through contacts 8 and 12 of the cut off relay CO and through the lower winding of the line relay LR to ground. Line relay LR upon energizing allows the off normal contacts ON to move to their alternate or operative positions.

As before mentioned, wipers 2, 3 and 4 always rest upon the set of contacts 5, 6 and 7 last used and assuming that the contacts upon which the wipers now rest are busy due to another subscriber's line switch having selected the first selector last used by the subscriber A, the private contact 5 will be connected to ground.

The operation of the off normal contacts ON connects the upper winding of line relay LR to the private bank contact 5, and having assumed that the private contact 5 contains a busy potential, a circuit is established through the upper winding of the line relay LR traced from battery through the upper winding of line relay LR, normal contact 30, of motor magnet MM, alternate contact 31 of off normal springs ON, contacts 13 and 9 of relay CO, conductor 32 to the private wiper 2 and the busy bank contact 5. The line relay LR will thus remain energized until its circuit is opened at normal contact 30 of the motor magnet MM. The closure of alternate contact 33 of line relay LR closes an energizing circuit for the motor magnet MM traced from battery through the winding of the said magnet MM, alternate contact 33 of relay LR to the private wiper 2, and the grounded bank contact 5. The motor magnet MM upon energizing opens the circuit of the line relay LR at its contact 30 thereby permitting the said line relay LR to de-energize. The motor magnet MM at the same time steps the wipers 2, 3 and 4 to the next set of bank contacts 5, 6 and 7. Relay LR restoring opens its alternate contact 33, thereby opening the circuit of motor magnet MM and permitting the said motor magnet MM to restore. Should the contacts now engaged by the wipers 2, 3 and 4 be busy, the relay LR again energizes through normal contact 30 of motor magnet MM and the closing of alternate contact 33 of LR again energizes motor magnet MM as above described. The relay LR and motor magnet MM are thus alternately energized and de-energized, the magnet MM stepping the wipers 2, 3 and 4 from one set of contacts 5, 6 and 7 to the next as long as busy, that is, as long as grounded contacts 5 are encountered, and line relay LR energizes each time a grounded bank contact is engaged. Motor magnet MM opens and closes its contact 34 thus producing a vibratory circuit through the winding of cut off relay CO and contact 35 to ground. The winding of relay CO is of high resistance and as the motor magnet MM energizes and de-energizes with great rapidity, the said winding of the relay CO is not effectively energized to attract its armature while the motor magnet MM is operating. The closure of contact 35 of off normal contacts ON places a ground upon the private normal contacts 36 of the connectors having access to the calling subscriber's line A to render such contacts busy to incoming calls. When an idle private contact 5 is encountered, line relay LR and motor magnet MM remain quiescent. The prolonged closure of contact 34 of motor magnet MM now closes an energizing circuit for the cut off relay CO, said circuit being traced from battery through the winding of relay CO, normal contact 34 of the motor magnet MM, alternate contact 35 of off normal contacts ON to ground.

Relay CO upon energizing restores the off normal contacts ON to their normal position and connects the subscriber's line to the line wipers 3 and 4 and connects the winding of cut off relay CO to the private wiper 2. The relay CO being slow to release is held up momentarily until a substitute circuit is established for the said relay CO as will be presently described. The connection of the subscriber's line to the line wipers 3 and 4 of the switch B closes an energizing circuit for the combined impulse and interrupter relay IR of the first selector C; over a circuit traced from battery through the lower winding 37 of relay IR, conductor 38, make-before-break contact 39, conductor 40, normally closed contact 41 of secondary off normal contacts SON, conductor 42, normally closed contact 43 of primary off normal contact PON, conductor 44, normally closed contact 45 of the switching relay T, conductor 46, contact 7, wiper 4, contacts 10 and 17, of cut off relay CO, through the substation A, back through contacts 8 and 15 of relay CO, wiper 3, contact 6, conductor 47, normal contact 48, of the relay T, conductor 49, to ground through the upper winding 50 of the relay IR.

Relay IR upon energization closes its

alternate contact 51, establishing an energizing circuit for the control primary relay CR, traced from battery through the winding of the said relay CR, to ground at alternate contact 51 of relay IR. The closure of alternate contact 52 of relay IR establishes an energizing circuit for the relay 53 traced from battery through the winding of said relay 53, conductor 54, normal contact 55 of primary off normal contacts PON, conductor 56, alternate contact 52 of relay IR, and conductor 57 to ground at alternate contact 58 of relay CR. The closing of alternate contact 67 of relay 53 establishes a substitute circuit for the interrupter relay IR traced from battery through the lower winding 37 of relay IR, conductor 38, alternate contact 67, conductor 44, normal contact 45, of the relay T and over the previously described path to ground through the upper winding 50 of the relay IR. The primary off normal contact 43 assumes its alternate position upon the first step of the wipers off normal and opens the initial energizing circuit of IR, but the substitute circuit just described for the relay IR holds the said relay IR energized to receive the remaining impulses that are sent from the calling device CD. The closing of alternate contact 59 of relay CR establishes a substitute holding circuit for the cut off relay CO of the line switch B before it has had time to de-energize, said circuit being traced from battery through the winding of the cut off relay CO, normal contact 34, wiper 2, contact 5, conductors 60 and 61, to ground at alternate contact 59 of relay CR. The cut off relay CO remains energized until time of release.

If the private contact 5 engaged by the wiper 2 is idle, when subscriber A initiates a call, the line relay LR is energized as before described and contacts ON assume their alternate position, but the closing of alternate contact 33 of relay LR does not energize magnet MM since there is no ground on contact 5 and motor magnet MM remains at normal. The cut off relay CO is immediately energized to ground at normal contact 35, and restores contacts ON as before described, and the cut off relay CO is energized over the circuit to ground at the first selector C as already described. The switch B only travels when its wipers 2, 3 and 4 are in engagement with a busy set of contacts when a call is initiated by the subscriber at substation A.

An idle first selector C having been seized, as just described, and assuming that the number of the called substation E is 345, the subscriber A actuates the calling device CD to send three impulses of current over the line, which impulses bring about three rapid de-energizations and energizations of the impulse relay IR. The primary magnet PM is energized and de-energized three times due to the closing and opening of the normal contact 52 of relay IR. The circuit for magnet PM extends from battery through the winding of the said primary magnet PM, alternate contact 62 of relay 53, conductor 63, normal contact 52 of relay IR, and conductor 57 to ground at alternate contact 58 of relay CR. The magnet PM operates to step the wipers 18, 19 and 20 of the first selector C in a downward primary direction to the third group of contacts, thus selecting the three hundredth group of connectors.

The primary off normal contacts PON assume their alternate position upon the first step of the wipers 18, 19 and 20 off normal and the opening of normal contact 55 of primary off normal contact PON opens the initial energizing circuit of the relay 53, but the relay 53 is held up from battery through the winding of the said relay 53, its alternate contact 64, conductor 65, and alternate contact 66 of relay CR to ground at normal contact 51 of relay IR, upon each de-energization of the said relay. Relays CR and 53 being slow-acting relays, are held in an energized condition during the rapid interruptions of the contact 51 of the relay IR. After the last impulse is sent the relay 53 restores to normal due to the continued energization of the relay IR, which relay now remains energized over a circuit traced from battery through the lower winding 37 thereof, conductor 38, make-before-break contact 39 of relay 53, conductor 40, normal contact 41 of secondary off normal contacts SON, conductor 42 to ground at alternate contact 43 of the primary off normal contacts PON. The closing of normal contact 70 of relay 53 closes an energizing circuit for the secondary magnet SM, traced from battery through the winding of the said magnet, conductors 71 and 72, normal contact 70 of relay 53, alternate contact 55 of primary off normal contact PON, conductor 56, alternate contact 52 of relay IR, to ground at alternate contact 58 of the control relay CR. The secondary magnet SM upon energization steps the wipers 18, 19 and 20 into engagement with the first set of contacts 21, 22 and 23 of the selected group. Upon the first step of the wipers 18, 19 and 20 in a secondary direction, the secondary off normal contacts SON assume their alternate position opening the previously traced circuit through the lower winding of relay IR. Relay IR upon restoring, opens its alternate contact 52, allowing the secondary magnet SM to restore to normal. Should the private wiper 18 of the first selector C engage a contact leading to a busy connector, a substitute circuit is established for the relay IR traced from battery through the lower winding 37 of the said relay, conduc-

tor 38, normal contact 73 of magnet SM, conductor 74, normal contact 75 of switching relay T, conductor 76 and wiper 18 to the grounded busy contact 21. The relay IR, upon energization again closes its alternate contact 52 again closing an energizing circuit for the secondary magnet SM. The magnet SM and the relay IR are thus alternately energized and de-energized to step the wipers 18, 19 and 20 in a secondary rotary direction to seek the contacts of an idle connector switch as D. When a contact 21 leading to an idle connector is encountered by the wiper 18, the energizing circuit of the relay IR remains open, and no further energization of the secondary magnet SM occurs.

By this see-saw action of the relay IR and secondary magnet SM a positive driving operation of the magnet SM is secured and the selector C will not stop on a busy contact or pass an idle contact, because, unless relay IR is energized, magnet SM cannot be energized and relay IR can only be energized when magnet SM is at normal and private wiper 18 is resting on a busy contact. The switching relay T does not energize during the secondary movement of the wipers due to its adjustment and the rapid interruptions of the contact 52 of the relay IR. The relay IR after the wipers 18, 19 and 20 have engaged an idle set of contacts remains at normal and the control relay CR, due to its slow release construction, is held energized long enough to close an energizing circuit for the switching relay T, traced from battery through the winding of the said relay T, over conductor 78, normal contact 62 of relay 53, conductor 63, normal contact 52 of relay IR, and conductor 57 to ground at contact 58 of relay CR. The closing of alternate contact 79 of secondary off normal contacts SON places a substitute ground upon private conductor 60.

The closing of alternate contacts 48 and 45 of relay T extends the connection of the calling subscriber A to an idle connector D engaged by wipers 18, 19 and 20 of the first selector C, bringing about the energization of the impulse relay IR′ of the connector switch D over a circuit traced from ground through one winding of the said relay IR′, contact 23, wiper 20, alternate contact 45 of relay T, conductor 46, contact 7, wiper 4, contacts 17 and 10 of the cut off relay CO, through the substation A back through contacts 8 and 15 of relay CO, wiper 3, contact 6, conductor 47, alternate contact 48 of relay T, wiper 19, contact 22, through the other winding of the impulse relay IR′ of connector D to battery and ground.

The restoration of the control relay CR of the selector switch C opens the initial energizing circuit of the relay T of the selector switch C but a locking circuit is established for the switch relay T which may be traced from battery through the winding of the said relay, its alternate contact 75, conductor 76, wiper 18, contact 21, conductor 80, and conductor 81 to ground at alternate contact 82 of the now energized impulse relay IR′ of connector switch D. The said relay T remains energized until conversation is terminated.

The energization of the relay IR′ energizes relays 83 and 84, the circuit of relay 83 extending from battery through the right hand winding of said relay, normal contact 85 of the primary off-normal contacts PON′, conductor 80 and conductor 81 to ground at alternate contact 82 of relay IR′. Relay 83 upon energization, closes a locking circuit for itself through its alternate contact 89 to ground. The circuit for relay 84 extends from battery through the lower winding of the relay 84, conductors 86, 87 and alternate contact 88 to ground at alternate contact 82 of relay IR′. Four impulses are now transmitted from the calling device CD by the subscriber at substation A which impulses de-energize and energize relay IR′ four times causing the primary magnet PM′ to energize and de-energize four times to step the wipers 24, 25 and 26 in a downward primary direction to the fourth group of contacts containing the contacts of the called line. The circuit of the primary magnet PM′ may be traced from battery through the winding of the said magnet PM′, normal contact 90 of switching relay SW, conductor 91, alternate contact 92 of relay 84, normal contact 88 of relay IR′, conductor 81, conductor 80, through normal contact 85 of the primary off normal contacts PON′ to ground at alternate contact 89 of relay 83. After the primary off-normal contact 85 assumes its alternate position which occurs upon the first step of the switch shaft, a ground is fed from contact 93 of relay 94 and substituted for the ground fed through contact 89 of relay 83. After the last impulse of the set has been sent, the steady flow of current through both windings of relay 84 causes the said relay 84, due to its differential action, to neutralize and restore its contacts to normal, but it does not restore during the sending of impulses, due to its adjustment, construction and the rapidity of the interruptions of contact 88. The closing of normal contact 95 of relay 84 energizes switching relay SW over a circuit traced from battery through the winding of said relay SW, its make-before-break contact 96, normal contact 97 of secondary off-normal springs SON′, conductor 98, normal contact 95 of relay 84, and conductor 99 to ground at alternate contact 100 of primary off-normal contacts PON′, and relay SW locks itself to ground via contacts 101 and 100. The closing of alternate contact 90 of the switching

relay SW merely substitutes secondary magnet SM′ for magnet PM′, so that when the calling subscriber at the substation A sends the last set of impulses, which we have assumed are five in number, relay IR′ energizes magnet SM′ five times, and secondary magnet SM′ steps the wipers 24, 25 and 26 in a secondary rotary direction to engage contacts 27, 28 and 29 of the called line. Upon the first impulse of the last set, the relay 84 again energizes to permit the secondary magnet SM′ to be operated, as previously described, and after the last impulse the relay 84 is again de-energized, and closes a circuit for the test relay TR traced from battery, through the winding of the said relay, conductor 102, the alternate contact 103 of relay SW, alternate contact 97 of the secondary off normal contacts SON′, (said contacts having been moved to their alternate position upon the first step of the wipers in their secondary direction), conductor 98, normal contact 95 and conductor 99 to ground at 100. The closing of alternate contact 104 of relay TR connects the said relay over conductor 105 to the test or private wiper 24, and should the called line be busy the private contact 27 of the called line would be grounded, thus closing a locking circuit for the said relay TR through the private wiper 24 to the grounded busy contacts 27.

Called line idle.

Assuming that the called line is idle, private contact 27 of the called line will be free of ground, and the relay TR will not remain energized but will de-energize. The opening of normal contact 101 of relay TR upon its momentary energization opens the circuit of the switching relay SW, and the relay SW de-energizing opens the circuit of relay TR at its contact 103, leaving the relay TR dependent upon the potential found upon the private contact 27 of the called line. Since, as assumed, this contact is idle and thus free from ground, the relay T de-energizes and thereby causes the energization of relay 94 by current from battery, through the winding 106 of the cut-off relay CO′ of switch B′, conductor 107, contact 108, conductors 109 and 110, private contact 27, through wiper 24, conductor 105, normal contact 104 of relay TR, conductor 112, normal contact 113 of relay SW, conductor 114, through the lower winding of the relay 94, and conductor 115 to ground at 116. The closing of alternate contact 117 of relay 94 short circuits the lower winding of the said relay, and the closing of its alternate contact 118 closes a circuit through the upper winding of the said relay through the alternate contact 118 and conductor 115 to ground at 116. The relay CO′ of the line switch B′ associated with the called line E attracts its armature but its movement is limited, as previously described, but this movement allows contacts 119 and 120 to assume positions to remove the substation control of the line switch B′ of the called line E. The other contacts of the relay CO′ are not affected, due to this limited movement.

The closing of alternate contact 121 of relay 94 connects the interrupter I to the relay 122, over a circuit traced from battery through relay 122, conductor 123, alternate contact 121, of relay 94, conductor 124, normal contact 125 and through the interrupter I to ground. The relay 122 is thus intermittently energized and de-energized, and upon each de-energization ringing generator G is connected to the called line over a circuit extending from the ungrounded pole of the generator G, through normal contact 126, of ringing control relay RC, conductor 127, alternate contact 128 of relay 94, conductor 129, normal contact 130 of relay 122, wiper 26, bank contact 29, through the condenser and call bell of the called substation back through bank contact 28, wiper 25, normal contact 131 of relay 122, and conductor 132 to ground at alternate contact 93 of relay 94.

The call bell of the called subscriber at the substation E is thus intermittently rung, and when the called subscriber answers and the relay 122 is energized, a circuit for the relay SR is closed, traced from battery through the lower winding of the relay SR, through alternate contact 130 of relay 122, wiper 26, contact 29, through the now closed upper contacts of the substation switch hook at the called substation E, back through contact 28, wiper 25, alternate contact 131 of relay 122, and through the upper winding of the relay SR to ground. The relay SR, upon energizing, closes an energizing circuit for the ringing control relay RC, which may be traced from battery through the winding of the said relay RC, its make-before-break contact 133, to ground at 134. Contact 135 locks relay RC over a circuit traced from battery, through the winding of the said relay RC, its alternate contact 135 and conductor 99 to ground at alternate contact 100 of the primary off-normal contacts PON′. The opening of normal contacts 125 and 126 of relay RC disconnects the interrupter I and the ringing generator G to prevent further application of ringing current. A substitute circuit for the relay 122 is now established which may be traced from battery, through the winding of the relay 122, conductor 123, alternate contact 121 of relay 94, conductor 124, alternate contact 125 of relay RC, and conductor 99 to ground at 100. The subscribers are now in conversational circuit, and the talking circuit may be traced over the heavily marked conductors said conduc-

tors having the condensers K′ and K² interposed.

Release.

Assuming that the subscriber at the calling substation A is the first to replace his receiver, the resulting de-energization of the impulse relay IR′ of the connector D, opens the holding circuit of the relay T of the first selector C, and the closing of normal contact 140 of relay T closes an energizing circuit for the secondary magnet SM traced from battery, through the winding of magnet SM, conductors 71 and 72, normal contact 140 of relay T, conductor 141, normal contact 142 of relay CR, conductor 143, normal contact 144 of relay SM, conductor 145, alternate contact 41 of secondary off-normal contacts SON and conductor 42 to ground at alternate contact 43 of primary off normal contacts PON. The secondary magnet SM is alternately energized and de-energized, due to the opening and closing of its contact 144, thus stepping the wipers 18, 19 and 20 beyond the last row of bank contacts, from which point the wipers are restored to normal by spring tension.

The secondary off-normal contacts SON and primary off-normal contacts PON are restored to normal, and the opening of alternate contacts 79 of the secondary off-normal contacts SON opens the energizing circuit of the cut-off relay CO of the individual line switch B. The restoration of the cut-off relay CO restores the individual switch B to normal.

The subscriber E restoring his receiver upon its switch hook interrupts the circuit of the relay SR at the switch hook contacts, causing the said relay to de-energize. The closing of normal contact 150 of relay SR closes a circuit through the left hand winding of the relay 83 which circuit may be traced from battery, through the left hand winding of the said relay 83, alternate contact 151, conductor 151′, normal contact 150 of relay SR, and conductor 152 to ground at normal contact 82. Due to the differential construction of relay 83, the said relay neutralizes and restores to normal. The closing of normal contact 153 of relay 83 closes an energizing circuit for the secondary magnet SM′, from battery, through said magnet, conductor 154, normal contact 153, contact 155, through the interrupter, I′ to ground. The secondary magnet SM′ thus steps the wipers 24, 25 and 26 beyond the last set of contacts in the group, and the wipers then restore to normal from this position by spring tension. The restoration of the relay 83 opens the circuit of relay 94 at contact 116, and the relay 94 restoring opens the circuit of relay 122 at contact 121. The primary off-normal contacts PON′ having restored upon the restoration of the switch, the opening of the contact 100 de-energizes relay RC. The relay 83 also brings about the de-energization of the cut-off relay CO′ of the line circuit B′ which is associated with the called subscriber E.

All the apparatus used in establishing a connection between a calling subscriber at the substation A and the called subscriber at the substation E is now at normal and available for use in establishing other connections.

Assuming now that the subscriber at the called substation E was first to replace his receiver upon the switch hook, the opening of the switch hook contacts at the substation E brings about the de-energization of the relay SR. Nothing else happens at this time as the relay IR′ is still maintained energized over the line of the calling substation A. The calling subscriber at the substation A replacing his receiver interrupts the circuit of the impulse relay IR′ at the switch hook contacts. The relay IR′ de-energizing closes a circuit for the left hand winding of relay 83, causing the said relay to de-energize, as hereinbefore described. The restoration of the individual switch B, first selector C and connector D is the same as previously described from this point on. Should the called subscriber E fail to replace his receiver upon the switch hook after the conversation is terminated. the replacing of the receiver at the substation A brings about the de-energization of the impulse relay IR′ of connector D, the same as before, and the opening of alternate contact 82 of impulse relay IR′ opens the circuit of the relay T of first selector C as before described, and causes the release of selector C and individual line switch B.

The subscriber at the called substation failing to replace his receiver, permits the continued energization of the relay SR, thus holding the contact 150 of said relay in its alternate position preventing the differential wound relay 83 from restoring to normal, and closing the energizing circuit of the secondary magnet SM′. The relay 84 energizes when impulse relay IR′ drops back, but is immediately restored to normal, due to the closure of an energizing circuit through the lower winding of the said relay 84, which may be traced from battery, through the said lower winding, conductor 87, alternate contact 150 of relay SR, and conductor 152 to ground at alternate contact 82 of the now restored impulse relay IR′. Relay 84 being differentially wound, restores to normal, and the closing of normal contact 160 of the said relay 84 places a ground upon the private contact of the connector D over a circuit which may be traced from ground at contact 100, over conductor

99, through normal contact 95 of relay 84, conductor 98, alternate contact 97, normal contact 160, alternate contact 161 of the secondary off-normal contacts SON′, to the private contact 21. The placing of this busy potential upon the private contact prevents any first selector switch C from selecting the contacts of this busy connector.

Called line busy.

Assuming now that the called line is busy, the operation of the circuit is the same up to and including the time that the relay TR momentarily energizes. The line being busy, the private contact 27 has a ground connected to it, and a locking circuit is thus closed for the test relay TR, traced form battery, through the winding of the said relay, its alternate contact 104, conductor 105, and the wiper 24 to the grounded contact 27. Alternate contact 162 of the test relay TR remains closed and connects the busy signal BB to the calling line to transmit a busy signal to A, thus notifying the subscriber of the busy condition of the called substation E. Relay RC is also energized when connection is made to a busy line to prevent an application of ringing current being applied to the called line if the called line should become idle before the connector D is disconnected from the bank contracts of a called subscriber's line. The relay RC upon energizing locks up through its own make-before-break contacts 133 and 135 to ground at alternate contact 100. The calling subscriber now replaces his receiver, bringing about the de-energization of the impulse relay IR′, and the relay IR′ restoring, opens the circuit of the relay T of the first selector C, which, as previously described, brings about the release of the first selector C and the individual switch B. The relay IR′ de-energizing, restores relay 83 (since the relay SR has not been energized) and by the closing of circuit through the left hand winding of said relay 83, the closing of contact 153 now connects secondary magnet SM′ to interrupter I′, and the connector restores to normal. The primary off-normal contacts PON′ and secondary off-normal contacts SON′ are also restored, and all the apparatus used is now at normal and available for use in establishing other connections.

While I have shown a system of 1,000 capacity, it is to be understood that by inserting second selectors, the system may be increased to a 10,000 system, etc.

From the foregoing it is at once apparent that I have so arranged the combined impulse and test relay of my first selector switch that the said relay will operate very efficiently when energized over a subscriber's line circuit, due to the fact that the two windings of this relay are connected in series when so actuated and the windings are of the right resistance to operate most efficiently when its circuit is interrupted by the actuation of the calling device at a calling substation, and when the relay is used for testing purposes, only its one winding is connected in circuit, which winding is of the right resistance to permit a very efficient operation of this relay under these conditions, thereby permitting the motor magnet of the switch to operate at a very high rate of speed.

While I have described my invention operating in connection with a well-known system, I do not wish to be limited to this exact disclosure as my invention may be applied to other systems without departing from the spirit of the invention, and I, therefore, do not wish to be limited to this exact disclosure, but aim to cover all such changes and modifications as come within the spirit and scope of the appended claims.

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

1. An automatic numerical selector switch of the character described controlled over the two sides of the line in series, provided with only four operating relays, a pair of motor magnets, one of said relays and one of said magnets being adapted to be included in a vibratory circuit arrangement, test means including said relay included in said vibratory circuit for controlling the operating circuit of the other of said magnets, and restoring means including said last magnet whereby said last magnet operates to release said numerical switch to normal.

2. A two-dimension numerical automatic selector switch provided with operating magnets for moving the switch shaft of said selector, with only four relays for controlling said magnets, one of said relays and one of said magnets being adapted to be included in a vibratory circuit arrangement to operate the said magnet to move the switch shaft in one direction, test means including said relay included in said vibratory circuit for controlling the operating circuit of the other of said magnets to move the switch in its other direction, and restoring means including said other magnet whereby said other magnet releases said switch to normal.

3. A two-dimension numerical automatic selector switch provided with a switch shaft, operating magnets for moving said switch shaft, one of said magnets adapted to restore said switch to normal, a pair of slow-acting relays for said switch, a switching relay for said switch, and a combined line and test relay for controlling the operation of said operating magnets and of said relays.

4. A telephone system including a numer-

ical selector switch provided with a slow-acting circuit changing relay, a line relay, a circuit for said slow-acting relay adapted to be closed upon the energization of said line relay, off-normal contacts adapted to be operated to open said circuit, and a second circuit for said slow-acting relay including one of its own contacts.

5. A telephone system including a numerical selector switch provided with a slow-acting circuit changing relay, a line relay, a circuit for said slow-acting relay adapted to be closed upon the energization of said line relay, off-normal contacts adapted to be operated to open the said circuit, and a second circuit for said slow-acting relay including one of its own contacts and a back contact of said line relay.

6. A system of the character described including a subscriber's line, a selector switch for connection thereto provided with a pair of motor magnets, a line relay for controlling one of said motor magnets, an initial energizing circuit for said line relay including said subscriber's line, a second circuit for said line relay including a contact of the other of said motor magnets, a circuit for said last motor magnet including a contact of said line relay, and means including said last motor magnet for restoring said selector switch to normal.

7. A selector switch of the character described provided with a switch shaft adapted to be moved in two directions, motor magnets for moving said switch shaft, a line relay adapted to be intermittently operated to cause the operation of one of said motor magnets, circuit controlling means for connecting said line relay and the other of said motor magnets in a vibratory circuit arrangement, and restoring means including one of said motor magnets for restoring said switch shaft.

8. A selector switch of the character described including a switch shaft adapted to be moved in two directions, motor magnets for moving said switch shaft, a line relay, a circuit for said line relay adapted to be intermittently operated to cause the operation of one of said motor magnets, a circuit changing relay for opening the circuit of said line relay and for including said line relay in a vibratory circuit arrangement with the other of said other magnets, and motor-driven means for releasing said switch.

9. A telephone system including a numerical automatic switch provided with a contact maker, motor mechanisms for moving said contact maker, a double wound line relay for controlling one of said motor mechanisms, an initial energizing circuit for said relay including the two windings thereof in series, a second circuit for said line relay including one winding thereof and a contact controlled by the other part of said motor mechanisms, a circuit for said last motor mechanism including a contact controlled by said relay, and restoring means including one of said motor mechanisms for restoring said contact maker.

10. A numerical selector switch of the character described including a switch shaft adapted to be moved in two different planes, a pair of motor magnets for moving said switch shaft, a line relay for controlling one of said motor magnets, a local energizing circuit for said line relay including a contact of the other of said magnets, a circuit for said other motor magnet including a contact of said line relay, and means including said motor magnet for restoring said switch shaft to normal.

11. A telephone system of the character described including a subscriber's line, an automatic selector switch provided with a switch shaft adapted to be connected to said line, a line relay for said selector switch controllable over the two sides of said line in series, a motor magnet controllable by said line relay for advancing said switch shaft, a second motor magnet for advancing said switch shaft in a different plane, a local circuit for said line relay controllable by said second motor magnet, and restoring means including said second motor magnet for restoring said switch shaft to normal.

12. A telephone system including a subscriber's telephone line, a numerical automatic selector switch having motion in two different planes controllable over said line, a line relay for said selector switch, a circuit therefor including the two sides of said telephone line in series, a local test circuit including a winding of said line relay, a pair of motor magnets for operating said switch in its two different planes, and restoring means including one of said motor magnets for restoring said switch to normal.

13. A numerical automatic selector switch of the character described, a movable contact maker for said switch adapted to be moved in one direction to select a group of lines and in a second direction to select a line in the elected group, a line relay for controlling the group selecting movement of said switch shaft and for also controlling the contact selecting movement of said switch shaft, motor mechanisms for moving said contact maker in its first and second directions, and means including one of said motor mechanisms for restoring said contact maker.

14. An automatic numerical selector switch of the character described provided with a contact maker adapted to be moved in one direction to select a group of contacts and in another direction to select a contact in the group, motor mechanism, a line relay, means for interrupting the circuit of said

line relay to cause said motor mechanism to move the contact maker to a desired group of contacts, other motor mechanism, other means for interrupting the circuit of said line relay to cause the other motor mechanism to move the contact maker to an idle contact in the selected group of contacts, and restoring means including said other motor mechanism for restoring said contact maker.

15. An automatic numerical selector switch of the character described provided with a contact maker adapted to be moved in one direction to select a group of contacts and in another direction to select a contact in the group, motor mechanism, a line relay, means for interrupting the circuit of said line relay to cause said motor mechanism to move the contact maker to a desired group of contacts, other motor mechanism, other means for interrupting the circuit of said line relay to cause the other motor mechanism to move the contact maker to an idle contact in the selected group of contacts, a circuit changing relay for switching the line relay from one means to the other, and means including said other motor mechanism for restoring said contact maker to normal.

16. An automatic numerical selector switch of the character described provided with a contact maker adapted to be moved in one direction to select a group of contacts and in another direction to select a contact in the group, motor mechanism, a line relay, means for interrupting the circuit of said line relay to cause said motor mechanism to move the contact maker to a desired group of contacts, other motor mechanism, other means for interrupting the circuit of said line relay to cause the other motor mechanism to move the contact maker to an idle contact in the selected group of contacts, a circuit changing relay for switching the line relay from one means to the other, and a switching relay for rendering the second of said interrupter circuits ineffective.

17. An automatic numerical selector switch of the character described provided with a contact maker adapted to be moved in one direction to select a group of contacts and in another direction to select a contact in the group, motor mechanism, a line relay, means for interrupting the circuit of said line relay to cause said motor mechanism to move the contact maker to a desired group of contacts, other motor mechanism, other means for interrupting the circuit of said line relay to cause the other motor mechanism to move the contact maker to an idle contact in the selected group of contacts, and means for again rendering said second motor mechanism effective to restore said switch.

18. An automatic numerical selector switch of the character described, a pair of motor magnets for said selector switch, a line relay, an interrupter for interrupting the circuit of said line relay thereby causing the said relay to operate one of said motor magnets, a second interrupter for operating said line relay to cause the same to operate the other of said motor magnets, and means for again operating one of said motor magnets for releasing said selector switch.

19. An automatic numerical selector switch of the character described, a pair of motor magnets for said selector switch, a line relay, an interrupter for interrupting the circuit of said line relay thereby causing the said relay to operate one of said motor magnets, a second interrupter for operating said line relay to cause the same to operate the other of said motor magnets, a circuit changing relay for switching said line relay from one interrupter to the other, and means for advancing said switch to cause the restoration of said switch.

20. An automatic numerical selector switch of the character described, provided with a line relay for controlling the group selecting movement of said selector switch and for also controlling the contact selecting movement of said selector switch, and motor-driven means for releasing said selector switch.

21. An automatic numeral selector switch of the character described provided with a movable contact maker adapted to be moved to a group of contacts and then to an idle contact in the group, a line relay for controlling the first of said movements, a local circuit including a contact in said group of contacts for said line relay for controlling the second of said movements, and means for advancing said switch to cause the restoration of the same.

22. An automatic selector switch of the character described including a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the group, a combined line and test relay, an interrupter circuit for said line relay for controlling the first of said movements, a test circuit including a contact of said group of contacts for said line relay for controlling the second of said movements, and means for advancing said switch to cause the restoration of the same.

23. An automatic selector switch of the character described including a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the group, a combined line and test relay, an interrupter circuit for said line relay for controlling the first of said movements, a test circuit for said line relay for controlling the second of said movements, a circuit changing relay for switching the line relay from one circuit to the other, and

means for advancing said switch to its ultimate rotary position to cause the restoration of said switch.

24. An automatic selector switch of the character described including a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the group, a combined line and test relay, an interrupter circuit for said line relay for controlling the first of said movements, a test circuit for said line relay for controlling the second of said movements, a circuit changing relay for switching the line relay from one circuit to the other, and means for advancing the said selector switch to cause the release thereof.

25. In an automatic selector switch of the character described including a contact maker adapted to be moved to a group of contacts and then to an idle contact in the group, motor mechanism for producing the first of said movements, other motor mechanism for producing the second of said movements, a line relay, an interrupter circuit for said line relay for causing the intermittent operation of the same thereby causing the line relay to control the first of said motor mechanisms, a test means for controlling said line relay thereby permitting the same to control the other of said motor mechanisms, and means including said other motor mechanism for restoring said switch to normal.

26. An automatic selector switch of the character described provided with a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the desired group, a line relay and a slow-acting relay controlling the first of said movements, a second slow-acting relay, mechanism controlling the second of said movements controlled by said line relay and said second slow-acting relay, and means for advancing said contact maker to its ultimate rotary position whereby the same is restored to normal.

27. An automatic selector switch of the character described provided with a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the desired group, a line relay and a slow-acting relay controlling the first of said movements, a second slow-acting relay, mechanism controlling the second of said movements controlled by said line relay and said second slow-acting relay, a switching relay for said automatic switch controlled by said line relay, and means for advancing said contact maker in its secondary direction to cause the restoration of the same.

28. An automatic selector switch of the character described provided with a contact maker adapted to be moved to a desired group of contacts and then to an idle contact in the desired group, a line relay and a slow-acting relay controlling the first of said movements, a second slow-acting relay, mechanism controlling the second of said movements controlled by said line relay and said second slow-acting relay, a switching relay for said automatic switch controlled by said line relay, and means for advancing the said automatic switch to cause the release thereof.

29. An automatic numerical selector switch of the character described having movable wipers, provided with only four operating relays, bank contacts, and with a pair of motor magnets, one of said motor magnets controlling the release of the switch, and one of said relays operating when energized to electrically connect said wipers to said bank contacts.

30. A two-dimension numerical automatic selector switch having movable wipers provided with operating magnets for moving the switch shaft of said selector, a combined line and test relay, circuits controlled by said relay for controlling said magnets to step the said switch wipers in a primary and secondary direction, and means including one of said operating magnets to restore said switch shaft.

31. A selector switch of the character described provided with a switch shaft adapted to be moved in two directions, motor magnets for moving said switch shaft, a line relay adapted to be intermittently operated to cause the operation of one of said motor magnets, circuit controlling means for connecting said line relay and the other of said motor magnets in a vibratory circuit arrangement, and means operative thereafter to render said last magnet effective to restore said switch.

32. An automatic selector switch provided with a switch shaft, a combined impulse and test relay for controlling both the group selecting movement of said switch shaft and the trunk selecting movement thereof, a local test circuit for said relay for testing the trunks during the trunking selection movement of said switch, and means for advancing said switch to cause the release of said switch shaft.

33. An automatic selector switch of the character described including motor magnets, a slow-acting relay for controlling the release of the switch, a slow-acting relay for rendering one of said magnets inoperative and for rendering the other operative, a combined line and test relay for controlling the movements of said magnets, and means for rendering one of said motor magnets operable to permit the release of said switch.

34. An automatic selector switch of the character described including motor magnets, a slow-acting relay associated with one of said motor magnets for controlling the release of the switch, a slow-acting relay

for rendering one of said magnets inoperative and for rendering the other operative, a combined line and test relay for controlling the movements of said magnets, and a switching relay controlled by said line relay.

35. An automatic selector switch having motion in two different planes provided with a test wiper, a line relay for controlling one movement of said selector switch, means for thereafter connecting said line relay to said test wiper for controlling the other motion of said switch, and means for advancing said switch to cause the release of the same.

Signed by me at Chicago, in the county of Cook and State of Illinois, this 25th day of July, 1919.

HARRY H. IDE.