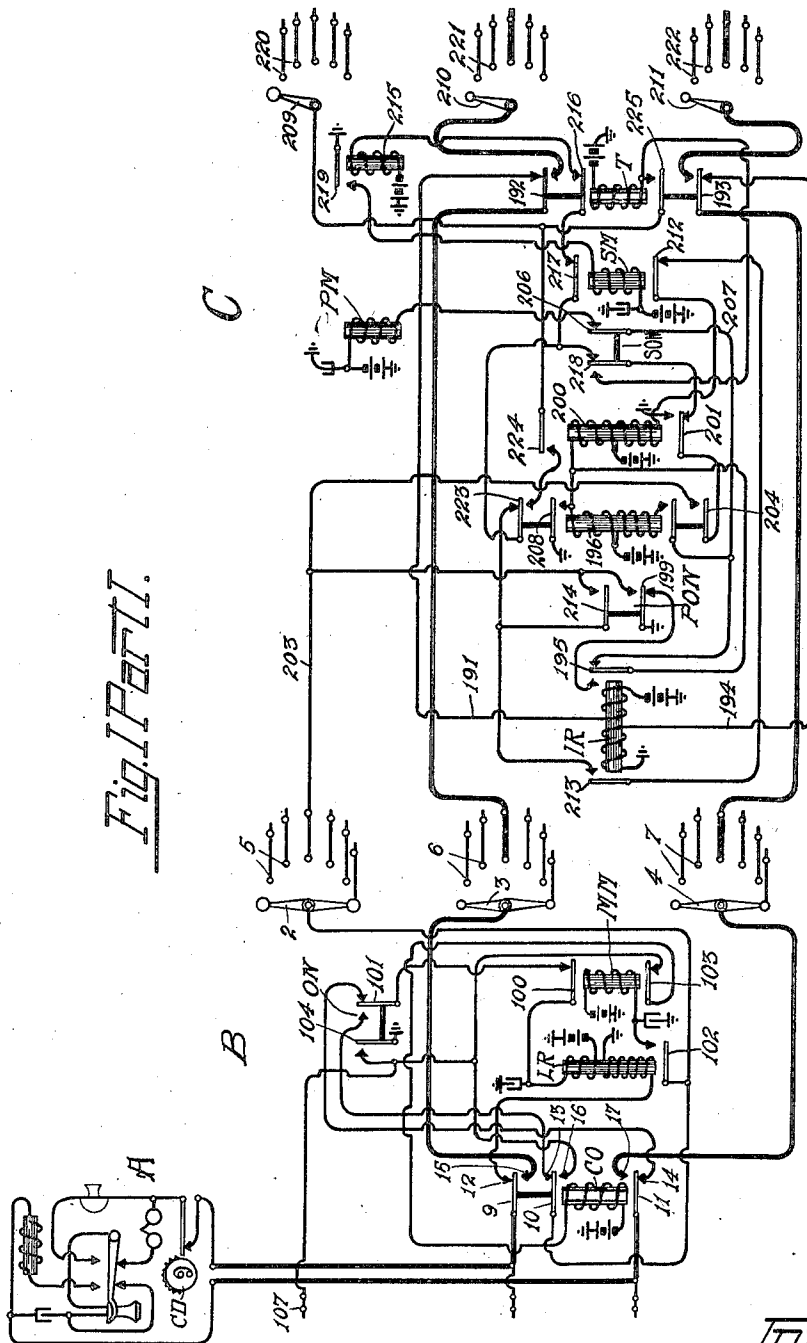


Mar. 27, 1923.

1,449,511

H. H. IDE
TELEPHONE SYSTEM
Filed Feb. 14, 1919

3 sheets-sheet 1



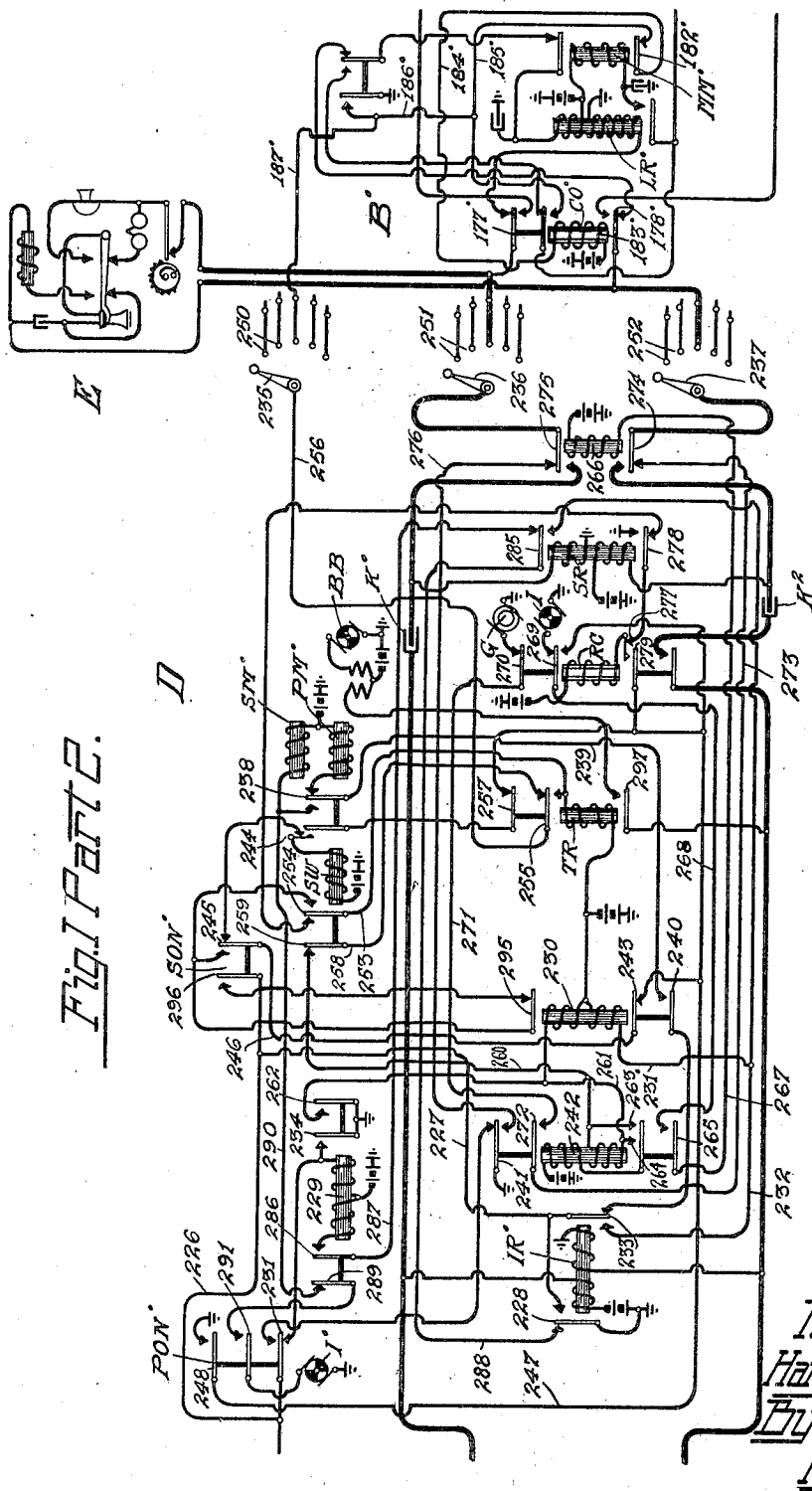
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H. H. IDE
TELEPHONE SYSTEM
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1,449,511

3 sheets-sheet 2

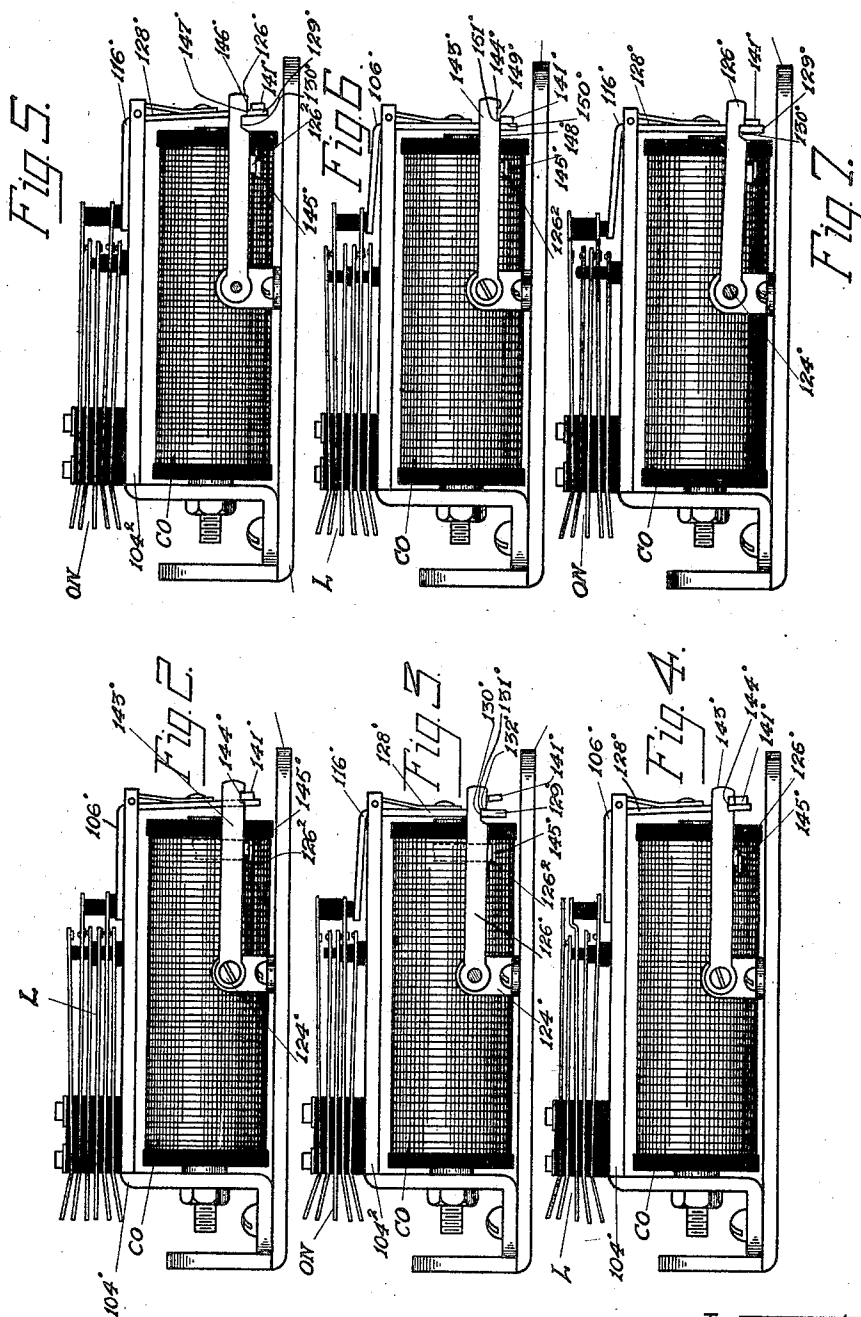


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Filed Feb. 14, 1919

3 sheets-sheet 3.



Inventor:
Harry H. Ide.
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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 February 14, 1919. Serial No. 276,923.

To all whom it may concern:

Be it known that I, HARRY H. IDE, a citizen of the United States of America, residing at La Grange, in the 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 directly controlled switches at the exchange are operated responsive to a series of rapid interruptions of the subscribers' line circuits, and to such systems as above outlined in which non-numerical automatic switches are employed for automatically extending the circuits of calling lines to idle directly controlled switches or from directly controlled switches to repeaters, or other trunking mechanism, and an object of my invention is to provide a system as outlined having simplified and improved circuit arrangements.

A feature of my invention is the provision of improved circuits for a switch of the non-restoring type, that is, one which remains in contact with the trunk last used when disconnection is effected, and which will again seize the trunk last used when a call is initiated, provided the trunk in the meantime has not been seized by another switch and is in use at the time the call is made.

A further feature of my invention is the provision of a switch of this character provided with an improved so-called positive drive circuit that does not permit the wipers of the switch to stop on busy contacts or to pass over idle contacts.

A still further feature is the provision of a positive drive circuit in which the rate of actuation of the motor magnet may be materially increased over the switches of the prior art provided with the so-called positive drive circuits.

With the switches of the prior art that were provided with the so-called positive drive circuit arrangement, that is, an arrangement in which the motor magnet is controlled by the test relay and the test relay is in turn controlled by the motor magnet, it has been found that the speed of operation of the motor magnet was confined within a certain limit unless very fine micrometer adjustments were provided; this was particularly true with the circuit ar-

rangements in which the test relays of the automatic switches were provided with single windings, which were first energized over the two sides of the subscribers' lines in series and afterwards placed in local test circuits in which the relays cooperated with the motor magnets of the switches in vibratory circuit arrangements to cause the switches to select idle passive contacts.

I have overcome this objection by providing the combined test and line relay of my switch with two windings which are first connected in series with the subscriber's line to cause the initial energization of the combined line and test relay and which relay then operates to connect its one winding in a local circuit with the private test wiper through a contact of the motor magnet for test purposes. By this arrangement I can arrange and construct the one winding of the test relay that is included in the local vibratory circuit in such a manner as to obtain the maximum speed of operation of the motor magnet of the switch. This is made possible because the other winding of the test relay is so arranged as to obtain the most efficient operation of the relay when it is used as a line relay and energized over the two sides of the subscriber's line in series.

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, and in which Figure 1, comprising parts 1 and 2, illustrates diagrammatically an automatic telephone system embodied in my invention.

Figs. 2 and 3 illustrate combined off-normal and cut-off relay control mechanism in its normal position.

Figs. 4 and 5 illustrate combined off-normal and cut-off relay control mechanism in one of its off-normal positions.

Figs. 6 and 7 illustrate combined off-normal and cut-off relay control mechanism in one of its off-normal positions.

Referring now more particularly to the system as shown in Fig. 1, the substation A comprises the usual switch-hook and substation equipment, and includes a calling device. The said substation A is connected by means of the two line limbs as shown, to a line switch B at the exchange. The said line switch B is adapted, upon the initiation

of a call from substation A, to automatically connect with an idle first selector C as shown in Fig. 1, part 1. The subscriber at A, by the use of the calling device in connection with his 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 further actuation of his calling device, operate the connector switch D to connect with the terminals of the called-for line E. If the called line is idle, ringing current is automatically applied to the terminals thereof to signal the called-for subscriber. 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 were used in extending his line to the line of the called-for subscriber.

The switch B, as diagrammatically illustrated, 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. The 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 contacting end of these wipers moves off the last contacts of their respective switch banks, the other contacting ends thereof move onto the first contacts of the switch banks. The off-normal 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 are so arranged that when the line relay LR is energized a catch mechanism is operated to release the off-normal springs 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 again is brought into operation to hold the off-normal springs in their normal position.

The switch shaft which carries wipers 2, 3 and 4 is provided with a ratchet mechanism

which is adapted to cooperate 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 the cut-off relay CO in such a manner that the armature of the cut-off relay CO can not 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, while if the cut-off relay CO is energized before the line relay LR is operated, the armature of the cut-off relay is permitted to move only a sufficient distance that its contacts 9, 10 and 11 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 from a connector switch and the cut-off relay CO energized, the subscriber's line can be disconnected from the line relay LR of the switch B, but cannot be connected with the switch wipers of the switch.

Referring now particularly to Figs. 2 to 7, inclusive, I illustrate the cut-off relay CO and its associated mechanism in its various operative positions, and in Fig. 2 I illustrate the cut-off relay CO in its normal position, in which its armature 106' is in its retracted position and its associated contacts L in their normal position, and in Fig. 3 I show the off-normal contacts ON in their normal position and mounted on the extension 104² of the heel iron 104' of the cut-off relay CO, and the movement of the off-normal contacts ON is jointly controlled by the line relay LR and the cut-off relay CO. An armature shaped member 116' is pivotally supported at the forward end of the extension 104² by means of a suitable pivot pin, which pin also pivotally supports the armature 106' of the cut-off relay CO. A bracket 124' suitably secured to the mounting plate, pivotally supports a latch 126', and the leg 128' of the member 116' is provided with a shoulder 129', which rests in a notch 130' in the latch 126'. The edge 131' of the said shoulder 129' engages the side 132' of the notch 130', retaining the member 116' in its position as illustrated in Fig. 3, to hold the off-normal contacts ON in their normal position.

An arm 141' secured to the armature 106' of the relay CO is operatively associated with a latch 143', which latch 143' is also pivotally supported by the bracket 124' and is also operatively associated with the leg 128' of the member 116', the said latch 143' lying adjacent to and parallel with the latch 126'. The latch 143' is provided with a

notch 144' at its forward end, in which the forward end of the arm 141' rests.

When a call is initiated the line relay LR is energized and its armature is attracted, and the angular arm 145' secured to the armature of the relay LR is moved in an upward direction and engages the extension 126² of the latch 126'. This causes the latch 126' to be raised, and when the face 132' of the notch 130' passes beyond the edge 131' of the shoulder 129' of the member 116', it releases the said member 116', allowing it to rotate about its pivot and permitting the off-normal contacts ON to assume their alternate position, as illustrated in Fig. 5. When in this position the edge 146' of the latch 126' rests upon the edge 147' of the shoulder 129'. The latch 143' is also raised due to the extension 126² passing under the latch 143' so that when the latch 143' is in this position, as illustrated in Fig. 4, the arm 141' is clear of the notch 144' in the forward end of the latch 143'. The positions of the latches 126' and 143' when in their off-normal position are illustrated in Figs. 4 and 5, and the shifted off-normal contacts CO in Fig. 5. After selection the cut-off relay CO energizes to attract its armature 106', followed by the de-energization of the line relay LR, and the attracted armature 106' carries the arm 141' with it and in its movement engages the member 116' and again rocks it about its pivot. The line relay LR upon restoring allows the arm 145' to disengage the extension 126² of the latch 126' and the movement of the member 116' continues until the edge 131' of the shoulder 129' of the member 116' passes the edge 132' of the notch 130 so that when in this position the latch 126' rocks about its pivot, allowing the shoulder 129' to again rest in the notch 130', as clearly illustrated in Fig. 7. A buffer on the member 116' again engages the off-normal contacts ON to move them back to their normal position, and as the edge 131' of the shoulder 129' engages the edge 132' of the notch 130', the off-normal contacts ON are locked in their normal position until another engagement of the line relay LR. The cut-off relay CO energizing shifts the springs L to their alternate positions and the latch 143' is in such a position that its bottom edge 148' rests on the upper edge 149' of the arm 141', as clearly illustrated in Fig. 6. Upon the restoration of cut-off relay CO, its armature retracts, the arm 141' moving therewith so that when its edge 150' passes the edge 151' of the notch 144' of the latch 143', the said latch 143' rocks on its pivot and again allows the arm 141' to rest in the notch 144' of the latch 143.

Now, should the line associated with the cut-off relay CO be a called line, the said cut-off relay CO will be energized, but due to

the arm 141' resting in the notch 144' of the latch 143' (Fig. 2), the movement of the armature 106' is limited by the amount of play that the arm 141' has in the notch 144'.

The circuits shown for the selector switch C and connector switch D are adapted to work with a switch structure similar to that shown in my co-pending application, Serial Number 175,364, filed June 18, 1917. It is to be understood, however, that the circuits may be used in connection with various switch structures of the art.

The first selector C comprises an impulse relay IR, which relay is energized and de-energized by impulses from the calling device CD at the calling substation A, and 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 209, 210 and 211 in a primary direction to a certain group of contacts. A secondary magnet SM is provided for said selector which automatically steps the wipers 209, 210 and 211 in a secondary direction over the contacts 220, 221 and 222 in the selected group to seek an idle set of contacts leading to a connector, as D. A switching relay T is also provided which, when energized, extends the connection of the calling substation A to the idle connector D. Primary and secondary off-normal contacts PON and SON, respectively, are provided. The said primary off-normal contacts PON assume their alternate position on the first step of the wipers in a primary direction, and the secondary off-normal contacts SON assume their alternate position upon the first step of the 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 at the calling substation A, which relay IR' brings about the actuation of the primary magnet PM' to step the connector switch wipers 235, 236 and 237 in a primary direction to a certain group of contacts containing contacts of the called line E. A switching 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 the de-energization thereof to step the connector switch wipers 235, 236, and 237 over the contacts 250, 251 and 252 in the selected group to seek the contacts of the called line.

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 calling subscriber of the busy condition of the called line. A ring control relay RC is provided for intermittently applying ringing current to the called sub-

scriber's line from the ringing current generator G. A back bridge or supervisory relay SR is also provided which operates upon the response of the called subscriber and controls disconnection or prevention of further applications of ringing current to the called subscriber's line. Primary and secondary off-normal contacts PON' and SON' are provided to assume their alternate positions, respectively, upon the movements of wipers 235, 236 and 237.

To the right of Sheet 2, I show a called substation E similar to substation A, the said substation E being connected to a line switch B' at the exchange similar to line switch B.

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

Assuming that a call is to be traced from the calling substation A to the called substation E, upon the removal of the receiver by the subscriber at the calling substation A, line relay LR of switch B is energized by current traced from battery, through the upper winding of relay LR, contact 100 of motor magnet MM, normal contact 101 of off-normal springs ON, contacts 14 and 11 of relay CO, through the calling substation back through contacts 9, 12 of relay CO and through the lower winding of relay LR to ground. Line relay LR upon energizing trips the off-normal contacts ON to their operated position. As before mentioned, wipers 2, 3 and 4 always rest upon the set of contacts 5, 6 and 7 last used, and assuming 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 engaged private contact will be found to contain a busy potential. The tripping of off-normal contacts ON connects the upper winding of line relay LR to the private bank contact 5, which we have assumed contains a busy potential, over a circuit extending from battery, through the upper winding of relay LR, normal contact 100 of motor magnet MM, alternate contact 101 of off-normal springs ON, contacts 13 and 10 of relay CO, to private wiper 2 and the grounded bank contact 5. The line relay will thus remain energized until its circuit is opened at contact 100 of the motor magnet MM. The closure of contact 102 of relay LR closes a circuit for motor magnet MM, extending from battery, through the winding of said motor magnet MM, contact 102 of relay LR, to the private wiper 2 and grounded bank contact 5.

The motor magnet MM upon energizing opens the circuit for test relay LR at its contact 100, thereby permitting the same to de-energize. The motor magnet at the same time of course steps the wipers 2, 3 and 4 to the next set of bank contacts.

Test relay LR restoring opens its contact 102, 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 be busy, relay LR energizes by current through normal contact 100 of motor magnet MM and again closes contact 102, energizing motor magnet MM, as before described. The line and test relay LR and magnet MM are thus alternately energized and de-energized, magnet MM stepping wipers 2, 3 and 4 from one set of contacts to the next as long as busy, that is, as long as grounded contacts 5 are encountered, and relay LR energizing each time a grounded bank contact is encountered. Magnet MM alternately opens and closes its contact 103, and thus a vibratory circuit is closed through the winding of cut-off relay CO to ground, through contacts 104 of off-normal contacts ON. The winding of relay CO is of high resistance and as motor magnet MM energizes and de-energizes with great rapidity, the said winding of relay CO does not effectively energize and attract its armature while the motor magnet MM is operating. The relay CO may also contain a copper sleeve to make it slightly slow to energize. Closure of contacts 104 of off-normal contacts ON places a ground upon private normal contacts 107 at 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, test relay LR and magnet MM remain unoperated and the prolonged closure of contact 103 of magnet MM now effectively energizes the relay CO by current over a path traced from battery, through the winding of relay CO, contact 103 of motor magnet MM, and contact 104 of off-normal contacts ON to ground. Relay CO upon energizing restores the off-normal contacts ON to their normal positions, connects the subscriber's line to line wipers 3 and 4 and connects the said winding of relay CO to private wiper 2. The relay CO being slow to release is held up momentarily until a substitute circuit is established for the relay CO, as will be presently described.

The connection of the subscriber's line to line wipers 3 and 4 of the switch B closes an energizing circuit for impulse relay IR of the idle first selector C over a circuit traced from battery through conductor 191, contact 192, contact 6, wiper 22, alternate contacts 15 and 9, substation A, back through alternate contacts 11 and 17, wiper 4, contact 7, normal contact 193, conductor 194 and through relay IR to ground. Closed alternate contact 195 of relay IR energizes relay 196 by current from battery, through the upper winding of relay 196, contact 195, to ground at normal contact 130

199 of the primary off-normal contacts PON. Relay 200 is now energized, from battery through the upper winding of said relay 200, alternate contact 195, to ground at normal contact 199. The closing of alternate contact 201 of relay 200 establishes a substitute energizing circuit for relay CO of the line switch C before it has had time to de-energize, said circuit being traced from battery through relay CO, normal contact 103, wiper 2, contact 5, conductor 203, alternate contact 204, to ground at alternate contact 201. Relay CO remains energized until time of release. The connector contacts 107 of A are also made busy by the ground just traced.

If the private contact 5 engaged by the wiper 2 is idle when the 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 contact 102 of relay LR does not energize magnet MM since there is no ground on contact 5 and the magnet MM remains inert. The cut-off relay CO is immediately energized to ground at contact 104, restores contacts ON as before described, and the relay CO is held energized over the circuit to ground at C, as already described. Thus switch B only travels when its wipers are in engagement with a busy trunk when a call is initiated.

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 normal contact 195 of relay IR (circuit being traced via 206, 207, 195, 208) which magnet operates to step the wipers 209, 210 and 211 of the first selector C in a downward primary direction to the third group of contacts, thus selecting the three-hundreds group of connectors. After the last impulse, the relay 200 de-energizes, due to a circuit being closed through the lower winding of the said relay 200, normal contact 212, alternate contact 213 of relay IR, and alternate contacts 214 and 199. The said primary off-normal contacts PON move to their alternate positions upon the first step of the wipers of the first selector D, and the energizing circuit for the lower winding of relay 200 just mentioned is closed upon the first step of the wipers off normal, but the relay 200 does not de-energize during the sending of impulses, it being differentially wound and only receiving short impulses of current through its neutralizing winding during the impulse operation of relay IR. As soon as the

above-mentioned circuit through the lower winding of relay 200 is steadily closed, the lower or neutralizing winding builds up and the said relay permits its armature to retract. The opening of contact 201 disconnects ground from conductor 203 at this point but a substitute ground from alternate contact 199 of the primary off-normal contact PON is substituted before said relay 200 de-energizes, to keep contact 5 busy and for other apparent purposes. Differential relay 196 is not de-energized during the rapid operation of relay IR, although rapid impulses are transmitted through its lower or neutralizing winding due to the construction and adjustment of the said relay 196. Upon the de-energization of the relay 200, an energizing circuit for the relay 215 is established from battery, through normal contact 216 of relay T, normal contact 217, normal contact 218 of the secondary off-normal contact SON, normal contact 201, alternate contact 204 to ground at 199, and relay 215 energizes secondary magnet SM by current from battery through said magnet SM to ground at contact 219. Secondary magnet SM steps the wipers 209, 210 and 211 one step in a rotary or secondary direction to engage the first set of contacts 220, 221 and 222, and the opening of normal contact 217 at magnet SM de-energizes relay 215. Contact 212 opens the circuit of the lower winding of relay 200 which energizes again. Relay 215 opens contact 219, de-energizing secondary magnet SM. Upon the first step of the wipers 209, 210 and 211, the secondary off-normal contacts SON assume their alternate position, opening the initial energizing circuit of the relay 215, and should the private wiper 209 of the first selector D engage a contact leading to a busy connector, a substitute circuit is established for relay 215 traced from battery through the winding of the relay 215, normal contact 216, normal contact 217, alternate contact 223, alternate contact 224 and wiper 209 to the grounded busy contact 220. The resulting closing of contact 219 again energizes secondary magnet SM. The relay 215 and magnet SM are thus alternately energized and de-energized to step the wipers 209, 210 and 211 in a secondary rotary direction to seek the contacts of an idle connector switch as E. When a contact 220 leading to an idle connector is encountered by the wiper 209, an energizing circuit of the relay 215 is not again closed, and no further energizations of the secondary magnet SM occur. By this see-saw action of relay 215 and magnet SM a positive driving operation of the secondary magnet SM is secured and the selector C will not stop on a busy contact or go past an idle contact because unless relay 215 is energized, magnet SM cannot be energized, and relay 215 can only be energized when magnet SM

is at normal and private wiper 209 is resting on a busy contact. The relay 200 does not de-energize during the secondary movement of the wipers, due to its adjustment and the rapidity of the interruptions of contact 212 of secondary magnet SM. The steady closure of contact 212 of magnet SM after its last de-energization closes a circuit for the lower winding of the relay 200, as previously described, and due to its differential construction, it de-energizes, whereon an energizing circuit for the relay T is established traced from battery through the winding of the said relay T, alternate contact 218 of the secondary off-normal contacts SON, normal contact 201, contact 204 to ground at 199. The opening of normal contacts 192 and 193 of relay T opens the energizing circuit of the impulse relay IR, and the closing of normal contact 195 of said relay IR closes a circuit through the lower winding of the relay 196 traced from battery, through the said lower winding, normal contact 195, to ground at contact 208 of relay 196, which relay 196, due to its differential winding, neutralizes and restores to normal, and 196 opens the circuit of relay 200 permitting the latter to restore. The closing of alternate contacts 192 and 193 of relay T extends the connection of the calling subscriber A to the idle connector D, engaged by wipers 209, 210 and 211 of the first selector C, bringing about the energization of the impulse relay IR' of connector D over a circuit traced from ground through one winding of the relay IR', contact 222, wiper 211, alternate contact 193, contacts 7-4, alternate contacts 17-11, through the substation A, alternate contacts 12-15, contacts 3-6, alternate contact 192, wiper 210, contact 221, and through the left hand winding of the relay IR' to battery and ground. The restoration of the relay 196 of the first selector C opens the initial energizing circuit of relay T at C, but the relay T being slow to release has a substitute circuit established for it, traced from battery through the winding of said relay, its alternate contact 225, wiper 209, bank contact 220, conductor 226, and conductor 227 to ground at alternate contact 228 of the impulse relay IR'. The said relay T remains energized until the termination of the conversation.

The energization of the relay IR' energizes relays 229 and 230, the circuit of relay 229 extending from battery through the right hand winding of said relay, normal contact 231 of the primary off-normal contacts PON', conductor 226 and conductor 227 to ground at alternate contact 228 of relay IR'. A circuit is also closed through the lower winding of relay 230 upon the energization of relay IR' extending from battery through the lower winding of the relay 230, conductors 231', 232 and alternate

contact 233 to ground at alternate contact 228 of relay IR'. However, the relay 230 does not operatively energize at this time owing to the fact that the energization of relay 229 closed a circuit through the upper winding of relay 230 and at the time relay 229 energized. The windings of relay 230 being wound differentially, prevents the relay operatively energizing. Relay 229 locks itself to ground at 234. Four impulses now transmitted from A de-energize and energize relay IR' four times causing the primary magnet PM' to energize and de-energize four times to step the wipers 235, 236 and 237 in a downward primary direction to the fourth group of contacts containing those of the called line. Upon the first energization of relay IR', the circuit through the lower winding of relay 230 is opened, thereby permitting the same to immediately energize. The circuit of the primary magnet PM' may be traced from battery through the winding of the said magnet PM', normal contact 238 of switching relay SW, conductor 239, alternate contact 240 of relay 230, normal contact 233 of relay IR', conductor 227, conductor 226, through normal contact 231 of the primary off-normal contacts PON' to ground at alternate contact 234 of relay 229. After the primary off-normal contact 231 assumes its alternate position, which occurs upon the first step of the switch shaft, the ground fed from contact 241 of relay 242 is substituted for the ground fed through contact 234 of relay 229. After the last impulse of the series has been sent, the steady flow of current through both windings of relay 230 causes the said relay 230, 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 233. The closing of normal contact 243 of relay 230 energizes switching relay SW by current through the winding of said relay SW, its make-before-break contact 244, normal contact 245 of secondary off-normal springs SON', conductor 246, normal contact 243 of relay 230, and conductor 247 to ground at alternate contact 248 of primary off-normal contacts PON'; and relay SW locks itself to ground via contacts 257 and 248. The closing of alternate contact 238 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 235, 236 and 237 in a secondary rotary direction to engage contacts 250, 251 and 252 of the called line. Upon the first impulse of the last set, the re-

lay 230 again energizes to permit the secondary magnet SM' to be operated, and after the last impulse the relay 230 is again de-energized, as previously described, and closes a circuit for the test relay TR traced from battery, through the winding of the said relay, conductor 253, the alternate contact 254, alternate contact 245 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 246, normal contact 243, conductor 247 to ground at 248. The closing of alternate contact 255 of relay TR connects the said relay over conductor 256 to the test or private wiper 235, and should the called line be busy the private contact 250 of the called line would be grounded, thus closing a locking circuit for the said relay TR through the private wiper.

Called line idle.

Assuming that the called line is idle, private contact 250 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 257 of relay TR upon its momentary energization opens the circuit of the switching relay SW, and the relay SW de-energizing opens the circuit for relay TR at its contact 254, leaving the relay TR dependent upon the potential found upon the private contact 250 of the called line. Since, as assumed, this contact is idle and thus free from ground, the relay TR de-energizes and thereby causes the energization of relay 242 by current from battery, through the winding 183' of the cut-off relay CO', conductor 184', contact 182', conductors 185', 186' and 187', private contact 250, through wiper 235, conductor 256, normal contact 255, conductor 258, normal contact 259 of relay SW, conductor 260, through the lower winding of the relay 242, and conductor 261 to ground at 262. The closing of alternate contact 263 of relay 242 short circuits the lower winding of the said relay, and the closing of its alternate contact 264 closes a circuit through the upper winding of the said relay through the alternate contact 264 and conductor 261 to ground at 262. 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 177' and 178' 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 265 of relay 242 connects the interrupter I of the relay 266, circuit for relay 266 being traced from battery through relay 266, conductor 267, alternate contact 265, conductor 268,

normal contact 269 and through I to ground. The relay 266 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 270 of ringing control relay RC, conductor 271, alternate contact 272, conductor 273, normal contact 274, wiper 237, bank contact 252, through the condenser and call bell of the called substation back through bank contact 251, wiper 236, normal contact 275 and conductor 276 to ground at alternate contact 241 of relay 242.

The call bell of the called subscriber at the substation E is thus intermittently rung, and when the called subscriber answers and the relay 266 is energized, a circuit for the relay SR is closed, from battery through the lower winding of the relay SR, through alternate contact 274 of relay 266, wiper 237, contact 252, through the now closed upper contacts of the substation switch hook at the called substation E, back through contact 251, wiper 236, alternate contact 275 of relay 266, 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 277, to ground at 278'. Contact 279 locks relay RC from battery, through the winding of the said relay RC, its alternate contact 279 and conductor 247, to ground at alternate contact 248 of the primary off-normal contacts PON'. The opening of normal contacts 269 and 270 disconnects the interrupter I and the ringing generator G to prevent further application of ringing current. A substitute circuit for the relay 266 is now established which may be traced from battery, through the winding of the relay 266, conductor 267, alternate contact 265, conductor 268, alternate contact 269 and conductor 247 to ground at 248. The subscribers are now in conversational circuit, and the talking circuit may be traced over the heavily marked conductors, said conductors 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 E opens the holding circuit of the relay T of the first selector D, and the closing of normal contact 216 of relay T energizes relay 215 by current from battery, through said relay 215, normal contact 216, normal contact 217, normal contact 223 and contact 214 to ground at 199. The closing of alternate contact 219 of relay 215 energizes secondary magnet SM, and the relay 215 and secondary magnet SM

are alternately energized and de-energized, (as before described), the secondary magnet SM thus stepping the wipers 209, 210 and 211 beyond the last contacts of the 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 contact 199 of the primary off-normal contacts PON 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 285 of relay SR closes a circuit through the left hand winding of the relay 229 which may be traced from battery, through the left hand winding of the said relay 229, alternate contact 286, conductor 287, normal contact 285 and conductor 288 to ground at normal contact 228. Due to the differential construction of relay 229, the said relay neutralizes and restores to normal. The closing of normal contact 289 of relay 229 closes an energizing circuit for the secondary magnet SM', from battery, through said magnet, conductor 290, normal contact 289, contact 291, through the interrupter I' to ground. The secondary magnet SM' thus steps the wipers 235, 236 and 237 beyond the last set of contacts in the group, the wipers then restoring to normal from this position by spring tension. The restoration of the relay 229 opens the circuit of relay 242 at contact 262, and the relay 242 restoring opens the circuit of relay 266 at contact 265. The primary off-normal contacts PON' having restored upon the restoration of the switch, the opening of the contact 248 de-energizes relay RC. The relay 229 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 inter-

rupts 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 229, 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 228 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 285 of said relay in its alternate position preventing the differential wound relay 229 from restoring to normal, and closing the energizing circuit for the secondary magnet SM'. The relay 230 energizes when the line 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 230, which may be traced from battery, through the said lower winding, conductor 232, alternate contact 285, conductor 288 to ground at alternate contact 228 of the now restored impulse relay IR'. Relay 230 being differentially wound, restores to normal and the closing of normal contact 295 of the said relay 230 places a ground upon the private contact of the connector D over a circuit which may be traced from ground at contact 248, conductor 247, normal contact 243 of relay 230, conductor 246, alternate contact 245, normal contact 295, alternate contact 296 of the secondary off-normal contacts SON', to the private contact 220. 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 250 has a ground connected to it, and it thus closes a locking circuit for the test relay TR from battery, through the winding of the said relay, its alternate contact 255, conductor 256, and the wiper 235 to the grounded contact 250. Alternate contact 297 of the test relay TR remains closed and connects the busy signal BB to the calling line to transit 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 from being applied to the called line if the called line should become idle before the connector D is disconnected from the bank contacts of a called subscriber's line. The relay RC upon energizing locks up through its own make-before-break contacts 277 and 279 to ground at alternate contact 248. 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 229, (since the relay SR has not been energized) and by the closing of circuit through the left hand winding of said relay 229, the closing of contact 289 now connects secondary magnet SM' and interrupter I', and the connector restores to normal by spring tension. 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 line and test relay of my individual 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, 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.

What I claim as new and desire to secure by United States Letters Patent is:

1. A telephone system including an automatic switch, a motor magnet for said

switch, a double wound line relay for controlling said motor magnet, an initial energizing circuit for said line relay including the two windings thereof in series, a second circuit for said relay including one winding thereof and a contact of said motor magnet, and a circuit for said motor magnet including a contact of said line relay.

2. A telephone system including an automatic switch provided with a contact maker, motor mechanism for controlling said contact maker, a double wound relay, an initial energizing circuit for said relay including the two windings thereof in series, a second circuit for said relay including one winding thereof and a contact controlled by said motor mechanism, and a circuit for said motor mechanism including a contact controlled by said relay.

3. A telephone system including an automatic non-restoring trunking switch, a motor magnet for said switch, a combined test and line relay for controlling said motor magnet, a cut off relay for said switch, an initial energizing circuit for said first relay including contacts controlled by said cut off relay, and a second circuit for said test relay including a contact of said motor magnet and a second contact of said cut off relay.

4. A telephone system including a non-numerical non-restoring switch, a double wound test relay and a driving magnet for said switch, a circuit for said test relay including the two windings thereof and a contact of said driving magnet, and a circuit for said driving magnet including a contact of said test relay.

5. A telephone system including a non-restoring automatic switch provided with a contact maker, a motor magnet for actuating said contact maker, a double wound test relay for said switch, an initial energizing circuit for said test relay including the two windings thereof in series, a second circuit for said test relay including only one winding thereof and a contact of said motor magnet, and a circuit for said motor magnet including a contact of said relay and said contact maker.

6. A telephone system including a non-restoring automatic switch, a double wound relay, a motor magnet, and a cut off relay for said switch, an initial energizing circuit for said double wound relay including the two windings thereof in series, a second circuit for said double wound relay including a contact of said motor magnet and a contact of said cut off relay, a circuit for said motor magnet including a contact of said double wound relay, and a circuit for said cut off relay including a contact of said double wound relay.

7. A telephone system including an automatic switch, a motor device for said switch,

a test contact, a double wound relay for controlling the said motor device, an energizing circuit for said double wound relay including the two windings in series, a second circuit for said relay including one winding thereof and an armature contact controlled by said motor device and said test contact, and a circuit for said motor device including a contact controlled by said double wound relay and said test contact.

8. A telephone system including a subscriber's telephone line, a trunking switch for said line, trunk lines extending from said switch, active contacts for said switch always in engagement with some one of said trunk lines, which trunk line is the one last employed by said switch for extending a connection therefrom, a double wound relay for said switch, a motor device for actuating said active contacts, means for closing a parallel circuit for said relay and said motor device whereby if one of said active contacts is in engagement with a busy passive contact said motor magnet will be operated to advance said active contacts, while if said active contact is in engagement with an idle passive contact said relay is de-energized to cause said subscriber's line to be connected with the engaged trunk line.

9. A telephone system including a subscriber's line, a switch individual thereto, a double-wound relay for said switch, a motor

magnet for said switch, an energizing circuit for said double-wound relay including the two windings thereof, a second test circuit for said double-wound relay including only one winding thereof and a contact of said motor magnet, and a circuit for said motor magnet including a contact of the said double-wound relay.

10. A telephone system including a non-numerical trunk switch, a double-wound line relay therefor, a motor magnet therefor, a circuit including the two windings of said line relay in series, a second circuit for said relay including one winding of the same and a contact of said motor magnet, and a circuit for said motor magnet including a contact of said relay.

11. A telephone system including a non-numerical non-restoring trunk switch, a double-wound relay and a motor magnet for said trunk switch, a circuit for said relay including the two windings thereof in series, a second circuit for said relay including one winding of the same and a switch contact of said motor magnet, and a circuit for said motor magnet including a contact controlled by said relay.

Signed by me at Chicago in the county of Cook and State of Illinois, this 12th day of February, 1919.

HARRY H. IDE.