

Oct. 21, 1924.

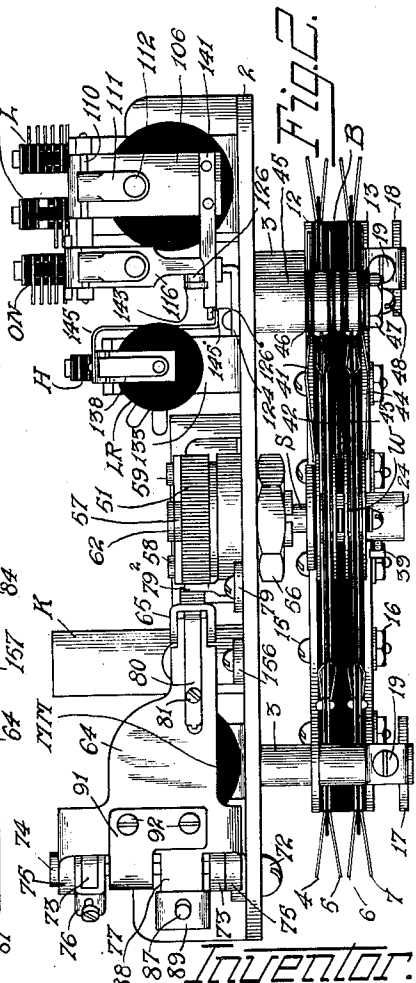
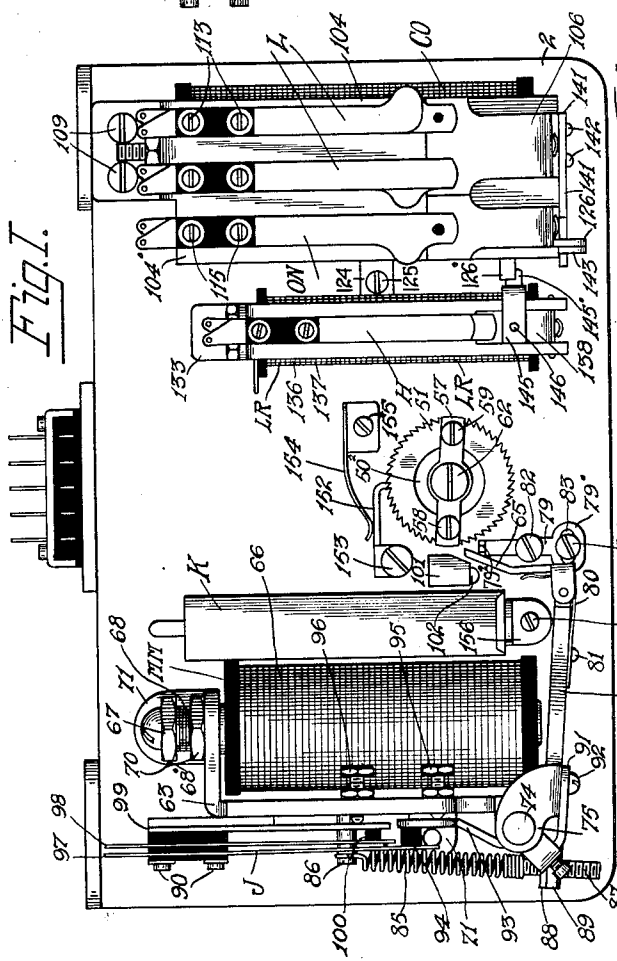
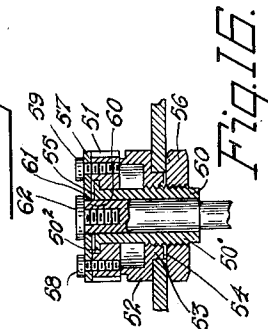
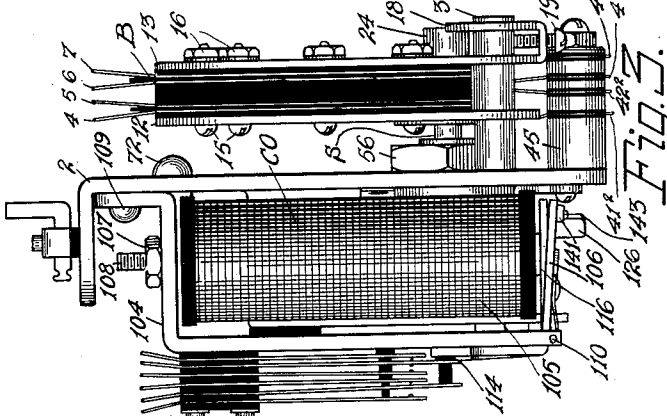
H. H. IDE

TELEPHONE SYSTEM

Filed Jan. 20, 1919

1,512,101

5 Sheets-Sheet 1



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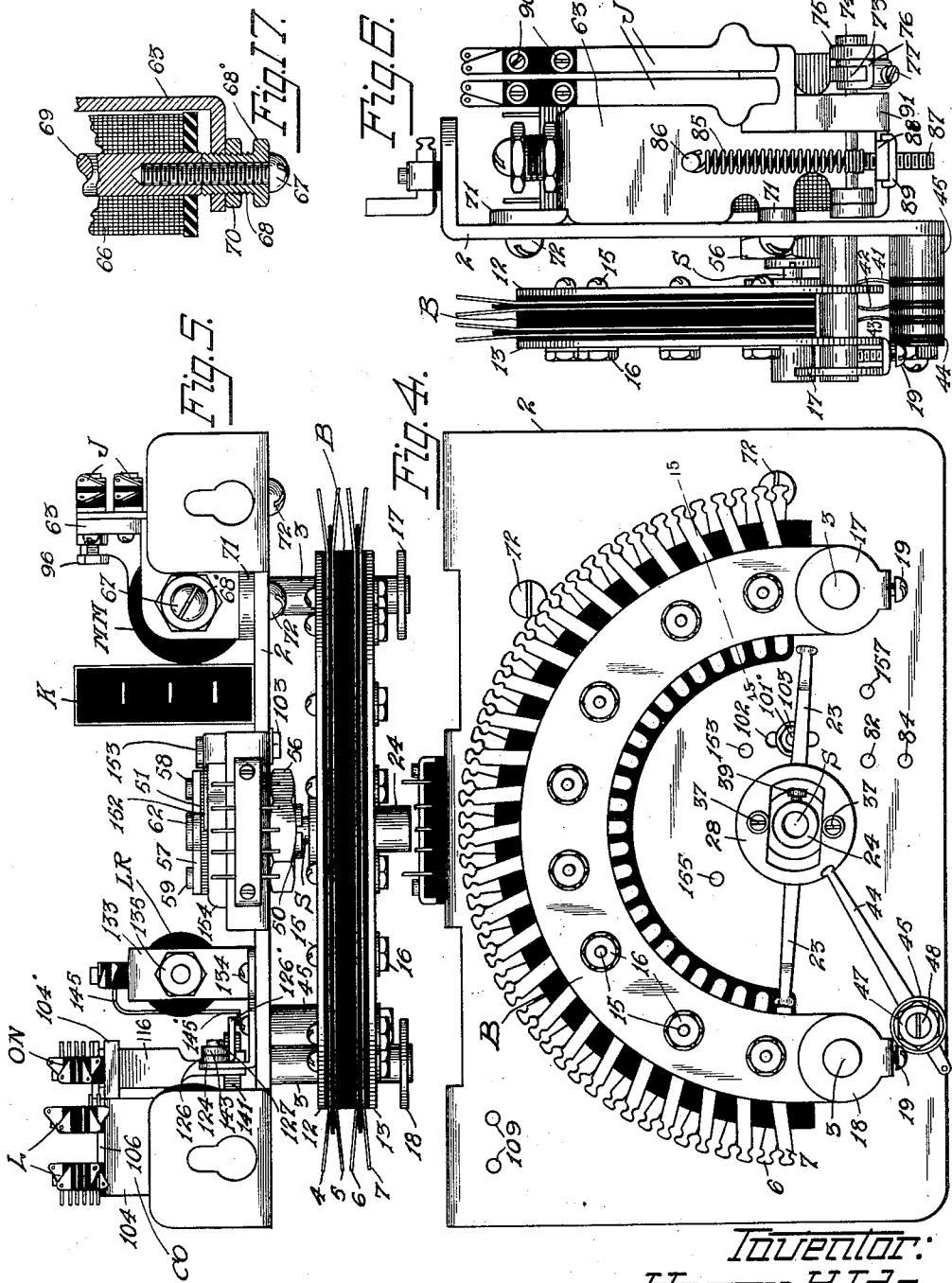
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5 Sheets-Sheet 2



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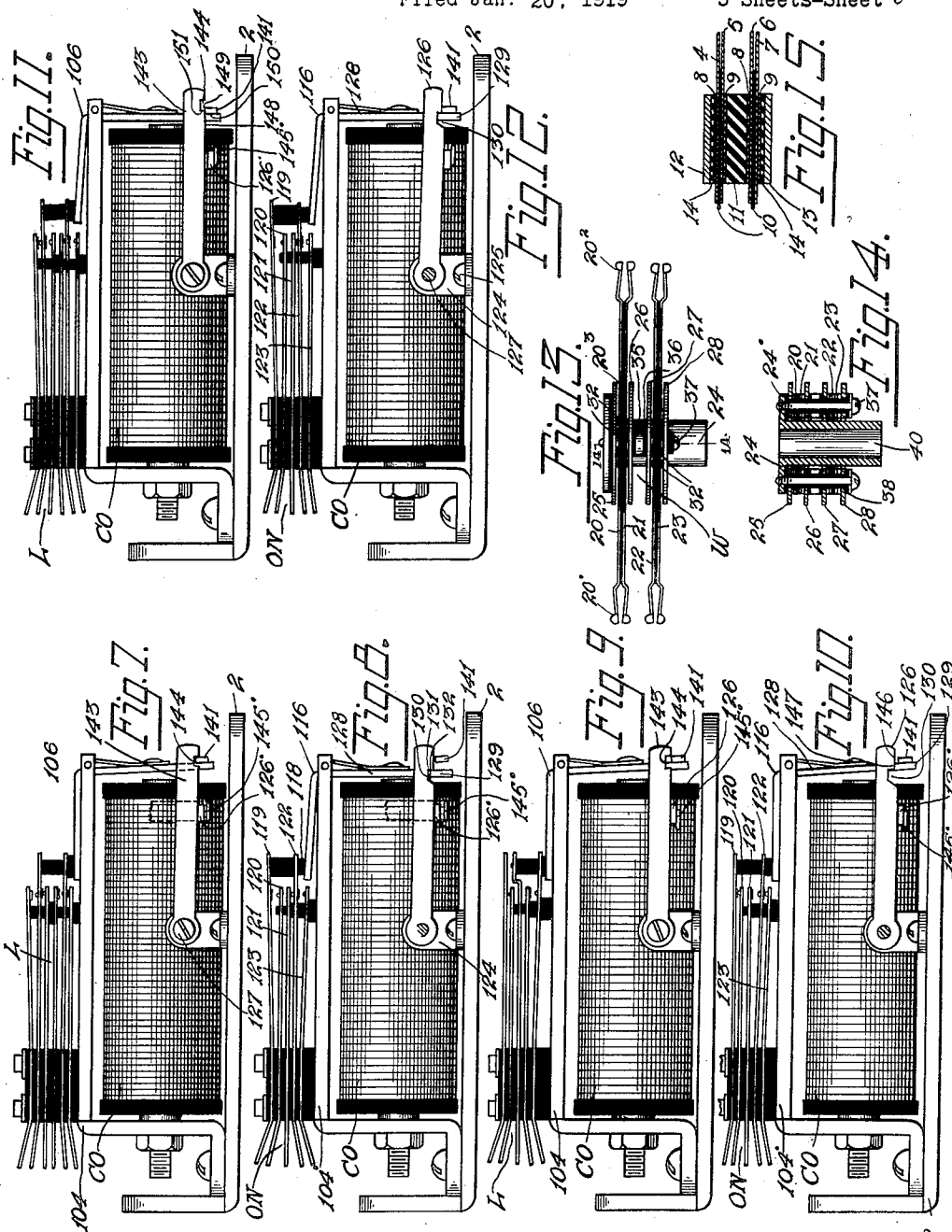
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5 Sheets-Sheet 3



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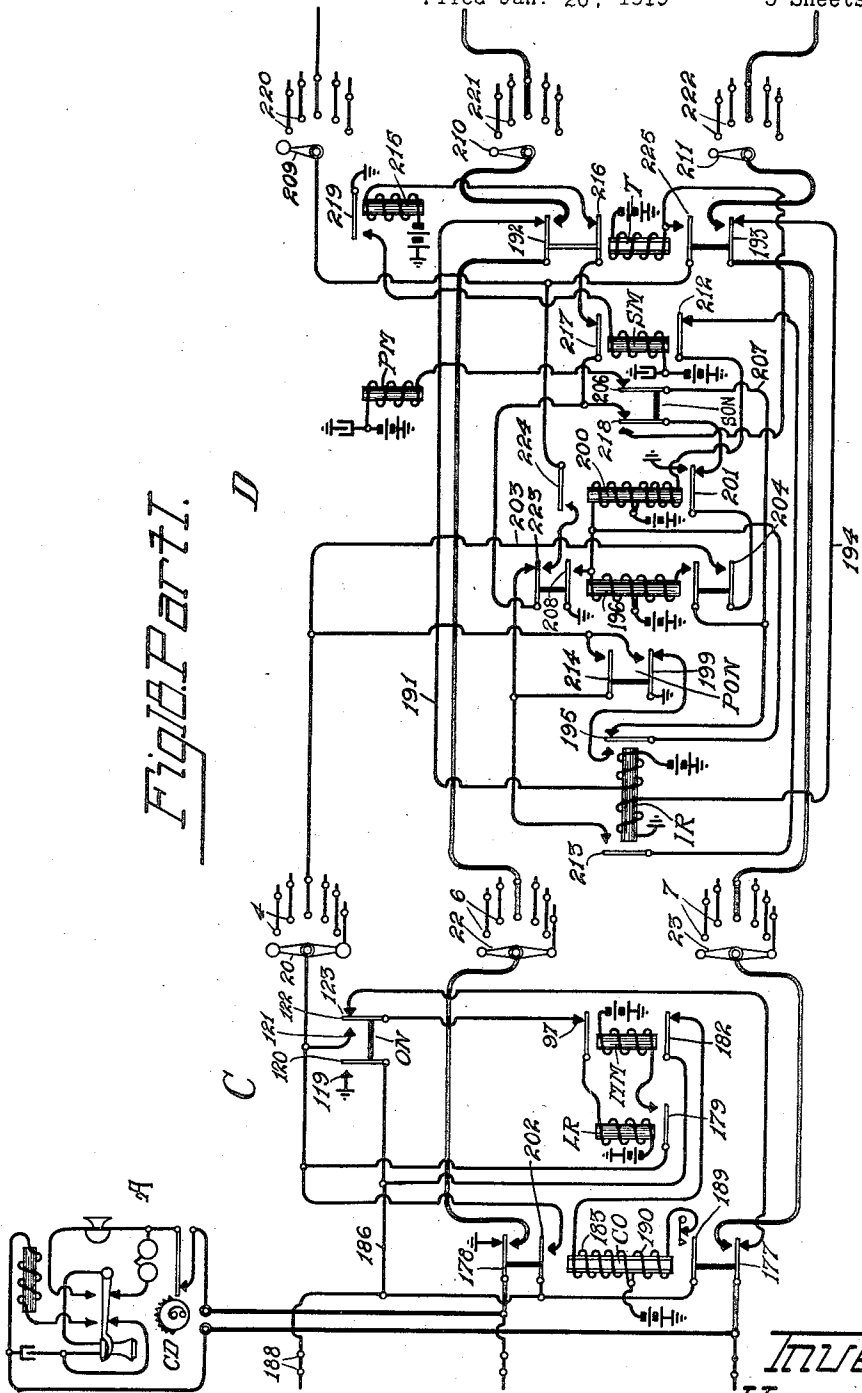
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5 Sheets-Sheet 4



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TELEPHONE SYSTEM

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5 Sheets-Sheet 5

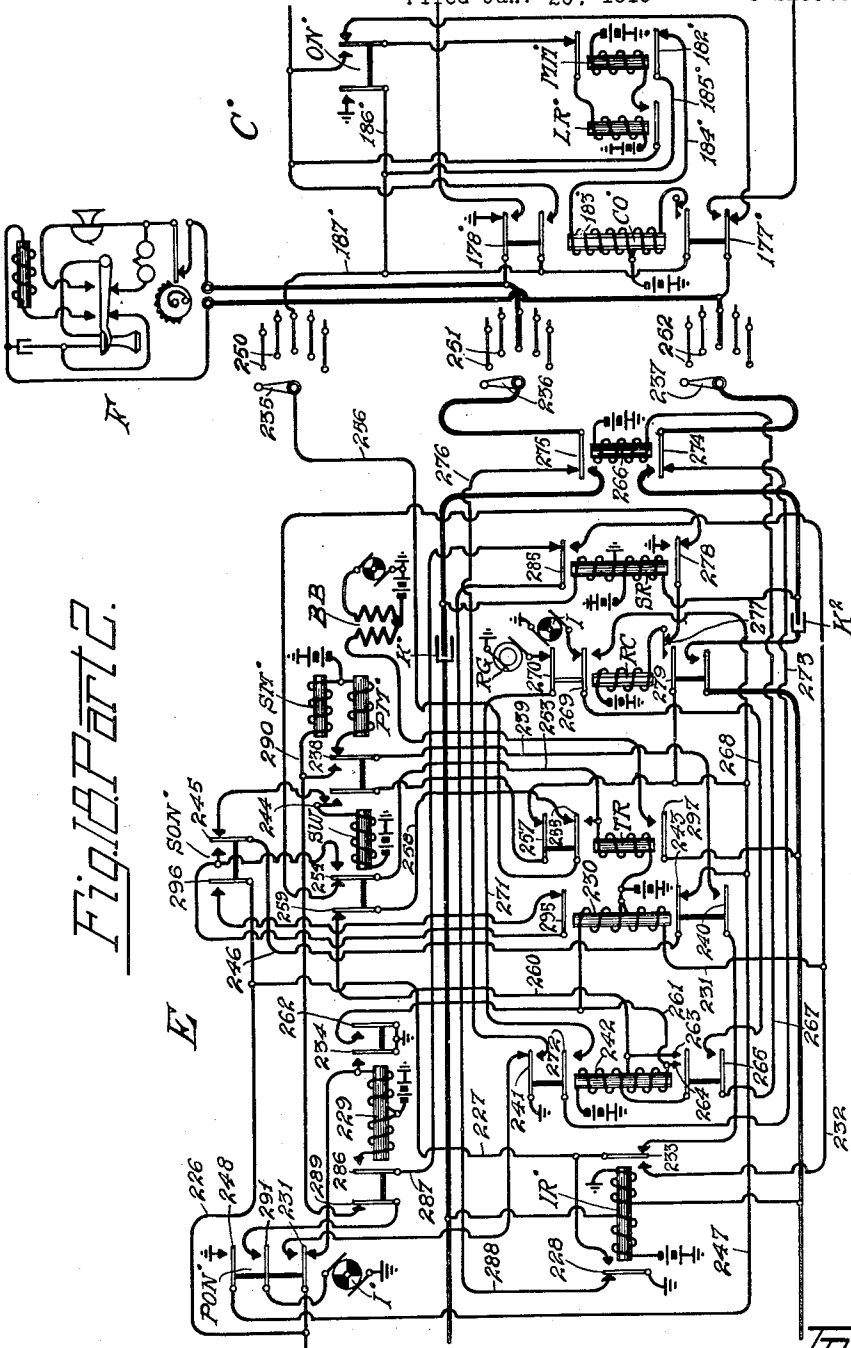


Fig. 13 Part 2.

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UNITED STATES PATENT OFFICE.

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

TELEPHONE SYSTEM.

Application filed January 20, 1919. Serial No. 271,960.

To all whom it may concern:

Be it known that I, HARRY H. IDE, a citizen of the United States of America, residing in Chicago, 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 and has to do more particularly with automatic or semi-automatic systems in which switches are used for connecting a calling line to an idle trunk and one object of my invention is the provision of an improved arrangement which embodies desirable features and advantages all in an efficient, simple, economical manner, and in which the parts are so constructed and combined as to make them readily accessible for manufacture, assembly, adjustment and repairs.

A feature of my invention is the provision of 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.

Another feature of my invention is a novel interlocking mechanism for controlling the operation of certain apparatus and functions of certain relays associated with the switch.

Still another feature of my invention is the provision of a switch with a positive drive circuit that does not permit the wipers of the switch to stop on busy contacts nor to pass over idle contacts.

The novel features of the invention through the provision of which the above-mentioned and other advantageous results are attained will be explained by reference to the accompanying drawings in which like reference characters in the several views denote like parts, and in which:

Fig. 1 is a plan view of the line switch of my invention;

Fig. 2 shows the switch in elevation;

Fig. 3 shows the switch in elevation from the right;

Fig. 4 shows the switch from below;

Fig. 5 is a rear elevation of the switch;

Fig. 6 shows the switch in elevation from the left;

Figs. 7 and 8 illustrate combined off-normal and cut-off relay control mechanism in its normal position;

Figs. 9 and 10 illustrate combined off-normal and cut-off relay control mechanism in one of its off-normal positions;

Figs. 11 and 12 illustrate combined off-normal and cut-off relay control mechanism in another of its off-normal positions;

Fig. 13 is a view of the wipers;

Fig. 14 is a sectional view along the line 14—14 of Fig. 13;

Fig. 15 is a sectional view along the line 15—15 of Fig. 4;

Fig. 16 is a sectional view of the main shaft showing its construction;

Fig. 17 is a sectional view showing the method of mounting the magnet coils;

Fig. 18 which comprises parts 1 and 2 illustrates diagrammatically an automatic telephone system including the line switch of my invention.

Referring now more particularly to the structure as illustrated in Figs. 1 to 17, inclusive, the line switch of my invention comprises a mounting plate 2 to which are secured the operating parts of the line switch, and also a bank of contacts B. The said bank of contacts B cooperate with the wipers W, which latter are supported upon a shaft S. Plate 2 further supports a motor magnet MM, a combined line and interrupter relay LR and a cut-off relay CO.

Contact bank B comprises any suitable number of contact sets, each set including a private contact 4, a common contact 5 and line contacts 6 and 7. Twenty-five sets of contacts per switch is a convenient number. The contacts are radially disposed between strips of insulation cloth 8 and 9. Strips 10 and 11 of micarta or other suitable material are placed between the contacts to properly space and insulate them. Contacts 5 may be connected together to form a common for private contacts 4 or they may be used for other connections. Strips of insulation 14 are placed between the clamping plates 12 and 13 and the contacts. Bolts 15 with nuts 16 secure the contact bank, as a whole, between plates 12 and 13.

To secure the bank to the supporting posts 3, (which are fastened to plate 2), I provide the lower plate 13 with ears 17 and 18 bent over parallel to the plane of said plate. Ears 17 and 18 and plates 12

and 13 have openings to receive posts 3. Bank B, as a whole, is slipped on the posts 3, and screws 19 which have screw-threaded engagement with the bridge portion of the ears 17 and 18 are tightened to maintain the bank B, as a whole, in its adjusted position. Wipers 20, 21, 22 and 23 comprise two oppositely extending arms each, while the contact bank, with which the wipers are operatively associated, forms a semi-circle so that when one set of arms leaves the last contact set 4, 5, 6 and 7, the other set of arms engages the first contact set. Wipers 20, 21, 22 and 23 mounted upon the shaft S are suitably insulated therefrom, hub 24 being provided for carrying the wipers and the conducting rings 25, 26, 27 and 28. The wipers 20, 21, 22 and 23 are similarly constructed; for example wiper 20 has a ring-shaped body portion 20³ and two arms 20¹ and 20² having flared ends for contacting with the contacts 4. The pair of conducting rings 25 and 26 are properly spaced from the wipers 20 and 21 by means of metal washers 32. Conducting rings 27 and 28 are associated with the wipers 22 and 23 and properly spaced from them by the metal washers 32. Spacer washer 35 and insulation washers 36 suitably space the various parts. Screws 37 clamp the wipers and disks to the hub 24 and pass through insulating bushings 38 to engage shouldered portion 24¹ of the hub 24. Hub 24 being provided with a central opening 40 for the purpose is slipped over shaft S and when the wipers are adjusted in alignment with their contacts respectively, the set screw 39 is tightened to hold the wiper unit W in its adjusted position upon the shaft S. The conductor rings 25, 26, 27 and 28 form contacting surfaces for wiper-brushes 41, 42, 43 and 44, suitably mounted upon a stud 45 and insulated from the stud and from each other by insulation washers 46. The wipers are held upon the stud 45 in any suitable manner as by means of the nut 47 which has screw-threaded engagement with a stud 45, the said stud 45 being fastened to the plate 2 by the screw 48. The wipers 41, 42, 43 and 44 contact respectively and permanently with the conducting rings 25, 26, 27 and 28, which rings are in turn conductively connected to the wipers 20, 21, 22 and 23 by washers 32. Thus the wipers 20, 21, 22 and 23 are always conductively connected to terminals 41², 42², 43², and 44².

Sleeve 50 supported by plate 2 serves as a bearing for the shaft S and also as a bearing for the ratchet 51 which operates to rotate the shaft S and the wiper unit W over the bank contacts. The sleeve 50 has its one end 50¹ threaded and its other end provided with a flanged portion 50², the said flanged portion 50² resting in a

recess 55 in the ratchet 51. A collar 52 has screw-threaded engagement with the threaded portion 50¹ of the sleeve 50 and its peripheral surface also forming a bearing for the ratchet 51. The collar 52 is provided with a reduced portion 53 which fits into a suitable orifice 54 in the plate 2. I provide a nut 56 which has screw-threaded engagement with the threaded portion 50¹ of the sleeve 50 and when the proper adjustment of the ratchet 51 and parts are obtained, the nut 56 is tightened to secure the sleeve 50 and its supported parts in their adjusted position. A plate 57 is secured to the ratchet 51 by means of the screws 58 and 59. The shaft S is provided with a squared portion 60 at its upper end which enters a square opening 61 in the plate 57. A suitable screw 62 passing through a suitable opening in the plate 57 has screw-threaded engagement with a suitable tapped orifice in the squared end 60 of the shaft S, thus connecting the shaft S to the plate 57 so that when the ratchet 51 is rotated, as will presently be described, the shaft S is also rotated therewith.

The motor magnet MM, which is adapted to move the wipers over bank contacts, includes a pole piece 63, an armature 64, and a driving pawl 65. The electromagnet 66 is suitably secured to the pole piece 63 by means of a screw 67 which passes through a stud 68, the said screw having screw-threaded engagement with a suitable tapped opening in the core 69 of the magnet 66. The stud 68 through which the screw 67 passes serves as an adjusting means for the magnet 66 in a forward or backward direction, and has screw-threaded engagement with a suitable tapped orifice in the heel iron 63, the other end of the stud 68 being provided with an integrally formed hexagonal head 68¹. To adjust the magnet 66, the screw 67 is loosened and the stud 68 turned to the right or left, as the case may be, to properly adjust the magnet 66 and when this adjustment is obtained, a lock nut 70 is tightened to hold the stud 68 in its adjusted position.

The pole piece 63 has projecting ears 71 bent at right angles to the main part of the said pole piece, the said ears having suitable tapped orifices which receive screws 72 to fasten the magnet 66, pole piece 63 and armature 64 as a unit to the mounting plate 2. The pole piece 63 is provided with projecting ears 73, bent at right angles to the main part of the pole piece, the said ears having suitable openings to receive the pivot pin 74, which pivot pin 74 pivotally supports the armature 64 of the motor magnet MM. The armature 64 is also provided with ears 75 which have suitable openings to receive the said pivot pin 74. A U-shaped member 76 is also provided, the arms of which also have suitable openings for re-

ceiving the pivot pin 74. To pivotally support the armature 64 upon the pole piece 63, the pivot pin 74 is inserted through the openings in the ears 73 of the pole piece 63 and ears 75 of the armature 64, and through the openings in the arms of the U-shaped member 76. One arm of the member 76 fits between one of the supporting ears 73 of the pole piece 63 and the adjacent ears 75 of the armature 64. A set screw 77 is provided and has screw-threaded engagement with the yoke end of the U-shaped member 71. The set screw 77 is used to securely hold the pivot pin 74 in place relative to the heel iron 63 and armature 64.

The armature 64 carries a pivoted driving pawl 65 which is normally held against an adjustable stop 79 by means of a leaf spring 80, the said leaf spring 80 being held in place by means of a screw 81. The adjustable stop 79 is pivotally secured to the mounting plate 2 by means of a screw 82. The stop 79 has an enlarged end 79' provided with a slot 83, through which a screw 84 passes. To adjust the pawl 65 the screws 82 and 84 are loosened and the stop 79 is then moved about its pivot screw 82, causing the angular portion 79² to move to the right or left, as the case may be, and when the proper adjustment is obtained, the screws 82 and 84 which have screw-threaded engagement with suitable tapped openings in the plate 2, are tightened to hold it in its adjusted position. The armature 64 is held in its normal position by means of a coil spring 85, the said spring having its one end fastened to a pin 86 which is staked to the pole piece 63, and its other end is secured to an adjustable screw 87. The screw 87 passes through a suitable opening in the arm 88, which arm 88 is integrally formed with the armature 64, the said screw 87 being provided with an adjustable nut 89. The tension of the spring 85 is regulated by means of the nut 89. A set of contact springs J are associated with the motor magnet MM, the said springs being insulatingly mounted upon the pole piece 63 by means of the screws 90, which are suitably insulated from the springs J. A plate 91 is suitably mounted upon the face of the armature 64 by means of the screws 92 and is provided with an angularly extending arm 93, preferably integrally formed with the plate 91. The arm 93 is provided with rubber buffers 94 which operate the spring sets J upon the attraction of armature 64 when motor magnet MM is energized. An adjustable screw stop 95 is provided, which stop has screw-threaded engagement with the pole piece 63 and acts as a stop for the arm 93 when the said arm is in its normal position. An adjustable screw 96 is provided and has screw-threaded engagement with the pole piece 63, and is

used for adjusting the normal position of the springs 97 and 98. A leaf spring 99 is provided and is mounted upon the pole piece 63 by means of the screws 90, and a rubber buffer 100 carried by the spring 98 is used to prevent the spring 97 from contacting with spring 98. The springs 97 and 98 may be adjusted so that they are separated upon a partial attraction of the armature 64, or not until a full attraction of the armature 64 takes place. This adjustment of spring 97 and 98 of magnet MM is for the purpose of timing the instant at which the line relay LR has its circuit interrupted, as will be more fully hereinafter described.

The pawl 65 is adapted to engage a tooth of the ratchet wheel 51 upon each actuation of the motor magnet MM, and an adjustable post 101 is provided to limit the stroke of the pawl 65 so that the wipers 20, 21, 22 and 23 are only advanced one step at a time. The post 101 has a threaded stud 101' which passes through a suitable slot 102 in the plate 2. The stop 101 may be moved forward or backward as the case may be, and when the desired adjustment is obtained a nut 103 having screw-threaded engagement with the stud 101' is tightened to securely hold the stop 101 in its adjusted position.

The cut-off relay CO includes a pole piece 104, an electromagnet 105 and armature 106, the said magnet 105 being mounted upon the heel iron 104 by means of a nut 107 which has screw-threaded engagement with the threaded portion of the core 108 of the magnet 105. The pole piece 104, magnet 105 and armature 106 as a whole are mounted upon the mounting plate 2 by means of the screws 109 which pass through suitable openings in the angular portion of the pole piece 104, which screws have screw-threaded engagement with suitable tapped orifices in the mounting plate 2. The armature 106 is pivotally supported by means of the pivot pin 110 which pin 110 rests in a suitable groove cut in the face of the armature, and a retaining clip 111 secured to the face of the armature 106 by means of the rivet 112 is provided to retain the armature in place. A set of contact springs L are associated with the cut-off relay CO and are insulatingly mounted upon the heel iron 104 by means of the screws 113, the said springs L being operatively associated with the armature 106 but insulated therefrom by means of the rubber buffers 114 and actuated by the armature 106 upon the energization of the cut-off relay CO.

I provide a set of off normal contacts ON insulatingly mounted upon an extension 104' of the heel iron 104 by means of the screws 115. The movement of the off normal contacts ON is jointly controlled by relay LR and the cut-off relay CO, as will presently

be described. An armature-shaped member 116 is pivotally supported at the forward end of the extension 104' of the heel iron 104 by means of the pivot pin 110 of the armature of cut-off relay CO. A bracket 124 suitably fastened to the mounting plate by means of the screw 125 is provided for pivotally securing a latch 126 by means of a pivot screw 127. The leg 128 of the armature-shaped member 116 is provided with a shoulder 129, and the latch 126 is provided with a notch 130 into which the shoulder rests, its edge 131 engaging the side 132 of the notch 130 retaining the armature-shaped member 116 in a position as clearly illustrated in Fig. 8 to hold the springs 119, 120, etc., of the off-normal contacts ON in their normal position as also illustrated in Fig. 12.

A line relay LR is suitably supported by a bracket 133 secured to the plate 2 by means of the screw 134. The line relay LR is secured to the bracket 133 by means of a nut 135 which nut 135 has screw-threaded engagement with the threaded extension of the core of the relay LR. The relay LR comprises a heel iron 136, an electromagnet 137, armature 138 and a pair of interrupter springs H for purposes as will be more fully hereinafter described.

An arm 141 secured to the armature 106 of the cut-off relay CO in any suitable manner as by means of the rivets 142 is operatively associated with a latch 143 which is also pivotally supported on the bracket 124 by means of the pivot screw 127, the said arm 141 being also operatively associated with the armature-shaped member 116. The members 126 and 143 lie adjacent to and parallel with each other. The latch 143 is provided with a notch 144 at its forward end in which the forward end of the arm 141 rests for purposes as will presently be described. When a call is initiated, the line relay LR is energized, bringing about the attraction of the armature 138. Arm 145 secured to the armature 138 by means of the rivet 146 is moved in an upward direction and its extension 145' engages the angular extension 126', preferably integrally formed with 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, permitting the off-normal contacts ON to assume their alternate position, as clearly illustrated in Fig. 10. 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 126' passing under the latch 143 so that when the latch is in this position, as clearly illustrated in Fig. 9, 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 off-normal position are clearly illustrated in Figs. 9 and 10, and the shifted off-normal springs in Fig. 10. After selection the cut-off relay CO is energized followed by the de-energization of the line relay LR, and the cut-off relay CO attracts its armature 106 carrying the arm 141 with it, and the said arm 141 in its movement engages the leg 128 of the armature-shaped member 116 and rocks it about its pivot. The line relay LR in restoring allows the extension 145' of the arm 145 to disengage the extension 126' of the latch 126. The movement of the member 116 continues until the edge 131 of the shouldered portion 129 of the leg 128 passes the edge 132 of the notch 130 so that when in this position, the latch 126 rocks on its pivot allowing the shoulder 129 to again rest in the notch 130, as clearly illustrated in Fig. 12. The buffer 118 due to the rocking movement of the member 116 engages the spring 122 of the off-normal springs 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 energization of the line relay LR. The cut-off relay CO upon its energization shifts its springs J 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. 11. Upon the restoration of the cut-off relay CO, its armature 106 restores, 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. 7), the movement of the armature 106 is limited by the amount of play that arm 141 has in notch 144 (Fig. 7), as hereinafter explained.

A retaining pawl 152 is pivoted to plate 2 by screw 153 and engages a tooth of the ratchet wheel 51, and is thus yieldingly held by leaf spring 154 fastened to plate 2 by screw 155. Pawl 152 retains the wipers W in engagement with a set of contacts as selected by the switch. A condenser K is mounted upon plate 2 by means of a bracket 156 secured to plate 2 by screw 157.

The circuit in Fig. 18, parts 1 and 2, shows a calling substation A connected to circuits of an individual line switch C, which is the switch of my invention, and selects an idle first selector D. The first selector D selects an idle connector E, and the connector E connects to the terminals

of the called substation F which has its line switch C' similar to C. The substation A has the usual talking apparatus and a calling device CD to send impulse sets to operate the switches D and E to select the called substation F, which is similar to A.

Line switch C of my invention may have twenty-five contact sets, and the circuit as shown at C is adapted to work with the switch structure described and illustrated in Figs. 1 to 17, inclusive. The switch structure for the first selector D and connector E may be the same as illustrated and described in my application, Serial Number 175,364, filed June 18, 1917, issued as Patent No. 1,402,936, Jan. 10, 1922.

Assuming now that a call is to be traced from the calling substation A to the called substation F, upon the removal of the receiver by the subscriber at the calling substation A, line relay LR of switch C energizes by current from battery, through relay LR, contacts 97, normal contact 123 of the off-normal contacts ON, normal contact 177, through the substation, back to ground at normal contact 178. Wipers 20, 22 and 23 always rest upon the set of contacts 4, 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 grounded. Energized relay LR closes contact 179 and the arm 145 engages extension 126' lifting the latch 126, whereby shoulder 129 disengages notch 130 in the latch 126, (see Fig. 7), and contacts ON assume their alternate positions. Closed contact 179 energizes motor magnet MM by current from battery through said magnet, alternate contact 179, wiper 20 to the ground at the busy private contact 4, and magnet MM steps wipers W to engage the next contact set. Magnet MM energizing opens the energizing circuit for the line relay LR at 97, and relay LR restoring opens contact 179 in the circuit of magnet MM which restores. Should the contacts now engaged by the wipers be busy, line relay LR energizes by current through normal contact 97, contacts 121 and 122 to the ground at busy contact 4, and again closes contact 179, energizing magnet MM as before described. The line relay LR and magnet MM are thus alternately energized and de-energized, magnet MM stepping wipers 20, 22 and 23 from one set of contacts to the next as long as busy, i. e. grounded, contacts are encountered. Magnet MM alternately opens and closes contact 182 and thus a vibratory circuit is closed through winding 183 of cut-off relay CO to ground through contacts 119 and 120. The winding 183 of relay CO is of high impedance, and as motor magnet MM energizes and de-energizes with great rapid-

ity, the said winding 183 of relay CO does not effectively energize during the time that the magnet MM is operating. The ground at contacts 119 and 120 is connected to the line's private normal contacts 188 at the connectors having access to it to render such contacts busy. When an idle private contact 4 is encountered, relay LR and magnet MM remain unoperated and the prolonged closure of contact 182 now effectively energizes the winding 183 of relay CO by current to ground through contacts 119 and 120. The relay CO now closes its make-before-break contact 189, energizing its winding 190 by battery through said contact 189 to ground through contacts 119, 120, momentarily reinforcing the initial actuating force of the relay. Relay CO upon energization attracts its armature 106 and the arm 141 carried thereby engages the member 116 and causes the off-normal contacts ON to again assume their normal position. (See Fig. 12). The shoulder 129 of the member 116 now again rests in the notch 130 of the latch 126 to again lock the contacts ON in their normal position. Contacts 119, 120, opening, open the circuit of relay CO, but said relay being slow to release is held up momentarily until a substitute circuit is established for the said relay CO, as will presently be described. The circuit which is momentarily closed through winding 190 is opened upon the full attraction of the armature, as will be observed.

The relay CO having energized, its contacts 177 and 178 assume their alternate position, and the wipers of switch C now engaging the contacts of the idle first selector D, impulse relay IR, at D energizes, circuit being traced from battery through conductor 191, contact 192, contact 6, wiper 22, alternate contact 178, substation A, back through alternate contact 177, wiper 23, 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 199 of the primary off-normal contacts PON. Relay 200 is also energized, over a circuit extending from battery through the upper winding of said relay 200, alternate contact 195, to ground at normal contact 199. Relay 196 upon energizing closes a circuit through the upper winding of relay 200 through alternate contact 208 of relay 196. 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 upper winding 183 of relay CO, normal contact 182, conductor 186, alternate contact 202, contact 20-4, conductor 203, alternate contact 204, to ground at

alternate contact 201. Relay CO remains energized until time of release. The connector contacts 188 of A are also made busy by the ground just traced.

5 If the private contact 4 engaged by the wiper 20 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 179 of relay LR does not energize magnet MM since there is no ground on contact 4 and the magnet MM remains inert. The cut-off relay CO is immediately energized to ground at contacts 119 and 120, restores contacts ON as before described, and the relay CO is held energized over the circuit to ground at D, as already described. Thus switch C only travels when its wipers are in engagement with a busy trunk when a call is initiated.

An idle first selector D having been seized as just described, and assuming that the number of the called substation F 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 D 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 4 busy and for other apparent purposes. Differen-

tial 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 D 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 construc-

tion, 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 connection E, engaged by wipers 209, 210 and 211 of the first selector D, bringing about the energization of the impulse relay IR' of connector E over a circuit traced from ground through one winding of the relay IR', contact 222, wiper 211, alternate contact 193, contacts 7-23, alternate contact 177, through the substation A, alternate contact 178, contact 22, alternate contact 192, contact 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 D opens the initial energizing circuit of relay T at D, 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'. The circuit for relay 230 extends 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'. 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. 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 238, 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 I 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 relay 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 259 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 upper 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 C' associated with the called line F attracts its armature but its movement is limited due to the arm 141 associated with its armature 106 resting in the notch 144 of the latch 143 as previously described, but this movement allows contacts 177' and 178' to move sufficiently to open normal contacts 177' and 178' but not enough to close their alternate contacts. This movement of contacts 177' and 178' removes the substation control of the line switch C' of the called line F. 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 RG is connected to the called line over a circuit extending from the ungrounded pole of the generator RG, 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 F 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 F, 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 RG 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 C. The restoration of the cut-off relay CO restores the individual switch C to normal.

The subscriber F 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 deenergization of the cut-off relay CO' of the line circuit C' which is associated with the called subscriber F.

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

Assuming now that the subscriber at the called substation F was first to replace his receiver upon the switch hook, the opening of the switch hook contacts at the substation F 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 229, causing the said relay to de-energize, as hereinbefore described. The restoration of the individual switch C, first selector D and connector E is the same as previously described from this

point on. Should the called subscriber F 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 E, 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 D as before described, and causes the release of selector D and individual line switch C.

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 LR' 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 E 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 D 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 transmit signal to A, thus notifying the subscriber of the busy condition of the called substation F. 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 E 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 D, which, as previously described, brings about the release of the first selector D and the individual switch C. 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.

It is to be understood that I do not wish to be limited to the matter shown, as various other arrangements will readily suggest themselves to one skilled in the art, and the invention may be used in a wide variety of circumstances and relations.

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

1. An automatic telephone system including a traveling switch and an adjusting magnet therefor, and a relay initially energized by current flowing over the talking circuit and thereafter serving in vibratory relation with the magnet, and test means serving when in a particular electrical condition, to render the initial energization of said relay ineffective to set up said relation.

2. An automatic switch including a relay and magnet in vibratory relation, said relay initially energized by current over the talking circuit and thereafter by current over a local circuit, and test means serving when in a particular electrical condition, to render the initial energization of said relay ineffective to set up said relation.

3. In an automatic telephone system a relay initially energized in series with a subscriber's line and thereupon automatically disconnected from said line, a switch-adjusting magnet in vibratory relation with said relay, and test means serving when in a particular electrical condition, to render the initial energization of said relay ineffective to set up said relation.

4. A telephone system including a line

relay, an energizing circuit therefor including the talking circuit, a switch adjusting magnet having a normally closed contact in said energizing circuit, said contact opening when said magnet energizes, means whereby said relay energizes said magnet, and local test means serving when in a particular electrical condition to prevent an initial operation of said relay from energizing said magnet.

5. A telephone system including a telephone line, a source of current connected across the talking circuit thereof, a step-by-step vibratory magnet adapted when energized to open its armature contact to disconnect a side of said source from said line, a line relay connected between said source and said line its circuit including said contact, and local test means serving when in a particular electrical condition to prevent an initial energization of said magnet when the talking circuit is closed, and in another condition to permit such energization.

6. A selecting system including a line relay and switch controlling magnet both connected to the same test circuit during switch adjustment, and when so connected in vibratory relation one with the other and a slow pull-up relay, its circuit intermittently closed during the vibratory operation, but actuating only at cessation of operation.

7. A selecting system including a line relay and switch controlling magnet both connected to the same test circuit during the switch adjustment, and when so connected in vibratory relation one with the other and a slow pull-up relay, its circuit intermittently closed during the vibratory operation, but actuating only at cessation of operation and switch contacts controlled thereby, whereby said test circuit is freed from said first relay and said magnet.

8. A selecting system including a line relay and a switch controlling magnet, both connected to the test wiper of the switch during selection, and in vibratory relation with each other.

9. A selecting system including a relay to be energized by current over a subscriber's line, a step-by-step magnet in vibratory relation with said relay, and said relay with said magnet, a second relay automatically operated to alter said relation, and local test means serving when in a particular electrical condition, to render the initial energization of said relay ineffective to set up said relation.

10. The selecting system comprising a switch adjusting magnet and a relay, both energized one after the other by current traversing a test wiper when said wiper is connected to a circuit in an abnormal electrical condition.

11. A selecting system including a test circuit switch devices namely, a relay and a

switch adjusting magnet, connections from said circuit to said devices, the connection to the one device including a normally open contact controlled by the other device and the connection to said other device including a normally closed contact controlled by said one device, and means for connecting said test circuit successively to a plurality of circuits to be tested.

12. A telephone line and switch therefor, a line relay connected to the line and operated by current in said line, an adjustment controlling magnet for the switch, means whereby said relay and magnet operate in vibratory relation with each other and test contacts, said magnet being responsive to the normal or abnormal electrical condition of said contacts on initial energization of said line relay to determine whether or not said vibratory relation shall be set up.

13. A non-restoring, non-numerical line switch having a line relay and a switch adjusting magnet, said line relay serving in vibratory relation with said magnet.

14. A line switch having a line relay and a switch adjusting magnet, an armature contact of said magnet in the circuit of said relay, an armature contact of said relay in the circuit of said magnet, and connections for energizing said magnet, including a traveling contact maker connected to said first mentioned contact.

15. A line switch, having a line relay and a switch-adjusting magnet in see-saw relation while said switch travels, a trip contact shifted by the relay armature on its energization, and a line cut-off relay energized on selection made to restore said contacts.

16. A line switch, including a line relay, an armature, trip contacts shifted by said armature on initial energization of said relay, one of said contacts being in the circuit with the winding of said relay, and a line cut-off relay actuated on selection to place said contacts in normal relation.

17. In a line switch for automatic exchanges or the like, a line relay and a line cut-off relay, trip contacts shifted by said line relay and restored by said cut-off relay and means controlled by said line relay and effective unless said contacts are in tripped condition to prevent the complete operation of said cut-off relay.

18. In a line switch for automatic exchanges or the like, a line relay and a double-wound line cut-off relay, an energizing circuit for said cut-off relay including one of the windings of said double wound cut-off relay, a locking circuit for said cut-off relay including the other winding of said double wound cut-off relay, mechanism normally permitting a partial operation only of the armature of said cut-off relay, means controlled by said line relay when energized to permit a full operation of said armature,

and means controlled by the restoration of the armature of said cut-off relay to place said mechanism in normal position.

19. In a line switch circuit a line relay, a trip contact actuated by said relay on energization to disconnect said relay from the line, and a line cut-off relay restoring said contact on selection made.

20. In a line switch, a double-wound line cut-off relay, an energizing circuit for said cut-off relay including one of the windings of said double-wound cut-off relay, a locking circuit for said cut-off relay including the other winding of said double-wound cut-off relay, an armature for said cut-off relay having a definite limit of excursion when said line is connected to as a called line, and means for changing such limit of excursion when a call is initiated over said line, said means including mechanism co-operating with an extension arm connected to the armature of said cut-off relay.

21. In a line switch, a line relay, a line cut-off relay having a normally partially blocked armature and a normally caught trip contact and armature mechanism for the line relay to unblock said armature and trip said contact.

22. In a line switch a line cut-off relay, a contact mounted on the heel iron of said relay operable at all times by said relay, another contact on said relay operable by said relay only when said switch is used to extend the calling line, and a catch controlled by said line relay for placing said second contact under the control of said cut-off relay.

23. In a line switch, a line relay, a line cut-off relay, a switch contact solely controlled by the line relay, a switch contact solely controlled by the cut-off relay, a third switch contact secured to the heel iron of one of said relays and jointly controlled by said relays, and a catch controlled by said line relay for placing said third switch contact under the control of said cut-off relay.

24. In a line switch, a line relay and its armature, a line cut-off relay, a switch contact shifted by said cut-off relay and a catch to hold it in shifted position, mechanism of said line relay operable to release said catch, a relay contact of said cut-off relay, said mechanism of said line relay serving in one position to permit a partial excursion of said contact only, and in another position a full excursion thereof, and circuits of said switch connected to said contacts.

25. In a line switch, a line cut-off relay, a switch contact secured to the heel iron thereof and under the sole control of said relay, a line relay and switch contact of said cut-off relay operatively controllable by said cut-off relay only after an operation of said line relay, and a catch controlled by

said line relay for placing said second contact under the control of said cut-off relay.

26. In a line switch, a line cut-off relay, a switch contact thereof under sole control of said relay, a line relay, a switch contact of said cut-off relay and interlocking mechanism requiring operation of both relays to render said second switch contact effective, and a catch controlled by said line relay for placing said second contact under the control of said cut-off relay.

27. A relay combination including two relays and their inter-locking armature mechanism, two switch contacts and a shifting lever for each, said levers actuating by the energization of the first relay, a member normally holding one lever in a position to which it is moved by the energization of the first relay, said member controlled by the second relay to release said lever, a second member normally preventing a full excursion of the other lever but permitting a partial excursion thereof, said second member controllable by said second relay to permit the full excursion.

28. An automatic telephone system including a traveling switch and an adjusting mag-

net therefor, and a relay serving in vibratory relation with the magnet, and test means serving when in a particular electrical condition, to render the initial energization of said relay ineffective to set up said relation.

29. In a line switch circuit a line relay, a trip contact actuated by said relay on energization to disconnect said relay from the line, and a line cut-off relay restoring said contact.

30. A system of the character described including a non-numerical, non-restoring line switch provided with a pair of magnets, circuits for each of said magnets extending through the contacts of each other, a double-wound cut-off relay having its energizing circuit extending through one of said contacts, said energizing circuit including one winding of said double wound cut-off relay, and a locking circuit for said cut-off relay including the other winding of said cut-off relay.

Signed by me at Chicago, in the county of Cook, and State of Illinois, this 16th day of January, 1919.

HARRY H. IDE.