H. H. IDE.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED JUNE 18, 1917.

1,402,936.

Patented Jan. 10, 1922.

4 SHEETS—SHEET 1.

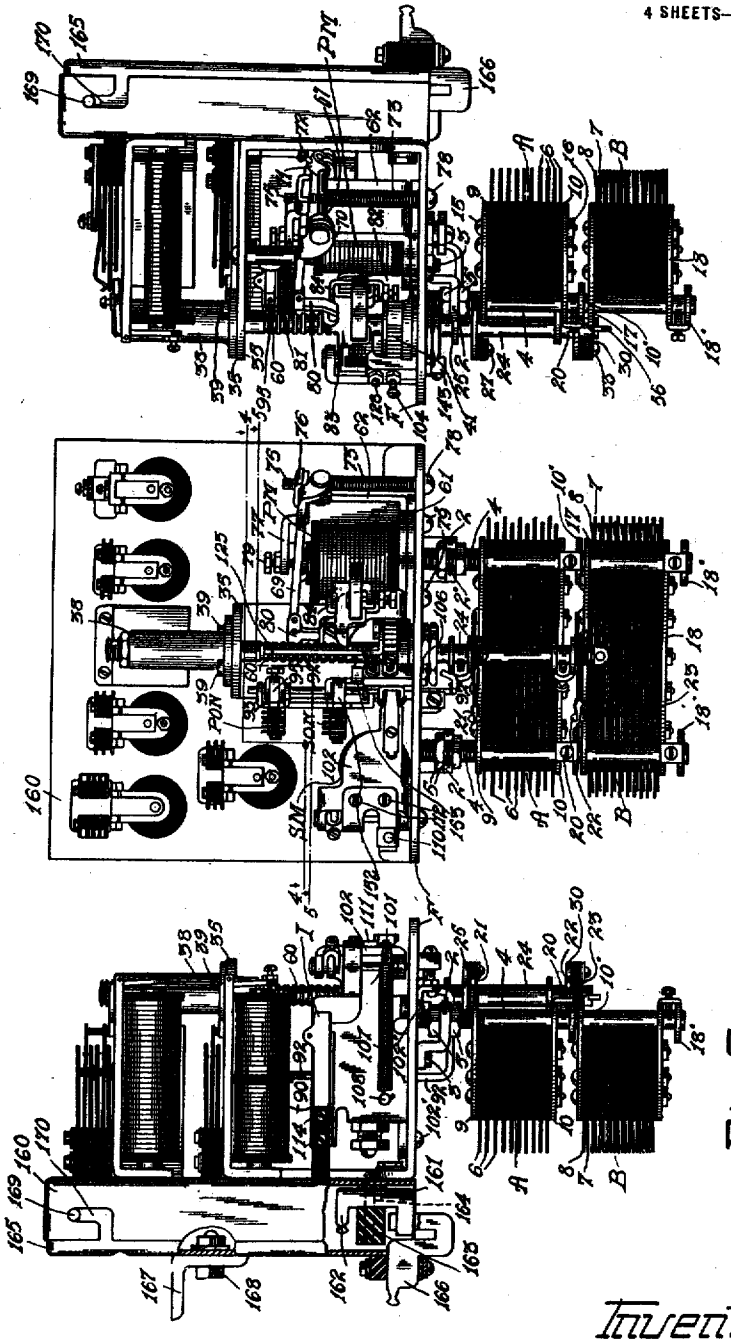

Fig. 3.

Fig. 1.

Fig. 2.

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4 SHEETS—SHEET 2.

Fig. 4.

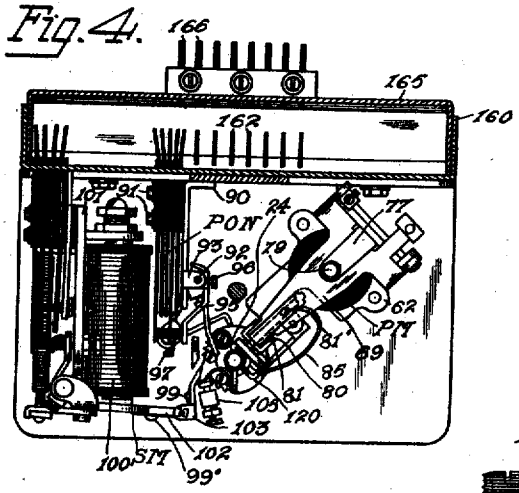
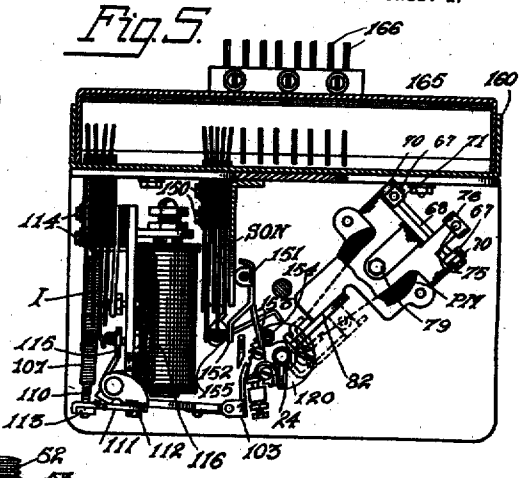


Fig. 5.



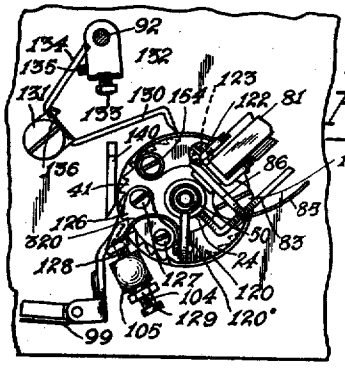


Fig. 6.

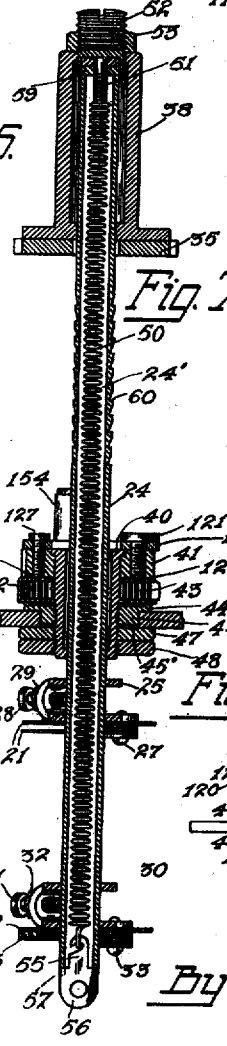


Fig. 7.

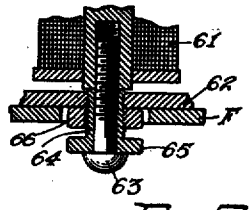


Fig. 9.

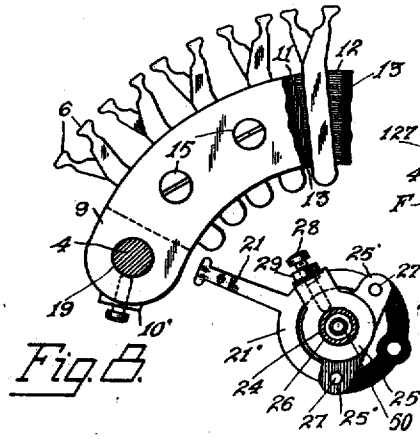


Fig. 8.

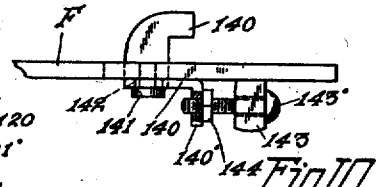


Fig. 10.

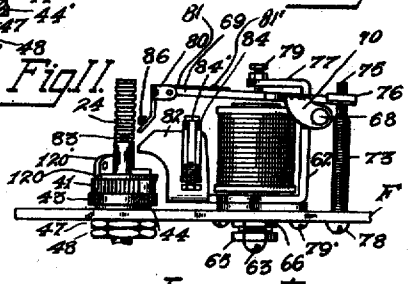


Fig. 11.

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4 SHEETS—SHEET 3.

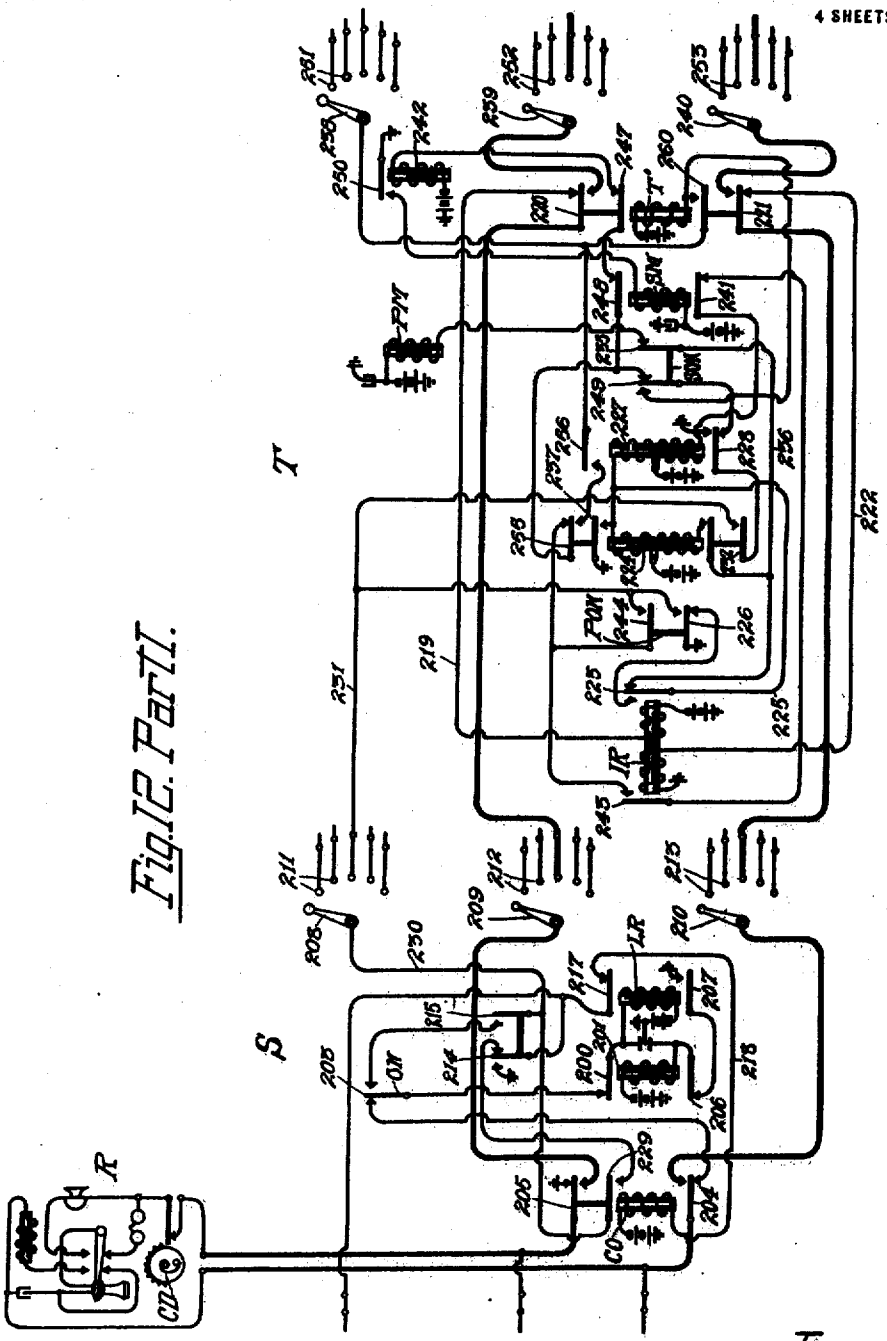

Fig. 12 Part I.

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4 SHEETS—SHEET 4.

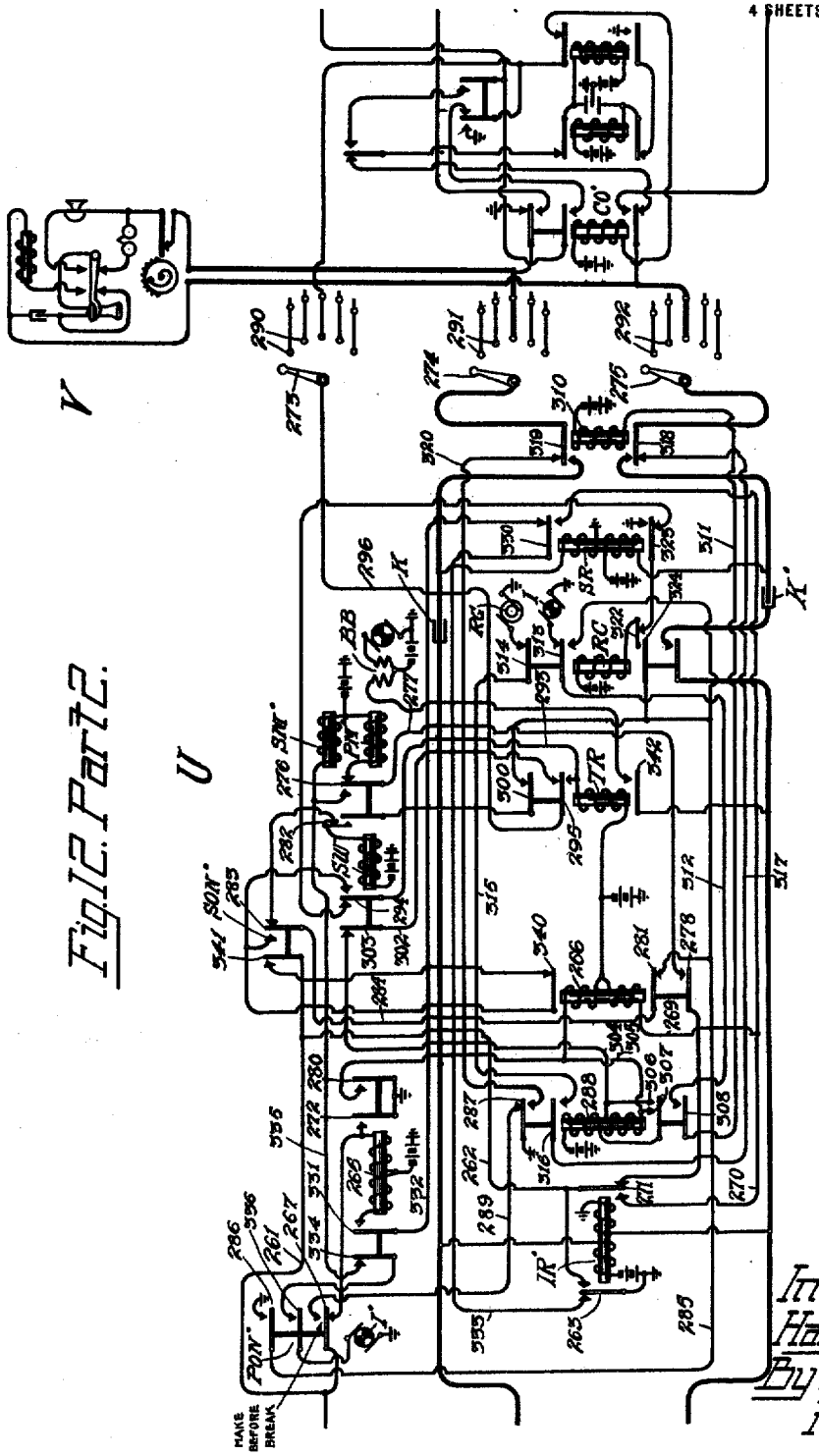

Fig.12. Part 2.

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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.

AUTOMATIC TELEPHONE SYSTEM.

1,402,936. Specification of Letters Patent. Patented Jan. 10, 1922.

Application filed June 18, 1917. Serial No. 175,364.

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, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Automatic Telephone Systems, of which the following is a specification.

My invention relates to automatic telephone systems in which automatic switches known as the two-dimensions type are employed, these switches comprising bank contacts divided into groups and cooperating wipers adapted to receive a primary adjustment to select a group of contacts, and thereafter a secondary adjustment to select a contact in the selected group. My invention has to do more particularly with the mechanical construction of the switches of the above type and with the circuit arrangements adapted for use with these switches.

Prior to this, switches having the above characteristics and provided with a single operating shaft, usually employ an extra release magnet to be operated to allow the wipers to be restored, or where no release magnet is employed, the wipers are aided by gravity in their restoration.

An object of my invention is to provide a single operating shaft for a switch which has no extra release magnet and which has the wipers restored by spring tension, and not by gravity, thus providing a switch which is most positive and sensitive in its operation as well as simple in construction.

A further object of my invention is the means employed for adjustably attaching or securing the contact banks to the mounting plate which carries the switch mechanism.

Further objects of my invention reside in the means provided to operate the off-normal contacts, the novel manner in which the holding and driving pawls are controlled, and the unique method of restoring the switch shaft to normal.

However, the main object of my invention is to produce an improved switch which embodies desirable features and advantages all in a simple, efficient and economical manner, which is most efficient and economical in its operation, and which has its parts so constructed and combined as to make them readily accessible for repair and adjustment.

Other features of my invention will be more particularly pointed out in the following specification and in the appended claims.

For a more complete understanding of my invention, reference may be had to the accompanying drawings in which like reference characters denote like parts in the different views, and in which:

Fig. 1 is a front elevation of the switch structure embodying my invention;

Fig. 2 is a left side elevation of the structure illustrated in Fig. 1;

Fig. 3 is a right side elevation of Fig. 1;

Fig. 4 is a sectional view on the line 4—4 of Fig. 1, showing the primary off-normal springs;

Fig. 5 is a sectional view on the line 5—5 of Fig. 1, showing the secondary off-normal springs;

Fig. 6 is an enlarged view of a portion of the switch showing the driving ratchet and retaining pawls;

Fig. 7 is an enlarged sectional view of the switch shaft;

Fig. 8 is a view of a portion of a switch bank and its associated wiper;

Fig. 9 is a partial section showing the method of mounting the driving magnets to their heel irons;

Fig. 10 is a view showing the adjustable stop for the driving pawl of the secondary magnet of the switch;

Fig. 11 is a side view of the primary operating mechanism showing certain parts broken away, and

Fig. 12, which comprises parts 1 and 2 is a diagrammatic illustration of the circuit arrangement adapted to be used in connection with the switch structure of my invention.

Referring now to the switch structure of my invention, as shown in Figs. 1 to 11, inclusive, it comprises a frame F on which are mounted all of the movable parts for operating the wipers of the switch, and to which I also attach the banks of contacts. To support the banks of contacts A and B upon the frame F, I provide a pair of brackets 2 which are securely fastened to the frame F by means of the screws 3, a pair of screws 3 being provided for each bracket 2. The brackets 2 have bifurcated portions 2^1 into which the posts 4 fit, said posts 4 being securely held to the brackets 2 by means of clamping nuts 5. The banks

of contacts A and B are adjustably secured to the post 4, as will be presently described. The upper bank contacts A comprise the private bank contacts, as they are commonly known in the art, which include one hundred contacts 6, arranged in ten horizontal rows of ten each. The lower bank of contacts B is adjustably secured to the post 4 and comprises the two sets of line contacts, namely, the vertical and rotary contacts 7 and 8, as they are commonly known in the art, there being one hundred pairs of contacts arranged in ten horizontal rows, ten pairs of contacts to each row. The bank of private contacts is securely clamped between the clamping plates 9 and 10. The individual contacts that form the bank of contacts are suitably insulated from each other, as clearly illustrated in Fig. 8. The contacts of each row are radially disposed and are placed between pieces of insulation cloth 11 and 12, and a strip of insulating material 13, such as micarta or some other suitable material, is placed between each of said rows of contacts. The ten rows of contacts are placed between the clamping plates 9 and 10 and clamped together to form the bank of contacts A. The bolts 15 and nuts 16 form the clamping means for securing the rows of contacts together as a whole.

The vertical and rotary contacts are securely clamped between the clamping plates 17 and 18, and are suitably insulated from each other in a manner similar to that just described in connection with the private bank A. A further description is therefore deemed unnecessary. To secure the private bank A to the supporting post 4, I provide the lower clamping plate 10 with ears 10^1 preferably formed integrally with said plate 10 and bent over parallel to the plane of the plate proper. The plates 9 and 10 and portions 10^1 of plate 10 are provided with openings 19 to receive the posts 4. The bank A as a whole is slipped on the posts 4 and when in the desired proper position the screws 20 are tightened to maintain the bank in this position. The screws 20 have screw threaded engagement with the ear portions 10^1 of the plate 10. The bank B which comprises the line contacts is similarly secured to the post 4. The lower clamping plate 18 is provided with ears 18^1 which serve the purpose as above described, and further description is not deemed necessary.

Adapted to co-operate with the contacts 6, 7 and 8 are the wipers 21, 22 and 23, the said wipers being mounted upon the shaft 24 and suitably insulated therefrom. The wiper 21, which is operatively associated with the private bank contacts 6, is commonly known in the art as the private wiper, and is mounted upon the shaft 24 by means of a U-shaped carrier 25. The parallel arms of the U-shaped carrier 25 have suitable openings 26 which permit the carrier 25 to be slipped onto the shaft 24. The wiper 21 has a portion 21^1, U-shaped in construction, and suitably fastened to the portion 25^1 of the carrier 25 by means of the screws 27, the said wiper 21 being suitably insulated from the shaft 24 and the screws 27. The wiper 21 and carrier 25 as a whole are slipped upon the shaft 24 and when in the proper relation with the contacts of private bank A are clamped to the shaft 24 by means of the set screws 28 and lock nut 29. The wipers 22 and 23, which are commonly known in the art as the line wipers, are also mounted insulatingly upon a carrier 30, by means of the screws 33. The carrier 30 and the wipers 22 and 23, as a whole, are mounted upon the shaft 24 in operative relation with the contacts of the line bank B by means of the set screw 31 and lock nut 32, the wipers being suitably insulated from each other and also insulated from the carrier 30. The shaft 24 carries the wipers 21, 22 and 23 in a primary downward and a secondary rotary direction.

The frame F has a portion 35 bent at right angles to the vertical portion of the said frame F to form mounting means for the sleeve 38, which sleeve is suitably fastened to the frame portion 35 by means of the screws 39. The sleeve 38 acts as suspending means for the shaft 24 and also forms one of the bearings for the said shaft 24. A sleeve 40 is also provided, which sleeve is supported by the frame F, and serves as a bearing for the other end of shaft 24. The sleeve 40 also acts as a bearing for the ratchet wheel 41 which operates to drive the shaft 24 in a secondary direction. A spring casing 42 is also mounted upon the sleeve bearing 40 and contains a spiral spring 43, the said spring 43 having one end fastened to the casing 42 and the other end fastened to the sleeve 40. The tension of the said spring 43 is such that it has a tendency to hold the shaft 24 in its normal position, that is, it normally retains the wipers of the shaft 24 to the left of the rows of bank contacts. The sleeve 40 has one end threaded, and its other end is provided with a flanged portion. The said flanged end rests in a recess in the ratchet 41. A collar 44 is slipped over the sleeve 40, and its upper peripheral surface forms a bearing for the drum 43 that contains the rotary restoring spring 42; and the lower portion of the said collar 44 is provided with a reduced portion 44^1 that fits into a suitable orifice 45^1 in the frame F. I provide a nut 47 and a lock nut 48 which have screw threaded engagement with the threaded portion of the sleeve 40, and when a proper adjustment of the ratchet 41 and parts is

secured the said nuts 47 and 48 are tightened to secure the sleeve 40 in adjusted position.

A coil spring 50 is provided and has its one end secured to a reduced screw threaded portion 51 of a plug 52, which plug in turn has screw threaded engagement with the sleeve 38. A lock nut 53 is provided for locking the plug 52 in its adjusted position in the sleeve 38. The said spring 50 passes through a suitable cylindrical opening 24^1, extending the full length of the shaft 24, and has its lower end attached to the hook shaped portion 55 of a plate 56. The plate 56 fits into a slot 57 cut in the lower extremity of the shaft 24. The spring 50 maintains the shaft 24 in its normal vertical position and due to the fact that this spring is quite long, extending the full length of the shaft, the yielding force that it exerts upon the shaft 24 is not materially changed when the said shaft is moved downward the full distance that it is permitted to travel.

The shaft 24 when in its normal position rests against a suitable piece of material 59, such as rubber, which is inserted in an annular orifice in the plug 52, the said plug serving as a stop for the shaft and the insert 59, to deaden the noise when the shaft is restored to normal by the spring 50. The plug 52, which has screw threaded engagement with the sleeve 38 serves as an adjusting means to determine the normal vertical position that the shaft 24 is to occupy, and when this position is secured the lock nut 53 is tightened to keep the said plug 52 in its proper position. The shaft 24 is provided with circularly cut ratchet teeth 60 which are acted upon by a driving pawl to move the shaft 24 in a downward primary direction to move the wipers 21, 22 and 23 to a predetermined group of contacts in the private bank A, and in the line bank B.

The primary magnet PM, which is adapted to move the shaft 24 and wipers 21, 22 and 23 in a primary downward direction, includes a pole piece 62, an armature 69, and a driving pawl 80. The magnet 61 is suitably secured to the pole piece 62 by means of a screw 63 which passes through a stud 64, said screw 63 having screw threaded engagement with the core of the electromagnet 61. The stud 64 through which the screw 63 passes serves as adjusting means for the electromagnet 61 in an up or down direction, and has screw threaded engagement with the heel iron 62, the other end of the stud 64 being provided with an integrally formed hexagonal head 65. To adjust the electromagnet 61, the screw 63 is loosened and the stud 64 turned to the right or left, as the case may be, to properly adjust the magnet, and when this adjustment is obtained a lock nut 66 is tightened to hold the stud in its adjusted position. Pole piece 62 has projecting ears 67 bent at right angles to the main part of said pole piece, and the said ears have suitable openings to receive a pivot pin 68, which pin pivotally supports the armature 69 of primary magnet PM. The armature 69 is also provided with ears 70 which have suitable openings to receive the pivot pin 68. A U-shaped member 71 is also provided (see Fig. 5), the arms of which have suitable openings for receiving the pivot pin 68. To pivotally support the armature 69 upon the pole piece 62, the pivot pin 68 is inserted through the openings in the ears 67 and 70 of the pole piece and the armature, and through the openings in the arms of the U-shaped member 71. One ear of the member 71 fits between one of the supporting ears 67 of the pole piece and the adjacent ear 70 of the armature. A set screw 72 is provided and has screw threaded engagement with the yoke end of the U-shaped piece 71. The said screw 72 is used to securely hold the pivot pin 68 in place relative to the heel iron 62 and the armature 69. A coil spring 73 for holding the armature 69 in its normal position has its one end fastened to a screw 78 which passes through an orifice in the frame F, and its other end fastened to an adjustable screw 75, which screw passes through a suitable opening in the armature 69 and has screw threaded engagement with a saddle member 76. An extended portion 77 of the pole piece is bent forward at right angles and is provided with an adjustable stop screw 79 for securing the proper air gap between the armature 69 and core of the electromagnet 61. The primary magnet PM as a whole is fastened to the frame F by means of screws 79^1 which pass through suitable openings in the frame F, the said screws having screw threaded engagement with the pole piece 62. The free end of the armature 69 pivotally supports a driving pawl 80, the said pawl 80 being adapted to engage the ratchet teeth 60 on the shaft 24 to move the said shaft downward against the tension of spring 50.

In the operation of the primary magnet PM, the armature 69 is attracted, moving away from the stop 79, and during this movement a leaf spring 81 suitably fastened to the armature 69 by means of a screw 81^1 acts upon the pawl 80, rotating the said pawl 80 about its pivot and into engagement with the teeth 60 of the primary ratchet upon the shaft 24, and the armature 69 continuing in its movement moves the shaft 24 in a downward direction until the pawl 80 engages a stop 82, the said stop being preferably formed integrally with the pole piece 62. This movement of the shaft 24 moves the wipers 21, 22 and 23 one step in a downward direction. A retaining pawl 83 is provided which is pivotally secured to a U-shaped member 84 by means of a pin 84^1 which has

screw threaded engagement with one of the arms of the U-shaped member 84. The member 84 is secured to the stop 82 by means of screws. The retaining pawl is held in the teeth 60 of the ratchet by a leaf spring 85 which is suitably clamped between the U-shaped member 84 and the stop 82. A guiding arm 86 is provided which is preferably formed integrally with the retaining pawl 83. Upon the retraction of the armature 69, due to the spring 73, the pawl engages the arm 86 to disengage said pawl from a tooth 60 of the ratchet on the shaft 24, and upon the attraction of armature 69 the guide arm 86 acts to properly guide the pawl 80 into the next tooth of the ratchet 60. Upon each actuation of the primary magnet PM, the shaft 24, and the wipers 21, 22 and 23 are moved downward one step from a position opposite one row of contacts 6, 7, and 8 to the next.

I provide a set of primary off-normal contacts PON which are moved to their alternate position upon the first step of the shaft 24 in a primary downward direction. A mounting plate 90 is suitably fastened to the frame F, upon which the primary off-normal contacts PON are insulatingly mounted by means of insulated screws 91. A rod 92 is pivotally supported by ears 93 which are integrally formed in the plate 90. An arm 95 is supported upon the rod 92 by means of a set screw 96, the said arm 95 having an insulation button 97 which operates the primary off-normal contacts PON when the rod 92 is operated. The rod 92 extends through the frame F and has its lower portion 92^1 bent in such a manner that it engages and is operated by the U-shaped wiper carrier 25. Upon the first step of the shaft 24 in a downward primary direction, the U-shaped carrier 25 disengages the portion 92^1 of the rod 92 so that the off-normal springs PON which are normally under tension, due to the arm 95 engaging the said springs, force the arm 95 to the right. This movement of arm 95 causes the rod 92 to rotate about its pivot, and also allows the said springs PON to move to their alternate position. The primary off-normal contacts PON are again restored to normal upon the restoration of the shaft 24 by the spring 50. The carrier 25 again engaging the portion 92^1 of the rod 92, moves the arm 95 to the left and forces the primary off-normal contacts PON into their normal position.

The secondary magnet SM, which steps the shaft 24 and wipers 21, 22 and 23 in their secondary rotary direction, is provided with a suitable pole piece 101. The magnet SM is adjustably mounted to the pole piece 101 in a manner similar to that previously described in connection with the primary magnet PM so that a further description is unnecessary. The electromagnet 100 and pole piece 101, as a whole, are fastened to the frame F by means of the screws 102'. Pivoted to the forward end of the pole piece 101 is an armature 102 carrying a pivoted pawl 103 which is normally held against an adjustable screw stop 104 by means of a leaf spring 99. The leaf spring 99 is held in place by a screw 99^1. The screw 104 has screw threaded engagement with a post 105 suitably fastened to the frame F by means of the nut 106 (Fig. 1.) The armature 102 is held in its normal position by means of the coil spring 107, the said coil spring having one end fastened to a pin 108, the said pin being staked to the pole piece 101, and the other end is adjustably secured to a screw 110. The screw 110 passes through a suitable opening in a plate 111, which plate is suitably fastened to the armature 102 by means of screws 112, and is provided with an adjusting nut 113. The tension of the said spring 107 is regulated by means of said nut 113. A set of interrupter springs I are associated with the secondary magnet SM, the said springs being insulatingly mounted upon the pole piece 101 by means of the insulated screws 114. The interrupter springs are held in their normal position by means of an arm 115 which is preferably formed integrally with the plate 111, the said arm 115 being provided with a rubber buffer which operates the springs of the set. An adjustable screw 116 is provided which has screw-threaded engagement with the pole piece 101 and acts as a stop for the arm 115 when the said arm is in normal position. A plate 120 is pivotally secured to the ratchet 41 by means of a screw 121. A screw 122, having screw threaded engagement with the ratchet 41, passes through a slot 123 in the plate 120 and permits a limited movement of the plate 120 about the pivot screw 121. The portion 120^1 of the plate 120 is bent at right angles to form a nose which fits into a vertical slot 125 cut in the shaft 24 for purposes to be presently described. A stop 126 is mounted upon the ratchet 41 by means of the screws 127 and limits the return of the shaft 24. An adjustable screw 128, which has screw threaded engagement with the post 105, is provided for the stop 126. A lock nut 129 is provided which locks the said screw 128 in its adjusted position. The pivot screw 121 and one of the screws 127, which are diametrically opposite each other, have reduced ends 127^1 and 121^1 (Fig. 7) in the form of pins which enter suitable openings in the spring casing 42 to keep the said spring casing 42 and ratchet 41 in proper relation. A retaining pawl 130 operatively associated with the ratchet 41 is pivotally supported upon the frame F by means of a pivot screw 131. The said pawl

130 is held in its normal position by means of a U-shaped member 132 secured to the rod 92 by means of a set screw 133. An arm 134 formed integrally with the pawl 130 engages a downwardly extended arm 135 of the U-shaped member 132, so that upon the first step of the shaft in a primary downward direction the rod 92 rotates as previously described, rotating the U-shaped member 132 to the right, causing the arm 135 to disengage arm 134. The pawl 130, being under tension of a coil spring 136, moves about its pivot 131, thereby permitting the pawl 130 to engage the teeth of the ratchet 41. When the secondary magnet SM is energized, its armature 102 is attracted, and during the movement of the said armature 102 leaf spring 99 acts upon the pawl 103, rotating the said pawl about its pivot into proper engagement with a tooth of the ratchet 41, and the armature continuing its movement causes the pawl 103 to rotate the said ratchet 41 until the said pawl engages the adjustable stop 140 mounted upon the frame F.

The rotation of the ratchet 41 by the pawl 103 causes the shaft 24 to be rotated through the medium of the angular portion 120^1 of the plate 120 which engages slot 125 of shaft 24, thereby rotating the shaft and wipers one step in a secondary direction. The retaining pawl 130 engaging a tooth in the ratchet wheel 41 prevents the back rotation of the shaft 24. Upon the retraction of armature 102 by the spring 107, the driving pawl 103 disengages the tooth of the ratchet 41 and assumes a position to engage the next tooth of the said ratchet 41. The stop 140 is fastened to the under side of the frame F by means of a screw 141 (Fig. 10) which extends through a slot 142 in the said stop 140, said screw 141 having screw threaded engagement with the frame F. A post 143 is suitably fastened to the under side of the frame, and supports an adjusting screw 143^1 which has screw threaded engagement with the angular portion 140^1 of stop 140. The stop 140 may be moved forward or backward by loosening the screw 141 and turning the adjusting screw 143^1; then when the proper adjustment of the stop 140 is obtained the screw 141 is tightened. The adjusting screw 143^1 is provided with a lock nut 144 to lock the said stop in its adjusted position.

I provide a set of secondary off-normal contacts SON which are moved to their alternate position upon the first step of the shaft in a secondary direction. The contacts SON are insulatingly mounted upon the frame 90 by means of the insulated screws 150. A U-shaped member 151 provided with a pair of arms 152 and 153 is loosely pivoted upon the rod 92. The arm 153 normally engages a stud 154 which is suitably fastened to the plate 120. The arm 152 has an insulation button 155 secured to it. The said button normally engages a spring of the secondary off-normal switch SON. When in the position shown in Fig. 5, the secondary off-normal contacts SON are at normal and upon the first step of the shaft 24 in a secondary direction, the stud 154 moves away from the arm 153, thereby permitting the U-shaped member 151 to turn about its pivot point and the springs SON to assume their alternate position. Upon the restoration of the shaft 24 to normal, the contacts SON are caused to return to normal by the stud 154 engaging the arm 153, thus rotating the member 151 and causing the arm 152 to be moved to restore the said secondary off-normal contacts SON.

A curved leaf spring 320 is provided for normally maintaining the feather 120^1 in its normal position in slot 125 of shaft 24. One end of the said spring is firmly secured to said feather 120^1 and the other end of said spring engages the stop 126. When the shaft has been rotated to its releasing position, the stud 154 engages the vertical holding dog 83 and turns the plate 120 about its pivot point, loosening the guide 120^1 in the slot 125 of the shaft 24. A further result due to the stud 154 engaging the holding dog 83 is the removal of the holding dog from engagement with the teeth 60 of the shaft 24. The removal of the feather 120^1 from the slot 125 and the removal of the vertical holding pawl permits the shaft to restore vertically to its vertical normal position. The stud 154 is made eccentrically so that it may be adjusted to limit the amount that the vertical holding pawl is moved out of engagement with the teeth 60 of the shaft 24.

Secured to the vertical part of the frame F by means of suitable bolts and nuts is a relay mounting plate 160, upon which are mounted the relays that control the operations of the switch. A strip of insulation 161 is provided having suitable slots to receive the U-shaped terminals 162. A retaining block 163, also of insulating material, is placed on top of the block 161 and the said strip 161, block 163 and terminals 162 are then mounted, as a whole, upon the member 160 by means of screws 164. A cover plate 165 is provided to which the spring jacks 166 are insulatingly mounted in a suitable manner, the said terminals 162 being adapted to be inserted between the said spring jacks 166 to complete the necessary electrical circuits. The cover plate 165 is mounted to a suitable frame 167 by means of bolts and nuts 168, the said cover being provided with a pair of pins 169, one on each side wall, suitably fastened thereto. Member 160 is provided with L-shaped or bayonet slots 170 in each wall into which the pins 169 fit, the switch, as a whole, being sus-

pended by the said pins to the cover plate 165. To remove the switch, as a whole, from its supporting pins 169, the said switch is moved upward until the horizontal portion of the L-shaped slot 170 is in line with the pins 169, and when in this position, the switch may be removed from its support by pulling it forward.

The switch is made up of certain units which are detachably secured to the frame F; the primary magnet PM including all of the parts carried thereby to form a unit may be removed from the frame F by taking out the screws 79^1 and another substituted. The secondary magnet SM and the parts carried thereby also form a unit and may be removed by taking out the screws 102^1, and replaced by another one. To remove the shaft and wipers, as a whole, the spring 50 is removed from the hook 55 thus allowing the shaft to be withdrawn and permitting another shaft to be inserted. It will thus be seen from the foregoing description that should either of the magnets, or any of the parts carried thereby, be in need of repair they may be readily replaced by other units without disturbing other parts of the switch.

In the operation of the switch, the primary magnet PM is alternately energized and de-energized, causing the pawl 80 to engage successive teeth of the ratchet 60 to step the shaft 24 and wipers 21, 22 and 23 in a downward primary direction from one group of contacts to the next, the retaining pawl 83 engaging successive teeth of the ratchet 60 to prevent the shaft from restoring. Portion 92^1 of the rod 92 disengages the carrier 25, allowing the primary off-normal contacts PON to assume their alternate position, as already described. Upon the first step of the shaft 24 in a primary downward direction, the pawl 130 is allowed to move into engagement with a tooth of the ratchet 41, this movement being brought about by the rotation of the rod 92 when the carrier 25 disengages the rod 92. When the secondary magnet SM is alternately energized and de-energized the pawl 103 engages successive teeth of the ratchet 41, causing the shaft 24 and wipers 21, 22 and 23 to be stepped in a secondary rotary direction from one set of contacts to the next. Upon the first step of the wipers in a secondary rotary direction, the stud 154 disengages the arm 153, allowing the secondary off-normal contacts SON to assume their alternate position. The retaining pawl 130 also engages successive teeth of the ratchet wheel 41, preventing the release of the switch shaft. In the release of the switch after the wipers 21, 22 and 23 have been moved to engage a set of bank contacts 6, 7 and 8, secondary magnet SM is again alternately energized and de-energized to rotate the wipers until the said wipers 21, 22 and 23 have been advanced one step beyond the last set of the contacts 6 7 and 8. As the shaft and wipers are advanced to this position, the stud 154 engages the retaining pawl 83, as before described, moving it out of engagement with a tooth of the ratchet 60 upon shaft 24, allowing spring 50 which was tensioned by the movement of of the shaft 24 in a downward direction to restore the shaft 24 and wipers 21, 22 and 23 upward, until the top of the shaft engages the buffer 59. The stud 154 engaging retaining pawl 83 moves feather 120^1 out of the slot 125 of shaft 24 a sufficient amount to permit the shaft to restore vertically. The removal of the feather from the slot lessens the friction of the feather in the slot, thereby permitting the use of a lighter spring 50 for returning the shaft. When in this position, the carrier 25 engages portion 92^1 of the rod 92, rotating the said rod, causing the arm 135 of the member 132 to engage the arm 134 of the retaining pawl 130 causing the pawl 130 to disengage a tooth of the ratchet wheel 41, the spring 43 now restoring the wipers and shaft to their normal position. The shaft is stopped in its normal position by the stop 126 engaging the screw stop 129. The stud 154 engages the arm 153 upon the restoration of the shaft to normal, bringing about the restoration to normal of the secondary off-normal contacts SON, the primary off-normal contacts PON having been restored to normal when the carrier 25 engaged the portion 92^1 upon the upward movement of the shaft 24.

I represent diagrammatically in Fig. 12, the complete circuit arrangement necessary for connecting a calling subscriber to a called subscriber. The said circuit shows a calling substation R terminating in an individual line switch S. The line switch S is adapted to connect with an idle first selector T. The first selector T in turn is adapted to connect with an idle connector U, and the connector U is adapted to connect with the terminals of the called substation V. The called substation V also terminates in an individual line switch S. The circuits shown for the selector T and the connector U are adapted to work with the switch structure shown in Figs. 1 to 11, inclusive. It is to be understood, however, that the switch structure shown may be used in connection with various other circuit arrangements and, likewise, the circuits shown are adapted for use with other switch structures. In order to more fully understand the circuits as pointed out, Fig. 12, Part 2, is to be placed at the right of Fig. 12, Part 1, to form a continuation thereof and a complete circuit.

The substation R includes the usual talking equipment of a common battery telephone with the addition of the calling switch CD, adapted to break the continuity of the

subscriber's line circuit. The circuit for the subscriber's substation R will be carried through a series of continuations, finally establishing connection with the subscriber's telephone V which is also shown as having an individual line switch at the central exchange.

The line switch S is provided with a rotary shaft that carries a private test contact 208 and a pair of line contacts or wipers 209 and 210. A line relay LR is provided which is energized over the subscribers' line conductors in series. A cut-off relay CO is also provided for disconnecting the subscriber's line circuit from the relay LR and for connecting the switch wipers to the subscriber's line circuit. A motor magnet 201 is provided for stepping the switch wipers step by step over the bank contacts 211, 212 and 213. An off-normal switch ON is provided which is actuated with each first step of the wipers. The switch wipers are spring restored and are adapted to be released to normal when the cut-off relay CO is de-energized.

As herein-before mentioned, the switch structure shown in Figs. 1 to 11, inclusive, is adapted for use as a selector T or as a connector U, it only being necessary to change the combination of the off-normal springs and to add additional relays to control the circuits required. Of course, the secondary operating magnet of the connector U is not provided with interrupter contacts as the connector U does not perform a secondary selecting operation but rather a seconadry electing operation in picking out the contacts of the desired called line. The relay mounting bridge 160 of the connector U is made of sufficient size to carry the extra relays needed for controlling the circuits of the connector.

Assuming now, for instance, that a call is to be traced from the calling substation R to the called substation V, upon the removal of the receiver by the subscriber at the substation R a circuit for the line relay LR of the individual line switch B is established, this circuit being traced from battery through the winding of relay LR, normal contact 200 of relay 201, normal contact 203 of the off-normal switch ON, normal contact 204 of relay CO, and through the closed contacts of the substation switch hook to ground at normal contact 205 of relay CO. The line relay LR, upon energization, establishes an energizing circuit for the relay 201. The said circuit for relay 201 extends from battery through the winding of the relay 201, normal contact 206 of said relay 201, and alternate contact 207 of relay LR to ground. The opening of normal contact 200 of relay 201 opens the energizing circuit of the line relay LR, de-energizing the said relays and causing the wipers 208, 209 and 210 of the line switch S to engage the first set of contacts 211, 212 and 213. Upon the first step of the switch shaft, the off-normal contacts ON assume their alternate position, and contacts 214 and 215 are also moved to their alternate position. The opening of alternate contact 207 of line relay LR brings about the de-energization of the relay 201, and should the private wiper 208 of the line switch S engage a busy contact 211, upon the first step a substitute circuit for the line relay LR is established, traced from battery through the winding of relay LR, normal contact 200 of relay 201, alternate contact 203 of off-normal contacts ON, and alternate contact 215 to ground at the busy contact engaged by private wiper 208. The closure of the alternate contact 207 of the line relay LR again establishes a circuit for relay 201, as previously described, causing the switch wipers to take another step and engage the second set of contacts 211, 212 and 213. If the next private contact 211 is busy, relay 201 and line relay LR are again energized and de-energized to step the wipers 208, 209 and 210 step by step until an idle private contact 211 is encountered. When the contacts leading to an idle first selector T have been found, the line relay LR de-energizes, bringing about the de-energization of the magnet 201. The closing of normal contact 217 of relay LR establishes an energizing circuit for the cut-off relay CO traced from battery through the winding of the said relay CO, conductor 218 and normal contact 217 of relay LR to ground at alternate contact 214. The energization of the relay CO brings about the restoration of the contacts 214 and 215 to their normal position, opening the initial energizing circuit of the relay CO. The relay CO being slow to release, has a substitute circuit established for it, as will be presently described, before it has had time to de-energize and permit its contacts to return to normal. The wipers 209 and 210 having engaged contacts 212 and 213 of the idle first selector T bring about the energization of the impulse relay IR of the said first selector T over a circuit traced from battery through the right hand winding of the relay IR, conductor 219, normal contact 220 of the relay T^1, bank contact 212, wiper 209, alternate contact 205 of relay CO, through the substation and back through alternate contact 204 of relay CO, wiper 210, bank contact 213, normal contact 221 of relay T^1, conductor 222, and through the left-hand winding of relay IR to ground. The closing of alternate contact 223 of relay IR establishes an energizing circuit for the relay 224 traced from battery through the upper winding of the relay 224, over conductor 225, and through alternate contact 223 of relay IR to ground at normal contact 226 of primary off-normal contacts

PON. An energizing circuit for the relay 227 is also established when relay IR is energized, traced from battery through the upper winding of the said relay, conductor 225, and alternate contacts 223 of relay IR to ground at normal contact 226. The closing of alternate contact 228 of relay 227 establishes a substitute circuit for the cut-off relay CO of the line switch S before it has had time to de-energize, said circuit being traced from battery through the winding of the relay CO, normal contact 217 of relay LR, normal contact 214, alternate contact 229 of relay CO, conductor 230, wiper 208, contact 211, conductor 231, and alternate contact 232 of relay 224 to ground at alternate contact 228 of relay 227, thus maintaining the relay CO of the switch S continuously energized until the conversation is terminated. The idle first selector T having been selected by the line switch S, the subscriber at the calling substation R now actuates his calling device CD to call the first digit of the called number. Assuming that the number of the subscriber of the called substation V is 345, the subscriber at substation R actuates the calling device CD to send three impulses of current over the line, which impulses bring about three successive energizations and de-energizations of the impulse relay IR. Upon the first de-energization of the impulse relay IR, the circuit for the primary magnet PM is established, traced from battery through the winding of the magnet PM, normal contacts 235 of the secondary off-normal contacts SON, conductor 236, normal contact 223 and conductor 225 to ground at alternate contact 237 of relay 224. The primary magnet PM is energized and de-energized three times due to the opening and closing of contact 223 of relay IR, which magnet operates to step the wipers 238, 239 and 240 of the first selector T in a downward primary direction to the third group of contacts corresponding with the desired second selector or connector. After the last impulse, the relay 227 de-energizes, due to a circuit being closed through the lower winding of the relay 227, traced from battery through the winding of the said relay, normal contact 241 of relay SM, alternate contact 243 of relay IR, and alternate contacts 244 and 226 of primary off-normal contacts PON to ground. The said primary off-normal contacts PON move to their alternate positions upon the first step of the wipers of the first selector T. The energizing circuit for relay 227 just mentioned is closed upon the first step of the wipers off normal, but the relay 227 does not de-energize during the sending of impulses due to the construction and adjustment of the said relay 227. The differential relay 227 only receives short impulses of current during the operation of relay IR which do not affect the relay sufficiently to cause it to de-energize. As soon as the above-mentioned circuit through the lower winding of relay 227 is permanently closed, the said relay permits its armature to retract. The opening of contact 228 disconnects ground from conductor 231 at this point but a substitute ground from alternate contact 226 of the primary off-normal contact PON is substituted before said relay 227 de-energizes. This ground also places a busy potential upon private contact 211, preventing any other individual line switch from engaging multiples of said contact. The differential relay 224 is not de-energized during the rapid operation of relay IR and the closure of a circuit through its lower winding, owing to the construction and adjustment of the same. Upon the de-energization of the relay 227, an energizing circuit for the relay 242 is established traced from battery through the winding of the said relay 242, normal contact 247 of relay T^1, normal contact 248 of secondary magnet SM, normal contact 249 of the secondary off-normal contact SON, normal contact 228 of relay 227, and alternate contact 232 of relay 224 to ground at alternate contact 226 of primary off-normal contacts PON.

The energization of the relay 242 establishes an energizing circuit for the secondary magnet SM traced from battery through the winding of the said magnet to ground at alternate contact 250 of relay 242. Secondary magnet SM steps the wipers 238, 239 and 240 one step in a rotary secondary direction to engage the first set of contacts 251, 252 and 253. The energization of the secondary magnet SM brings about the restoration of the relay 242 due to the opening of normal contact 248 of said magnet SM. The opening of contact 241 of magnet SM again permits the energization of relay 227 by opening the circuit of its lower winding. The restoration of the relay 242 opens its alternate contact 250, bringing about the restoration of the secondary magnet SM. Upon the first step of the wipers 238, 239 and 240, the secondary off-normal contacts SON assume their alternate position, and the opening of the normal contact 249 of secondary off-normal contacts SON removes the initial ground from the relay 242 and should the private wiper 238 of the first selector T engage a contact leading to a busy connector U, an energizing circuit for the relay 242 is again established, traced from battery through the winding of the relay 242, normal contact 247 of relay T^1, normal contact 248 of magnet SM, alternate contact 255 of relay 224, alternate contact 256 of relay 227 and wiper 238 to the grounded busy contact 251. The closing of the alternate contact 250 of relay 242 brings about the energization of secondary magnet SM. The relay 242 and

magnet SM are thus alternately energized and de-energized to step the wipers 238, 239 and 240 in a secondary horizontal direction to seek the contacts of an idle connector switch. When a contact 251 leading to an idle connector is encountered by the wiper 238, the energizing circuit of the test relay is not again closed, thereby preventing further energizations of the secondary magnet SM. It will thus be seen that by this see-saw action of relay 242 and magnet SM a positive driving operation of the secondary magnet is secured and that it is impossible to stop the selector T on a busy contact or to drive the said selector past an idle contact because unless relay 242 is energized magnet SM cannot be energized and relay 242 can only be energized when magnet SM is at normal and private wiper 238 is resting on a busy contact. The relay 227 does not de-energize during the secondary movement of the wipers, due to its adjustment and the rapidity of the interruptions of normal contact 241 of secondary magnet SM. The closure of normal contact 241 of secondary magnet SM after its last de-energization closes a circuit for the lower winding of the relay 227, as previously described, and due to its differential action it de-energizes. Upon the restoration of the relay 227, an energizing circuit for the relay T^1 is established traced from battery through the winding of the said relay T^1, alternate contact 249 of the secondary off-normal contacts SON, normal contact 228 of relay 227, alternate contact 232 of relay 224 to ground at alternate contact 226 of primary off-normal contacts PON. The opening of normal contacts 220 and 221 of relay T^1 opens the energizing circuit of the impulse relay IR, and the closing of normal contact 223 of said relay IR closes a circuit through the lower winding of the relay 224 traced from battery through the said lower winding normal contact 223 of said relay IR, to ground at alternate contact 237 of said relay 224. The relay 224, due to its differential winding, neutralizes and restores to normal. The relay 224 restoring, opens the circuit of relay 227 permitting the said relay 227 to restore. The closing of alternate contacts 220 and 221 of relay T^1 extends the connection of the calling subscriber R to the idle connector U engaged by wipers 238, 239 and 240 of selector T. The closing of alternate contacts 220 and 221 of relay T^1 brings about the energization of the impulse relay IR^1 of connector U from ground through one winding of the relay IR^1, bank contact 253, wiper 240, alternate contact 221 of relay T^1, bank contact 213, wiper 210, alternate contact 204 of relay CO, through the substation R, the alternate contact 205 of relay CO, wiper 209, bank contact 212, alternate contact 220 of relay T^1, wiper 239, bank contact 252, and through the left hand winding of the interrupter relay IR^1 to battery and ground. The restoration of the relay 224 of the first selector T opens the initial energizing circuit of relay T^1 of the first selector T, 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 260, wiper 238, bank contact 251, conductor 261, and conductor 262 to ground at alternate contact 263 of the impulse relay IR^1. The said relay T^1 remains energized until the termination of the conversation.

The energization of the relay IR^1 brings about the energization of the relays 265 and 266, the circuit of relay 265 extending from battery through the right hand winding of said relay, normal contact 267 of the primary off-normal contacts PON^1, conductor 261 and conductor 262 to ground at alternate contact 263 of relay IR^1. The circuit for relay 266 extends from battery through the lower winding of the relay 266, conductor 269, conductor 270, and alternate contact 271 of relay IR^1 to ground at alternate contact 263 of impulse relay IR^1. Upon the energization of relay 265, a locking circuit is closed for the said relay extending from battery through its alternate contact 272 to ground. The subscriber now operates his calling device CD to send four impulses of current over the line. These four impulses bring about four energizations and de-energizations of the relay IR^1 causing the primary magnet PM^1 to energize and de-energize four times to step the wipers 273, 274 and 275 in a downward primary direction to the fourth group of contacts containing the contacts of the called line. The circuit of the primary magnet PM^1 may be traced from battery through the winding of the said magnet, normal contact 276 of switching relay SW, conductor 277, alternate contact 278 of relay 266, normal contact 271 of relay IR^1, conductor 262, conductor 261, and normal contact 267 of the primary off-normal contacts PON^1 to ground at alternate contact 272 of relay 265. After the primary off-normal contact 267 has moved on the first step of the switch shaft, the ground fed from contact 287 of relay 288 is substituted for the ground fed through contact 272 of relay 265. After the last impulse of the series has been sent, the steady flow of current through both windings of relay 266 causes the said relay 266, due to its differential action, to neutralize and restore its contacts to normal. Relay 266 does not restore during the sending of impulses due to its adjustment, construction and the rapidity of the interruptions of contact 271. The closing of normal contact 281 of relay 266 brings about the energization of the switching relay SW traced from battery through the winding of said relay to make-before-break

contact 282 of said relay, normal contact 283 of secondary off-normal springs SON¹, conductor 284, normal contact 281 of relay 266, and conductor 285 to ground at alternate contact 286 of primary off-normal contacts PON¹, the said primary off-normal contacts PON¹ having been moved to their alternate position on the first step of the wipers 273, 274 and 275 of the connector switch. The closing of alternate contact 276 of the switching relay SW now renders the secondary magnet SM¹ operative so that when the calling subscriber at the substation R actuates his call device again to send the last set of impulses, which we have assumed are five in number, the said magnet SM¹ will be energized and de-energized by the impulse relay IR¹ five times over a circuit traced from battery through the winding of the said magnet SM¹, alternate contact 276 of relay SW, conductor 277, alternate contact 278 of relay 266, normal contact 271 of relay IR¹, conductor 262, conductor 261, and alternate contact 267 of the primary off-normal contacts PON¹, and conductor 289 to ground at normal contact 287 of relay 288. The secondary magnet SM¹ now steps the wipers 273, 274 and 275 in a secondary rotary direction to engage contacts 290, 291 and 292 of the called line. Upon the first impulse of the last set, the relay 266 again energizes to permit the secondary magnet SM¹ to be operated, and after the last impulse the relay 266 is again de-energized, as previously described. The restoration of the relay 266 closes a circuit for the test relay TR traced from battery through the winding of the said relay, conductor 293, the alternate contact 294 of relay SW, (the said relay SW having been energized and locked up when the differential relay 266 permitted its armature 281 to be retracted) alternate contact 283 of the secondary off-normal contacts SON¹, (said contacts having been moved to their alternate position upon the first step of the wipers in their secondary direction) conductor 284, normal contact 281 of relay 266, conductor 285 to ground at alternate contact 286 of the primary off-normal contacts PON¹. The closing of alternate contact 295 of relay TR connects the said relay over conductor 296 to the test wiper 273, and should be called line be busy the private contact 290 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 290 of the called line will have a battery potential upon it, and the relay TR will not remain energized but will de-energize. The opening of normal contact 300 of relay TR opens the circuit of the switching relay SW. The relay SW de-energizing opens the circuit for relay TR at its contact 294, leaving the relay TR dependent upon the potential found upon the private contact 290 of the called line for its holding potential, and, as assumed, this contact is free from ground potential, therefore the relay TR de-energizes and returns to normal. The relay TR de-energizing causes the energization of the relay 288 over a circuit which may be traced from battery through the cut-off relay CO¹, to bank contact 290, through wiper 273, conductor 296, normal contact 295 of relay TR, conductor 302, normal contact 303 of relay SW, conductor 304, through the lower winding of the relay 288, and conductor 305 to ground at alternate contact 280 of relay 265. The closing of alternate contact 306 of relay 288 short circuits the lower winding of the said relay, and the closing of alternate contact 307 of relay 288 closes a circuit through the upper winding of the said relay through the alternate contact 307 and conductor 305 to ground at alternate contact 280 of relay 265.

The closing of alternate contact 308 of relay 288 connects the interrupter I to the relay 310. The circuit for relay 310 may be traced from battery through the winding of the said relay 310, conductor 311, alternate contact 308 of relay 288, conductor 312, normal contact 313 of relay RC and through the interrupter I to ground. The relay 310 is thus intermittently energized and de-energized, and upon each de-energization of the relay 310 the ringing generator RG is connected to the called line over a circuit extending from the ungrounded pole of the generator RG, through normal contact 314 of ringing control relay RC, conductor 315, alternate contact 316 of relay 288, conductor 317, normal contact 318 of relay 310, wiper 275, bank contact 292, through the condenser and call bell of the called substation back through bank contact 291, wiper 274, normal contact 319 of relay 310, and conductor 320 to ground at alternate contact 287 of relay 288.

The call bell of the called subscriber at the substation V is thus intermittently rung, due to the energization and de-energization of the relay 310 by the interrupter I. When the called subscriber answers and the relay 310 is in its energized position, a circuit for the relay SR is closed, which may be traced from battery through the lower winding of the relay SR, through alternate contact 318 of relay 310, wiper 275, contact 292, through the now closed contacts of the substation switch hook at the called substation V, back through contact 291, wiper 274, alternate contact 319 of relay 310 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 and make-before-break contact 322 to ground at alternate contact 323 of relay SR. The closing of alternate contact 324 of relay RC closes a locking circuit for the said relay which may be traced from battery through the winding of the said relay, its alternate contact 324 and conductor 285 to ground at alternate contact 286 of the primary off-normal contacts PON[1]. The opening of normal contacts 313 and 314 disconnects the interrupter I and the ringing generator RG to prevent further application of ringing current. A substitute circuit for the relay 310 is now established which may be traced from battery through the winding of the relay 310, conductor 311, alternate contact 308 of relay 288, conductor 312, alternate contact 313 of relay RC, and conductor 285 to ground at alternate contact 286 to primary off-normal contacts PON[1]. 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 K[1] interposed.

The subscribers having finished conversation, and assuming that the subscriber at the calling substation R is first to replace his receiver upon the switch hook, the opening of the switch hook contacts brings about the de-energization of the impulse relay IR[1] of the connector U. The restoration of the relay IR[1] brings about the opening of the holding circuit of the relay T[1] of the first selector T. The closing of normal contact 247 of the restored relay T[1] of the first selector T closes an energizing circuit for relay 242 which may be traced from battery through the winding of said relay 242, normal contact 247 of relay T[1], normal contact 248 of magnet SM, normal contact 255 of relay 224, and alternate contacts 244 and 226 of primary off-normal contacts PON to ground. The closing of alternate contact 250 of relay 242 brings about the energization of secondary magnet SM. The relay 242 and secondary magnet SM are alternately energized and de-energized, (as before described) the secondary magnet SM thus stepping the wipers 238, 239 and 240 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 normal contact 226 of the primary off-normal contacts PON opens the energizing circuit of the cut-off relay CO of the individual line switch S. The restoration of the cut-off relay CO of the line switch S brings about the restoration of the said individual switch S.

The subscriber V 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 330 of relay SR closes a circuit through the left hand winding of the relay 265 which may be traced from battery through the left hand winding of the said relay 265, alternate contact 331 of relay 265, conductor 332, normal contact 330 of relay SR and conductor 333 to ground at normal contact 265 of relay IR[1]. Due to the differential construction of relay 265, the said relay neutralizes and restores to normal. The closing of normal contact 334 of relay 265 closes an energizing circuit for the secondary magnet SM[1], which may be traced from battery through the winding of said secondary magnet SM[1], conductor 335, normal contact 334 of relay 265, alternate contact 336 of the primary off-normal contacts PON[1], through the interrupter I[1] to ground. The secondary magnet SM[1] thus steps the wipers 273, 274 and 275 beyond the last set of contacts in the group. The wipers then restore to normal from this position by spring tension. The restoration of the relay 265 brings about the opening of the circuit of the relay 288 at alternate contact 280, and the relay 288 restoring opens the circuit of relay 310 at contact 308 of relay 288, and the primary off-normal contacts PON having restored upon the restoration of the switch, the opening of the alternate contact 286 of PON[1] brings about the de-energization of the relay RC. The relay 265 also brings about the de-energization of the cut-off relay CO[1] of the line circuit S[1] which is associated with the called subscriber V.

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

Assuming now that the subscriber at the called substation V was first to replace his receiver upon the switch hook, the opening of the switch hook contacts at the substation V brings about the de-energization of the relay SR. Nothing else happens at this time as the relay IR[1] is still maintained energized over the line of the calling substation R. The calling subscriber at the substation R replacing his receiver interrupts the circuit of the impulse relay IR[1] at the switch hook contacts. The relay IR[1] de-energizing closes a circuit for the left hand winding of relay 265, causing the said relay to de-energize, as herein-before described. The restoration of the individual switch S, first selector T and connector U is the same as previously described from this point on. Should the called subscriber V fail to replace his receiver upon the switch hook after the conversation is terminated,

the replacing of the receiver at the substation R brings about the de-energization of the impulse relay IR^1 of connector U, the same as before, and the opening of alternate contact 263 of impulse relay IR^1 opens the circuit of the relay T^1 of first selector T as before described, and causes the release of selector T and individual line switch S.

The subscriber at the called substation failing to replace his receiver, permits the continued energization of the relay SR, thus holding the contact 330 of said relay in its alternate position, preventing the differential wound relay 265 from restoring to normal and closing the energizing circuit for the secondary magnet SM^1. The relay 266 energizes when the line relay IR^1 drops back but is immediately restored to normal due to the closure of an energizing circuit through the lower winding of the said relay 266 which may be traced from battery through the said lower winding, conductor 270, alternate contact 330, conductor 333, to ground at alternate contact 263 of the now restored impulse relay IR^1. Relay 266 being differentially wound, restores to normal, and the closing of normal contact 340 of the said relay 266 places a ground upon the private contact of the connector U over a circuit which may be traced from ground at alternate contact 286 to the primary off-normal contact PON^1, conductor 285, normal contact 281 of relay 266, conductor 284, alternate contact 283, normal contact 340, alternate contact 341 of the secondary off-normal contacts SON^1, to the private contact 251. The placing of this busy potential upon the private contact prevents any first selector switch T from engaging 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 290 has a busy potential placed upon it, thus closing a locking circuit for the test relay TR from battery through the winding of the said relay, its alternate contact 295, conductor 296, and the wiper 273 to ground at contact 290. The closing of alternate contact 342 of the test relay TR connects the busy signal BB to the line to transmit a busy signal to said calling subscriber at substation R, thus notifying him of the busy condition of the said called substation V. 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 U 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 to ground at the primary off-normal springs PON'. The calling subscriber now replaces his receiver, bringing about the de-energization of the impulse relay IR^1. The relay IR^1 restoring opens the circuit of the relay T^1 of the first selector T which closes a circuit for the secondary relay SM, as previously described, thus bringing about the release of the first selector T and the individual switch S. The relay IR^1 de-energizing, brings about the restoration of the relay 265, due to the fact that the relay SR has not been energized. The closing of the circuit through the left hand winding of the relay 265 brings about the neutralization of said relay 265. The closing of normal contact 334 of the said relay 265 closes a circuit through the secondary magnet SM^1 an interrupter I', which magnet steps the wipers 273, 274 and 275 beyond the last set of contacts. The wipers then restore to normal by spring tension. The primary off-normal contacts PON^1 and secondary off-normal contacts SON^1 are also restored, and the apparatus used in this busy connection 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 exact matter shown, as various other arrangements may readily suggest themselves to one skilled in the art. Therefore, I desire 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. An automatic switch including groups of contacts arranged in parallel rows, a shaft for said switch provided with wipers for engaging said contacts, step-by-step mechanism for driving the shaft and wipers to a row of contacts, mechanism for thereafter driving said shaft and wipers to a set of said contacts, spring restoring means for restoring said shaft and wipers in one direction, and other spring means for restoring said shaft and wipers in the other direction to normal.

2. An automatic switch including a bank of passive contacts arranged in groups, a switch shaft provided with wipers adapted to be moved vertically to a group of contacts and then rotated into engagement with contacts in a selected group of contacts, electromagnetic means for moving said shaft and wipers vertically, electromagnetic means for thereafter rotating said shaft and wipers beyond said bank of contacts, and suitable spring restoring means for moving said shaft and wipers in two directions over a

different path to restore them to normal position.

3. An automatic switch including a bank of passive contacts, a switch shaft and a wiper carried thereby associated with said bank of contacts, suitable means for primarily driving said shaft and wiper against spring pressure to a group of said passive contacts, means for secondarily driving said shaft and wiper against spring pressure to move said wiper into engagement with one of said passive contacts, means for thereafter driving said shaft and wiper beyond said bank of contacts whereby said shaft and wiper are restored to normal position by said spring pressure.

4. A switching device including bank contacts arranged in levels, a switch shaft provided with wipers adapted to be moved to a level of contacts and then to a contact in the level, a magnet for driving the said shaft and wipers against opposing spring tension to a level of contacts, a second magnet for then driving said shaft and wipers against opposing spring tension to a contact in the level, and means whereby said second magnet restores the shaft and wipers to normal.

5. An automatic switch including a bank of passive contacts, a suitable shaft provided with a wiper for co-operating with said passive contacts, means for moving said shaft and wiper in two different directions to engage one of said passive contacts, a retarding device effective in each direction of movement, said retarding device becoming active when said shaft and wiper are moved beyond said bank of contacts to restore said shaft and wiper to normal.

6. An automatic switch including a bank of passive contacts, a switch shaft and a wiper carried thereby associated with said bank of contacts, suitable means for primarily driving said shaft and wiper against spring pressure to a group of said passive contacts, means for secondarily driving said shaft and wiper against spring pressure to move said wiper into engagement with one of said passive contacts, means for thereafter driving said shaft and wiper beyond said bank of contacts whereby said shaft and wiper are restored.

7. An automatic switch including a switch shaft, step-by-step means for moving said switch shaft in a vertical direction and then in a rotary direction, spring means opposing the movement of said shaft in one direction, other spring means opposing the movement of said shaft in the other direction, both of said spring means being operable to restore the said switch shaft to normal.

8. An automatic switch including a bank of passive contacts comprising a plurality of parallel rows of contacts, a shaft provided with a wiper for co-operating with said passive contacts, means for moving said shaft in two different directions to move said wiper into engagement with one of said passive contacts, and means for moving said wiper beyond said bank of contacts whereby said shaft and wiper are restored by spring means to normal.

9. In an automatic switch, passive contacts arranged in rows, a movable switch shaft provided with wipers adapted to engage said contacts, an electromagnet and apparatus controlled thereby for moving said shaft in a vertical direction to select a row of contacts, a second electromagnet and step-by-step apparatus controlled thereby for rotating said shaft and wipers to select contacts in the row, the said second electromagnet also being adapted to rotate said wipers to a position beyond the last contact in the row, and a pair of springs for restoring the shaft and wipers to normal position.

10. An automatic switch including a bank of passive contacts, a step-by-step shaft for said switch provided with an active contact, means for moving said shaft and active contact against the action of two retarding springs into engagement with one of said passive contacts, and means for continuing the movement of said shaft and wiper beyond said bank, said springs being thereupon effective to restore said shaft and active contact to normal position.

11. An automatic switch including an endwise movable and rotatable switch shaft, an active contact carried by said switch shaft, a bank of passive contacts, means for moving said switch shaft in a vertical direction against the tension of a retarding spring, means for rotating said switch shaft against the tension of a retarding spring, said springs forming means for thereafter returning said switch shaft to normal.

12. An automatic switch including an endwise movable and rotatable switch shaft, a retarding spring opposing the endwise movement of said shaft, a retarding spring opposing the rotation of said shaft, said springs forming means for returning said shaft to normal.

13. An automatic switch including a single endwise movable and rotatable switch shaft, a wiper carried by said switch shaft, a bank of contacts, electromagnetic means for moving said shaft in a vertical direction against the action of a retarding spring, electromagnetic means for then rotating said shaft and wipers against action of a second retarding spring, said retarding springs being adapted to return said switch shaft to normal position when said wiper is rotated beyond said bank of contacts.

14. An automatic switch including a switch shaft provided with a contact maker, a bank of contacts, step-by-step electromagnetic means for moving said switch shaft downwardly and for then rotating the same

to carry said contact maker into engagement with one of the contacts of said bank, spring means opposing the movement of said shaft in both of said directions, said spring means being adapted to return the switch shaft to normal position.

15. An automatic switch including a mounting frame, a pair of bifurcated lugs attached to said mounting frame, a pair of bank rods adapted to fit into the bifurcated portions of said lugs, and a pair of nuts for each of said rods for securing said rods in position and for permitting adjustment of the bank.

16. An automatic switch including a movable switch shaft adapted to be moved in a lineal direction and to be rotated, a movable contact carried by said switch shaft, a member secured to said switch shaft carrying said contact, off-normal contacts, and means actuated by said member for controlling said off-normal contacts.

17. An automatic vertically and rotatably movable switch including a switch shaft, a wiper carrying member secured to said switch shaft, off-normal springs, and means operated by said wiper carrying member for actuating said off-normal springs.

18. An automatic switch including a mounting frame, a vertically and rotatably movable hollow switch shaft supported by said frame, and a spring extending through the hollow of said switch shaft opposing the movement of said shaft.

19. An automatic switch including a hollow switch shaft, a bank of passive contacts, a movable contact carried by said shaft for engagement with said passive contacts, and a spring extending through the entire length of the hollow in said switch shaft for opposing the movement thereof.

20. An automatic switch provided with a downwardly movable and rotatable switch shaft carrying switch wipers which partake of the same movement as the switch shaft, a spring opposing the endwise movement of said switch shaft, and a second spring opposing the rotatable movement of said switch shaft.

21. An automatic switch including an endwise movable and rotatable hollow switch shaft, a spring extending through the hollow in said switch shaft opposing the endwise movement of the same, and a second spring encircling the said switch shaft opposing the rotary movement of said switch shaft.

22. An automatic switch provided with a switch shaft, a magnet provided with a pawl for moving said switch shaft, and a member formed integrally with the heel iron of said driving magnet for limiting the return movement of said driving pawl.

23. An automatic switch including a switch shaft, a driving pawl for moving said switch shaft, and a retaining pawl and a guiding pawl for said driving pawl formed integrally with each other.

24. An automatic switch including a switch shaft, a rotary ratchet for rotating said switch shaft, a key-way cut in said shaft, a feather pivoted to said rotary ratchet and adapted to engage the key-way in said shaft, and means for moving said feather out of engagement with said key-way when said shaft is being restored.

25. An automatic switch including a switch shaft, a rotary ratchet for rotating said shaft, a slot cut in said shaft, a key pivoted to said rotary ratchet and adapted to fit into said slot, and means for removing said key from said slot when the release of said shaft is desired.

26. An automatic switch including a movable switch shaft, a magnet for moving said switch shaft, an armature for said magnet, a driving pawl pivotally secured to the free end of said armature, and an angularly shaped spring secured to said armature having its free end lying flat against the back of said driving pawl for pressing the same into engagement with the notches of said switch shaft when said magnet is operated.

27. An automatic switch including a movable switch shaft, a driving magnet for said switch, an armature provided with a pawl attached to its free end for said magnet for moving said switch shaft, and a heel iron for said magnet provided with integrally formed ends adapted to limit both movements of said driving pawl.

28. An automatic switch including a switch shaft, a driving magnet for said switch shaft, a driving pawl controlled by said driving magnet, and a pair of guides for guiding said driving pawl into and out of engagement with teeth on said shaft, said guides being formed integrally and pivotally attached to the extended end of the heel iron of said electromagnet.

29. An automatic switch including a movable switch shaft, a driving magnet, an armature provided with a driving pawl for said magnet for moving said switch shaft, and a pair of limiting stops for said driving pawl formed integrally with the heel iron of said electromagnet.

30. An automatic switch including an endwise movable switch shaft, a rotary ratchet associated with said switch shaft for rotating the same, a rotary holding pawl, a member controlled by said switch shaft for actuating said holding pawl, rotary off-normal springs, and a member secured to said rotary ratchet for operating said rotary off-normal springs and for use in releasing the switch shaft.

31. An automatic switch including an endwise movable and rotatable switch shaft, a rotary ratchet associated with said switch

shaft, rotary off-normal springs, a holding member for preventing the return endwise movement of said switch shaft, and an element secured to said rotary ratchet for operating said rotary off-normal springs and said holding member.

32. An automatic switch including a vertical and rotary switch shaft, vertical off-normal springs, a rotary holding pawl, and a member controlled by said switch shaft for actuating said vertical off-normal springs and said rotary holding pawl.

33. An automatic switch including a switch shaft, a ratchet for rotating said switch shaft, a vertical slot cut in said switch shaft, a member pivotally secured to said ratchet and provided with an end portion adapted to fit into said slot, and means for moving said end portion out of engagement with said slot when said shaft is being restored.

34. An automatic switch including an endwise movable and rotatable switch shaft, bearings for said switch shaft, adjustable means for limiting the normal vertical position of said shaft, and a spring for returning said switch shaft to normal fastened to said adjustable means.

35. An automatic switch including an endwise movable and rotatable switch shaft, bearings for said switch shaft, adjustable means for limiting the normal vertical position of said shaft, adjustable means for limiting the normal rotary position of said shaft, and a spring for returning said switch shaft to normal fastened to said first adjustable means.

36. An automatic switch including a bank of contacts, a pair of plates between which said contacts are secured, extended portions for one of said plates bent back parallel to the plane of the said plate, orifices for said plates through which bank rods extend, and screws having screw-threaded engagement with the bent back portions of said extended ends for securing the bank in place upon said bank rods.

37. An automatic switch including a mounting plate, a pair of bank rods secured thereto, a bank of contacts mounted between a pair of plates, extended portions for one of said plates bent back parallel to the plane of said plate, orifices in said plates through which said bank rods extend, and screw members having screw-threaded engagement with the yoke portions of the extended bent back portions of said plate for securing said bank of contacts to said bank rods.

38. An automatic telephone exchange system including a subscriber's telephone line, an automatic selector switch for extending a call from said line, an impulse relay for said switch controlled over said line, a differential secondary relay controlled by said impulse relay for controlling a secondary switching circuit, a test relay and a driving magnet for said switch, a circuit for said test relay including a contact of said driving magnet, and a circuit for said driving magnet including a contact of said test relay.

39. An automatic telephone exchange system including a subscriber's telephone line, an automatic selector switch for extending a call from said line, an impulse relay for said switch controlled over said line, a test magnet and a driving magnet for said automatic switch, circuits for said driving magnet and said test magnet controlled by contacts of each other, whereby when one of said magnets is energized it operates to de-energize the other of said magnets, and a differential release relay responsive to a prolonged de-energization of said impulse relay for controlling release means of said automatic selector.

40. A telephone system including a subscriber's line circuit, a two-wire automatic switch, automatic means for connecting said subscriber's line circuit to said automatic switch, an impulse relay for said switch, a transmitter connected in said line circuit for interrupting the circuit of said impulse relay, thereby causing said relay to be intermittently operated, a differential relay controlled by said impulse relay for controlling a switching circuit, a test magnet and a motor magnet for said switch, and circuits for said motor magnet and said test magnet controlled by contacts of each other, whereby when one of said magnets energizes it operates to de-energize the other of said magnets.

41. A telephone system including a subscriber's line circuit, an automatic switch adapted to be connected to said line, an impulse relay for said switch, a differential relay for said switch operated to attract its armature responsive to the first operation of said impulse relay, a neutralizing winding for said differential relay effective upon a prolonged energization of said impulse relay to cause the retraction of its armature, a test magnet and a motor magnet, a circuit for said test magnet controlled by said differential relay, and circuits for said motor magnet and test magnet controlled by contacts of each other, whereby when one of said magnets is energized it operates to de-energize the other of said magnets.

42. A telephone system including a subscriber's telephone line, an automatic selector switch adapted to be connected to said line, a test relay and a driving magnet for said automatic switch, a circuit for said test relay including a contact of said driving magnet, a circuit for said driving magnet including a contact of said test relay, and means controlled by said driving magnet for restoring said automatic switch.

43. A telephone system including an automatic switch provided with wipers, a motor magnet for advancing said wipers, a test magnet, circuits for said motor magnet and said test magnet controlled by contacts of each other, whereby when one of said magnets is energized it operates to de-energize the other of said magnets, and release means for said automatic switch controlled by said motor magnet.

44. A telephone system including an automatic selector switch provided with movable contacts, a motor magnet for advancing said movable contacts, an auxiliary relay, a circuit for said motor magnet and said auxiliary relay controlled by contacts of each other, whereby when one of said magnets is energized it operates to de-energize the other of said magnets, said motor magnet adapted to also control the release of said automatic switch.

45. A telephone system including an automatic switch having motion in two intersecting planes, a motor magnet and an auxiliary magnet for said switch, a circuit for said motor magnet including contacts of said auxiliary magnet, a circuit for said auxiliary magnet including contacts of said motor magnet, and a supplemental circuit for said motor magnet for controlling the restoration of said switch.

46. A telephone system comprising a telephone line, an automatic switch for extending a connection from said telephone line in the direction of a called subscriber's line, an impulse relay for said switch responsive to circuit changes in said telephone line, a differential secondary relay responsive to said impulse relay for controlling a secondary circuit, a test magnet included in said secondary circuit, a motor magnet, a circuit for said motor magnet controlled by said test magnet, a circuit for said test magnet controlled by a contact of said motor magnet, and a differential release relay responsive to a prolonged de-energization of said impulse relay for effecting the closure of a release circuit.

47. A telephone system comprising a subscriber's telephone line, a two-dimension switch for extending a connection from said line having one motion for electing groups of trunk lines and a second motion for selecting an idle trunk in an elected group of trunk lines, a differential secondary relay for controlling the second of said motions, a test magnet adapted to be controlled by said differential secondary relay, a motor magnet adapted to be controlled by said test magnet and circuits for said two magnets including contacts of each other, and a differential release relay for controlling the release of said switch.

48. A telephone system including an automatic selector switch, a relay and a motor magnet for said switch, a circuit for said relay controlled by a contact of said magnet, a circuit for said magnet controlled by said relay, and release means controlled by said magnet.

49. A telephone system including an automatic selector switch having motion in one direction to select groups of lines and in another to select lines in the groups, a relay and a motor magnet for said switch, a circuit for said relay controlled by a contact of said magnet, a circuit for said magnet controlled by said relay, and release means controlled by said magnet.

50. A telephone system including an automatic selector switch, a relay and a motor magnet for said switch, a circuit for said relay controlled by a contact of said magnet, a circuit for said magnet controlled by said relay, and a differential release relay for said switch.

51. A telephone system including an automatic selector switch, a relay and a motor magnet for said switch, a circuit for said relay controlled by a contact of said magnet, a circuit for said magnet controlled by said relay, and a differential switching relay for said switch.

52. A telephone system including an automatic selector switch, a relay and a motor magnet for said switch, a circuit for said relay controlled by a contact of said magnet, a circuit for said magnet controlled by said relay, and differential switching and release relays for said switch.

Signed by me at Chicago, in the county of Cook and State of Illinois, this 15th day of June, 1917.

HARRY H. IDE.