No. 616,714. Patented Dec. 27, 1898.

F. A. LUNDQUIST & J. & C. J. ERICKSON.

AUTOMATIC TELEPHONE EXCHANGE.

(Application filed Mar. 28, 1893.)

(No Model.) 7 Sheets—Sheet 1.

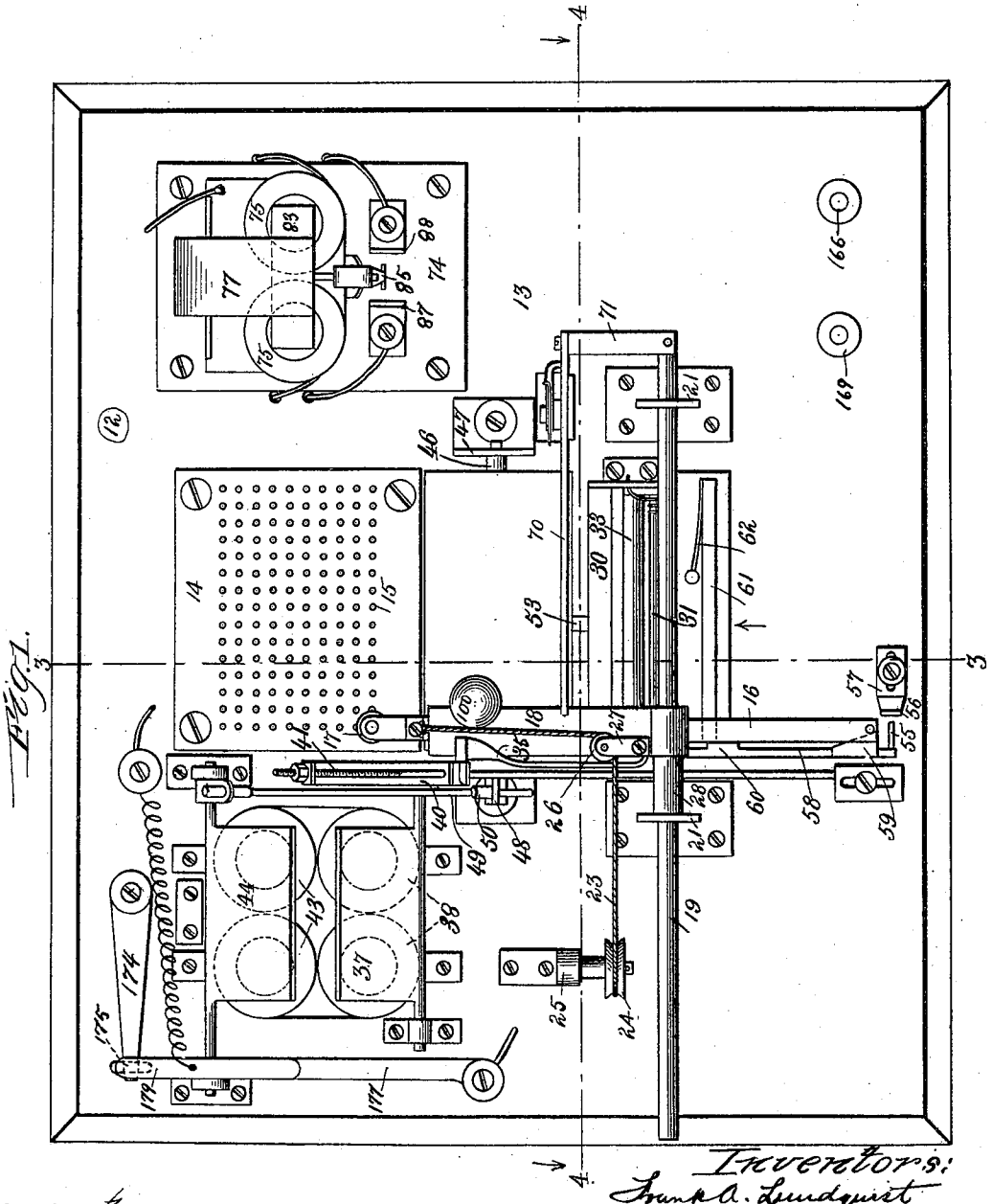

Fig. 1.

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(No Model.) 7 Sheets—Sheet 2.

Fig. 2.

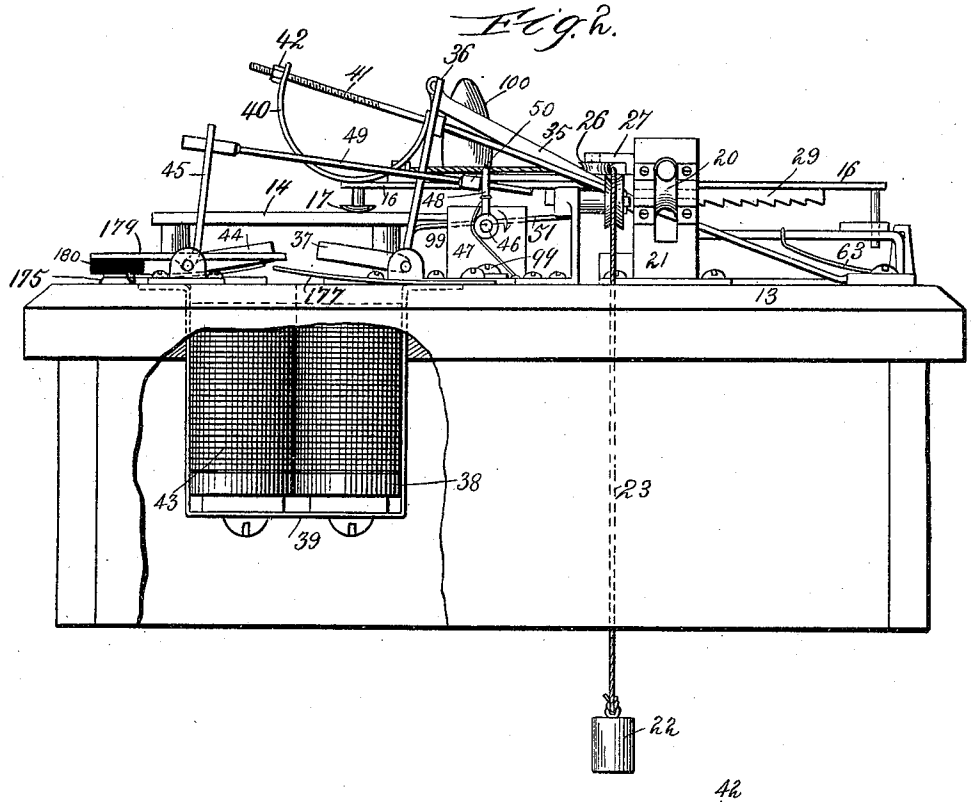

Fig. 3.

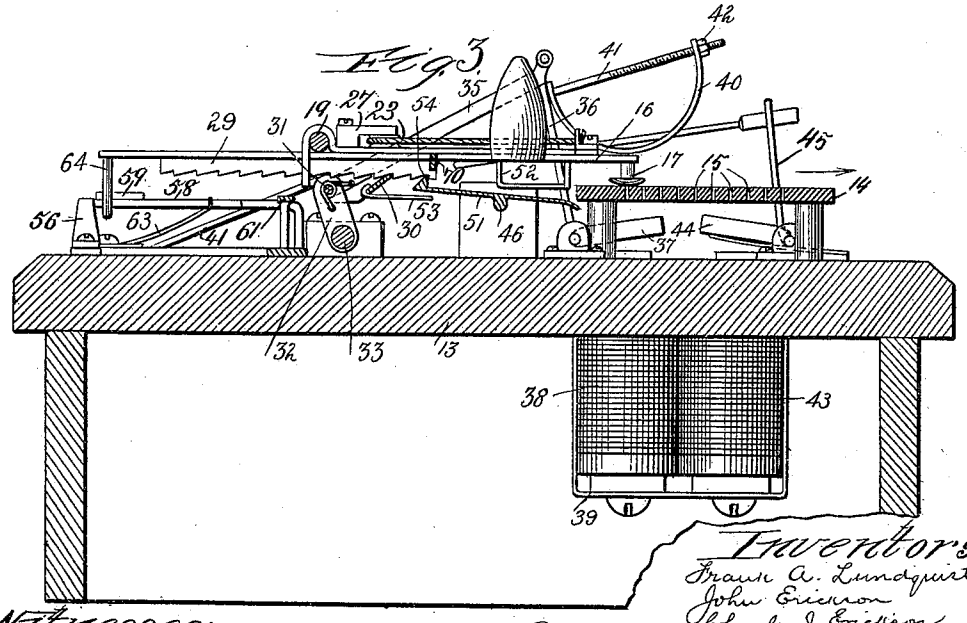

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Fig. 4.

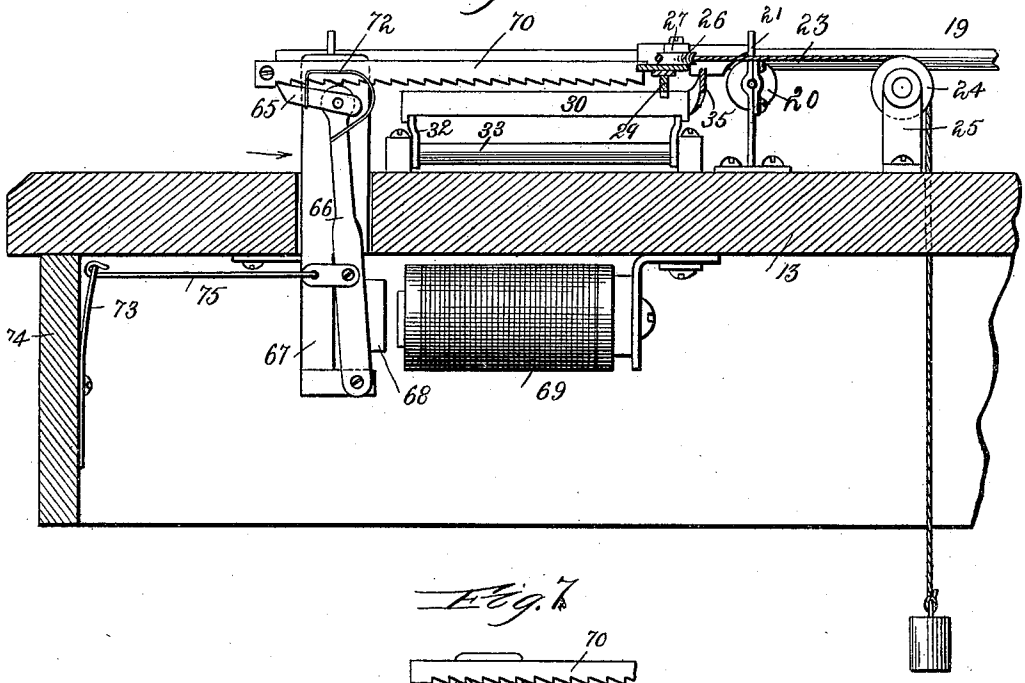


Fig. 7.

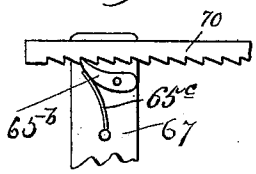


Fig. 5.

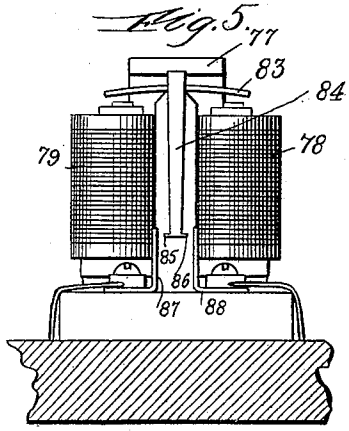
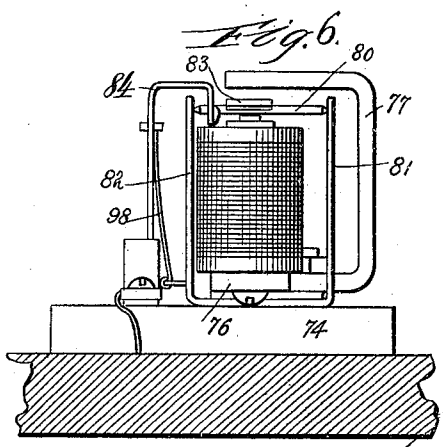


Fig. 6.



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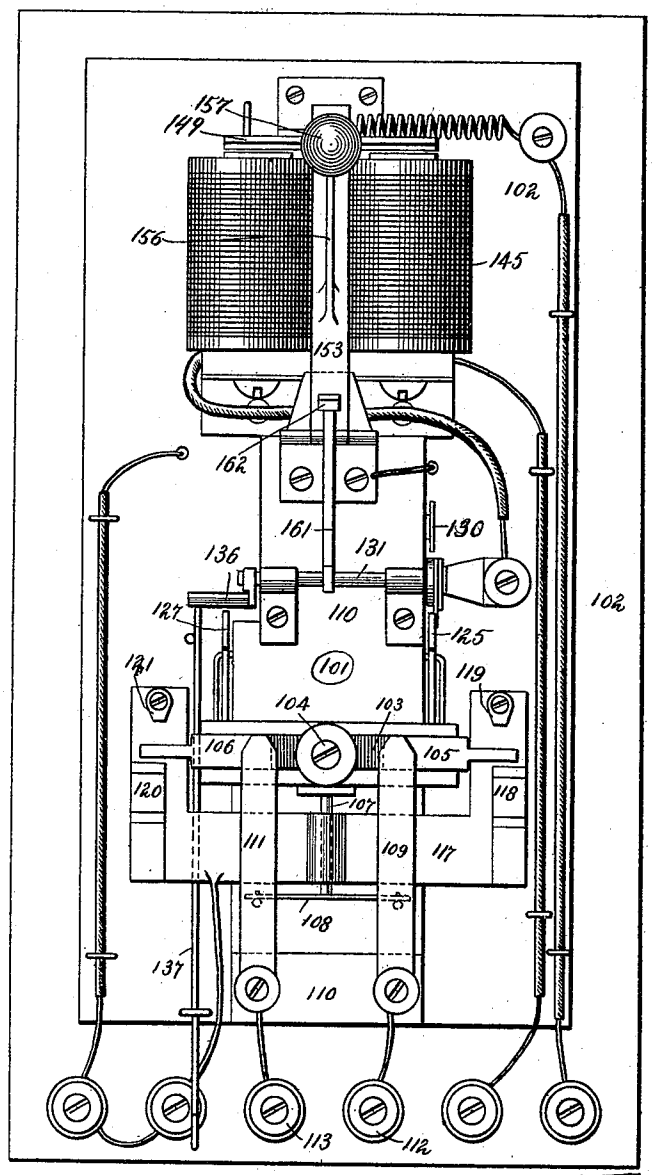
(No Model.) 7 Sheets—Sheet 4.

Fig. 8.



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(No Model.) 7 Sheets—Sheet 5.

Fig. 9.

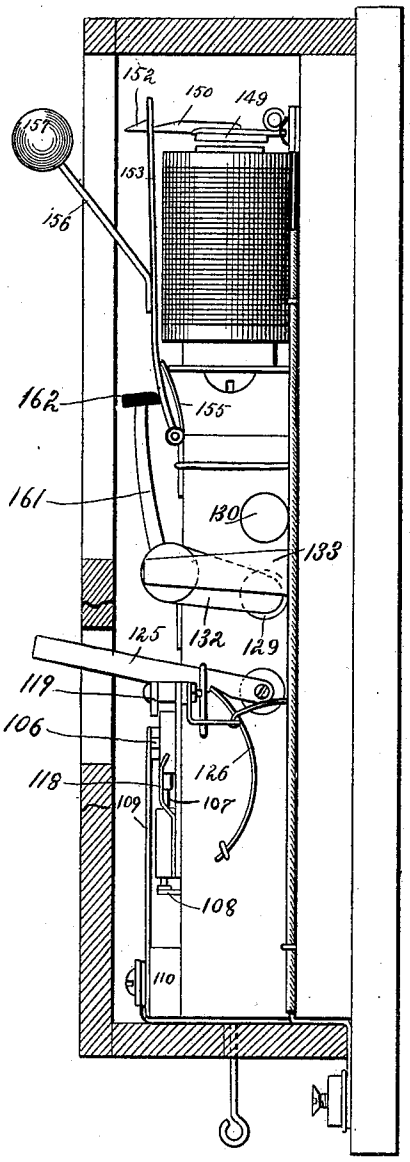
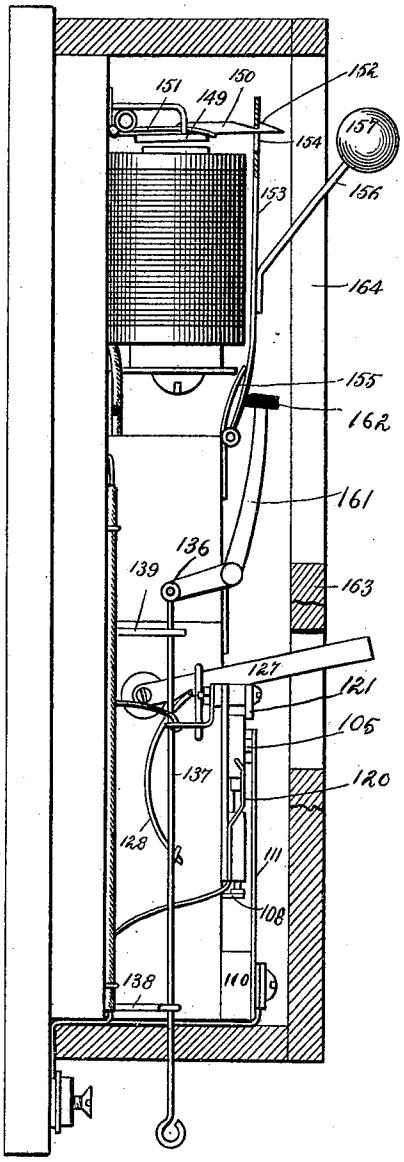


Fig. 10.



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AUTOMATIC TELEPHONE EXCHANGE.

(Application filed Mar. 28, 1893.)

(No Model.) 7 Sheets—Sheet 6.

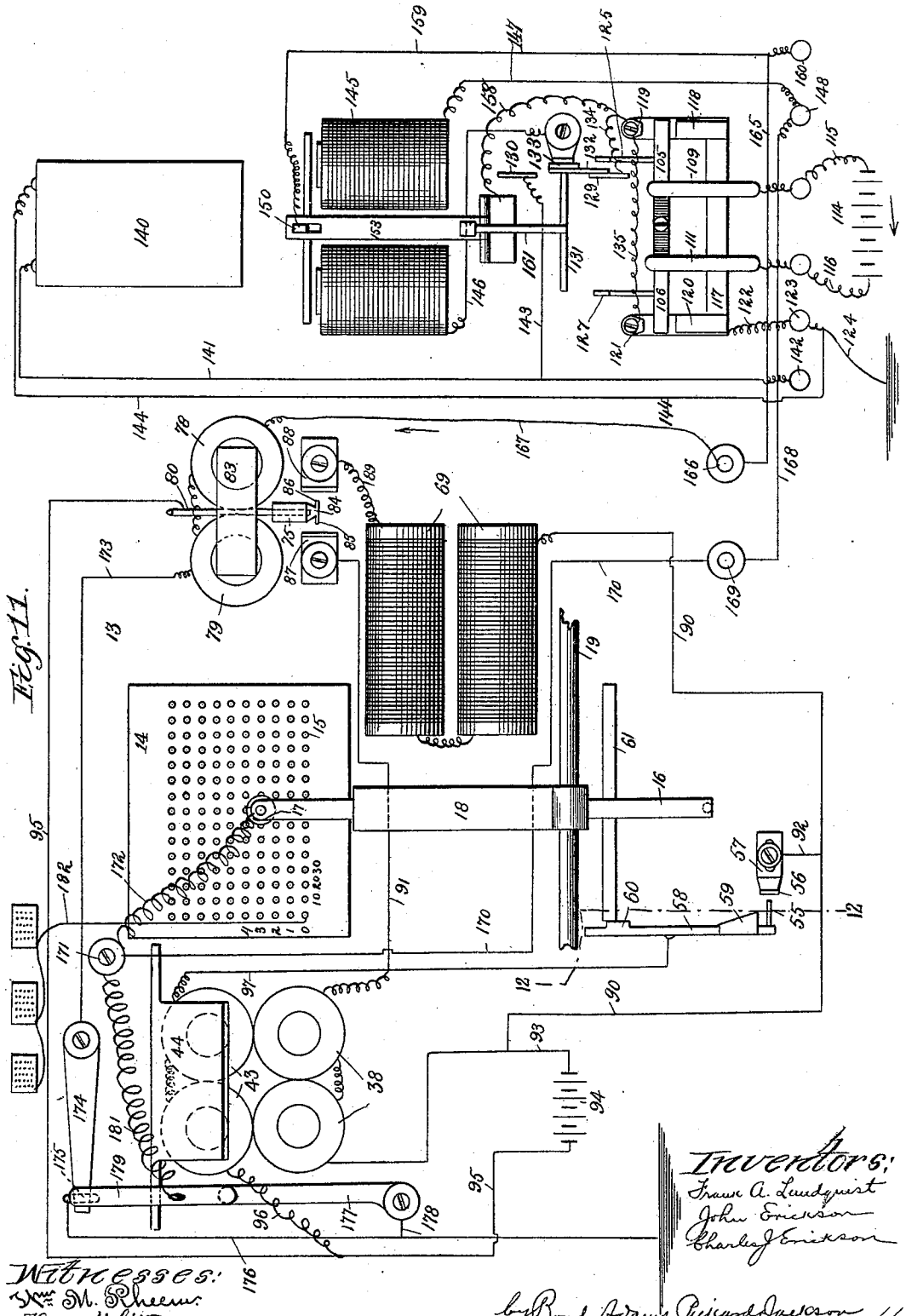

Fig. 11.

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AUTOMATIC TELEPHONE EXCHANGE.

(Application filed Mar. 28, 1893.)

(No Model.) 7 Sheets—Sheet 7.

Fig. 12.

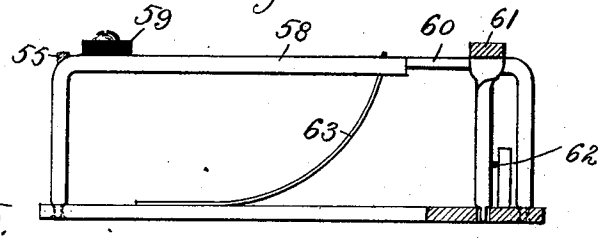


Fig. 15.

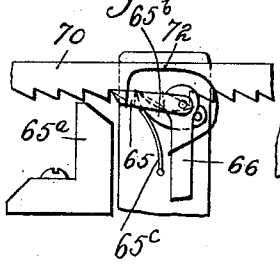


Fig. 13.

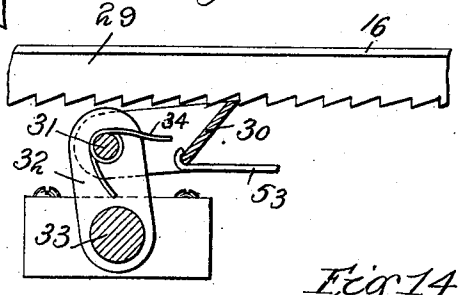
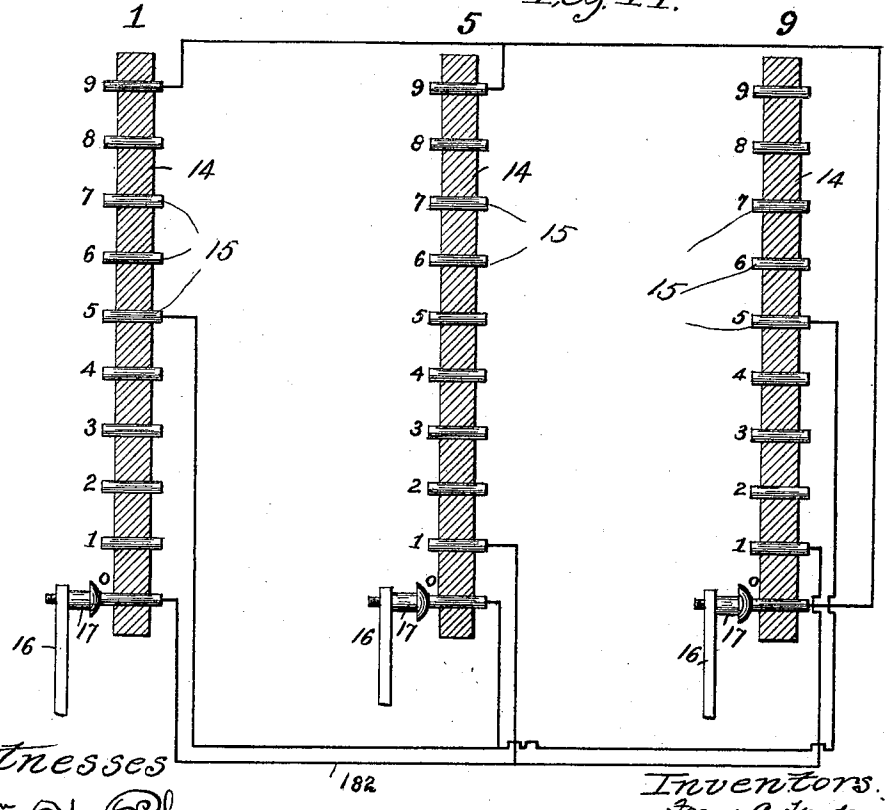


Fig. 14.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE-EXCHANGE.

SPECIFICATION forming part of Letters Patent No. 616,714, dated December 27, 1898.

Application filed March 28, 1893. Serial No. 468,083. (No model.)

To all whom it may concern:

Be it known that we, FRANK A. LUNDQUIST, JOHN ERICKSON, and CHARLES J. ERICKSON, citizens of the United States, residing at Lindsborg, McPherson county, Kansas, have invented a certain new and Improved Automatic Telephone-Exchange, of which the following is a specification, reference being had to the accompanying drawings, in which—

Figure 1 is a top or plan view of the exchange. Fig. 2 is a side elevation, part being broken away. Fig. 3 is a vertical cross-section on line 3 3 of Fig. 1 looking to the left. Fig. 4 is a longitudinal section on line 4 4 of Fig. 1 looking to the right. Fig. 5 is a detail, being a front elevation of the relay. Fig. 6 is a side elevation of the same. Fig. 7 is a detail showing the detent which normally prevents reverse movement of the secondary carriage or circuit-closing device. Fig. 8 is a front elevation of the switch-box located at the substations, the covering being removed. Fig. 9 is a side elevation of the switch-box looking to the left, one side being removed. Fig. 10 is a side elevation of the switch-box looking to the right, one side being removed. Fig. 11 is a diagrammatic view of an exchange, a switch-box, and a telephone, showing the arrangement of the wires. Fig. 12 is a section on line 12 12 of Fig. 11. Fig. 13 is an enlarged detail of certain of the parts shown in Fig. 3. Fig. 14 is a diagrammatic view showing the connections between different exchanges at the central station, and Fig. 15 is a detail of part of the mechanism for operating the secondary carriage or circuit-closing device.

Our invention relates to instruments used for automatically establishing an electric circuit between instruments located at different points, and particularly to such instruments used in connection with telephonic systems.

The objects of our invention are to provide a new and improved automatic telephone-exchange by means of which the operator may connect his instrument with any other instrument in the system at will, to provide an improved arrangement of the circuits whereby the number of wires connected to each instrument will be reduced to the minimum, and to otherwise improve the construction and operation of instruments of this class. We accomplish these objects as hereinafter specified and as illustrated in the drawings.

That which we regard as new will be set forth in the claims.

With our improved exchange a central station is provided in which are located exchanges equal in number to the number of telephone-substations in the system, and each exchange is connected by a wire to its appropriate substation and is also connected to the other exchanges. Each substation is provided with a telephone and a switch-box, and by operating the keys or levers of any switch-box the exchange bearing the same number may be operated to connect the operator's telephone to any other in the system.

We will now describe specifically the construction of our improved exchange and switchboard by reference to the accompanying drawings.

12 indicates an exchange the parts of which are mounted upon a suitable base-board 13. The exchange is provided with a switchboard 14, which is provided with a number of contact-points 15, arranged at regular distances apart upon its surface, forming substantially a rectangular figure. Each contact-point is in electrical connection with a different wire of the system. We prefer to arrange the contact-points in ten rows, so that the decimal system may be used in making connections, beginning to number with the lower left-hand contact-point and numbering those in the left-hand row "0," "1," "2," "3," "4," "5," &c., the next row beginning with "10," the next with "20," and so on, by which arrangement the location of any contact-point may be readily determined.

Connections are made through a secondary carriage or circuit-closing arm 16, which carries a button 17, adapted to be moved into contact with any of the points 15. The operator's telephone is connected to the button 17 through the secondary carriage or circuit-closing arm 16, and by moving such contact device until the button 17 rests upon any desired contact-point the operator may connect his instrument with any other in the system.

The arrangement of the circuit will be more fully hereinafter set forth.

The secondary carriage or circuit-closing arm is movable transversely and longitudinally of the board 13, it being mounted in a primary carriage or frame 18, which in the construction here shown extends transversely of the board 13, said frame constituting a circuit-closing carriage by which the contact device or circuit-closing arm is carried to different parts of the switchboard. The secondary carriage is movable longitudinally upon the primary carriage, which is movable longitudinally of the board 13, it being mounted upon a rod 19, mounted upon rollers 20, which rollers are supported in brackets 21, rising from the board 13, as best shown in Figs. 1 and 2.

The circuit-closing arm 16 is normally held in such position that the button 17 will rest upon the contact-point in the lower left-hand corner of the switchboard by a counterpoise 22, supported by a cord 23, which is connected to the forward portion of the circuit-closing arm 16, as best shown in Fig. 1. The cord 23 passes over a pulley 24, supported by a bracket 25, and a pulley 26, supported by a bracket 27, which bracket 27 is carried by the frame 18. The bracket 25 rises from the board 13 to the left of the normal position of the frame 18. By arranging the pulleys 24 26 as above described when the frame 18 and circuit-closing arm 16 are free to move the counterpoise will immediately cause them to return to their normal position.

The frame 18 carries a sleeve 28, which is adapted to engage the left-hand bracket 21 to limit the backward motion of the frame 18. For convenience the term "forward" will be applied to movement of the circuit-closing arm toward the right-hand end of the board 13.

The circuit-closing arm 16 carries on its under side a ratchet-bar 29, as best shown in Figs. 2 and 3. The teeth of the ratchet-bar 29 are adapted to be engaged by a pallet 30, pivotally mounted upon a rod 31, arranged under the ratchet-bar. The rod 31 is carried by arms 32, carried by a rock-shaft 33, as best shown in Figs. 3 and 13. The pallet 30 extends the length of the switchboard 14 and is normally held in contact with the teeth of the ratchet-bar 29 by a spring 34, as best shown in Fig. 13. The shaft 33 is rocked through one of the arms 32 by means of a bar 35, which is connected through a rod 36 to an armature 37, pivotally mounted upon the board 13, as best shown in Figs. 1 and 3.

The armature 37 is adapted to be depressed by an electromagnet 38, the poles of which are placed under such armature, the magnet 38 being supported under the board 13 by a bracket 39, as best shown in Fig. 3. The arrangement is such that when the magnet 38 is active the armature 37 will be drawn downward, thereby rocking the shaft 33 and operating the pallet 30 to move the circuit-closing arm in the direction indicated by the arrow in Fig. 3, which direction will be hereinafter referred to as "upward."

When the magnet 38 becomes inactive, the shaft 33 will be rocked in the opposite direction and the pallet 30 will be moved backward to engage the next tooth of the bar 29 by means of a spring 40, mounted upon a rod 41, secured upon the board 13 in an inclined position, as shown in Fig. 2. One end of the spring 40 bears against a nut 42, carried by the rod 41, the opposite end of the spring bearing against the upper end of the bar 36, as best shown in Figs. 2 and 3. By this construction each time the poles of the magnet 38 are magnetized the circuit-closing arm will be moved upward the space of one tooth of the ratchet-bar 29. The teeth of the ratchet-bar 29 are eleven or more in number and they are so spaced that each operation of the pallet 30 will move the button 17 upward into contact with the next contact-point upon the switchboard 14. To return the button 17 to the lower left-hand corner of the switchboard, the following apparatus is provided:

43 indicates a second electromagnet which is arranged similarly to the magnet 38, being supported by the bracket 39 under the board 13, the poles of the magnet projecting to the surface of the board.

44 indicates an armature pivotally mounted upon the board 13 over the poles of the magnet 43.

45 indicates a bar rigidly connected to the armature 44 and projecting upward therefrom.

46 indicates a rock-shaft mounted in brackets 47, supported by the board 13, which shaft extends under the frame 18, as best shown in Fig. 3. The shaft 46 is provided with an arm 48, which is rigidly connected thereto, as best shown in Fig. 2.

49 indicates a rod which is connected to the bar 45 and passes through a slot in the arm 48.

50 indicates a collar secured upon the rod 49 and bearing against the arm 48. By this construction by depressing the armature 44 the shaft 46 may be rocked. When the magnet 43 becomes inactive, the shaft 46 is returned to its former position by a spring 99, as best shown in Fig. 2.

51 indicates a plate which is centrally secured upon the shaft 46.

52 indicates a bracket secured to the under side of the circuit-closing arm 16, near the button 17, which bracket is adapted to be engaged by the plate 51 when the shaft 46 is rocked in the direction indicated by the arrow in Fig. 2. By this construction when the armature 44 is moved downward into contact with the poles of the magnet 43 the shaft 46 will be rocked in the direction indicated by the arrow in Fig. 2, thereby turning the plate 51 into contact with the bracket 52 and lifting the forward portion of the circuit-closing arm. At the same time the opposite edge of the plate 51 will come into contact with an

arm 53, which is connected to the pallet 30 and projects therefrom under the plate 51. The pallet 30 will thereby be moved downward out of engagement with the ratchet-bar 29 and the circuit-closing arm will be free to move down until the button 17 rests upon the contact-point in the lower left-hand corner of the switchboard. The object of raising the circuit-closing arm is for the purpose of permitting said circuit-closing arm and frame 18 to move backward; but the way in which that is effected will be more fully hereinafter set forth.

The upper edge of the plate 51, which lies over the arm 53, is provided with a tooth 54, which is adapted to engage the teeth of the ratchet-bar 29, which tooth serves to prevent reverse motion of the circuit-closing arm.

The magnet 43 is automatically cut into circuit by moving a pin 55 into contact with a plate 56, carried by suitable supports 57, as best shown in Fig. 1. The pin 55 is carried by a rocking bar 58, mounted upon the board 13. (See Fig. 12.) The bar 58 carries a block 59 near the pin 55, which block is provided with an inclined edge, as shown in Fig. 1.

60 indicates a lug formed upon the bar 58, near its forward end, as shown in Figs. 1 and 12.

61 indicates a second locking bar pivotally supported on the base, as shown in Fig. 12, and arranged at right angles to the bar 58, which bar 61 is adapted to engage the lug 60 upon the bar 58. (See Fig. 12.) The arrangement is such that when the bar 58 is tilted to move the pin 55 out of contact with the plate 56 the bar 61 will be thrown back by a spring 62 until the end adjacent to the lug 60 bears against said lug, thereby holding the bar 58 back and the pin 55 out of contact with the plate 56. By moving the bar 61 in the direction indicated by the arrow in Fig. 1 it will pass out of contact with the lug 60, thereby permitting the bar 58 to swing in the opposite direction, throwing the pin 55 into contact with the plate 56. Such return motion of the bar 58 is accomplished by a spring 63, as shown in Figs. 3 and 12.

The bars 58 and 61 are operated by the circuit-closing arm 16, which arm carries a depending pin 64, which is adapted to engage the inclined surface of the block 59 when such arm is in its normal position and to engage the bar 61 to move it out of contact with the lug 60 when such arm moves upward beyond the tenth contact-point. As has been hereinbefore stated, by closing the circuit through the pin 55 and plate 56 an electric current will be caused to flow through the electromagnet 43, thereby causing said magnet to attract the armature 44, throwing the pallet 30 out of engagement with the ratchet-bar 29. In practice this result is accomplished by moving the button 17 upward one space beyond the tenth contact-point, when the pin 64 will engage the bar 61 and move it out of contact with the lug 60, permitting the pin 55 to come into contact with the plate 56. As soon as the pallet 30 is thrown out of engagement with the rack-bar 29 the counterpoise 22 will pull the circuit-closing arm back to its normal position and the pin 64 will engage the inclined surface of the block 59, thereby rocking the bar 58 and throwing the pin 55 out of contact with the plate 56. The circuit-closing arm is moved forward or longitudinally of the board 13 by means of a pallet 65, carried by a lever 66, which is pivoted at its lower end to a bracket 67, which extends through the board 13 and is rigidly secured thereto. The lever 66 carries at its lower end an armature 68, which is arranged opposite an electromagnet 69, supported at the under side of the board 13 in a horizontal position, as shown in Fig. 4. The pallet 65 is adapted to engage the teeth of a ratchet-bar 70, which extends longitudinally of the board 13 and is connected at one end to the frame 18, its other end being connected to a bar 71, projecting from and secured to the rod 19, as best shown in Fig. 1. The pallet 65 is normally held in contact with the teeth of the ratchet-bar 70 by a spring 72, as best shown in Figs. 4 and 15. 65^a indicates a stop which limits the movement of the pallet 65. 65^b indicates a detent which engages the rack 70 and prevents retrogressive movement of the rack when it is in its normal position. The detent 65^b is held in engagement with the rack 70 by a spring 65^c, as shown in Fig. 7.

73 indicates a spring which is secured to a bracket 74, depending from the under side of the board 13, which spring is connected by a rod 75 to the lever 66 and operates to hold the lever 66 normally in such position that the armature 68 will be out of contact with the poles of the magnet 69, as best shown in Fig. 4. The arrangement is such that when the magnet 69 is active it will attract the armature 68, thereby moving the lever 66 in the direction indicated by the arrow in Fig. 4 and causing the pallet 65 to engage the next succeeding tooth of the ratchet-bar 70. When the magnet 69 is cut out, the spring 73 operates to draw back the lever 66, thereby moving the ratchet-bar 70 the space of one notch, and thereby moving the circuit-closing arm 16 forward an equal distance. The teeth of the ratchet-bar 70 are spaced a distance equal to the longitudinal distance which separates the contact-points, by which arrangement at each operation of the lever 66 the button 17 will be moved in a longitudinal or forward direction into connection with the contact-point of the next succeeding row of contact-points.

To return the circuit-closing arm to its normal position, the button 17 is moved to the space beyond the uppermost row of contact-points, as hereinbefore described, when the lifting of the circuit-closing arm, hereinbefore described, will raise the ratchet-bar 70 out of contact with the pallet 65 and detent

65[b], thereby permitting the return motion of the circuit-closing arm.

100 indicates a weight placed upon the frame 18 to exert a downward pressure thereupon and secure better contact between the button 17 and the contact-points 15.

74 indicates a relay, which is mounted upon the board 13 and consists of an electromagnet 75, consisting of two spools 78 79, connected by the usual bar 76.

77 indicates a U-shaped permanent magnet, one pole of which is connected to the bar 76, the other pole extending over the electromagnet 75 between the two spools.

80 indicates a rod pivotally mounted between standards 81 82, rising at opposite sides of the magnet 75, as best shown in Fig. 6.

83 indicates an armature rigidly secured upon the rod 80 and extending over the poles of the magnet 75.

84 indicates an arm the upper end of which is connected to the rod 80, its lower end being bent over the standard 82 and extending downward, being held normally in a vertical position by a spring 98, as best shown in Fig. 6. The arm 84 carries at its lower end points 85 86, as best shown in Fig. 5, which points are movable into contact with plates 87 88, respectively, rigidly secured at the base of the relay, as best shown in Figs. 1 and 5. The arrangement is such that by rocking the rod 80 the points 85 86 may be moved into contact with the respective plates.

The circuits for operating the circuit-closing arm are arranged as follows: 89 indicates a wire connecting the plate 88 with one end of the wire which forms the electromagnet 69. 90 indicates a wire connecting the opposite end of said coil with one end of the coil of the magnet 38. 91 indicates a wire connecting the opposite end of the coil of the magnet 38 to the plate 87. 92 indicates a wire connecting the wire 90 with the plate 56. 93 indicates a wire connecting the wire 90 with a battery 94. 95 indicates a wire connecting the opposite end of the battery 94 to the arm 84 through the bar 80. 96 indicates a wire connecting the wire 95 to one end of the coil which forms the magnet 43. 97 indicates a wire connecting the opposite end of said coil to the bar 58 and through said bar to the pin 55.

The course of the current is as follows: When the rod 80 is tilted to throw the point 85 into contact with the plate 87, the current from the battery 94 will flow through wire 93, electromagnet 38, and wire 91 to the plate 87, thence through arm 84, rod 80, and wire 95 back to the battery. The magnet 38 will therefore become magnetic and will attract the armature 37, thereby actuating the pallet 30 and moving the circuit-closing arm 16 and button 17 upward one space. When the arm 84 is tilted in the opposite direction, bringing the point 86 into contact with the plate 88, the current from the battery 94 will flow through wires 93 90 to electromagnet 69, thence through wire 89 to plate 88, thence through arm 84 and rod 80 to wire 95, and back to the battery. The magnet 69 will thereby be magnetized, causing it to attract the armature 68 and moving the pallet 65 into engagement with the next tooth of the ratchet-bar 70. As soon as the point 86 moves out of contact with the plate 88 the spring 73 will move and operate the lever 66, and will thereby move the ratchet-bar 70 and circuit-closing arm 16 forward one space. When the button 17 is moved one space beyond the uppermost row of contact-points, the pin 55 will be permitted to move into contact with the plate 56, as hereinbefore described, thereby permitting the current from the battery 94 to flow through wires 93 90 92 to plate 56, thence through pin 55, bar 58, and wire 97 to magnet 43, thence through wires 96 95 to the battery. The magnet 43 will thereby be made magnetic, and the operating mechanism will be thrown out of operation, as has been hereinbefore described, permitting the circuit-closing arm to return to its normal position.

The swinging of the arm 84 is produced by tilting the armature 83, which tilting is effected by causing a current of electricity to pass through the spools 78 79 in one direction or the other, the direction in which the armature 83 tilts being determined by the polarity of the electromagnet 75.

The relay 74 is operated from a substation by means of a keyboard or switchboard 101, as shown in Figs. 8, 9, and 10, which keyboard is constructed as follows:

102 indicates a base-board which supports the different parts of the apparatus.

103 indicates a lever which is provided at its center with a pivot 104, by means of which it is mounted upon the board 102. The lever 103 is made of some suitable non-conducting material, such as vulcanized rubber, and is provided at its ends with plates 105 106, preferably of brass. The lever 103 is normally held transversely of the board 102 by means of a plunger 107, which is held in contact with the under surface of the lever 103 by means of a spring 108, as best shown in Fig. 8. The plunger 107 has an extended bearing-surface, by which construction when the lever 103 is tilted the plunger 107 will be moved backward and the spring 108 put under tension.

109 indicates a spring brush or plate, one end of which is secured upon a support 110, carried by the board 102, the other end of said plate bearing upon the inner end of the plate 105.

111 indicates a second plate similar to the plate 109, which plate is similarly secured upon the support 110 and bears upon the inner end of the plate 106. The lower ends of the plates 109 111 are connected, respectively, to binding-posts 112 113.

114 indicates a battery which is connected by wires 115 116 to binding-posts 112 113, as best shown in Fig. 11.

117 indicates a connecting-plate, preferably of brass or copper, which is mounted upon the support 110 under the plates 109 111, as best shown in Fig. 8. The plate 117 is U-shaped and carries at one end contact-plates 118 119, arranged at opposite sides of the plate 105, as best shown in Fig. 8, the plate 119 being insulated from the plate 117. At its opposite end the plate 117 carries contact-plates 120 121, arranged at opposite sides of the plate 106, the plate 121 being insulated from the plate 117. The arrangement is such that when the lever 103 is tilted in one direction the plate 106 will come in contact with the plate 120 and the plate 105 will at the same time come into contact with the contact-plate 119. When the lever 103 is tilted in the opposite direction, the plate 105 will come into contact with the contact-plate 118 and the plate 106 will come into contact with the contact-plate 121. The plate 117 is connected by a wire 122 to a binding-post 123, which is grounded by a wire 124, as best shown in Fig. 11.

125 indicates a lever pivotally mounted at one side of the board 102 and adapted to be moved into engagement with the upper edge of the lever 103 at one side of the pivot 104 to move said lever downward, throwing the plate 105 into contact with the plate 118.

126 indicates a spring which bears against the lever 125 and serves to hold it out of contact with the lever 103, as best shown in Fig. 9.

127 indicates a second lever which is pivotally mounted at the opposite side of the board 102 and is adapted to be moved into contact with the opposite end of the lever 103 to move the plate 106 into contact with the plate 120.

128 indicates a spring similar to the spring 126, which spring 128 serves to hold the lever 127 out of contact with the lever 103, as best shown in Fig. 10.

130 129 indicate contact-plates which are mounted upon the board 102 in proximity to each other, as best shown in Figs. 9 and 11.

131 indicates a rock-shaft pivotally mounted upon the support 110, which shaft extends between the plates 129 130 and carries an arm 132, which is movable into contact with either of the plates 129 130 by the rocking of said shaft.

133 indicates a brush which bears against one end of the shaft 131.

134 indicates a wire connecting the contact-plate 119 with the plate 129.

135 indicates a wire connecting the plate 121 with the plate 119, as shown in Fig. 11.

136 indicates a crank-arm which is secured upon one end of the rock-shaft 131, as best shown in Fig. 10.

137 indicates a rod which is connected to the crank-arm 136 and extends to the bottom of the keyboard, as best shown in Figs. 8 and 10, by which arrangement the shaft 131 may be rocked by operating the rod 137.

138 139 indicate guides or supports for the rod 137.

140 indicates a telephone which is connected by a wire 141 to a binding-post 142, carried by the keyboard 101. The wire 141 is connected by a wire 143 to the plate 130, as best shown in Fig. 11.

144 indicates a second wire of the telephone 140, the end of which wire is connected to the binding-post 123, as best shown in Fig. 11.

145 indicates an electromagnet which is mounted upon the board 102 above the rock-shaft 131, as best shown in Figs. 8 and 11. One of the wires 146 of the magnet 145 is connected to the brush 133, the other wire 147 of the magnet 145 being connected to a binding-post 148, carried by the board 102, as best shown in Fig. 11.

149 indicates the armature of the magnet 145, which armature is supported opposite the poles of the magnet 145 by a lever 150, which is pivoted upon the board 102, as best shown in Figs. 9 and 10. The armature 149 is normally held out of contact with the poles of the magnet 145 by a spring 151, which is mounted upon the board 102 and is connected to the lever 150, as best shown in Figs. 8 and 10. The lever 150 is provided at its free end with a tooth 152, as best shown in Figs. 9 and 10.

153 indicates a bar, the lower end of which is pivotally mounted upon the support 110 a short distance above the rock-shaft 131. The bar 153 is provided at its upper end with a slot 154, adapted to receive the end of the lever 150, as best shown in Fig. 10.

155 indicates a spring mounted upon the support 110 near the pivot of the bar 153, which spring exerts an outward pressure upon the bar 153. By this construction when the parts are in the position shown in Figs. 9 and 10 the tooth 152 of the lever 150 will securely hold the bar 153 in substantially a vertical position. When the magnet 145 is active, the armature 149 will be moved downward, throwing the lever 150 downward and moving its tooth within engagement with the upper edge of the slot 154, when the elasticity of the spring 155 will throw the bar 153 outward and downward.

156 indicates a bar which is secured to the bar 153 and projects at an angle thereto, which bar 156 carries a ball 157, as shown in Figs. 9 and 10.

The bar 153 is electrically connected to the plate 119 by a wire 158, as best shown in Fig. 11, and the lever 150 is connected by a wire 159 to a binding-post 160. (Also shown in Fig. 11.)

161 indicates a lever, one end of which is rigidly secured to the rock-shaft 131, the other end being adapted to project upward slightly beyond the pivot of the bar 153, against which it is adapted to bear when the shaft 131 is in the position shown in Figs. 9 and

10—that is, when the arm 132 is in contact with the plate 129. The rod 161 is insulated from the bar 153 by a block 162 of insulating material. By this arrangement when the bar 153 falls downward the lever 161 will also be thrown outward and downward, rocking the shaft 131 and moving the arm 132 into contact with the plate 130.

163 indicates a box or cover which is adapted to inclose the working parts of the keyboard. The levers 125 and 127 project through suitable slots provided in the cover. The bar 156 also projects through a slot 164 in the cover, the ball 157 being on the outside thereof. The object of the bar 156 and ball 157 is to serve as a signal to indicate the position of the bar 153.

165 indicates one of the line-wires, which wire extends from the binding-post 160 of the keyboard to a binding-post 166 of the exchange, which binding-post 166 is connected by a wire 167 to one of the wires of the relay 74.

168 indicates a second line-wire, which connects the binding-post 148 of the keyboard to a binding-post 169 of the exchange.

170 indicates a wire which connects the binding-post 169 with a binding-post 171, also carried by the board 13.

172 indicates a wire which connects the binding-post 171 with the button 17.

173 indicates a wire which connects the other end of the wire which forms the electromagnet of the relay 74 to a spring-plate 174, mounted upon the board 13. The free end of the spring-plate 174 lies over a contact-plate 175, mounted upon the board 13, which plate 175 is grounded by a wire 176, as best shown in Fig. 11. The spring-plate 174 is normally out of contact with the plate 175, but is adapted to be moved into contact therewith by downward pressure.

177 indicates a plate mounted upon the board 13 and connected by a wire 178 to the wire 176.

179 indicates a plate which is rigidly secured upon one of the pivots of the armature 44, one end of said plate projecting over the plate 177, the other end of said plate 179 projecting over the plate 174, as best shown in Figs. 2 and 11.

180 indicates a non-conducting block which is secured to the under side of the plate 179 over the plate 174, as best shown in Fig. 2. The arrangement is such that by depressing the armature 44 the block 180 will be moved out of contact with the plate 174 and the opposite end of the plate 179 will be moved downward into contact with the plate 177. By this arrangement the plates 177 179 will be in electrical connection, while the plate 174 will be permitted to move out of contact with the plate 175.

181 indicates a wire which connects the plate 179 to the binding-post 171.

When the telephone at any substation is not in use, the arm 132 on its keyboard is in contact with the plate 130, and the button 17 of the circuit-closing arm connected to such telephone rests upon the "0" contact-point at the lower left-hand corner of the switchboard. The operator at any substation desiring to connect his instrument with any other in the system may do so by operating the levers 125 127 in the following manner: Suppose the number which he desired is "35" and that a current flowing along wire 167 in the direction indicated by the arrow in Fig. 11 would cause the arm 84 of the relay to swing to the right, throwing the pin 86 into contact with the plate 88. To move the button 17 to the contact-point connected to telephone 35, it would be necessary to move it five points upward and three points to the right, as indicated upon the switchboard 14. By depressing the lever 125 the lever 103 will be tilted, moving the plate 105 into contact with the plate 118 and the plate 106 into contact with the plate 121. The current would then pass from the ground over wires 124 122 to bar 117, thence through plates 118 105 to plate 109, thence through battery 114 in the direction indicated by the arrow in Fig. 11, thence through wire 116 to plate 111, thence to contact-plate 121, through wires 135 158 to bar 153, thence through lever 150 and wires 159 165 167, through the magnet 78 of the relay 74, thence through wire 173 to plate 174, thence through contact-plate 175 and wire 176 to the ground, establishing a closed circuit through the electromagnet 78. The armature 83 will thereby be tilted, moving the arm 84 to the right and bringing the pin 86 in contact with the plate 88. As has been hereinbefore described, this will close the circuit through the magnet 69 and move the circuit-closing arm 16 and button 17 one space to the right, as shown in Fig. 11. Three operations of the lever 125 will therefore move the button 17 to the right three rows, and it will then rest upon the contact-point connected to telephone. By operating the lever 127 the lever 103 will be tilted in the opposite direction, causing the current to flow from the ground through wire 176, plates 175 174, wire 173 to the magnet 75 of the relay 74, flowing through the magnet in the opposite direction to that which it did before, thence through wires 167 165 159 to the lever 150, thence through bar 153 and wire 158 to contact-plate 119, thence through plates 105 109 to the battery 114, thence through plates 111 106 120 and wires 122 124 to the ground. This will cause the armature 83 to tilt in the opposite direction from that in which it tilted before, throwing the arm 84 to the left and bringing the point 85 into contact with the plate 87, thereby closing the circuit through the magnet 38 and moving the circuit-closing arm upward one point, as has been hereinbefore described. In order to move the button 17 into contact with the contact-point connected to telephone 35, the lever 127 would be operated five times. The operator would then be connected with telephone 35, and by ring-

ing the usual alarm-bell the attention of the operator at substation 35 would be attracted in the usual manner. The current would then pass from the ground over wires 124 144 to telephone 140, thence over wires 141 143 to contact-plate 130, thence through arm 132 and brush 133 to wire 146, thence through electromagnet 145, thence through wires 147 168 170 172 to the button 17, thence along the line-wire connected to telephone 35, thence through such telephone, and then to the ground. The current is prevented from short-circuiting through plates 179 177 and wires 178 and 176 by reason of the fact that the plates 177 179 are at this time out of contact with each other, as shown in Fig. 2.

To disconnect the telephones and to return the button 17 to the contact-point at the lower left-hand corner of the switchboard of the calling subscriber, the rod 137 is operated to move the arm 132 into contact with the plate 129. The lever 127 is then operated until the button 17 passes beyond the uppermost row of contact-points, when, as has been hereinbefore described, the magnet 43 will become active and will attract the armature 44, thereby moving the plate 179 into contact with the plate 177 and permitting the plate 174 to rise out of contact with the plate 175. The current from the battery 114 will thereby be short-circuited and grounded over wire 176, the course of the current being from the ground over wires 176 178 to plate 177, thence to plate 179, and through wires 181 170 168 147 to electromagnet 145, thence through wire 146 to arm 132, thence to plate 129, thence through wire 134 to plates 119 105 109 to the battery 114, thence through plates 111 106 120 to the ground through wires 122 124. The resistance being thereby reduced, the intensity of the current would be sufficient to cause magnet 145 to attract the armature 149, thereby releasing the bar 153 and permitting the signal-ball 156 to fall, indicating that the button 17 has been returned to its normal position upon the "0" contact-point at the lower left-hand corner of the switchboard 14. The operator's telephone is then connected with the appropriate contact-points of all the other exchanges in the central station by a wire 182, which is connected to the "0" contact-point of the operator's exchange and to such exchanges, so that the operator at any other substation can make connections with it. The connections between the different exchanges at the central station are illustrated in Fig. 14, wherein three exchanges are shown connected to substations Nos. 1, 5, and 9, respectively. From an inspection of said figure it will be noted that the "0" contact-point of the exchange operated from substation No. 1 is connected to contact-points numbered "1" of exchanges Nos. 5 and 9. Similarly the "0" contact-point of exchange No. 5 is connected to contact-points numbered "5" of exchanges Nos. 1 and 9, and in like manner the "0" contact-point of exchange No. 9 is connected to No. 9 contact-point of exchanges Nos. 1 and 5. By this construction any telephone in the system would be in position to be called up by other telephones only when the button 17 of its circuit-closing arm rested upon the "0" contact-point. When any operator connects his instrument with any other in the system, other operators cannot connect with him, and privacy of conversation is thereby secured.

The falling of the bar 153 will throw the lever 161 down and return the arm 132 into contact with the plate 130, thereby leaving the keyboard in its operative position, so that a telephone connected to it can be cut into circuit by other operators.

It will be seen that the electromagnet 145 is also in circuit with the battery 114 when the arm 132 is in contact with the plate 129 and one of the levers 125 or 127 is operated; but no appreciable amount of the current will pass through the electromagnet, owing to the greater resistance in that direction, since the current passing from the electromagnet 145 would be conducted to the button 17 and thence through any line-wire with which such button might then be in contact. In certain cases, where such telephone line-wire is very short, it may be necessary to use a resistance-coil to keep the resistance sufficiently high to prevent a sufficient quantity of electricity from passing through the magnet 145 to cause it to attract the armature 149 when the arm 132 is in contact with the plate 129.

Our invention includes, in the broadest sense, the combination, in an automatic switchboard, of a movable primary carriage and a secondary carriage carried thereby and movable thereupon to effect different connections, and in our broadest claims we do not restrict ourselves to secondary carriages which are movable angularly only, as a primary carriage bodily movable in a curved path and carrying a secondary carriage movable thereupon in a circular path or arranged to rotate on the primary carriage would involve our invention.

Although our improved exchange is intended primarily for use in telephone systems, it may be used in making electrical connections for any other purpose to which it is adapted.

Although we prefer to locate the "0" contact-point at the lower left-hand corner of the switchboard, we do not wish to limit ourselves to arranging such switchboard only in that manner, as it is evident that the arrangement of the contact-points may be varied provided the movements of the circuit-closing arm are varied to correspond. It is also obvious that many changes may be made in details of construction, and we do not therefore wish to limit ourselves to the specific devices used.

That which we claim as our invention, and desire to secure by Letters Patent, is—

1. In an electrical exchange, the combination with a switchboard, of a primary carriage, a secondary carriage carried by said primary carriage and movable thereupon, a series of contact-points adapted to be engaged by said secondary carriage, and devices for automatically operating said primary and secondary carriages to move the latter into contact with any desired contact-point, substantially as described.

2. In an electrical exchange, the combination with a switchboard, of a primary carriage movable in one direction, a secondary carriage carried by said primary carriage and movable thereupon at an angle to the direction of movement of said primary carriage, a series of contact-points adapted to be engaged by said secondary carriage, devices for automatically operating said primary and secondary carriages to move the latter into contact with any desired contact-point, and means for returning said primary carriage to its normal position, substantially as described.

3. In an electrical exchange, the combination with a switchboard having a number of contact-points arranged thereupon, of a primary carriage, a secondary carriage carried by said primary carriage and movable thereupon, a pair of electromagnets, mechanism operated by said magnets for moving said primary and secondary carriages, and means for cutting said magnets into and out of circuit, substantially as described.

4. In an electrical exchange, the combination with a switchboard having a series of contact-points arranged thereupon, of a primary carriage, a secondary carriage carried by said primary carriage and movable thereupon, mechanism for moving said secondary carriage into contact with any desired contact-point, and electrically-operated devices for throwing said operating mechanism out of operation to permit said primary carriage to return to its normal position, substantially as described.

5. In an electrical exchange, the combination with a switchboard 14, and a series of contact-points arranged thereupon, of a movable primary carriage, a secondary carriage carried by said primary carriage and movable thereupon, whereby said secondary carriage may be brought into contact with any desired contact-point, means for moving said primary carriage over the surface of said switchboard, and means for returning said secondary carriage normally to contact with the point at one of the corners of the switchboard, substantially as described.

6. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged thereupon, of a movable primary carriage, a secondary carriage carried by said primary carriage and movable thereupon, a ratchet-bar carried by said primary carriage, a pallet adapted to engage the teeth of said ratchet-bar to move said primary carriage over the switchboard, an electromagnet, mechanism for operating said pallet from said electromagnet, and means for moving said secondary carriage on said primary carriage, substantially as described.

7. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged thereupon, of a primary carriage, a secondary carriage carried by and movable on said primary carriage, a ratchet-bar carried by said primary carriage, a pallet adapted to engage the teeth of said ratchet-bar to move said primary carriage, an electromagnet, mechanism for operating said pallet from said electromagnet, means for throwing said pallet out of engagement with said ratchet-bar, devices for returning said primary carriage to its normal position, and means for moving said secondary carriage independently of said primary carriage, substantially as described.

8. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged thereupon, of a circuit-closing arm, a button carried thereby and adapted to rest upon said contact-points, said circuit-closing arm being movable over said switchboard to move said button into contact with different contact-points, a ratchet-bar 29 carried by said circuit-closing arm, a rock-shaft 33, arms 32 carried thereby, pallet 30 supported by said arms 32, electromagnet 38, armature 37 pivotally mounted over the poles of said magnet, a bar 36 connected to said armature and projecting upward therefrom, bar 35 connecting said bar 36 and one of said arms 32, a spring normally holding said armature 37 out of contact with the poles of the magnet 38, and devices for cutting said magnet into and out of circuit, substantially as described.

9. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged thereupon, of a circuit-closing arm, a button carried thereby and adapted to rest upon said contact-points, said circuit-closing arm being movable over said switchboard to move said button into contact with different contact-points, a ratchet-bar 29 carried by said circuit-closing arm, a rock-shaft 33, arms 32 carried thereby, pallet 30 supported by said arms 32, an electromagnet 38, an armature 37 pivotally mounted over the poles of said magnet, bar 36 connected to said armature and projecting upward therefrom, bar 35 connecting said bar 36 and one of said arms 32, a spring normally holding said armature 37 out of contact with the poles of the magnet 38, devices for cutting said magnet into and out of circuit, electromagnet 43, an armature therefor, means for cutting said magnet 43 into and out of circuit, and devices operated by said magnet 43 to move the pallet 30 out of engagement with the ratchet-bar 29, substantially as described.

10. In an electrical exchange, the combination with a switchboard, and a series of contact-points thereupon, of a movable primary

carriage, a secondary carriage carried by said primary carriage and movable thereupon, devices for moving said secondary carriage over said contact-points, and mechanism for returning said secondary carriage to its normal position, said returning mechanism being automatically thrown into operation whenever said secondary carriage is moved into a certain position on the switchboard, substantially as described.

11. In an electrical exchange, the combination with a switchboard, and a series of contact-points thereupon, of a movable primary carriage, a secondary carriage carried by said primary carriage and movable thereupon over said contact-points, a ratchet-bar carried by said primary carriage, a pallet adapted to engage the teeth of said ratchet-bar, mechanism for operating said pallet to move said primary carriage, devices operating to throw said pallet out of engagement with said ratchet-bar, said devices being automatically thrown into operation whenever said secondary carriage is moved into a certain position, means for returning said primary carriage to its normal position on the switchboard, and means for moving said secondary carriage on said primary carriage, substantially as described.

12. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged thereupon in substantially a straight line, of a circuit-closing arm movable over said row of contact-points, a button carried thereby adapted to rest upon said contact-points, a ratchet-bar carried by said circuit-closing arm, a pallet 30 engaging the teeth of said ratchet-bar and adapted to be operated to move said circuit-closing arm over said row of contact-points, an arm 53 carried by said pallet 30, an electromagnet 43, armature 44 therefor, bar 45 connected to said armature 44 and extending upward therefrom, a shaft 46, an arm 48 connected thereto, a rod 49 connecting said bar 45 and arm 48, a plate carried by said shaft 46 and projecting over said arm 53, whereby by tilting said plate said arm 53 and pallet 30 may be depressed, a spring normally holding said plate out of operation, and means for cutting said electromagnet into circuit, whereby its armature will be attracted and the pallet 30 moved out of engagement with the teeth of the ratchet-bar, substantially as described.

13. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged thereupon in substantially a straight line, of a circuit-closing arm movable over said row of contact-points, a button carried thereby adapted to rest upon said contact-points, a ratchet-bar carried by said circuit-closing arm, a pallet 30 engaging the teeth of said ratchet-bar and adapted to be operated to move said circuit-closing arm over said row of contact-points, an arm 53 carried by said pallet 30, an electromagnet 43, armature 44 therefor, bar 45 connected to said armature 44 and extending upward therefrom, a shaft 46, an arm 48 connected thereto, a rod 49 connecting said bar 45 and arm 48, a plate carried by said shaft 46 and projecting over said arm 53, whereby by tilting said plate said arm 53 and pallet 30 may be depressed, a spring normally holding said plate out of operation, and mechanism for automatically cutting said magnet into circuit when the button carried by said circuit-closing arm is moved to a certain position, substantially as described.

14. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged thereupon, of a transversely-movable frame, circuit-closing devices carried thereby, a ratchet-bar carried by said frame, a pallet adapted to engage the teeth of said ratchet-bar to move said frame transversely, an electromagnet adapted to move said pallet back into engagement with the next succeeding tooth, a spring for returning said pallet to its former position to advance said frame, and means for cutting said magnet into and out of circuit, substantially as described.

15. In an automatic telephone-exchange, the combination with a switchboard, and a number of contact-points arranged thereupon, of a longitudinally-movable frame, circuit-closing devices carried thereby adapted to be moved into contact with said contact-points, a ratchet-bar carried by said frame, a pallet engaging the teeth of said ratchet-bar, means for operating said pallet to move said frame, means for lifting said frame out of engagement with said pallet, and devices for returning said frame to its normal position, substantially as described.

16. The combination with a switchboard, and contact-points arranged thereupon, of a frame 18, circuit-closing devices carried thereby, ratchet-bar 70 carried by said frame, a pivoted lever 66 mounted under said ratchet-bar, a pallet 65 carried by said lever, a spring holding said pallet in contact with the teeth of said ratchet-bar, an armature carried by said lever, an electromagnet arranged opposite said armature, a spring 73, connecting-rod 75 connecting said spring 73 with said lever 66, and means for cutting said magnet into and out of circuit, substantially as described.

17. In an electrical exchange, the combination with a switchboard 14, having a series of contact-points 15 arranged thereupon in substantially rectangular form, of a frame 18 movable longitudinally of said switchboard, a circuit-closing arm 16 carried by said frame and movable transversely of said switchboard, a button carried by said circuit-closing arm and movable into contact with said contact-points, means for moving said frame 18 longitudinally of said switchboard, means for moving said circuit-closing arm transversely of said switchboard, means for throwing said operating devices out of operation, pulleys 24 26, a cord 23 connected to said cir-

cuit-closing arm and passing over said pulleys, a counterpoise secured to said cord, all substantially as described.

18. In an electrical exchange, the combination with a switchboard and a series of contact-points arranged thereupon in substantially rectangular form, of a frame 18 movable longitudinally of said switchboard, a ratchet-bar carried thereby, a pallet engaging the teeth of said ratchet-bar, mechanism operating said pallet to move said frame 18 transversely, a circuit-closing arm carried by said frame and movable transversely of said switchboard, a button carried by said circuit-closing arm and adapted to be moved into contact with said contact-points, a ratchet-bar 29 carried by said circuit-closing arm, a pallet 30 adapted to engage the teeth of said ratchet-bar 29, an arm 53 carried by said pallet 30, mechanism for actuating said pallet 30 to move said circuit-closing arm transversely of the switchboard, a shaft 46, plate 51 mounted upon said shaft under said circuit-closing arm and projecting over said arm 53, an electromagnet 43, mechanism operated by passing a current of electricity through said magnet to rock said shaft 46 to depress said pallet 30 and raise said circuit-closing arm and frame 18, and mechanism for returning said circuit-closing arm and frame to their normal positions, substantially as described.

19. In an electrical exchange, the combination with a switchboard and a series of contact-points arranged thereupon in substantially rectangular form, of a frame 18 movable longitudinally of said switchboard, a ratchet-bar carried thereby, a pallet engaging the teeth of said ratchet-bar, mechanism operating said pallet to move said frame 18 transversely, a circuit-closing arm carried by said frame and movable transversely of said switchboard, a button carried by said circuit-closing arm and adapted to be moved into contact with said contact-points, a ratchet-bar 29 carried by said circuit-closing arm, a pallet 30 adapted to engage the teeth of said ratchet-bar 29, an arm 53 carried by said pallet 30, mechanism for actuating said pallet 30 to move said circuit-closing arm transversely of the switchboard, a shaft 46, plate 51 mounted upon said shaft under said circuit-closing arm and projecting over said arm 53, an electromagnet 43, mechanism operated by passing a current of electricity through said magnet to rock said shaft 46 to depress said pallet 30 and raise said circuit-closing arm and frame 18, mechanism for returning said circuit-closing arm and frame to their normal positions, and means for automatically cutting said magnet 43 into circuit when the button carried by said circuit-closing arm is moved into a certain position, substantially as described.

20. In an electrical exchange, the combination with a switchboard, contact-points arranged thereon, a circuit-closing arm 16 movable over the surface of said switchboard, a button carried thereby adapted to rest upon said contact-points, and devices for moving said circuit-closing arm over said switchboard, of an electromagnet 43, devices operated by said magnet to throw said devices for operating said circuit-closing arm out of operation, a bar 58, contact-plate 56, said bar 58 being adapted to be moved into electrical connection with said contact-plate, a wire connecting said bar 58 with said electromagnet, an electric battery, a wire connecting said battery with said contact-plate 56, a wire 95 connecting said battery with said electromagnet 43, and means for moving said bar 58 into contact with said plate 56, whereby the circuit will be closed through said magnet 43, substantially as and for the purpose specified.

21. In an electrical exchange, the combination with a switchboard 14 having a series of contact-points 15 arranged thereupon, a transversely-movable circuit-closing arm 16, and mechanism for moving said circuit-closing arm over the surface of said switchboard, of an electromagnet 43, devices operated thereby to release said circuit-closing arm to permit of its being returned to its normal position, a rocking bar 58, wire 97 connecting said bar 58 with said electromagnet, contact-plate 56 arranged opposite said bar 58, an electric battery, a wire connecting said contact-plate with said battery, a wire connecting said battery with said electromagnet, a spring normally holding said bar 58 in electrical connection with said plate 56, devices for holding said bar 58 out of contact with said contact-plate, and devices operated by said circuit-closing arm to release said bar 58 when the circuit-closing arm assumes a certain position, whereby the circuit will be closed through said electromagnet, substantially as and for the purpose specified.

22. In an electrical exchange, the combination with a switchboard, a series of contact-points arranged thereupon, a circuit-closing arm movable longitudinally and transversely over said switchboard, a pin 64 carried by said circuit-closing arm, and mechanism for moving said circuit-closing arm over said switchboard, of an electromagnet, devices operated thereby for releasing said circuit-closing arm to permit of its being returned to its normal position, a rocking bar 58, having a lug 60, a block 59 mounted upon said bar 58, a pin 55 carried by said bar 58, contact-plate 56 arranged opposite said pin, a spring normally holding said pin 55 in contact with said contact-plate 56, a rocking bar 61 adapted to engage said lug 60 to hold said bar 58 normally in such position that the pin 55 will lie out of contact with the plate 56, said pin 64 being adapted to engage said bar 61 when the circuit-closing arm arrives at the limit of its transverse movement, to move said bar 61 out of contact with the lug 60 and permit the pin 55 to come into contact with

the plate 56, a wire connecting said bar 58 with said magnet 43, an electric battery, a wire connecting said plate 56 with said battery, and a wire connecting said battery with said magnet 43, substantially as described.

23. In an electrical exchange, the combination with a series of contact-points, a movable primary carriage, and a secondary carriage carried by said primary carriage and movable thereupon into contact with said contact-points, of electromagnetic devices for operating said carriages, a polarized relay controlling the operation of said electromagnetic devices, and a key adapted to be located at a substation for controlling the polarity of the current which operates said relay, whereby the primary or secondary carriage may be moved at the will of the operator, substantially as described.

24. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged thereupon, of a movable primary carriage, and a secondary carriage carried thereby and movable thereupon over said contact-points, an electromagnet, devices operated thereby for moving said primary carriage, a relay for operating said electromagnet, and means for moving said secondary carriage, substantially as described.

25. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged thereupon, of a primary carriage arranged to move longitudinally, a secondary carriage carried thereby and arranged to move transversely of said switchboard, electromagnets, devices operated thereby for moving said primary carriage longitudinally and said secondary carriage transversely of said switchboard, and a relay for cutting said magnets into and out of circuit, substantially as described.

26. In an electrical exchange, the combination with a series of contact-points, and a circuit-closing device movable in two directions over said contact-points, of electromagnets for operating said circuit-closing device, a relay for closing the circuit through said electromagnets, said relay being operated by the polarity of the current, and means for directing a current of electricity through said relay in either direction, substantially as described.

27. In an electrical exchange, the combination with a switchboard having a series of contact-points arranged thereupon, a circuit-closing arm 16 movable longitudinally and transversely over said switchboard, electromagnets 38 69, and devices operated thereby for moving said circuit-closing arm over said switchboard, of a relay 74, said relay consisting of an electromagnet 75 and a permanent magnet 77, armature 83 mounted over the poles of said electromagnet 75 and under one pole of said permanent magnet, a swinging arm 84 connected to said armature, contact-plates adapted to be engaged by said arm 84, one of said contact-plates being connected to the electromagnet 38 and the other being connected to the electromagnect 69, an electric battery, wires connecting said battery with said electromagnets 38 69, a wire connecting said battery with said swinging arm, and means for passing an electric current through the electromagnet 75 of the relay 74 in either direction, substantially as described.

28. In an electrical exchange, the combination with a series of contact-points, a movable primary carriage, and a secondary carriage carried thereby and movable thereupon into contact with the different contact-points, said carriages being adapted to be operated by currents of different polarity, of keys, a line-wire connecting the switchboard with said keys, and devices operated by said keys for directing a current over said line-wire in either direction whereby the operation of said primary and secondary carriages may be controlled at the will of the operator, substantially as described.

29. The combination, in an electrical exchange, of a series of contact-points, a movable primary carriage, and a secondary carriage carried thereby and movable thereupon into contact with said contact-points, with devices operated by currents of different polarity for operating said carriages, means, as an electric battery, for supplying a current of electricity, a keyboard, two keys mounted thereupon, a line-wire connecting said keyboard with said devices for operating the primary and secondary carriages, and means whereby either pole of said battery may be connected to said line-wire by operating one or the other of said keys, whereby the current may be directed in either direction through said line-wire, substantially as described.

30. The combination with a swinging lever, contact-plates 105 106 carried at each end of said lever, an electric battery having its poles connected respectively to said contact-plates, and means for swinging said lever in either direction, of a line-wire pole, contact-plates 119 121 arranged opposite said plates 105 106 in a position to be engaged by said plates when said lever is swung in one direction or the other, said contact-plates 119 121 being in electrical connection with said line-wire pole, whereby by swinging said lever either pole of said battery may be connected with said line-wire pole, and means for grounding the disconnected pole of the battery, substantially as described.

31. The combination with a plate 117, carrying contact-plates 118 120 at opposite sides thereof, contact-plates 119 121 arranged opposite said contact-plates 118 120 respectively, and means for grounding said plates 118 120, of a swinging lever 103, contact-plates 105 106 carried thereby, plates 109 111 adapted to connect said plates 105 106 with the poles of a battery, means for swinging said lever 103, a line-wire pole, and wires connecting said plates 119 121 with said line-wire pole, substantially as described.

32. The combination with a switchboard, having a number of contact-points, circuit-closing devices movable into contact with said contact-points, and electrically-operated mechanism for moving said circuit-closing devices into contact with said contact-points, of a keyboard, a line-wire connecting said keyboard to said circuit-closing devices, line-wire connecting said keyboard to said devices for operating said circuit-closing devices, means for directing an electric current through said last-mentioned line-wire for operating said circuit-closing devices, means for automatically returning said circuit-closing devices to their normal position when they assume a certain position, and devices operated thereby to cut off the current from said devices for operating said circuit-closing devices, substantially as specified.

33. In an electrical exchange system, the combination with a series of contact-points, an electrically-operated circuit-closing device movable into contact with said contact-points, and means for operating said circuit-closing device, of a keyboard, a line-wire 170 connecting said circuit-closing device to said keyboard, line-wire 167 connecting said operating device to said keyboard, an electromagnet 145, an armature 149 therefor, bar 150 carried by said armature, hinged bar 153 adapted to engage said bar 150, a wire connecting said armature 149 to the line-wire 167, an electric battery, a switch for connecting said bar 153 with the electric battery, whereby an electric current will be directed through said line-wire 167, wire connecting electromagnet 145 with said line-wire 170, devices for automatically returning said circuit-closing device to its normal position when it assumes a certain position, and devices operated thereby for short-circuiting the current from said battery through said magnet 145, whereby the armature 149 will be attracted and the bar 153 thereby released, cutting out line-wire 167, substantially as described.

34. In an electrical exchange system, the combination with a switchboard having a series of contact-points, a circuit-closing arm movable over said switchboard, electromagnets for moving said circuit-closing arm, an electromagnet 43, devices operated thereby for returning said circuit-closing arm to its normal position when it assumes a certain position, and a relay 74, of a keyboard, line-wire 170 connecting said circuit-closing arm with said keyboard, line-wire 167 connecting said relay with said keyboard, an electric battery connected to said keyboard, means for connecting said line-wire 167 with either pole of said battery, an electromagnet 145, devices operated thereby for cutting out said line-wire 167, said electromagnet 145 being in circuit with said line-wire 170, plates 177 179, said plate 177 being connected to the ground and said plate 179 being connected to said line-wire 170, and devices operated by said electromagnet 43 for moving said plate 179 into contact with said plate 177, thereby short-circuiting the current through said magnet 145, substantially as specified.

35. In an electrical exchange system, the combination with a series of contact-points, an electrically-operated movable primary carriage, a secondary carriage carried thereby and movable thereupon into connection with said contact-points, and mechanism for operating said primary and secondary carriages, of devices located at a substation for operating said primary and secondary carriages, an instrument—as a telephone—located at said substation, a line-wire connecting said instrument with said secondary carriage and with other exchanges, means for cutting said instrument into or out of circuit, devices for automatically releasing said secondary carriage when it assumes a certain position, and mechanism for automatically cutting said instrument into circuit with said line-wire when said secondary carriage is released, substantially as described.

36. In a system of electrical communication, the combination with a number of instruments located at substations, a corresponding number of exchanges located at a central station, and a circuit-closing device connecting each of said instruments with its appropriate exchange, said circuit-closing device when in its normal position connecting its appropriate instrument with the other exchanges at the central station, of devices located at the various substations for operating their respective circuit-closing devices at the central station to make connection with other instruments, and means whereby when any circuit-closing device is moved from its normal position the connection between the operator's instrument and the other exchanges, except the one with which he makes special connection, will be broken, substantially as described.

37. The combination, in an electrical exchange, of a series of contact-points, a movable primary carriage, a secondary carriage carried thereby and movable thereupon into contact with the different contact-points, said primary carriage being movable in one direction, and the secondary carriage being movable in another direction upon the primary carriage, and electrically-actuated mechanisms for moving said carriages in one direction or the other, with a polarized relay for closing the circuit through the different carriage-operating mechanisms, and a device adapted to be located at a substation for directing a positive or a negative electric current through said relay at will, so that either of said operating mechanisms may be actuated and either of said carriages be moved at will, substantially as described.

38. In an electrical exchange, the combination with a switchboard and a series of contact-points arranged in a plurality of rows, of a movable carriage and a second carriage

mounted on the first-named carriage and movable at right angles thereto in contact with either of said contact-points, substantially as described.

39. In an electrical exchange, the combination with a switchboard and a series of contact-points arranged in a plurality of rows, of a movable carriage, and a second carriage mounted on the first-named carriage and movable into contact with either of said contact-points, substantially as described.

40. In an electrical exchange, the combination with a switchboard, and a series of contact-points arranged in a plurality of rows, of a movable carriage, a second carriage mounted on the first-named carriage and movable at an angle into contact with either of said contact-points, substantially as described.

41. In an electrical exchange, the combination with a switchboard and a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, and a second carriage mounted on the first-named carriage and movable at right angles thereto into contact with either of said contact-points, substantially as described.

42. In an electrical exchange, the combination with a switchboard and a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, a second carriage mounted on the first-named carriage and movable at right angles thereto, and devices for automatically operating said carriages to make contact with either of said contact-points, substantially as described.

43. In an electrical exchange, the combination with a switchboard and a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, a second carriage mounted on the first-named carriage and movable at right angles thereto, devices for automatically operating said carriages to make contact with either of said contact-points, and means for returning said carriages to normal position, substantially as described.

44. In an electrical exchange, the combination with a switchboard having a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, a second carriage mounted on the first-named carriage and movable at right angles thereto, a pair of electromagnets, mechanism operated by said magnets for moving said carriages into contact with either of said contact-points, and means for cutting said magnets into and out of circuit, substantially as described.

45. In an electrical exchange, the combination with a switchboard having a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, a second carriage mounted on the first-named carriage and movable at right angles thereto, mechanism for moving said carriages into contact with either of said contact-points, and electrically-operated mechanism for throwing said operating mechanism out of operation to permit said carriages to return to normal position, substantially as described.

46. In an electrical exchange, the combination with a switchboard having a plurality of contact-points arranged in parallel straight rows equidistant apart, of a movable carriage, a second carriage mounted on the first-named carriage and movable at right angles thereto, whereby said carriages may be brought into contact with either of said contact-points, means for moving said carriages over the surface of said switchboard, and means for returning said carriages normally to contact with the point at one of the corners of the switchboard, substantially as described.

47. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged in parallel straight rows equidistant apart, of a circuit-closing device comprising a movable carriage and a second carriage mounted on the first-named carriage and movable at right angles thereto, a ratchet-bar carried by said circuit-closing device, a pallet adapted to engage the teeth of said ratchet-bar to move said circuit-closing device over the switchboard, an electromagnet, and mechanism for operating said pallet from said electromagnet, substantially as described.

48. In an electrical exchange, the combination with a switchboard, and a number of contact-points arranged thereupon in parallel straight rows equidistant apart, of a circuit-closing device comprising a carriage movable over said switchboard and a second carriage mounted on the first-named carriage and movable at right angles thereto, a ratchet-bar carried by said circuit-closing device, a pallet adapted to engage the teeth of said ratchet-bar to move said circuit-closing device over the switchboard, an electromagnet, mechanism for operating said pallet from said electromagnet, means for throwing said pallet out of engagement with said ratchet-bar, and devices for returning said circuit-closing device to its normal position, substantially as described.

49. In a system of electrical communication, the combination with an exchange consisting of a switchboard having a series of contact-points, all but one of said contact-points being in electrical communication with instruments in the system, and a series of exchanges in electrical connection with the remaining contact-point, of a circuit-closing device adapted normally to be in electrical communication with the latter contact-point, an instrument electrically connected to said circuit-closing device, and means for operating said circuit-closing device to move it into contact with the different contact-points, whereby when said circuit-closing device is moved out of its normal position the instrument permanently connected thereto will be cut out from all other exchanges, substantially as described.

50. In an electrical exchange, the combination with a switchboard, and a series of contact-points thereupon, of a circuit-closing device movable into contact with said contact-points, means for operating said circuit-closing device to cause it to move into contact with the different contact-points, and means for automatically returning said circuit-closing device to its normal position when it is moved into a certain position, substantially as described.

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