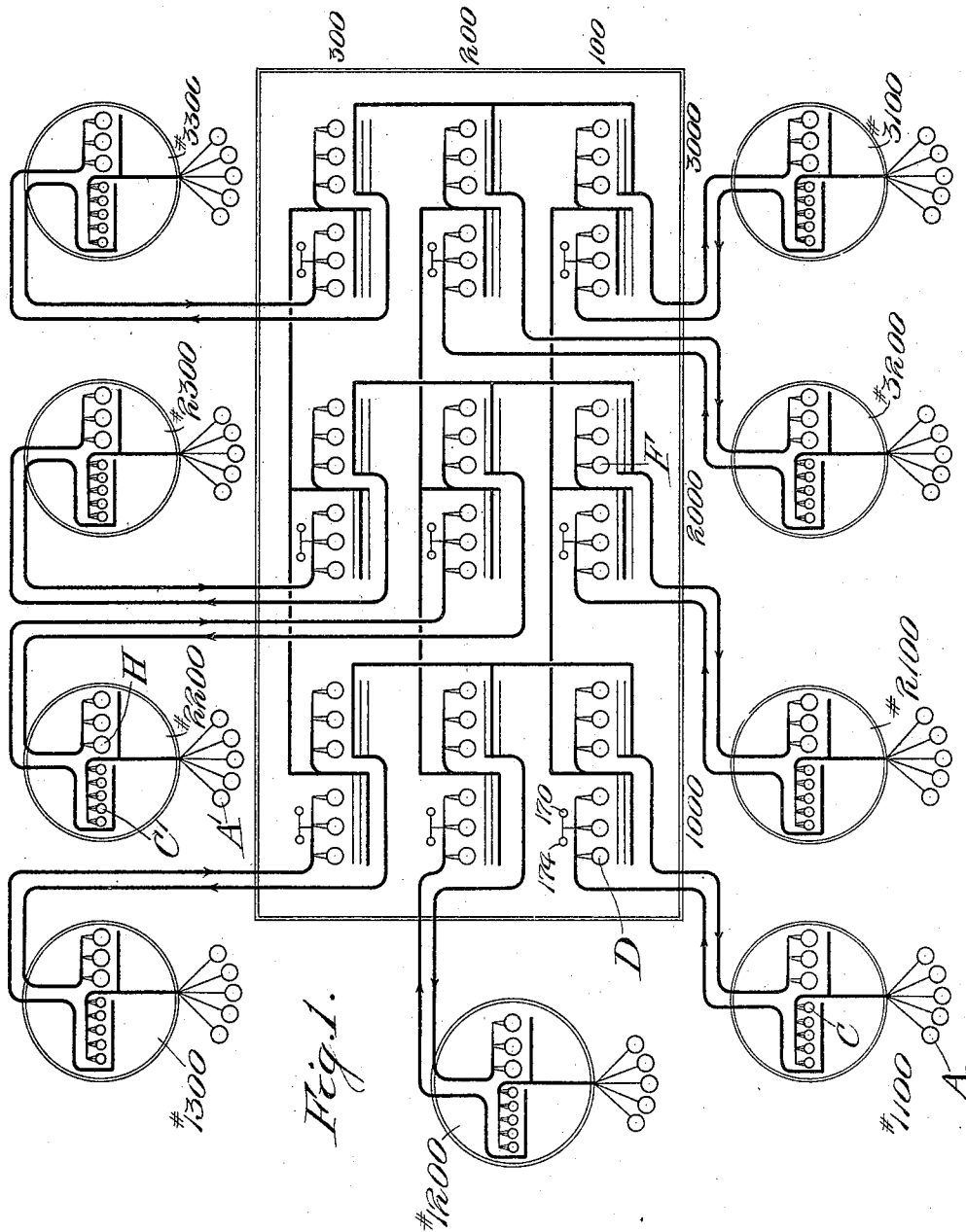


F. LUBBERGER.
 AUTOMATIC TELEPHONE AND SUPERVISORY SYSTEM.
 APPLICATION FILED NOV. 30, 1907.

1,196,876.

Patented Sept. 5, 1916.
 6 SHEETS—SHEET 1.



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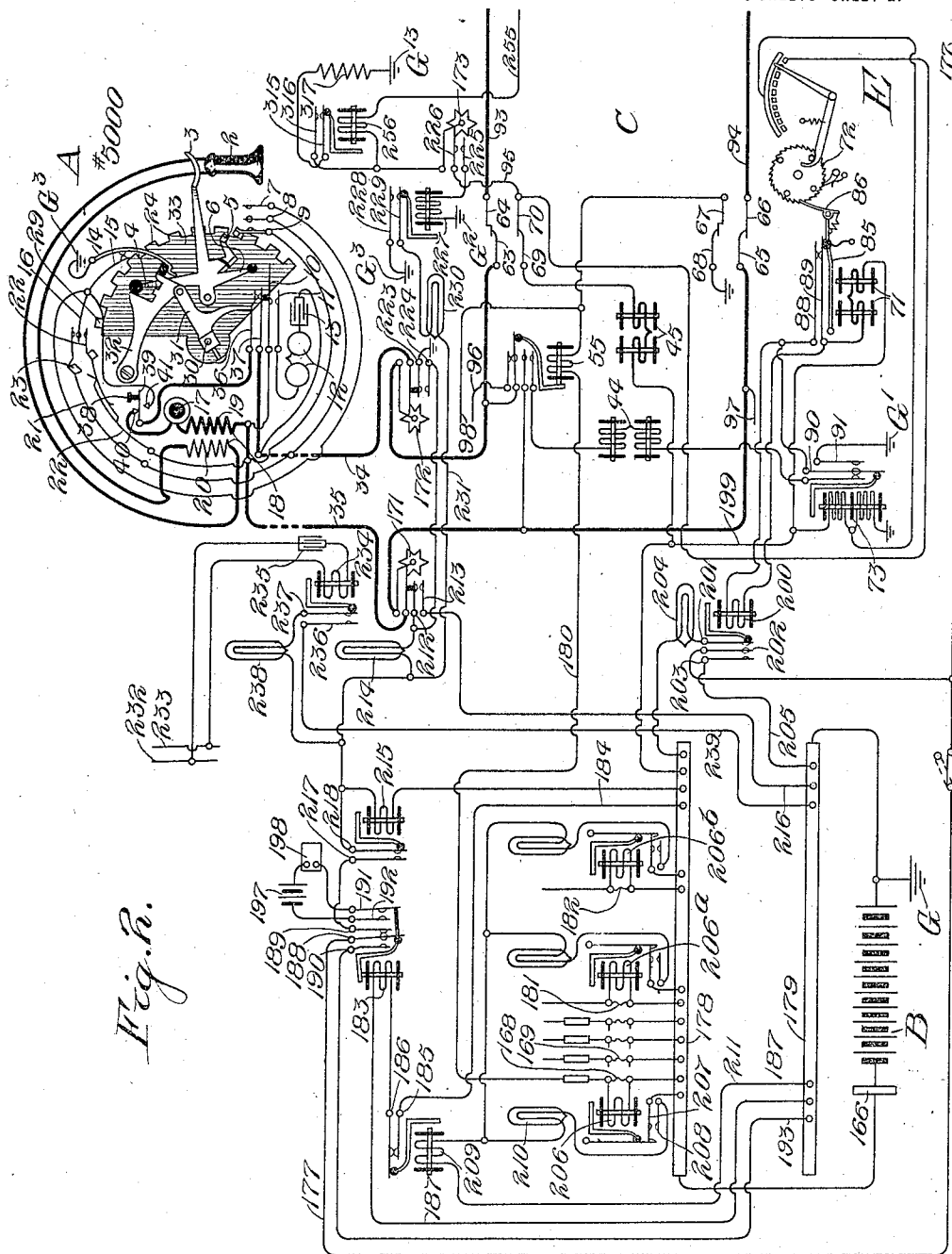


Fig. 2.

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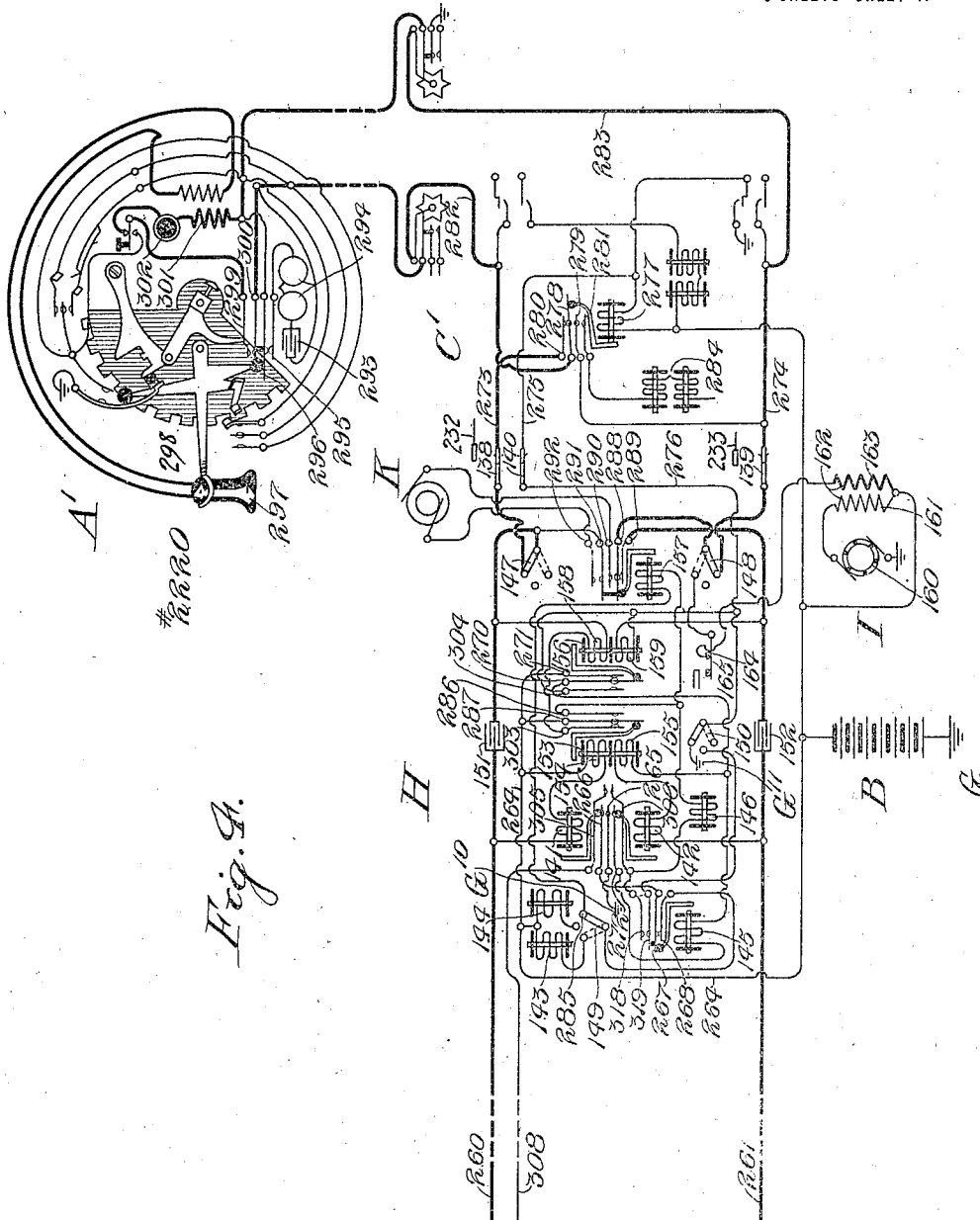


Fig. 4.

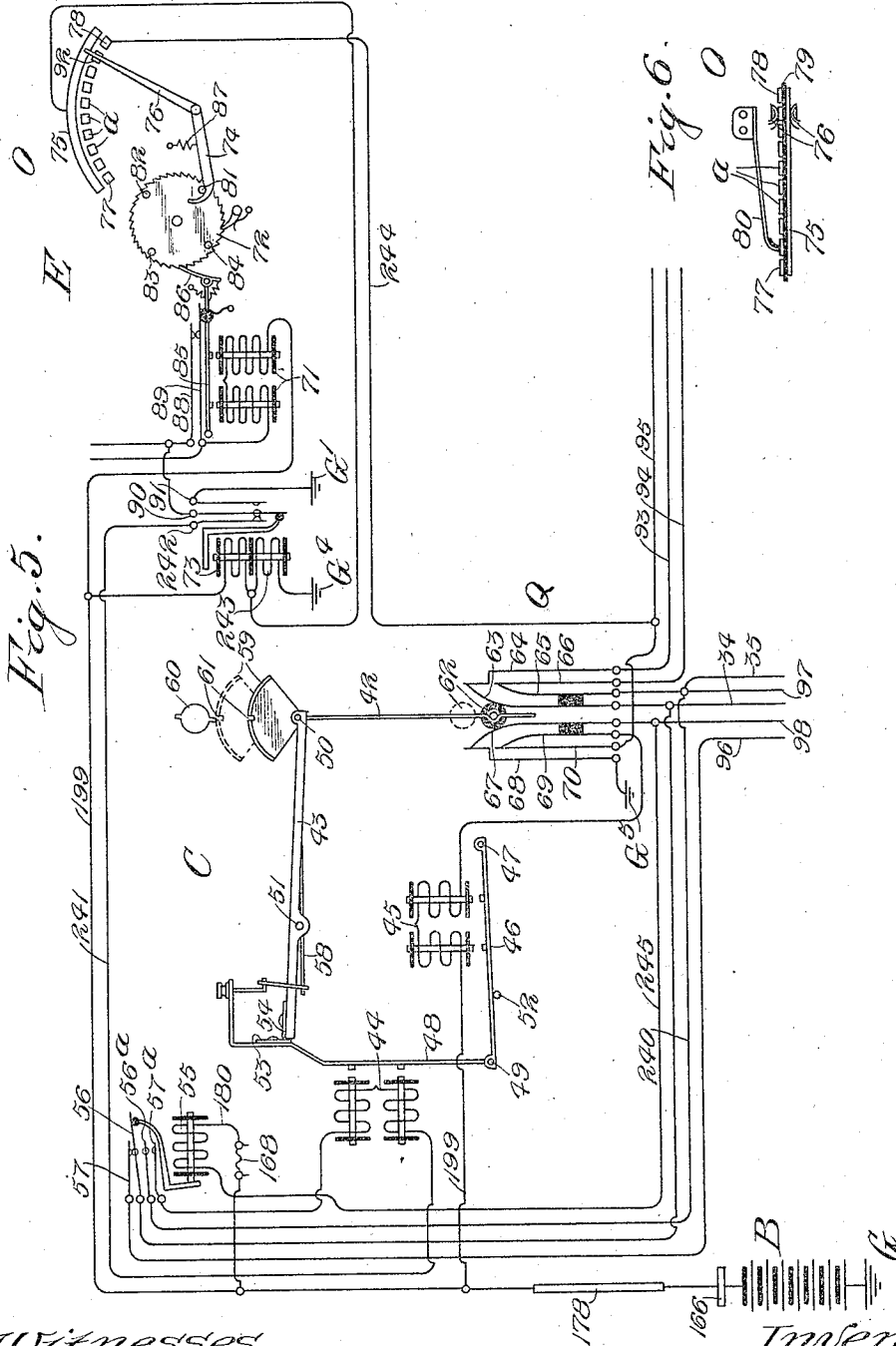
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 6 SHEETS—SHEET 5.



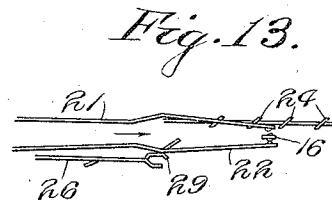
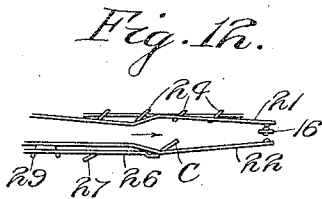
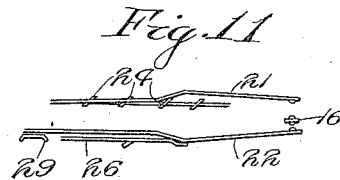
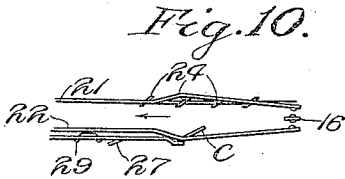
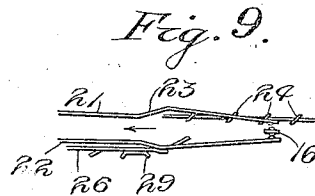
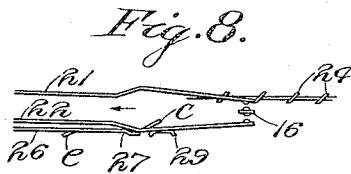
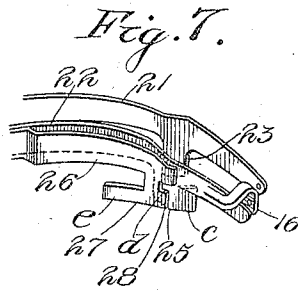
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1,196,876.

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 6 SHEETS—SHEET 6.



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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE AND SUPERVISORY SYSTEM.

1,196,876.

Specification of Letters Patent.

Patented Sept. 5, 1916.

Application filed November 30, 1907. Serial No. 404,536.

To all whom it may concern:

Be it known that I, FRITZ LUBBERGER, a subject of the Emperor of Germany, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Automatic Telephone and Supervisory Systems, of which the following is a specification.

My invention relates to automatic telephone systems in general, but more particularly to automatic telephone systems in which electrically-propelled and step-by-step automatic switches are employed, such as selectors and connectors, and especially to systems of this kind in which the automatic exchange apparatus is distributed between a main or central station and one or more sub-central or outlying stations.

The principal object of my invention is the provision of improved means for enabling the attendant at the main or central station to automatically be signaled in case of trouble at any one of the sub-central or outlying stations.

It is also an object to provide an arrangement by which different kinds of trouble at the sub-central or outlying stations will produce different kinds of signals at the main or central station, whereby the attendant may not only readily locate the station at which the trouble had developed, but may also know immediately the character of such trouble.

Another object is to provide improved means by which the attendant at the main or central station may at will test the apparatus, or certain portions thereof, at the sub-central or outlying stations.

To the foregoing and other useful ends, my invention consists in matters hereinafter set forth and claimed.

In the accompanying drawings Figure 1 shows in a general way the relative location of the different switches employed in the district system in connection with which I have elected to explain my invention. As shown in this figure, the large circles represent the district or sub-central stations. As shown at the top of the figure the 2200 sub-central comprises line switches C' and connector switches H. At A' there are represented the subscribers' stations. First and second selectors are provided in the central exchange for trunking and are divided into 55 thousand groups. The one-thousand-group

is indicated at the left of the central portion; those allotted to the two-thousand-group are represented in the center; while the selector switches of the three-thousand-group are represented at the right. In each group the first-selector switches are at the left (as the first-selector D), and the second-selector switches at the right.

Fig. 2 represents diagrammatically a subscriber's substation A and its allotted line switch C, the master switch E for controlling the line switches of the group of which C is a member; and a battery B, having its positive terminal preferably grounded at G, for operating the apparatus. At the left of the diagram there is shown the sub-central supervisory equipment and apparatus, which is one of the important features of my invention, and with which each sub-central of Fig. 1 is equipped.

In Fig. 3 is shown diagrammatically one of the first-selector switches D and one of the second-selector switches F, both of the general type of selector disclosed in United States Patent No. 815,321, granted March 13, 1906, to Keith, Erickson and Erickson, which, as stated, are located in the main central office. Also, a battery B is shown which may be located at the main central station.

Fig. 4 shows diagrammatically one of the connector switches H of the general type disclosed in United States Patent No. 815,176, granted March 13, 1906, to Keith, Erickson and Erickson, but modified somewhat to adapt it to common battery work. At C' there is shown a line switch allotted to the line of substation A', which is the same as line switch C. The battery B is also shown. It will be understood that with a main central battery, separate leads or conductors will extend to each sub-central; but for convenience I have shown a battery at each sub-central station, as well as one at the main central station.

Figs. 2, 3 and 4 taken together represent diagrammatically the switching apparatus involved in establishing a connection between a subscriber of the sub-central #5000, for example, and a subscriber of the #2200 sub-central.

Fig. 5 is a diagrammatic view of the line switch C and the master switch E.

Fig. 6 is a detail view showing the construction of the master switch bank O.

Figs. 7, 8, 9, 10, 11, 12 and 13 are detail

views showing the various positions of the substation impulse springs.

It will be understood that the first-selectors, second-selectors and connectors are employed upon a percentage basis—that is, in an automatic exchange of ten-thousand capacity a somewhat common arrangement is to divide the subscribers and their allotted line switches into groups of one-hundred each. Then to each group of line switches there is allotted a group of first-selectors, usually ten in number, making one-thousand first-selectors in a ten-thousand system. Furthermore, the second-selector switches are arranged in suitable groups with regard to the first-selector banks, and the connectors are also arranged in suitable groups with regard to the second-selector banks.

In a district system it is, of course, desirable to provide supervisory means whereby the main exchange attendant may be kept informed at all times of the condition of the sub-central equipment. As has been shown by practice, there are various troubles which arise at a sub-central station that effect its successful operation more or less. It is desirable, of course, that these troubles be known to the main exchange attendant as soon as they occur, in order that he may act accordingly. Some of the troubles which arise at a sub-central station are of a very serious character, since they affect all of the subscribers allotted to a sub-central, while others are minor and affect only one particular line. Of the former class—that is, those which may be termed the serious—are the following: the blowing of the main fuse; the blowing of the fuse which provides the bridge-cut-off relays with battery current; and master switch trouble. The occurrence of any one of the above mentioned troubles would seriously impair the service of a whole group of subscribers. These serious troubles are indicated to the main exchange attendant by the glowing of a red lamp. The minor troubles—that is, those which do not affect the whole sub-central, but only one line—are as follows: the blowing of a line fuse; and the blowing of a trunk-line fuse. The blowing of either of these fuses affects only one line and is indicated to the main exchange attendant by the glowing of a white light. Thus, the main exchange attendant is not only informed of the trouble at a sub-central, but is also able to tell whether or not the trouble is serious and demands immediate attention.

The substations may be of any suitable or approved type. Those in connection with which I have elected to explain my invention comprise, as shown at substation A, a receiver 2, a switch-hook 3 for controlling the substation circuits, which controlling operations are accomplished through the medium of any suitable means, such as the

cam-arms 4, 5 and 6. As the switch-hook is lowered the cam-arm 5 momentarily presses the release springs 7, 8 and 9 into engagement, whereby the substation line conductors may be grounded simultaneously. When the switch-hook is down the cam-arm 6 maintains a contact between the springs 10 and 11, thereby bridging the ringer 12 in series with the condenser 13 across the line. The substation is provided with a grounded circuit which is normally broken between the so-called ground springs 14 and 15 by the cam-arm 4; but when said springs are together, ground is provided to the ground post 16 and to the release spring 7, as is usually the case in telephones of this type. The said substation comprises the usual transmitter 17, and the induction-coil 18 having the primary winding 19 and secondary winding 20. Being an automatic substation it is provided with the usual vertical and rotary impulse springs 21 and 22. For operating the impulse springs 21 and 22 the substation is provided with an impulse wheel 33 that is secured to the shaft 30. This impulse wheel carries on its periphery the so-called vertical impulse teeth 24 and one rotary impulse tooth 29. The vertical impulse spring is provided with an oblique projection or lug 23 (Fig. 7) on its under side, with which the vertical impulse teeth 24 are adapted to engage for intermittently driving the spring 21 onto the ground post 16. The rotary impulse spring 22 is provided with a somewhat similar mechanism, whereby the rotary impulse spring may be driven onto the ground post once when the dial is rotated in one direction, and once when rotated in the opposite direction. The said rotary impulse spring 22 has on its under side a V-shaped member 25 having two sides *c* and *d*, and there is in addition an auxiliary spring 26 which works in conjunction with the V-shaped member.

As shown more clearly in Fig. 7, the auxiliary spring 26 is provided with a lower curved part 27 having the rear section *e* curving outwardly, as shown in Figs. 7, 8 and 9. The front section 28 of the said member 27 is designed to fall just below the apex of the V-shaped member 25, so that when the rotary impulse tooth 29 is moved in the direction indicated by the arrow in Fig. 8, it will pass onto the curved member 27, thus pressing the rotary impulse spring 22 onto the ground post 16 for a comparatively long time, as shown in Fig. 9, thereby sending a comparatively long impulse to the line. As the impulse wheel advances, the vertical impulse teeth 24 approach the lug 23 of the vertical impulse spring 21 (Fig. 9), and eventually the first tooth that meets the lug 23 clears the said lug, as shown in Fig. 10, but not until after the rotary impulse tooth 29 clears the curved member 27. As

the impulse wheel continues to advance in the direction indicated by the arrow in Fig. 10, the succeeding impulse tooth will clear the projection 23, as shown in Fig. 11. Then when the impulse wheel is released, first the vertical impulse spring 21 is carried into engagement with the ground post 16 twice by the vertical teeth previously cleared, as indicated in Fig. 12; but as the impulse wheel nears its normal position the rotary impulse tooth 29 passes under the curved member 27 of the auxiliary spring 26 (Fig. 11), engaging the V-shaped member 25 directly and for a short time only, sending the ordinary impulse to the line through the medium of the rotary impulse spring 22; after which the said member 27 is cleared, as shown in Fig. 8, as the impulse wheel reaches its normal position.

The operations, as thus described, are repeated each time that the dial is turned, and the number of impulses produced through the medium of the vertical impulse spring are accurately and definitely determined at each operation of the dial. Said substation is, of course, provided with a dial (not shown) which is secured to the shaft 30, together with the locking dog 31. Furthermore, there is a locking cam 32 that locks the dog 31, while the receiver is on the switch-hook, to prevent a rotation of the dial. The said impulse teeth 24 and 29 are so arranged that when the dial is drawn down the rotary impulse spring 22 is pressed into contact with the ground post 16 while the impulse spring 21 is not carried into contact with the said ground post; but as the dial returns, first the vertical teeth 24 engage the vertical impulse spring 21, and after they have completed their work the rotary impulse tooth 29 operates the rotary impulse spring 22. In this operation the subscriber's rotary line conductor 35 is given a so-called preliminary impulse, and the vertical line conductor 34 is given a number of ground impulses, and then the rotary line conductor 35 is given another ground impulse. It will be seen that the construction is such that as long as the dial is out of normal position the dog 31 permits the primary circuit springs 36 and 37 to separate, thus preventing the impulses that are delivered to either line conductor from passing to the other. The means whereby a subscriber may signal a called subscriber comprises the push-button 38 which, when pressed, carries the spring 39 out of engagement with the contact point 40 and into engagement with the contact point 41, whereby the vertical line conductor 34 is grounded. The line switch C (Fig. 5) comprises a plunger 42, plunger arm 43, trip magnet 44 and switch-release magnet 45, all of which are assembled upon a suitable base or frame not shown. The said switch-re-

lease magnet is provided with an armature 46 that is pivoted on a pin 47 which rises from the base of the switch. The said armature carries pivotally secured on its end a second armature 48 that is controlled by the trip magnet 44. The pin 49 about which the armature 48 moves is carried on the end of the armature 46. The plunger 42 is pivotally secured by the pin 50 to the plunger arm 43, which latter is in turn pivoted to a pin 51 that rises from the switch frame (not shown).

The lug 52 may be stamped from the frame and is provided as a stop for the armature 46. Upon the armature 48 is secured the catch 53 which is adapted to normally engage the end 54 of the plunger arm 43. Furthermore, the said line switch is provided with a bank of terminals, usually ten in number but only one of which is shown at Q (Fig. 5). The said terminal Q is shown twisted from its true position with respect to the swing of the plunger 42, and the bushing 62 is correspondingly turned, all for the purpose of making the illustration clearer. The terminal Q comprises the springs 63 and 64, 65 and 66, 67 and 68, and 69 and 70. These springs are normally disconnected from each other, but are driven into contact in the above-mentioned order when the plunger 42 engages the terminal Q. When the plunger 42 disengages from the bank terminal Q the said plunger may take one of two positions in relation to the plunger shaft 60—that is, the plunger may return to locking or sliding engagement with the shaft 60. When the plunger 42 is in locked engagement with the plunger shaft 60 the notch 61 is in engagement with the flange or web of the shaft 60, and when in sliding engagement the hub rests in the position shown by the dotted lines in Fig. 5—that is, when the plunger shaft is operated the plunger 42 is not carried along with the locked plungers, but remains in the dotted position, the plunger shaft sliding upon the edge 59.

The general operation of the switch is as follows: The trip magnet 44 is energized by the preliminary impulse, and the armature 48 is attracted against the magnet cores. When the armature 48 is attracted the catch 53 slides out of contact with the end 54 of the plunger arm 43, and the said plunger arm 43, owing to the tension of the spring 58, moves about the pin 51 and thrusts the plunger 42 into the bank terminal Q, as shown in Fig. 5; and when the trip magnet again deenergizes, the trip armature 48 falls against the end of the plunger arm 43, as shown. Furthermore, when the line switch operates, and the plunger 42 is thrust into the bank terminal Q, the shaft 60 is advanced one step, as will be explained, to carry the remaining plungers opposite the

next idle trunk-line. The switch is restored when the release magnet 45 becomes energized, whereby the armature 46 is attracted, and accordingly the trip armature 48 is moved upwardly until the catch 53 slides over the end 54; then when the release magnet 45 becomes deenergized the armature 46 returns to normal position and remains at rest against the stop 52, furthermore, since the plunger arm 43 is now in engagement with the armature 48, the said plunger arm is also moved about the pin 51, whereby the plunger 42 is moved from the terminal Q. Also, since the plunger shaft has advanced one step, the hub 59 of the plunger 42 comes to rest in the position shown by the dotted line in Fig. 5, in sliding engagement with the plunger shaft 60; and as the said plunger shaft advances each time an idle trunk is seized, the plunger 42 is not advanced, but remains in this position opposite the trunk terminal from which it last disengaged, since the slot 61 is not in engagement with the plunger shaft 60. After all the trunk-lines have been successively seized, the shaft 60 then passes from its last position and moves toward the starting point, picking up the plunger 42 when the web of the said shaft, over which the slot 61 normally rides, arrives at the position at which the plunger 42 was originally released—that is, the plunger passes into locked engagement with the shaft when the slot 61 slips over the web of said shaft. From thence on the plunger 42 is carried in locked engagement by the shaft 60 until it is again released when another call is made. But if, after the plunger is released, and before the shaft 60 returns to pick up said plunger, the switch C is again operated, the plunger 42 again engages the same terminal Q. The bridge-cut-off relay 55 is provided for controlling the springs 56, 57, 56^a and 57^a and, upon energizing, operates to shift the spring 56 from the spring 56^a to the spring 57. When the spring 56 is thus operated the springs 56^a and 57^a also disengage.

The master switch E, which may be of any suitable or approved type, is provided for operating the plunger shaft 60 and for controlling certain circuits that will be disclosed hereinafter. It comprises the following details: A motor magnet 71 for operating the ratchet wheel 72, which latter is designed for operating the plunger shaft 60 through the medium of the cam 74, and a differential relay 73 for controlling the energizing circuit of the motor magnet 71. The said master switch also has a bank O comprising a plurality of individual contact segments α and a common metallic segment 75, as shown in Fig. 5. The wiper 76 is adapted to remain in constant engagement with the bank O, and to maintain at all

times, except when the wiper is passing from the extreme left contact 77 to the extreme right contact 78, some one of the segments α in electrical connection with the common segment 75. As shown in Fig. 6, the individual segments α are separated from the common segment by the insulating strip 79. The spring 80 is provided in order that when the wiper 76 passes to the last contact point 77, then on the next step the wiper is carried to the contact 78 on the extreme right, and the upper part of the wiper 76 slides on the guide spring 80, thus preventing the wiper from placing any of the individual segments α in contact with the common segment 75, as otherwise some interference might be caused with the master switch. The wiper 76 is operated in a step-by-step manner by the ratchet wheel 72, through the medium of the cam member 74 rigidly secured to the said wiper 76 and adapted to successively engage the pins 81, 82, 83 and 84 upon the said ratchet wheel 72. The motor magnet 71 is provided with an armature 85 upon the end of which there is suitably secured a pawl 86. Each time that the said magnet is energized the armature 85 is attracted against the magnet cores, and the pawl 86 engages the next lower tooth on the ratchet wheel 72; then when the magnet deenergizes, the pawl 86 engages the ratchet wheel 72, advancing the latter one step. It will be seen, therefore, that as the ratchet wheel 72 advances in a clockwise direction, the wiper 76 advances step by step from right to left; and when the pin 81, for example, clears the cam 74 the retracting spring 87 restores the wiper 76 to its first position at the right of the bank and in engagement with the first segment 78. The said motor magnet is provided with a couple of interrupter springs 88 and 89 that are included in the energizing circuit of the said motor magnet, which energizing circuit also comprises the springs 90 and 91 controlled by the differential relay 73. Therefore, whenever the differential relay is energized the springs 90 and 91 are pressed into contact, and the motor magnet 71 operates step by step as long as the differential relay 73 remains energized. Furthermore, it is assumed that the terminal Q of the line switch C is the first terminal of the line switch bank. While in normal locking engagement with the shaft 60 the plunger 42 is retained in front of said terminal by the plunger shaft 60 whenever the master switch wiper 76 is in engagement with the bank segment 78; but as the motor magnet 71 advances the wiper 76 onto the second segment 92, the said plunger and all idle plungers similarly engaging the shaft 60 are carried opposite the next terminal of the line switch bank. It should be noted that in each switch bank all of the springs

63 are permanently connected and may be made of one common piece; the springs 64, however, are individual—that is, there is one separate and distinct spring for every bank set Q, there being ten in the bank. The springs 65, 67, 68 and 69, like the springs 63, are also common, and the springs 70 and 66, like the springs 64, are individual. For every bank terminal Q there is a trunk-line of three conductors 93, 94 and 95 leading to a selector, and there is also a normal trunk-line comprising the conductors 96, 97 and 98 leading to the connector banks. The subscriber's line conductors 34 and 35 terminate in the springs 63 and 65 which, as has been stated, are common springs. When the subscriber operates the line switch C and the plunger 42 engages the terminal Q the subscriber's line conductors 34 and 35 are extended to the vertical and rotary trunk conductors 93 and 94, thence to the switch D.

The mechanical details of the first-selector are, in general, well known, involving a vertical magnet 99 and a rotary magnet 100, a release magnet 101 and a private magnet 102. The said private magnet 102, of course, controls the side switch wipers 103, 104, 105 and 106, the said private magnet also controlling the circuit of the vertical magnet 99 in the usual manner by means of the springs 107 and 108, but not the circuit of the release magnet, for the release magnet spring is omitted. The movement of the switch shaft and, therefore, of the wipers 109, 110 and 111 is controlled by the vertical magnet 99, and the rotary movement by the rotary magnet 100, the rotary magnet circuit being provided with the usual interrupter springs 112. The operative magnets of the switch are, of course, controlled by the subscriber through the medium of the vertical and rotary line relays 113 and 114, as is well known. Said relays have under their control the usual springs 115, 116 and 117, and in addition the trunk-release springs 118 and 119, whereby the said switch may be released when the side switch wipers are in first or second position. By means of the back-release relay 120 the release of the switch D is brought about after the side switch has passed to third position. Furthermore, the selector switch D is provided with a supervisory relay 121 which, upon energizing, operates to close a circuit through the signal lamp 122, whereby the exchange attendant is notified that the trunk-line to which the first-selector is allotted has been seized by a line switch. The supervisory lamp 123 is common to the group of first-selectors of which the selector D is a member, and is provided for indicating to the attendant when a first-selector switch has fully operated and established connection with a second-selector switch,

The selector F is also a modified form of the selector of the said selector patent. It is of the trunk-release type, in which the line relays 124 and 125 are permanently connected with the side switch contact points 126 and 127. It is also provided with the vertical magnet 128 and the rotary magnet 129, the release magnet 130 and the private magnet 131. As shown, the line relays 124 and 125 control the so-called trunk-release springs 132 and 133, the former being connected with the trunk-release conductor and the latter with the release magnet 130. The rotary magnet 129 is provided with the usual interrupter springs 134. Since the selector is of the trunk-release type, the back-release relay 135 affords means of releasing the said switch after the side switch passes to third position.

The mechanical details of the selector and connector (Fig. 4); as is well known, are very much the same. For instance, the connector switch shaft (not shown), like the selector, carries a set of line wipers 138 and 139 and a private wiper 140. The connector switch is also controlled by the calling subscriber through the medium of the vertical and rotary line relays 141 and 142. The vertical line relay 141 directly controls the vertical magnet 143 and also the rotary magnet 144. The purpose of the vertical magnet 143 is to give the shaft and shaft wipers a vertical motion and the rotary magnet 144 imparts to the shaft and shaft wipers a rotary or circular motion. The rotary line relay 142 controls the private magnet 145 which, under certain conditions, controls in turn the vertical and rotary magnets 143 and 144, the release magnet 146, and also the side switch wipers 147, 148, 149 and 150. The side switch of the connector, like the side switch of the selector, has a normal or first position, a second position and a third position. The release magnet 146 is also controlled by the vertical and rotary line relays 141 and 142 conjointly. By the use of the condensers 151 and 152 the circuit through the connector is divided into two sections. The connector is provided with a differentially-wound relay 153 which is composed of the windings 154 and 155. Through the windings of this relay the calling subscriber's substation is provided with talking battery current when the primary circuit of the called substation is bridged across the line. The sub-central stations are equipped with the busy-signaling apparatus I of any suitable design, as, for example, the one comprising an interrupter 160 in series with the primary winding 161 of the induction-coil 162, whereby a busy-signaling current is induced in the secondary winding 163 of the said induction-coil. When the side switch is in first position, and when the connector shaft is raised one or more steps, the

secondary winding 163 is connected with the side switch wiper 148 through the normal springs 164 and 165.

The operation of the switching apparatus represented in Figs. 2, 3 and 4 may be more clearly understood from a detailed description of its operation when one subscriber calls another, as follows: To call the number 2220 (substation A') the subscriber at substation A (Fig. 2) removes his receiver from the switch-hook and operates the calling device once for each digit, in the well-known manner—that is, when the dial is rotated for the first digit a preliminary impulse is transmitted over the rotary line conductor. This preliminary impulse energizes the trip magnet 44, whereby the line switch C is operated to seize an idle trunk-line leading to a first-selector. In returning to normal position for the first digit the dial operates the first-selector switch to establish connection with an idle trunk-line leading to a second-selector switch. It will be understood, of course, that when the dial is turned for each digit a preliminary rotary impulse is transmitted to the rotary line, which impulse, if the selector D or a connector H is on the line, is received by the rotary line relay of the switch while the side switch is in first position. This rotary line relay energizes, of course; but since the side switch is in first position, this is without effect, and the switch is not operated until the dial delivers the vertical impulses. Said preliminary impulse is effective only in operating the line switches. The impulses delivered by the dial for the second digit are received by the second-selector. The impulses for the last two digits are directed toward the connector H which operates to place its shaft wipers in connection with the contacts corresponding to the desired line. The preliminary impulse for operating the line switch C, and which occurs when the calling subscriber rotates the dial in a forward direction for the first digit, is caused by the rotary impulse spring 22 being pressed against the ground post 16. As a result of the impulse the trip magnet 47 of the line switch C is energized by a flow of current from ground G³ to the springs 14 and 15, ground post 16, impulse spring 22 to the rotary line conductor 35, line fuse 171, conductor 240, cut-off relay springs 56^a and 57^a to the trip magnet 44, thence through said trip magnet to the conductor 241, springs 242 and 90, springs 88 and 89, through the winding of the motor magnet 71 to the battery lead 199, thence through battery B to ground G. Although this circuit includes the motor magnet 71, this magnet does not operatively energize, since the magnet 44 is of much higher resistance than the magnet 71. As soon as the trip magnet 44 energizes, the armature

48 is attracted and the plunger 42 is liberated and thrust into the bank terminal Q by the spring 58, assuming that the plunger 42 is opposite the terminal Q at the time. When the plunger 42 engages the bank terminal Q an energizing circuit is closed through the motor magnet relay 73, which in turn operates to close an energizing circuit through the motor magnet 71. The motor magnet then operates to advance all idle plungers that are in locking engagement with the shaft 60 to a point opposite the next idle bank terminal similar to the terminal Q. The circuit through the relay 73 extends from ground G⁴ through the winding 243 of the relay 73, segment 75, wiper arm 76, segment 78, conductor 244, bank terminal springs 70 and 69, release magnet 45, to the battery lead 199, thence through battery B to ground G. Although this circuit includes the release magnet 45, the magnet 45 does not operatively energize, since the windings of the relay 73 are of a high resistance while the windings of the release magnet is comparatively low. The relay 73, upon energizing, operates to place the springs 90 and 91 in contact, whereby a circuit is completed through the motor magnet 71 extending from ground G¹ through the springs 91 and 90, motor magnet springs 88 and 89, through the motor magnet 71 to the battery lead 199, thence through battery B to ground G. The motor magnet 71, upon energizing, attracts its armature 85, whereby the pawl 86 is driven down and engages the next lower tooth on the ratchet wheel 72. When the motor magnet 71 de-energizes, the armature 85 returns to normal position, rotating the ratchet wheel 72 one step.

When the armature 85 is attracted against the magnet cores, the springs 88 and 89 disengage, thereby breaking the energizing circuit through the motor magnet. The cam 74, being in engagement with the pin 81, is operated to advance the plunger shaft 60, and consequently all idle plungers that may be in normal locked position with the shaft 60, one step and opposite another trunk terminal similar to the terminal Q (assuming the next succeeding trunk is idle). Consequently, the wiper 76 is carried from the contact point 78 (which corresponds to the terminal Q) to the contact point 92, which latter corresponds to the terminal before which the advanced idle plungers are now resting. Suppose that nine subscribers have called, and that the master switch has thus been operated nine steps, carrying the wiper 76 to the last contact point 77. Now, when the motor magnet 71 operates for the next step, and when the tenth subscriber calls, the wiper 76 passes back and drops into engagement with the contact point 78, as already explained. If the first trunk is still busy

the wiper 76 finds battery current on the contact 78, and an energizing circuit is established through the differential relay 73, which in turn operates to close an energizing circuit through the motor magnet 71. The current through the said relay 73 flows from the said contact 78 through the wiper 76 to the common segment 75, through the winding 243 of the differential relay 73 to ground G^4 . When the differential relay 73 attracts its armature, the differential relay springs 90 and 91 are pressed into contact, thereby closing an energizing circuit for the motor magnet 71 from ground G^1 through the said springs 91 and 90, through the motor magnet springs 88 and 89, motor magnet 71, thence to the battery lead 199 and through battery B to ground G. The motor magnet then operates, as previously explained, to rotate the ratchet wheel 72 one step for advancing the plunger shaft 60 one step, and the master switch bank wiper 76 one step also and into engagement with the second segment 92. The plunger shaft 60, when thus advanced one step, carries all idle plungers that are in engagement with the said shaft to a point opposite the next bank terminal, as previously explained. If there should still be a guarding potential at the bank segment 92 of the master switch bank the differential relay 73 will remain energized, whereby the energizing circuit through the motor magnet 71 is again completed when the motor magnet springs 88 and 89 again engage, and as a result the motor magnet 71 is again operated, whereby the plunger shaft 60 and the master switch wiper 76 are advanced another step. This process continues as long as the wiper 76 finds segments with guarding potentials. As soon as an idle segment is found, however, the energizing circuit through the differential relay 73 is broken, at which time the said relay in turn breaks the energizing circuit for the motor magnet 71 until the next subscriber makes a call. At the instant that the plunger 42 enters the said bank terminal Q the following springs are pressed into contact: 63 and 64, 65 and 66, 67 and 68, and 69 and 70. The engagement of the springs 67 and 68 closes a circuit through the cut-off relay 55 extending from ground G^5 through the springs 68 and 67, conductor 245, relay 55 to the conductor 180, fuse 168, bus bar 178, thence through battery B to ground G. The said relay, upon energizing, breaks the contact between the springs 56, 56^a and 57^a, whereby the vertical and rotary line conductors 34 and 35 become disconnected from the trip magnet 44. The cut-off relay, upon energizing, places the springs 56 and 57 in contact, which connects the subscriber's vertical line conductor 34 with the normal conductor 96.

The engagement of the bank springs 67 and 68 establishes a guarding potential by way of the normal conductor 98 to the connector private bank contacts corresponding to the line that terminates in the line switch C, to prevent any subscriber from calling the said line after the calling subscriber at substation A operates his dial preparatory to making a call, as explained. The circuit over which the said guarding potential is established extends from ground G^5 through the bank springs 68 and 67 to the private normal conductor 98. Also, the closure of connection between the springs 69 and 70 establishes a guarding potential at the master switch bank contact 78, over the following circuit: from battery B to the battery lead 199, thence through the release magnet 45 and springs 69 and 70 over the conductor 244 to the said contact point 78. This guarding potential protects the seized trunk conductors 93, 94 and 95 from being seized by other plungers, as already explained. Furthermore, the engagement of the bank springs 69 and 70 also closes an energizing circuit through the supervisory relay 121 of the first-selector switch (Fig. 3). This circuit extends from ground G^7 at the selector switch through the side switch wiper 105, conductor 254, through the winding of the relay 121, conductor 255, through the relay 256, heat coil 173, conductor 95, bank springs 70 and 69, release magnet 45 to the battery lead 199, thence through battery B to ground G. Although this circuit includes the magnet 45 and the relay 256, the said magnet and relay do not operatively energize, since the winding of the supervisory relay 121 is of comparatively high resistance. The relay 121, upon energizing, places the springs 257 and 258 in contact, thus closing a circuit through the signal lamp 122 from ground G^9 through the said springs and lamp 122 to the battery lead 245, thence through battery B to ground G. The glowing of this lamp indicates to the exchange attendant that the first-selector switch D has been seized by a line switch at the sub-central. It will be understood that the bank terminal Q, being the first bank terminal of the line switch bank, corresponds to the first segment 78 of the master switch bank O and, therefore, to the trunk-line the conductors 93, 94 and 95 of which terminate in the first-selector D. When the selector switch is operated, and the side switch wiper 105 passes to second position, the energizing circuit through the relay 121 becomes broken, the supervisory relay 121 deenergizing and in turn breaking the circuit for the lamp 122. The closure of connection between the springs 63 and 64 extends the calling subscriber's vertical line conductor 34 to the vertical trunk conductor 93 and to the side switch wiper 103 of the first-selector D. The closure of contact between the springs 65 and 66 in a similar

manner extends the subscriber's rotary line conductor 35 to the rotary trunk conductor 94 and to the side switch wiper 104 of the selector D. The subscriber has thus established connection with the selector D, which is now operated by the impulses that are sent in as the dial returns.

The first digit being 2, the spring 21 is pressed onto the ground post 16 twice. As a result the vertical line relay 113 of the first-selector D is energized each time by a flow of current from the substation ground G^3 through the springs 14 and 15 to the ground post 16, thence through the spring 21 to the vertical line conductor 34, line fuse 172, line switch bank springs 63 and 64, vertical trunk conductor 93, side switch wiper 103 of the selector D, vertical line relay 113 to the battery lead 245, thence through battery B to ground G. Each time that the vertical line relay 113 energizes, the line relay spring 115 is pressed onto the ground spring 116. The vertical magnet 99 is thereby energized, and the wipers 109, 110 and 111 of the selector D are raised to the second level and brought opposite the first contact of said level. The energizing circuit for the said vertical magnet 99 extends from ground G^6 through the springs 116 and 115, private springs 107 and 108 to the vertical magnet 99, thence to the battery lead 245, and through battery B to ground G. Following the vertical impulses the rotary impulse spring 22 is then pressed onto the ground post 16, grounding the rotary line conductor 35 and, therefore, energizing the rotary line relay 114 of the selector D. The energizing current passes from ground G^3 to the rotary line conductor 35, thence it flows through the line switch bank springs 65 and 66, rotary trunk conductor 94, side switch wiper 104 of the selector D to the rotary line relay 114, to the battery lead 245, and through battery B to ground G. The rotary line relay, upon energizing, presses the line relay spring 117 onto the ground spring 116, thereby establishing a circuit through the private magnet 102 from ground G^6 through the springs 116 and 117 to the private magnet 102, and through the said magnet to the battery lead 245, thence through battery B to ground G. The private magnet, upon energizing and deenergizing, permits the selector side switch to pass from first to second position, permitting the side switch wipers 105 and 106 to engage the contact points 246 and 247, respectively. The closure of connection between the side switch wiper 105 and the contact point 246 sets up an energizing circuit for the rotary magnet 100 from ground G^7 through the side switch wiper 105, contact point 246, interrupter springs 112, rotary magnet 100 to the battery lead 245, and then through battery B to ground G. The

said rotary magnet 100 then operates to rotate the wipers 109, 110 and 111 of the selector D into engagement with the first contact of the second level of the selector D, from which contact it is assumed the trunk-line conductors 248, 249 and 250 lead to the second-selector F. If the first trunk is busy, however, and the wipers have to pass over busy trunk-lines, then as soon as the private wiper 111 engages the first grounded private bank contact point, the private magnet 102 energizes again, locking the side switch in second position. The energizing circuit for said private magnet extends from the grounded terminal G of battery B through an occupying switch (not shown) to the private wiper 111, thence through the back-release relay 120 to the side switch wiper 106, contact point 247, private magnet 102, thence through said magnet to the battery lead 245, and through battery B to ground G. The private magnet 102, upon thus becoming energized, locks the side switch wiper 105 in engagement with the contact point 246, whereby the rotary magnet 100 will be energized step by step until the wipers are carried beyond the last busy trunk-line. At the instant that the private wiper leaves the last busy contact point the energizing circuit through the private magnet 102 is destroyed, and as result the selector side switch passes to third position. If, however, there are no busy trunk-lines, the rotary magnet 100 releases the side switch to third position as soon as the wipers are carried into engagement with the first trunk-line.

As soon as the side switch passes to third position, as stated, the subscriber's line conductors 34 and 35 are extended to the conductors 248 and 249 which, in this case, it is assumed lead to the second-selector switch F. The extension of the line occurs, of course, as soon as the side switch wipers 103 and 104 engage the contact points 251 and 252, respectively. Not only is the subscriber's line thus extended, but a guarding potential is established at the private wiper 111, when the side switch wiper 106 passes onto the ground contact point 253, for protecting the seized trunk-line from interference by other calling subscribers. This guarding potential is established from ground G^8 to the contact point 253, thence through the side switch wiper 106, and through the back-release relay 120 to the private wiper 111. It will be seen that the energizing circuit for the rotary magnet 100, to which reference has already been made, is destroyed when the idle trunk-line is seized—that is, when the grounded side switch wiper 105 leaves the contact point 246. When the side switch wiper 105 passes to third position and engages the contact point 259, a circuit is

closed through the lamp 123 which is allotted to the group of selector switches of which selector D is a member. The circuit through the said lamp extends from ground G⁷ through the side switch wiper 105, contact point 259, through the lamp 123 to the battery lead 245, thence through battery B to ground G. The glowing of this lamp indicates to the attendant that a selector switch has operated and seized a trunk-line leading to a second-selector switch. As shown in Fig. 3, the lamp 123 is also connected to the side switch wiper 105^a, which is the side switch wiper of another first-selector and corresponds to the wiper 105 of the switch D. In a similar manner the lamp 123 is common to each first-selector of the group of which the selector D is a member, and when caused to glow indicates that one or more of the first-selectors to which it is allotted has operated and seized a trunk-line leading to a second-selector switch.

The second digit of the number called being 2, the calling subscriber again operates his dial accordingly, as a result grounding the vertical line conductor 34 when the spring 21 meets the ground post 16. The vertical line relay 124 of the switch F is, therefore, energized twice by a flow of current from the substation ground G³ to the vertical line conductor 34, thence through the line switch bank springs 63 and 64 to the vertical trunk conductor 93, thence to the side switch wiper 103 of the selector D, contact point 251, vertical line wiper 109, vertical trunk conductor 248, side switch wiper 259, vertical line relay 124 to the battery lead 245, thence through battery B to ground G. When the vertical line conductor 34 is grounded for the second digit the vertical line relay 124 operates to close a circuit through the vertical magnet 128, which magnet operates to carry the shaft wipers step by step to a point opposite the bank terminals of the second level, as explained in connection with the selector D. When the rotary line conductor 35 is grounded, after the vertical impulses; the rotary line relay 125 is energized, whereby an energizing circuit is established through the private magnet 131, which in turn operates to release the side switch, as described in connection with the selector D. After the switch F comes to rest the shaft wipers 136 and 137 are in engagement with the trunk conductors 260 and 261, respectively, which lead to the connector switch H (Fig. 4). The private wiper 262 establishes a protecting potential at the contact 263 for guarding the seized trunk-line. The grounding of the line conductors 34 and 35 for the last two digits affects the connector by operating the vertical and rotary line relays 141 and 142. When the said vertical line conductor 34 is grounded the vertical line

relay 141 is energized by a flow of current from the substation ground G³, vertical impulse spring 21 to the vertical line conductor 34, bank springs 63 and 64, trunk conductor 93, side switch wiper 103, shaft wiper 109, side switch wiper 259, shaft wiper 136, conductor 260, through the connector vertical line relay 141, winding 154 of the differential relay 153 to the battery lead 264, thence through battery B to ground G. The winding 154 of the relay 153 being included in this circuit, the said relay energizes, but its operation at this particular time is without effect.

Each time that the vertical line relay 141 operates for the third digit the vertical magnet 143 operatively energizes to carry the shaft wipers 138, 139 and 140 in a vertical direction one step at a time until said wipers are carried two steps and thus brought opposite a level in which are located the terminals of the line #2220. The circuit through the vertical magnet 143 extends from ground G¹⁰ through the springs 265 and 266, private magnet springs 267 and 268, side switch wiper 149, vertical magnet 143 to the battery lead 264, and through battery B to ground G. When the rotary line conductor 35 is grounded, following the grounding of the vertical line conductor, the connector rotary line relay 142 becomes energized through a circuit extending from the substation ground G³, through the rotary impulse spring 22, rotary line conductor 35, bank springs 65 and 66, conductor 94, side switch wiper 104, shaft wiper 110, conductor 249, side switch wiper 269, shaft wiper 137, conductor 261, rotary line relay 142, winding 155 of the differential relay 153, through the springs 270 and 271 to the battery lead 264, thence through battery B to ground G. The winding 155 of the differential relay 153 being included in this circuit, as is the winding 154 in the vertical line relay circuit, the said relay 153 energizes, but with no effect. The rotary line relay 142, upon energizing, operates to close an energizing circuit through the private magnet 145, which latter in turn operates to release the side switch from first to second position. The energizing circuit through the private magnet 145 extends from ground G¹⁰ through the springs 265 and 272, through the private magnet 145, springs 270 and 271 to the battery lead 264, and through battery B to ground G.

For the last digit the subscriber operates the dial as previously described, grounding the vertical line conductor 34 ten times and the rotary line conductor 35 once. The connector vertical and rotary line relays 141 and 142 are operated over previously traced circuits. However, when the vertical line relay operates, a circuit is closed through the rotary magnet 144 instead of through

the vertical magnet 143, since the side switch wiper 149 is now in second position. Each time that the rotary magnet is energized the shaft wipers 138, 139 and 140 are rotated one step at a time until the said wipers are carried into engagement with the normal conductors 273, 274 and 275; the first two of which conductors lead to the line terminals of the desired substation. The rotary line relay 142, upon energizing, completes an energizing circuit through the private magnet 145, which latter now operates with one of two results, namely the release of the side switch from second to third position, or the so-called busy-release of the connector. It will be assumed that the former result occurs, and that the side switch passes to third position, whereby the side switch wipers 147 and 148 are placed in connection with the shaft wipers 138 and 139, respectively. Furthermore, when the side switch passes to third position a guarding potential is established for protecting the called line. This guarding potential extends from ground G^{11} through the side switch wiper 150, conductor 276 to the private wiper 140 which engages the private contact of the called line. Furthermore, when the side switch wiper 150 passes to third position an energizing circuit is closed through the bridge-cut-off relay 277 of the line switch C^1 . This circuit extends from ground G^{11} through the side switch wiper 150, shaft wiper 140, conductor 275, through the winding of the bridge-cut-off relay 277 to the battery lead, thence through battery B to ground G. This relay, upon energizing, operates to carry the spring 278 out of engagement with the spring 279 and into engagement with the spring 280, and the springs 279 and 281 disengage. When the springs 278 and 280 engage, the normal conductor 273 is placed in contact with the subscriber's line conductor 282. The disengagement of the springs 279 and 281 disconnects the substation rotary line conductor 283 from the trip magnet 284 of the line switch C^1 . In order to signal, the subscriber at substation A presses the signaling button 38, whereby the vertical line conductor 34 is grounded, and the connector vertical line relay 141 and the differential relay 153 become energized as before.

It will be remembered that the side switch has passed from second to third position, and that the side switch wiper 149 is in engagement with the contact point 285, thereby placing the vertical line relay 141 in control of the ringer relay 157 in the same manner in which the rotary magnet 144 came under the control of the vertical line relay when the side switch passed from first to second position. Therefore, when the vertical line relay presses the springs 266 and 265 into contact the ringer relay 157 is ener-

gized by a flow of current from ground G^{10} through the springs 265 and 266, private magnet springs 267 and 268, side switch wiper 149, contact point 285, ringer relay 157, springs 286 and 287 (bearing in mind that the differential relay 153 is energized) to the battery lead 264, thence through battery B to ground G. The ringer relay, upon energizing, shifts the spring 288 from the spring 289 to the spring 290, and the spring 291 is shifted into engagement with the spring 292. This results in bridging the terminals of the ringer generator K across the called subscriber's line. A signaling current is, therefore, sent from the generator K to the ringer relay springs 292 and 291, side switch wiper 147, shaft wiper 138, normal conductor 273, bridge-cut-off relay springs 280 and 278, vertical line conductor 282, condenser 293, ringer 294, springs 295 and 296 to the rotary line conductor 283, rotary normal conductor 274, shaft wiper 139, side switch wiper 148, ringer relay springs 288 and 290 back to the generator K. As soon as the calling subscriber ceases to press the signaling button 38 the ringer relay 157 becomes deenergized, and the springs 288 and 291 assume their normal position. In response to the signal the subscriber at substation #2220 removes the receiver 297 from the switch-hook 298, whereby the switch-hook rises and permits the springs 299 and 300 to engage, and the springs 295 and 296 to disengage, thereby removing the ringer 294 from across his line. The engagement of the springs 299 and 300 closes a series energizing circuit through both windings of the relay 156 at the connector H, which circuit extends from ground G^{11} to the side switch wiper 150, winding 159 of the relay 156, springs 289 and 288, side switch wiper 148, shaft wiper 139, rotary normal conductor 274, rotary line conductor 283, primary winding 301, transmitter 302, through the signaling device of the called substation, springs 299 and 300, vertical line conductor 282, normal conductor 273, shaft wiper 138, side switch wiper 147, through the winding 158 of the relay 156, springs 303 and 287 to the battery lead 264, thence through battery B to ground G. The relay 156, upon energization, operates to shift the spring 270 from the spring 271 (which latter is connected to the battery lead 264) to the spring 304, which latter is in turn connected with ground. The reversal of the polarity of the spring 270 sets up a circuit which provides the calling substation with battery current for talking purposes. This circuit may be traced from ground G^{11} to the side switch wiper 150, through the springs 304 and 270, winding 155 of the differential relay 153, rotary line relay 142, conductors 261, 249 and 94, rotary line conductor 35, primary

winding 19, transmitter 17, springs 36 and 37, vertical line conductor 34, bank springs 63 and 64, conductors 93, 248 and 260, vertical line relay 141, winding 154 of the differential relay 153 to the battery lead 264, thence through battery B to ground G. Both windings of the relay 153 now carry current, but the windings are so arranged that the said relay does not operatively energize. The vertical and rotary line relays 141 and 142 being included in the above circuit operatively energize and place the springs 265, 266 and 272 in contact, and the release springs 305 and 306 are also brought into contact; but the simultaneous action of these relays at this particular time is without effect, since there are no energizing circuits established thereby. The two substations A and A¹ being thus provided with battery current for talking purposes, conversation may be carried on over the circuit shown by the heavy line conductors in Figs. 2, 3 and 4.

The release of the switching apparatus is brought about when the calling subscriber restores the receiver 2 to the switch-hook 3, thereby pressing the release springs 7, 8 and 9 into engagement for a moment. The contact of the said release springs grounds the vertical and rotary line conductors 34 and 35 simultaneously from ground G³ to the release spring 7, thence through the springs 8 and 9 to the vertical and rotary line conductors. The grounding of the rotary line conductor 35 produces a short-circuiting of the rotary line relay 142, in series with the winding 155 of the differential relay 153, said circuit extending from ground G¹¹ at the connector to the side switch wiper 150, springs 304 and 270, winding 155 of the differential relay 153, rotary line relay 142 to the trunk conductors 261, 249 and 94, bank springs 66 and 65 to the rotary line conductor 35, release springs 9, 8 and 7 to the substation ground G³. Therefore, since the winding 154 of the differential relay 153 alone carries current, the said relay becomes energized and attracts its armature, which shifts the spring 287 out of contact with the spring 303 into contact with the spring 286. The disengagement of the springs 287 and 303 destroys the energizing circuit through the relay 156, and the spring 270 passes out of engagement with the spring 304 and into engagement with the spring 271, which removes the said short-circuit of the rotary line relay 142 and winding 155, and establishes an energizing circuit instead from the substation ground G³ through the release springs 7, 8 and 9 to the rotary line conductor 35, then to the rotary line relay 142, as previously traced, winding 155 of the differential relay 153, through the springs 270 and 271 to the battery lead 264, thence through battery B to ground G.

The rotary relay 142 now operates, and the springs 305 and 306 come into contact whereby an energizing circuit is established through the release magnet 146 of the connector H and the release relay 135 of the selector F. However, the current now in passing, as above stated, through the winding 155 aids the winding 154 in maintaining the springs 287 and 286 in contact. The energizing circuit through the release relay 135 and release magnet 146 extends from ground G¹¹ at the selector F to the side switch wiper 307, release relay 135, shaft wiper 262, conductor 308, trunk-release springs 305 and 306, release magnet 146, springs 286 and 287 to the battery lead 264, and through battery B to ground G. When the connector release magnet 146 is thus supplied with current it energizes, and as a result the switch shaft and side switch are restored to normal position, thus breaking the connection between the connector switch shaft wipers 138, 139 and 140 and the normal conductors 273, 274 and 275. The back-release relay 135 being in the same circuit with the release magnet energizes simultaneously with the latter and operates to close an energizing circuit through the selector release magnet 130, in series with the release relay 120 of the selector D, by pressing the back-release springs 309 and 310 together. This circuit extends from ground G³ at the first-selector D through the side switch wiper 106 and back-release relay 120 to the shaft wiper 111, through the springs 309 and 310, winding of the release magnet 130 to the battery lead 245, thence through battery B to ground G. The release relay 120, upon energizing, places the springs 311 and 312 in contact, whereby an energizing circuit is closed through the release magnet 101, which in turn places the springs 313 and 314 in contact, which springs close a circuit through the releasing relay 256 (Fig. 2). This circuit extends from ground G¹² through the springs 313 and 314 to the trunk-release conductor 255, through the relay 256 (Fig. 2), fuse coil 173, winding of the release magnet 45 to the battery lead 199, thence through battery B to ground G. When the ground to the line conductors 34 and 35 is interrupted all the magnets involved in the release are deenergized and all of the switches are fully restored. If the called line #2220 is busy at the time that the calling subscriber #5000 attempts to establish connection, the connector H is released by the last impulse to the rotary line connector 35, as follows: The said impulse energizes the rotary line relay 142 of the connector H, which relay in turn energizes the private magnet 145, pressing the private springs 318 and 319 into contact after the private wiper 140 has been carried onto the grounded private bank contact.

It is understood, of course, that whenever the line #2220 is busy the connector private bank contacts connected with the private normal 275 are all connected to ground. Therefore, since the connector side switch is in second position when the private magnet springs 318 and 319 are brought into contact, an energizing circuit is established through the release magnet 146 from the said grounded private bank contact to the private wiper 140, thence to the side switch wiper 150 (which is in second position) to the private magnet springs 319 and 318, to the release magnet 146, through the springs 286 and 287 to the battery lead 264, thence through battery B to ground G. The connector switch shaft and side switch are thus released and connection is not established with the called line. Now, when the calling subscriber presses the signaling button, the vertical line relay 141 becomes energized and operates to close a circuit through the vertical magnet 143. The vertical magnet operates to carry the switch shaft vertically, whereby the off-normal springs 164 and 165 engage to permit the busy-signaling current to pass to the calling subscriber in the usual manner. Of course, when the subscriber hangs up his receiver after receiving the busy-signal, he grounds the line relays 141 and 142 of the connector H, as already explained, producing the release of the switching apparatus as formerly.

In the preceding it has been shown how the sub-central main office switch operates in establishing a connection. It will now be pointed out how the sub-central supervisory apparatus operates to indicate to the main exchange attendant the various troubles—that is, serious troubles, such as, first, the blowing of the main fuse 166 when the whole sub-central will be deprived of battery current, thus rendering all of the subscribers' substations of this sub-central inoperative; second, the fuse 168 in the bridge-cut-off circuit may blow. It will be understood that in a sub-central the group of bridge-cut-off relays 55 (Fig. 2), for example, will be supplied with battery current from the same fuse 168; another group, if it is desired to subdivide the line switches in one sub-exchange, may be in the same manner supplied with current from a second fuse 169. Hence, when any bridge-cut-off fuse blows, a group of bridge-cut-off relays is deprived of battery current and the lines allotted thereto are rendered inoperative; third, the master switch E may fail to operate, and all of the subscribers' line switches which are operated by the master switch E will remain opposite the same trunk-line, seizing the same trunk-line to the main exchange. Or, minor troubles, such as, first, the blowing of the fuse 171 or the fuse 172 in a subscriber's line (Fig. 2); second, the blowing of the

fuse 173 in the private trunk conductor of a trunk-line connecting a sub-central with the main exchange may blow and open the said conductor, thereby preventing the release of any line switch which might seize this particular line.

The central office apparatus which operates in connection with the aforesaid sub-central supervisory equipment comprises the two relays 175 and 176 which are connected in series with the battery, as shown in Fig. 3. Normally, both of the said relays are maintained in an operated position; but when either relay deenergizes and permits its springs to engage, a circuit is closed through its allotted lamp, ringer and generator. It will be seen that the conductor 177 which leads to the sub-central is connected between the relays 175 and 176, and hence, when the potential (either positive or negative) appears at the conductor 177, one of the said relays is short-circuited and deenergized, while the other relay remains energized. For example, when a positive or ground potential is presented on the conductor 177, then the relay 176 is short-circuited and, therefore, deenergized with the above-noted result, while the circuit through the relay 175 is maintained by the ground upon the conductor 177. If a negative or main battery potential appears, the relay 175 becomes short-circuited, deenergizing and permitting its springs to engage, thus closing the circuit controlled thereby, while a new circuit is established through the relay 176 by the negative potential at the conductor 177.

As shown in Fig. 2, the negative terminal of the battery B is connected with the busbar 178, through the fuse 166, and the positive terminal is connected with the busbar 179. From these two busbars taps or conductors lead to the various substation apparatus. As shown, the bridge-cut-off relay 55 is connected with the main battery busbar 178 over the conductor 180 through the fuse 168. Through the fuses 181 and 182 battery current may be supplied to any other apparatus. As shown in Fig. 2, the relay 183 is normally energized, since it is bridged directly across the terminals of the battery B, the circuit extending from battery B through the fuse 166 to the busbar 178, conductor 184, through the springs 185 and 186, through the relay 183, conductor 187 to the ground busbar 179, thence to ground G. When the main fuse 166 blows, then this-energizing circuit through the relay 183 becomes broken, and said relay permits the spring 188 to pass out of engagement with the spring 189 and into engagement with the spring 190; also, the spring 191 passes into engagement with the spring 192. When the spring 188 engages the spring 190 a ground potential is established on the conductor 177, as follows: From

ground G to the busbar 179 over the conductor 193, through the springs 190 and 188 to the conductor 177. As previously explained, the conductor 177 extends from the sub-central station to the main central station, hence the relay 176 becomes short-circuited and de-energizes, permitting the springs 194 and 195 to engage, whereby a local circuit is closed through the red lamp 170 in multiple with the ringer 196 and in series with the ringer generator 167. The main central attendant is thereby given both an audible and visual signal, indicating that one of the serious troubles previously mentioned has occurred at the sub-central. Furthermore, the ground upon the conductor 177 maintains the relay 175 in an energized condition, since a circuit is maintained through the said relay by the ground on the conductor 177 at the sub-central. When the springs 191 and 192 at the sub-central engage, a local circuit is closed through the battery 197 and the alarm or buzzer 198, thus giving to the sub-central attendant, if one is there, a signal indicating that the main fuse has blown. When the fuse 166 is restored the energizing circuit through the relay 183 is again established, and the relay is maintained in this energized position, as shown. Suppose a case of master switch trouble to be as follows: The master switch relay 73 energizes and places the springs 90 and 91 into contact, thereby in turn closing an energizing circuit through the master switch motor magnet 71. This circuit extends from ground G' through the springs 91 and 90, motor magnet springs 88 and 89, winding of the motor magnet 71 to the battery lead 199, thence through the busbar 178, and through battery B to ground G. The motor magnet energizes and attracts its armature 85, whereby the pawl 86 engages the next lower tooth, but for some reason the armature 85 sticks or remains in its operated position. When the springs 88 and 89 disengage a circuit is closed through the relay 200, since the said relay is bridged across the springs 88 and 89. The relay 200 now energizes and places the springs 201, 202 and 203 in contact, whereby a circuit is closed through the lamp 204 extending from ground G to the busbar 179, conductor 205, through the springs 203, 202 and 201, through the lamp 204 to the main battery busbar 178, thence through battery B to ground G. The glowing of this lamp indicates to the sub-central attendant that the master switch remains in an operated position. Also, when the said springs engage, a ground potential is placed upon the conductor 177 extending from ground G through the conductor 205, springs 203 and 202 to the conductor 177, whereby the main central signal relay 176 is again short-circuited and the main central office attendant is again given a red signal, as be-

fore. When the master switch is operating normally an energizing circuit is momentarily closed through the relay 200 when the springs 88 and 89 separate for each step of the motor magnet 71. Hence, the red signal lamp at the main central office flashes each time that the motor magnet operates the ratchet wheel 72 one step. The momentary flashing of the red signal lamp in this manner indicates to the main exchange attendant that the master switch is operating normally.

Suppose again that the fuse 168 which normally short-circuits the relay 206, and which feeds battery to the bridge-cut-off relays, blows; in that event an energizing circuit is established through the signal relay 206. The relay 206 then energizes, whereby the springs 207 and 208 are placed in contact, thus closing a series circuit including the relay 209 and lamp 210. This circuit extends from ground G through the busbar 179, conductor 211, through the relay 209, lamp 210, springs 208 and 207 to the main battery busbar 178, thence to battery B and to ground G. The glowing of the lamp 210 at the sub-central indicates that the fuse 168 has blown. The relay 209, upon energizing, disengages the springs 185 and 186, thus breaking the normally closed circuit through the relay 183. The relay 183 now deenergizes, permitting the spring 188 to engage the spring 190, whereby a ground potential is placed upon the conductor 177, as before, and again the main central office relay 176 deenergizes, giving the red signal. When the fuse 168 is restored the energizing circuit through the relay 206 is broken and the relay returns to normal position, breaking the energizing circuit through the relay 209, which also returns to normal position, permitting the springs 185 and 186 to engage, whereby the normal circuit through the relay 183 is again established and this latter relay is in turn restored to its normal energized condition.

In the preceding it has been shown how the main central attendant is signaled by the red light 170 when any one of the three serious troubles appears at the sub-central, and it will now be pointed out how the minor troubles are signaled to the main exchange attendant. Suppose that the line fuse 171 becomes blown, either by lightning or by accidental ground upon the line conductor 35, or for any reason. When the fuse 171 blows, the springs 212 and 213 engage and close an energizing circuit through the lamp 214 in series with the relay 215. This circuit extends from ground G through the conductor 216, through the springs 213 and 212, lamp 214, through the relay 215 to the main battery busbar 178, thence through battery B to ground G. The glowing of the lamp 214 indicates to the sub-central attendant that a heat coil of the group of which 171 is

a member has blown. The relay 215, upon energizing, places the springs 217 and 218 in contact, whereby a negative potential is placed upon the line conductor 177, since the resistance of the winding of the relay 215 is very low compared with the resistance of the signal lamp 214. This negative potential extends from the main battery busbar 178 through the winding of the relay 215, through the springs 218 and 217, springs 189 and 188 to the conductor 177, and to the main central office, thus short-circuiting the relay 175, which latter is connected to the battery, and completing a new energizing circuit through the relay 176 which is connected with ground. The relay 175, upon being short-circuited, deenergizes and permits the springs 219 and 220 to engage, whereby a circuit is closed through the ringer 221 in multiple with the white signal lamp 174 and in series with the ringer generator 222. The main central office attendant is thus given an audible and visual signal indicating that one of the minor troubles has occurred at the sub-central. When the heat coil 171 is restored the circuit through the lamp 214 and the relay 215 is broken, thus restoring the sub-central apparatus and central office relay 175 to normal condition. When the line fuse 172 blows, an energizing circuit is established through the relay 215 in series with the lamp 214 by the engagement of the springs 223 and 224. Also, when the heat coil 173, which is placed in the trunk-release circuit, blows, then the springs 225 and 226 engage, thus closing an energizing circuit through the relay 227 extending from ground G^2 through the relay 227, springs 225 and 226, through the bank springs 70 and 69, winding of the release magnet 45 to the main battery busbar 178, thence through battery B to ground G. It will be seen that the release magnet 45 is also included in this circuit; but since the winding of this magnet is comparatively low said magnet does not energize, but the relay 227 operates to place the springs 228 and 229 in contact, whereby a series circuit is closed extending from ground G^3 through the springs 228 and 229, lamp 230, conductor 231, relay 215 to the main battery busbar 178, thence through battery B to ground G. The glowing of the lamp 230 indicates to the sub-central attendant that the heat coil 173 has operated. Furthermore, the relay 227 may be made common to a group of heat coils of which the heat coil 173 is a member, and the glowing of the lamp 230 would indicate the group. The relay 215, being included in the above circuit, energizes and places the springs 217 and 218 in contact, whereby the negative potential is placed upon the conductor 177 in the manner previously explained, and the main exchange attendant is in turn signaled, as before.

The sub-central (Fig. 2) may be provided with a line, across the conductors 232 and 233 of which there is bridged the relay 234 in series with the condenser 235. Now, if the main exchange attendant desires to test the substation ringer generator, similar to the ringer generator K, allotted to the sub-central of which sub-central substation A' (Fig. 4) is a member, the main exchange attendant then calls the number allotted to this line, just as he would call any other line and the same connector switch (connector switch H, Fig. 4, for example) is operated to bridge the ringer generator across the terminals 232 and 233 (Fig. 2); and an energizing circuit is also established through the relay 234 in series with the condenser 235, providing the ringer generator is operating. The relay 234 energizes and places the springs 236 and 237 in contact, whereby the energizing circuit is closed through the relay 215 in series with the signal lamp 238. This circuit extends from ground G through the conductor 239, springs 236 and 237, through the lamp 238, relay 215, main battery busbar 178, thence through battery B to ground G. The relay 215 now operates to place the springs 217 and 218 in contact, with the previously explained results. By operating his signaling button the exchange attendant causes the lamp 174 to flash and thus show that the ringer generator at the sub-central is operating. If the ringer generator at the sub-central is not operating, then when this test is made the signal lamp 174 will not flash.

Fig. 4 shows the manner in which the special line 232—233 is connected to the bank contacts of the subcentral connector switches. It is to be understood, of course, that the line 232—233 in each subcentral is connected to the bank contacts of connectors in its own subcentral only.

I therefore provide a system of supervision and testing by which the main exchange is automatically kept informed of certain kinds of trouble as soon as they make their appearance; also, as to how promptly a sub-exchange attendant attends to cases of trouble, if there is an attendant at the sub-exchange, and if not, someone may be sent to look up the trouble and remedy same. I also provide means for testing the conductors of the ringer and the master switch at any instant.

From the foregoing it will be seen that I provide a telephone system in which provision is made for automatically reporting trouble to the central station operator or attendant. Furthermore, the operator or attendant may know immediately whether the trouble is of one character or another. If the trouble is of a general nature, such as would be likely to put an entire sub-central station out of service, then the automatic

signal is of a certain character. If, however, the trouble is of a less serious nature, such as would be likely to interfere only with the service of a single line at the sub-central station, then the signal is of a different character. In this way, therefore, as explained, the attendant or operator at the central station is not only enabled to readily locate the section of the exchange in which the trouble is developed, but is also in a position to know the character of such trouble. It will be seen, therefore, that the trouble man who starts out to locate the difficulty knows the nature of the work ahead of him, and can prepare himself accordingly. As shown, the cables running to the sub-central or outlying stations include outgoing and incoming trunk-lines for each station, and also a supervisory trunk-line for each sub-central station. With this arrangement there is a supervisory or signal-receiving apparatus for each group of first-selectors, comprising a red lamp and a white lamp, as described. Furthermore, the arrangement is such, as will be seen from the foregoing, that the attendant or operator at the central station can at will investigate the condition or operativeness of the apparatus at the sub-central stations. For example, the attendant or operator can call a special testing line at any sub-central station for the purpose of testing the means for applying the ringing current at such sub-central station. My invention is, therefore, of such character as to afford much closer and accurate supervision of systems of this kind than heretofore.

What I claim as my invention is:—

1. In a telephone system, a main exchange, a sub-exchange, a battery at the main exchange having one terminal grounded, two relays connected in series and bridged between the terminals of said battery, supervisory apparatus allotted to each of said relays separately, a trunk-line conductor leading from a point between the said relays to the sub-exchange, circuits at the sub-exchange, means whereby if one circuit is rendered inoperative the said conductor is grounded and one of said relays operated to give a supervisory signal, and means whereby if another circuit is rendered inoperative the said conductor is connected to the non-grounded terminal of the battery and the other of said relays operated to give a different signal.

2. A telephone system comprising a sub-exchange and a main exchange, a relay normally bridged between the positive and negative terminals of a battery at the sub-exchange, a trunk-line running to the main exchange, and a normally energized relay at the main exchange, adapted to be controlled over said trunk line by said first relay.

3. A telephone system comprising the red

lamp signal relay, a normally closed energizing circuit for said relay, an auxiliary relay for controlling said energizing circuit, a normally open energizing circuit for the auxiliary relay, a plurality of relays and a circuit associated with each one thereof, fuses, one in each of said last-mentioned circuits, whereby if any one of said fuses blows its associated relay is energized, and in turn the auxiliary relay is energized and the lamp lighted, said auxiliary relay upon energizing in turn adapted to deenergize the signal relay for causing the red signal to be displayed at the main central office, the aforesaid lamp adapted to light for indicating at the sub-exchange that the fuse has blown, as set forth.

4. In a telephone system, a main central station, a sub-central station, a main current-supplying circuit for the sub-exchange, a relay adapted to operate whenever said main circuit is broken, means responsive to such breaking for causing a signal to be given at the main central station, a plurality of subsidiary current-supplying circuits at the sub-central station, and means whereby if any one of said subsidiary circuits is opened the aforesaid relay is also operated for the same purpose.

5. In a telephone system, a main central station, a sub-central station, a main current-supplying circuit for the sub-exchange, a relay adapted to operate whenever said main circuit is broken, means responsive to such breaking for causing a signal to be given at the main central station, a plurality of subsidiary current-supplying circuits at the sub-central station, means whereby if any one of said subsidiary circuits is opened the aforesaid relay is also operated for the same purpose, and means whereby at the same time a signal is displayed at the sub-central station whenever one of the circuits is broken.

6. In a telephone system, a main central station, a sub-central station, a suitable signaling apparatus at the main central station adapted to be operated automatically from the sub-central station, current-supplying circuits of one general character at the sub-central station, current-supplying circuits of another general character at the sub-central station, automatic switching apparatus receiving current over said circuits, and suitable means at the sub-central station whereby if any circuit of one character aforesaid is opened the signaling apparatus at the main central station is caused to give a signal, and whereby if any circuit of the other character aforesaid is opened the central station signaling apparatus is caused to give a different signal.

7. In a telephone system, a main central station, a sub-central station, a suitable signaling apparatus at the main central sta-

tion adapted to be operated automatically from the sub-central station, current-supplying circuits of one general character at the sub-central station, current-supplying circuits of another general character at the sub-central station, and suitable means at the sub-central station whereby if any circuit of one character aforesaid is opened the signaling apparatus at the main central station is caused to give a signal, and whereby if any circuit of the other character aforesaid is opened the central station signaling apparatus is caused to give a different signal, said sub-central station comprising also means whereby if a signal is being displayed at the main central station to indicate an open circuit of the second general character aforesaid, then the breaking of a circuit of the first general character will relieve one signal at the main central station and substitute therefor the other signal.

8. In a telephone system, a main central station and a sub-central station, a main current-supplying circuit for the sub-central station comprising the main fuse, a plurality of subsidiary current-supplying circuits including fuses for said sub-central station, a red signal at the main central station, a red signal relay at the sub-central station associated with all of said current-supplying circuits, other current-supplying circuits comprising the heat coils and a trunk-release conductor, a white signal relay also at the sub-central station, a red signaling relay at the main central station, a white signaling relay at the main central station, a red and white signal trunk-line running from the main central station to the sub-central station, and means at the sub-central station whereby if any one of the circuits associated with the white signal relay is opened at a certain point, then the white signal relay operates to close a circuit over the said trunk-line for operating the white signal at the main central station, and means whereby if any one of the circuits associated with the red signal relay is opened at a certain point, then said relay operates to cut off the white relay circuit and substitute therefor a circuit to the trunk-line that will operate the red signal at the main central station.

9. In an automatic telephone system, a main central station, a sub-central station, a signal at the main central station, a source of current-supply at the sub-central station, a line at the sub-central station, a connector at the sub-central station, means whereby said connector may be caused to seize the said line, means whereby the said connector is operative to connect the said current-supply source with the said line, and suitable apparatus allotted to said line whereby, when the said current source is thus applied, the signal at the main central station is operated.

10. In an automatic telephone system, a couple of stations, automatic switches for connecting said stations, means including a conductor connecting the two stations exclusively for transmitting supervisory signals of more than one character, to give an attendant at one station supervision over the apparatus of the other station, and signaling means responsive to the different signals.

11. An automatic telephone system comprising a couple of stations, automatic switches for connecting said stations, telephone lines for one of said stations, means including a conductor connecting the two stations for the purpose of transmitting supervisory signals of more than one character, and signaling means at the other station responsive to the different signals.

12. An automatic telephone system comprising an automatic main central station, an automatic sub-central station, telephone lines for the sub-central station, a conductor connecting the two stations, supervisory apparatus associated with said conductor, and means whereby supervisory signals of more than one character may be transmitted over said conductor to the main station.

13. In a telephone system, a battery, two relays connected in series between the poles of said battery, signaling apparatus allotted to each of said relays, and a line connected to a point between said relays, the arrangement being such that if the said line is connected to one pole of the battery one of said relays operates its allotted signal, and if the said line is connected to the other terminal of the battery the other of said relays operates the other signal.

14. A telephone system comprising means for applying ringing current to subscribers' lines, a special testing line, a relay bridged across the said line, means by which an operator or attendant may call the said line to test the condition of the ringing current by energizing said relay, and signaling means responsive to the energizing of said relay.

15. A telephone system comprising subscribers' stations divided into groups, a group of first-selectors for each group of subscribers, and a pair of signals for each group of first-selectors, one signal of each pair being responsive to one kind of trouble within the group to which it is allotted, and the other signal of each pair being responsive to another kind of trouble within the same group.

16. A telephone system comprising a main station, sub-central stations, trunk-lines for talking purposes leading from the main station to the sub-central stations, a special supervisory trunk-line for each sub-central station, and a pair of signals for each supervisory trunk-line, said signals located at

the main central station, one signal of each pair being automatically responsive to one kind of trouble at the sub-central station thereof, and the other signal of each pair being responsive to a different kind of trouble at the same sub-central station.

17. In a telephone system, the combination of subscribers' lines, main and sub-central stations, automatic switches at said stations for extending connection from a subscriber's line, trunks for talking purposes connecting the said stations, a special trunk extending between said stations, not adapted for talking purposes, and automatic means whereby an attendant at the main station has supervision over said special trunk of the apparatus at the sub-central station with respect to different kinds of trouble thereat.

18. In a telephone system, the combination of subscribers' lines, main and sub-central stations, automatic switches at said stations for extending connection from a subscriber's line, trunks for talking purposes leading from the main to each sub-central station, a special trunk for each sub-central station, not adapted for talking purposes, signal devices at the main station, and means for automatically transmitting trouble signals over said special trunks from the said subcentral stations to said signal devices.

19. In a telephone system, the combination of subscribers' lines, main and sub-central stations, automatic switches for extending connection from a subscriber's line, a set of lamp signals at a main station responsive to and adapted to discriminate between different kinds of trouble at a sub-central station, and means for automatically controlling said signals.

20. In a telephone system, a central station and a subcentral station, a battery, and means including two relays at the central station permanently connected in series in a normally closed circuit for supervising different kinds of trouble at a subcentral station.

21. In a telephone system, a battery and a pair of relays connected in series, signals controlled by said relays, a line connected to a point between said relays, and

means for connecting said line to one or the other terminal of said battery to thereby operate one or the other of said signals.

22. In a telephone system, a battery and a pair of relays connected in series, signals controlled by said relays, a trunk line normally connected to a point between said relays, and means for connecting said line with one pole of said battery to thereby cause one of said relays to operate the signal controlled thereby.

23. In a telephone system, a pair of relays connected in series and normally energized, a signal controlled by each of said relays, and means for short-circuiting one of said relays to thereby deenergize said relay to operate the signal controlled thereby.

24. In a telephone system, a pair of relays connected in series and normally energized, a signal controlled by each of said relays, and means for short-circuiting either of said relays to thereby deenergize said relay to operate the signal controlled thereby.

25. In a telephone system, a main exchange and a sub-exchange, a pair of relays at said main exchange connected in series and normally energized, a signal controlled by each of said relays, a line connected at a point between said relays and extending to said sub-exchange, and means controllable over said line for short-circuiting one or the other of said relays to thereby operate the signal controlled thereby.

26. In a telephone system, a main exchange and a sub-exchange, a pair of relays at said main exchange connected in series and normally energized, a signal controlled by each of said relays, a line connected at a point between said relays and extending to said sub-exchange, and means at the sub-exchange for connecting said line with one or the other pole of said battery to thereby cause the operation of one or the other of said signals.

Signed by me at Chicago, Cook county, Illinois, this 26th day of November, 1907.

FRITZ LUBBERGER.

Witnesses:

EDWARD D. FALES,
R. H. BURFEIND.