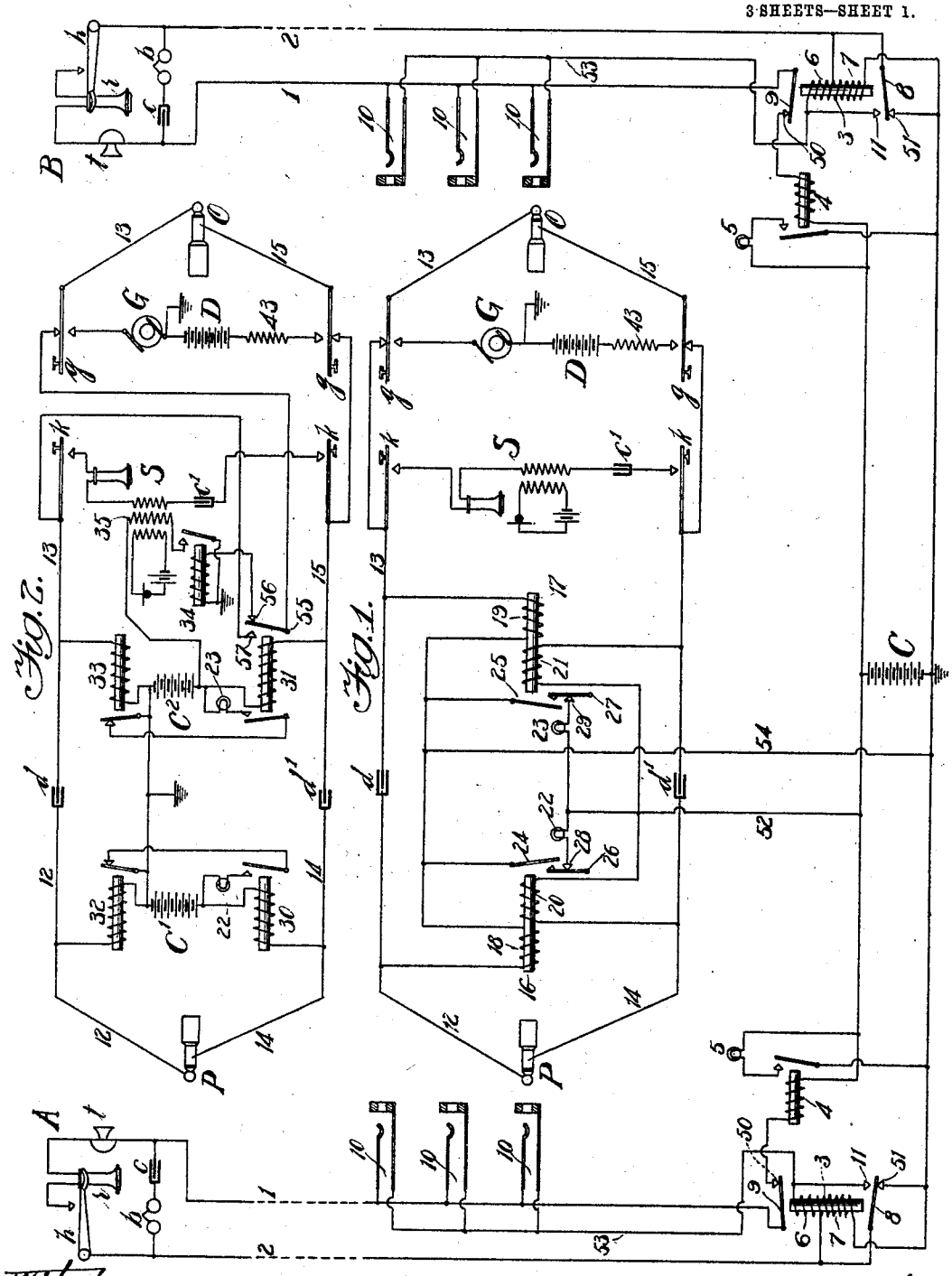
No. 795,872. PATENTED AUG. 1, 1905.

H. G. WEBSTER.

TELEPHONE EXCHANGE.

APPLICATION FILED NOV. 16, 1904.

3 SHEETS—SHEET 1.



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3 SHEETS—SHEET 2.

Fig. 3

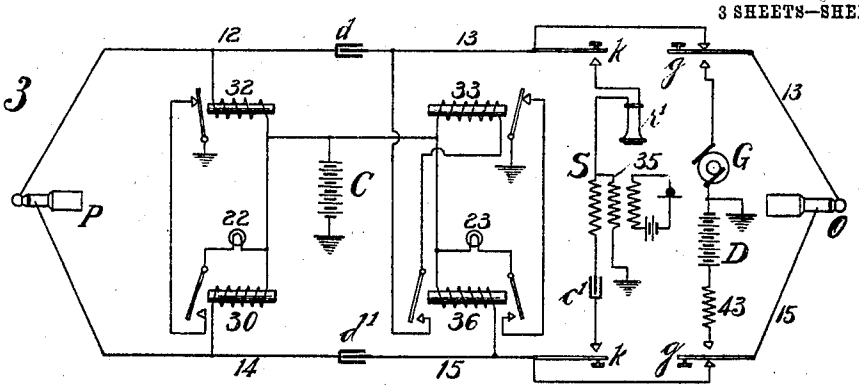


Fig. 4

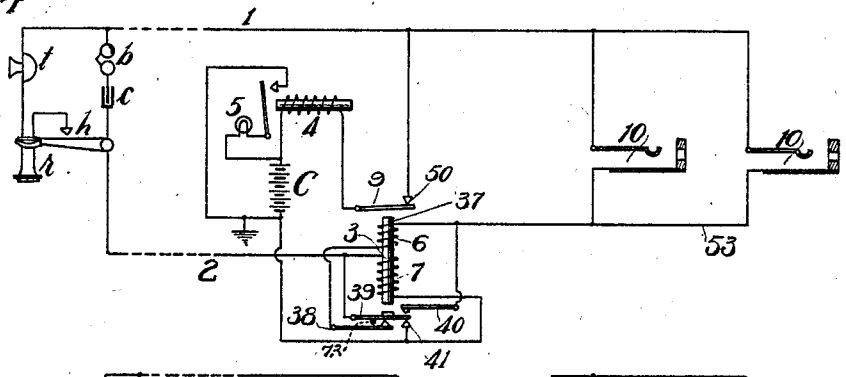


Fig. 5

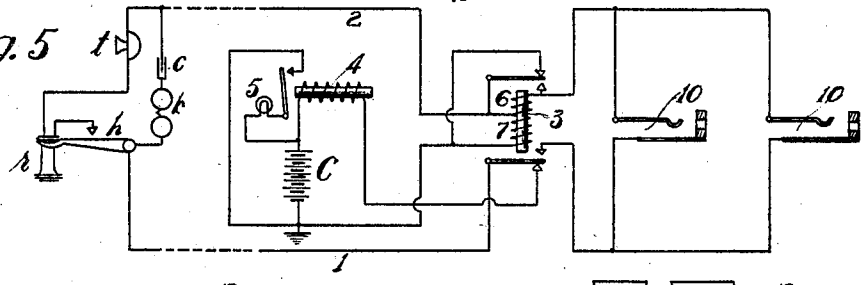
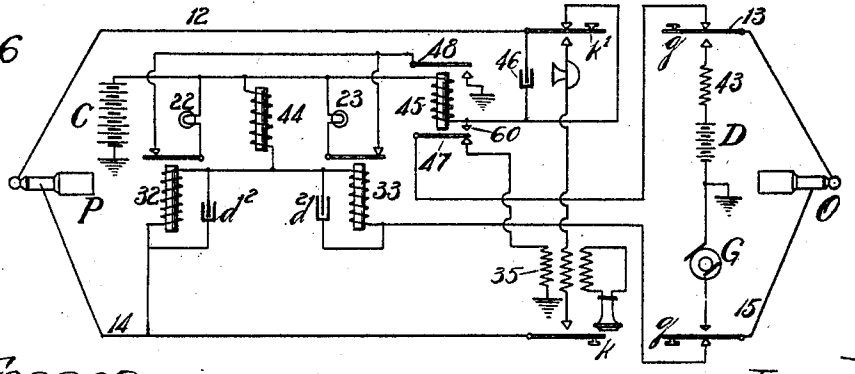


Fig. 6



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3 SHEETS—SHEET 3.

Fig. 7

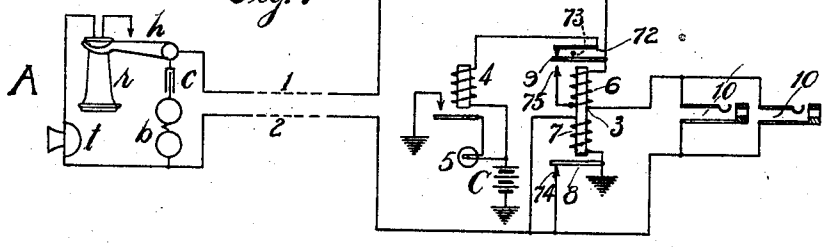


Fig. 8

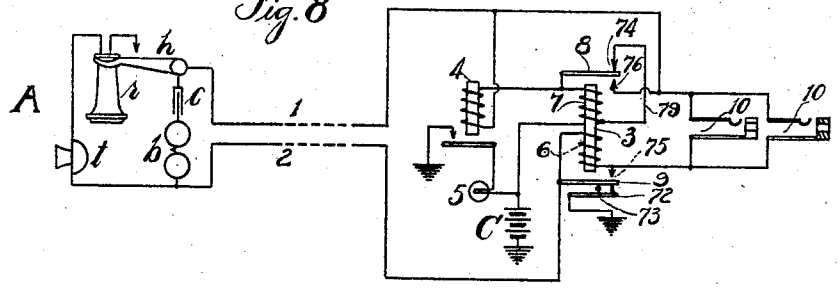


Fig. 9

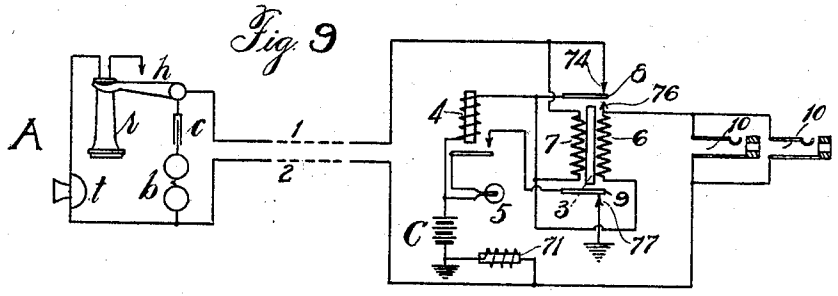
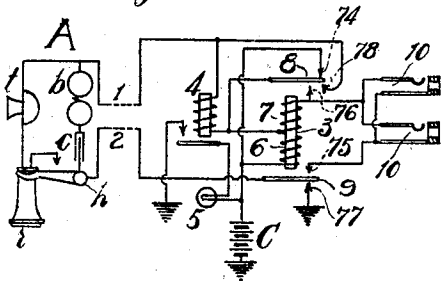


Fig. 10



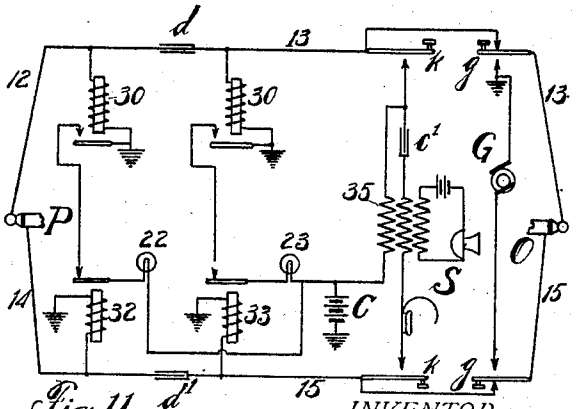


Fig. 11

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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE.

No. 795,872. Specification of Letters Patent. Patented Aug. 1, 1905.

Application filed November 16, 1904. Serial No. 232,994.

To all whom it may concern:

Be it known that I, HARRY G. WEBSTER, a citizen of the United States, and a resident of Chicago, county of Cook, and State of Illinois, have invented a certain new and useful Improvement in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

My invention relates to telephone-exchange systems employing a central battery for signaling, and particularly to that type adapted for central-battery transmission, in which the switching-terminals or spring-jacks of the lines are constructed each with only two contact-pieces connected with the two line conductors respectively, the connecting-plugs being correspondingly provided each with only two contacts, these forming the terminals of link conductors by which lines are temporarily switched together.

The principal object of my invention is to provide improved means for controlling the display of the subscriber's calling-signal and the connections of the talking-circuit, a second object being the provision of improved means for securing a positive busy test.

Other objects and advantages of my invention will be apparent to those skilled in the art from the following description.

In accordance with my invention I associate with the line-circuit a signal-controlling electromagnet, the signal being normally under the control of the subscriber, whereby a call may be initiated at the central office. A second electromagnet normally under the control of the exchange operator is also associated with the line-circuit, adapted when actuated to destroy the substation control of the said signal and to change the normal circuit of the line to one adapted for the satisfactory transmission of speech. This electromagnet and its associated mechanism may be in the form of a relay-magnet and will for convenience be hereinafter referred to as the "cut-off relay." The windings of this relay are divided into two portions, which may be of equal or different energizing capacities, and connected cumulatively with respect to their effect upon the magnet or may be of unequal energizing capacity and connected differentially with respect to their effect upon the magnet. In its preferred form the two portions are arranged upon opposite ends of the magnet-core, although I have indicated a modification in which they may be twin windings or superimposed windings.

In the preferred embodiment of my invention that portion of one line-limb extending to the substation is connected to the intermediate point of the winding or windings, one portion of the windings being connected directly to the return side of the central battery and the other portion being normally included in that portion of the line-limb extending to the switching-terminals. A normal earth connection is provided for the intermediate point of the windings of a character adapted to substantially short-circuit that portion of the windings which is connected to the return side of the battery and to prevent extraneous currents upon the line-limb from altering the electrical condition of the associated contacts of the switching-terminals.

The signal-controlling electromagnet above referred to may be in the form of a magnet controlling a mechanical signal or may be a relay-magnet controlling a signal in a local circuit, such as an incandescent lamp, and the display of this signal may be prevented either by opening its local circuit or by opening the circuit of the electromagnet or by a locking-winding adapted to prevent such display or by other obvious means well known to those skilled in the art, and I do not wish to be limited to any specific arrangement of magnet and signal or means by which the display of the signal is prevented.

Cord connecting apparatus is provided adapted upon the insertion of its connecting-plug into a switching-terminal to complete a battery-circuit which includes that portion of the relay-windings normally in circuit with a contact of the switching-terminal. The cut-off relay being thus energized, its actuation will destroy the substation control of the calling-signal, as above referred to. Furthermore, the actuation of the cut-off relay operates to disconnect the aforesaid normal earth connection, thus removing the short circuit from that portion of the windings associated with the return side of the battery, bringing said portion into branch circuit of the line, and to connect the associated line-limb directly to its corresponding contact of the switching-terminal. This direct connection may be accomplished either by short-circuiting the first-mentioned portion of the windings or by connecting the line-limb directly

to its wire leading to the switching-terminal and opening the circuit of said portion. While I have referred to this relay as having a "winding" or "windings," it will be understood that the two terms are used interchangeably and that the relay has actually a winding which is normally continuous, although a portion of this winding may be normally short-circuited or may be subsequently divided into two portions, or one portion of the winding may be connected differentially with respect to the other, and this explanation is made for the sake of clearness and to avoid limiting myself unnecessarily, inasmuch as the two portions of the winding will be hereinafter referred to as different windings for the sake of brevity.

I will describe my invention more fully by reference to the accompanying drawings, forming a part of this specification, in which—

Figure 1 illustrates two complete line-circuits together with appropriate cord connecting apparatus, all organized in accordance with the preferred form of my invention. Figs. 2 and 3 illustrate alternative cord connecting structures adapted for use with the line-circuit arrangement of Fig. 1. Fig. 4 illustrates a modification of the line-circuit arrangement of Fig. 1 in which the relay-winding associated with the switching-terminal is disconnected after the operation of the relay. Fig. 5 illustrates another modification of the line-circuit arrangement of my invention, and Fig. 6 is a diagram indicating cord connecting apparatus adapted to coöperate with the structure of Fig. 5. Figs. 7, 8, and 9 illustrate further modifications of the line-circuit of my invention, and Figs. 10 and 11 illustrate an additional modification with appropriate cord connecting apparatus.

Like characters refer to like parts in the various figures.

Referring first to Fig. 1, the subscriber's apparatus is represented as consisting of a telephone-hook switch *h*, signal-bell *b*, condenser *c*, transmitter *t*, and receiver *r*, the bell and condenser being in permanent bridge of the two line-limbs and the receiver and transmitter being in a normally open circuit, which is closed upon the elevation of the switch-hook. Although I have shown but one arrangement, it will be understood by those skilled in the art that various other arrangements of the subscriber's apparatus may be used, and I do not confine myself to the particular arrangement illustrated. Under normal conditions the receiver being upon its switch-hook the condenser *c* prevents a normal flow of current from the battery C at the central office over the telephone-line. When, however, the subscriber removes his telephone from its hook, thus establishing a relatively low resistance path for the flow of current through the transmitter *t* and receiver *r*, the signal-controlling relay 4 at the central office will be energized by the flow of current from the said battery through the winding of relay 4, anvil 50, and armature 9 of the cut-off relay 3, over limb 1 of the telephone-line, through the substation, back to the central office over limb 2, through armature 8 and anvil 51 of relay 3 to the return side of the said battery C. This energization of relay 4 closes the local circuit of the calling-lamp 5, causing its illumination and indicating to the operator that the subscriber has removed his telephone from its hook for the purpose of making a call. It will be noticed that winding 7 of relay 3 is at this time short-circuited by the contact between anvil 51 and armature 8 and that winding 6 is included in the circuit of the line-limb, which normally stands open at the sleeve contact-piece of the spring-jacks 10. Each subscriber's line is provided with one or more spring-jacks, each having contact-pieces connected thereto, and each operator is provided with cord-circuits adapted to unite the lines for conversation. On observing the calling-signal the operator will insert the left-hand or answering plug P of the cord-circuit into a spring-jack of the line corresponding to the calling-signal, thus causing the tip and sleeve contact-pieces of the plug to engage, respectively, with corresponding contact-pieces of the spring-jack. The sleeve contact-pieces of the plug and spring-jack complete a new circuit for the flow of current from battery C, which may be traced as follows: through conductor 52, winding 20 of relay 16, strand 14, wire 53, winding 6 of relay 3, armature 8, and anvil 51 to the grounded pole of the battery. This flow of current will cause the operation of relay 3, causing it to break the normal circuit of relay 4 at anvil 50 and armature 9, thereby extinguishing the calling-lamp 5. Also the attraction of armature 8 first disengages anvil 51, thus removing the short circuit from winding 7 of the relay 3 and allowing its energizing-current to now flow through both windings. The continued attraction of armature 8 causes it to engage anvil 11, thus short-circuiting winding 6; but the current which now flows through winding 7 maintains the energization of the relay as long as the plug P is in the spring-jack. Under normal conditions—namely, when the receiver at the substation is upon its switch-hook—the current which flows over the path including winding 20 of relay 16, which is established by the insertion of a plug into the spring-jack and includes the winding or windings of relay 3, suffices to cause the partial attraction of armature 24 of relay 16, bringing it into engagement with spring 26, causing the illumination of supervisory lamp 22 by current flowing from battery C through conductor 52, lamp 22, anvil 28, spring 26, armature 24, and conductor 54 to the grounded pole of the battery. The current-flow at

this time is therefore limited by the resistance of the windings of the relay 3. When the receiver is removed from its switch-hook, another path for current-flow through winding 20 is thus established, which includes limbs 1 and 2 of the line, the substation receiver and transmitter, tip contact-pieces of the spring-jack and plug, strand 12, winding 18 of relay 16, and conductor 54, which is connected to the grounded pole of the battery C. The increased energization of relay 16 due to the increase in current through winding 20 or to the energizing effect of the current through winding 18, or to both, causes the further attraction of armature 24, breaking the circuit of lamp 22 at anvil 28 and spring 26, causing the extinguishment of the lamp. Condensers *d d'* unite strands 12 and 13 and strands 14 and 15 of the cord-circuit, allowing the operator to converse with the calling subscriber at this time and to allow conversation between the two subscribers when the connection has been established. The operator actuates her listening-key levers *k k*, thus cutting her telephone S into the conversation-circuit, and having determined from the calling subscriber the number of the subscriber desired, as B, touches the tip contact-piece of the right-hand or calling plug O to the sleeve contact-piece, which also constitutes a testing-terminal of the spring-jack of the line wanted. If the line be busy, this testing-terminal will have a potential different from that of the ground or common terminal of the battery C, and a flow of current will result from said battery to tip-strands 13 through winding 19 of relay 17 and thence by conductor 54 to the return side of battery C in the well-known manner. This flow of current will alter the potential at the terminals of condenser *c'*, and thereby cause the click in the operator's receiver, which indicates that the line is busy. Should, however, the desired line be idle, the testing-terminal of the line will be at the potential of the earth or return pole of the battery C regardless of any extraneous currents or disturbances upon the line-limbs on account of the normally closed contact between armature 8 and anvil 51 of relay 3. It will be well understood that this normal connection completes a circuit from the central-office ground at battery C to that side of winding 6 which is connected to limb 2, and thereby normally short-circuits any current which might be present in the outside wire of limb 2 and prevents such current from altering the normal electrical condition of the sleeve contact-pieces or testing-terminals associated with that line-limb. Under this normal condition the testing-terminal and plug-tip would be at the same potential and no current will flow when they are brought in contact. The operator would thus hear no click, would know that the desired line was idle, would insert the right-hand plug O into the spring-jack of the desired line, and actuate the ringing-key levers *g g* to include the calling-generator G in circuit with the calling-bell *b* at the subscriber's station, thus causing the desired subscriber's bell to ring. During the actuation of the ringing-key levers relay 3 is energized by current from battery D, through resistance 43 and strand 15, in a manner the same as in case of the insertion of the answering-plug already described. Upon the restoration of the ringing-key the circuit is established through winding 21 of relay 17 and through relay 3 similar to those described with relation to relay 16, the relays 17 and 3 operating in a manner similar to that already described in connection with the line of subscriber A. Both subscribers are now in conversation with each other through the cord-strands 12 13 and 14 15, which include the condensers *d d'*, their transmitters being energized by current from battery C through the windings of relays 16 and 17 over their respective line-circuits. In this system the windings of relays 16 and 17 are of comparatively low resistance compared with the resistance of winding 7 of relays 3, thus providing for the proper distribution of the talking-current. As soon as either subscriber replaces his telephone upon its hook the corresponding relay 16 or 17 is partially deënergized, thus allowing the completion of the circuit of lamp 22 or 23 by means of the engagement of spring 26 or 27 with its corresponding anvil, causing the illumination of the lamp. When both subscribers have replaced their telephones upon their hooks, both of the said supervisory lamps will be illuminated, thus indicating to the operator that disconnection is desired. Upon withdrawing the plugs from the spring-jacks the interruption of all current through relays 16 and 17 and their consequent complete deënergization allows their armatures to return to their normal positions, extinguishing both lamps. While relays 3 are indicated as having two armatures 8 and 9, it will be understood in this and the following drawings that the relay-armatures and their associated contacts or anvils are simply diagrammatic illustrations of the switching mechanism controlled by the relay-magnet and do not refer to any particular mechanical construction. It will be understood by those skilled in the art that the switching mechanism of the relay might be controlled by a single armature or two armatures or in any other convenient manner and that this is also true of the diagrammatic illustration of relays 16 and 17 in the cord-circuit.

In Fig. 2 is indicated cord connecting apparatus adapted for association with the line-circuit apparatus of Fig. 1, differing from that previously described in that the circuits of the supervisory lamps are controlled by two relays for each lamp, rather than by a single relay adapted to two separate degrees of energization, and differs also in the arrangement

of the testing-circuit. When a subscriber, as that of line A, calls, the insertion of the answering-plug P completes a circuit from battery C′ through relay 30, strand 14, conductor 53, and relay 3, causing relay 3 to operate in the manner previously described in connection with Fig. 1. The energization of relay 30 by current flowing through this circuit would cause the illumination of lamp 22 were its circuit not open at relay 32 on account of the energization of relay 32 by current flowing through the substation apparatus and the two line-limbs. When the subscriber replaces his receiver, the circuit of relay 32 being thus interrupted, its armature closes the local circuit of lamp 22, causing its illumination. In making a busy test, if the line tested be in use current will flow from its associated sleeve-contact or testing-terminal through strand 13, armature 55 of relay 31, and its associated anvil 56 to test-relay 34 and ground or office return. Relay 34 being thus energized will complete a circuit of battery C^2 through winding 35 of the operator's induction-coil and produce the click which indicates that the line is busy. The subscriber is called, as in Fig. 1, and the restoration of the ringing-key lever completes a circuit of battery C^2 through relay 31, strand 15, conductor 55, and relay 3, causing the energization of both relays. Relay 3 operates in the manner previously described and relay 31 operates to close the circuit of the supervisory lamp 23 to disconnect the test-relay 34 at anvil 56 and to complete the circuit of strand 13 through the engagement of armature 55 with anvil 57, this contact subsequently remaining closed as long as the plug O is in the spring-jack. When the called subscriber answers, current then flows through the two line-limbs and substation apparatus, strand 13, and relay 33, energizing relay 33, which by its contacts opens the circuit of supervisory lamp 23, extinguishing it. The two subscribers are now united for conversation as in the system of Fig. 1, current, however, being furnished to the transmitter of the calling subscriber from battery C′ and to that of the called subscriber from battery C^2, and the windings of relays 30, 31, 32, and 33 are of comparatively low resistance as compared with that of winding 7 of relay 3 of the lines in order to secure the proper distribution of current.

Fig. 3 illustrates another arrangement of cord connecting apparatus adapted for association with the line-circuit apparatus of Fig. 1 and differs from that of Fig. 2 only in regard to the busy-test arrangement and in regard to the battery connections of the cord-relays. When this cord-circuit of Fig. 3 is associated with the line-circuit of Fig. 1, the winding of relay 32 and winding 7 of relay 3 of the line would both be of relatively low resistance, as compared with the windings of relay 30 or 36, in order to secure the proper distribution of current to the substation-transmitter. Upon the insertion of a plug a circuit from battery C will be completed through relay 30 and through the windings of relay 3, causing the two relays to operate, as previously described; but when the subscriber removes his receiver from its switch-hook current will then also flow from battery C through relay 32, the two line-limbs, and the substation apparatus, returning to the grounded side of the battery C through winding 7 of relay 3. This is a case, therefore, in which the current which supplies the substation-transmitter is fed to the line through cord-relay 32 and a winding of the cut-off relay 3 rather than through the two cord-relays. Referring to the busy test of the cord-circuit apparatus of this figure, it will be noticed that relay 33 is normally disconnected from tip-strand 13 of the cord and that the operator's set S is provided with an induction-coil winding 35, constituting an earth connection for strand 13 and the operator's receiver. If the line tested is idle, its testing-terminal being connected directly to ground, no current will flow through this winding 35; but if the line be busy the current will flow through strand 13, receiver r', and winding 35 to ground, causing the customary click. It will be understood that this winding 35 may have sufficient resistance and impedance to prevent undue interference with any conversation which may be taking place in the circuit of a line tested, and this will also hold good with regard to the winding of relay 34 in the cord-circuit arrangement of Fig. 2. When the plug O of Fig. 3 is inserted into the called line, a circuit for relay 36 being thus completed through conductor 53 and the windings of relay 3 of the line, the action of relay 36 brings relay 33 into connection with strand 13 of the cord, maintaining this connection as long as the plug remains in the jack, and also controls the circuit of the supervisory lamp in a manner similar to relay 30.

Fig. 4 indicates an alternative arrangement of the line-circuit apparatus of Fig. 1 and differs from it only in that winding 6 of relay 3 is opened after being short-circuited, and the two windings of the relay may consequently in this arrangement be arranged concentrically upon the magnet-core, if desired, rather than upon separate ends, as indicated in Fig. 1. When the subscriber calls, the circuit of battery C is completed, through relay 4, limb 1, transmitter and receiver, limb 2, armature 39 and anvil 41, to the grounded or return side of the battery, energizing relay 4 and causing the illumination of lamp 5. Upon the insertion of a plug current being supplied to winding 6 through conductor 53 causes the relay to operate as follows: Armature 39 first disengages anvil 41, thus allowing current to flow through winding 7 as well, engages spring 40, thus

short-circuiting winding 6, and the relay being now energized by current through winding 7 the final movement of the armature disengages armature 39 from spring 38, thus opening the circuit of winding 6. The circuit of relay 4 has also been opened at armature 9 and anvil 50 and the lamp extinguished, and a direct circuit now exists between limb 2 and the sleeve-contact of the jacks 10, which includes armature 39 and spring 40. The relay operates in a similar manner when current is supplied to conductor 53 through the actuation of the ringing-key or when the operator plugs in to answer a subscriber, as will be well understood from the previous descriptions.

In Fig. 5 is illustrated a line-circuit arrangement embodying a modification of my invention, which differs from that of Fig. 1 in that the cut-off relay 3 has its windings associated with that line-limb which is connected to the tip contact-piece of the spring-jacks rather than the sleeve-contact and in that the sleeve contact-piece or testing-terminal of the jacks is normally disconnected from the line-circuit, and therefore does not require the normal ground connection shown in Figs. 1 and 4.

Fig. 6 illustrates a cord-circuit arrangement adapted to coöperate with the line-circuit arrangement of Fig. 5, and it is to be understood that other cord-circuits are equally adaptable thereto. When a calling-plug P is inserted into a jack 10, current flows from battery C, through relay 45 and strand 12, through winding 6 of relay 3, to the return side of the battery, energizing both relays. The actuation of relay 3 breaks the normal short circuit of winding 7 and then short-circuits windings 6, as in the other systems shown, and also disconnects the line-relay 4 from the line-limb and closes the circuit of limb 1 to the sleeve contact-pieces of the jacks 10. Current is now furnished to the subscriber's line through impedance-coil 44 and relay 32, thence through limb 1, and, the receiver being removed, through the substation apparatus, limb 2, and winding 7 of relay 3, and this current also serves to energize relay 3 as long as the receiver is removed from its switch-hook and the plug P remains in the spring-jack. The operator now actuates her listening-key, obtains the number of the line desired, and makes the customary busy test. It will be observed that upon the depression of the ringing-key lever k' the circuit of relay 45 is opened at the upper contact of the lever and that if at this time the line tested is found to be busy current will flow through tip-strand 13, armature 47, and induction-coil winding 35 to ground, giving the customary click. When the operator releases her ringing-key and proceeds to call the desired subscriber, the circuit of relay 45 is again reëstablished and armature 47 is brought into engagement with contact 60, thus completing the circuit of strands 12 and 13, and armature 48, engaging its contact, completes the local circuit for the supervisory lamps 22 and 23. The operation of relay 3 during the application of the calling-current to the line will be readily understood from the foregoing descriptions, as well as its operation by current flowing through relay 45 upon the restoration of the ringing-key. When the called subscriber answers, current is supplied to his line through the winding of relay 33, finding its path to the return side of the battery through winding 7 of relay 3, associated with that line, and the current through relays 32 or 33 serves to control the circuit of the supervisory lamps in the well-known manner. The two subscribers are now connected for conversation, and their conversational circuit includes the condensers d^2 in bridge of the windings of relays 32 and 33, and current is furnished to the two lines through the impedance 44, which is common to both. If the operator actuates her listening-key while conversation is in progress, the connection between strands 12 and 13 will be broken at the upper contact of lever k'; but the conversational circuit will then be maintained by the condenser 46, as is readily apparent. It will also be understood that at this time relay 3 of the line called will have its energization maintained by current from battery C, through relay 45, contact 60, armature 47, and strand 13, and that relay 3, associated with the calling-line, will be energized by current flowing through relay 32 and the two line-limbs. The resistance of relay-winding 45 is made relatively high in this arrangement as compared with that of windings 7 and impedance 44 in order to secure the proper distribution of current, and it will be understood that other means than the condensers d^2 may be employed for preventing the ordinary impedance of the windings of relays 32 and 33 from interfering with the rapidly-alternating telephonic currents.

The line-circuit arrangement of Fig. 7 differs principally from that of Fig. 1, in that the normally open winding 6 of the relay 3 is associated with the opposite limb of the line from that with which the normally short-circuited winding 7 is connected. It also differs in that the arrangement of relay-contacts is such that the normal connection of armature 8 with its anvil will be positively broken before the corresponding connection of armature 9 is broken, as is indicated by the spring 72 and stop 73. This line-circuit arrangement is adapted for association with the cord-circuit arrangement of Fig. 2, and when so associated its operation is as follows: The subscriber A calls in the usual manner, completing a circuit of battery C through relay 4, contact-spring 72, armature 9, limbs 1 and 2 of the

line, anvil 74, and armature 8, to the ground or return side of the battery, causing the illumination of the line-signal lamp 5, but producing no effect upon the cut-off relay 3. Upon the insertion of an answering-plug a circuit of battery C is closed, which may be traced as follows: through relay 4, spring 72, armature 9, winding 6, tip contact-pieces of spring-jacks 10 and plug P, strand 12 and relay 32, thence to the ground or common return of the exchange. This current causes an initial movement of the relay-armatures, which first brings armature 8 out of engagement with anvil 74, thus removing the short circuit and allowing current from battery C′ to flow through relay 30, strand 14, the sleeve contact-pieces of the plug and spring-jack, through winding 7 of relay 3 to the return side of the battery. It will be seen that at this time the spring 72 follows the movement of armature 9 until it engages stop 73. The further actuation of the relay-contacts disengages armature 9 from spring 72, causing it to engage anvil 75, thus short-circuiting winding 6, the relay then being wholly energized by current through winding 7 and the subscriber's transmitter being energized by current from battery C′ flowing through relays 30 and 32 of the cord-circuit. In calling subscriber A the operator secures the busy test in the ordinary way, the sleeve contact-pieces of the spring-jacks 10 being normally at the potential of the central-office return, the potential being raised upon the insertion of a connecting-plug by current from battery C′ or C^2 through relay 30 or 31, as the case may be. In ringing the cut-off relay 3 is initially energized by current from generator G through winding 6; but, as will be readily seen, after this initial energization current from battery D, through winding 7, will maintain the energization during the process of ringing. After the restoration of the ringing-key current from battery C^2 through relay 31, strand 15, anvil 74, and armature 8 will cause the energization of relay 31, completing the circuit of strand 13 at armature 55 and anvil 57, after which time the operation of the cut-off relay 3 will be the same as described when the operator is answering a call. The operation of the supervisory signals of the cord-circuit is the same as that previously described for Fig. 2 and will be, therefore, clearly understood.

The line-circuit arrangement of Fig. 8 differs from that of Fig. 7, in that the normally open winding 6 of cut-off relay 3 is associated with the sleeve side of the line, and consequently with the testing-terminal of the spring-jack, the normally short-circuited winding 7 being connected with the opposite line-limb. It also differs in that the extinguishment of the line-lamp signal is secured by short-circuiting the winding of line-relay 4 rather than by opening its circuit. It is adapted for association with the cord-circuit arrangement of Fig. 1; but when this cord-circuit is used in connection with Fig. 8 the connections of the ringing-generator G should be similar to those indicated in Fig. 11, the ground being shifted to the tip side of the generator and the battery D being omitted. The protective resistance 43 may or may not be employed, as desired. The subscriber calls, as usual, by removing his receiver, thus closing a circuit of battery C through conductor 79, anvil 74, armature 8, relay 4, limbs 1 and 2, armature 9, and spring 72 to the return side of the battery. Upon the insertion of the answering-plug circuit is first completed from battery C of Fig. 1 through conductor 52, winding 20 of relay 16, strand 14, sleeve-contact of the plug and spring-jack, winding 6, armature 9, and contact 72 to the return side of the battery. This current causes an initial actuation of relay 3, and armature 8 first disengages anvil 74, thus bringing winding 7 into circuit. Current then flows from battery C of Fig. 8 through winding 7, relay 4, limbs 1 and 2 of the line to the return side of the battery and also through limb 1 to the tip contact-pieces of the spring-jacks 10, and thence to strand 12 and winding 18 of relay 16 to the office-return through conductor 54. The further movement of the relay-armatures causes armature 9 to disengage spring 72, thus breaking the normal earth connection of limb 2 and to engage anvil 75, thus short-circuiting winding 6. Armature 8 also at this time engages anvil 76, thus short-circuiting the winding of relay 4 and extinguishing the calling-lamp 5. Current is now supplied to the substation-transmitter through winding 20 of relay 16 in the cord-circuit and reaches the return side of the battery through winding 18 of the same relay, while a circuit for winding 7 is provided from battery C of Fig. 8 through armature 8, anvil 76, strand 12 of the cord-circuit, and winding 18 of the relay 16. The relay 16 is thus fully energized and supervisory lamp 22 not illuminated. When the subscriber replaces his receiver upon its switch-hook, thus opening the circuit of limbs 1 and 2, the relay 16 is then only energized by current flowing through the last-mentioned circuit, and its contacts assume their intermediate position, causing lamp 22 to become lighted. In calling subscriber A the operator tests in the usual way, the sleeve contact-pieces of jacks 10 being normally at the potential of the office-return, their potential being raised upon the insertion of a connecting-plug. Upon the actuation of the ringing-key, the generator connections being those of Fig. 11, the cut-off relay 3 is initially actuated by current from generator G through winding 6; but as soon as armature 8 disengages anvil 74 current will flow from battery C of Fig. 8 through winding 7, tip contact-pieces of the spring-jack and plug and strand

13 to the office-return, causing the complete actuation of the relay to remove the normal ground from limb 2 to short-circuit winding 6 and to short-circuit the winding of relay 4, thus preventing the display of calling-signal 5, and providing an unobstructed path for ringing-current over limbs 1 and 2. After the restoration of the ringing-key the further operation is similar to that described when answering a subscriber and will be clearly understood.

The structure of Fig. 9 differs from those of the preceding figures in that the windings of relay 3 are arranged concentrically and in that the normally short-circuited winding 7 is serially included in the line-limb after the actuation of the cut-off relay and in other respects which will appear from this description. It is adapted for association with the cord-circuit of Fig. 3 and operates as follows: The subscriber A calls in the usual manner, completing a circuit of battery C through relay 4, armature 8, anvil 74, limbs 1 and 2, and impedance 71 to the return side of the battery, thus energizing relay 4 and lighting the calling-lamp 5. Upon the insertion of the answering-plug P current will flow from battery C of Fig. 3 through relay 32, strand 12, plug and jack contacts, winding 6 of relay 3, armature 8, anvil 74, limbs 1 and 2, and impedance 71. This current will energize relay 3, extinguishing lamp 5 by opening its local circuit at armature 9 and anvil 77. Upon the disengagement of armature 8 from anvil 74 the current through relay 32 will then flow through both windings of the relay 3, and current of battery C of Fig. 9 will continue to flow through relay 4 and winding 7, and upon the engagement of armature 8 with anvil 76 winding 6 becomes short-circuited, the relay then being energized by current flowing through relays 32 and 4, through winding 7, and thence through limbs 1 and 2 and impedance 71 to the office-return. Under this condition it will be seen that while winding 7 is serially included in the line-limb it presents no objectionable interference to voice-currents, for the reason that its associated concentric winding 6 is short-circuited. It will also be seen that upon the insertion of an answering or a calling plug relay 30 or 36 of the cord-circuit of Fig. 3 will be energized by current flowing from battery C of that figure through strand 14 or 15 of the cord-circuit, the corresponding contact-pieces of the plug and spring-jack and impedance 71 to the return side of the battery, thus controlling the local circuit of the supervisory lamps and the connection of relay 33 to strand 13 in the manner previously described for this cord-circuit. The insertion of a connecting-plug into a spring-jack raises the potential of the sleeve or testing contact, and the busy test is secured in the well-known manner. In considering the operation of the apparatus when calling a subscriber it will be understood that the battery D and resistance 43 (shown in Fig. 3) would be unnecessary and therefore omitted when this cord-circuit is used in combination with the line structure of Fig. 9. Upon the actuation of the ringing-key current will flow through strand 13, winding 6, causing a partial or complete energization of the relay, and then through winding 7 and limbs 1 and 2 of the line to the return side of the generator, the partial or complete energization of relay 3 preventing the display of lamp-signal 5, which might otherwise occur through an energization of relay 4, due to the connection of the ringing-generator G to the line-limb. Upon the restoration of the ringing-key the switching mechanism of relay 3 returns to its normal position; but when the subscriber removes his receiver current flowing through relays 32 and 4 over the line-limbs will cause the initial and complete actuation of relay 3, as upon the insertion of an answering-plug.

Figs. 10 and 11 illustrate a line-circuit arrangement with appropriate cord connecting apparatus differing from that of the preceding figures in that the windings of both relays are associated with the tip side of the line-circuit and operates as follows: When subscriber A calls, the circuit of battery C is completed through anvil 74, armature 8, relay 4, limbs 1 and 2, armature 9, and anvil 77. Upon the insertion of an answering-plug P the relay 3 is initially actuated by current from battery C through anvil 74, armature 8, winding 7, strand 12, and relay 30. Upon the disengagement of armature 8 from anvil 74 current will flow through winding 6 as well, and upon the engagement of armature 8 with anvil 76 and anvil 78 the relay will be entirely energized by current through winding 6, winding 7 will be short-circuited by means of anvil 76, and relay 4 will be short-circuited by means of anvil 78. At the same time armature 9 has disengaged anvil 77 and engaged anvil 75, thus breaking the normal ground of limb 2 and completing the circuit of limb 2 to the sleeve contact-pieces of the spring-jack and plug, thence through strand 14 and relay 32. The short-circuiting of relay 4 causes the extinguishment of line-lamp 5, and current will be furnished to the substation-transmitter through winding 6 and relay 32, while the circuit of the supervisory lamp will be controlled at relay 30 by means of current flowing through this same winding 6. The sleeve-contact or testing terminal of the spring-jack being normally disconnected and being connected to earth or office return upon the insertion of a plug, the manner of securing a busy test will be understood without further description. When ringing a subscriber, relay 3 is energized by current from battery C flowing first through anvil 74, armature 8, and winding 7, to strand 13, and the office-return associated with the generator-circuit, subse-

quently flowing through winding 6 and 7, and finally through winding 6, armature 8, and anvil 76, thus preventing the false illumination of signal-lamp 5 and completing the circuit of limb 2 through armature 9 and anvil 75 to the sleeve-terminal of the spring-jacks. After the restoration of the ringing-key the operation of the line and cord circuit apparatus is similar to that described during the use of the answering-plug and needs no further description.

While various separate batteries C, C', C^2, and D are indicated in the several drawings, it will be understood that these may be one and the same battery, and also that the several grounds shown are or may be the office-return associated with the grounded side of the central battery.

In its broader phases my invention contemplates, first, a structure in which the display of the calling-signal is prevented by means of an electromagnet having two windings, one normally short-circuited, but adapted to be brought into circuit with the line when the short-circuit is removed, and the other normally included in that portion of the line-circuit extending to the spring-jack and adapted to be excluded therefrom, together with means whereby the connection of cord-circuit apparatus to the spring-jack energizes the electromagnet, and mechanism actuated by such energization adapted to remove the short-circuit, to exclude the said other winding, and to destroy the substation control of the calling-signal. Secondly, my invention contemplates the use in a two-wire central-battery telephone-exchange system of a normal earth connection substantially devoid of resistance and impedance from that line-limb connected with the testing-terminal, and therefore adapted to prevent extraneous currents in the line-limb from altering the electrical condition of said terminal, in association with means whereby the connection of the cord-circuit apparatus with a spring-jack of the line causes the removal of this normal earth connection.

Wherever the phrase "effective difference in electrical potential" or "effective difference in potential" is employed in the following claims, it is to be understood as meaning a difference of potential sufficient to cause a flow of current adapted to operate the test-receiving instrument or operator's testing instrument.

It will be understood by those skilled in the art that various modifications of my invention may be made differing from those illustrated without departing from its spirit, and I therefore do not limit myself to the precise structures shown and described; but

I claim—

1. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit with one limb of the line, means under the control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit.

2. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally connected with one limb of the line in a circuit not under control of the subscriber, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to include the said first winding in branch circuit of the line.

3. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding

being normally included in circuit with one limb of the line, means under the control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line.

4. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit with one limb of the line, means under control of the operator for causing the energization of the electromagnet, switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line, and switching mechanism adapted to destroy the substation control of the line-signal.

5. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line between the source of current and the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit.

6. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally connected with the line between a line-limb and the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to include the said first winding in branch circuit of the line.

7. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line between the source of current and the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second from the direct line-circuit and to include the said first winding in branch circuit of the line.

8. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line be-

tween the source of current and the switching-terminals, means under control of the operator for causing the energization of the electromagnet, switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line, and switching mechanism adapted to destroy the substation control of the line-signal.

9. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit.

10. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat normally not connected to said line for conversation, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally connected between a line-limb and the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to include the said first winding in branch circuit of the line and complete the conversational connection of the switching-terminals to the line.

11. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, means under control of the operator for causing the energization of the electromagnet and switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line.

12. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, means under control of the operator for causing the energization of the electromagnet, switching mechanism associated with said electromagnet adapted upon its energization to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line, and switching mechanism adapted to destroy the substation control of the line-signal.

13. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals normally not connected to said line for conversation, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts,

a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal normally controlled from the substation, an electromagnet having a normally short-circuited winding in bridge of the line with said source of current and a second winding normally connecting the line with the switching-terminal, a cord-circuit terminating in a connecting-plug, means whereby the connection of the plug with the switching-terminal causes the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to remove the short circuit from the first-mentioned winding and complete the conversational connection of the switching-terminals to the line.

14. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal, an electromagnet having a normally short-circuited winding in bridge of the line with said source of current and a second winding in the direct circuit of the line intermediate of the bridged connection and the switching-terminal, a cord-circuit terminating in a connecting-plug, means whereby the connection of the plug with the switching-terminal causes the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to remove the said second winding from the direct circuit of the line.

15. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal, an electromagnet having a normally short-circuited winding in bridge of the line with said source of current and a second winding in the direct circuit of the line intermediate of the bridged connection and the switching-terminals, a cord-circuit terminating in a connecting-plug, means whereby the connection of the plug with the switching-terminal causes the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to remove the short circuit from the first-mentioned winding and to remove the said second winding from the direct circuit of the line.

16. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having a normally short-circuited winding in bridge of the line with said source of current and a second winding in the direct circuit of the line intermediate of the bridged connection and the switching-terminals, a cord-circuit terminating in a connecting-plug, means whereby the connection of the plug with the switching-terminal causes the energization of the electromagnet, switching mechanism controlled by the electromagnet adapted upon its energization to remove the short circuit from the first-mentioned winding and to remove the said second winding from the direct circuit of the line, and switching mechanism adapted to destroy the substation control of the line-signal.

17. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal, an electromagnet having a winding in bridge of the line with said source of current and a second winding normally connecting the line with the switching-terminal, a low-resistance connection at the central office from said source of current to that line-limb associated with the first-mentioned winding, means under control of the operator for causing the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to interrupt said low-resistance connection.

18. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and pro-

vided thereat with a plurality of switching-terminals, a source of current at the central office, a magnet and an associated line-signal, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, an electromagnet having a winding in bridge of the line with said source of current and a second winding in direct circuit of the line intermediate of the bridged connection and the switching-terminals, a low-resistance connection at the central office from said source of current to that line-limb associated with the first-mentioned winding, means under control of the operator for causing the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to interrupt said low-resistance connection and to remove the said second winding from the direct circuit of the line.

19. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having a winding in bridge of the line with said source of current and a second winding in the direct circuit of the line intermediate of the bridged connection and the switching-terminals, a low-resistance connection at the central office from said source of current to that line-limb associated with the first-mentioned winding, means under control of the operator for causing the energization of the electromagnet and switching mechanism controlled by the electromagnet adapted upon its energization to interrupt the said low-resistance connection and to remove the said second winding from the direct circuit of the line, and switching mechanism adapted to destroy the substation control of the line-signal.

20. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal, an electromagnet having its winding in circuit with a talking-contact of said switching-terminals and source of current, said winding being connected to a line-limb from its intermediate point, switching mechanism controlled by said electromagnet adapted to alternately complete a circuit of low resistance from said intermediate point to either end of said winding and means under control of the operator for controlling the position of said switching mechanism.

21. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal, an electromagnet having its winding in circuit with a talking-contact of said switching-terminals and source of current, said winding being connected to a line-limb from its intermediate point, switching mechanism controlled by said electromagnet adapted to normally short-circuit one portion of said winding and when actuated to remove said short circuit and means under control of the operator for controlling the position of said switching mechanism.

22. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and provided with a plurality of switching-terminals thereat, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing instrument provided with a testing-terminal having normally no effective difference in potential from that of the normal potential of the said testing-contacts, a magnet and an associated line-signal, an electromagnet having its winding in circuit with a talking-contact of said switching-terminals and source of current, said winding being connected to a line-limb from its intermediate point, switching mechanism controlled by said electromagnet adapted to normally short-circuit one portion of said winding and when actuated to remove said short circuit and to short-circuit the other portion of said winding and means under control of the operator for controlling the position of said switching mechanism.

23. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office and pro-

vided thereat with a plurality of switching-terminals, a source of current at the central office, a testing-contact for each of said switching-terminals, an operator's testing-terminal having normally no effective difference in electrical potential from that of the normal potential of the said testing-contacts, a test-receiving instrument adapted to respond to an effective difference of potential between the said testing-terminal and testing-contacts produced through the establishment of a connection with said line, a magnet and an associated line-signal, an electromagnet having its winding in circuit with a talking-contact of said switching-terminals and source of current, said winding being connected to a line-limb from its intermediate point, switching mechanism controlled by said electromagnet adapted to normally short-circuit one portion of said winding and when actuated to remove said short circuit, to short-circuit the other portion of said winding and to destroy the substation control of the line-signal, and means under control of the operator for controlling the position of said switching mechanism.

24. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding normally connecting said terminals with one limb of the line, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection.

25. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit with one limb of the line, testing means for determining the idle or busy condition of the line, a normal earth connection substantially devoid of resistance and impedance for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and to remove the said second winding from the direct line-circuit.

26. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally interposed between said terminals and one limb of the line, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and to include the said first winding in branch circuit of the line.

27. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit with one limb of the line, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line.

28. In a telephone-exchange system, the

combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing windings the first winding being normally short-circuited and the second winding being normally included in circuit with one limb of the line, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove said second winding from the direct line-circuit, to include the said first winding in branch circuit of the line and to destroy the substation control of the line-signal.

29. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit between the line and said switching-terminals, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces, adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and complete the conversational connection of said contact-pieces to the line.

30. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line between the source of current and the switching-terminals, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces, adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and to remove the said second winding from the direct line-circuit.

31. In a telephone-exchange system, the combination with a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in circuit between the line and said switching-terminals, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces, adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with the said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to include the said first winding in branch circuit of the line and complete the conversational connection of said contact-pieces to the line.

32. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line between the source of current and the switching-terminals, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces, adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connec-

tion with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line.

33. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in direct circuit of the line between the source of current and the switching-terminals, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove said second winding from the direct line-circuit, to include the said first winding in branch circuit of the line and to destroy the substation control of the line-signal.

34. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included intermediate of the line-circuit and the switching-terminals, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection.

35. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and to remove the said second winding from the direct line-circuit.

36. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included intermediate of the line-circuit and the switching-terminals, testing means for determining the idle or busy condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection and to include the said first winding in branch circuit of the line.

37. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal, an electromagnet having two energizing-windings the first winding being normally short-

circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove the said second winding from the direct line-circuit and to include the said first winding in branch circuit of the line.

38. In a telephone-exchange system, the combination of a telephone-line connecting a substation with the central office, switching-terminals for the line having testing and talking contact-pieces normally connected to its two limbs, a source of current at the central office, a magnet and an associated line-signal normally under the control of the subscriber, an electromagnet having two energizing-windings the first winding being normally short-circuited and the second winding being normally included in that portion of the line-circuit extending to the switching-terminals, testing means for determining the busy or idle condition of the line, a normal earth connection for that line-limb associated with the testing contact-pieces adapted to prevent extraneous currents from interfering with the normal operation of said testing means, a cord-circuit adapted to make connection with said switching-terminals and to complete a circuit of said source including said second winding whereby the electromagnet is energized and switching mechanism associated with said electromagnet adapted upon its energization to interrupt said normal earth connection, to remove said second winding from the direct line-circuit, to include the said first winding in branch circuit of the line and to destroy the substation control of the line-signal.

In witness whereof I hereunto subscribe my name this 11th day of November, A. D. 1904.

HARRY G. WEBSTER.

Witnesses:
L. D. KELLOGG,
A. H. DYSON.