

931,906.

Patented Aug. 24, 1909.

2 SHEETS—SHEET 1.

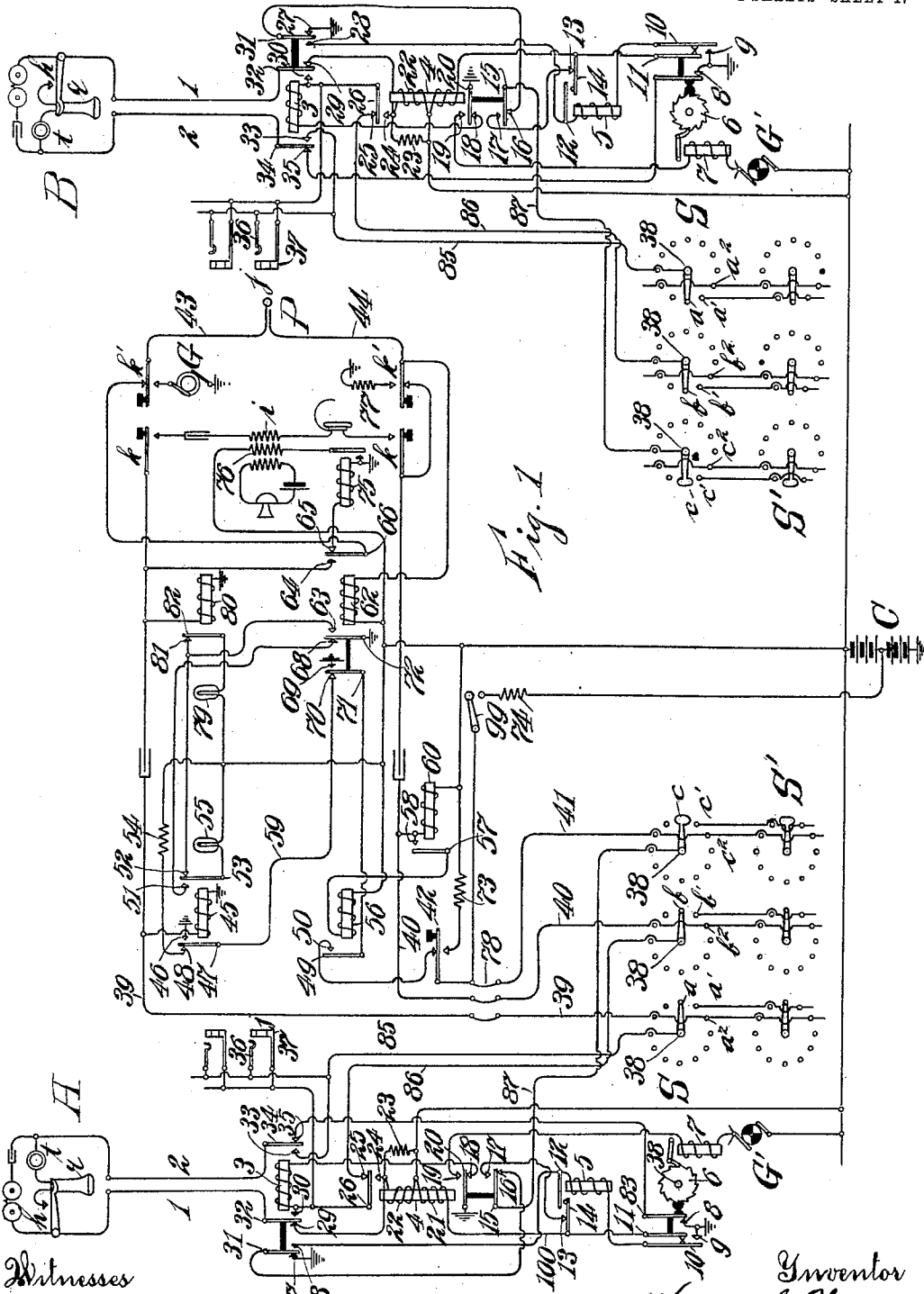


Fig. 1

Witnesses

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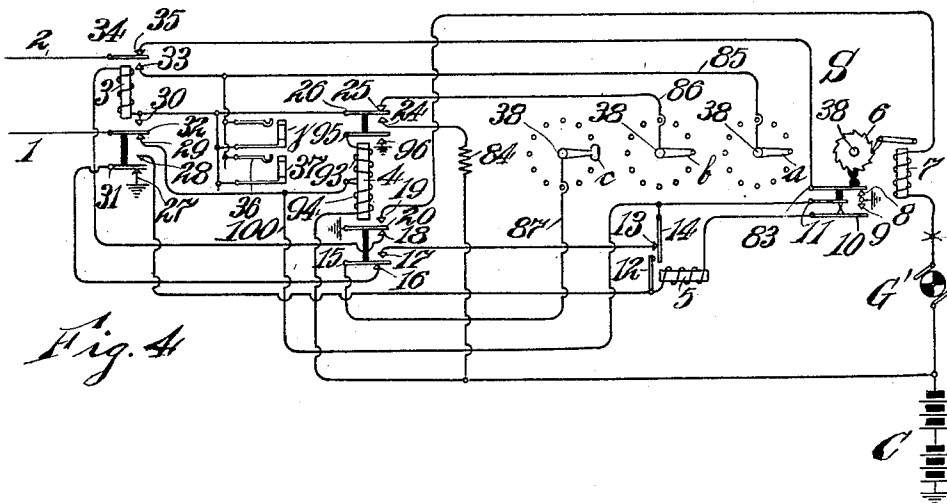
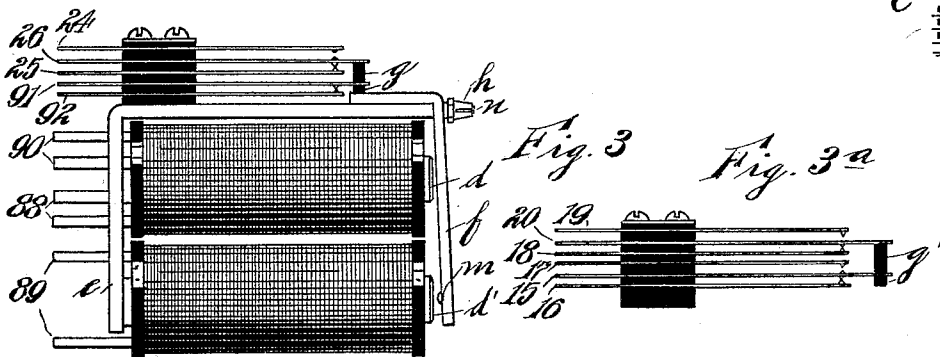
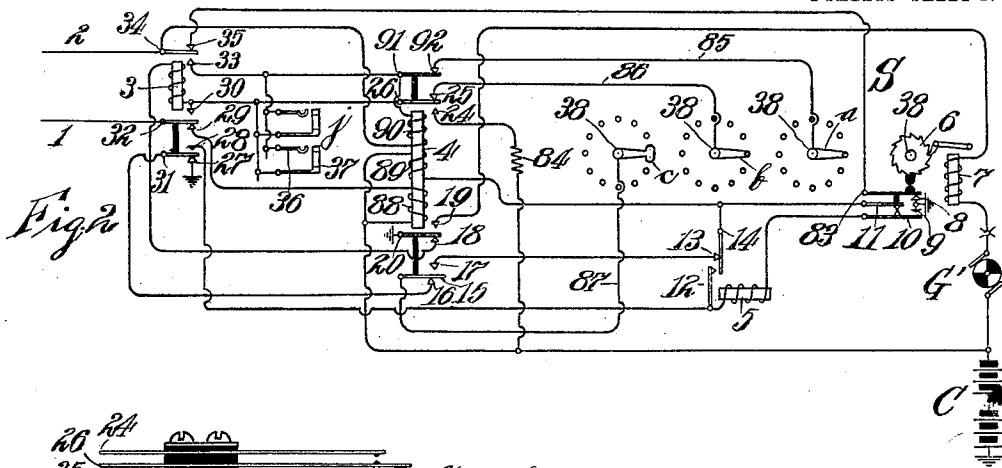
H. G. WEBSTER.
TELEPHONE SYSTEM.

APPLICATION FILED AUG. 13, 1906.

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2 SHEETS—SHEET 2.



Witnesses

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TELEPHONE SYSTEM.

931,906.

Specification of Letters Patent.

Patented Aug. 24, 1909.

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To all whom it may concern:

Be it known that I, HARRY G. WEBSTER, a citizen of the United States, and resident of Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Telephone Systems, of which the following is a specification.

My invention relates to telephone exchange systems and particularly to that type in which link-conductors are interchangeably associated with the subscribers' lines, mechanism being provided for each subscriber's line which is automatically actuated when the receiver is taken for use to connect the subscriber's line to an idle link-circuit and to cause the display of a calling signal associated with a manually controlled terminal of the link-circuit. In systems of this character, the automatic mechanism has heretofore been controlled by relay magnets in a strictly local circuit, the circuits of these magnets being initially controlled by a relay normally included in circuit with the line limbs.

One object of the present invention is to provide means whereby the last mentioned relay may be dispensed with and the line be normally connected to the local circuit, in an organization in which electrical variations occurring in the local circuit shall not be unduly propagated upon either of the line limbs.

A further object of my invention is the provision of novel means for indicating the presence of an accidental ground upon the outside circuit of the line and improved means for properly controlling the local circuit at the time connection is established between the subscriber's line and the link-conductor.

An additional feature of my invention consists in the novel structure of the relay magnet which responds at one time to current in the line, and subsequently is energized by current in the local circuit.

In accordance with my invention I provide for each subscriber's line a traveling switch which is preferably a rotating switch adapted to carry its movable contacts in one direction only. This switch is rotated by step-by-step mechanism preferably actuated by current from a pulsating generator. The switch is provided with three moving contacts or wipers which constitute the terminals individual to the line, and with fixed contacts adapted to be

engaged thereby which constitute terminals of the circuits individual to various link-conductors. These link-conductors terminate preferably in cords and plugs at the various operators' positions of a multiple switchboard, and the subscribers' lines are provided with multiple jacks at the multiple sections. The wipers of the traveling switch have a normal position in which they do not engage any of the fixed contacts of the switch, and when rotated will engage preferably first the contacts connected to a link-circuit terminating at the first operator's position, then contacts connected with a link-circuit at the second operator's position, then one leading to the third operator's position and so on; and these fixed contacts are multiply connected to similar switches individual to other subscribers' lines in a group. The other link-circuits terminating at the first, second, third and other operators' positions may be similarly connected to the switches of lines in other similar groups. The arrangement is such that if the link-conductor connected to the first terminals of a particular group of switches be in use, the switch will step ahead to the second terminal and so on until an idle link-circuit is reached when it will come to rest and the operation of associated mechanism will connect the line limbs to the talking conductors of the link-circuit and cause the display of a calling signal associated therewith. The operator, after ascertaining what connection is desired, tests the multiple jack of the desired line and makes connection by the insertion of the plug and rings the subscriber in the usual way. When conversation is finished, the removal of the connecting plug causes a further rotation of the switch to restore its wipers to their normal position.

The organization is such that if the line become accidentally crossed or grounded, the switch will rotate without stopping; or will be stepped to an idle link-circuit, but instead of coming to rest and indicating a call, will be caused to continue its rotation thereafter indefinitely and without subsequently selecting an idle circuit, and the continuous rotation of the switch will therefore indicate to those in charge the presence of the accidental cross or ground.

To secure the proper operation of the apparatus and circuits, I provide three relays individual to the subscriber's line and in this respect the present invention differs from.

others heretofore proposed. One of these relays may be called a "cut-off" relay and in addition to its usual functions its operation serves to interrupt the normal circuit of the line and to connect the line limbs to the wipers of the switch when the link-circuit is selected. A second relay, which may be called a "private" relay, serves among other functions to start and stop the traveling switch during the selection and disconnection of the link-circuit. The third relay which may be called a "release" relay is energized at the removal of the connecting plug from the jack of a called line, and controls a circuit which causes the switch to return to normal or to rotate continuously.

In further accordance with my invention I associate with that end of the link-circuit leading to the fixed contacts a pair of relays which serve to control the display of the calling signal and to control the circuit of the private and release relays; and so connect them that although connection is first completed for one talking wire only of the link-circuit, when the switch comes to rest, the relay, which is associated with that talking wire and which serves at that instant to control the circuit of the release relay, shall not be operated before the other relay associated with the opposite talking wire of the link-circuit can operate.

My invention will be more fully understood from the accompanying drawings in which—

Figure 1 illustrates two subscribers' lines extending to a central office and there associated with an appropriate link-circuit, the entire organization being in accordance with a preferred form of my invention. Fig. 2 illustrates a modification of the line circuit arrangement of Fig. 1, Figs. 3 and 3^a illustrate a novel form of relay adapted for use as the private relay in the structures of Figs. 1 and 2, and Fig. 4 illustrates a further modification of the line circuit of Fig. 1.

Like characters refer to corresponding parts in the several figures.

Referring to Fig. 1, two subscribers' lines A and B are shown, the substations being provided with the usual bell and condenser in permanent bridge of the line and the receiver *r* and transmitter *t* being in the normally open bridge closed at the upper contact of the hookswitch *h*. The limbs 1 and 2 extend to the central office and are there connected to the central battery C through the normally closed contacts of the cut-off relay 3 and through winding 22 of the private relay 4. A rotary switch S is provided for each line which is diagrammatically indicated as having a ratchet wheel 6 and wipers *a*, *b* and *c* carried on a shaft 38, the same being driven with a step-by-step motion by the motor magnet 7 when included in a closed circuit with the pulsating

generator G'. The wipers *a* and *b* are associated with limbs 2 and 1 of the line respectively, and when the shaft is rotated by the action of the magnet 7, they engage the contact pieces or fixed contacts *a'*, *a''* and *b'*, *b''*, respectively, moving out of engagement with one contact piece before engaging the next. Wiper *c* is shown as having a broad terminal and is associated with the local circuits of the system. When it is rotated it engages contact *c'* and, in stepping from *c'* to *c''*, engages *c''* before disengaging *c'*, and likewise with the other contacts over which it wiper. The fixed contacts are multiply connected to corresponding contact pieces of other switches in the same group of lines, such another switch being indicated diagrammatically at S'. The contact pieces *a'*, *b'* and *c'* are to be understood as connected to the wires of a link-circuit terminating in a cord and plug at the first operator's position, the contact pieces *a''*, *b''* and *c''* being connected, as shown, to the wires of a link-circuit terminating at what may be assumed to be a second operator's position, and so on through all of the contacts of the switch. The wires leading from the fixed contacts are indicated as being carried through a distributing rack 78, by which any other desired distribution or association of the fixed contacts and link-conductors may be made throughout the exchange. The switch is also provided with so-called "off-normal" contacts numbered 8, 9, 10, 11 and 83, which are normally in the position shown; but which are actuated at the first step of the switch to separate contacts 8 and 83, to cause contacts 9 and 10 to engage and 10 and 11 to immediately thereafter disengage. A release relay 5 is provided which is energized at the time of release and thereafter remains energized until the switch comes to rest.

When a subscriber desires to initiate a call, the removal of his receiver closes a circuit which may be traced as follows: from the upper terminal of battery C through winding 22 of relay 4, contact 29 and armature 32 of relay 3, limbs 1 and 2 of the line, armature 34 and contact 35 and through contacts 83 and 8 to the ground or return side of the battery. This current energizes relay 4 and operates all of its contacts. The attraction of armature 26 disconnects wiper *b* from its connection with the cut-off relay, and connects the test terminal 37 of the spring-jack *j* to battery C through winding 22 and resistance 23 of relay 4, thus providing the necessary potential at contact 37 of the jack to indicate that the line is busy at this time. The attraction of armature 20 disconnects the winding of relay 3 from the return side of the battery, thus preventing the energization of the relay by the battery connection just described, and completes the circuit of gen-

erator G' through motor magnet 7. The attraction of armature 15 disconnects the private wiper *c* from its normal earth connection at contact 16 and connects it to the normally closed contact 13 of the release relay 5. As will be pointed out hereafter, the contacts engaged by the private wiper *c* are connected to earth when their corresponding link-conductor is in use, and if it be idle, the wire leading from this contact stands open; and it will be assumed for the purpose of this description that the link-circuit corresponding to *c'* is at this time busy. At the energization of magnet 7, the switch makes one step, and the following action takes place. The separation of contacts 83 and 8 remove the normal ground from limb 2; the engagement of contacts 9—10 connects the winding of the release relay 5 to ground, and the disengagement of contacts 10 and 11 interrupts the connection between the winding of relay 5 and its contact 14 for a purpose to be subsequently explained. The engagement of wiper *c* with contact *c'*, which is now assumed to be connected to ground or the return side of the battery, completes an energizing circuit for relay 4 which may be traced from the upper terminal of the battery through the winding 21 of relay 4, the contacts 14—13 of relay 5, contact 17 and armature 15 of relay 4, and thence through wire 87 to the wiper *c*, and to ground through the wire leading from contact *c'*. This circuit serves to maintain the energization of relay 4 and thus the circuit of motor magnet 7, and the switch takes another step. It is to be noted that during the stepping of the wipers, wiper *a* is disconnected from the line limb 2 at contact 33, and wiper *b* from the other side of the line circuit at contact 25. As wiper *c* during the second step moves off contact *c'* and on to contact *c''*, which is open at this time at contact 49, and at switch 99 of the link-circuit, the energizing circuit just traced through winding 21 is interrupted, and the energizing circuit previously traced through winding 22 and through the line limbs was interrupted at contact 83 at the first step of the switch. Relay 4 is therefore deenergized and its contacts assume their normal position. The retraction of armature 20 opens the circuit of magnet 7, preventing further rotation of the switch, and connects the winding of relay 3 to the return side of the battery. The retraction of armature 15 connects wiper *c* to ground through contact 16, armature 31 and contact 27, the object of this ground connection at this instant being to create the busy condition immediately upon all contacts, *c''*, of other switches in the group. The retraction of armature 26 connects wiper *b* to the winding of the cut-off relay and to contact 30 of limb 1 through wire 86 and contact 25. Wiper *b* being now at rest upon contact *b''*, a

circuit for relay 3 may be traced from the upper terminal of the battery through relay 60, wire 40 of the link-circuit, contact *b''*, wiper *b*, wire 86, contact 25, armature 26, the winding of relay 3 and to the return side of the battery through contact 18 and armature 20. Relay 3 being thus energized, the attraction of its armature 34 disconnects limb 2 from the contact 83 of the switch and connects it through contact 33 to the spring 36 of the jack *j* and through wire 85 to wiper *a* which is now resting on contact *a''*. The attraction of armature 31 disconnects wiper *c* from ground at contact 27 and connects it through the winding of release relay 5 to ground at contacts 10—9 of the switch. The attraction of armature 32 disconnects the line limb 1 from winding 22 of relay 4 and connects it at contact 30 to the sleeve 37 of the spring-jacks and through armature 26 and contact 25 to the circuit previously traced, through wire 40 of the link-circuit. The energization of relay 60 has at the same time connected relay 56 to wire 40, at armature 57 and contact 58. Current will now flow from battery C through relay 56, wire 40, contact *b''*, wiper *b*, wire 86, contact 25, armature 26, contact 30, armature 32, limbs 1 and 2, armature 34, contact 33, wire 85, wiper *a*, contact *a''*, wire 39, and through the winding of relay 45 to ground, energizing relays 56 and 45. The attraction of armature 53 of relay 45 completes a circuit from battery C through lamp 55, armature 53, contact 51, and through contact 68 and armature 72 of relay 62 to the return side of the battery, thus displaying the calling signal to the operator. The attraction of armature 47 disconnects wire 59 from its normal active battery connection at 48, and connects it to the return side of the battery at contact 46. The attraction of armature 49 of relay 56 subsequently connects wire 59 through contact 70, armature 71, armature 49, contact 50, key 42 and wire 41 to contact *c''*, thus providing an alternate ground connection to that first established through contact 27, and preventing the wiper *c* of another switch from stopping on a corresponding contact *c''*.

Upon observing the calling signal, the operator answers in the usual way and, assuming that connection is desired with the line B, makes the usual busy test. If subscriber B is at this time making a call or if a connection exists at some other spring-jack of the line, or if his private relay 4 be energized as in releasing or when the switch is constantly rotating, the potential of contact 37 will be raised above that of the earth and a current will flow through the tip of the plug, strand 43, armature 66 of relay 62, contact 65, and to ground through the common test relay 75. The energization of this relay connects winding 76 of the operator's induc-

tion coil i to battery, thus giving the necessary testing indication. Assuming the line to be idle, the operator inserts the calling plug P, when current will flow from battery C, through relay 62, strand 44, contact 37, relay 3, contact 18, and armature 20 to the return side of the battery, energizing both relays. The attraction of armature 72 interrupts the circuit of lamp 55 at contact 68 and completes a circuit for lamp 79 through armature 82, contact 81 of relay 80 and through contact 63 of relay 62, and this lamp 79 remains lighted until the called subscriber answers. The attraction of armature 71 of relay 62 interrupts the earth connection of contact c^2 which was previously established through contact 46 and armature 47 and provides a new earth connection beyond the control of relay 45, at contact 69. The attraction of armature 66 disconnects strand 43 from test relay 75 at contact 65 and completes the circuit of the strand to relay 80 at contact 64. The energization of relay 3 has meanwhile caused the disconnection of limbs 1 and 2 from winding 22 of relay 4 and from the normal earth connection at contact 8, and connected them to terminals 37 and 36 of the jack j at contacts 30 and 33 respectively.

When the ringing key k' is operated, current will flow from the generator G through the cord strands and line limbs and to ground or the return side of the generator through resistance 77, relays 3 and 62 remaining energized. When the subscriber answers, current will flow through relay 62 through the line limbs and to the return side of the battery through relay 80, which by the attraction of its armature 82 extinguishes lamp 79. The two subscribers are now connected for conversation, and current flowing to wire 40, through relays 56 and 60, creates the necessary potential at contact 37 associated with line A to indicate that that line is busy and a similar condition exists at contact 37 of line B. When subscriber A replaces his receiver, the consequent interruption of the circuit through limb 2 deenergizes relay 45 and the retraction of its armature does nothing but to cause the illumination of lamp 55. When subscriber B replaces his receiver, the consequent deenergization of relay 80 causes lamp 79 to be illuminated. The illumination of both lamps constitutes the signal for disconnection, the calling plug P is then removed and the contacts of relay 3 of line B assume their normal position leaving the line in readiness for another call. The removal of plug P from the spring-jack likewise interrupts the circuit of relay 62. The retraction of its armature 72 extinguishes lamps 79 and 55 and the retraction of armature 71 removes the earth connection from the private contact c^2 and establishes a releasing circuit for the switch as follows:

from the upper terminal of battery C through resistance 54, contact 48, armature 47, contact 70, armature 71, armature 50, contact 49, the upper contact of key 42, wire 41, contact c^2 , wiper c , wire 87, armature 15, contact 16, armature 31, contact 28, and to the return side of the battery through relay 5 and contacts 10—9 of the off-normal switch. The ensuing energization of relay 5 causes its armature 12 to engage contact 14, thus completing a circuit from battery C through winding 21 of relay 4 and to ground through the winding of relay 5, and this circuit is thereafter maintained until interrupted at contacts 10—9 when the switch reaches its normal position. The energization of relay 4 interrupts the circuit of relay 3 at armature 26 and contact 25, which previously existed through wiper b and relays 56 and 60, thus allowing these relays to assume their normal positions. The busy potential is established as before for contact 37, the attraction of armature 15 disconnects wiper c from the contacts of relay 3, thus preventing interference with other connections while the wiper is rotating, and the attraction of armature 20 again closes the circuit through the motor magnet 7. The switch therefore continues to rotate until the normal position is reached, when the interruption of the circuit through winding 21 brings it to rest.

While I have shown contacts on the switch S for but 11 link-circuits, it is evident that the number is only limited by mechanical considerations and provision may be readily made for 75 or 100 such circuits. It has been found that when the wiper c is passing over the contacts of busy link-circuits and also when it comes to rest, that momentary variations in the strength of current flowing through wire 87 at such times are liable to occur, particularly after the surfaces of the contacts and wiper become worn through use. It is evident, therefore, that if but one winding be provided for the relay 4, such current variations would result in transmitting momentary impulses over the line limbs and that these impulses might create noise in other lines of the system as well as in the receiver of the calling line. To overcome this objectionable feature, the relay 4 is therefore provided with two windings, 21 and 22, and these windings are preferably arranged upon opposite ends of the core. The current variations referred to are not sufficient to interfere with the operation of the switch or to allow relay 4 to become deenergized and are therefore of instantaneous duration only, and the arrangement of winding shown tends to prevent the propagation of impulses through the line limbs. It has also been shown that when the wiper c is moving over busy contacts during the selection of an idle circuit, limb 2 of the line is

open at the contact 83 of the off-normal switch; and to still further prevent the propagation of objectionable impulses in the line limbs, the non-inductive resistance 23 is provided in shunt of winding 22 of the relay to form a short circuiting path for any impulses which may be generated in the winding at this time; and the arrangement of windings shown constitutes one feature of my invention. In case limb 1 of the line should become accidentally grounded, it will be seen that a circuit is provided for energizing relay 4 through such ground. The attraction of armature 20, completing the circuit of magnet 7, therefore causes the switch to rotate and its rotation will be continued as long as the accidental ground is present and no circuit will be selected. The arrangement of windings indicated also takes care of this condition in which the passing of wiper *c* from an idle to a busy contact or vice versa will cause an intermittent current flow through winding 21. It will also be seen from the foregoing description that as wiper *c* is traveling over busy contacts, the current which then flows through winding 21 of relay 4 tends to energize relay 5 of the line associated with such busy contacts; and such busy connection would be released except for the low resistance earth connection existing upon wire 41 of such busy contacts, which is provided at armature 71 and contact 69 or at armature 47 and contact 46. If limb 2 of the line become accidentally grounded, no operation will result until the subscriber tries to make a call. In such case, the operation of the mechanism will proceed to the point where circuit is closed through relay 56 and relay 45. On account of the presence of the accidental ground, relay 45 will be short circuited under these circumstances, and therefore unenergized. The resulting condition will be that as soon as relay 56 attracts its armature, the releasing circuit is completed from battery C through resistance 54, contact 48, armature 47, contact 70, armature 49, contact 50, key 42, and thence through wire 41, operating the release magnet 5; the switch will then rotate as at the time of regular release but if the subscriber has not yet replaced his telephone at the time the switch reaches normal, the following action will occur. The releasing circuit at the time the normal point is reached is traced from battery C through winding 21 of relay 4, contact 14, armature 12, the winding of relay 5 and to the return side of the battery through contacts 10—9 of the off-normal switch. As contact 11 is brought into engagement with contact 10 by the action of the switch, relay 5 is short circuited through the path including contacts 10—11, contact 14 and armature 12. Immediately thereafter the circuit of relay 4 through winding

21 is broken by the separation of contacts 10—9. If at this time the circuit be closed through the substation and the accidental ground of limb 2, the relay 4 is maintained energized by the resulting current through winding 22 and does not release.

The interval between the pulsations from generator G' which causes the step-by-step motion of the switch is such that, on account of the short circuit referred to, relay 5 does not have time to become deenergized and released as the switch passes the normal point. As the switch passes the normal point, the circuit through relay 5 is reestablished, the short circuit being broken at contact 9—10—11, and the switch will thus continue to rotate as long as circuit is closed at the substation. If the subscriber replaces his telephone, the switch will come to rest when the normal point is again reached through the interruption of the circuit through winding 21 and the consequent deenergization of relay 4. This method of securing the continuous rotation of the switch by short circuiting the release relay during the instant when the switch is passing the normal point, and thus delaying its deenergization, constitutes one of the features of my invention. If the two limbs of the line become accidentally crossed, the apparatus will operate as if a subscriber were calling. When the operator tries to answer the supposed call and finds that the subscriber is not calling, she will release the connection by operating key 42. The depression of this key completes a circuit from battery C through resistance 73 and the lever of key 42 to wire 41, thus energizing relay 5 as before and establishing the release circuit. The switch will now rotate until the normal point is reached but is now prevented from stopping as before, the only difference being that the circuit through winding 22, which was previously completed through the accidental ground of limb 2, is now completed over limb 2 through armature 34, contact 35, contact 83, and contact 8 when the normal point is reached. During the time that the switch is in the normal position, relay 5 as before does not have time to release and the switch therefore continues to rotate, indicating that the line is in trouble. If the subscriber should accidentally displace his receiver and then immediately replace it, thus closing circuit through the line limbs momentarily, it will be evident from the foregoing description that the switch would rotate until an idle link-circuit was selected and that then, as in the case of the accidental ground, the energization of relay 56 and the inert condition of relay 45 would result in the establishment of the release circuit. The switch is then rotated and comes to rest at the normal position. In order that the number of calls handled by each operator by means of her plurality of

link-circuits may be regulated according to the ability of the operator, or that certain cords which may become defective may be put out of service, the key 99 is provided located at any convenient point. When this key is closed, the circuit thus completed from the intermediate terminal of battery C through resistance 74 and to wire 41 results in making the cord circuit associated with that wire and switch artificially busy. When wiper *c* in its travel engages the contact of a link-circuit so connected, if the switch be selecting, the current through winding 21 will flow through resistance 74 and to the upper half of the battery. If, for any reason, as the blowing of a fuse, the wiper *c* should come to rest on a contact so connected, current would then flow from the lower half of the battery through resistance 74 and thence through wire 41, energizing relay 5 and establishing the regular release circuit, thus positively preventing the connection of a calling line to a cord circuit so put out of service.

Fig. 2 is a diagram illustrating a modification of the line circuit of Fig. 1, whereby the relay 60 associated with the link-conductor may be dispensed with and the relay 56 be directly connected to wire 40 of the link-circuit. This is accomplished by having limb 2 of the line connected normally with the wiper *a* so that when the private relay is released at the instant of selection, circuit is immediately closed through the relay 45 over the line limbs, and through relay 56 over the winding of the cut-off relay 3; thus allowing wire 59 to be disconnected from the active terminal of the central battery, before it is connected to wire 41 through the operation of relay 56; and consequently preventing the establishment of the release circuit at this time. In the structure of this figure, two windings 88 and 90 are provided for relay 4 in normal connection with the line limbs, in place of the winding 22 in the former figure. They are differentially connected in order that when the relay is deenergized at the instant of selection, the immediate completion of the circuit through the two windings and the line limbs to relay 45 of the link-circuit shall not cause the relay to become again energized. The differential connection also prevents current changes in the local circuit including winding 89, which corresponds to winding 21 of the previous figure, from causing inductive disturbances in the substation receiver. The windings 88 and 90 are preferably wound upon a different section of the core from that of winding 89. It will be understood that those portions of the system not shown in this figure may be the same as indicated in Fig. 1. When the subscriber desires to initiate a call, the closing of the circuit at the substation causes current to flow through winding 88 and

through the line limbs, but the winding 90 is excluded from circuit at this time by the earth connection through contact 35 and contacts 83 and 8. The relay 4 is therefore energized and the switch comes to rest upon the first idle link-circuit, this operation being the same as in Fig. 1. At the deenergization of relay 4 at this time, circuit is closed from battery C through winding 88, limbs 1 and 2, winding 90, armature 91, contact 92, wire 85, wiper *a*, and then referring to Fig. 1, through contact *a*², strand 39 and relay 45 to ground. At the same time circuit is closed through relay 56 of Fig. 1, wire 40, contact *b*², wiper *b* of Fig. 2, contact 25, armature 26, relay 3, contact 18 and armature 20 to ground. The current flowing through windings 88 and 90 at this instant being opposed in the two windings, relay 4 remains deenergized; and relays 56 and 45 being energized at substantially the same instant, the active battery connection of wire 59 is removed before wire 59 is connected to wire 41 at contact 50. The energization of relay 3 by current through relay 56 then disconnects winding 88 from limb 1' and short-circuits winding 90 at armature 34 and contact 33, thus establishing a satisfactory talking circuit to the wipers *a* and *b*. After the subscribers have finished their conversation, the release circuit is established in the manner previously described and the switch comes to rest at the normal position. As in the previous case, the wipers *a* and *b* are disconnected from the circuits of the line while the switch is rotating. The conditions resulting from accidental crosses or grounds produce the same results as in the previous structure.

Fig. 3 illustrates a new form of relay adapted for use as the relay 4 in the structures of Figs. 1 and 2, the arrangement of springs and windings being that diagrammatically indicated in Fig. 2. The relay has two cores, *d* and *d'*, core *d* being provided with windings 88 and 90, and core *d'* with a winding 89. A polar extension *e* of magnetic material is provided for the two cores and carries, on its extremity, the armature *f*. This armature rocks upon the end of the extension *e*, is held in place by the threaded pin *n* and nut *h*, is provided with an air-gap spacer or stop *m* of non-magnetic material, and it is in mechanical engagement with the circuit changing springs 26, 91, 20 and 15 by means of the pieces of insulation *g* and *g'*. The springs and contacts of this figure are those shown at the upper end of the relay core in Fig. 2. Fig. 3^a indicates the springs at the lower end of the relay core in Fig. 2 and these are assumed to be mounted upon the extension *e* by the side of those shown in Fig. 3, and in a similar manner. When the relay is energized by current through either of its windings, the attraction of armature *f* raises springs 26, 91,

20 and 15, causing them to disengage their lower contacts and to engage their upper contacts. By reference to the diagram of Fig. 2, it will be seen that the relay is initially energized by current through winding 88; that its subsequent energization is maintained by current through winding 89; that, when it is deenergized at the instant of selection, the circuit through winding 89 is broken while the currents through windings 88 and 90 are opposed; and that, at the time of release, it is energized by current through winding 89. The relay has the advantage over those heretofore used in that, when its armature is attracted, current variations in the windings on one core are not propagated in the windings on the other core, for the reason that the magnetic lines of force generated in one core by such variations do not traverse the opposite core on account of the air-gap between such core and the armature, but are shunted therefrom by the closed magnetic path through the extension *c* and the armature. While I have shown one particular structural arrangement embodying this principle, I do not wish to be limited to the particular arrangement shown.

Fig. 4 indicates a modification of the line circuit of Fig. 1 in which the relay 4 is provided with two windings differentially connected. The energizing winding 94 is included in circuit with the line limbs and in the local circuit as well; the opposing winding 93 serves to provide a path to earth for disturbing currents arising through current variations in the local circuit, thus preventing their undue propagation in the line limbs, without causing such earth connection to interfere with the operation of relay 4. The two windings have equal turns and may be concentric windings if desired, or may be on different sections of the core as shown. The subscriber calls in the usual way, relay 4 being energized by current through winding 94 and when the attraction of armature 95 engaging contact 96 closes a circuit through the opposing winding 93, the excess of current in winding 94 is sufficient to maintain the attraction of the relay armatures. As wiper *c* engages busy contacts, the necessary excess of current is maintained; and when wiper *c* engages the contact of an idle link-circuit, the interruption of this excess current allows relay 4 to be deenergized; and the normal operation is in all other respects similar to that of the structure of Fig. 1. When wiper *c* is passing over busy contacts during the process of selection or constantly rotating through the presence of accidental grounds or crosses on the line limbs, the momentary interruption or variation in the current flowing through wire 100 will not cause objectionable disturbances upon the line limbs

for the reason that the disturbing currents, set up in the two windings 93 and 94 at such time, will be in opposition and also for the reason that the earth connection of wire 100, through winding 93, armature 95 and contact 96, tends to prevent an increase of potential at wire 100 when the circuit through wiper *c* is varied or interrupted.

While I have described one arrangement of grouping the link-conductors or cord-circuits in their relation to the various switches and to the several operators' positions of a system, it is obvious that other methods may be employed, and I do not, therefore, wish to be limited to the particular arrangement described; neither do I wish to be limited to the particular kind of traveling switch indicated, as it is obvious that various means may be employed for causing the contacts associated with the line to travel over the contacts associated with the link-circuits. It will be understood that the various grounds indicated in the diagram are connections to the office return or to the grounded terminal of the battery *C*, that other arrangements of the windings of relay 4 than those indicated may be employed, and that various other modifications and alterations of my invention may be made without departing from its spirit.

What I consider as new and novel and desire to secure by Letters Patent of the United States, is:—

1. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and means for preventing electrical variations in the local circuit from producing disturbing currents in the line.

2. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connections between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and windings of said magnet so disposed as to prevent electrical variations in the local circuit from producing disturbing currents in the line.

3. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a travel-

ing switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and a local winding of said magnet so disposed as to prevent electrical variations in the local circuit from producing disturbing currents in the line.

4. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and a magnetic circuit for said magnet so organized that current variations in the local circuit are prevented from producing disturbing currents in the line.

5. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and a magnetic circuit and energizing windings for said magnet so organized that current variations in the local circuit are prevented from producing disturbing currents in the line.

6. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, an energizing winding of said magnet normally in circuit with the line, and a neutralizing winding of said magnet momentarily included in circuit with said energizing winding when said connection is established.

7. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to

cause the actuation of said contacts, an energizing winding of said magnet normally in circuit with the line, and a neutralizing winding for said magnet momentarily included in circuit with said energizing winding when said connection is established whereby current may flow through said energizing winding without energizing the magnet.

8. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, an energizing winding of said magnet normally in circuit with the line, an energizing winding of said magnet in a local circuit, and means for preventing electrical variations in the local circuit from producing disturbing currents in the line.

9. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, an energizing winding of said magnet normally in circuit with the line, an energizing winding of said magnet in a local circuit, and a magnetic circuit for said magnet so organized that current variations in the local circuit are prevented from producing disturbing currents in the line.

10. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, an energizing winding of said magnet normally in circuit with the line, an energizing winding of said magnet in a local circuit, and a magnetic circuit and energizing windings for said magnet so organized that current variations in the local circuit are prevented from producing disturbing currents in the line.

11. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, an energizing

winding of said magnet normally in circuit with the line, a neutralizing winding of said magnet momentarily included in circuit with said energizing winding when said connection is established, an energizing winding of said magnet in a local circuit and means for preventing electrical variations in the local circuit from producing disturbing currents in the line.

12. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay operating when energized to establish a locking-circuit for said magnet, means for interrupting said locking circuit when said moving contacts reach their normal position, and means for causing the continuous travel of said switch if said magnet remains energized after said interruption.

13. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay operating when energized to establish a locking circuit for said magnet, means for interrupting said locking circuit when said moving contacts reach their normal position, and means controlled by the travel of said switch for reestablishing the locking circuit if said magnet remains energized after said interruption.

14. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay operating when energized to establish a locking circuit for said magnet, means for interrupting said locking circuit when said moving contacts reach their normal position, and means for retarding the release of said relay at the time of said interruption whereby said locking-circuit may be reestablished by the travel of said switch.

15. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said

switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay operating when energized to establish a locking-circuit for said magnet, means for interrupting said locking-circuit when said moving contacts reach their normal position, and means for momentarily short circuiting said relay when said locking-circuit is interrupted whereby said locking-circuit is reestablished if said magnet remains energized.

16. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay in a local circuit operating when energized to establish a locking-circuit including a winding of said magnet and said relay, means for interrupting said locking-circuit when said moving contacts reach their normal position, and means for causing the continuous travel of said switch if said magnet remains energized after said interruption.

17. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay in a local circuit operating when energized to establish a locking-circuit including a winding of said magnet and said relay, means for interrupting said locking-circuit when said moving contacts reach their normal position, and means controlled by the travel of said switch for reestablishing the locking-circuit if said magnet remains energized after said interruption.

18. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay in a local circuit operating when energized to establish a locking-circuit including a winding of said magnet and said relay, means for interrupting said locking-circuit when said moving contacts reach their normal position, and means for retarding the release of said relay at the time of said interruption whereby said locking-circuit may be reestablished by the travel of said switch.

19. A telephone exchange system comprising

ing a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a release relay in a local circuit operating when energized to establish a locking-circuit including a winding of said magnet and said relay, means for interrupting said locking-circuit when said moving contacts reach their normal position, and means for momentarily short circuiting said relay when said locking-circuit is interrupted whereby said locking-circuit is reestablished if said magnet remains energized.

20. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, and a local controlling circuit for the magnet in part individual to each link-circuit and a manually operated connection therefrom to an intermediate terminal of said source to prevent the connection of a line to said link-circuit by said switch.

21. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, and a local controlling circuit for the magnet in part individual to each link-circuit and a manually operated connection therefrom to an intermediate terminal of said source to cause the establishment of a release circuit for a traveling switch associated with said link-circuit.

22. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, and a local controlling circuit for the magnet in part individual to each link-circuit and a manually operated connection therefrom to an intermediate terminal of said source whereby current through said connection shall at one time prevent the connection of a line to the link circuit by said switch and

at another time shall cause the establishment of a release circuit for a traveling switch associated with the link-circuit.

23. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a signal indicator for each link-circuit, a controlling magnet for said driving means normally in circuit with the line, said magnet operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, and means for causing a normal operation of the indicator when a calling line is connected to a link circuit.

24. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a signal indicator for each link-circuit, a controlling magnet for said driving means operating when energized to cause the actuation of said contacts, a local controlling circuit for the magnet, means for causing a normal operation of the indicator when a calling line is connected to a link-circuit, and means for causing an abnormal operation of said indicator when a line is abnormally connected to a link-circuit.

25. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, and an energizing circuit for the release relay, said circuit including a moving contact of the switch and being controlled at one point by the cut-off relay and at another point by contacts of said magnet.

26. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, and a local

energizing circuit for said magnet completed over a moving contact of the switch and controlled at one point by contacts of the release relay and at another point by contacts of said magnet.

27. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, and a moving contact for said switch normally connected to an inactive terminal of said source, means for including said contact in circuit with an energizing winding of said magnet when energized, means for including said contact in circuit with the release magnet after connection is established, and means for opening the circuit of said contact when said magnet and said release relay are both energized.

28. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, and a restoring circuit for said switch completed at the energization of the release relay, said circuit including a winding of said magnet, contacts and winding of the release relay and contacts of the off-normal switch.

29. A telephone exchange system comprising a plurality of telephone lines, a plurality of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, a normal battery connection for the cut-off relay controlled at contacts of said magnet, and an energizing circuit for said magnet including contacts of the cut-off relay.

30. A telephone exchange system comprising a plurality of telephone lines, a plurality

of link-circuits, a source of current, a traveling switch having moving contacts for establishing connection between a calling line and an idle link-circuit, driving means for said switch, a relay magnet normally in circuit with the line for controlling said driving means operating when energized to cause the actuation of said moving contacts, a cut-off relay for the line, a release relay for the line, an off-normal switch controlled by the motion of the traveling switch, and an energizing circuit for the release relay completed through contacts of the cut-off relay, contacts of said magnet and contacts of the off-normal switch.

31. A plurality of telephone lines, a plurality of associated link-circuits, automatic switching means for establishing connection between a calling line and an idle link-circuit, a relay normally connected to one talking strand of the link-circuit, second relay normally disconnected from the other talking strand of the link-circuit, a controlling circuit for said switching means jointly controlled by the relays, and means for completing circuit through the two relays simultaneously when connection is established between a calling line and the link-circuit.

32. A plurality of telephone lines, a plurality of associated link-circuits automatic switching means for establishing connection between a calling line and an idle link-circuit, a relay normally connected to one talking strand of the link-circuit, second relay normally disconnected from the other talking strand of the link-circuit, a controlling circuit for said switching means jointly controlled by the relays, and separate means simultaneously actuated for connecting the link-circuit to a calling line and for connecting said second relay to the said other strand whereby said relays are simultaneously energized.

33. A plurality of telephone lines, a plurality of associated link-circuits, automatic switching means for establishing connection between a calling line and an idle link-circuit, a relay normally connected to one talking strand of the link-circuit, second relay normally disconnected from the other talking strand of the link-circuit, a controlling circuit for said switching means jointly controlled by the relays, an electromagnet for connecting the link-circuit to a calling line, a second electromagnet for connecting said second relay to said other strand and means for establishing an energizing circuit for the two electromagnets simultaneously, whereby the said relays are simultaneously actuated.

34. A telephone exchange system comprising a plurality of telephone lines, an associated link-circuit and automatic switching means for connecting said lines for conversation, a relay normally connected to one talking strand of the link-circuit, a second

relay normally disconnected from the other talking strand of said link-circuit, a controlling circuit for said switching means jointly controlled by said relays, and means for completing circuit through the two relays simultaneously when a definite point in the establishment of said conversational circuit is reached.

35. A telephone exchange system comprising a plurality of telephone lines, an associated link-circuit and automatic switching means for establishing connection between said link-circuit and said lines, a relay normally connected to one talking strand of said link-circuit, a second relay normally disconnected from the other talking strand of said link-circuit, a controlling circuit for said switching means jointly controlled by said relays, and separate means simultaneously actuated for connecting the link-circuit and one of said telephone lines and for connecting said second relay to the said other strand whereby said relays are simultaneously energized.

36. A telephone exchange system comprising a plurality of telephone lines, an associated link-circuit and automatic switching means for establishing connection between said link-circuit and said lines, a relay normally connected to one talking strand of the link-circuit, a second relay normally disconnected from the other talking strand of said link-circuit, a controlling circuit for said switching means jointly controlled by said relays, an electromagnet for connecting the link-circuit to a definite one of said lines, a second electromagnet for connecting said second relay to said other strand, and means for establishing an energizing circuit for the two electromagnets simultaneously, whereby said relays are simultaneously actuated.

In witness whereof, I hereunto subscribe my name this 10th day of August, 1906.

HARRY G. WEBSTER.

Witnesses:

H. C. OLMSTEAD,
CAROLYN WEBER.