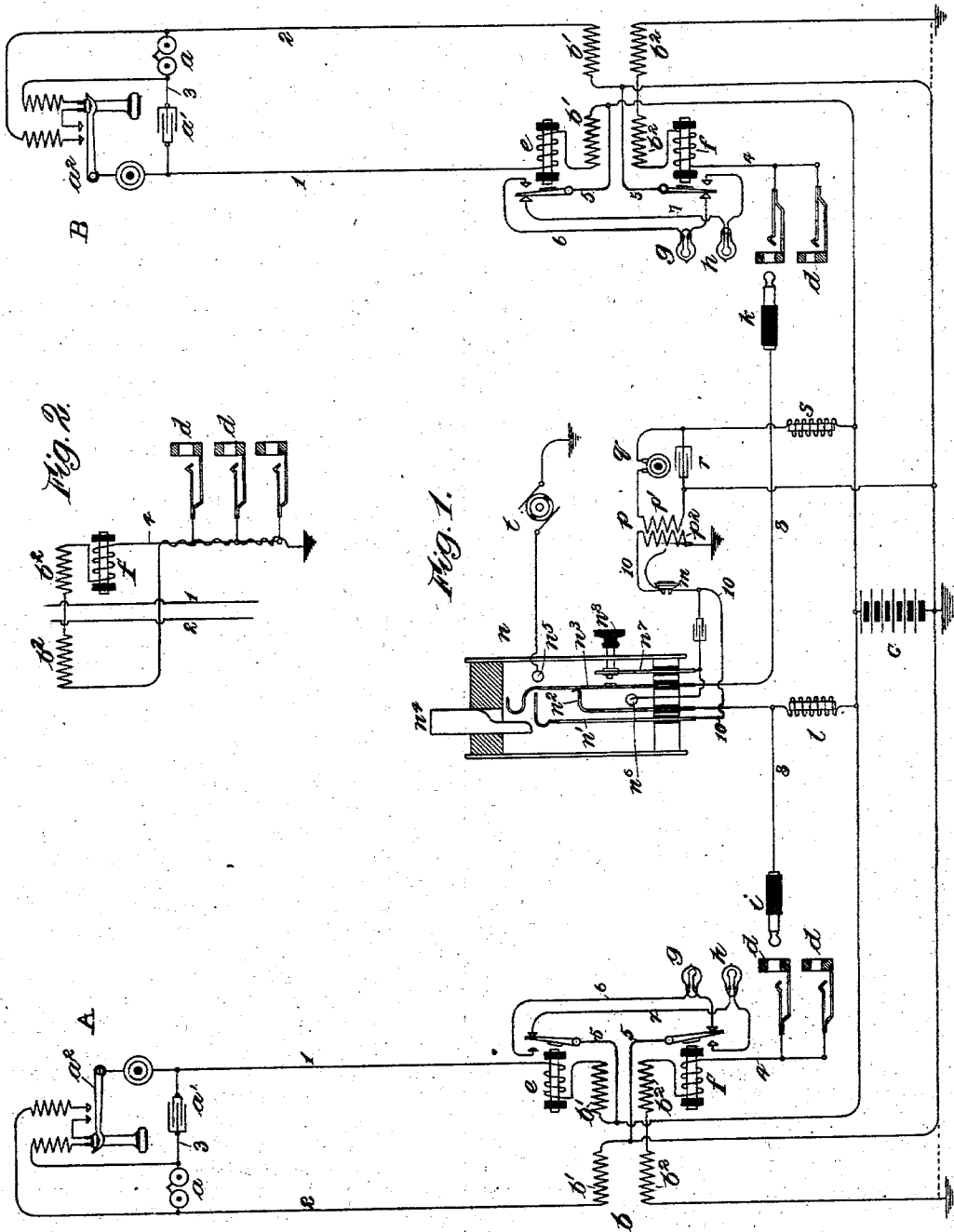


J. J. O'CONNELL.  
TELEPHONE EXCHANGE SYSTEM.  
APPLICATION FILED NOV. 30, 1900.

NO MODEL.



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# UNITED STATES PATENT OFFICE.

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## TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 730,291, dated June 9, 1903.

Application filed November 30, 1900. Serial No. 33,105. (No model.)

*To all whom it may concern:*

Be it known that I, JOSEPH J. O'CONNELL, a citizen of the United States, residing at Chicago, in the 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.

This invention relates to a telephone-exchange system; and its object is in general to improve and simplify the apparatus involved in connecting and disconnecting lines and in supervising connections.

My invention concerns more particularly telephone systems in which call-signals are automatically transmitted to the operator at the central office from the substations in the use of the substation-telephones, the switchboard-signals being subsidiary signaling instruments controlled through the medium of relays responsive to currents in the lines.

One of the principal features of the invention consists in the provision of two signals for each telephone-line at the central office, with a relay connected in the line for controlling both said signals at different times, said relay being responsive to the flow of current in the line, which is controlled through the agency of a switch at the substation. When the line is idle, one of the signals is under the control of the relay, and the other is independent of the control of said relay, and means are provided for bringing the second signal under the control of the relay when connection is made with the line, the first signal being preferably at the same time rendered inert and its control taken away from the line-relay. One of said signals, therefore, may serve as a call-signal when the line is idle, and the other may serve as a disconnect-signal or supervisory signal.

In systems heretofore proposed a supervisory signal has been associated with each operator's plug-circuit, being associated with a given line only when the plug-circuit is connected with that line; but in the system of my invention both of the signals are permanently associated with the line-relay.

I preferably associate the signaling system of my invention with a peculiar system of circuits and apparatus at the central office for

connecting lines together. In this system of my invention a repeating-coil is provided for each line, one of the windings of the repeating-coil being included in the line-circuit, together with a source of current and the signal-controlling line-relay. The other winding of the repeating-coil of each line is connected with a local circuit which has a terminal in a contact portion of the spring-jack of the line and is made up in part of the operator's plug-circuit—that is, the local circuit is adapted to be completed in registering contacts of the spring-jack and one of the plugs of the operator's plug-circuit. A second signal-controlling relay may be provided in the local switchboard-circuit of each line for changing the association of the signal-lamps with the line-relay when connection is made with the line.

One terminal of each local repeating-coil circuit is preferably connected to ground or other common return-conductor, and the other terminal thereof is led to the spring-jack of the line. Single-strand connecting-cords may therefore be employed, the spring-jacks having but a single contact-piece. It will thus be seen that the operator's cord-circuit is reduced to its simplest form—that is, a pair of plugs and a single link conductor uniting them. The operator is, however, provided with the usual call-signaling apparatus and head-telephone, together with keys for connecting such apparatus with the link conductors of her several cord-circuits.

Where one side of the local switchboard repeating-coil circuit of each telephone-line is grounded or connected with a return-conductor, I preferably lead the conductor which passes to ground alongside the conductor leading to the several multiple spring-jacks of the line, the two conductors forming a twisted pair to avoid inductive disturbances on neighboring circuits.

The conductive independence of the portion of each line extending from the substation to the repeating-coil and common battery at the central office from the portion formed by the local circuit, including the other winding of the repeating-coil and leading to the several spring-jacks of the line, has the advantage that no variation of current

in the line is produced in the act of making connection therewith. The switch connections being independent and local, annoying clicks and disturbances in the substation-telephone during the process of making connections are avoided.

Danger from fire in the switchboard caused by the access of heavy currents thereto over the telephone-line, as where the line becomes crossed with an electric-light circuit, is also prevented, because the switchboard apparatus is conductively separated from the line by the repeating-coil.

The spring-jacks and their connections being greatly simplified permit the size of the jacks to be greatly reduced, so that a much larger number of jacks may be placed within a given space within the reach of the operator.

The local signal-circuits of the two signal-controlling relays of each line are made interdependent, so that the operator in establishing or breaking the local repeating-coil circuit of each line by means of a plug can exercise a certain control over the subsidiary signal-lamp controlled by the relay, which is permanently in the line-circuit, and when the line has a connection at one of its spring-jacks, although the two portions of the line are separated by the repeating-coil, yet the subscriber at the substation may by manipulating his switch-hook exercise control to some extent over the subsidiary signal associated with the relay in the local switchboard-circuit. Two subsidiary signals, in other words, are provided for each telephone-line controlled through the agency of relays, one of said signals serving to indicate a call and the other for use to attract the operator's attention during the connection or to call for a disconnection. When a subscriber desires a connection, the removal of his telephone from its switch-hook at the substation causes the call-lamp associated with his line at the central office to be lighted, and when the operator plugs in to answer the call this lamp is extinguished and the other or disconnect lamp is brought under the subscriber's control.

I will describe my invention more particularly by reference to the accompanying drawings, in which—

Figure 1 is a diagram illustrating, by means of conventional symbols, two telephone-lines extending from substations to a central office, together with the apparatus at the central office involved in connecting the lines together, the system being provided with the apparatus and circuits of my invention. Fig. 2 illustrates how the effect of varying currents in one of the telephone-circuit conductors may be neutralized to prevent inductive disturbances on neighboring circuits.

Similar characters of reference are used to designate the same parts in both figures.

In the drawings two telephone-lines are represented extending from substations and

terminating at a central-office switchboard. Line conductors 1 2 of each line are permanently united at the substation through a conductor 3, which includes a polarized signal-bell  $a$  and which is interrupted as to unvarying currents by a condenser  $a'$ , interposed therein. The telephone talking apparatus is connected in a bridge of the line, which is normally open at the contacts of a switch-hook  $a^2$ .

At the central office the line conductors 1 2 are united through the winding  $b'$  of the repeating-coil  $b$  and through the battery  $c$ . In other words, the line conductor 1 may be considered as extending from one half of the winding  $b'$  of the repeating-coil to one pole of the battery  $c$  and the line conductor 2 through the other half of the same winding to the other pole of battery  $c$ . This battery may be common to all the telephone-lines of the exchange. The other helix  $b^2$  of the repeating-coil is included in a conductor 4, which extends from the contact-pieces of the several multiple spring-jacks  $d d$  of the line to ground or to other return-conductor.

A line-relay  $e$  is included in the line-circuit and is responsive to the flow of current in the line from battery  $c$  at the central office when a bridge of the line is closed at the substation. The conductor 4 includes the winding of a relay  $f$ . The armatures of relays  $e$  and  $f$  are united by a conductor 5 through the battery  $c$ . Two subsidiary signals, which may be incandescent lamps, are associated with each telephone-line. One of these signal-lamps  $g$  is the "call-lamp" and is included in a conductor 6, extending from the front contact of relay  $e$  to the back contact of relay  $f$ . The lamp  $h$  is the "disconnect-lamp" and is included in a conductor 7, which extends from the back contact of relay  $e$  to the front contact of relay  $f$ .

Normally when both relays are inert neither of the lamps  $g h$  will be lighted. When relay  $f$  is inert, the lamp  $h$  is cut out of the circuit and the lamp  $g$  is brought under the control of the relay  $e$ , so that when said relay becomes excited the lamp  $g$  will receive current. When relay  $f$  is excited, the lamp  $g$  is cut out of circuit and the other lamp  $h$  is brought under the control of relay  $e$ , the conditions of its control being reversed—that is to say, lamp  $h$  will be lighted when relay  $e$  is inert, but will not be lighted when said relay is excited.

The operator's cord-circuit for connecting lines together is of the simplest type, comprising a pair of plugs  $i k$ , each having but a single contact portion and a link conductor uniting them. A grounded central-office battery  $c$  is connected with the conductor 8 through a retardation-coil  $l$ .

The operator is provided with a head-telephone receiver  $m$ , which is included in a conductor 10, extending from ground to a contact-spring  $n'$  of a combined ringing and listening key  $n$ . Said conductor 10 includes the secondary winding  $p^2$  of the induction-coil  $p$ .

The primary winding of the induction-coil forms part of a local circuit which includes a transmitter  $q$  and a condenser  $r$ , and the main battery  $c$  is connected with this local circuit in shunt about the condenser  $r$  through a retardation-coil  $s$  for supplying current to the transmitter.

The combined ringing and listening key  $n$  comprises two springs  $n^2 n^3$ , which are normally in contact with each other and form the terminals of the two halves of the link conductor leading to the answering and calling plugs  $i k$ , respectively. The spring  $n^1$ , which forms the terminal of conductor 10, leading to earth through the operator's telephone, is normally out of contact with the other parts; but when the plunger  $n^4$  is depressed it first moves said spring  $n^1$  into engagement with spring  $n^3$ , separating the latter from its normal contact with  $n^2$  and allowing  $n^2$  to close against an anvil  $n^6$ , which is connected through a condenser with conductor 10 and so through the operator's telephone and the induction-coil winding  $p^2$  to earth. The spring  $n^3$  is adapted to be engaged by a shoulder on the plunger  $n^4$  when said plunger is pressed clear down, so that a complete depression of the plunger thrusts said spring  $n^3$  out of engagement with spring  $n^2$  and over against a contact-stud  $n^5$ , which is connected with the free pole of a grounded source of calling-current  $t$ , adapted to ring the call-bell at a subscriber's station. The free pole of battery  $c$  is connected through retardation-coil  $l$  with that portion of conductor 8 which extends from spring  $n^2$  to the answering-plug, so that when the plunger  $n^4$  is depressed to break the contact between  $n^2$  and  $n^3$  the connecting-plug  $k$  will be cut off from the battery. To repeat, a partial depression of the plunger serves to break the conductor 8 between the two plugs  $i k$ , leaving the answering-plug connected with the free pole of battery  $c$  and also connecting said plug through a condenser with the operator's telephone set. At the same time plug  $k$  is disconnected from battery and connected directly to the operator's telephone set. The key should be put in this position to answer the subscriber's call and to make the busy test of the called line. The key is also provided with an extra contact-spring  $n^7$ , connected through the condenser with the operator's telephone, said spring being adapted to be actuated by a push-button  $n^8$  to throw the same into contact with spring  $n^3$ . The effect of pressing button  $n^8$  when plunger  $n^4$  is in its normal position is thus to connect the telephone set through a condenser in a leg 10 to ground from the conductor 8, which unites the two plugs. This key is used in "supervising" on the circuit of the two connected subscribers.

Fig. 2 shows the manner in which conductor 4 is led from the multiple spring-jacks of each telephone-line to the repeating-coil of the line and then back around itself to ground.

The effect of varying currents in one part of the wire is thus neutralized by the effect in the mate wire, so that inductive disturbances on neighboring circuits are prevented.

The operation of the system is as follows: Subscriber A, desiring a connection, removes his telephone from its hook, thus closing a bridge of his line, whereby the circuit of battery  $c$  is completed through his line-relay. Relay  $f$  being inert at this time, the lamp  $g$  is brought under the control of relay  $e$ , and when the relay is excited and attracts its armature the local circuit 5 6 is established, whereby the lamp  $g$  receives current and becomes illuminated. The operator at the central office in response to the signal inserts her answering-plug  $i$  into the answering spring-jack of the calling-line and depresses the plunger  $n^4$  part way. This connects her telephone set with the answering-plug through the condenser and also connects it directly with the calling-plug, from which battery connection is cut off. The operator's telephone set is thus included inductively in the circuit of repeating-coil winding  $b^2$  of the calling-line, and so with the subscriber's telephone. The insertion of the plug  $i$  also closes circuit of battery  $c$  through the conductor 4, which includes the relay  $f$ , whereby said relay becomes excited and cuts out the lamp  $g$ . Relay  $f$  in drawing down its armature not only breaks the circuit of lamp  $g$ , but also brings the circuit 7, containing the disconnect-lamp  $h$ , under the control of relay  $e$ . The disconnect-lamp is not lighted, because the circuit thereof is broken at the contacts of relay  $e$ . When the number of the desired correspondent-line B has been obtained, the operator may test the multiple spring-jack of that line at her board in the usual way, by touching the tip of the connecting-plug to the spring-jack and listening in with her head-telephone. If the called line has a connection at any one of its multiple spring-jacks, grounded battery will be applied to all the multiple spring-jacks of the line in establishing connection, and when the tip of the operator's connecting-plug  $k$  is touched to any one of the multiple spring-jacks a circuit will exist from the plug through conductor 8 to spring  $n^3$ , spring  $n^1$  in contact therewith, conductor 10, through the operator's head-telephone to ground. Current in this circuit will cause a click in the telephone, which will notify the operator that the line is busy. If the called line is free, the operator inserts the connecting-plug  $k$  into the spring-jack and presses her plunger  $n^4$  clear down, thus severing the link conductor 8 and applying the grounded ringing-generator  $t$  to the connecting-plug. Ringing-current will thus find its way from the grounded generator to the spring-jack of the called line through the conductor 4 thereof, which includes the winding  $b^2$  of its repeating-coil, and thence to ground. The passage of current through the winding  $b^2$  of the repeating-coil will induce a

similar current in the other winding  $b'$ , which current will flow out over the line and ring the bell at the called station. The insertion of the connecting-plug into the spring-jack  
 5 of the called line will close the circuit of battery  $c$  through the relay  $f$  of that line, whereby the disconnect-lamp will be brought under the control of the line-relay of that  
 10 line. Until the called party responds the line-relay will be inert, so that the circuits 5 7 will be completed and the disconnect-lamp will be lighted. The operator at the particular multiple section of the switchboard where this lamp may be located will  
 15 attach no importance to the signal. In practice the disconnect-lamps will all be red and the call-lamps white. An operator seeing a red lamp lighted at any time will pay no attention to it unless it is the lamp of a line  
 20 whose answering-jack is on her section and which she herself has connected. If a red lamp, however, should remain lighted for a considerable length of time or should flash, it will indicate that the line of that subscriber  
 25 is tied up on some other section of the board and is not receiving proper attention, whereupon the operator at whose board the lamp is flashing will call the attention of the chief operator to the trouble. When the called  
 30 party responds, his disconnect-lamp will be extinguished. The two subscribers A B are now connected together for conversation, the two lines being united inductively through the medium of their respective repeating-coils, the circuit through the switchboard being a local circuit with no conductive connection with the line-circuits. The operator may at any time listen in by depressing her key  $n^8$ , which will connect her telephone inductively in a bridge of the switchboard-circuit. When the conversation is finished, the disconnect-signal must be given by the calling subscriber. When he replaces his telephone on its hook, the bridge of his line is broken, thus depriving his line-relay  $e$  of current. The armature of relay  $e$  on falling back closes the circuit 5 7 through the red disconnect-lamp  $h$ , whereby said lamp is illuminated, constituting a signal to the operator that the conversation is finished. The operator thereupon removes the plugs from the spring-jacks of the lines which have been connected. This breaks the switchboard-circuit 4 of each line, whereby the relay  $f$  is deenergized and allows its armature to fall back, thus cutting out the disconnect-lamp and bringing the call-lamp under the control of the line-relay.

Having thus described my invention, I claim as new, and desire to secure by Letters  
 60 Patent, the following:

1. The combination with a telephone-line extending from a substation to a central office, of a source of current and a signal-controlling relay in the line-circuit, a switch at the substation for determining the flow of current in the line, a subsidiary signal  $g$  normally under the control of said relay, a second sub-

70 subsidiary signal  $h$  permanently connected with the relay and individual to the line, but normally independent of the control of said relay, and means, controlled by connection with the line at the central office, for bringing the last-mentioned signal under the control of the relay, substantially as set forth.

2. The combination with a line-circuit, of a source of current and a line-relay in the circuit, a switch for determining the flow of current in the line, two subsidiary signals permanently associated with the line, a local circuit for each signal, and switch-contacts operated by the line-relay, controlling said local circuits alternately, said switch-contacts being adapted to close one or the other of said local circuits alternately as the relay is inert or excited, substantially as set forth. 85

3. The combination with a line-circuit, of a source of current and a line-relay in the circuit, a switch for determining the flow of current in the line, two subsidiary signals permanently associated with the line, a circuit for each signal, and switch-contacts operated by the line-relay, controlling said signal-circuits, said switch-contacts being adapted to close one or the other of said signal-circuits alternately as the relay is inert or excited, a local circuit forming an inductive extension of the aforesaid line-circuit, means for controlling the same, a second relay  $f$  in said local circuit, and switch-contacts, controlled by said relay  $f$ , for alternately bringing either  
 90 the one or the other of said subsidiary signals under the control of the line-relay, substantially as described. 95

4. The combination with a telephone-line extending from a substation to a central office, of a source of current, a line-relay and a winding of a repeating-coil included in the line-circuit, a switch at the substation for determining the flow of current in the line, a spring-jack for the line, and a local switchboard-circuit including a second winding of said repeating-coil and forming an inductive extension of the line, an operator's plug and plug-circuit for making connection with the line, to complete said local switchboard-circuit, two subsidiary signal-lamps  $g$   $h$  for the line, and circuits including the same, said circuits being adapted to be controlled by the line-relay, a second relay in the local switchboard-circuit of the telephone-line, and switch-contacts, controlled by said relay, for bringing said subsidiary signals alternately under the control of the line-relay, substantially as set forth. 110 115 120

5. The combination with a line-circuit including a source of current, a line-relay and a switch for controlling the flow of current in the line, a local circuit including a source of current and a second relay  $f$ , and means for opening and closing said local circuit, an armature for each of the aforesaid relays, a source of current in a conductor uniting said armatures, front and back contacts for each armature, a conductor 6 including a signal  $g$ , 125 130

uniting the front contact of one relay and the back contact of the other, and a conductor 7, including a second signal *h*, uniting the back contact of the first-mentioned relay with the front contact of the other, substantially as set forth.

6. The combination with a telephone-line extending from a substation to a central office, of a source of current, a line-relay and a winding of a repeating-coil included in the line-circuit, means at the substation for determining the flow of current in the line, a local switchboard-circuit including a second winding of the repeating-coil and forming an inductive extension of the line, said local circuit being closed in registering contacts of a spring-jack of the line and a plug of an operator's plug-circuit, a signal *g* normally under the control of the line-relay, a second signal *h* and a relay in said local circuit, adapted to bring said second signal under the control of the line-relay, substantially as set forth.

7. The combination with two telephone-lines extending from substations to a central office, each of said lines having two limbs united at the central office through a source of current and a winding of a repeating-coil, a line-relay in each line and a switch at each substation for determining the flow of current in its line, a spring-jack for each line, and an operator's plug-circuit for uniting said spring-jacks, a secondary winding for each repeating-coil, a local switchboard-circuit including the secondary windings of the repeating-coils of both lines, established in connecting the spring-jacks of said lines together, a supervisory relay in said local switchboard-circuit, and a subsidiary signal controlled jointly by the supervisory relay and the line-relay, substantially as set forth.

8. The combination with a telephone-line extending from a substation to a central office, of a winding of a repeating-coil included in the line-circuit, a spring-jack for the line, a plug adapted for insertion in said spring-jack and a conductor connecting said plug with ground or other return-conductor, a second winding for said repeating-coil, and a conductor 4 extending from a contact-piece of the spring-jack with which the plug is adapted to engage through said second winding of the repeating-coil and back upon itself, forming a mate wire, and thence to said return-conductor, the two ends of said conductor forming a twisted pair, whereby the inductive

effect of varying currents in each limb of the conductor upon neighboring circuits is neutralized by the effect of the current in the mate wire, substantially as described. 60

9. The combination with a telephone-line and a switch at the substation for determining current in the line in the use of the telephone, a line-relay for the line, a line-signal associated with the line, and a local circuit of said line-signal controlled by the line-relay, a supervisory signal, a spring-jack and plug for making connection with the line, a local circuit closed in registering contacts of said spring-jack and plug, and a switching-relay in said local circuit, said switching-relay controlling the circuits of both the line and supervisory signals, being adapted to break the control of the line-relay over the line-signal and to bring the other signal under control of the line-relay, as described. 75

10. In combination with a telephone-line and means for producing current in the line in the use of the telephone, a line-relay in the line and alternative local circuits of said relay, a subsidiary signal in each of said circuits, a switching-relay, a spring-jack for the line, a plug and plug-circuit for making connection therewith, and a local circuit for said switching-relay closed in making connection with the line at the spring-jack thereof, said switching-relay being adapted to break one of said alternative circuits and to close the other, as described. 85

11. In combination, two telephone-lines each having its circuit completed through windings of a repeating-coil, said circuits being inductively united by a link conductor, together with individual portions of line-circuits containing other windings of the same repeating-coils, a line-relay in each line and two subsidiary signals adapted for control thereby, a switching-relay for each line, in the individual portion of said line associated with the link conductor, and a source of current for exciting said switching-relays connected with said link conductor, said switching-relays being adapted to shift the controlling-circuit of said line-relays, respectively, from one to the other of the subsidiary signals of the same line, as described. 105

In witness whereof I hereunto subscribe my name this 11th day of October, A. D. 1900.

JOSEPH J. O'CONNELL.

Witnesses:

DE WITT C. TANNER,  
W. W. LEACH.