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PATENTED FEB. 19, 1907.

F. W. DUNBAR.
TELEPHONE TRUNKING SYSTEM.
APPLICATION FILED AUG. 6, 1902.

2 SHEETS—SHEET 1.

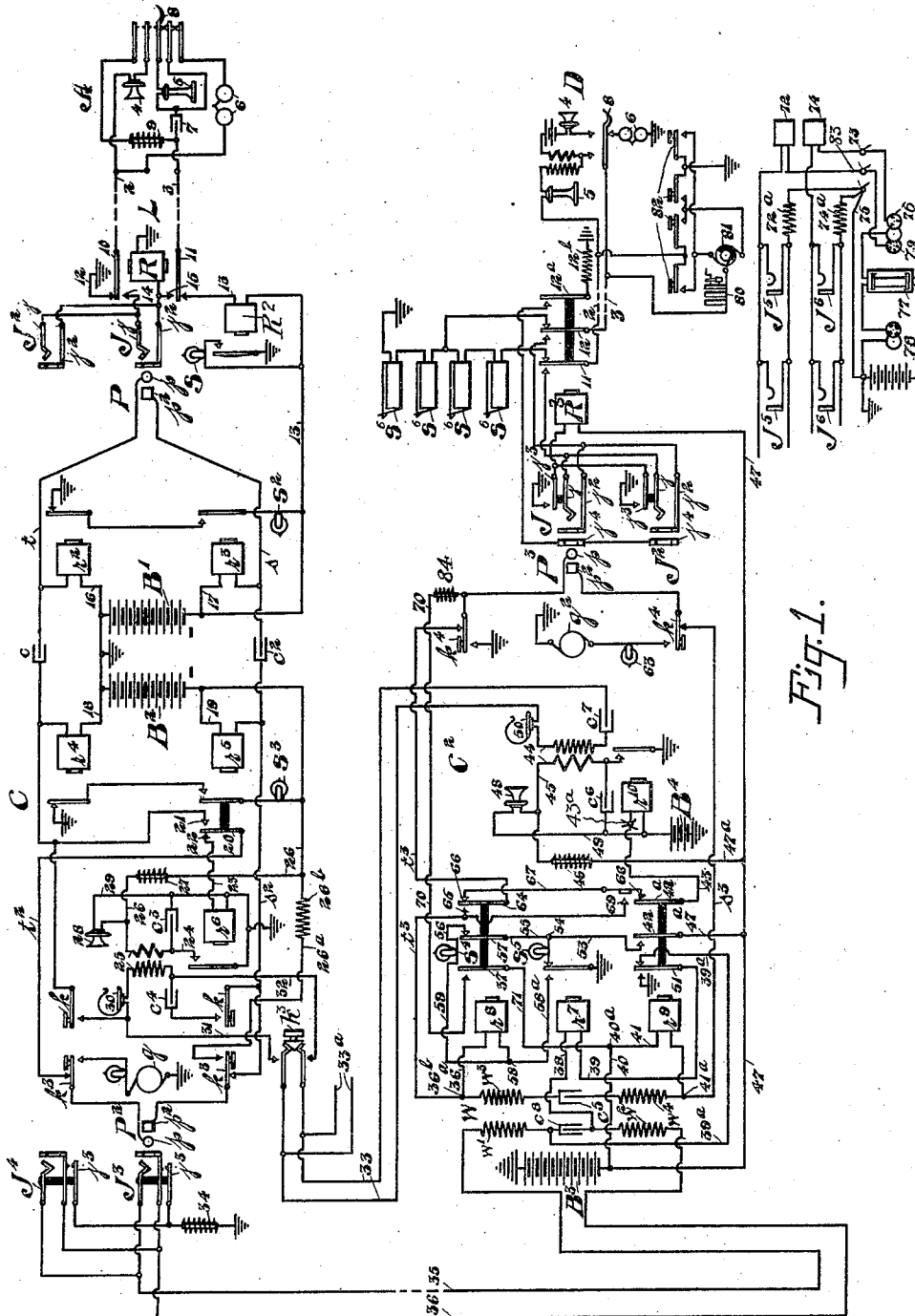


Fig. 1.

Witnesses.

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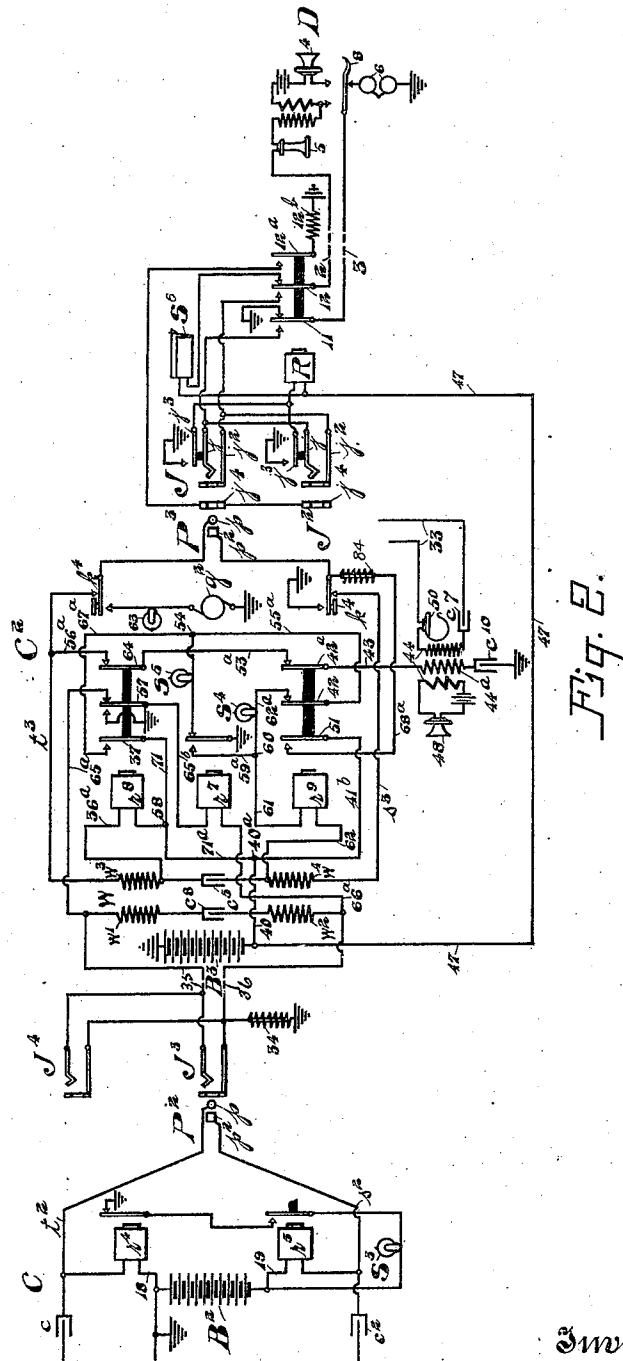
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by Robert Lewis Ames
Attorney.

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UNITED STATES PATENT OFFICE.

FRANCIS W. DUNBAR, OF CHICAGO, ILLINOIS, ASSIGNOR TO KELLOGG SWITCHBOARD AND SUPPLY COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

TELEPHONE TRUNKING SYSTEM.

No. 844,506.

Specification of Letters Patent.

Patented Feb. 19, 1907.

Application filed August 6, 1902. Serial No. 118,582.

To all whom it may concern:

Be it known that I, FRANCIS W. DUNBAR, a citizen of the United States of America, and a resident of Chicago, county of Cook, and State of Illinois, have invented a certain new and useful Improvement in Telephone Trunking Systems, of which the following is a specification.

My invention relates to telephone trunking systems extending between different switchboard-sections and adapted to connect subscribers' lines together for conversation.

In an application filed by Harry C. Goldrick September 17, 1902, Serial No. 123,696, a trunking system is shown, described, and claimed in which subscribers' lines of one type terminate at the outgoing office and lines of a different type terminate at the incoming office. The latter lines are provided with ground connections at the subscribers' stations, with normally insulated test-contacts for the switch connections at the central office, and with cut-off relays actuated over local circuits independent of the line-circuits.

This invention relates to the same features, generally speaking, as is shown in the said application, but includes in addition means for opening the locking-circuit of one of the relays at the incoming end without disconnecting the trunk from the called line. A different testing system is also employed from that of said application, in which a low-resistance test-relay is connected to ground from the tip-strand of the cord-circuit, said relay or test-receiving device being connected with a battery. The testing-circuit is also carried through the normal contacts of two relays adapted to be actuated at different times, whereby when either relay is actuated the testing-circuit is opened.

My invention is illustrated in the accompanying drawings, in which the same reference characters designate like parts throughout the several views, and in which—

Figure 1 is a diagram showing a subscriber's line of the "Dunbar" or "two-wire" type terminating in one office and a subscriber's line of the four-wire type terminating at a second office, with a suitable trunk-circuit extending between said offices to connect the lines together for conversation; and Fig. 2 is a diagram of a trunk-circuit to con-

nect lines of a general three or four wire type with the two-wire or Dunbar type of lines.

Referring to Fig. 1, L designates one of the plurality of subscribers' lines terminating at the central office C. This line extends in two limbs 2 and 3 from the subscriber's station A to the said central office C, where it is fitted with suitable answering and multiple jacks or connection-terminals J J'. At the subscriber's station the usual telephone instruments are provided, and consist of a transmitter 4, a receiver 5, a ringer or call-bell 6, and the condenser 7. The switch-hook 8 is adapted in its normal position and when the receiver is placed thereon to open the circuit through the transmitter 4 and receiver 5 and to close it through the call-bell 6 and condenser 7. A retardation-coil 9 is connected at the substation when the hook is raised in parallel with the receiver 5 and condenser 7 to provide a path transparent to steady currents, but opaque to voice-currents. The line conductors 2 and 3 include, respectively, the armatures or springs 10 and 11 of the cut-off relay R, which is permanently legged to ground from the sleeve-contacts $j^2 j^2$ of the jacks J J'. The armature or spring 10 is normally connected with ground through the conductor 12, while the opposite armature 11 is normally connected with conductor 13, containing the line-relay R' for the line, said conductor leading to the live or ungrounded pole of the central battery B', the opposite pole of which is grounded. The line-relay R' controls through its armature the circuit of the line-signal S. The forward contacts 14 and 15 of the cut-off relay R are adapted to connect the jacks and the switchboard-sections of the line with the external line-circuit when the said cut-off relay is energized. This, it is to be understood, is a typical two-wire line-circuit and is the particular kind with which I prefer to use my trunk-circuits, although I do not wish to so limit the use of the invention in all respects.

At the central office C the usual operator's cord-circuit is provided, said cord-circuit having an answering-plug P and a calling-plug P', each being provided with a tip-contact p and a sleeve-contact p^2 , adapted to register with like contact-surfaces j and j^2 in the jacks of the line when the plug is inserted therein. The tip-contacts of the plugs are

connected together by means of the tip-strands t and t^2 of the cord-circuit and the interposed condenser c , while the sleeve-contacts are likewise connected by the sleeve-strands s and s^2 and the interposed condenser c^2 . A conductor 16 extends from the grounded pole of the battery B' to the tip-strand t and contains the winding of the tip supervisory relay r^2 associated with the answering-plug P , while the live pole of the battery is connected, by means of conductor 17, with the answering sleeve-strand s and includes the winding of the sleeve supervisory relay r^3 . These relays r^2 and r^3 serve to control the circuit of the supervisory lamp S^2 associated with the answering-plug P , the former relay serving to normally close said circuit of the lamp, while the latter relay normally opens the same. The battery B^2 is associated with the opposite or calling end of the cord-circuit and is connected by conductors 18 and 19 with the tip and sleeve strands t^2 and s^2 , respectively, the former conductor including the winding of the supervisory relay r^4 , while the latter conductor includes the similar relay r^5 . These relays serve in a manner similar to the relays r^2 and r^3 to control the circuit of the supervisory lamp S^3 associated with the calling-plug P^2 .

The relays r^2 and r^4 are conveniently referred to as the "tip-relays" and relays r^3 and r^5 as the "sleeve-relays," since they are connected with and operated by current flowing over the corresponding strands of the cord-circuit. The tip-strand t^2 of the calling and testing plug P^2 is normally open through the extra spring or movable contact 20 of the sleeve-relay r^5 , but is adapted to be closed by the said spring and its forward contact 21 when the relay is energized. The back contact 22 of this extra spring 20 is connected, through the medium of conductor 23, with one side of the high-resistance and high-impedance relay r^6 , known as the "test-relay," the other side of which is grounded. The armature of this relay is likewise grounded, and its forward contact is connected with the primary winding of the operator's induction-coil 25 by means of conductor 24. The other end of the said primary winding is connected, through the medium of conductor 26, to the live pole of the battery B^2 , a retardation-coil 27 being included in this circuit. The operator's transmitter 28 is joined on one side to conductor 26, intermediate her primary coil and the coil 27, and on the other side through conductor 29 to ground. A condenser c^3 is included in the operator's local circuit to facilitate talking and is connected as shown. The secondary winding of her induction-coil 25 is adapted to be included, together with her receiver 30 and a condenser c^4 , in a bridge between the strands of the cord-circuit by means of any suitable key and indicated dia-

65 grammatically by k k . Branch connections

31 and 32 lead from opposite sides of the receiver and secondary to an order-key k^2 , connected with an order circuit or wire 33, leading to the office C^2 . A grounded alternating-current ringing-generator g is adapted to be connected, through a resistance-lamp, with the tip-strand t^2 of the cord-circuit by means of the tip ringing-key spring k^3 , the sleeve-contact k^3 of said key being connected with battery-lead 26 through wire 26^a and resistance 26^b .

A trunk-circuit is shown extending between the central offices C and C^2 , said trunk-circuit being fitted at the outgoing end with multiple jacks, such as J^3 and J^4 , and with a retardation-coil 34, connected with the third spring of the jacks and adapted to be connected with the sleeve side of the circuit when a plug of the cord-circuit is inserted in one of the jacks. The trunk extends in two limbs 35 and 36 to the central office C^2 , where it is provided with suitable means for testing the condition of the wanted line, for ringing the desired subscriber, and with signals to enable the operator to properly attend the connection. The tip and sleeve trunk conductors 35 and 36 terminate at the incoming office in the windings w' and w^2 of the repeating-coil W , between which windings is connected the interposed condenser c^8 . A trunk-relay r^7 is connected with the sleeve conductor 36 of the trunk by wire 38 and on its opposite side by wire 39 with a contact-spring 51 of sleeve-relay r^8 , the forward contact of this spring being grounded, while the back contact is connected by a conductor 39^a with the trunk conductor 35 between the condenser c^8 and the winding w' of the repeating-coil W . By this arrangement when said sleeve-relay is actuated the trunk-relay is connected between the trunk conductor 36 and ground and is therefore energized over the grounded circuit and at all other times is connected in the metallic circuit of the outgoing end of the trunk and is adapted to be energized thereover. The opposite windings w^3 and w^4 of the repeating-coil are connected together with an interposed condenser c^5 between the tip-strand t^3 and sleeve-strand s^3 of the trunk-cord, which strands terminate in the corresponding contacts p and p^2 of the trunk connecting-plug P^3 .

The subscriber's line terminating at the office C^2 is of a different type from that shown terminating at the office C and in which the cut-off relay R is operated over a local circuit upon the insertion of the connecting-plug instead of over a portion of the talking-circuit. With this construction a greater number of wires is required throughout the switch-board. The particular line shown is adapted for a "four-division system"—that is, one in which the line is provided with a calling-annunciator upon each of four different divisions and with connecting-jacks upon said

divisions and in which the subscriber is provided with means to select and operate any of such signals. The several annunciators are shown at S^6 S^6 , &c., which are connected with the ground and with the normal contacts of the springs 11 and 12 of the cut-off relay in such manner as to be operated by current sent out from the ringing apparatus at the subscriber's station, said apparatus including the magneto-generator 80, having a commutator 81 mounted upon its shaft and with the push buttons or keys 82 82, &c. By the simultaneous operation of the generator and one of the keys the corresponding signal S^6 may be operated. The transmitter 4 at the subscriber's station is operated over a local circuit, while the receiver, together with the secondary of the subscriber's induction-coil, is adapted to be included in the metallic circuit upon the removal of the receiver from the hook. The call-bell is grounded from the sleeve side of the circuit by means of the hook-switch. The cut-off relay R^3 is operated by current from the battery B^3 over wire 47 when the plug is inserted in one of the jacks and closes the jack-spring J^3 to ground, thereby disconnecting the annunciators and connecting springs 11 and 12 of the cut-off relay with the conductors leading to the tip and sleeve contacts of the jacks, respectively. The test-rings J^4 of the jacks are connected together, but are normally disconnected from the line, and are connected with the forward contact of the spring 12^a of the cut-off relay R^3 , which is grounded through a five-hundred-ohm resistance-coil 12^b. When the connecting-plug is inserted in one of the jacks therefor, the said signals are disconnected from the line, the jacks are placed in operative condition with the line, and the test-rings are connected to ground.

The trunk-circuit is provided with a sleeve-relay r^9 , which is connected, by means of conductors 40 and 41, with the live pole of the battery B^3 and with the sleeve-strand s^3 at the point 41^a, said relay being actuated over the sleeve side of the said trunk-cord, the sleeve conductor of the line upon the insertion of the connecting-plug in the line jack, and through the grounded signaling-bell at the subscriber's station. A tip relay r^8 is legged from the point 36^b upon the tip trunk-cord by conductor 36^a to the point 58, thence by conductor 58^a to the forward contact of the trunk-relay r^7 , whereby when the trunk-relay is operated the trunk-plug is inserted in a jack of the line, and when the subscriber has responded current flows from the battery B^3 over the sleeve side of the trunk-cord and subscriber's line and back to the central office through said tip-relay and to ground. The tip conductor of the trunk-cord is normally connected through spring 64 of tip-relay and back contact 66, conductor 67, back contact 68, and spring 42^a of

the sleeve-relay r^9 , and through conductor 43 with the testing-relay r^{10} , the other side of which is connected through a small battery B^4 to ground. When the sleeve-relay is operated and connection with the test-relay is broken, the tip-strand is completed between spring 68 and contact 69, and upon the operation of the tip-relay the strand is also completed between the spring 64 and contact 65. The various signal-lamps are controlled through the springs 42 and 57 of the sleeve and tip relays, respectively, both receiving current through the sleeve-spring 42 and the sleeve-relay when the latter is operated, the ringing-lamp S^4 being energized before the tip-relay is operated and after the trunk-relay is operated, while the disconnect-lamp S^5 is operated only when the trunk-relay is deenergized. The operator's receiver 50 is connected with the secondary of her induction-coil and the condenser c^7 in the order-circuit 33 from the A station, while her transmitter 48 is fed by current from the battery B^3 , flowing over the wires 47 47^a, through resistance 46, thence through the transmitter 48, conductor 49 to ground, the primary of her induction-coil 44 and the condenser c^6 being connected in multiple with the said transmitter. The armature of the test-relay serves when operated to shunt the transmitter. The operator is enabled to call the subscriber by means of the grounded generator g^2 , which is adapted to be connected with the sleeve side of the cord-circuit upon the operation of the ringing-key k^4 .

In tracing the circuits hereinafter the plan of pointing out the path for current from the live or ungrounded pole of the battery to the ground only will be followed for convenience, it being understood that the return-current will seek the grounded pole of the battery and that the circuit will therefore be complete.

The operation is as follows: The A subscriber desiring a connection with a subscriber located at another exchange, removes his receiver from the hook, and thereby closes a path for current between the limbs 2 and 3 of his line through the transmitter 4 and retardation-coil 9, the condenser 7 and receiver 5 being connected in parallel with the retardation-coil. The closing of this circuit permits current to flow from the battery B^1 through conductor 13, line-relay R^2 , spring 11 of cut-off relay R , limb 3 of the telephone-line, through retardation-coil 9 and transmitter 4 at the substation, and thence over limb 2 back to the central office and spring 10 of cut-off relay R , through conductor 12 to ground. The line-relay R^2 is thus operated and closes the circuit of the signal-lamp S to ground from the conductor 13. The operator upon seeing the line-signal exposed inserts the answering-plug P into the answering-jack J of the subscriber's line

and connects her telephone 30 with the cord-circuit by depressing the listening-key k to receive the order from the subscriber. The insertion of the plug P closes a circuit through the cut-off relay R from the live pole of the battery B' through conductor 17, sleeve supervisory relay r^3 , sleeve-strand s , sleeve-contacts p^2 and j^2 of the plug and jack, thence through the winding of the cut-off relay R to ground. The operation of this relay disconnects the armatures 10 and 11 from the ground-wire 12 and from the battery-lead 13 and connects them through the forward contacts 14 and 15 of said armatures to the normally disconnected jacks J^2 . The operation of the supervisory relay r^3 over the path just traced serves to close, through its armature and front contact, the circuit of the supervisory signal S^2 , which is associated with the plug P ; but it is prevented from glowing by the operation of the tip supervisory relay r^2 , which is connected in the conductor 16, and receives current over telephone-line and the tip-strand t of the cord-circuit and through the conductor 16 to the grounded pole of the battery B' as soon as the cut-off relay R is operated. The supervisory signal S^2 therefore remains inert while the battery B' furnishes current over the metallic telephone-line for the operation of the supervisory relays and for conversational purposes. The operator's transmitter 28 is receiving current at this time from the battery B^2 over the conductor 26 through retardation-coil 27, thence through the transmitter 28 and over conductor 29 to ground. When sound-waves strike the transmitter 28, the current flowing therethrough is varied, which causes a variation of the charge in the condenser c^3 and a corresponding surge of current through the primary of her induction-coil 25. These induce voice-currents in the secondary, which are transmitted to the line, and the operator is therefore able to converse with the calling subscriber. Upon learning that a subscriber in the exchange C^2 is desired the A operator depresses the order-key k^2 to connect her telephone with the order-wire circuit 33 and repeats the number of the wanted subscriber to the B operator, whose head telephone 50 is permanently connected to the said order-wire. The latter operator designates to the A operator the trunk to be used for the connection and proceeds to test the condition of the wanted line with the tip of the incoming trunk designated. If the line is idle, no click will be received; but if busy the test-rings of the jacks, as above explained, are connected with ground through the resistance-coil 12^b , and since the tip of the plug is normally connected by means of the forward portion of the tip-strand t^3 , the contacts 64 and 66 of tip-relay r^8 , conductor 67, contacts 68 and 42^a of the sleeve-relay r^9 , the conduc-

tor 43, with the test-relay r^{10} and a source of current through the test-relay and battery B^4 , a complete circuit will be established, which will operate the test-relay r^{10} and close a path for current through the battery B^3 to the operator's circuit, causing inductively a click in her receiver. The relay r^{10} is preferably of low resistance, and the battery B^4 should have about five volts of electromotive force, and while it may be a portion of the battery B^3 it is advantageous, for some reasons, as will be pointed out, to provide a separate battery to ground the opposite pole from that of battery B^3 . The operator's receiver will respond to this click at all times, even though the order-circuit should be open at the exchange, since the electrostatic capacity of her circuits and that of the order-circuit is ample to produce the click. The test-relay is preferably common to all of the incoming trunks at one operator's position, as indicated by the branching lines 43^a. On finding the line idle the plug P^2 is inserted in one of the multiple jacks of the wanted subscriber's line. The A operator having received the number of the trunk to be used, inserts the calling-plug P^2 of her cord-circuit in the jack of the trunk at her section, with the result that a circuit is closed from the live pole of the battery B^2 at the A office through the conductor 19 and the sleeve supervisory relay r^5 , sleeve-strand s^2 of the cord-circuit, sleeve-contacts of the plug and jack and through the retardation-coil, which is now connected with the sleeve side of the talking-circuit, to ground. This has the effect of positively operating the supervisory relay r^5 , which attracts its armature and cuts out the test-relay r^6 , connected with the cord-circuit, and completes the tip-strand of said circuit for conversational purposes. At substantially the same moment the trunk-plug P^3 has been inserted, with the result that the sleeve-relay r^9 is operated from the battery B^3 over the sleeve-strand of the cord-circuit and the sleeve side of the subscriber's line and through the grounded signaling-bell 6. The operation of this relay serves to ground the spring 51, thus closing a path for current from the trunk-relay r^7 over the sleeve side of the A cord-circuit and the sleeve side of the trunk through the branch 38, the trunk-relay r^7 , branch 39, spring 51, and ground, thus operating the trunk-relay r^7 and causing it to attract its armature, thus cutting out the disconnect-lamp S^5 and closing the circuit to ground from the tip-relay of branch 58^a. At the same time the test-relay r^{10} is cut out through the spring 42^a and the tip-strand of the trunk cord-circuit is completed through the contacts 68 and 69. Moreover, spring 42 of the sleeve-relay r^9 admits current from the battery-lead 47 to the lamps S^5 and S^4 , the former being prevented from operation by the actuation of the trunk-relay r^7 , and

the latter having its circuit closed over conductors 53 and 55, spring 57 of the tip-relay r^s , conductor 59, through the lamp S^4 , conductor 59, point 58, and thence over conductor 58^a to the armature of the trunk-relay and ground. This light is therefore lighted and remains in this condition until the called subscriber responds. Upon the response of the called subscriber the circuit over the sleeve side of the line is broken, a return path being completed from the tip side of the line and the tip side of the trunk cord-circuit and through the tip-relay r^s to ground, through the armature of the trunk-relay. In case the line at the subscriber's station should be left open long enough while the switch-hook is moved from its lower to its uppermost position, to permit the deenergization of relay r^s , a path for the return current when the hook reaches its upper position will be provided over the tip side of the line and the forward portion of the tip-strand through the normal contacts of spring 64 of the tip-relay and spring 42^a of the sleeve-relay, thence through the low-resistance test-relay r^{10} and the battery B^4 to ground. On account of the low resistance of the test-relay r^{10} and the low voltage of the battery B^4 a current flowing over this path from the battery B^3 is able to actuate the sleeve-relay r^9 , which restores conditions at the time the subscriber lifts his receiver from the hook. By reversing the polarity of the battery B^4 from that of B^3 the effects of the two batteries will be added and a more positive action of the apparatus caused. As soon as this path has been established the sleeve-relay r^9 has been actuated providing a path through the tip-relay r^s , as described, which will immediately close spring 64 upon its forward contact, and thus complete a second path across the breach in the tip-strand that is independent of the position of the sleeve-relay. The operation of the tip-relay opens the circuit of the ringing-lamp S^4 at spring 57, which is thus rendered inert and remains so throughout the connection. This relay also closes a locking-circuit, said circuit being completed from the live-pole of the battery B^3 over conductor 40, the point 40^a, thence over conductor 71, spring 37, and forward contact of relay r^s , conductor 70, and through the fifty-ohm retardation-coil 84, and thence over the tip-strand t^3 , and through the tip-relay r^s , and over conductor 58, to ground through the armature of the trunk-relay r^t . This constitutes a locked circuit for the tip-relay r^s through the contacts of the trunk-relay r^t . This circuit is moreover in parallel with that completed through the subscriber's station, but as it is of considerably less resistance a sleeve-relay r^9 is deprived of operating current, which permits its armatures to fall back into normal position. It will be noticed that

the locking-circuit and the retardation-coil is completed in advance of the ringing-key k^4 , whereby should the contacts of the plug be accidentally crossed in inserting the same in the jack of the wanted line and the tip-relay therefor operate the latter the act of calling the wanted subscriber will open the locking-circuit and restore all parts to normal condition without withdrawing the connecting-plug. The restoration of the contact-springs of sleeve relay r^9 does not affect the conversational circuit, for the reason that the tip-spring first completed is now completed by the spring 64 of the tip-relay r^s . The signal-lamps are not affected by the operation, for the reason that they are intended to remain inert during conversation. The touching of spring 51, however, upon its normal contact completes the metallic circuit of the outgoing end of the trunk through the trunk-relay r^t , which is thus energized during conversation, and since it is of low resistance a sufficient flow of current takes place over the metallic line to actuate the tip supervisory relay in the A cord-circuit, thus rendering the supervisory signal associated therewith inert. This indicates to the A operator that the called subscriber has responded, while the putting out of the ringing-lamp indicates the same fact to the B operator. The subscribers are now connected together for conversation, and the supervisory signals of both exchanges are extinguished. The battery B' is furnishing current over the answering end of the A cord-circuit to the A subscriber for talking purposes and for the operation of the supervisory relays. The battery B^2 is furnishing current over the trunk-line for the operation of the supervisory relays associated with the answering end of the A cord-circuit and the trunk relay at the incoming end, and the battery B^3 is sending current through the tip-relay r^s to maintain the same operated. Voice-currents are transmitted inductively from the subscriber's line L to the trunk-circuit through the condenser c and c^2 in the A cord-circuit and from the trunk-circuit to the incoming end thereof and the subscriber's line connected therewith through the medium of the repeating-coil W . A local battery is employed at the D-subscriber's station to furnish current for talking. At the termination of the conversation the subscribers return their receivers to the hooks, with the result, in the case of subscriber A, that the tip supervisory relay r^2 , connected with the A cord-circuit, is deenergized and closes, through its armature and back contact, the circuit of the supervisory signal S^2 , thus indicating to the operator that subscriber A is through talking. When the D subscriber hangs up his telephone, the original path for current through the sleeve-relay r^9 is established through his grounded signaling-bell 6. This relay is therefore

again operated, with the result that the trunk-relay circuit is now changed from the metallic line to the sleeve side of the trunk-circuit and ground, which deenergizes the tip supervisory relay in the A cord-circuit, thus causing the supervisory lamp to operate, thus indicating to the A operator that the called subscriber has ceased talking. The circuit of the disconnect-lamp is also completed at one point by spring 42 of the sleeve-relay r^9 . The A operator observing the disconnect-signal at both ends of the cord-circuit takes down the connection, with the result that the trunk-relay is deprived of operating-current, and the circuit of the disconnecting-lamp S^5 is completed through its spring and back contact. This lamp is therefore lighted and indicates to the B operator that the trunk-plug should be withdrawn, which is done, and all parts are returned to normal position. The locking-circuit of the tip-relay is opened by the deenergization of the trunk-relay.

The order-circuit 33, as is indicated by the branching lines 33^a, connects the B operator with several A operators either at the same or different exchanges, and the A operator is also provided with a plurality of keys k^2 to connect herself with the different B operators.

As the line leading to the subscriber D operates upon the local-battery principle, the relays r^9 and r^8 are preferably of five-hundred-ohms resistance instead of one hundred ohms, as is usual, so as not to throw an excessive current upon the subscriber's telephone.

In Fig. 2 I show a similar trunking system provided to cooperate with called subscriber's lines, in which local batteries are employed for talking purposes, but in which the call-signals are operated by means of a common battery located at the central office and in which the cut-off relay is actuated over a local circuit entirely distinct from the talking-circuit, the test-contacts being also local and disconnected from the talking-circuit. In this line the subscriber's bell 6 is grounded from the tip side of the line; but when the receiver is removed from the hook current is permitted to flow from the central battery B^3 to the calling-drop S , which actuates the signals and indicates the call at the central office. The test-rings j^4 are entirely isolated from the talking-circuit when the plug is inserted, the cut-off relay R^3 actuated and connected through the armature 12^a and the resistance 12^b to ground. The springs 11 and 12 of the cut-off relay serve to connect the terminals of the spring-jacks with limbs 2 and 3 of the subscriber's line, while the auxiliary contacts j^3 in the jacks serve to complete the circuit of the cut-off relay from the main battery B^3 . The calling telephone line and the apparatus at the subscriber's station is the same, as shown in Fig. 1, merely the

calling end of the cord-circuit being indicated in the present figure. In view of the fact that the bell is grounded from the tip side of the line at the subscriber's station, its tip-relay in this form of trunk, which responds to the actuation of the subscriber's hook, is legged from the tip-strand of the trunk-cord, by means of conductor 36^a, to the point 58, thence by conductor 71^a to point 40^a, and thence by conductor 40 to the live pole of the battery B. The trunk-relay is permanently connected by conductor 36 on one side of the sleeve-strand of the trunk-cord and on the other side by conductor 65^b with the spring 57 of the tip-relay, the forward contact of which is grounded and the back contact of which is connected by means of conductor 65^a with the tip-conductor of the outgoing end of the trunk, whereby when the connection exists at the outgoing end of the trunk and the tip-relay is deenergized the trunk-relay is actuated over the metallic end of the trunk, and when the tip-relay is energized the trunk-relay is actuated over the sleeve side of the trunk to ground. The sleeve-relay r^9 is connected on one side by conductor 62 with the sleeve-strand s^3 of the trunk-cord and on the other side by conductor 61 to the point 60, and thence by conductor 59^a to the forward contact of the trunk-relay, thence by the armature of the trunk-relay to ground. The ringing-lamp S^4 and the disconnect-lamp S^5 are controlled by the several relays.

The operation is as follows: Upon receiving a call for a connection the B operator tests the condition of the wanted line. If the line is busy, the test-rings are connected to ground, as stated, and since the tip of the plug is always connected with battery through the tip-relay r^8 , a complete circuit is established which allows current to flow over the same, thus changing the potential of the conductor c^{10} in the operator's outfit. The path for the condenser charge and discharge being provided from the tip-strand t^3 over conductor 56, armature 64, and spring 42^a of sleeve-relay r^9 , conductor 43, tertiary winding 44^a of the operator's induction-coil, and condenser c^{10} to ground. The operator's receiver, as described with reference to Fig. 1, is always in condition to respond to this click. Upon finding the line idle the plug is inserted, which permits current to flow from the main battery B^3 through the tip-relay r^8 , the tip side of the trunk-cord and tip side of the subscriber's line to ground through the signaling bell. The tip-relay is therefore operated, closing a spring 57 upon its grounded contact and furnishing a path for current from the A cord-circuit over the sleeve side of the trunk, and through the trunk-relay r^7 to ground, thus operating said latter relay and causing its armature to close upon its forward contact, and thus completing the ground branch

of the sleeve-relay r^9 . The tip-relay r^8 also actuates the ringing-lamp S^4 over the following path: conductor 40 to point 40^a, conductor 71^a to point 58, conductor 71, spring 37 and its forward contact, conductor 67^a to point 54, conductor 55^a, spring 42, and back contact of sleeve-relay r^9 , conductor 62^a through the ringing-lamp S^4 to point 60, thence over conductor 59^a and the armature of the trunk-relay r^7 to ground. This circuit being completed, as stated, through one of the forward contacts of the tip-relay r^8 and through a back contact of a sleeve-relay r^9 . At the same time the testing-circuit is open at spring 64 of the tip-relay r^8 . Upon the response of the called subscriber a complete circuit for battery-current is provided over the metallic telephone-line which finds a return-path over the sleeve side of the circuit, the sleeve-strand of the trunk-cord to conductor 62, sleeve-relay r^9 , conductor 61 to point 60, and thence over conductor 59^a and the armature of the trunk-relay to ground. The sleeve-relay r^9 is therefore operated, opening the circuit of the ringing-lamp at its spring 42 and opening the testing-circuit at a second point by means of spring 42^a. It also closes a locking-circuit for itself through spring 51, said circuit being traced from the live pole of the battery B^3 over conductor 40 to point 40^a, thence over conductor 41^b, spring 51 and its forward contact, conductor 68^a, 50-ohm retardation-coil 84, ringing-key k^4 , sleeve-strand s^3 of the cord-circuit, conductor 62, sleeve-relay r^9 , conductor 61 to point 60, and thence over conductor 59^a and through the armature of the trunk-relay to ground. It will be noticed that a portion of this circuit from the live pole of the battery to the point where it joins the sleeve-strand of the trunk-cord is in parallel with the former circuit through the tip-relay over the tip side of the line and back to the central office. That circuit is therefore deprived of sufficient current to operate the tip-relay r^8 , which is immediately deenergized, and thus permitting its spring 57 to close a metallic circuit of the outgoing end of the trunk, by means of which the trunk-relay r^7 is operated during conversation, and since it is of low resistance sufficient current is permitted to flow in said metallic-trunk line to actuate the tip supervisory relay in the A-cord circuit and to render the supervisory signal associated therewith inert. The closing of the test-circuit through spring 64 has no effect, for the reason that the circuit is open at spring 42 of the sleeve-relay r^9 . Inasmuch as local battery is employed at the substation of the line, the relays r^8 and r^9 may be of high resistance to prevent throwing out current upon the subscribers' instruments. A retardation-coil 84 is connected with the strand of the trunk-cord circuit in advance of the ringing-

key k^4 , so that should the contacts of the plug be accidentally crossed when inserted in the jack of the line the locking-circuit may be opened during the process of ringing. The battery B^3 , as stated, furnishes current for the operation of the cut-off relays and for the operation of the sleeve-relay during conversation. The operator of course receives the order over the order-circuit 33. At the termination of the conversation the subscriber D hangs up his receiver, thus again completing the original circuit of the tip-relay r^8 , which is immediately energized, thus opening the metallic circuit at the outgoing end of the line to cause the operation of the supervisory signal in the A-cord circuit, while at the same time the circuit of the trunk-relay is connected over the sleeve side of the trunk to cause its operation and prevent actuating the disconnecting signal S^5 until the A operator withdraws the cord-circuit. On observing the disconnect-signal the A operator withdraws the cord-circuit, thus depriving the trunk-relay of current, which is deenergized, thereby opening a locking-circuit of the sleeve-relay r^9 and closing the circuit of the disconnect-signal S^5 , said circuit being traced as follows: from the live pole of the battery B^3 over conductor 40 to point 40^a, thence over conductor 71^a to point 58, conductor 71, spring 37 and its forward contact, conductor 67^a, point 54, thence through the disconnecting-lamp S^5 and the armature of trunk-relay r^7 to ground. The B operator, observing the lighting of the disconnect-signal, withdraws the trunk-plug and restores all parts to normal condition.

It will be noted that in Fig. 1 the retardation-coil 34 is normally disconnected from the trunk, while in Fig. 2 it is permanently connected therewith. Either of these arrangements may be employed in either of the systems, it being preferable merely to employ the normally disconnected retardation-coil where earth currents are found to be present.

The ground connections heretofore described, it will be understood, may and in practice usually are one and the same, or they may be the common office return, although it is found by experience that it is practically necessary to place a dead ground upon one side of the common battery. It is also apparent that the other poles may be grounded so far as the operation of the system is concerned. It is also apparent, so far as some features of the invention are concerned, that lines may terminate in single cords and plugs in place of the double cords shown and described and that the trunks may terminate in jacks in place of the plugs and cords.

While I have described several forms and several different ways of carrying out my in-

vention, I would have it understood that I do not wish to be limited to the process and details so shown and described, as it is apparent to those skilled in the art that various changes and substitutions may be made therein and still come within its scope and principle; but

What I do claim as my invention, and desire to secure by Letters Patent, is—

1. The combination with a trunk-circuit, extending between different switchboard-sections and adapted to connect lines together for conversation, of a supervisory signal at the outgoing end of the trunk placed in condition to operate by current over one side of the same when the connection is established at said end, a relay at the incoming end and actuated by current over one side of said end when connection is established with the called line to control the path for current over the said one side of the outgoing end of the trunk, a second relay at the incoming end responsive to current in the metallic line when the called subscriber answers to short-circuit said first-named relay, to cause it to complete the metallic circuit of the outgoing end of the trunk over which current flows to render said supervisory signal inoperative, said relay serving at the same time to close a locking-circuit for itself, and means to unlock said relay by the actuation of the ringing-key after said relay has been operated, substantially as described.

2. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a supervisory signal at the outgoing end of the trunk placed in condition to operate by current over one side of the same when the connection is established at said end, a relay at the incoming end actuated by current over one side of said end when connection is established with the called line to control the path for current over the said one side of the outgoing end of the trunk, a second relay at the incoming end responsive to current in the metallic line when the called subscriber answers to short-circuit said first-named relay, to cause it to complete the metallic circuit of the outgoing end of the trunk over which current flows to render said supervisory signal inoperative, said relay serving at the same time to close a locking-circuit for itself, and means for opening said locking-circuit in the actuation of the ringing-key to call the wanted subscriber, whereby the accidental crossing of the plug-contacts and the locking of the said relay does not affect the ordinary operation of the system, substantially as described.

3. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a disconnect-signal for the incoming end of the trunk,

a relay actuated over a portion of the talking-circuit when connection is established with the called line to place signal in condition to operate, a second relay at the incoming end actuated by current over the trunk when the connection exists at the outgoing end to prevent the operation of said signal, a third relay at the incoming end responsive to current in the metallic line when the called subscriber answers, said relay serving to short-circuit the first-named relay and to deprive the called line of current, said relay also serving to close a locking-circuit for itself, and means for unlocking the relay after it has been locked, without disconnecting the cord from the trunk or the trunk from the called line, substantially as described.

4. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a disconnect-signal for the incoming end of the trunk, a relay actuated over a portion of the talking-circuit when connection is established with the called line, a second relay at the incoming end actuated by current over the trunk when the connection exists at the outgoing end to prevent the operation of said signal, a third relay at the incoming end responsive to current in the metallic line when the called subscriber answers, said relay serving to short-circuit the first-named relay and to deprive the called line of current, said relay also serving to close a locking-circuit for itself, and means for unlocking said relay in the actuation of the ringing-key to call the wanted subscriber, substantially as described.

5. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a disconnect-signal for the incoming end of the trunk, a relay actuated over one side of the called line to ground at the substation when connection is established therewith to place said signal in condition to operate, a second relay at the incoming end actuated by current over the trunk when the connection exists at the outgoing end to prevent the operation of said signal, a third relay at the incoming end responsive to current in the metallic line when the called subscriber answers and serving to short-circuit the first-named relay and to deprive the called line of current, a locking-circuit for said relay, and means for opening said locking-circuit in the actuation of the ringing-key to call the wanted subscriber, substantially as described.

6. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk actuated when connection is established with

the called line, a relay energized by current in the metallic talking-circuit when the called subscriber answers to render said signal inoperative, said relay serving when actuated to close a locking-circuit for itself, and means to open said locking-circuit in the actuation of the ringing-key to call the wanted subscriber, substantially as described.

7. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk actuated when connection is established with the called line, a relay energized by current in the metallic talking-circuit when the subscriber answers, said relay serving when actuated to close a locking-circuit for itself, and means for unlocking said relay in the actuation of the ringing-key to call the wanted subscriber, substantially as described.

8. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk, a relay actuated over one side of the telephone-line to the substation and ground to place said signal in condition to operate, a second relay responsive to current in the metallic circuit of the line to render said signal inoperative when the called subscriber responds, and a locking-circuit for said relay to prevent its undesired deenergization during the remainder of the connection, and means to open the locking-circuit without disconnecting the trunk from the called line, substantially as described.

9. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk, a relay actuated over one side of the telephone-line to the substation and ground to place said signal in condition to operate, a second relay responsive to current in the metallic circuit of the line to render said signal inoperative when the called subscriber responds, a locking-circuit for said relay closed by itself when actuated to prevent deenergization during the remainder of the connection, a retardation-coil included in said locking-circuit, and means to open the said locking-circuit in the actuation of the ringing-key to call the wanted subscriber, substantially as described.

10. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk, a relay ac-

tuated over one side of the telephone-line to the substation and ground to place said signal in condition to operate, a second relay responsive to current in the metallic circuit of the line to render said signal inoperative when a called subscriber answers, a locking-circuit for said relay closed by itself when actuated to prevent deenergization during the remainder of the connection, and a retardation-coil included in said locking-circuit, substantially as described.

11. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk, said signal being actuated when connection is established with the called line, and a relay energized by current in the metallic telephone-line when the called subscriber responds and serving to render said signal inoperative and to deprive the line of current, said relay also closing a locking-circuit for itself when actuated, and means for opening said locking-circuit in calling the wanted subscriber, substantially as described.

12. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a ringing-signal for the incoming end of the trunk, a relay actuated over one side of the called line to ground at the substation to place said signal in condition to operate, a second relay at the incoming end energized by current in the metallic line when the subscriber answers, said relay serving to render said signal inoperative and as soon as actuated to close a locking-circuit for itself, said locking-circuit serving to short-circuit the line to deprive the same of current, and means for opening said locking-circuit in calling the wanted subscriber, substantially as described.

13. The combination with a telephone-line having a plurality of switch connections provided with testing-terminals, of a trunk-circuit having an operator's connective circuit, a connecting-plug therefor having a testing-contact, a pair of relays associated with said connective circuit, one responsive to current over a portion of the talking-circuit when connection is established with the line and the other to current in the metallic line when the subscriber responds, a supervisory signal whose operative condition is affected by said relays, and a testing-circuit completed from the test-contact of the plug through the contacts of said relays, substantially as described.

14. The combination with a trunk-circuit extending between different switchboard-sections and adapted to connect a called telephone-line with a cord-circuit which has been connected to a calling telephone-line, of a

signal associated with the incoming end of said trunk-line, a relay actuated over one limb of the called subscriber's line to place said signal in condition for operation when connection is made with said line, a second relay actuated over the metallic circuit of said line to render said signal inoperative when the called subscriber responds, means whereby the actuation of said latter relay closes a locking-circuit for itself and means actuated during ringing on the called line for breaking said locking-circuit in one place and deenergizing said relay, if said relay becomes accidentally locked in the insertion of the trunk-plug, substantially as described.

15 15. The combination with a telephone trunking line, of a signal at its outgoing end, a relay upon the actuation of which the condition of said signal depends, a locking-circuit for said relay, and means whereby said circuit if accidentally closed by the insertion of the trunk-plug in the jack of the called subscriber's line, will be broken by the opera-

ton of the ringing-key in calling said subscriber, substantially as described.

16. In a telephone system, the combination with a telephone-line, of a connective means adapted to be united with said line for conversational purposes, a ringing-key, a signal for said connective means, and a relay adapted to be actuated by current over said telephone-line to control the circuit of said signal, a locking-circuit for said relay, and means actuated by the operation of said ringing-key to deprive said relay of locking-current without disconnecting said connective means from said line if said relay becomes accidentally locked in the connection of said connective means with said line, substantially as described.

Signed by me at Chicago, county of Cook, State of Illinois, this 29th day of July, 1902..

FRANCIS W. DUNBAR.

Witnesses:

ROBERT LEWIS AMES,
GAZELLE BEDAR.