

No. 846,557.

PATENTED MAR. 12, 1907.

F. W. DUNBAR.  
TELEPHONE TRUNKING SYSTEM.

APPLICATION FILED AUG. 1, 1902.

2 SHEETS—SHEET 1.

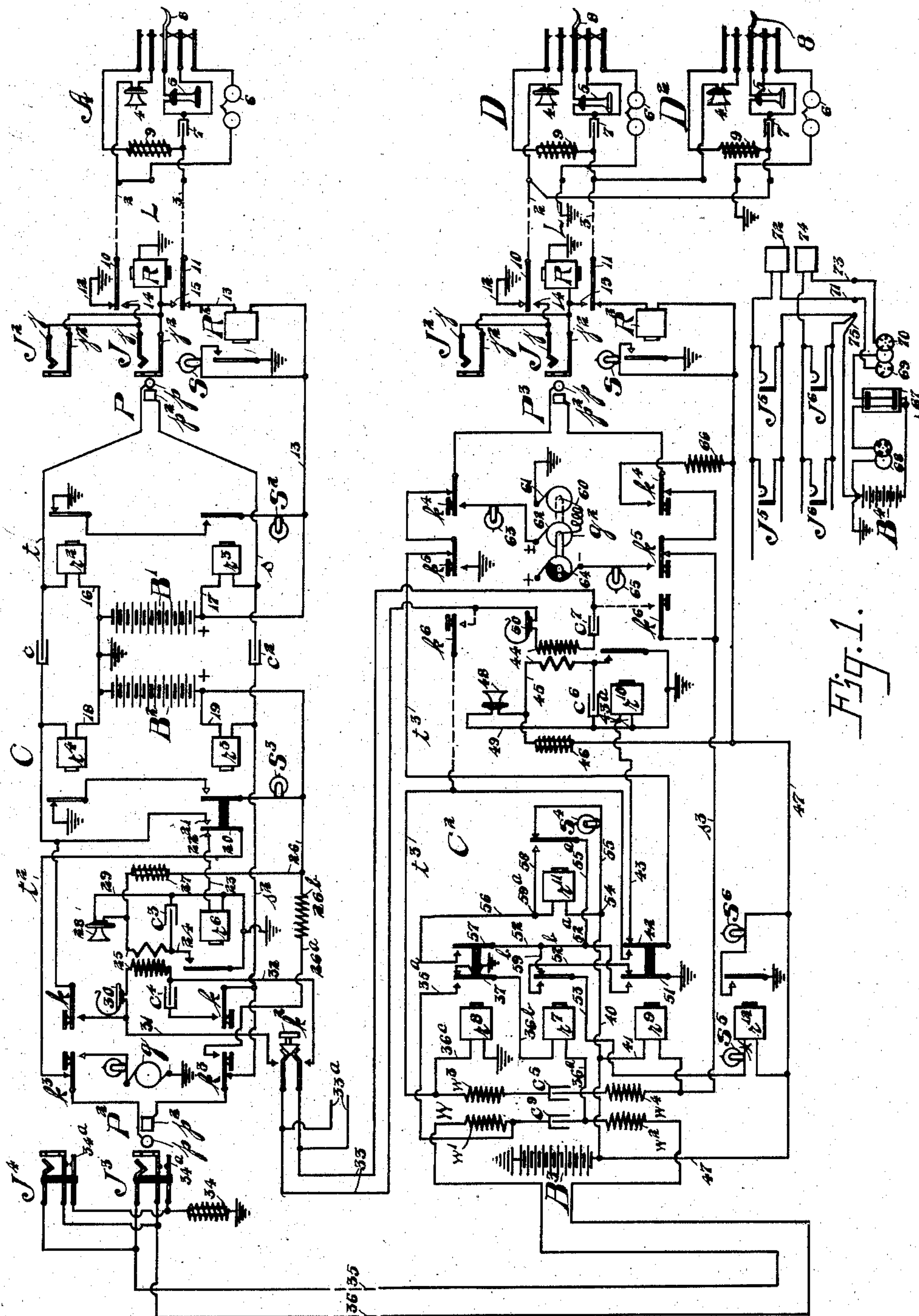


Fig. 1.

Witnesses.  
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Inventor:-  
Francis W. Dunbar,  
by Robert Lewis Ames,  
Attorney.

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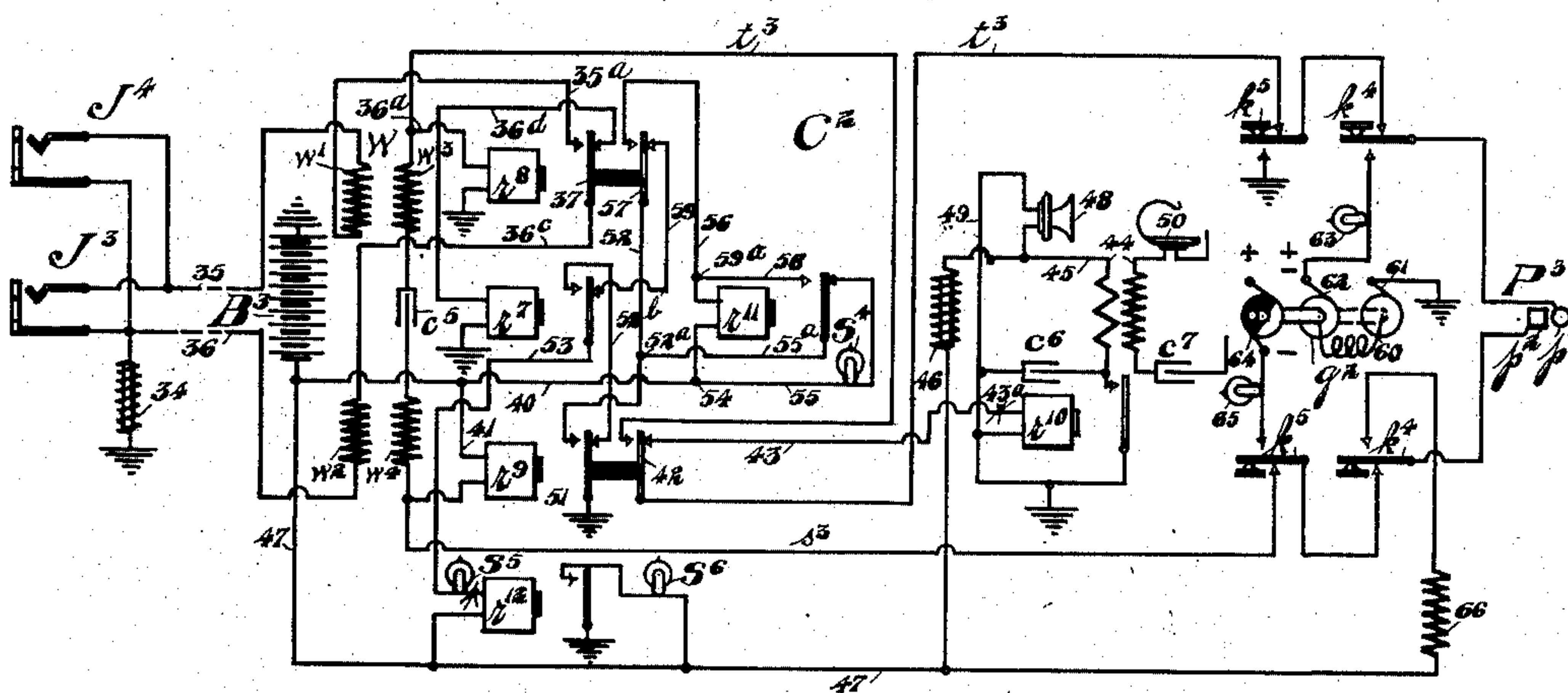


Fig. 2.

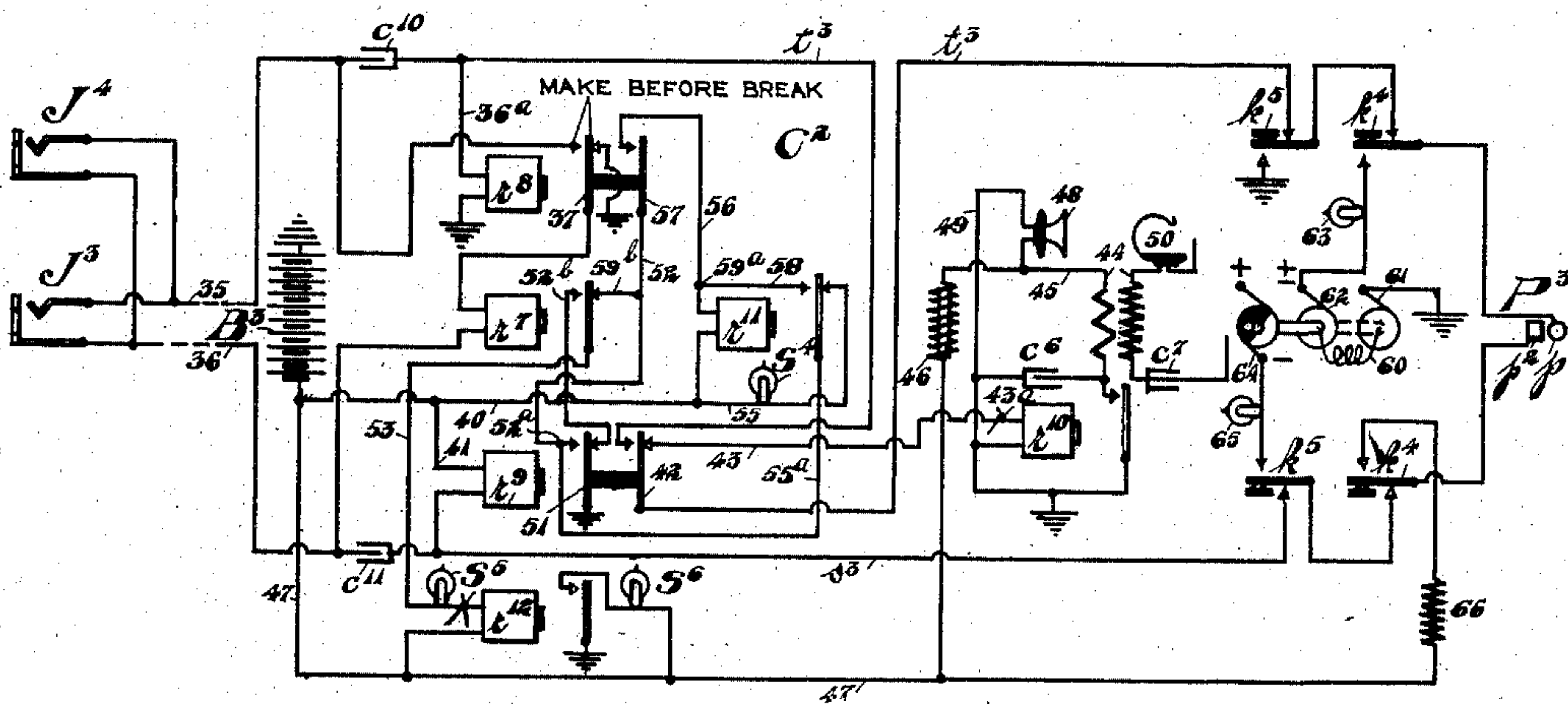


Fig. 3.

Witnesses.  
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# UNITED STATES PATENT OFFICE.

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## TELEPHONE TRUNKING SYSTEM.

No. 846,557.

Specification of Letters Patent.

Patented March 12, 1907.

Application filed August 1, 1902. Serial No. 117,923.

*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 improvements in telephone trunking systems, and particularly those adapted to be employed in connection with the so-called "Dunbar" or "two-wire" line-circuits in which the cut-off relays and other auxiliary apparatus are operated over a portion of the talking-circuits, whereby a great saving in expense and room results.

In an application filed by William W. Dean, June 28, 1902, Serial No. 113,581, a trunking system is shown and described in which the trunk-relay is of high resistance, so that sufficient current cannot flow through it and over the metallic trunk-line to operate a supervisory relay in the calling cord-circuit to render the associated supervisory signal inoperative. In the present system I contemplate accomplishing the same results by means of an ordinary relay connected with one side of the trunk-circuit at its incoming end and with ground, so that when a cord-circuit is connected with the outgoing end of the trunk the current finds no path over the metallic circuit, and therefore the supervisory signal is not rendered inoperative until the called subscriber responds and the two sides of the metallic trunk-circuit are connected together to permit a flow of current therethrough. In the preferable form this trunk-relay is of low resistance and is included in the metallic trunk-circuit so formed, whereby sufficient current flows to operate the supervisory relay in the manner specified.

My invention also contemplates so arranging and so operating the trunk-relay that it is unnecessary to carry the disconnect signaling-circuit through the normal contacts of any other relay, whereby a simplification in the apparatus results.

My invention further consists in the novel arrangement and combinations hereinafter described, and particularly pointed out in the appended claims.

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 subscribers' lines leading to different central offices, together with the necessary trunking connections between said offices to enable the subscribers to be connected for conversation. Fig. 2 is a modification of the trunk, and Fig. 3 is likewise a modification in the trunking connection.

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<sup>2</sup>. At the subscriber's station the usual telephone instruments are provided and consists 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<sup>2</sup> j<sup>2</sup> of the jacks J J<sup>2</sup>. 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<sup>2</sup> 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<sup>2</sup> 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-section 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<sup>2</sup>, each being provided with a tip-contact *p* and a sleeve-contact *p*<sup>2</sup>, adapted to register with like contact-surfaces *j* and *j*<sup>2</sup> 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*<sup>2</sup> of the cord-circuit and the interposed condenser *c*, while the sleeve-contacts are likewise connected by the sleeve strands *s* and *s*<sup>2</sup> and the interposed condenser *c*<sup>2</sup>. 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*<sup>2</sup> 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*<sup>3</sup>. These relays *r*<sup>2</sup> and *r*<sup>3</sup> serve to control the circuit of the supervisory lamp S<sup>2</sup> 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<sup>2</sup> 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*<sup>2</sup> and *s*<sup>2</sup>, respectively, the former conductor including the winding of the supervisory relay *r*<sup>4</sup>, while the latter conductor includes the similar relay *r*<sup>5</sup>. These relays serve in a manner similar to the relays *r*<sup>2</sup> and *r*<sup>3</sup> to control the circuit of the supervisory lamp S<sup>3</sup> associated with the calling-plug P<sup>2</sup>.

The relays *r*<sup>2</sup> and *r*<sup>4</sup> are conveniently referred to as the "tip-relays" and relay *r*<sup>3</sup> and *r*<sup>5</sup> 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*<sup>2</sup> of the calling-plug and testing-plug P<sup>2</sup> is normally open through the extra spring or movable contact 20 of the sleeve-relay *r*<sup>5</sup>, 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*<sup>6</sup>, 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<sup>2</sup>, 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*<sup>3</sup> 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*<sup>4</sup> in a bridge between the strands of the cord-circuit, by means of any suitable key and indicated diagrammatically by *k* *k*. Branch connections 31 and 32 lead from opposite sides of the receiver and secondary to an order-key *k*<sup>2</sup>, connected with an order circuit or wire 33, leading to the office C<sup>2</sup>. A grounded alternating-current ringing-generator *g* is adapted to be connected through a resistance-lamp with the tip-strand *t*<sup>2</sup> of the cord-circuit by means of the tip ringing-key spring *k*<sup>3</sup>, the sleeve-contact *k*<sup>3</sup> of said key being with battery-lead 26 through wire 26<sup>a</sup> and resistance 26<sup>b</sup>.

A trunk-circuit is shown extending between central offices C and C<sup>2</sup>, said trunk-circuit being fitted at the outgoing end with multiple jacks, such as J<sup>3</sup> and J<sup>4</sup>, and with a retardation-coil 34, connected to ground on one side and adapted to connect on the other with the sleeve side of the trunk-circuit when a connecting-plug is inserted in one of the jacks by means of the auxiliary spring 34<sup>a</sup>, which is pressed into contact with the sleeve-contact of the jack when the tip-spring is lifted by the tip of the plug upon the insertion of the same into the jack. The trunk-circuit extends in two limbs 35 and 36 to the central office C<sup>2</sup>, 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*' of the repeating-coil W, the winding *w*<sup>2</sup> being connected by conductor 36<sup>a</sup> with one side of the low-resistance trunk-relay *r*<sup>7</sup>, the other terminal of which is connected by conductor 36<sup>b</sup> with the armature 37 of the tip-relay *r*<sup>8</sup>, said armature being normally grounded through its back contact and being adapted through its forward contact and the conductor 35<sup>a</sup> to complete the metallic circuit of the outgoing end of the trunk when the tip-relay is actuated. A condenser *c*<sup>5</sup> is connected in parallel with the trunk-relay *r*<sup>7</sup> to furnish a free passage for the voice-currents passed by the trunk-relay. The opposite windings *w*<sup>3</sup> and *w*<sup>4</sup> of the repeating-coil W are connected with an interposed condenser *c*<sup>5</sup> between the tip-strand *t*<sup>3</sup> and the sleeve-strand *s*<sup>3</sup> of the flexible end of the trunk-circuit, which strands terminate in the corresponding contacts *p* and *p*<sup>2</sup> of the trunk connecting-plug P<sup>3</sup>. A tip-relay *r*<sup>8</sup> is legged to ground from the tip-strand *t*<sup>3</sup> of the trunk-circuit and controls, through its spring



37 and forward contact, the circuit of the low-resistance trunk-relay  $r^7$ . A sleeve-relay  $r^9$  is connected on one side with the live pole of the battery  $B^3$  by means of conductors 40 and 41 and on the other side with the sleeve-strand  $s^3$ . This incoming end of the trunk-circuit is provided with a testing apparatus similar to that described for the cord-circuit at the central office C. The forward portion of the tip-strand  $t^3$  is connected with spring 42 of the sleeve-relay  $r^9$ , while the other portion is connected with the forward contact of said spring. The back contact of spring 42 is joined by conductor 43 with the common high resistance and impedance test-relay  $r^{10}$ , the opposite terminal of which is grounded. The armature of this test-relay serves when actuated to ground one side of the primary winding of the operator's induction-coil 44, which winding is connected on the other side with a conductor 45, containing the resistance and impedance coil 46 and joined to conductor 47, leading directly to the live pole of the battery  $B^3$ . The operator's transmitter 48 is in a conductor 49, leading from conductor 45 to ground. A condenser  $c^6$  is connected between conductor 49 and the side of the primary that is adapted to be grounded. The operator's receiver 50, together with the secondary of her induction-coil and condenser  $c^7$ , are connected permanently with the order circuit or wire 33, leading to the central office C. The conductor 40 leads to the point 54, from which point branch 55, containing the ringing-lamp  $S^4$ , leads to the back contact of the armature of the locking-relay  $r^{11}$ , said armature being connected by conductor 55<sup>a</sup> to the point 52<sup>a</sup> upon the conductor 52, extending between the spring 57 of tip-relay  $r^8$  and the front contact of spring 51 of sleeve-relay  $r^9$ , the latter spring being grounded, as shown. A conductor 56, extending from the point 54 to the front contact of spring 57 of tip-relay  $r^8$ , includes the winding of the locking-out relay  $r^{11}$ . The forward contact of the armature of this relay is connected to conductor 56 at point 59<sup>a</sup> by means of conductor 58. The back contact of the trunk-relay  $r^7$  is connected by conductor 59<sup>b</sup> with a contact 52. The armature of the trunk-relay  $r^7$  is connected with a conductor 53, leading to the battery-wire 47 and including the guard and disconnect lamp  $S^5$  and the pilot-relay  $r^{12}$ , said latter relay serving to control the circuit of the pilot-signal  $S^6$ . This incoming end of the trunk is equipped for selectively ringing subscribers upon a party-line. It comprises the ringing-key contacts  $k^4 k^4$  and  $k^5 k^5$ , placed in the strands of the trunk-cord and adapted when actuated to suitably connect the alternating-current generator  $g^2$  with the plug  $P^3$ . This ringing-generator comprises the armature 60, the grounded brush 61, the brush 62, from which the alternating current is directed

through the resistance-lamp 63 to tip-key spring  $k^4$  when depressed, and brush 64, from the split commutator-ring, which is adapted to deliver a current of negative pulsations only through lamp 65 to the sleeve-key  $k^5$  when the key is operated. The sleeve-contact of key  $k^4$  when operated connects the sleeve of the plug to battery-lead 47 through resistance-coil 66 to maintain the cut-off relay of the line operated during ringing. The subscriber's line shown in connection with this office is of the "party-line" type and is connected to subscribers D and D<sup>2</sup>. The apparatus at these stations is similar to that at the station A and are likewise indicated, except that the bell 6 at station D is connected between the sleeve conductor 3 and ground, while at station D<sup>2</sup> the bell is connected between the tip-conductor 2 and ground. The same type of normally disconnected jacks  $J^2$ , line-relay  $R^2$ , cut-off relay R, and the line-signals S are employed and are designated by the same reference characters. The battery  $B^3$  furnishes current for the operation of these various relays and signals, as well as for talking.

$J^5$   $J^5$  and  $J^6$   $J^6$  are respectively "busy-back" and "don't-answer" jacks associated with the incoming trunks. These circuits comprise an induction-coil 67, having its primary in circuit with a rapidly-rotating circuit-breaker 68 and the battery  $B^4$ , this battery being preferably the same as battery  $B^3$ , although shown separately for convenience. The secondary of the induction-coil 67 is connected in circuit with the rapid circuit-interrupter 69 and the more slowly-operating interrupter 70. From interrupter 69 a conductor 71 leads to the tip-contacts of busy-back jacks  $J^5$   $J^5$  through a fifty-ohm resistance-coil 72, while interrupter 70 leads by conductor 73 through resistance-coil 74 to the tips of the don't-answer jacks. The sleeves of both sets of jacks are united by conductor 75 with the grounded pole of the battery. The circuit-breaker 68 causes induced currents in the secondary circuits which are interrupted at short intervals by breaker 69 and at longer intervals by breaker 70 to cause distinctive tones at the jacks  $J^5$  and  $J^6$ , whereby when a trunk-plug is inserted in one or the other jack a corresponding signal is transmitted to the waiting subscriber.

In tracing the circuits hereinafter the plan for 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 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' through conductor 13, line-relay R<sup>2</sup>, 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<sup>2</sup> 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*<sup>3</sup>, sleeve-strand *s*, sleeve-contacts *p*<sup>2</sup> and *j*<sup>2</sup> of the plug and jack, thence through the winding of the cut-off relay R to ground. The operation of this relay disconnects the armature 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 J<sup>2</sup>. The operation of the supervisory relay *r*<sup>3</sup> over the path just traced serves to close through its armature and front contact the circuit of the supervisory signal S<sup>2</sup> which is associated with the plug P; but it is prevented from glowing by the operation of the tip supervisory relay *r*<sup>2</sup>, 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<sup>2</sup> 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<sup>2</sup> 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 there-through is varied, which causes a variation of the charge in the condenser *c*<sup>3</sup> 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<sup>2</sup> is desired, the A operator depresses the order-key *k*<sup>2</sup> to connect her telephone

with the order wire or circuit 33 and repeats the number of the wanted subscriber to the B operator, whose head-telephone 50 is permanently connected with 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 plug of the incoming trunk named. If the line is idle, no "click" will be received, but if busy, the sleeve-contacts of the jacks of the line will be connected with the live pole of a battery through the sleeve contact and strand of the inserted plug. A complete circuit will therefore be established from the sleeve-contact of the tested jack, which, it is assumed, is connected with the live pole of the battery, through the tip of the plug P<sup>3</sup>, tip-strand *t*<sup>3</sup>, spring 42, and back contact of sleeve-relay *r*<sup>9</sup>, conductor 43, through the common high resistance and impedance test-relay or responsive device *r*<sup>10</sup> to ground. This test-relay will therefore operate and ground through its armature and front contact one side of the primary of the operator's induction-coil 44, the other side of which is connected by conductor 45 through resistance 46 and conductor 47 to the live pole of the battery B<sup>3</sup>. The completion of this circuit will permit a flow of current therethrough which will induce a current in the secondary of the said induction-coil and produce a click in the receiver 50 of the operator's set. The operator's receiver will respond to this click at all times, since the electrostatic capacity of her circuits and that of the order-circuit is ample for the purpose of producing the click.

In the three-wire systems where the test-circuits are insulated from the subscriber's line there is no danger of varying the current flowing in the line to the annoyance of the subscriber during testing; but in the two-wire systems, where the testing contacts are connected directly with the talking-circuit, some means is necessary or at least desirable to prevent noticeably varying the current upon lines connected for conversation when testing their condition at other sections of the switchboard. This is accomplished in the circuit described by means of the test-relay *r*<sup>10</sup>, which is of such high resistance as to vary the current upon the tested line but slightly and which is also of high impedance, so that its current will build up slowly, to thereby prevent a sudden variation of current on the line. The subscriber or subscribers whose lines are tested are therefore undisturbed by a sudden or large variation of current through their instruments. It is apparent that any other suitable test responsive device or indicator than the relay 10 can be employed and that the operator's telephone can be used in place of the same or in the circuit with a retardation-coil; but the arrangement described is preferred. This



relay is preferably common to all the incoming trunks at one operator's position, as indicated by the branching lines at 43<sup>a</sup>. Upon finding the line idle the plug P<sup>3</sup> is inserted in one of the multiple jacks of the wanted subscriber's line.

The A operator having received the number of the plug to be used inserts the plug P<sup>2</sup> of her cord-circuit in the jack J<sup>3</sup> of the trunk at her section. This connects the retardation-coil 34 with the sleeve side of the circuit and provides a direct path for current from the battery B<sup>2</sup> over conductor 19, strand s<sup>2</sup>, sleeve-contact of plug and jack to the retardation-coil 34 to ground, thus positively operating the sleeve supervisory relay r<sup>5</sup>, which attracts its armatures but cuts out the test-relay r<sup>6</sup> and completes the tip-strand of the cord-circuit through armature 20 and its forward contact 21. At the same time a path for current from the battery B<sup>2</sup> is provided over the sleeve strand of the cord-circuit and the sleeve-conductor 36 of the trunk-line through winding w<sup>2</sup> of the repeating-coil W, conductor 36<sup>a</sup>, trunk-relay r<sup>7</sup>, conductor 36<sup>b</sup>, armature 37 and back contact of relay r<sup>8</sup> to ground. This relay is therefore operated and opens the circuit of the disconnecting-lamp S<sup>5</sup> and pilot-relay r<sup>12</sup>. The supervisory signal s<sup>3</sup>, connected with the A cord-circuit, is also operated, for the reason that current is entirely cut off from the tip-relay r<sup>4</sup>. The A operator is therefore informed that the called subscriber has not yet responded. By the insertion of the incoming trunk-plug in the jack of the wanted line a circuit is closed from the live pole of the battery B<sup>3</sup> over conductors 40 and 41, through sleeve-relay r<sup>9</sup> and thence from the sleeve-strand s<sup>3</sup> of the flexible end of the trunk cord-circuit through the sleeve-contacts of the plug P<sup>3</sup> and jack J<sup>2</sup> of the called line and thence through the cut-off relay R to ground. The sleeve-relay r<sup>9</sup> and the cut-off relay are thus operated, the latter serving to disconnect the line-relay R<sup>2</sup> to render the line-signal inoperative and to connect the normally disconnected jacks with the limbs of the line extending to the substations. The operation of the sleeve-relay r<sup>9</sup> disconnects the test-relay r<sup>10</sup> and closes the tip-strand t<sup>3</sup> through the spring 42 and its forward contact, and thereby establishes the circuit for conversation. It also completes the circuit of the ringing-lamp S<sup>4</sup> from the battery B<sup>3</sup> over conductor 40 to the point 54, thence over conductor 55 and through lamp S<sup>4</sup> to the back contact and armature of the locking-relay r<sup>11</sup>, thence through the armature and over conductor 55<sup>a</sup> to point 52<sup>a</sup>, over conductor 52 to the forward contact of spring 51 of the sleeve-relay r<sup>9</sup> and thence to ground. The completion of this circuit causes the operation of the ringing-lamp S<sup>4</sup>, which indicates to the operator that the subscriber has not yet responded.

The operation of the trunk-relay r<sup>7</sup> at this time opens, through its armature and back contact, the circuit of the guard and disconnect lamp S<sup>5</sup> to thereby prevent its operation.

Upon the insertion of the trunk-plug P<sup>3</sup> the B operator rings the wanted subscriber. If the subscriber D is the one desired, the ringing-key k<sup>5</sup> k<sup>5</sup> is depressed, which throws ringing-current upon the sleeve-strand connected with the plug P<sup>3</sup> and operates the subscriber's bell over the following path: from ground at the generator g<sup>2</sup>, brush 61, armature 60 of the generator, brush 64, through resistance-lamp 65, key k<sup>5</sup>, thence over the sleeve-strand of the cord to the plug P<sup>3</sup>, over the sleeve-limb 3 of the telephone-line to the station D, and thence through condenser 7 and bell 6 to ground, the receiver 5 being at this time upon the hook 8, and therefore completing the circuit between the condenser 7 and bell 6.

It will be noticed that just previous to the depression of the ringing-key k<sup>5</sup> the cut-off relay R was receiving a negative current through its coils from the battery B<sup>3</sup>. At the instant the ringing-key k<sup>5</sup> is depressed this path of current from the battery B<sup>3</sup> is broken, but a new path is immediately established through the relay R from the negative source of pulsating ringing-current. The relay R is so constructed as to be maintained in continuous operation when this negative pulsating current is passing through its windings, and as pulsations are used of the same direction as the current furnished by the battery B<sup>3</sup> the relay R is prevented from even momentarily releasing its armatures at the moment the ringing-key was depressed. The bell 6 at the subscriber's station may be of the ordinary polarized type, as the presence of the condenser 7, which is connected directly in the ringing-circuit permits the operation of such a bell from the pulsating source of ringing-current. The tip-spring of ringing-key k<sup>5</sup> is grounded at this time to provide a path to ground for the return current if the subscriber should respond during ringing. Should the subscriber D<sup>2</sup> be the one desired, the ringing-key k<sup>4</sup> k<sup>4</sup> is depressed, which serves to connect the generator g<sup>2</sup> with the tip-strand of the cord-circuit to operate the bell at the station D<sup>2</sup>. The ringing-circuit may be traced as follows: from ground at the generator g<sup>2</sup>, brush 61, armature-winding 60 of the generator, brush 62, through resistance-lamp 63, spring k<sup>4</sup> in the tip-strand of the cord-circuit, thence over the tip-strand and tip-conductor 2 of the line to the station D<sup>2</sup>, and thence through condenser 7 and normally closed contacts of the hook 8 and through bell 6 to ground. The bell is thus operated. To maintain the cut-off relay R operated during ringing, the inner contact of the sleeve-spring k<sup>4</sup> is connected through a resistance-coil 66 with the



battery lead 47, extending to the live pole of the battery B<sup>3</sup>. This prevents the deenergization of cut-off relay R while ringing.

It is apparent that the arrangement of the ringing-keys is such that either key may be used to call a subscriber at whose station the apparatus is connected in the manner shown at A, which shows the arrangement which I preferably use where but one subscriber is placed upon the line. In this case the ringing-circuit would be complete over the subscriber's metallic circuit, the current returning to the grounded side of the ringing-generator by means of the grounded key k<sup>5</sup> or battery-contact of the ringing-key k<sup>4</sup>.

The subscriber having been called responds by taking up his receiver, and thereby closes a path for current between the limbs of his line from the main battery B<sup>3</sup> over conductors 40 and 41, sleeve-strands s<sup>3</sup> of the incoming end of the trunk-line 3 of the telephone-line, thence through retardation-coil 9 and transmitter 4 at the substation, thence over limb 2 of the telephone-line back to the central office and over tip-strand t<sup>3</sup> of the incoming end of the trunk, including spring 42 and its forward contact of sleeve-relay r<sup>9</sup>, through conductor 36<sup>c</sup> and tip-relay r<sup>8</sup> to ground. This relay thus responds and opens the grounded circuit through the trunk-relay r<sup>7</sup> by means of its spring 37 and back contact and closes a circuit therefor through its forward contact and through conductor 35<sup>a</sup>, the repeating-coil winding w' to the tip-conductor 35 of the trunk, the tip-strand of the cord-circuit and conductor 18 to the opposite pole of the battery B<sup>2</sup>. The trunk-relay r<sup>7</sup> and the tip supervisory relay r<sup>4</sup> are now included in the metallic circuit; but the resistance of the trunk-relay being small sufficient current flows therein to operate both, whereby the disconnecting-lamp and the pilot-relay at the B exchange will be prevented from operating as before, and the circuit of the supervisory signal S<sup>3</sup> is broken, so that the said signal is rendered inert, thus indicating to the A operator that the subscriber has responded. The closing of spring 57 of tip-relay r<sup>8</sup> upon its forward contact completes the circuit of the locking-relay r<sup>11</sup> from the live pole of the battery B<sup>3</sup> over conductors 40 and 56 and through armature 57 to ground. This relay therefore operates and cuts off the ground connection from one side of the lamp S<sup>4</sup>, which becomes inert and closes said ground connection upon its forward contact, which completes a second path for current through the winding of the relay r<sup>11</sup>, which path is independent of the tip-relay, but, as before explained, is completed through the spring 51 of the sleeve-relay. Should the tip and sleeve contacts of the plug be crossed when the plug is inserted in the jack and the locking and other relays operated, they will be immediately released by the opening of the

sleeve-strand during ringing, and no confusion will result therefrom.

The subscribers are now connected together for conversation, and the supervisory signals at both exchanges are extinguished. The battery B' is furnishing current over the answering end of the A cord-circuit to the A subscriber's line for talking purposes, and for the operation of the supervisory relays the battery B<sup>2</sup> 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 battery B<sup>3</sup> is sending current over the incoming end of the trunk and to the substation D to furnish current for talking, and for the operation of the several relays. The voice-currents are transmitted inductively from the subscriber's line L to the trunk-circuit through the condenser c and c<sup>2</sup> 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. The condenser c<sup>5</sup> between the windings w<sup>3</sup> and w<sup>4</sup> of the repeating-coil at the incoming end of the trunk prevents the flow of steady current therethrough, but permits a free passage of the voice-currents.

At the termination of the conversation the subscribers return their receivers to their hooks with the result in the case of subscriber A that the tip supervisory relay r<sup>2</sup>, connected with A cord-circuit, is deenergized and closes, through its armature and back contact, the circuit of the supervisory signal S<sup>2</sup>, thus indicating to the operator that subscriber A has returned his receiver to the hook. When the subscriber D hangs up his telephone, current is cut off from the metallic line in the same way, and the tip-relay r<sup>8</sup> is therefore deenergized. This serves to open the metallic circuit of the outgoing end of the trunk, thus deenergizing the supervisory relay r<sup>4</sup> in the A cord-circuit, which closes the circuit of the supervisory signal S<sup>3</sup> and indicates to the operator that the D subscriber has hung up his receiver. The trunk-relay r<sup>7</sup>, however, is again operated over the grounded circuit, as described. The locking-relay remains operated over this ringing-circuit to prevent the operation of the ringing-lamp S<sup>4</sup>. The A operator seeing both signals in her cord-circuit exposed pulls out both plugs, thus restoring all parts to normal at her position. The withdrawal of the plug P<sup>2</sup> at the A exchange deprives the trunk-relay r<sup>7</sup> at the incoming end of the trunk of operating-current, which is therefore deenergized and closes, through its armature and back contact, a circuit of the disconnecting-lamp S<sup>5</sup> and of the pilot-relay r<sup>12</sup>, said circuit being traced from the live pole of the battery B<sup>3</sup>, over conductor 47, through the pilot-relay r<sup>12</sup> and the lamp S<sup>5</sup>, over conductor 53 to the armature of the trunk-relay r<sup>7</sup>, thence over its



back contact, the conductor 59<sup>b</sup>, conductor 52, forward contact and armature 51 of sleeve-relay  $r^9$  to ground. The pilot-signal  $S^6$  is therefore operated to attract the attention of the operator to the bank of incoming trunk disconnect-signals, and the lamp  $S^5$  indicates the particular trunk to be disconnected. The B operator therefore withdraws the plug  $P^3$ , thus rendering the signal-lamp  $S^5$  inert, and deenergizing pilot-relay  $r^{12}$  and locking-relay  $r^{11}$ . All parts are thus returned to normal position.

Upon the withdrawal of the plug  $P^2$ , as explained, from the trunk-jack the retardation-coil 34 is disconnected therefrom, thus preventing the operation of the trunk-relay  $r^7$  by means of the so-called "earth-currents," which may be present in sufficient amount to flow over the grounded side of the trunk-circuit, if the retardation-coil is permanently connected, and thus preventing the deenergization of trunk-relay  $r^7$ , and therefore preventing the operation of the disconnecting-lamp. It will be understood, however, that the retardation-coil may be connected permanently with the sleeve side of the outgoing end of the trunk-circuit, if preferred.

The disconnecting-signal  $S^5$  serves also as a guard-lamp in case the A operator inserts the calling-plug  $P^2$  of her circuit into the wrong jack, for the reason that the trunk-relay of that trunk will be operated, while the sleeve-relay is not operated. A circuit will therefore be completed from the live pole of the battery  $B^3$  over conductor 47, the pilot-relay  $r^{12}$  and disconnecting-lamp  $S^5$ , conductor 53, armature, and forward contact of trunk-relay, conductor 52<sup>b</sup>, back contact, and spring 51 of sleeve-relay  $r^9$  to ground. This lamp will therefore glow and indicate to the operator that a mistake has been made.

In case the wanted subscriber's line is found busy or in case the subscriber having been called does not respond, the plug  $P^3$  is inserted in one of the jacks  $J^6$  or  $J^5$ , and the corresponding signal is transmitted to the waiting subscriber.

Upon inserting the plug  $P^3$  in one of the busy-back or don't-answer jacks—for example, one of the jacks  $J^5$ —a path for current is provided from the battery  $B^3$  through the sleeve-strand of the trunk-cord, sleeve-contacts of the plug and jack, and over conductor 75 to ground. This will serve to operate the sleeve-relay  $r^9$  to complete the continuity of the tip-strand  $t^3$  of the trunk-cord through its spring 42 and the front contact. Upon the completion of the strand at this point the tip-relay  $r^8$  is provided with current from the live pole of the generator  $B^4$ , through the secondary winding of the induction-coil 67, through circuit-breaker 69, and thence over conductor 71, through resistance 72 and the tip-contacts of the jack and plug, and over the tip-strand, and through the re-

lay  $r^8$  to ground. This circuit is interrupted at the breaker 69, so that the relay  $r^8$  is alternately energized and deenergized to correspondingly make and break the short circuit of the trunk-relay  $r^7$ , which is therefore simultaneously removed from and inserted in the circuit of the outgoing end of the trunk. This causes the intermittent operation of the tip-relay  $r^4$  in the A cord-circuit to effect the flashing of the supervisory signal  $S^3$ , whereby the A operator is notified that the called-subscriber's line is busy. The flashing of this light of course corresponds to the rapidity of the breaking of the circuit at breaker 67 or 70, which indicates to the operator whether the line is busy or does not answer. The subscriber is also notified by the tone caused in his receiver.

The order-circuit 33, as is indicated by the branching lines 33<sup>a</sup>, connects the B operator with several A operators, either at the same or different exchanges. The A operator is also provided with a plurality of keys  $k^2$  to connect herself with the different B operators. The busy-back or don't-answer apparatus is common to the various sections of the incoming trunk-board, as is indicated by the branching lines.

Although I have described the method of making connections through the medium of the order-circuit, I do not wish to so confine the invention, for it is apparent that the A operator is able by means of her testing apparatus to test the condition of the several trunks before her until an idle trunk is found. Upon so testing and finding an idle trunk she may insert the calling-plug  $P^2$  of her cord-circuit with the result that the trunk-relay  $r^7$  operates and lights the lamp  $S^5$ , which lamp has been previously termed the "guard-lamp," but in this method of operation it would act as a calling-signal from the A operator to the B operator. The B operator, upon seeing the signal  $S^5$ , would depress her listening-key  $k^6$   $k^5$ , which would connect her receiver in series with the repeating-coil windings  $w^3$  and  $w^4$ , these receiver connections being indicated in dotted lines in Fig. 1. She is therefore able to communicate with the A operator. It will be understood also that had the subscriber A called for a connection with another subscriber in the same exchange the line of that subscriber would have been tested in the ordinary manner by means of the cord-plug  $P^2$ , and the subscriber would have been called by the ringing-generator  $g$ .

Fig. 2 shows a modification of my invention in which the sleeve conductor of the trunk at the B exchange passes by means of conductor 36<sup>c</sup> to the armature 37 of the tip-relay  $r^8$ , the back contact of which is connected with a conductor 36<sup>a</sup>, leading to ground through the trunk-relay  $r^7$ , this relay being also of low resistance. The forward



contact of spring 37 of tip-relay  $r^8$  connects, through conductor 35<sup>a</sup>, with the repeating-coil winding  $w'$  and the tip conductor 35 of the trunk. When, therefore, the tip-relay operates, the branch containing the trunk-relay is entirely disconnected from the sleeve conductor of the trunk and the two conductors of the trunk are connected together through the armature 37 and its forward contact. In view of this arrangement, in which the trunk-relay is deenergized during conversation and during the period of operation of the tip-relay  $r^8$ , the circuit of the disconnecting-lamp is extended in series through the back contact and spring 57 of tip-relay  $r^8$ . In order to operate the disconnecting-lamp, therefore, the simultaneous deenergization of both the tip-relay and the trunk-relay is required; otherwise, the construction and operation is the same as in Fig. 1. The retardation-coil is here shown connected permanently with the sleeve-strand at the outgoing end of the trunk; but it will be understood that it may be normally disconnected, as in Fig. 1.

In Fig. 3 a slightly-different arrangement is presented, in that condensers are used in the strands of the trunk in place of the repeating-coil  $W$ . The condenser  $c^{10}$  is placed between the tip-strand  $t^3$  and the tip-conductor 35 of the trunk, while the similar condenser  $c^{11}$  is included between the sleeve-strand  $s^3$  and the conductor 36 of the trunk; otherwise, the operation and construction is the same as in Fig. 1, and is therefore not specifically described. It will be apparent that the voice-currents will be transmitted from end to end of the trunk through the inductive action of the condensers, while the steady currents will be forced to take the paths corresponding to those heretofore described. In this figure also I have omitted the retardation-coil at the outgoing end of the trunk and have provided a "make-before-break" contact for the tip-relay  $r^8$ , whereby when the cord-circuit is connected with the trunk at the outgoing end the sleeve supervisory relay is actuated over one side of the trunk and through the grounded contact of the tip-relay, and when the called subscriber responds the metallic circuit of the trunk is completed before the ground is disconnected, to thereby prevent the deenergization of the sleeve supervisory relay in the A cord. It will be understood that the return-circuit over which the trunk-relay is actuated may be a common return-wire instead of the ground-return, as heretofore described.

The ground connections heretofore referred to, 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 of the batteries may be grounded so far as the operation of the system is concerned, the only variation necessary from that shown in the drawing being to remove the present ground connections and replace them by other conductors and replace the ground upon the opposite pole of the battery. While the exact dimensions of the relays are not the essence of my invention, I have secured good results with trunk-relays from two hundred and fifty to five hundred ohms resistance, tip and sleeve-relays of one hundred ohms resistance, and locking-relays of five hundred ohms, while the other parts may be of the usual or desired dimensions. It is also apparent, so far as some features are concerned, that the 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 plugs and cords.

While I have described several forms and several different ways of carrying out my invention, I would have it understood that the invention is not so limited, as it is apparent 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-line adapted to connect with a calling telephone-line at its outgoing end and a called telephone-line at its incoming end, of a guard-signal at the incoming end of the trunk, means operated by current flowing over one side only of the trunk for placing said signal in condition to operate when the connection is established at the outgoing end of the trunk; and further means actuated by current sent over a portion of the talking-circuit when the trunk is connected with the called line and before the response of the called subscriber for rendering said signal inoperative, substantially as described.

2. The combination with a trunk-line adapted to connect with a calling telephone-line at its outgoing end and with a called telephone-line at its incoming end, of a guard-signal for the incoming end of the trunk, a relay actuated over one side of the trunk and ground when the connection is established at the outgoing end of the trunk for operating said signal and a second relay adapted to be actuated over one side of the talking-circuit when the connection with the called line is established, said latter relay serving to prevent the operation of said signal, substantially as described.

3. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end and a called telephone-line at its incoming end, of a signal associated with said incoming end, a relay also at said incoming end adapted to be op-



erated by current sent over one side of the trunk and ground before the subscribers are in conversation and over the metallic trunk-line during conversation, and a second relay at said incoming end adapted to be operated by current flowing over a portion of the talking-circuit when the trunk is connected with the called line, said relays jointly controlling said signal so as to operate the same to give a guard indication when the connection is established at the outgoing end only and so as to give a disconnect indication when the connection is severed at the outgoing end and the incoming end is connected with the called line, substantially as described.

4. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end, and with a called telephone-line at its incoming end, of a relay actuated over one side of the trunk and ground before the subscribers are in conversation and over the metallic trunk during conversation, a second relay adapted to be operated over one side of the talking-circuit when the trunk is connected with the called line, and a signal for the incoming end of the trunk, said signal being actuated when either of said relays is energized and the other de-energized, whereby in the one instance it serves as a guard-signal and in the other as a disconnect-signal, substantially as described.

5. The combination with a trunk-line extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a relay at the incoming end of the trunk responsive to current over one side only of the trunk with suitable return when the connection is established at the outgoing end and the called subscriber's telephone is not in use, a second relay at said end actuated over a portion of the talking-circuit when connection is established with the called line, a signal whose actuation depends upon said relays and adapted to be operated to indicate when a connection exists at either end only, and a pilot-signal also associated with the trunk and actuated whenever said first-named signal is actuated, substantially as described.

6. The combination with a trunk-line extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a relay at the incoming end of the trunk responsive to current over one side only of the trunk with suitable return when the connection is established at the outgoing end and the called subscriber's telephone is not in use, a second relay at said end actuated over a portion of the talking-circuit when connection is established with the called line, a signal whose actuation depends solely upon said relays and adapted to be operated to indicate when a connection exists at either end only, and a

pilot-signal also associated with the trunk and actuated whenever said first-named signal is actuated, substantially as described.

7. The combination with a trunk-line extending between different switchboard-sections and adapted to connect telephone-lines together for conversation, of a relay at the incoming end of the trunk responsive to current over one side only of the trunk with suitable return when the connection is established at the outgoing end and the called subscriber's telephone is not in use, a second relay at said end actuated over a portion of the talking-circuit when connection is established with the called line, and a signal entirely controlled by said relays and actuated when connection exists at either end only whereby it acts under one condition as a guard-signal and under the other as a disconnect-signal, substantially as described.

8. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end and a called subscriber's line with which its incoming end is adapted to be connected, of a retardation-coil legged to ground from one side of the talking-circuit established by the connection of the cord with the trunk but normally disconnected therefrom, a supervisory signal associated with the cord-circuit and placed in condition to operate by current flowing through said retardation-coil and means actuated by the response of the called subscriber for rendering said supervisory signal inoperative, substantially as described.

9. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end, of a called subscriber's line with which its incoming end is to connect, a retardation-coil legged to ground from one side of the talking-circuit established by the connection of the cord with the trunk, but normally disconnected therefrom, and a supervisory signal associated with the cord-circuit and placed in operative condition by current flowing over one side of the talking-circuit and through the retardation-coil, said signal being rendered inoperative by current flowing over the other side of the talking-circuit when the called subscriber responds, substantially as described.

10. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end and a called subscriber's line with which its incoming end is to connect, a retardation-coil legged to ground from one side of the talking-circuit established by the connection of the cord with the trunk, said coil being normally disconnected therefrom, a supervisory signal in connection with the cord and placed in operative condition by current flowing over one side of the talking-circuit and through said retardation-coil, and a relay actuated by current flowing over the



other side of the cord-circuit upon the response of the called subscriber to render said signal inoperative, substantially as described.

11. The combination with a trunk-line, of  
5 a cord-circuit to connect with its outgoing end and a called subscriber's line with which its incoming end is to connect, a retardation-coil legged to ground from one side of the talking-circuit established by the connection  
10 of the cord with the trunk, said retardation-coil being normally disconnected therefrom, a relay actuated by current flowing over one side of the cord-circuit and through said retardation-coil, a supervisory signal associated with the cord-circuit and placed in operative condition by said relay when actuated, and a second relay actuated by current  
15 flowing over the other side of the talking-circuit upon the response of the called subscriber to render said signal inoperative, substantially as described.

12. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end and a called subscriber's line with which  
25 its incoming end is adapted to connect, a retardation-coil legged to ground from one side of the trunk-circuit during conversation only, said retardation-coil being normally disconnected from said trunk-circuit, a supervisory signal associated with the cord-circuit and placed in operative condition by current flowing through said retardation-coil, and means  
30 actuated upon the response of the called subscriber for rendering said supervisory signal inoperative, substantially as described.

13. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end and a called subscriber's line with which  
40 its incoming end is to connect, a retardation-coil legged to ground from one side of the trunk-circuit during conversation only, said retardation-coil being normally disconnected from the trunk, a supervisory signal associated with the cord-circuit and placed in condition to operate by current over one side of the talking-circuit and through said retardation-coil to ground, and means actuated by  
45 current flowing over the other side of the trunk-circuit upon the response of the called subscriber for rendering said signal inoperative, substantially as described.

14. The combination with a trunk-line, of a cord-circuit to connect with its outgoing end and a called subscriber's line with which  
55 its incoming end is to connect, a retardation-coil normally disconnected from the trunk-circuit but connected with one side thereof by the connection of the cord-circuit with the trunk, a supervisory signal associated with the cord and placed in operative condition by current flowing through said retardation-coil, and means actuated upon the response of the called subscriber for rendering said supervisory signal inoperative, substantially  
60 as described.

15. The combination with a trunk-line having spring-jacks at its outgoing end, of a cord-circuit to connect with said jacks and a called subscriber's line with which its incoming end is to connect, an additional contact  
70 in said jack normally disconnected from the line, a retardation-coil connected between ground and said contact, means for connecting said contact with one side of the trunk when the cord-circuit plug is inserted in the jack, a supervisory signal associated with the  
75 cord-circuit and placed in operative condition by current flowing through said retardation-coil, and means actuated by the response of the called subscriber for rendering said signal inoperative, substantially as described.

16. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end and a called  
85 telephone-line at its incoming end, of an electromagnetic device normally legged to ground at its incoming end for the operation of certain telephonic apparatus, and a retardation-coil legged to ground at the outgoing end during conversation over which current is adapted to flow for the operation of certain telephonic apparatus, said retardation-coil being normally disconnected from the circuit whereby the presence of earth  
90 currents cannot normally cause the undesired operation of the said electromagnetic device, substantially as described.

17. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end and a called  
100 telephone-line at its incoming end, of a relay normally legged to ground from one side of the trunk-circuit at its incoming end and arranged to control telephonic apparatus at said end, and a retardation-coil legged to ground at the outgoing end during connection over which current is adapted to flow to operate telephone apparatus, said retardation-coil being normally disconnected from  
105 the circuit whereby the presence of earth currents will not effect the undesired operation of the relay, substantially as described.

18. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end and a called  
115 telephone-line at its incoming end, of a relay normally legged to ground from one side of the trunk-line at its incoming end for the operation of telephonic apparatus, and a retardation-coil legged to ground from the same side of the trunk-circuit at the outgoing end when a connection exists therewith over which current is adapted to flow for the operation of telephonic apparatus, said retardation-coil being normally disconnected from the trunk, whereby the presence of earth currents will not effect the undesired operation of the relay, substantially as described.  
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19. The combination with a trunk-line adapted to be connected with a calling telephone-line at its outgoing end and a called telephone-line at its incoming end, of a relay 5 normally legged to ground from one side of said trunk-line at the incoming end to control telephone apparatus at said end, a retardation-coil normally disconnected from the trunk at its outgoing end, and means for 10 automatically connecting the same with the trunk when the connection is established therewith at its outgoing end over which current is adapted to flow for the operation of telephonic apparatus, whereby the undesired 15 operation of the relay by earth currents is prevented, substantially as described.

20. The combination with a trunk-circuit

extending between different switchboard-sections, of a trunk-relay at the incoming end of said trunk energized by current over one 20 limb only of the outgoing end, a second relay energized over one limb only of the incoming end when a connection is established with a called line, and a signal at said incoming end which will be displayed at the actuation of 25 either of said relays but effaced at the actuation of both, substantially as described.

Signed by me at Chicago, county of Cook,  
State of Illinois, this 26th day of July, 1902.

FRANCIS W. DUNBAR.

Witnesses:

ROBERT LEWIS AMES,  
GAZELLE BEDER.