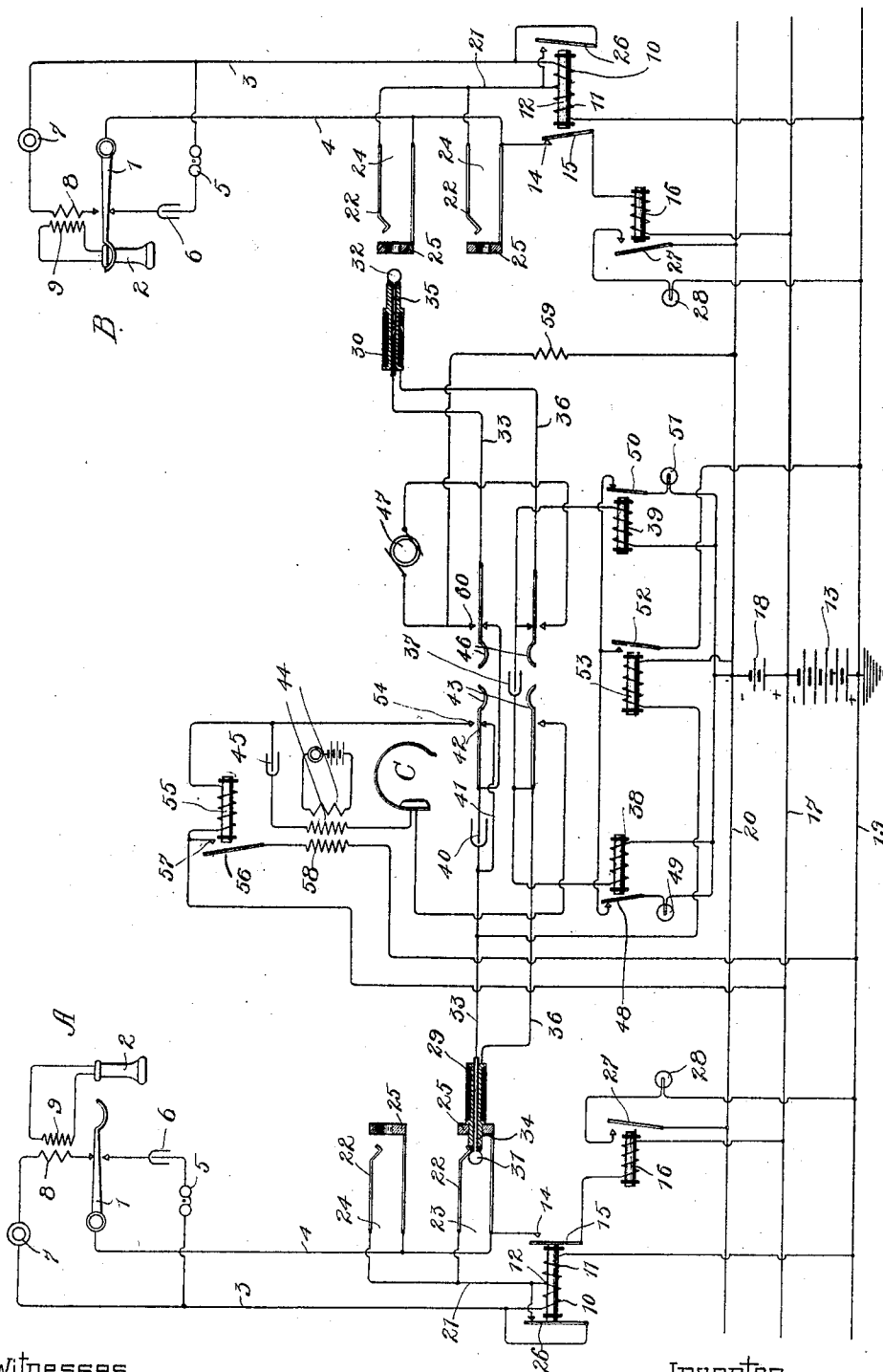


No. 804,077.

PATENTED NOV. 7, 1905.

H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.

APPLICATION FILED MAY 7, 1903.



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TELEPHONE-EXCHANGE SYSTEM.

No. 804,077.

Specification of Letters Patent.

Patented Nov. 7, 1905.

Application filed May 7, 1903. Serial No. 156,070.

To all whom it may concern:

Be it known that I, HARRY G. WEBSTER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawing, forming a part of this specification.

My invention relates to telephone-exchange systems, and particularly to exchange systems employing a common source of current located at the central exchange for the purpose of supplying talking and signaling currents to the telephone-lines associated therewith and to a so-called "multiple-switchboard" system.

In general my invention relates to an improved telephone-line circuit and a busy-test circuit adapted for use in conjunction therewith.

The particular objects of my invention are to provide a telephone system in which the two line-contacts of the multiple spring-jacks are sufficient both for connecting and testing purposes, a special test-thimble being unnecessary; to provide a system in which the line-signal may be connected with that side of the common battery at the central station which is not connected with the ground; to provide a system in which the sleeve-contacts of the jacks are permanently connected with the line, whereby the telephonic talking-circuit does not include relay-contacts, and to provide a test-circuit for use in conjunction with the line-circuit such that the operation of the system will not produce disagreeable clicks in the subscribers' telephone instruments and such that false busy-test signals will be avoided.

The features of my invention will be best understood by reference to the accompanying drawing, in which at each of the substations A and B, I have illustrated the usual subscriber's substation apparatus, comprising in each instance a switch-hook 1, which when in its normal depressed condition, due to the weight of the receiver 2, serves to connect between the line-limbs 3 and 4 the call-bell 5 and the condenser 6. When relieved of the weight of the receiver 2, the switch-hook 1 serves to connect between the line-limbs 3 and 4 the battery-transmitter 7 and the primary 8 of an induction-coil whose secondary 9 is

connected with the receiver 2. The line-limbs 3 and 4 lead to the central exchange C, where the line-limb 3 is normally serially connected, through the differential windings 10 and 11 of the differential cut-off relay 12, with the positive grounded pole of the section 13 of the common battery. The line-limb 4 is normally connected, through the back contact 14, the armature 15 of the differential cut-off relay 12, the line-relay 16, and the bus-bar 17, with the negative pole of the section 13 of the common battery. In accordance with my invention the common battery is preferably divided, as shown, into two sections, section 13 being of, say, thirty volts potential, while section 18 may be of approximately ten volts potential. These sections of the common battery may be connected, as shown, with the bus-bars 17, 19, and 20. It will be understood, of course, that the exact potentials or voltages of the batteries as herein set forth are immaterial and that these voltages may be varied to suit various conditions and requirements met in practice.

The common terminal of the windings 10 and 11 of the differential cut-off relay is connected by a conductor 21 with the tip-springs 22 of the answering-jack 23 and the multiple line-jacks 24. The sleeve-contacts 25 of these jacks, which also constitute the test-thimbles thereof, are connected permanently with the line-limb 4, as shown. An armature 26 of the differential cut-off relay serves when attracted into its forward position to close a low-resistance short circuit in shunt of the winding 10 of the differential cut-off relay, thereby connecting the tip-springs 22 through a low-resistance non-inductive path directly with the line-limb 3. The line-relay 16 serves, by means of its armature 27, to control a local illuminating-circuit through the line signaling-lamp 28.

The operator's cord-connecting apparatus comprises an answering-plug 29 and a calling-plug 30, the tip-contacts 31 and 32 of these plugs being connected by means of the tip-strand 33, while the sleeve-contacts 34 and 35 are connected by means of the sleeve-strand 36. The conductive continuity of the sleeve-strands is interrupted by the serial inclusion of a condenser 37, this condenser, however, being shunted by a conductive circuit through the winding of the supervisory relays 38 and

39. A condenser 40 is included in the tip-strand, this condenser, however, being normally shunted by a conductor 41, making connection with the contact 42 of the operator's listening-key 43, which serves to connect the usual operator's telephone set 44 in bridge of the cord-strands, a condenser 45 being included in the operator's telephone-circuit, as shown.

10 The usual ringing-key 46 serves when manipulated to connect the terminals of the ringing-generator 47 in bridge of the cord-strands leading to the calling-plug 30. The supervisory relay 38 is connected between that section of the sleeve-strand leading to the answering-plug and the negative pole of the section 18 of the common battery. The supervisory relay 39 is connected between the portion of the sleeve-strand leading to the calling-plug 30 and the negative pole of the section 18 of the common battery. The supervisory relay 38 controls an armature 48, which in turn controls a local illuminating-circuit through the supervisory signaling-lamp 49. In the same manner the armature 50 of the supervisory relay 39 controls a local illuminating-circuit through the supervisory signaling-lamp 51. The connection of the positive pole of the common battery with the supervisory lamp-circuit is controlled by the armature 52 of a supervisory controlling-relay 53, this supervisory controlling-relay being connected between the bus-bar 20 and the tip-strand of the cord-circuit leading to the answering-plug 29.

A manipulation of the listening-key 43 to connect the operator's telephone set in bridge of the cord-circuit serves, by means of the upper contact-spring of the listening-key and a contact 54, to connect the test-relay 55 in a circuit to the bus-bar 17. The test-relay 55 controls, by means of its armature 56 and front contact 57, a local circuit through the test-winding 58 in inductive relation with the induction-coil associated with the operator's telephone set.

The operation of a telephone system constructed in accordance with my invention may be described as follows: The subscriber at substation A upon removing the telephone-receiver from the switch-hook closes a conductively-continuous circuit, which may be traced as follows: from the grounded terminal of the section 13 of the common battery through the bus-bar 19, the windings 11 and 10 of the differential cut-off relay 12, line-limb 3, transmitter 7, primary coil 8, switch-hook 1, line-limb 4, contact 14, armature 15, line-relay 16, to the bus-bar 17, connected with the negative pole of the section 13 of the common battery. Current flowing through this circuit causes the energization of the line-relay 16, whereupon its armature 27 is attracted to close a local illuminating-circuit through the line-signaling lamp 28. No net energization of

the cut-off relay 12 is caused due to the passage of this current through the windings thereof for the reason that the windings are differentially related one to the other. The central operator answers the signal caused by the illumination of the lamp 28 by inserting the answering-plug 29 of her cord-connecting apparatus within the answering-jack 23. The insertion of this plug causes the closure of a circuit, which may be traced as follows: from the bus-bar 20, through the supervisory controlling-relay 53, the tip-strand 33, tip-contact 31, tip-spring 22, conductor 21, and winding 11 of the differential cut-off relay 12 to the bus-bar 19, connected with the positive pole of the common battery. By the closure of this circuit the increased current through the winding 11 of the differential cut-off relay serves to unbalance the neutral condition thereof, whereupon a net energization is produced to cause the attraction of the armatures 15 and 26. The attraction of the armature 15 serves to break the electrical connection with the back contact 14, whereupon the previously-traced circuit through the line-relay 16 is interrupted to cause its deenergization and the consequent retraction of the armature 27 to cause the extinguishment of the lamp 28. The attraction of the armature 26 serves to close a circuit of low resistance in shunt of the winding 10 of the differential cut-off relay, whereby the tip-springs 22 are connected through a non-inductive circuit of low resistance directly with the line-limb 3. The energization of the supervisory controlling-relay 53, due to the passage of current through the last-described circuit, causes the consequent attraction of its armature 52 to connect the positive pole of the common battery with the back contacts of the supervisory relays 38 and 39 to connect battery-current with the supervisory signaling-lamps 49 and 51. The insertion of the answering-plug 29 within the answering-jack also causes the closure of a circuit, which may be traced as follows: from the bus-bar 20, through the supervisory relay 38, the sleeve-strand 36, sleeve-contact 34, sleeve-contact 25, line-limb 4, switch-hook 1, primary coil 8, transmitter 7, line-limb 3, armature 26 and its front contact to the winding 11 of the differential cut-off relay, and thence to the bus-bar 19, connected with the positive pole of the common battery. Current flowing through this circuit causes the energization of the supervisory relay 38 to attract the armature 48, thereby preventing the illumination of the supervisory lamp 49. Having thus established connection with the line to substation A, the operator manipulates her listening-key 43 to connect her telephone set in bridge of the cord-circuit, and thereupon ascertains by telephonic communication with the calling subscriber the number of the substation with which connection is desired. Learning that the desired

connection is with the subscriber located at substation B, the operator first applies the tip-contact 32 of her calling-plug to the test-thimble of a line-jack associated with the line to substation B. If an operator at some other position on the multiple switchboard has inserted a plug of her cord connecting apparatus within a multiple line-jack associated with the line to substation B, the application of the testing tip-contact 32 to the test-thimble will cause the closure of a circuit which may be traced as follows: from the bus-bar 17, through the test-relay 55, contact 54, tip-strand 33, tip-contact 32, test-thimble 25, and thence through the sleeve-contact and sleeve-strand of the other connected cord-strand through the associated supervisory relay corresponding with relay 39 to the negative pole of the common battery 18. Current flowing through this circuit will cause the energization of the test-relay 55 to attract the armature 56, thereby closing a local circuit through the test-winding 58 to produce a click in the operator's telephone-receiver, thereby notifying her that the line to substation B is in use. If the subscriber at substation B has removed his telephone-receiver from the switch-hook, but the answering operator at the central station has as yet not connected a plug of her cord-circuit with the telephone-line a test-circuit may be traced as follows upon the application of the test-contact 32 to the test-thimble: from the bus-bar 17, through the test-relay 55, contact 54, tip-strand 33, tip-contact 32, test-thimble 25, line-limb 4, switch-hook 1, primary coil 8, transmitter 7, line-limb 3, the windings of the differential cut-off relay 12, and thence to the bus-bar 19. It will thus be seen that the test-thimbles 25 are normally charged to a potential of thirty volts above the zero potential of the ground—that is to say, when the receiver at the substation is upon the switch-hook and there is no connection between cord-connecting apparatus and the line-jacks the test-thimbles 25 are connected through the winding of the line-relay with the bus-bar 17, which, it will be remembered, may be made of approximately thirty volts difference in potential from the ground to which the bus-bar 19 is connected. The insertion of the plug of a cord-circuit within a line-jack causes the attraction of the armature 15 of the differential cut-off relay, thereby disconnecting the test-thimbles from the thirty-volt bus-bar 17 and connecting the test-thimbles through the sleeve-strand of the connected cord-strand and a supervisory relay with the forty-volt bus-bar 20. The removal of the receiver at the substation from its switch-hook causes the closure of a circuit either through the line-relay 16 before the connection with the cord connecting apparatus or through a supervisory relay after the connection with the cord connecting apparatus and the winding or windings of a differential cut-off relay. The resistances of the relays may be such, and the resistance of the line-circuit is in practice such, as to charge the test-thimbles of such a conductively completed line-circuit to a potential in the neighborhood of twenty-two or twenty-four volts above that of the earth. The testing tip-contact 32 being directly connected through the test-winding 55 with the thirty-volt bus-bar 17 when applied to the test-thimble of an idle line, causes no current to flow through the test-relay 55 for the reason that the test-thimble is also at a potential of thirty volts. In either of the other conditions specified, in which the test-thimble has been raised to forty volts or decreased to approximately twenty-four volts, the application of the tip-contact to the test-thimble causes the closure of a circuit through the test-relay 55 to cause an actuation thereof. The operator upon learning that the line to substation B is idle inserts the calling-plug 30 within a line-jack 24 and thereupon manipulates her listening-key 46 to connect the terminals of the alternating-current generator 47 with the line-limbs, thereby causing an actuation of the call-bell 5 at substation B. The insertion of the calling-plug 30 within a line-jack also serves, as described, for the line-circuit to substation A to cause an actuation of the differential cut-off relay 12 to disconnect the line-signal and short-circuit the winding 10. In order that the armatures of the differential cut-off relay may remain in their forward attracted positions during the connection of the generator 47 with the line, it may be found desirable to connect the resistance 59 between the tip-strand contact 60 and the bus-bar 20, as shown. It will be remembered that the attraction of the armature 52 of the supervisory controlling-relay 53 has caused the closure of a local illuminating-circuit through the supervisory signaling-lamp 51. The removal of the receiver from the switch-hook at substation B, however, causes the closure of a circuit through the supervisory relay 39, whereby the armature 50 is attracted to break the local circuit through the lamp 51, whereupon the lamp is extinguished to indicate to the central-station operator that the subscriber at substation B has answered the calling-signal. Upon the completion of the conversation either subscriber upon replacing his receiver upon the associated switch-hook interrupts the continuity of the circuit through the supervisory relay connected therewith, whereby the supervisory-relay armature is retracted to cause the closure of a circuit through the associated supervisory signaling-lamp, thereby indicating to the operator that the connected subscribers have finished their conversation, whereupon she removes the plug of the cord connecting apparatus from the line-jacks, thus restoring the line and cord circuit apparatus to its normal condition. It will be seen that a leakage

path or ground on the line-limb 4 if of sufficiently low resistance will cause the closure of a circuit through the line-relay 16 to cause the energization thereof and the consequent illumination of the line signaling-lamp. The operator in attempting to respond to the signal thus produced will of course learn that the apparent call is due to a leakage path or ground rather than to a call initiated from the substation connected with the line. She may thereupon notify the proper authorities, who may proceed to put the line in proper repair. In the same manner a ground upon the line-limb 4 might if of sufficiently low resistance cause an actuation of the test-relay 55 to indicate that the tested line was in use. For this reason the resistance and adjustment of the line-relays and the test-relay are desirably made such that any ground upon the line which would cause the actuation of the test-relay will also cause the actuation of the associated line-relay. In order that the flow of current through the test-circuit may be comparatively small and in order that the testing-current shall rise gradually to its full maximum value, the winding of the test-relay is desirably of high resistance and high impedance.

While I have herein shown and described one preferred embodiment of my invention, it will be apparent to those skilled in the art that many modifications may be employed without departing from the spirit thereof. I do not therefore wish to limit myself to the precise disclosure herein set forth; but,

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

2. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of

a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

3. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay, and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

4. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation,

tion, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an
5 actuation thereof to destroy the substation control of said line-signal.

5. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of
10 a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a
15 grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack
20 having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for
25 connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to
30 destroy the substation control of said line-signal.

6. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of
35 a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal
40 of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently
45 connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line
50 with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the sub-
55 station control of said line-signal.

7. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a
60 source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay
65 serially included in a path from the second

line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common
70 terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the con-
75 nection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

8. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a
80 source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of
85 said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently
90 connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversa-
95 tion, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.
100

9. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a
105 source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded ter-
110 minal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-
115 spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said
120 line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof
125 to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.
130

10. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

11. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

12. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb

to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

13. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

14. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit

through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

15. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

16. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to close a low-resistance path in shunt of the other winding of the cut-off relay.

17. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said

line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

18. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

19. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit

through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

20. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal and to close a low-resistance path in shunt of the other winding of the cut-off relay.

21. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the insertion of a plug of said cord connecting apparatus within any one of said line-jacks causes the closure of a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal and to close a low-resistance path in shunt of the other winding of the cut-off relay.

22. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a terminal of said source of current, a line-relay serially included in a path from the

second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

23. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

24. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in an electrical path from one of said line-limbs to a terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal.

25. In a telephone-exchange system, the combination with a telephone-line extending

by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings permanently included in an electrical path from one of said line-limbs to a terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second terminal of said source of current, a line-signal controlled by said line-relay, a line-jack having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal and to close a low-resistance path in shunt of the other winding of the cut-off relay.

26. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current.

27. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-

spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current.

28. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second and thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current.

29. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said

line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current.

5 30. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay of high resistance and high impedance having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

31. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, to close a low-resistance path in shunt of the other winding of the cut-off

relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay of high resistance and high impedance having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

32. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay of high resistance and high impedance having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

33. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with

said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay of high resistance and high impedance having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

34. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

35. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected

with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

36. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

37. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-

spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay.

38. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay, the relative resistance and adjustment of said line-signal and said test-relay being such that the line-signal will be actuated by any leakage-current of sufficient strength to cause the actuation of said test-relay.

39. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said

line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal to close a low-resistance path in shunt of the other winding of the cut-off relay, and to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay, the relative resistance and adjustment of said line-signal and said test-relay being such that the line-signal will be actuated by any leakage-current of sufficient strength to cause the actuation of said test-relay.

40. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple-line jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact permanently directly connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact

connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay, the relative resistance and adjustment of said line-signal and said test-relay being such that the line-signal will be actuated by any leakage-current of sufficient strength to cause the actuation of said test-relay.

41. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a cut-off relay having two differential windings included in a path from one of said line-limbs to a grounded terminal of said source of current, a line-relay serially included in a path from the second line-limb to a second thirty-volt terminal of said source of current, a line-signal controlled by said line-relay, multiple line-jacks each having a tip-spring permanently connected to the common terminal of the differential windings of said cut-off relay and a sleeve-contact connected with the second line-limb, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit through one winding of said cut-off relay to cause an actuation thereof to destroy the substation control of said line-signal, and means adapted upon actuation of said cut-off relay to cause a connection of said sleeve-contact with a forty-volt terminal of said source of current, a testing-contact associated with said cord connecting apparatus, a test-relay having one terminal connected with the thirty-volt terminal of said source of current, a test-contact connected with the other terminal of said test-relay, and a signaling device controlled by said test-relay, the relative resistance and adjustment of said line-signal and said test-relay being such that the line-signal will be actuated by any leakage-current of sufficient strength to cause the actuation of said test-relay.

42. In a telephone-exchange system, the combination with a source of current at the central exchange adapted to supply signaling and talking currents to telephone-lines, of a line-jack, a test-thimble thereof adapted to form a part of a telephonic talking-circuit, a telephone-line circuit whose conductive continuity is controlled by switching apparatus located at the associated substation adapted to maintain said test-thimble at a normal potential intermediate between the potentials of the extreme terminals of said source of current, and adapted to cause a reduction in said normal potential upon a closure of the line-circuit at said substation, cord connecting apparatus at the exchange having a plug adapted for insertion within said line-jack, means whereby the insertion of said plug within said line-jack, when said line-circuit is conductively discontinuous through the substation

apparatus, causes a rise in the potential of the test-thimble above the normal potential thereof, and a test-relay of high impedance and resistance having one terminal connected to a terminal of said source of current whose potential is equal to the normal potential of said test-thimble and whose other terminal is connected to a test-contact.

43. In a telephone-exchange system, the combination with a source of current at the central exchange adapted to supply signaling and talking currents to telephone-lines, of a line-jack, a test-thimble thereof adapted to form a part of a telephonic talking-circuit, a telephone-line circuit whose conductive continuity is controlled by switching apparatus located at the associated substation, adapted to maintain said test-thimble at a normal potential intermediate between the potentials of the extreme terminals of said source of current, and adapted to cause a reduction in said normal potential upon a closure of the line-circuit at said substation, cord connecting apparatus at the exchange having a plug adapted for insertion within said line-jack, means whereby the insertion of said plug within said line-jack, when said line-circuit is conductively discontinuous through the substation apparatus, causes a rise in the potential of the test-thimble above the normal potential thereof, and a test-circuit having a test-contact charged to the normal potential of said test-thimble.

44. In a telephone-exchange system, the combination with a source of current at the central exchange adapted to supply signaling and talking currents to telephone-lines, of a line-jack, a test-thimble thereof adapted to form a part of a telephonic talking-circuit, a telephone-line circuit whose conductive continuity is controlled by switching apparatus located at the associated substation, adapted to maintain said test-thimble at a normal potential intermediate between the potentials of the extreme terminals of said source of current, and adapted to cause a reduction in said normal potential upon a closure of the line-circuit at said substation, cord connecting apparatus at the exchange having a plug adapted for insertion within said line-jack, means whereby the insertion of said plug within said line-jack, when said line-circuit is conductively discontinuous through the substation apparatus, causes a rise in the potential of the test-thimble above the normal potential thereof, and a test-relay having one terminal connected to a terminal of said source of current whose potential is equal to the normal potential of said test-thimble and whose other terminal is connected to a test-contact.

45. In a telephone-exchange system, the combination with a central exchange, of a telephone-line leading therefrom and terminating in substation apparatus, a source of current at the exchange for supplying talking and sig-

nalng currents to the substation, a positive grounded bus-bar connected with one terminal of said battery, a negative bus-bar connected with the other terminal of said battery, a third bus-bar connected with a point intermediate of said battery, a cut-off relay having two differential windings, one limb of said telephone-line being connected serially through said windings with the grounded bus-bar, a line-relay, a combined test and line spring permanently connected with the other line-limb and normally connected through an armature of the cut-off relay and through the winding of said line-relay with the intermediate bus-bar, and cord connecting apparatus at the central exchange, connection of said cord connecting apparatus with said line causing closure of a local circuit through one winding of said cut-off relay, whereby said line-relay becomes inert, and whereby said test-spring is disconnected from the intermediate bus-bar and connected through the cord-circuit with the negative bus-bar.

46. In a telephone-exchange system, the combination with a central exchange, of a telephone-line leading therefrom and terminating in substation apparatus, a battery at the central exchange, a grounded bus-bar connected with the positive terminal of said battery, a negative bus-bar connected with the negative terminal of said battery, an intermediate bus-bar connected with an intermediate point of said battery, one limb of said line being permanently connected with the grounded bus-bar, a line-spring permanently connected with said limb, a combined test and line spring permanently connected with the other line-limb and normally connected with the intermediate bus-bar, and cord connecting apparatus at the central exchange, connection of said cord connecting apparatus with said line-springs causing said test-spring to be disconnected from said intermediate bus-bar and to be connected with the negative bus-bar through cord-circuit conductors.

47. In a telephone-exchange system, the combination with a central exchange, of a telephone-line leading therefrom and terminating in substation apparatus, a source of current at the central exchange, a grounded bus-bar connected with the positive terminal of said source, a negative bus-bar connected with the other terminal of said source, an intermediate bus-bar connected with an intermediate point of said source, one line-limb being permanently connected with the positive bus-bar, the other line-limb being normally connected with the intermediate bus-bar, multiple spring-jacks connected with said line, the tip-springs of said jacks being permanently

connected to the first line-limb, combined test and line springs for said spring-jacks, permanently connected with the other line-limb and normally with the intermediate bus-bar, an operator's cord-circuit at the central exchange and an operator's listening-key therefor, a test-relay permanently connected with the intermediate bus-bar and normally disconnected from said cord-circuit, insertion of a plug in one of said multiple jacks causing the test-springs to be disconnected from the intermediate bus-bar and to be connected with the negative bus-bar through cord-circuit conductors, actuation of said listening-key and contact with the tip of the test-plug of said cord-circuit with another test-spring of the multiple jacks when a plug is inserted in one of said jacks causing current-flow through said test-relay, a local circuit controlled by said test-relay and bridged between the positive bus-bar and the intermediate bus-bar, and a signaling device included in said local circuit adapted to be actuated upon closure of said local circuit by said test-relay.

48. In a telephone-exchange system, the combination with a telephone-line leading from a central exchange and terminating in substation apparatus, of a battery at the central exchange for supplying talking and signaling currents for said substation, one terminal of said source being grounded, multiple spring-jacks connected with said line, a combined line and test spring for each multiple jack permanently connected with one line-limb and normally connected with an intermediate point of said battery, an operator's cord-circuit at the central exchange, a test-relay associated with said cord-circuit having one terminal permanently connected with said intermediate point, an operator's listening-key, actuation of said key causing the tip of the test-plug of said cord-circuit to be connected through said test-relay with said intermediate point, insertion of a plug in one of said multiple jacks causing said test-spring to be disconnected from said intermediate point and to be connected with one of the terminals of said source, whereby the potential of the test-springs of said multiple jacks is raised, and whereby contact of a testing-tip with one of said testing-springs will cause actuation of said test-relay upon actuation of said listening-key, and a local circuit including signaling apparatus controlled by said test-relay.

In witness whereof I hereunto subscribe my name this 5th day of May, A. D. 1903.

HARRY G. WEBSTER.

Witnesses:

LYNN A. WILLIAMS,
HARVEY L. HANSON.