

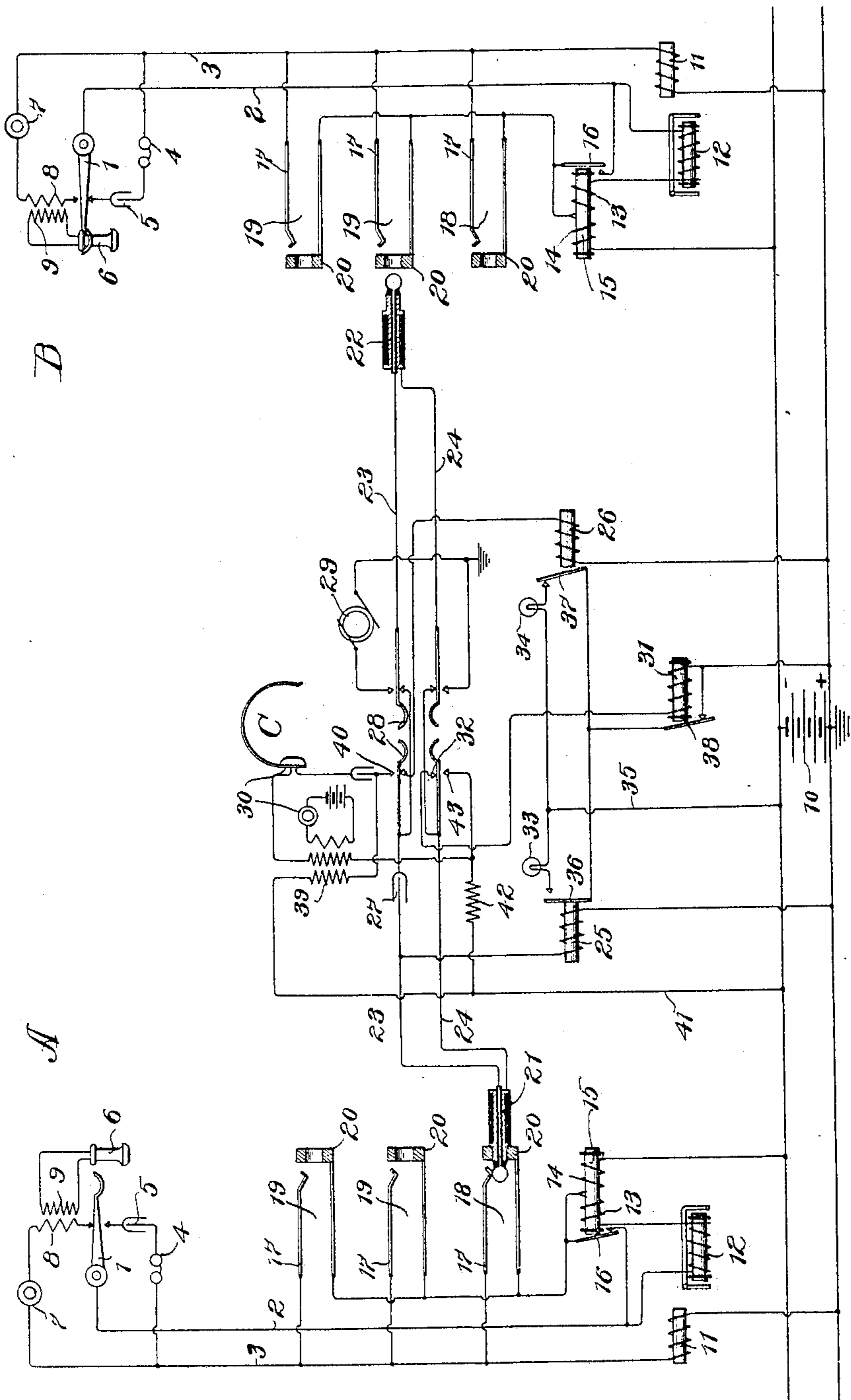
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H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.

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NO MODEL.



Witnesses:

Leonard W. Novander
Lynn A. Williams

By

Inventor
Harry G. Webster
Charles A. Brown
Attorney

UNITED STATES PATENT OFFICE.

HARRY G. WEBSTER, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, OF ROCHESTER, NEW YORK, A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 775,228, dated November 15, 1904.

Application filed February 14, 1903. Serial No. 143,306. (No model.)

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 drawings, forming a part of this specification.

My invention relates to telephone-exchange systems, and more particularly to common-battery exchange systems in which a differential cut-off relay is employed.

The principal objects of my invention are to provide a differential-relay system in which defective insulation or leakage on a telephone-line will not impair the satisfactory and efficient operation of the system, to provide an improved means whereby the operator may test the condition of the line to ascertain whether or not the same is in use, and to provide a satisfactory system of great simplicity and freedom from defective operation due to the use of complicated parts and cord-circuits.

The objects of my invention are attained by the provision of a common source of current at the central exchange to the terminals of which are permanently connected the two limbs of each line leading to a subscriber's substation.

One of the limbs of the telephone-line is connected with a terminal of this battery through a serially-included impedance-coil adapted to prevent the short-circuiting of voice-currents. The outer limb of each line is connected with a terminal of the common source of current through a line-relay and the two differential coils of the cut-off relay. Means are provided whereby the insertion of the plug of a suitable cord-circuit within a line-jack closes a circuit of decreased resistance through one of the windings of the differential cut-off relay, whereby the core of the cut-off relay is given a net energization to actuate the armature thereof. The actuation of this cut-off-relay armature closes a shunt-circuit

of low resistance about the other winding of the cut-off relay and the serially-connected winding of the line-relay.

The contacts of the spring-jacks are permanently connected with the two limbs of the telephone-line, the test-contacts, however, being normally connected with the limb leading to the substation through the intervening line-relay and a winding of the cut-off relay. The actuation of the cut-off relay, however, connects the test-contacts of the spring-jacks directly with this limb of the telephone-line without the intervention of inductive resistance.

My invention will be fully understood by reference to the accompanying drawings, diagrammatically illustrating the circuits and mechanism constituting a preferred embodiment of my invention.

I have illustrated at each of the substations A and B the usual substation telephone apparatus, comprising in each instance a switch-hook 1, adapted when in its lower depressed position to connect the limbs 2 and 3 of the telephone-line in circuit with a call-bell 4 and a serially-connected condenser 5. When in its abnormal upper position, due to the removal of the receiver 6, the switch-hook serves to close a continuous circuit through the battery-transmitter 7 and the primary 8 of the induction-coil 9, which is serially connected with receiver 6. The limbs 2 and 3 of the telephone-line extend to the exchange C, where the limbs 3 are connected each with the positive pole of a common battery 10 through an impedance-coil 11. The limbs 2 of the telephone-line are connected with the negative pole of the battery 10, each limb serially including in circuit therewith the winding of the line-relay 12 and the differential windings 13 and 14 of the cut-off relay 15. The armature 16 of the cut-off relay serves, when in its attracted position, to close a shunt-circuit of low resistance about the winding of the line-relay 12 and winding 13 of the differential cut-off relay 15. The tip-springs 17 of the answering-jack 18 and the multiple calling-jacks 19 are permanently connect-

ed with the limb 3 of the telephone-line. The sleeve-contacts 20, which are also the testing-thimbles of these jacks, are connected to a common terminal of the windings 13 and 14 of the differential cut-off 15.

The form of cord-connecting apparatus employed comprises an answering-plug 21 and a calling-plug 22, the tip-contacts of these plugs being connected by a tip-strand 23, and the sleeve-contacts of the plugs being connected by a sleeve-strand 24. There are serially included in the tip-strand 23 the supervisory relays 25 and 26, which relays, however, are shunted by the condenser 27, the condenser serving to more readily transmit voice-currents through the cord-circuit. The usual ringing and listening key 28 serves when manipulated in one direction to connect the ringing-generator 29 in bridge of the cord-strands leading to the calling-plug while when manipulated in the reverse direction it serves to connect the operator's telephone set 30 in bridge of the cord-circuit. A supervisory controlling-relay 31 is connected, as shown, between the positive grounded side of the battery 10 and the contact 32, normally making connection with the sleeve-spring of the listening-key. One terminal of each of the supervisory signal-lamps 33 and 34 is connected by a conductor 35 with the negative pole of the battery 10. The armatures 36 and 37 of the supervisory relays 25 and 26 serve when in their unattracted positions and in connection with the attracted armature 38 of the supervisory controlling-relay 31 to close the circuit through these supervisory lamps 33 and 34.

There is wound in inductive relation to the induction-coil of the telephone set the test-winding 39, whose terminals are connected, one with the contact 40 of the listening-key and the other through the conductor 41 with the negative pole of the battery 10. A resistance 42 is connected between the contact 43 of the listening-key and the negative pole of the battery.

The operation of the system of my invention may be explained as follows: The subscriber at substation A desiring a connection with subscriber at substation B removes his receiver from the switch-hook, thereby closing the circuit between the limbs 2 and 3 of the associated telephone-line. A circuit may then be traced as follows: from the positive pole of the battery 10, through the impedance-coil 11 and the limbs 3 and 2 of the telephone-line leading to substation A, to the line-relay 12, the differential coils 13 and 14 of the cut-off relay 15 to the negative pole of the battery 10. On account of the differential winding of the coils 13 and 14 the core of the cut-off relay receives no net energization due to the current flowing through this circuit. The line-relay 12, however, is actuated to produce a visual signal, which is apprehended by the

central-station operator, who inserts the answering-plug 21 of her cord-circuit within the answering-jack 18 of the line leading to the calling-subscriber at substation A. The insertion of this answering-plug within the answering-jack causes the closure of a circuit which may be traced as follows: from the positive pole of the battery 10, through the winding of the supervisory controlling-relay 31, the sleeve-strand 24 of the cord-circuit, the sleeve-contact 20 of the answering-jack 18, the winding 14 of the differential relay 15, to the negative pole of the battery 10. This circuit through the winding 14 being of decreased resistance causes a net energization of the core of the cut-off relay 15 and causes the attraction of its armature 16. A short-circuit path is thereby closed in shunt of the line-relay 12 and the winding 13 of the cut-off relay. The line-relay is thereby sufficiently deenergized to cause its restoration, while the test-thimbles forming the sleeve-contacts of the line-jacks are connected through this short-circuit shunt-path directly with the limb 2, leading to substation A, without the intervention of the inductive resistance of the line-relay of the winding 13 of the cut-off relay.

Having established the connection between the cord connecting apparatus and the line leading to the calling-subscriber's instrument, the operator manipulates her listening-key connecting her telephone set in bridge of this line and thereupon ascertains in the well-known manner the substation with which the calling subscriber desires connection. She thereupon inserts her calling-plug 22 within a calling-jack 19 associated with the line leading to the substation B and manipulates her ringing-key to connect the generator 29 in bridge of the cord-circuit, whereupon a calling-current passes through the call-bell 4 at substation B to signal the subscriber thereat. The insertion of the plug 22 within the calling-jack 19 closes a circuit of decreased resistance through the winding 14 of the cut-off relay associated with the line to substation B similar to that traced in connection with the apparatus associated with the line running to substation A. The cut-off relay is thereupon energized to attract its armature 16, whereupon the sleeve-contacts of the spring-jacks are connected directly with the limb 2 leading to substation B, and the energization of the line-relay 12 upon the removal of the receiver from its hook at substation B is prevented.

The insertion of the answering-plug 21 within a spring-jack associated with the calling-substation A caused the closure of the following circuit through the supervisory relay 25: from the positive grounded pole of the battery 10, through the supervisory relay 25, the tip-strand 23, the tip-spring 17 of the answering-jack 18, the limb 3, the transmitter 7, the primary coil 8, the switch-hook 1, the limb 2, through the shunt-circuit about the line-relay

12 and winding 13 of the cut-off relay, through the winding 14 of the relay to the negative pole of the battery 10.

The consequent energization of the supervisory relay 25 will have caused the attraction of its armature 36, thereby preventing the illumination of the corresponding supervisory lamp 33 upon the attraction of the armature 38, which connects the armatures 36 and 37 with the positive pole of the battery 10. No such circuit, however, can be traced through the supervisory relay 26 until the subscriber at substation B removes his receiver from its hook. The lamp 34 therefor will glow to give the exchange-operator a suitable signal as to whether or not the subscriber at substation B has answered his call. As explained in connection with the apparatus associated with substation A, the removal of the receiver from its switch-hook at substation B causes the closure of a circuit through the supervisory relay 26, whose armature 37 is thereupon attracted to cause the extinguishment of the supervisory lamp 34.

As is well understood by those skilled in the art, it is desirable that an operator have means of testing a line before the insertion of her calling-plug with the associated jack to ascertain whether or not such line is in use. The means of applying such a busy test in connection with my improved system is as follows: It will be seen that the test-thimbles 20 of an idle line are connected through the winding 14 of the associated cut-off relay with the negative pole of the battery 10. Since there is no current flowing through this circuit of an idle line, these test-thimbles are normally charged to the potential of the negative terminal of the battery 10. The insertion of the plug of the cord-circuit within any one of the multiple jacks connected with a given line causes the closure of an electrical circuit through the winding 14 of the corresponding cut-off relay, the sleeve-strand 24 of the cord-circuit, and the winding of the supervisory controlling-relay 31, which is connected with the positive pole of the battery. A current flowing through this circuit causes a drop in the potential of the test-thimbles connected therewith. Thus the test-thimbles of an idle line are maintained at the potential of the negative pole of the battery 10, while the test-thimbles of a busy line are caused to assume a somewhat lower potential. The tip-strand 23, connected with the tip-contact of the plug 22, which is used in conjunction with the test-thimbles 20 to test the condition of a line, is normally maintained at the zero potential of the grounded positive side of the battery 10; but a manipulation of the listening-key, which always precedes the application of the tip of the testing-plug to a test-thimble, causes, by means of the contact 40 and the circuit leading therefrom through the test-winding 39 and conductor 41 to the negative pole of the battery 10, a change in the poten-

tial of the tip of the plug 22 to that of the negative pole of the battery 10. The tip of the testing-plug being thus brought to the potential of the negative pole of the battery is applied in making a busy test to a test-thimble. If this test-thimble is connected with an idle line, it, too, will be at the potential of the negative pole of the battery 10, whereupon no current is caused to flow through the test-winding 39, and the operator perceiving no click in her telephone-receiver is made aware of the fact that the tested line is not in use. If, on the other hand, as previously pointed out, the line is busy, the associated test-thimbles will be charged to a reduced potential, whereupon the connection between the tip-contact of the calling-plug and the test-thimble of the tested line will cause a current to flow through the test-winding 39, whereby the consequent click in the operator's telephone apprises her of the busy condition of the tested line.

While I have herein described one particular embodiment of my invention, it will be apparent to those skilled in the art that many modifications may be made without departing from the principles involved, and I therefore do not 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 source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with one limb of said line, 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.

2. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently included in circuit with one limb of said line, 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.

3. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay serially

included in circuit with one limb of said line, a test-contact permanently connected to the common terminal of the windings of said cut-off relay, 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.

4. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with one limb of said line, a spring-jack having a contact permanently connected with the other limb of said line, and a test-contact permanently connected with the common terminal of the two windings of the cut-off relay, 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.

5. In a telephone-exchange system, the combination with a source of current at the exchange having one terminal permanently connected to the ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with the limb of said line not connected with the grounded terminal of said source of current, a spring-jack having a contact permanently connected with the other limb of said line, and a test-thimble permanently connected with the common terminal of the two windings of said cut-off relay, 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.

6. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with one limb of said line, 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, and switching means controlled by the actuation of said cut-off relay to close a low-resistance non-inductive circuit in shunt

of one winding of said cut-off relay and the line-relay.

7. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with one limb of said line, 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, and switching means controlled by the actuation of said cut-off relay to close a low-resistance circuit in shunt of one winding of said cut-off relay and the line-relay.

8. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently included in circuit with one limb of said line, 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, and switching means controlled by the actuation of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and the line-relay.

9. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently included in circuit with one limb of said line, 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, and switching means controlled by the actuation of said cut-off relay to close a low-resistance circuit in shunt of one winding of said cut-off relay and the line-relay.

10. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay serially included in circuit with one limb of said line, 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and the line-relay.

5 11. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the wind-
10 ings of a differential cut-off relay serially included in circuit with one limb of said line, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connect-
15 ing apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means controlled by the actuation of said cut-off relay to close a
20 low-resistance circuit in shunt of one winding of said cut-off relay and the line-relay.

12. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its
25 limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with one limb of said line, a spring-jack having a contact per-
30 manently connected with the other limb of said line and a test-contact permanently connected with the common terminal of the two windings of the cut-off relay, cord connecting apparatus for connecting said line with an-
35 other 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, and switch-
40 ing means controlled by the actuation of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and the line-relay.

13. In a telephone-exchange system, the
45 combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay serially in-
50 cluded in circuit with one limb of said line, a spring-jack having a contact connected with one limb of said line and a test-contact connected with the common terminal of the two windings of the cut-off relay, cord connecting
55 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
60 relay to cause an actuation thereof, and switching means controlled by the actuation of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and the line-relay, whereby said
65 test-contact is connected directly with the limb

of said line through a low-resistance non-inductive circuit.

14. In a telephone-exchange system, the combination with a source of current at the ex-
change having one terminal permanently con- 70 nected to the ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay and the windings of a differential cut-off relay permanently serially included in cir- 75 cuit with the limb of said line not connected with the grounded terminal of said source of current, a spring-jack having a contact permanently connected with the other limb of said line and a test-thimble permanently con- 80 nected with the common terminal of the two windings of said cut-off relay, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus 85 with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means controlled by the actuation of said cut-off relay to close a low-resistance non-in- 90 ductive path in shunt of one winding of said cut-off relay and the line-relay whereby said test-thimble is connected directly with one limb of said line through a low-resistance non-inductive path. 95

15. In a telephone-exchange system, the combination with a source of current at the ex-
change, of a telephone-line extending by its limbs from the terminals of said source of cur- 100 rent to a substation, an impedance-coil permanently serially included in one limb of said line, a line-relay and the windings of a differential cut-off relay permanently serially in- 105 cluded in circuit with the second limb of said line, cord connecting apparatus for connect- ing said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line closes a circuit of low resistance about said line-re- 110 lay whereby said relay becomes inert.

16. In a telephone-exchange system, the combination with a source of current at the ex-
change, of a telephone-line extending by its limbs from the terminals of said source of cur- 115 rent to a substation, an impedance-coil permanently serially included in one limb of said line, a line-relay and the windings of a differential cut-off relay permanently serially in- 120 cluded in circuit with the second limb of said line, cord connecting apparatus for connect- ing 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, and switching means controlled 125 by the energization of said cut-off relay to close a low-resistance non-inductive circuit in shunt of the line-relay whereby said relay becomes inert. 130

17. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently included in one limb of said line, a line-relay and the windings of a differential cut-off relay permanently included in circuit with the second limb of said line, 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 low resistance about said line-relay whereby said relay becomes inert.

18. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently included in one limb of said line, a line-relay and the windings of a differential cut-off relay permanently included in circuit with the second limb of said line, 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, and switching means controlled by the energization of said cut-off relay to close a low-resistance non-inductive circuit in shunt of the line-relay whereby said relay becomes inert.

19. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil serially included in one limb of said line, a line-relay and the windings of a differential cut-off relay serially included in circuit with the second limb of said line, 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.

20. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil serially included in one limb of said line, a line-relay and the windings of a differential cut-off relay serially included in circuit with the second limb of said line, 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, and switching means controlled by the energization of

said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and the line-relay.

21. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently serially included in circuit with one limb of said line, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with a second limb of said line, a spring-jack having a contact permanently connected with the common terminal of the two windings of the cut-off relay, 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.

22. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently serially included in circuit with one limb of said line, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with a second limb of said line, a spring-jack having a test-contact permanently connected with the common terminal of the two windings of the cut-off relay, 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, and switching means controlled by the actuation of said cut-off relay to close a low-resistance non-inductive path in shunt of one winding of said cut-off relay and the line-relay whereby said test-contact is connected directly with the second limb of said line through a low-resistance non-inductive path.

23. In a telephone-exchange system, the combination with a source of current at the exchange having one terminal permanently connected to the ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently serially included in circuit with the limb of said line connected with the grounded terminal of said source of current, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with the second limb of said line, a spring-jack having a contact permanently connected with said first limb of said line and a test-thimble normally connected with the second limb through the line-relay winding, 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 about said line-relay whereby said test-contact is connected directly with said second limb.

24. In a telephone-exchange system, the combination with a source of current at the exchange having one terminal permanently connected to the ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, an impedance-coil permanently serially included in circuit with the limb of said line connected with a grounded terminal of said source of current, a line-relay and the windings of a differential cut-off relay permanently serially included in circuit with the second limb of said line, a spring-jack having a contact permanently connected with said first limb of said line and a test-thimble normally connected with the second limb through one of said windings and the line-relay, 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, and switching means controlled by the actuation of said cut-off relay to close a decreased resistance-path in shunt of the line-relay whereby said relay becomes inert and whereby to establish a direct non-inductive connection between said test-contact and said second limb.

25. In a telephone-exchange system, the combination with a common battery at the central exchange adapted to supply current to the substation-transmitters, of a telephone-line extending by its limbs from the terminals of said common battery to the substation, cord connecting apparatus at the exchange for connecting said line with another for conversation, a line-relay and the two differential windings of a cut-off relay permanently serially included in one of said limbs, an impedance-coil permanently serially included in the other limb of said line, a spring-jack having a contact permanently directly connected with said second line-limb and a test-thimble permanently connected to the common terminal of the two windings of said cut-off relay, means whereby the insertion of a plug of the cord connecting apparatus within said spring-jack causes the closure of a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means controlled by the actuation of said cut-off relay to cause a closure of a low-re-

sistance non-inductive circuit in shunt of said line-relay and one winding of said cut-off relay, thereby connecting said test-contact directly with one limb of said line.

26. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source to a substation, a line-relay and the windings of a differential cut-off relay serially included in one limb of said line, 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 low resistance about said line-relay, whereby said relay becomes inert.

27. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs to the central exchange and permanently connected with the terminals of said source, a differential cut-off relay permanently serially included in one limb, a line-relay normally serially included in circuit with said cut-off relay, cord connecting apparatus for connecting said line with another for conversation, and means upon connection of said cord connecting apparatus with said line for causing said cut-off relay to establish a shunt-circuit about said line-relay whereby said line-relay becomes inert.

28. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs to the central exchange and permanently connected with the terminals of said source, a differential cut-off relay permanently serially included in one limb of said line, a line-relay normally included serially in circuit with said cut-off relay, a test-contact normally connected with one limb of said line through one of said differential windings and the winding of said line-relay, cord connecting apparatus at the central exchange, and means upon connection of said cord connecting apparatus with said line for causing said cut-off relay to connect said contact directly with said limb and to establish a shunt-circuit about said line-relay whereby said line-relay becomes inert.

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

HARRY G. WEBSTER.

Witnesses:

LYNN A. WILLIAMS,
HARVEY L. HANSON.