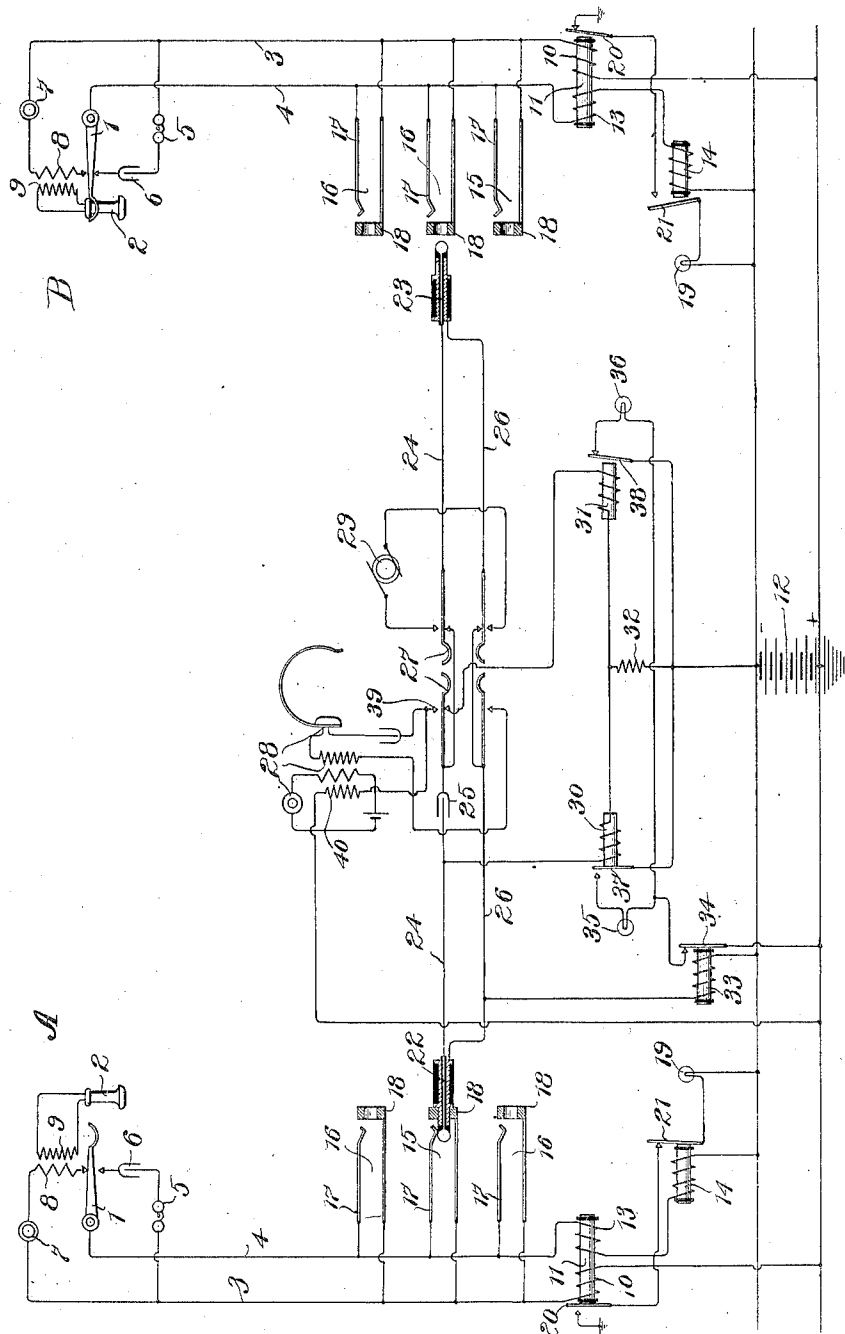


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H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.
APPLICATION FILED FEB. 14, 1903.



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

No. 802,671.

Specification of Letters Patent.

Patented Oct. 24, 1905.

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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 particularly to systems in which a common source of current located at the central station is employed to furnish current both for the operation of the necessary signaling apparatus and the substation-transmitters.

My invention relates more particularly to such systems in which a so-called "differential" cut-off relay may be employed.

My invention provides a system in which there are no relay-contacts included in the talking-circuit. The limbs of the telephone-line extending from a substation to an exchange are permanently connected with the terminals of the common source of current. The well-known spring-jacks employed in making connections between subscribers may be permanently connected with the telephone-lines, whereby a system of great simplicity and reliability in operation is secured.

My invention also provides improved means whereby a central-station operator may test the operative condition of a subscriber's line to know whether or not it is busy. The mechanism associated with the cut-off relay comprises a single armature and back contact therefor.

In accordance with my invention I provide at the central station a common source of current, to opposite terminals of which the two limbs of a line from each substation are permanently connected, one limb serially including a line-relay and a coil of a differentially-wound cut-off relay, the other limb including the other coil of the differential relay.

The multiple spring-jacks used in connection with the customary cord-circuit in connecting subscribers are permanently connected with the limbs of the telephone-line between the substation and the cut-off and line relays. A line-signal is provided, desirably in the form of a small incandescent lamp, whose local circuit is jointly controlled by the line and cut-

off relays. When the armature of the cut-off relay is in its normal unattracted position, the energization of the line-relay causes an actuation of its armature to close circuit through the line-signal lamp and switch-contacts of the cut-off relay. The connection of the cord connecting apparatus with the line whose signal-lamp has been caused to glow causes the closure of a circuit of decreased resistance through one winding of the cut-off relay, whereby the balanced differential energization of the cut-off relay is destroyed to cause an energization thereof and a consequent actuation of the armature of the cut-off relay. The actuation of this armature serves to break the local circuit through the line-signal lamp. The cord-circuit adapted for use in connection with the line-circuit thus described may be of any suitable design adapted to cause the proper operation of the differential cut-off relay and to serve the customary uses of cord connecting apparatus in connecting for conversation any desired substations.

My invention will be best understood by reference to the accompanying diagrammatic drawing, in which at each of the substations A and B is shown a common form of substation apparatus comprising a switch-hook 1, adapted when in its normal depressed position, due to the weight of the receiver 2, to serially connect in circuit with the limbs 3 and 4 of the telephone-line the calling signal-bell 5 and the condenser 6. Upon the removal of the receiver from the switch-hook the latter assumes a position adapted to close a circuit between the telephone-limbs 3 and 4 through a battery-transmitter 7 and the primary 8 of an induction-coil, whose secondary 9 is connected with the receiver 2. The limbs 3 of the telephone-lines extend each to the substation and there through a winding 10 of the differential relay 11 to the positive ground-terminal of the common battery 12. The limbs 4 of the telephone-lines extend each to the negative pole of the battery 12, there being serially included in each of said limbs the winding 13 of the differential relay 11 and the winding of a line-relay 14. The answering-jack 15 and the multiple calling-jacks 16 are permanently connected with the telephone-line, as shown, the tip contacts 17 17 being shown in this instance connected with the limb 4, while the sleeve-contacts and thim-

bles 18 18 are connected with the limb 3. A line-signal lamp 19 is adapted to be illuminated through a local circuit containing the battery 12, the continuity of this circuit being jointly controlled by switch-contacts of the cut-off relay and the line-relay. When the armature 20 of the cut-off relay is in its normal unattracted position, the energization of the line-relay 14 causes the attraction of its armature 21 to cause the closure of the local circuit adapted to illuminate the lamp 19. The energization of the cut-off relay causes the attraction of the armature 20 to break this circuit.

The cord-circuit employed is shown as comprising an answering-plug 22 and a calling-plug 23, whose tip-contacts are suitably connected through a cord-strand 24, including the condenser 25, and whose sleeve-contacts are normally connected through the sleeve-strand 26.

The customary ringing and listening key 27 is provided, a manipulation of this key in one direction serving to connect the operator's telephone set 28 in bridge of the cord-circuit, while a manipulation of the key in a reversed direction serves to connect the ringing-generator 29 between the cord-strands 24 and 26, leading to the calling-plug 23.

A circuit in shunt of the condenser 25 includes the supervisory relays 30 and 31, the common terminal of which is connected through a resistance 32 with the negative pole of the common battery 12. A supervisory controlling-relay 33 is connected between the negative pole of the battery 12 and the sleeve-strand 26 of the cord-circuit. The armature 34 of this supervisory controlling-relay when in its attracted position, as shown, serves to connect the positive pole of the battery 12 with the supervisory signal-lamps 35 and 36, the continuity of the circuit through the lamp 35 being established through the armature 37 of the supervisory relay 30 when in its normal unattracted position, and the continuity of the circuit through the supervisory signal-lamp 36 being similarly established by the armature 38 of the relay 31.

The operation of my improved system may be described as follows: The removal of the receiver at substation A from its switch-hook causes the closure of a circuit, which may be traced as follows: from the positive pole of the battery 12 through the coil 10 of the differential relay and the limb 3 of the telephone-line to the transmitter and primary winding of the induction-coil at the substation A through the limb 4 of the telephone-line, the winding 13 of the differential cut-off relay, and the winding of the line-relay 14, to the negative pole of the battery 12. The closure of this circuit does not cause the actuation of the armature of the cut-off relay on account of the differential relation of the windings 10 and 13. The closure of the cir-

cuit through the line-relay, however, causes the attraction of its armature to close the local battery-circuit through the line-signal 19. The operator apprehending the signal given by the illumination of the lamp 19 inserts the answering-plug 22 within the answering-jack 15, thereby connecting her cord-connecting apparatus in circuit with the limbs 3 and 4 of the line leading to substation A. The insertion of the plug 22 immediately causes the closure of a circuit, which may be traced as follows: from the positive pole of the battery 12, through the winding 10 of the differential cut-off relay 11, to the sleeve-spring 18 of the answering-jack 15, to the sleeve-contact of the plug 22, through the sleeve-strand 26 and the winding of the supervisory controlling-relay 33, to the negative pole of the battery 12. Thus a circuit of decreased resistance is closed through the winding 10 of the differential cut-off relay, causing a net energization of the relay-core, whereupon the cut-off relay-armature 20 is attracted from its back contact connected with the ground, as shown. Since the local circuit adapted to cause the illumination of the lamp 19 includes the ground connection between the back contact of the armature 20 and the grounded-side of the battery 12, this actuation of the cut-off relay-armature breaks the local circuit through the line-signal 19, whereupon the lamp is extinguished. This circuit established by the insertion of the plug within a jack also causes the energization of the relay 33 to attract its armature 34, whereupon the supervisory signal-lamps 35 and 36 are connected with the positive pole of the battery 12. The armature 38 of the cut-off relay 31 being in its normal unattracted position completes the circuit through the lamp 36, whereupon this supervisory signal-lamp is caused to glow. The receiver at the substation A being removed from its hook, closes a circuit through the supervisory relay 30, which may be traced as follows: from the negative pole of the battery 12, through the resistance 32, the supervisory relay 30, the tip-strand 24 of the cord-circuit, the tip-contact of the answering-plug 22, the tip-spring of the answering-jack 15, the limb 4 of the telephone-line, the primary coil 8, the transmitter 7, the limb 3 of the telephone-line, and the winding 10 of the cut-off relay. The consequent energization of the relay 30 causes the attraction of its armature 37 to open the otherwise completed circuit through the supervisory signal-lamp 35. This lamp, which is intended to apprise the operator of the operative condition of the subscriber's substation apparatus is therefore not permitted to glow upon the insertion of the answering-plug within the answering-jack. The operator manipulates her listening-key to connect her telephone set in bridge of the cord-circuit connected with the calling-substation. Upon ascertaining that the subscriber at sub-

station A desires connection with the subscriber at substation B she inserts the calling-plug 23 within a calling-jack 16, associated with the telephone-line leading to substation B. She thereupon manipulates her ringing-key to send current from the alternating-current generator 29 through the call-bell 5 at substation B. The insertion of the calling-plug 23 within the jack 16 immediately closes a circuit similar to that previously traced for the calling subscriber through the supervisory relay 33 and the coil 10 of the differential cut-off relay associated with the telephone-line running to substation B. An actuation of the armature 20 of this cut-off relay is thereby caused to immediately open a circuit, which otherwise might be closed through the line-signal 19, corresponding to the substation B. Upon the removal of the receiver at substation B from its switch-hook a circuit is closed through the supervisory relay 31, the consequent energization of this relay causing the attraction of the armature 38 to extinguish the lamp 36. Either subscriber upon finishing the conversation with the other replaces his receiver upon its switch-hook, thereby opening the previously-traced circuit through the corresponding supervisory relay 30 or 31, as the case may be. The armature 34 of the supervisory controlling-relay 34 being still in its abnormal attracted position, due to the continuance of the insertion of the plugs within the line-jacks, the release of an armature 37 or 38 of the supervisory relay causes the closure of the local circuit through the corresponding supervisory signal-lamp 35 or 36, whereby the latter is caused to glow, thereby giving the operator a signal that the connecting-plug may be withdrawn from the corresponding line-jack. The removal of the cord-connecting plug causes the restoration of the line and cut-off relays to their normal condition. Upon the removal of both plugs the supervisory relays and the supervisory controlling-relay 33 are also restored to their normal condition.

The means employed by an operator to see whether or not a line is in use before inserting a plug within a jack is as follows: It will be seen that upon the manipulation of the listening-key to connect the operator's telephone set in bridge of the cord-circuit the connection through the supervisory relay 31 between the negative pole of the battery and the tip-strand 24 of the cord-circuit is broken. There is connected with the contact 39 a conductor leading through a test-winding 40 in inductive relation with the induction-coil of the operator's telephone set to the grounded side of the battery 12.

It will be seen that under normal conditions in which the line running to substation B is not in use the test-contacts 18 of the associated multiple jacks are connected with the grounded side of the battery by conductors

through which no current is flowing, and therefore these test-contacts are at the zero potential of the ground. Upon the insertion of a plug of a cord-circuit within any of the multiple jacks a circuit is closed which includes the coil 10 of the associated cut-off relay and the coil of a supervisory controlling-relay 33. The test-contacts are all connected with this circuit. Upon the connection of the cord-circuit with a line all of the associated test-contacts are therefore raised in potential above that of the ground. While the tip-strand of an idle cord-circuit is normally at the potential of the negative terminal of the common battery, still upon the manipulation of the listening-key the connection between the part of the tip-strand leading to the testing-tip contact and the negative side of the battery is broken, and this part of the tip-strand is connected through the test-winding 40 with the positive grounded side of the battery 12. When no current flows through the cord-circuit and when the listening-key is thus manipulated, the tip of the calling-plug 23 is charged to the zero potential of the grounded side of the battery 12.

In making a test of a line when the test-thimbles are at the zero potential of the ground no current will be caused to flow between the testing-tip contact and the test-thimble. Therefore no click will be heard in the operator's receiver, the operator knowing thereby that the tested line is idle. If, on the other hand, the line is busy and, as previously described, the test-thimbles have been raised in potential above that of the ground, the connection of the tip of the calling-plug and a test-thimble will cause a current to flow through the test-winding 40, which induces a current in the secondary winding of the induction-coil connected with the operator's telephone, whereupon a click in the operator's receiver notifies her of the busy condition of the tested line.

While I have herein shown and described one particular embodiment of my invention, it will be apparent to those skilled in the art that many modifications thereon may be made without departing from the spirit of my invention. 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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connect-

ingsaid line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the

5 substation control of the 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, to the terminals of which are permanently connected the limbs of said lines, a line-relay serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said lines, a line-relay included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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 a source of current at the exchange, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each serially included in a limb of said line, a line-signal jointly controlled by

said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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 a source of current at the exchange, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings permanently serially included in circuit with a telephone-line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes an actuation of the said cut-off relay to destroy the substation control of the 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 source of current at the exchange, to the terminals of which are permanently connected the limbs of said line, a line-relay included in circuit with one limb of said line, a cut-off relay having two differential windings serially included in the limbs of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation with said cut-off relay to destroy the substation control of the line-signal.

8. In a telephone-exchange, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange, to the terminals of which are connected the limbs of said line, a line-relay permanently included in a line-circuit, a cut-off relay having two differential windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of said line-signal.

9. 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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having

two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings permanently serially included in circuit with a telephone-line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a line-relay included in circuit with one limb of said line, a cut-off relay having two differential windings serially included in the limbs of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

16. In a telephone exchange, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange, to the terminals of which are connected the limbs of said line, a line-relay permanently included in a line-circuit, a cut-off relay having two differential windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said lines, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay permanently included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay included in circuit

with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the line-signal.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to destroy the substation control of the line-signal.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limb of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings permanently serially included in circuit with a telephone-line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation means whereby the connection of said cord connecting apparatus with said line causes an actuation of the said cut-off relay to destroy the substation control of the 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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay included in circuit with one limb of said line, a cut-off relay having two differential windings serially included in the limbs of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus

ratus with said line causes an actuation with said cut-off relay to destroy the substation control of the 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, to the terminals of which are connected the limbs of said line, a spring-jack having contacts permanently connected to the limbs of said line, a line-relay permanently included in a line-circuit, a cut-off relay having two differential windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, 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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay permanently included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each permanently included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings, each serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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, to the terminals of which are permanently connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently di-

rectly connected with the limbs of said line, a line-relay permanently serially included in circuit with one of said line-limbs, a differential cut-off relay having two windings permanently serially included in circuit with a telephone-line; a line-signal jointly controlled by said line and cut-off relays, 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.

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, the terminals of which are permanently connected with the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay included in circuit with one limb of said line, a cut-off relay having two differential windings serially included in the limbs of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

32. In a telephone-exchange, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange, to the terminals of which are connected the limbs of said line, a spring-jack having tip and sleeve contacts permanently directly connected with the limbs of said line, a line-relay permanently included in a line-circuit, a cut-off relay having two different windings, each permanently serially included in a limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay permanently serially included between one terminal of the source of current and the substation, a second winding of said differential relay permanently serially included between the other terminal of the source of current and the substation, a line-signal jointly controlled by said line and said

cut-off relays, and a spring-jack permanently connected with said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay permanently included between one terminal of the source of current and the substation, a second winding of said differential relay permanently included between the other terminal of the source of current and the substation, a line-signal jointly controlled by said line and said cut-off relays, and a spring-jack permanently connected with said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay serially included between one terminal of the source of current and the substation, a second winding of said differential relay serially included between the other terminal of the source of current and the substation, a local line-signal circuit jointly controlled by the armatures of said line and said cut-off relays, and a spring-jack permanently connected with said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay included between one terminal of a source of current and the substation, a second winding of said differential cut-off relay included between the other terminal of the source of current and the substation, a local line-signal circuit jointly controlled by the armatures of said line and said cut-off relays, and a spring-jack permanently connected with said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay permanently serially included in circuit between one terminal of the source of current and the substation, a second winding of said differential relay permanently serially included between the other terminal of the source of current and the substation, a line-signal jointly controlled by said line and cut-off relays, a spring-jack having a contact permanently connected with the limb of the line included in said line-relay, and a test-contact perma-

nently connected with the other limb of said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay included in circuit between one terminal of the source of current and the substation, a second winding of said differential relay permanently serially included between the other terminal of the source of current and the substation, a local line-signal circuit jointly controlled by the armatures of said line and cut-off relays, a spring-jack having a contact permanently connected with the limb of the line included in said line-relay, and a test-contact permanently connected with the other limb of said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay permanently serially included in a circuit between the one terminal of the source of current and the substation, a second winding of said differential relay included between the other terminal of the source of current and the substation, a line-signal jointly controlled by said line and cut-off relays, a spring-jack having a contact permanently connected with the limb of the line included in said line-relay, and a test-contact permanently connected with the other limb of said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay included in circuit between one terminal of the source of current and the substation, a second winding of said differential relay included between the other terminal of the source of current and the substation, a local line-signal circuit jointly controlled by the armatures of said line and cut-off relays, a spring-jack having a contact permanently connected with the limb of the line included in said line-relay, and a test-contact permanently connected with the other limb of said line.

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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay serially included in circuit between one terminal of the source of

current and the substation, a second winding of said differential relay serially included between the other terminal of the source of current and the substation, a local line-signal circuit jointly controlled by the armatures of said line and cut-off relays, a spring-jack having a contact permanently connected with one limb of the line included in said line-relay, and a test-contact permanently connected with the other limb of said line.

42. 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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay permanently included in circuit between one terminal of the source of current and the substation, a second winding of said differential relay permanently included between the other terminal of the source of current and the substation, a line-signal jointly controlled by said line and cut-off relays, a spring-jack having a contact permanently connected with the limb of the line included in said line-relay, and a test-contact permanently connected with the other limb of said line.

43. 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 adapted to supply current to a substation-transmitter, a line-relay and one winding of a differential cut-off relay permanently serially included in one limb of said line between one terminal of the source of current and the substation, a second winding of said differential relay permanently serially included in the second limb of said line between the other terminal of the source of current and a substation, a line-signal jointly controlled by said line and cut-off relays, and a spring-jack having one contact permanently directly connected with said first line-limb between the substation and the line and cut-off relays and having a test-contact permanently directly connected with the second limb of said line between said substation and said cut-off relay.

44. 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 adapted to supply current to the substation-transmitters, a line-relay and one winding of a differential cut-off relay serially included between one terminal of the source of current and the substation, a second winding of said differential relay serially included between the other terminal of the source of current and the substation, and a local line-signal circuit jointly controlled by the armatures of said line and cut-off relays.

45. 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 adapt-
ed to supply current to the substation-trans-
mitters, a line-relay and one winding of a dif-
ferential cut-off relay included between one
terminal of the source of current and the sub-
station, a second winding of said differential
cut-off relay included between the other ter-
minal of the source of current and the sub-

station, and a local line-signal circuit jointly
controlled by the armatures of said line and
said cut-off relays.

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.