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H. G. WEBSTER.

TELEPHONE EXCHANGE SYSTEM.

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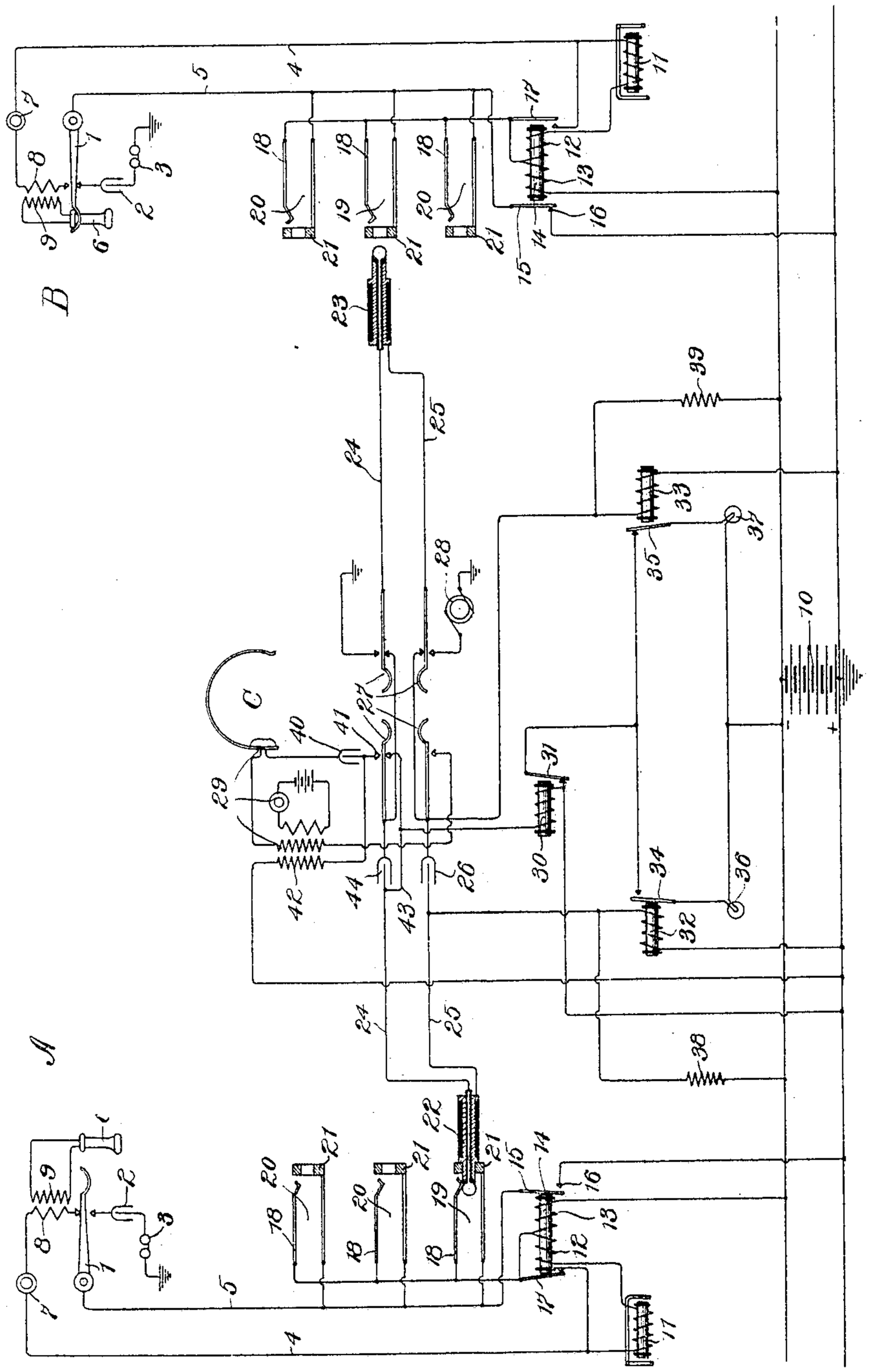
NO MODEL.



Witnesses:
Leonard W. Novander.
Lynn A. Williams

Inventor
Harry G. Webster.
by Charles A. Brown
Attorney

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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. 775,227, dated November 15, 1904.

Application filed February 14, 1903. Serial No. 143,305. (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 drawing, forming a part of this specification.

My invention relates to telephone-exchange systems, and more particularly to telephone-exchange systems in which the source of current for supplying signaling and talking currents is located at the central station.

My invention may further be described as relating to telephone systems in which a differential cut-off relay is employed at the central station for the purpose of destroying the substation control of a suitable line-signal.

My invention provides such a telephone system in which the contacts of the line-jacks are permanently connected with the limbs of the telephone-line. The test-thimbles of the line-jacks are normally connected to ground, whereby there is no variation of the potential of the test-thimbles due to earth-currents or inductive or static disturbances on the line.

A further advantage in my improved system consists in the provision of a clear ringing-circuit between the alternating-current generator at the central and the sub station.

My invention will be clearly understood by reference to the accompanying drawing, in which is shown at substations A and B the customary substation apparatus, comprising in each instance a switch-hook 1, which when in its normal depressed condition connects the condenser 2 and call-bell 3 between the limbs 4 and 5 of the telephone-line. Upon the removal of the receiver 6 from the switch-hook 1 a circuit is closed between the line-limbs 4 and 5 through the transmitter 7 and the primary 8 of an induction-coil whose secondary winding 9 is connected with the receiver 6. The line-limbs 4 and 5 lead to the central-station exchange C, where the limbs are normally connected with the terminals of a common source of current, such as the battery 10, whose positive pole is connected with the ground, as shown. The line-limb 4 is connected with the negative pole of the battery 10 through a line relay or signal 11 and the two differential windings 12 and 13 of a cut-off relay 14. The line-limb 5 is normally connected through an armature 15 of the cut-off relay 14 and its back contact 16 with the positive grounded terminal of the battery 10. The second armature 17 of the cut-off relay 14 serves when in its attracted position to close a low-resistance shunt-circuit about the line-relay 11 and the winding 12 of the cut-off relay 14.

The tip-contacts 18 of the answering-jack 19 and the calling-jacks 20 are connected with the armature 17 and through the cut-off relay-winding 12 and line-relay 11 with the limb 4 of the telephone-line. It will be seen that the attraction of the armature 17 closes a circuit which directly connects the tip-contacts 18 of the line-jacks with the limb 4 of the telephone-line. The sleeve-contacts, which in this instance are also shown as the test-thimbles 21 of the line-jacks, are permanently connected with the limb 5 of the telephone-line.

The operator's cord connecting apparatus comprises an answering-plug 22 and a calling-plug 23, the tip-contacts of which are connected through a tip-strand 24 and the sleeve-contacts of which are connected through a sleeve-strand 25. The continuity of the sleeve-strand is interrupted by the inclusion of a condenser 26.

The usual operator's ringing and listening key 27 is provided, which when actuated in one direction connects the calling-generator 28 with the cord-circuit and which when manipulated in the other direction connects the operator's telephone set 29 in bridge of the cord-circuit.

A supervisory controlling-relay 30 is connected between the positive grounded side of the battery 10 and the tip-strand of the cord-circuit. This supervisory controlling-relay is provided with an armature 31, which when

in its attracted position serves to connect the positive pole of the battery 10 with a supervisory lamp-circuit. The supervisory relays 32 and 33 are connected between the positive pole of the battery 10 and the sleeve-strand of the cord-circuit on the opposite side of the condenser 26. These supervisory relays control armatures 34 and 35, which when in their normal unattracted condition serve to close a circuit through the associated supervisory signal-lamps 36 and 37. High resistances 38 and 39 are connected between the conductors, leading from the supervisory relays 32 and 33 to the sleeve-strand of the cord-circuit and the negative pole of the battery 10.

I find it desirable to provide a condenser 40 in the operator's telephone-circuit and to connect the contact 41, associated with the listening-key, through a test-winding 42 with the positive pole of the battery 10. The manipulation of the listening-key serves to interrupt the continuity of the tip-strand of the cord-circuit through the conductor 43, a condenser 44 being normally connected in shunt of this conductor.

The operation of my improved system will now become apparent.

A subscriber at substation A upon removing his receiver from the switch-hook 1 causes the closure of a circuit from the positive pole of the battery 10 through the cut-off relay-armature 15, the line-limb 5, the primary winding 8, the transmitter 7, the line-limb 4, the line-signal 11, the two windings 12 and 13 of the cut-off relay to the negative pole of the battery 10. The current flowing through this circuit causes the actuation of the line-signal 11 to notify the operator that connection is desired with some other subscriber. The coils 12 and 13 of the cut-off relay being differentially wound do not cause a net energization of the cut-off relay to attract the armatures 15 and 17. The operator answers the signal by the insertion of her answering-plug 22 within an answering-jack 19, associated with the substation A. The insertion of this answering-plug closes the following circuit of decreased resistance through the winding 13 of the cut-off relay, this circuit being traced as follows: from the positive pole of the battery 10 through the supervisory controlling-relay 30, the tip-strand 24 of the cord-circuit, the tip-contact 18 of the answering-jack, the winding 13 of the cut-off relay 14 to the negative pole of the battery 10. The energization due to the two windings of the cut-off relay is thereby unbalanced to cause a net energization of the cut-off relay and a consequent attraction of the armatures 15 and 17. The attraction of the armature 15 breaks the direct connection between the line-limb 5 and the positive pole of the battery 10, this limb of the line being thereupon connected with the positive pole of the battery through the supervisory relay 32. The attraction of the armature 17 causes the closure of a low-resistance circuit in shunt of the winding 12 of the cut-off relay and the line-signal 11. The closure of this shunt-path of low resistance also serves to connect the contacts 18 of the line-jacks directly with the limb 4 of the telephone-line. The operator manipulates her listening-key to connect her telephone set in bridge of the cord-circuit and thereupon ascertains the number of the substation to be called. Learning that substation B is desired she inserts her calling-plug 23 within one of the multiple calling-jacks 20, associated with the line to substation B. The insertion of the plug 23 within a jack at once closes a circuit through the winding 13 of the cut-off relay associated with the called line, thus causing an attraction of its armatures 15 and 17, the armature 15 serving to break the direct connection between the test-thimbles and the associated line 5 and the positive grounded terminal of the battery 10. The attraction of the armature 17 at once closes the low-resistance path in shunt of the winding 12 of the differential cut-off relay and the line-signal 11. The closure of this low-resistance shunt-path also connects the tip-springs of the associated line-jacks directly with the limb 4 of the line. The operator manipulates her ringing-key to send a current from the generator 28 through the telephone-line to the call-bell 3 at the substation B. Until the removal of the receiver at substation B from its switch-hook there is no circuit formed through the supervisory relay 33, whereby this relay-armature is not attracted, and since the armature of the supervisory controlling-relay has already been attracted into its alternate position, as previously described, the supervisory signaling-lamp 37 continues to glow. Upon the removal of the receiver at substation B a circuit is closed through the supervisory relay to cause the attraction of its armature, and therefore the extinction of the lamp 37. Upon completion of the conversation the replacement of the receivers at either substation A or B causes an interruption of the circuit through the associated supervisory relay 32 or 33, respectively, whereby the associated armature is released to cause the associated lamp to glow, thereby notifying the operator that the connected subscriber has finished his conversation. The removal of the cord-connecting plugs from the line-jacks breaks the circuit through the supervisory controlling-relay 30, whose armature is released to break the connection between the battery and one terminal of the supervisory signaling-lamps. The removal of the plugs from the jacks also causes the restoration of the line apparatus of the subscriber who has replaced his telephone-receiver upon its switch-hook.

As is well understood by those skilled in the art, it is desirable in a modern telephone-exchange system to provide means whereby an

operator may test the condition of the line to learn whether or not the line is in use before making a connection therewith. My improved system provides means for making such a busy test and may be described as follows: It will be seen that under normal conditions when a line is idle the test-thimbles of the associated line-jacks are connected through the armature 15 directly with the grounded terminal of the battery 10. Furthermore, when making a test the tip-strand of the cord-circuit leading to the tip-contact of the calling-plugs is connected through the test-winding 42 with the same positive grounded terminal of the battery 10. Therefore when an idle line is tested by the application of the tip-contact of the calling-plug to a test-thimble there is no current-flow, due to the fact that the test-thimble and the tip-contact of the plug are at the same potential, which is, in fact, the zero potential of the ground. It will be seen that there is a complete electric circuit between the opposite poles of the battery 10 through the supervisory relays 32 and 33 and the high-resistance coils 38 and 39, respectively, associated therewith. The coils 38 and 39 are of such high resistance that sufficient current cannot pass through the supervisory relays to affect the operation thereof. Sufficient current does flow through this circuit, however, to cause a rise in the potential of the sleeve-strand 25, each section of which is connected to a point in a circuit through a supervisory relay and a high-resistance coil. The insertion of a plug within a line-jack, therefore, causes a rise in the potential of the test-thimble to equal that of the connected sleeve-strand. The tip-contact of the calling-plug is, however, at the zero potential of the ground. Thus when the tip-contact of a calling-plug is connected with a test-thimble a momentary current is caused to flow through the test-winding 42, which, on account of the inductive relation between the test-winding 42 and the operator's telephone set, causes a click in her receiver, thereby notifying her of the busy condition of the tested line.

While I have herein described one preferred embodiment of my invention, it will be apparent that many modifications thereof may be employed 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 source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

2. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

3. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

4. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

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bination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

6. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

7. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

8. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

9. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

10. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

11. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

12. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off re-

lay included in circuit with said second 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

13. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

14. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

15. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

16. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

17. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

18. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

19. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in cir-

cuit with said second 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

20. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

21. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

22. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second 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 close a circuit in shunt of one winding of said cut-off relay and said line-relay to break the connection between said first limb and said source of current.

23. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

24. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

25. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

26. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

27. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

28. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

29. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

30. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

31. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 with said line causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current, 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 system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

33. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

34. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

35. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

36. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

37. In a telephone-exchange system, the

combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact permanently connected to said first limb of said line and a second contact permanently connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

38. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes 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 said line-relay to break the connection between said first limb and said source of current.

39. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes 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 said line-relay and to break the connection between said first limb and said source of current.

40. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

41. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

42. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes an actuation of said cut-off relay to close a circuit in

shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

43. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

44. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 causes an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

45. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

46. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

47. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

48. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 resistances through one winding of said cut-off relay to cause an actuation of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

49. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

50. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line normally connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

51. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a low-resistance non-inductive circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

52. In a telephone-exchange system, the combination with a source of current at the exchange, of a limb of a telephone-line connected with one terminal of said source of current, a second limb of said line connected with the other terminal of said source, a line-relay and the two differential windings of a cut-off relay included in circuit with said second limb, a spring-jack having one contact connected to said first limb of said line and a second contact and test-thimble connected to 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 of said cut-off relay to close a circuit in shunt of one winding of said cut-off relay and said line-relay and to break the connection between said first limb and said source of current.

53. In a telephone-exchange system, the combination with a source of current at the exchange, one of whose terminals is permanently connected to ground, of a limb of a telephone-line normally connected with the grounded terminal of said source of current, a second limb of said line permanently connected with the other terminal of said source of current, a line-relay and the two differential windings of a cut-off relay permanently serially included in circuit with said second limb, cord connecting apparatus for connecting said line with another for conversation, a test-thimble permanently connected to said first line-limb, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay to close a low-resistance circuit in shunt of one winding of said cut-off relay and to break the connection between said first limb and said source of current.

54. 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, a differential cut-off relay included serially in one limb of said line, a line-relay normally included serially in said limb with said cut-off relay, two

armatures for said cut-off relay, the other limb of said line normally including one of said armatures, cord connecting apparatus at the central exchange, and means upon connection of said cord connecting apparatus with said line for causing attraction of said cut-off-relay armatures to open said other limb and to establish a shunt-circuit about said line-relay whereby said line-relay becomes inert.

55. In a telephone-exchange system, the combination with a central exchange, of a source of current at the exchange, a line leading from a substation to said exchange, a differential cut-off relay permanently serially included in one limb of said line, armatures for said cut-off relay, a line-relay normally serially included in said limb with said line-relay, one of said armatures being normally serially included in the other limb, a spring-jack contact normally connected with the first limb through one of said differential windings and through 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 attraction of said cut-off-relay armatures, one armature serving to establish a shunt-circuit about said line-relay and to connect said jack-contact directly with said line-limb, and the other armature serving to open said other limb.

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.