

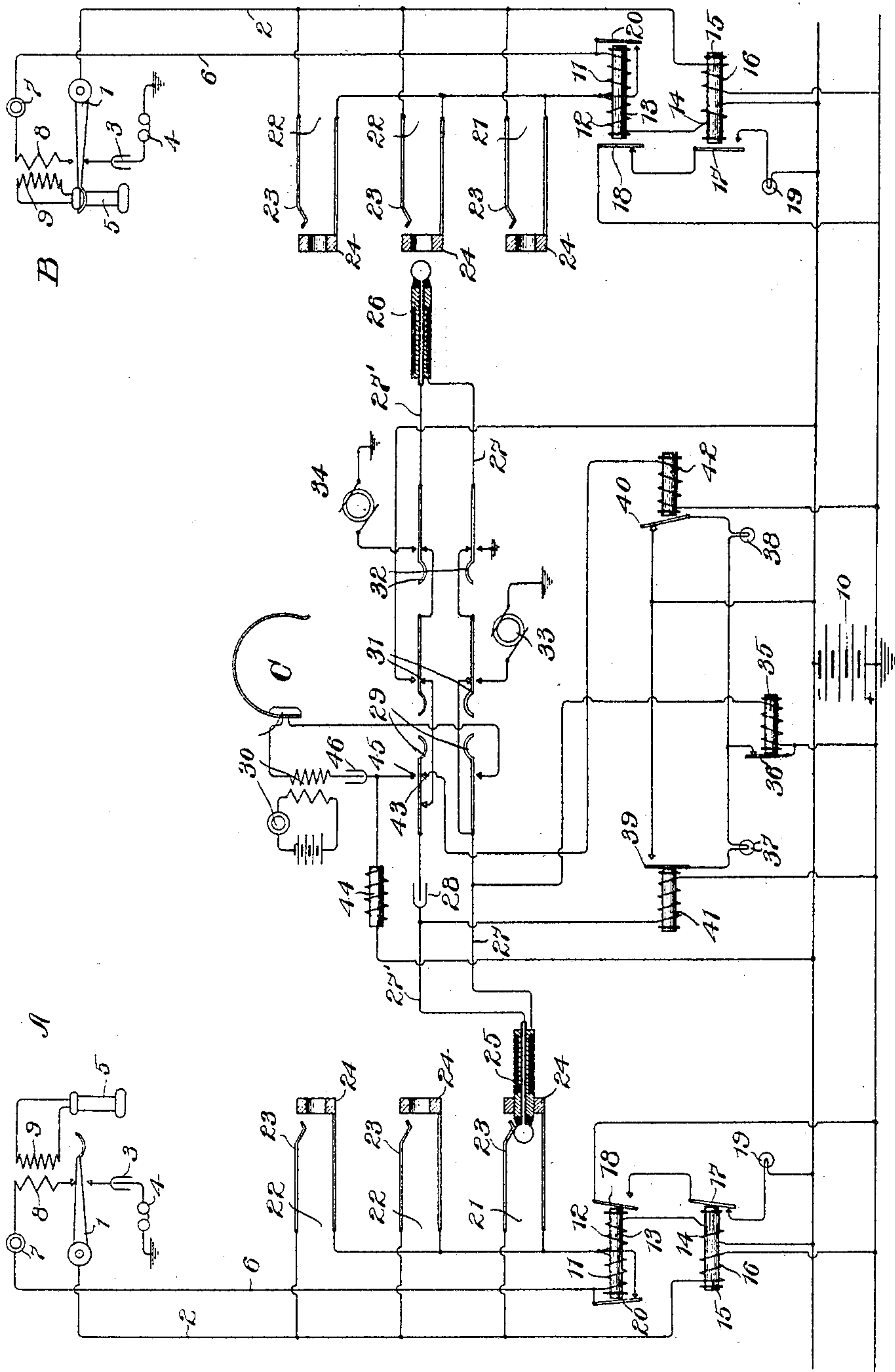
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H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.

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NO MODEL.



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UNITED STATES PATENT OFFICE.

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TELEPHONE-EXCHANGE SYSTEM.

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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 drawing, forming a part of this specification.

My invention relates to telephone-exchange systems, and more particularly to systems in which a common source of energy is located at the central station to supply talking-current to substation-transmitters.

My invention is particularly useful in conjunction with systems employing a so-called "differential cut-off relay," by means of which the use of the operator's cord-circuit at the central station controls the line-signal to cause the extinction thereof upon the connection of cord connecting apparatus with a subscriber's telephone-line.

The objects of my invention are to provide a system in which the apparatus employed may serve the double purpose of regulating and controlling the voice-currents transmitted from one line to another and at the same time to effect the operation of suitable line and supervisory signals. I provide a system in which current for the substation-transmitters may be supplied entirely through line-circuit apparatus, as distinguished from those systems in which the substation transmitter-current is supplied wholly or partially through cord-circuit apparatus.

My invention provides an improvement over other systems, in which the necessary impedance in the circuit supplying talking-current to the substation-transmitters is introduced by the provision of coils wound on iron cores on which there are short-circuited windings. These short-circuited windings tend to decrease the impedance.

In my improved system the impedance-coils are on the line and cut-off relays and serve other useful purposes in addition to that of providing the necessary impedance. The line-

circuit arranged in accordance with my invention is adapted for use with instruments and connecting devices in which an alternating calling-current may be sent through a call-bell at a substation over either the tip or the sleeve side of the telephone-line.

An improved ringing-circuit is one of the principal features of my invention.

The cord-circuit used in conjunction with my improved line-circuit may, if desired, be provided with two ringing-keys to correspond with lines some of which are operated with a calling-circuit over the sleeve side of the line and others in which there is a calling-circuit over the tip side of the line. Since the talking-current is supplied to the substation-transmitters through line-circuit apparatus rather than through the cord-circuit, it is possible to provide supervisory relays in the cord-circuit which are wound to comparatively high resistance—for instance, five hundred ohms—whereby the operation of the supervisory signaling devices is made more sensitive and reliable.

In accordance with my invention I provide at the central station a suitable common battery, to the terminals of which are connected two limbs of a telephone-line leading to a substation. One of these limbs includes in its circuit the two differential windings of a cut-off relay and one winding of a line-relay. The other limb includes in its circuit a second cumulative winding of the line-relay. A local circuit jointly controlled by said line and cut-off relays affords current adapted to illuminate a line signaling-lamp. It will be apparent to those skilled in the art that any other suitable form of line-signal may be employed in place of the well-known lamp and local circuit described herein. Cord connecting apparatus is provided for connecting lines for conversation, means being provided whereby the insertion of the plug of the cord connecting apparatus within a line-jack causes the closure of a low-resistance circuit through one winding of said cut-off relay, whereby the same is given a net energization, and consequently actuated to discontinue or prevent the

illumination of the line signal-lamp. A supervisory controlling-relay is provided and arranged to connect one battery-pole with suitable supervisory signaling apparatus upon the insertion of a plug of the cord-circuit within a line-jack.

My invention will be better understood by reference to the accompanying drawing, in which are illustrated at each of the substations A and B common-battery telephone sets, comprising in each instance a switch-hook 1, serving when in its normal depressed position to connect the line-limb 2, through a condenser 3 and call-bell 4, with the ground. When relieved of the weight of the receiver 5, the switch-hook assumes its alternative upper position in which the line-limb 6 is connected, through the transmitter 7 and primary winding 8 of the induction-coil, with the line-limb 2. The secondary coil 9 of the induction-coil is connected with the receiver 5. The limbs 2 and 6 lead to the central station C, where they are connected with the terminals of the common battery 10, whose positive terminal is grounded, as shown. The limb 6 includes in its circuit the two differential windings 11 and 12 of a differential cut-off relay 13 and a winding 14 of the line-relay 15. I have found it desirable to make each of the differential cut-off relay-windings 11 and 12 about one hundred ohms resistance and that of the winding 14 of the line-relay 15 of about one hundred ohms resistance. The limb 2 of the telephone-line is connected, through a two-hundred-ohm winding 16 of the line-relay 15. The windings 14 and 16 of the line-relay are made cumulative in their effects upon the relay-core.

The armature 17 of the line-relay and the armature 18 of the cut-off relay are included in a local circuit through a line signaling-lamp 19. The cut-off relay is provided with a second armature 20, adapted when in its attracted position to close a low-resistance circuit in shunt of the winding 11 of the cut-off relay. The telephone-lines are each associated with an answering-jack 21 and calling-jacks 22, the tip-contacts 23 of which are permanently connected to the limb 2 of the line, as shown. The sleeve-contacts, which may be in the shape of thimbles 24, are connected in parallel with the common terminal of the two windings 11 and 12 of the cut-off relay.

I have illustrated cord connecting apparatus having an answering-plug 25 and a calling-plug 26, the tip-contacts of which are connected by the tip-strand 27' and the sleeve-contacts of which are connected by the sleeve-strand 27, the continuity of the tip-strand being interrupted by the condenser 28. The usual listening-key 29 is provided, adapted when manipulated to connect the operator's telephone set 30 in bridge of the cord-circuit.

In the present embodiment of my invention I have shown two ringing-keys 31 and 32, the

ringing-key 31 serving when manipulated to connect the generator 33 between the ground and the sleeve-strand leading to the sleeve-contact of the calling-plug 26, while a manipulation of the ringing-key 32 serves to connect the generator 34 between the ground and the tip-contact of the calling-plug 26. A supervisory controlling-relay 35 is connected between the grounded side of the common battery 10 and the sleeve-strand 27 of the cord-circuit. An attraction of the armature 36 serves to connect the positive terminal of the battery 10 with one terminal of each of the supervisory signaling-lamps 37 and 38, whose circuits are further controlled by the armatures 39 and 40 of the supervisory relays 41 and 42, the relay 41 being connected in a circuit between the positive side of the battery 10 and the section of the tip-strand 27' of the cord-circuit leading to the tip-contact of the answering-plug and the supervisory relay 42 being connected in a circuit between the positive side of the battery 10 and a contact 43, which normally makes connection with the portion of the tip-strand 27' leading to the calling-plug 26. An impedance-coil 44 is connected in a path between the contact 45 of the listening-key and the negative pole of the battery 10. A condenser 46 is connected in the operator's telephone-circuit between the contacts of the listening-key.

The operation of my improved system will now become apparent. A subscriber at substation A upon removing the receiver 5 from its switch-hook 1 closes a circuit between the limbs 2 and 6 of the associated telephone-line. A circuit is thereby closed from the positive side of the battery 10 through the winding 16 of the line-relay, through the transmitter and primary winding 8, through the line-limb 6, the differential windings 11 and 12 of the cut-off relay 13, and the winding 14 of the line-relay 15 to the negative pole of the battery 10. Current flowing over this circuit causes no net energization of the cut-off relay on account of the differential relation of the windings 11 and 12. The windings of the line-relay, however, are cumulative in their effects, and the line-relay is therefore actuated to cause the attraction of its armature 17. The armature 18 of the cut-off relay being in its normal unattracted position, a circuit is thereby closed through the line signaling-lamp 19 to illuminate the same. The operator is thereby given a signal, to which she responds by the insertion of an answering-plug 25 of a cord-circuit within the answering-jack 21, associated with the calling telephone-line. The insertion of the answering-plug within the answering-jack closes the following circuit: from the positive pole of the battery 10, through the supervisory controlling-relay 35, to the sleeve-strand 27 of the cord-circuit, to the sleeve-contact 24 of the answering-jack, through the winding 12 of the cut-off relay and

the winding 14 of the line-relay, to the negative side of the battery 10. The differential effects of the windings 11 and 12 of the cut-off relay are thereby unbalanced and the relay-core is given a net energization due to the excess current flowing through the coil 12 over that flowing through the coil 11. The cut-off-relay armatures are therefore attracted, the armature 18 serving to break the local circuit through the line signal-lamp 19 and the armature 20 serving to connect a low-resistance circuit in shunt of the winding 11 of the cut-off relay. At the same time the current flowing through the supervisory controlling-relay 35 causes the attraction of its armature 36 to connect the positive pole of the battery 10 with the supervisory signal-lamps 37 and 38.

A circuit through the supervisory relay 41 may be traced as follows: from the positive pole of the battery 10 to the tip-strand 27' of the cord-circuit, to the tip-contact 23 of the answering-jack 21, to the line-limb 2, through the switch-hook 1, the primary winding 8, the transmitter 7, the line-limb 6, the low-resistance shunt-circuit about the winding 11, the winding 12 of the cut-off relay, the winding 14 of the line-relay, to the negative pole of the battery 10. The current flowing through the supervisory relay 41 causes the attraction of the armature 39 to break the otherwise completed circuit through the supervisory signal-lamp 37. The circuit through the supervisory signal-lamp 38 is completed by the armature 40 of the supervisory relay 42, which makes connection with its back contact, as shown. The operator manipulates her listening-key to connect her telephone set 30 in bridge of the cord-circuit and ascertains the number of the subscriber's station with which the subscriber at substation A desires communication. Learning that substation B is desired, the operator inserts her calling-plug 26 within a calling-jack 22, associated with the called line to substation B, and thereupon manipulates her ringing-key 32 to connect the generator 34 with the tip-strand of the cord-circuit. The ringing-circuit may be traced from the tip-contact 23 of the calling-jack 22 through the line-limb 2, the condenser 3, the call-bell 4, to the ground, with which one terminal of the ringing-generator is connected. Manipulation of the ringing-key 32 also serves to connect the sleeve-strand 27, leading to the sleeve-contact of the calling-plug 26, with the ground.

The insertion of the calling-plug 26 within a calling-jack 22 closes the following circuit: from the positive pole of the battery 10 through the supervisory controlling-relay 35, the sleeve-strand of the cord-circuit, the sleeve-contact 24 of the calling-jack 22, the winding 12 of the cut-off relay, the winding 14 of the line-relay, to the negative pole of the battery 10. This circuit, similarly to that traced for the apparatus associated with the call-

ing - substation, causes a current to flow, causing the attraction of the armatures 17 and 18, the armature 18 serving immediately to open the circuit through the line-lamp 19. The attraction of the armature 20 at once closes the low-resistance shunt-path about the winding 11 of the cut-off relay. The removal of the receiver at substation B from its switch-hook causes the closure of a circuit through the supervisory relay 42, whereupon its armature 40 is attracted to open the circuit through the supervisory lamp 38. Upon the replacement of either of the receivers of the connected lines upon its switch-hook the circuit through the associated supervisory relay is opened, whereupon the supervisory lamp is caused to glow, thus indicating to the operator that the subscriber has finished with the desired conversation. She thereupon removes the plugs of her cord-circuit from the line-jacks, whereupon the line-circuit apparatus is restored to its normal condition.

It will be apparent that by the arrangement of the resistances of the line and cut-off relays as hereinbefore pointed out talking-current is applied from the battery 10 to the substation-transmitter through limbs each of which includes an impedance-winding of two hundred ohms resistance. Since the battery-current is supplied to the transmitters through the apparatus of the line-circuit, it is possible to make the supervisory relays and the supervisory controlling-relay all of comparatively high resistance—for instance, five hundred ohms. It will be seen that when the ringing-generator at the central station is connected with a line a circuit is closed through the one-hundred-ohm winding of the line-relay to lock its armature in the attracted position. The ringing-current is transmitted to the call-bell at the substation past an impedance-coil having a resistance of two hundred ohms. It is seen that my invention provides for the necessary or desirable impedance in both limbs of the telephone-line without the introduction of auxiliary impedance-coils, which perform no other useful function than that of choking the voice-currents between connected substations.

It is the practice in telephone systems to provide means whereby an operator may test the condition of a line before connecting the calling-generator therewith in order to ascertain whether such line is in use. The means provided in my improved system for such a test are as follows: It will be seen that the test-thimbles 24 of an idle line are permanently connected, through the winding 12 of the cut-off relay and the winding 14 of the line-relay, with the negative pole of the battery 10. No current flowing through these windings, the test-thimbles are maintained at the potential of the negative side of the battery. When, however, a plug of a cord-circuit has been inserted within any one of the line-jacks,

a circuit is closed through the winding 14 of the line-relay, the winding 12 of the cut-off relay, and the winding of the supervisory controlling-relay 35. The passage of current through this circuit to the positive side of the battery 10 causes a drop in the potential of the test-thimbles 24. It will be seen that the manipulation of the listening-key to connect the operator's telephone set in bridge of the cord-circuit connects the contact 45 through the impedance-coil 44 with the negative side of the battery 10. This of course brings the tip of the calling-plug 26 to the potential of the negative pole of the battery 10. Thus when the tip of a calling-plug is applied to the test-thimble of an idle line no current will be caused to flow through the impedance-coil 44, since the test-thimble and the tip of the calling-plug are at the same potential. When, however, the potential of the test-thimbles has been reduced by connection with some other cord-circuit, a current will be caused to flow between the tip of the calling-plug and the test-thimble, this current passing through the impedance-coil 44, thereby causing a condenser-discharge which produces a click in the operator's receiver, thereby notifying 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 therein 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 source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, 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.

2. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings serially included in the telephone-line circuit, 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 closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof and switching means adapted upon actuation of said cut-off relay to short-circuit one winding thereof.

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

4. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings included in the telephone-line circuit, 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 closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof and switching means adapted upon actuation of said cut-off relay to short-circuit one winding thereof.

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

6. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings serially included in the telephone-line circuit, 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 said cut-off relay to destroy the substation control of the line-relay and switching means adapted upon actuation of said cut-off relay to short-circuit one winding thereof.

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

8. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings included in the telephone-line circuit, 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 said cut-off relay to destroy the substation control of the line-relay and switching means adapted upon actuation of said cut-off relay to short-circuit one winding thereof.

9. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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 source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay hav-

ing two differential windings permanently serially included in the telephone-line circuit, 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-relay.

11. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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.

12. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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.

13. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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.

14. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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.

15. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, whereby the same is actuated to destroy the substation control of the line-signal.

16. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second limb of said line, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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.

17. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second limb of said line, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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.

18. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source

of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second limb of said line, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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.

19. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second limb of said line, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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.

20. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second limb of said line, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, 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, whereby the same is actuated to destroy the substation control of the line-signal.

21. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, 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 closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

22. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings included in the telephone-line circuit, a local line-signal circuit jointly controlled by said line and cut-off relays, armatures for said relays adapted for serial inclusion in said local circuit with a line-signal, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

23. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, 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 said cut-off relay to destroy the substation control of the line-relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

24. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings included in the telephone-line circuit, a local line-signal circuit jointly controlled by said line and cut-off relays, armatures for said relays adapted for serial inclusion in said local circuit with a line-signal, 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 destroy the substation control of the line-relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance

path in shunt of one winding of said cut-off relay.

25. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, a local signal-circuit jointly controlled by said relays, armatures for said relays adapted for serial inclusion in said local circuit with a signal, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

26. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

27. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

28. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending

by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching mechanism adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

29. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

30. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, 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, whereby the same is actuated to destroy the substation control of the line-signal, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

31. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential

windings of a cut-off relay permanently serially included in a second 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, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

32. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

33. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

34. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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
 5 said line causes an actuation of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially
 10 equal to one-half the resistance of said first winding of said line-relay.

35. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source
 15 of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second limb of
 20 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
 25 resistance through one winding of said cut-off relay, whereby the same is actuated to destroy the substation control of the line-relay, the resistance of each winding of said cut-off relay and the resistance of said second winding
 30 of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

36. In a telephone-exchange system, the
 35 combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay
 40 having two differential windings permanently serially included in the telephone-line circuit, cord connecting apparatus for connecting said line with another for conversation, means whereby the connection of said cord connecting
 45 apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a
 50 low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the
 55 resistance of said first winding of said line-relay.

37. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending
 60 by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential
 65 windings of a cut-off relay permanently seri-

ally included in a second 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, means whereby the connection of said
 70 cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off
 75 relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.
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38. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source
 85 of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second limb of said line, a line-signal jointly
 90 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 actua-
 95 tion of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and
 100 the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

39. In a telephone-exchange system, the
 105 combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one
 110 limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second limb of said line, a line-signal jointly controlled by said line and cut-off re-
 115 lays, 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, and switching
 120 mechanism adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding
 125 of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

40. In a telephone-exchange system, the combination with a source of current at the
 130

central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

41. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, 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, whereby the same is actuated to destroy the substation control of the line-relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

42. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently included in the telephone-line circuit, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, a spring-jack having a test-contact permanently connected with the common terminal of the two windings of said differential cut-off relay, 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.

43. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently included in the telephone-line circuit, a line-signal jointly controlled by said line and cut-off relays, cord connecting apparatus for connecting said line with another for conversation, a spring-jack having a test-contact permanently connected with the common terminal of the two windings of said differential cut-off relay, 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-relay.

44. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay.

45. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay.

46. In a telephone-exchange system, the

combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay.

47. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, and means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay.

48. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, 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, whereby the same is actuated to destroy the substation control of the line-signal.

49. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of the cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

50. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

51. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connect-

ed with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching mechanism adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

52. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

53. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, 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, whereby the same is actuated to destroy the substation control of the line-signal, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

54. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-

relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, 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, whereby the same is actuated to destroy the substation control of the line-relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

55. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

56. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay permanently serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

57. In a telephone-exchange system, the combination with a source of current at the central station, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a winding of a line-relay permanently serially included in one limb of said line, a second cumulative winding of said line-relay and the two differential windings of a cut-off relay serially included in a second 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, a spring-jack having a contact permanently directly connected with the first limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching mechanism adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

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

of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line causes an actuation of said cut-off relay, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially equal to one-half the resistance of said first winding of said line-relay.

59. In a telephone-exchange system, the combination with a source of current at a central exchange, of a substation permanently connected therewith through the line-limbs, a line-relay having two windings one permanently included in each limb, and a cut-off relay for controlling said line-relay having two windings permanently included serially in one limb with the line-relay winding therein, the joint impedance of the windings in one limb being substantially equal to the impedance of the winding in the other limb.

60. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, cord connecting apparatus for connecting said line with another for conversation, a spring-jack having a contact permanently directly connected with one limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in shunt of one winding of said cut-off relay.

61. In a telephone-exchange system, the combination with a source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, a line-relay having two cumulative windings and a cut-off relay having two differential windings permanently serially included in the telephone-line circuit, cord connecting apparatus for connecting said line with another for conversation, a spring-jack having a contact permanently directly connected with one limb of said line and a test-contact permanently connected with the common terminal of the two differential windings of said cut-off relay, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased re-

sistance through one winding of said cut-off relay to cause an actuation thereof, and switching means adapted upon an actuation of said cut-off relay to close a low-resistance path in
5 shunt of one winding of said cut-off relay, the resistance of each winding of said cut-off relay and the resistance of said second winding of said line-relay being each substantially

equal to one-half the resistance of said first winding of said line-relay.

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.