

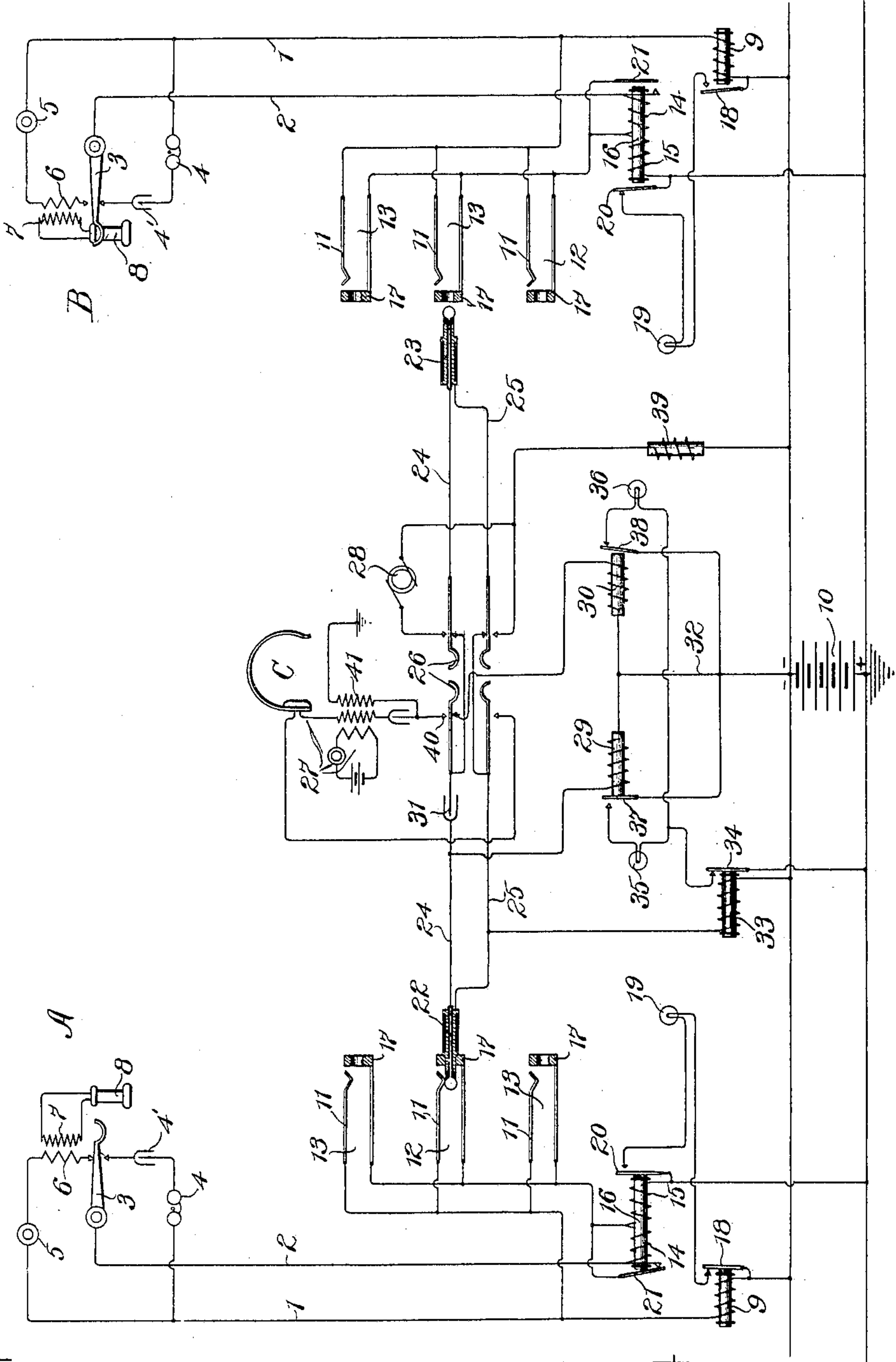
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H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.

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NO MODEL.



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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 such systems in which a source of current located at the central station may be employed for the purpose of supplying talking-current to substation-transmitters.

The principal objects of my invention are to provide a telephone-exchange system in which the complicated cut-off mechanism heretofore employed may be dispensed with and a system having an improved means whereby the operator may test the operative condition of a subscriber's line.

A further object of my invention consists in the provision of means whereby the disagreeable clicks produced in a subscriber's receiver, due to changes in the electrical circuits of the corresponding line, may be reduced.

I shall describe my invention by reference to the accompanying drawing, in which are diagrammatically illustrated subscribers' substations A and B, connected each by limbs 1 and 2 of a telephone-line with a central exchange at C. Each subscriber's substation apparatus comprises a switch-hook 3, adapted when in its normal position to connect a signal-receiving means, such as the bell 4 and a condenser 4', in series with the limbs of the telephone-line. When in its alternative or upper position, the switch-hook closes the line-circuit through a transmitter 5 and the primary 6 of an induction-coil, whose secondary 7 is connected with a receiver 8. The receiver 8 when placed upon the switch-hook 3 is adapted to depress the hook in the manner well understood by those skilled in the art.

Each of the limbs 1 leads to the central ex-

change and there through the winding of a line-relay 9 to the negative pole of a common battery 10, adapted to supply talking and signaling currents used in the operation of the system. The limb 1 from each substation is also permanently connected with the tip-springs 11 of an answering-jack 12 and multiple calling-jacks 13 13. The limb 2, running from each substation, is normally serially connected, through the differentially-wound coils 14 and 15 of the cut-off relay 16, with the positive grounded side of the common battery 10. The common terminal of the relay-coils 14 and 15 is permanently connected with the sleeve-contacts 17 17 of the answering and multiple calling-jacks. These sleeve-contacts 17 17 also constitute the testing-terminals of the jacks.

The line-relay 9 is provided with an armature 18, adapted, when attracted by the relay 9, to close a local circuit from the battery 10 through the line-signal 19, which signal may be in the form of a small incandescent lamp. The local circuit through this signal-lamp also includes an armature 20 of the cut-off relay, the attraction of this armature 20 from its back contact serving, however, to open the circuit through the signal-lamp 19. The cut-off relay 16 is further provided with a second armature 21, adapted when attracted to short-circuit the winding 14 of the relay, thereby connecting the line-limb 2 directly with the associated sleeve-contact 17 without the intervention of inductive resistance.

The operator's cord-circuit may desirably comprise answering and calling plugs 22 and 23, whose tip and sleeve contacts are respectively connected by the cord-strands 24 and 25.

The usual ringing and listening key 26 is provided, a manipulation of which in one direction serves to connect the operator's telephone set 27 in bridge of the cord-circuit and a manipulation of which in the reversed direction serves to connect the ringing-generator 28 in bridge of the cord-circuit.

The cord-strand 24 is electrically continuous through supervisory relays 29 and 30, these relays being shunted by a condenser

31, which serves to improve the transmission of voice-currents through the cord-circuit. A conductor 32 connects the common terminal of the relays 29 and 30 with the negative pole of the common battery 10. A supervisory controlling-relay 33 is connected between the negative side of the battery 10 and the sleeve-strand 25 of the cord-circuit. The armature 34 of this supervisory controlling-relay when attracted connects the positive pole of the battery 10 with supervisory signal-lamps 35 and 36, the circuits through these supervisory signal-lamps being respectively completed by the armatures 37 and 38 of the supervisory relays when in their normal unattracted positions.

An impedance-coil 39 is connected between the negative pole of the battery 10 and the terminal of the generator 28, adapted for connection with the sleeve-strand 25 of the cord-circuit.

The operation of my improved system will now be made apparent.

A subscriber at substation A upon removing his receiver from its switch-hook closes a continuous electrical circuit between the limbs 1 and 2 of the associated telephone-line, thereby permitting the passage of current from the battery 10 through the line-relay 9 to telephone-limbs 1 and 2 and through the two differentially-wound coils of the cut-off relay 16. A current flowing through this circuit causes the energization of the line-relay 9 to attract its armature 18. The armatures 20 and 21 of the cut-off relay are not attracted by current flowing through this circuit, for the reason that the coils 14 and 15 are differentially wound, thereby producing no appreciable net energization of the core of the cut-off relay. The armature 20 when in its unattracted position serves to close, in connection with the attracted armature 18, a local battery-circuit through the line-signal 19, causing this signal-lamp to glow, thereby notifying the operator that the subscriber at substation A desires connection with some other subscriber. She thereupon inserts an answering-plug 22 within the corresponding answering-jack 12. A circuit of decreased resistance is thus closed through the coil 15 of the differential relay, this circuit being traced as follows: from the negative pole of the battery 10, through the supervisory controlling-relay 33 to the sleeve of the plug 22, to the sleeve-contact 17 of the answering-jack 12, through the coil 15 of the differential relay to the positive pole of the battery 10. The increased flow of current through the single coil 15 causes a net energization of the cut-off relay, thereby causing the attraction of its armatures 20 and 21. The attraction of the armature 20 produces a break in the local circuit through the signal-lamp 19, whereby this lamp is extinguished. The attraction of the armature 21 causes the closure of a low-resistance circuit in shunt of the winding 14 of the differential relay 16 and

also serves to directly connect the sleeve-contacts 17 with the limb 2 of the associated telephone-line without the intervention of inductive resistance. This feature of my invention gives a talking-circuit between the spring-jack and the limbs of the telephone-line, which being free from inductive resistances is peculiarly suitable for the transmission of voice-currents.

As previously pointed out, the insertion of the plug 22 within the answering-jack 12 causes the closure of a circuit through the supervisory controlling-relay 33, whereupon the armature 34 is actuated to connect the positive side of the battery 10 with the lamps 35 and 36. The receiver at substation A being off its hook a circuit may be traced as follows: from the negative pole of the battery 10 through the relay 29, to the tip-strand 24 to the tip-spring 11 of the answering-jack 12, to the limb 1 of the telephone-line, through the transmitter 5 and primary coil 6, to the limb 2 of the telephone-line, through the short circuit in shunt of the coil 14, through the coil 15 of the differential relay to the positive pole of the battery 10. The core of the supervisory relay 29 being thus energized causes the attraction of its armature 37, whereby a circuit through the supervisory signal-lamp 35 is opened. The operator manipulates her ringing and listening key in the usual manner, connecting her telephone set in bridge of the cord-circuit, whereupon she ascertains the number of the substation with which the subscriber at substation A desires connection. Supposing this to be station B, she thereupon inserts her calling-plug 23 within a multiple jack 13 and manipulates her ringing-key to connect the generator 28 across the cord-strands 24 and 25 leading to the calling-plug 23, whereby a signaling-current is caused to actuate the call-bell 4 at substation B. The insertion of the calling-plug 23 within the jack 13 causes the closure of a circuit through the coil 15 of the differential relay 16 associated with the line running to substation B. The armatures of this relay are thereby attracted, causing in one instance a break in the local circuit through the associated line signaling-lamp 19 and in the other instance the closure of a shunt-circuit of low resistance about the winding 14 of its own cut-off relay. Upon answering the call the subscriber at substation B removes his receiver from its hook, thereby closing a circuit between the limbs of the associated telephone-line, which circuit includes the battery 10 at the central station, the associated line-relay 9, and the coil 15 of the associated cut-off relay. The consequent energization of the line-relay does not cause the illumination of the line signal-lamp 19, for the reason that the circuit through this lamp is open between the armature 20 of the cut-off relay and its back contact.

It will be remembered that the insertion of

the answering-plug 22 in the answering-jack 12 caused the attraction of the armature 34, whereby a circuit is closed through the supervisory signaling-lamp 36 and the armature 38 of the supervisory relay 30. This lamp 36 will continue to glow until the removal of the receiver from the switch-hook at the called substation. The removal of this receiver causes the closure of a circuit through the supervisory relay 30 similar to that previously traced for the supervisory relay 29, whereupon the armature 38 is attracted from its back contact, thereby causing a break in the circuit through the supervisory signal-lamp 36. Thus upon the extinguishment of the lamp 36 the operator receives a signal that the subscriber at substation B has answered the calling-signal.

It may be pointed out that the function of the impedance 39 is to prevent the opening of the circuit through the coil 15 of the differential relay associated with the line to substation B upon the connection of the generator 28 with the cord-circuit. The circuit through the relay-coil 15 may be traced during the connection of the generator with the cord-circuit through the impedance-coil 39 instead of through the supervisory controlling-relay 33, while a generator-circuit in shunt of the circuit through the calling-bell 4 and the condenser 4 at substation B is provided. This shunt-circuit being of comparatively high resistance and high self-induction, the proper actuation of the calling-signal is not materially affected.

The means employed for testing a line to ascertain whether or not it is in use before a connection therewith is made may be described as follows: It will be seen that the test-thimbles associated with an idle line—for instance, the line leading to substation B—are normally connected with the positive grounded side of the battery 10 through the coil 15 of the differential relay. There being no current-flow through this idle line or the coil 15 the test-thimbles are normally of the same zero-potential as the grounded side of the battery 10. Upon the insertion of the calling-plug within any one of the multiple jacks associated with this line to substation B an electric circuit is closed through the associated cut-off-relay coil 15 and the supervisory controlling-relay 33. On account of the current flowing through this circuit there is a consequent rise in the potential of all of the thimbles of the multiple jacks connected with this circuit. Therefore when the tested line is busy or has already been called by another operator at some other one of the positions on the multiple board the test-thimbles associated with that line will have been raised in potential above the normal potential of the grounded side of the battery 10. The tip-contact of the calling-plug is used in connection with the test-thimbles of a called line to learn

whether or not the called line is busy. In order to test a line, the operator manipulates her listening-key, thereby connecting her telephone set in bridge of the cord-circuit and by means of the contact 40 connecting the tip-strand 24 of the cord-circuit with the ground through a test-winding 41, wound in inductive relation with the secondary winding of the induction-coil associated with the operator's telephone set. Furthermore, it will be seen that the manipulation of the listening-key breaks the connection through the supervisory relay 30 between the negative side of the battery 10 and the tip-strand of the cord-circuit. Thus, while the tip of the calling-plug is normally maintained at a potential equal to that of the negative side of the battery 10, upon the manipulation of the listening-key the part of the tip-strand of the cord-circuit leading to the tip-contact of the calling-plug 23 is connected through the test-winding 41 directly with the ground, to which is connected the positive side of the battery 10. Thus the tip-contact when applied to a test-thimble to ascertain the condition of a tested line is always at the zero potential of the ground. It will be remembered that in case the line to substation B is not busy or has not been called by an operator at some other position the test-thimbles are also at the zero potential of the ground. Thus upon contact being made between the tip of the calling-plug and the test-thimble there is no difference of potential to cause a current to flow. Therefore there is no current-flow through the test-winding 41 or a condenser-discharge to cause a click in the operator's receiver, which click, as is well understood by those skilled in the art, is commonly employed to notify the operator of the busy condition of a line. If, on the other hand, the tested line is connected with a cord-circuit at some operator's position, then the test-thimbles associated with that line will have been raised in potential above that of the ground. Therefore upon contact being made between the test-thimble and the tip-contact of the calling-plug a current will be caused to flow through the tip-strand of the cord-circuit and the connected test-winding 41 to the grounded side of the battery 10. The flow of current through the test-winding 41 of course produces a click in the operator's telephone, 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 well 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 com-

combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

2. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

3. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

4. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

5. In a telephone-exchange system, the combination with a common source of current at the exchange, one terminal of said source being permanently connected to ground, of a

telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in the limb of said line connected to the grounded side of said source of current, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

6. In a telephone-exchange system, the combination with a common source of current at the exchange, one terminal of said source being permanently connected to ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in the limb of said line connected to the grounded side of said source of current, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

7. In a telephone-exchange system, the combination with a common source of current at the exchange, one terminal of said source being permanently connected to ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in the limb of said line connected to the grounded side of said source of current, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

8. In a telephone-exchange system, the combination with a common source of current at the exchange, one terminal of said source being permanently connected to ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having

two differential windings permanently serially included in the limb of said line connected to the grounded side of said source of current, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

9. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, a line-relay permanently serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

10. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, a line-relay serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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 a test-contact connected to the common terminal of the windings of said differential cut-off relay.

11. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, a line-relay permanently serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

12. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, a line-relay serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, and a test-contact connected to the common terminal of the windings of said differential cut-off relay.

13. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, 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, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

14. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, 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, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

15. In a telephone-exchange system, the combination with a common source of current at the exchange, one terminal of said source be-

ing permanently connected to ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close
 5 an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings permanently serially included
 10 in the limb of said line connected to the grounded side of said source of current, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of
 15 said cut-off relay to cause an actuation thereof, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of
 20 said relay to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

16. In a telephone-exchange system, the combination with a common source of current
 25 at the exchange, one terminal of said source being permanently connected to ground, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close
 30 an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in the limb
 35 of said line connected to the grounded side of said source of current, 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
 40 cause an actuation thereof, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect
 45 said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

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

18. In a telephone-exchange system, the combination with a common source of current
 75 at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect
 80 said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, a line-relay serially included in the other limb of
 85 said line, a line-signal jointly controlled by said line and cut-off relays, means whereby the connection of said cord connecting apparatus with said line closes a circuit of decreased resistance through one winding of
 90 said cut-off relay to cause an actuation thereof, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

19. In a telephone-exchange system, the combination with a common source of current
 100 at the exchange, of a telephone-line extending by its limbs from the terminals of said source of current to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect
 105 said line with another for conversation, a cut-off relay having two differential windings permanently serially included in one limb of said line, a line-relay permanently serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, means whereby the connection of said
 110 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, a spring-jack having one contact permanently connected with the limb of the line including said line-relay, a test-contact
 115 connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to the limb of said
 120 line including said cut-off relay through a low-resistance circuit in shunt of one winding of said cut-off relay.

20. In a telephone-exchange system, the combination with a common source of current
 130

at the exchange, of a telephone-line extending
by its limbs from the terminals of said source
of current to a substation, means at the sub-
station adapted to close an electrical connec-
5 tion between said limbs, cord connecting ap-
paratus at the exchange adapted to connect
said line with another for conversation, a cut-
off relay having two differential windings se-
rially included in one limb of said line, a line-
10 relay permanently serially included in the
other limb of said line, a line-signal jointly
controlled by said line and cut-off relays, means
whereby the connection of said cord connect-
ing apparatus with said line closes a circuit of
15 decreased resistance through one winding of
said cut-off relay to cause an actuation there-
of, a spring-jack having one contact perma-
nently connected with the limb of the line in-
cluding said line-relay, a test-contact con-
20 nected to the common terminal of the wind-
ings of said differential cut-off relay, and
switching means controlled by said cut-off re-
lay adapted upon an actuation of said relay to
connect said test-contact to the limb of said
25 line including said cut-off relay through a low-
resistance circuit in shunt of one winding of
said cut-off relay.

21. In a telephone-exchange system, the
combination with a common source of current
30 at the exchange, of a telephone-line extending
by its limbs from the terminals of said source
of current to a substation, means at the sub-
station adapted to close an electrical connection
between said limbs, cord connecting apparatus
35 at the exchange adapted to connect said line
with another for conversation, a cut-off relay
having two differential windings permanently
serially included in one limb of said line, a
line-relay serially included in the other limb
40 of said line, a line-signal jointly controlled by
said line and cut-off relays, means whereby
the connection of said cord connecting appa-
ratus with said line closes a circuit of decreased
resistance through one winding of said cut-off
45 relay to cause an actuation thereof, a spring-
jack having one contact permanently connect-
ed with the limb of the line including said line-
relay, a test-contact connected to the common
terminal of the windings of said differential
50 cut-off relay, and switching means controlled
by said cut-off relay adapted upon an actua-
tion of said relay to connect said test-contact
to the limb of said line including said cut-off
relay through a low-resistance circuit in shunt
55 of one winding of said cut-off relay.

22. In a telephone-exchange system, the
combination with a common source of current
at the exchange, of a telephone-line extending
by its limbs from the terminals of said source
60 of current to a substation, means at the sub-
station adapted to close an electrical connection
between said limbs, cord connecting apparatus
at the exchange adapted to connect said line
with another for conversation, a cut-off relay
65 having two differential windings permanently

serially included in the other limb of said line,
a line-signal jointly controlled by said line and
cut-off relays, means whereby the connection
of said cord connecting apparatus with said
line closes a circuit of decreased resistance 70
through one winding of said cut-off relay to
cause an actuation thereof, a spring-jack hav-
ing one contact connected with the limb of the
line including said line-relay, a test-contact
connected to the common terminal of the wind- 75
ings of said differential cut-off relay, and
switching means controlled by said cut-off re-
lay adapted upon an actuation of said relay to
connect said test-contact to the limb of said
line including said cut-off relay through a low- 80
resistance circuit in shunt of one winding of
said cut-off relay.

23. In a telephone-exchange system, the
combination with a common source of current
85 at the exchange, of a telephone-line extending
by its limbs from the terminals of said source
of current to a substation, means at the sub-
station adapted to close an electrical connection
between said limbs, cord connecting apparatus
90 at the exchange adapted to connect said line
with another for conversation, a cut-off relay
having two differential windings serially in-
cluded in one limb of said line, a line-relay
serially included in the other limb of said line,
95 a line-signal jointly controlled by said line and
cut-off relays, 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
100 cause an actuation thereof, a spring-jack hav-
ing one contact permanently connected with
the limb of the line including said line-relay,
a test-contact connected to the common ter-
minal of the windings of said differential cut-
105 off relay, and switching means controlled by
said cut-off relay adapted upon an actuation
of said relay to connect said test-contact to the
limb of said line including said cut-off relay
through a low-resistance circuit in shunt of
110 one winding of said cut-off relay.

24. In a telephone-exchange system, the
combination with a common source of current
at the exchange, of a telephone-line extending
by its limbs from the terminals of said source
115 of current to a substation, means at the sub-
station adapted to close an electrical connec-
tion between said limbs, cord connecting ap-
paratus at the exchange adapted to connect
said line with another for conversation, a cut-
120 off relay having two differential windings se-
rially included in one limb of said line, a line-
relay permanently serially included in the
other limb of said line, a line-signal jointly
controlled by said line and cut-off relays, means
125 whereby the connection of said cord connect-
ing apparatus with said line closes a circuit of
decreased resistance through one winding of
said cut-off relay to cause an actuation thereof,
a spring-jack having one contact connected
130 with the limb of the line including said line-

relay, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to the limb of said line including said cut-off relay through a low-resistance circuit in shunt of one winding of said cut-off relay.

25. In a telephone-exchange system, the combination with a common 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, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, a line-relay serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, 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, a spring-jack having one contact connected with the limb of the line including said line-relay, a test-contact connected to the common terminal of the windings of said differential cut-off relay, and switching means controlled by said cut-off relay adapted upon an actuation of said relay to connect said test-contact to the limb of said line including said cut-off relay through a low-resistance circuit in shunt of one winding of said cut-off relay.

26. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the central exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, means whereby the connection of said cord connection apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, a test-contact normally connected with one limb of the telephone-line through one of said windings, and an armature for said cut-off relay adapted upon actuation of said relay to connect said test-contact directly with said limb.

27. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the central exchange adapted to con-

nect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, 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, a test-contact normally connected with one limb of the telephone-line through one of said windings, and means upon connection of said cord connecting apparatus with said line for directly connecting said test-contact with said limb.

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

29. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connection apparatus at the central exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, means whereby the connection of said cord connection apparatus with said line closes a circuit of decreased resistance through one winding of said cut-off relay to cause an actuation thereof, a test-contact normally connected with one limb of the telephone-line through one of said windings, an armature for said cut-off relay adapted upon actuation of said relay to connect said test-contact directly with said limb, and a line-relay permanently included in the other limb of said line.

30. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source to a substation, means at the substation adapted to close an electrical connection between said limbs, cord connecting apparatus at the

central exchange adapted to connect said line with another for conversation, a cut-off relay having two differential windings serially included in one limb of said line, means where-
 5 by 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, a test-contact normally connected with one limb
 10 of the telephone-line through one of said windings, a line-relay permanently included in the other limb of said line, two armatures for said cut-off relay and an armature for said line-relay, a local line-signal circuit adapted to in-
 15 clude said line-relay armature and one of said cut-off-relay armatures, and means upon connection of said cord connecting apparatus with said line for causing actuation of said cut-off relay to attract its armatures, whereby said
 20 local circuit is opened by one of said cut-off-relay armatures and whereby said other cut-off-relay armature closes a short circuit about said winding, whereby said test-contact is connected directly with the line-limb.

25 31. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending by its limbs from the terminals of said source
 30 of current to a substation, switching mechanism at the substation adapted to close a circuit through said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a line-
 35 relay permanently serially included in one limb of said line and controlled by switching mechanism at the substation, a cut-off relay having two differential windings permanently serially included in the other limb of said line, a line-signal jointly controlled by said line and
 40 cut-off relays, a spring-jack having a contact permanently connected with said first limb, and a test-contact permanently connected with the common terminal of the differential windings of said cut-off relay, means whereby the
 45 insertion of a plug of said cord connecting apparatus in said spring-jack closes a circuit of decreased resistance through one winding of said cut-off relay to cause a net energization and actuation thereof, and switching means
 50 controlled by said cut-off relay adapted upon a net energization of said relay to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

55 32. In a telephone-exchange system, the combination with a common source of current at the exchange having one terminal permanently connected to ground, of a telephone-line extending by its limbs from the terminals
 60 of said source of current to a substation, switching mechanism at the substation adapted to close a circuit through said limbs, cord connecting apparatus at the exchange adapted to connect said line with another for conversation, a line-relay permanently serially included

in the line-limb which is connected with the terminal of the common source of current not connected to the ground and controlled by switching mechanism at the substation, a cut-
 off relay having two differential windings per- 70
 manently serially included in the other limb of said line, a line-signal jointly controlled by said line and cut-off relays, a spring-jack having a contact permanently connected with said
 75 first limb, and a test-contact permanently connected with the common terminal of the differential windings of said cut-off relay, means whereby the insertion of a plug of said cord connecting apparatus in said spring-jack closes
 80 a circuit of decreased resistance through one winding of said cut-off relay to cause a net energization and actuation thereof, and switching means controlled by said cut-off relay adapted upon a net energization of said relay
 85 to connect said test-contact to a limb of said line through a low-resistance circuit in shunt of one winding of said cut-off relay.

33. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending 90
 by its limbs from the terminals of said source to a substation, cord connecting apparatus at the exchange for connecting said line with another, a cut-off relay having two differential windings serially included in one limb of said
 95 line, an armature for said relay, a spring-jack contact permanently connected directly with one limb of said line, a test-contact normally connected with the other limb of said line through one of said relay-windings, and means 100
 upon connection of said cord connecting apparatus with said line for causing attraction of said armature to cause a short circuit about said winding to connect said test-contact directly with said other limb. 105

34. In a telephone-exchange system, the combination with a common source of current at the exchange, of a telephone-line extending
 by its limbs from the terminals of said source to a substation, cord connecting apparatus at 110
 the exchange for connecting said line with another, a cut-off relay having two differential windings permanently serially included in one limb of said line, an armature for said relay, a spring-jack contact permanently connected 115
 directly with one limb of said line, a test-contact normally connected with the other limb of said line through one of said relay-windings, and means upon connection of said cord connecting apparatus with said line for caus- 120
 ing attraction of said armature to cause a short circuit about said winding to connect said test-contact directly with said other limb.

35. In a telephone-exchange system, the combination with a common source of current 125
 at the exchange, of a telephone-line extending by its limbs from the terminal of said source to a substation, cord connecting apparatus at the exchange, a cut-off relay permanently serially included in one limb of said line, a spring- 130

jack contact permanently connected directly
with one limb of said line, a test-contact per-
manently connected with the other limb of said
line through part of said relay-winding, an
5 armature for said relay, and means upon con-
nection of said cord connecting apparatus with
said line for causing attraction of said arma-
ture to close a short circuit about said part of

the winding, whereby said test-contact is con-
nected directly with said other limb. 10

In witness whereof I hereunto subscribe my
name this 31st day of January, A. D. 1903.

HARRY G. WEBSTER.

Witnesses:

H. F. DAVIDSON,

LEE W. SINCLAIR.