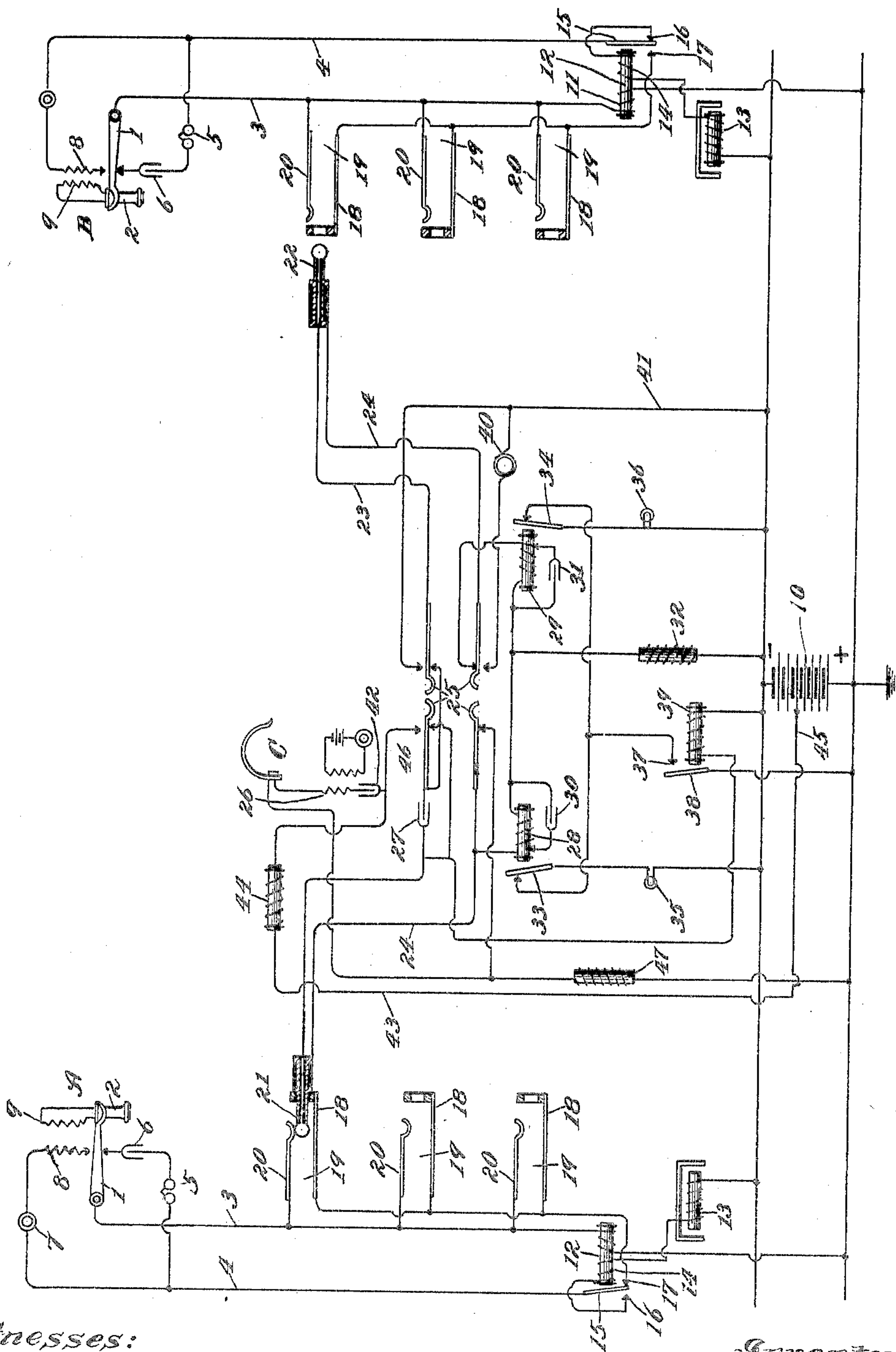


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H. G. WEBSTER.
TELEPHONE EXCHANGE SYSTEM.
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TELEPHONE-EXCHANGE SYSTEM.

SPECIFICATION forming part of Letters Patent No. 793,971, dated July 4, 1905.

Application filed April 17, 1903. Serial No. 153,085.

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 the so-called "test-circuit" for use in connection with multiple-exchange switchboards.

My invention is particularly well adapted for use in connection with telephone systems in which a source of current located at the central exchange is used for the purpose of supplying talking and signaling currents to the subscriber's substation apparatus.

It has been the common practice to provide each line connected with a multiple-switchboard exchange with a plurality of spring-jacks, one for each section of the multiple-switchboard. Test contacts or thimbles of the jacks associated with any one line have been so connected with the circuits of the system that the insertion of the plug of an operator's cord-circuit at any one of the operator's positions causes some change in the potential value of the test-thimbles associated with the same line. A test-contact, which has usually been the tip-contact of the operator's plug, when applied to a test-thimble of a busy line has caused the closure of an electrical circuit or caused the charge or discharge of a condenser, thereby producing a click in the operator's telephone-receiver to indicate the busy condition of the tested line. Under normal conditions, in which the tested line is not in use, the associated test-thimbles are either electrically insulated from the remainder of the system or are maintained at a potential equal to that of the tip of the testing-plug. The insertion of a plug within a jack has caused a considerable change in the potential of the test-thimbles, whereby an unduly loud click is produced in the subscriber's receiver.

It is the purpose of my invention to provide means whereby the potential of the test-contact of an operator's plug is made only slightly different from that of the test-thimble of a busy line. The test thimbles of a line which is not in use are preferably insulated from the remainder of the system, whereby the application of the tip-contact of the testing-plug does not affect the operator's telephone set to cause a busy-test signal.

In a common battery system, which I shall hereinafter more fully describe, I find it desirable to secure the desired potential of the testing-tip contact by connecting this contact to an intermediate point or element between the terminals of the common battery or other source of current used in operating the telephone system.

My invention is closely allied with that described and claimed in my copending application, Serial No. 149,559, filed March 25, 1903.

While my invention may be applied to a great variety of telephone systems, I shall describe it as applied to a differential relay system, such as that illustrated in the accompanying drawing.

At each of the substations A and B, I have illustrated the usual form of apparatus in which a receiver-hook 1 when in its normal depressed position, due to the weight of the receiver 2, connects between the line-limbs 3 and 4 the call-bell 5 and the condenser 6. When in its upper position, due to the removal of the receiver 2, the switch-hook 1 closes the circuit between the line-limbs 3 and 4 through the transmitter 7 and the primary 8 of an induction-coil whose secondary 9 is serially connected with the receiver 2.

The line-limb 3, extending to each of the substations, leads to the central station C, where it is connected with the grounded positive terminal of the common battery through a winding 11 of the differential cut-off relay 12. The limb 4 of each of the telephone-lines is normally connected, through a line-signal 13 and the winding 14 of the differential cut-off relay, with the negative pole

of the battery 10, there being included in this circuit the armature 15 of the differential cut-off relay, this armature normally closing a connection through the back contact 16. A front contact 17 of this armature 15 is connected with the sleeve-contacts 18 of the line-jacks 19, whose tip-contacts 20 are permanently connected with the limb 3 of the telephone-line, as shown. The sleeve-contacts 18, as will be hereinafter more fully explained, also form the test-thimbles of the spring-jacks.

The operator's cord-circuit comprises an answering-plug 21 and a calling-plug 22, whose tip-contacts are connected through the tip-strand 23 and whose sleeve-contacts are connected by the sleeve-strand 24. The usual operator's ringing and listening key 25 is provided, the manipulation of this key in one direction serving to connect the operator's telephone set 26 in bridge of the cord-strands. The manipulation of this key, in addition to connecting the operator's telephone set in bridge of the cord-circuit, also serves to break the conductive continuity of the tip-strand, the condenser 27 being then included in the tip-strand circuit.

The sleeve-strand includes in its circuit the supervisory relays 28 and 29, which are respectively shunted by condensers 30 and 31. The common terminal of the supervisory relays is connected, through an impedance-coil 32, with the negative pole of the common battery 10. The armatures 33 and 34 directly control the continuity of circuits through the supervisory signal-lamps 35 and 36, the operation of these lamps being dependent upon the connection with the contact 37 of the armature 38 of the supervisory controlling-relay 39, which is connected between the negative pole of the battery 10 and the tip-strand 23 of the operator's cord-circuit.

A manipulation of the ringing-key serves to connect the calling-generator 40 in bridge of the cord-circuit. A conductor 41 then serves to connect the tip-strand 23, leading to the calling-plug 22, with the negative pole of the battery 10. A condenser 42 is included in the operator's telephone-circuit. A conductor 43 connects the upper contact of the listening-key 25, through an impedance-coil 44, with a point 45 intermediate between the end terminals of the common battery 10.

The operation of the system described is as follows: The removal of the receiver at substation A from its switch-hook 1 causes the closure of a circuit from the battery 10 through the line-relay 13 and the two differential windings of the cut-off relay 12. On account of the differential relation of these windings of the cut-off relay no net energization thereof is produced and its armature 15 is therefore not attracted. The line-relay 13 being energized, however, causes the actuation of a visual signal, which the operator answers by the insertion of the plug 21 of her cord con-

necting apparatus within one of the line-jacks associated with the line leading to substation A. The insertion of this plug within a jack, as shown, causes the closure of a circuit, which may be traced as follows: from the negative pole of the battery 10, through the supervisory controlling-relay 39, the tip-strand of the cord connecting apparatus, the tip-contact of the plug 21, the tip-spring 20 of the line-jack, the winding 11 of the differential cut-off relay 12, to the positive pole of the battery 10. The closure of this circuit of decreased resistance through the winding 11 of the differential cut-off relay causes a net energization thereof, whereupon its armature 15 is attracted into the position shown. The attraction of this armature causes a break in the otherwise continuous circuit from the negative pole of the battery 10, through the line-relay and the winding 14 of the differential cut-off relay, to the substation A. At the same time the attraction of the armature 15 connects the line-limb 4, leading to the calling substation, directly with the sleeve-springs and test-thimbles 18 of the associated line-jacks 19. A circuit from the battery 10 may now be traced through the substation-transmitter as follows: from the positive pole of the battery 10, through the winding 11 of the differential cut-off relay, through the line-limb 3, switch-hook 1, primary winding 8, transmitter 7, line-limb 4, armature 15, contact 17, sleeve-spring 18, strand 24 of the cord-circuit, the winding of the supervisory relay 28, and the impedance-coil 32, to the negative pole of the battery 10. The closure of this circuit causes the attraction of the armature 33 of the supervisory relay 28, whereupon the otherwise completed local circuit through the supervisory signal-lamp 35 is broken. Upon the insertion of the answering-plug 21 within a line-jack 19 a circuit is established through the supervisory signal-lamp 36 on account of the attraction of the armature 38, the supervisory relay 29 not being energized to cause the attraction of its armature 34. The operator manipulates her listening-key and ascertains the number of the substation with which the calling subscriber desires connection. Learning that the substation B is desired, the operator applies the tip-contact of her calling-plug 22 to one of the test-thimbles 18 of the line-jacks associated with the telephone-line to substation B. If this line is not in use and the armature 15 of the differential cut-off relay is consequently not attracted, the test-thimbles will be insulated from other parts of the telephone system, and the application of the test-contact of a calling-plug will cause no change in the potential of the tip-strand associated therewith, nor will a closed electric circuit be established to cause a click in the operator's receiver. If, on the other hand, a plug of some other cord-circuit has already been inserted within a jack asso-

ciated with the line leading to substation B, the test-thimbles 18 of the associated jacks will have been connected, through a sleeve-strand corresponding with strand 24 and a supervisory relay similar to relay 29 and an impedance-coil such as the coil 32, with the negative pole of the battery 10. It will be seen that the tip-contact of the plug 22 when making a test is connected, by means of a manipulation of the listening-key, through the impedance-coil 44 with an element in the common battery intermediate between the terminals thereof. The potential of this testing tip-contact is therefore intermediate between the potentials of the terminals of the battery 10, the potential of the tip-contact being dependent upon the point of its connection relative to the end terminals of the battery. The potential of the testing tip-contact being therefore different from that of the test-thimble of a busy line, a current is caused to flow, which produces a partial charge or discharge of the condenser 42, whereby a click is produced in the operator's receiver. Upon the removal of the receiver at substation B from its switch-hook a circuit is completed from the negative pole of the battery through the impedance-coil 32, the supervisory relay 29, the sleeve-strand 24, the test-thimble 18, the contact 17, the armature 15, the transmitter 7, the primary winding 8, the switch-hook 1, the line-limb 3, and the winding 11 of the differential cut-off relay to the positive pole of the battery 10. The test-thimbles 18 being connected to this circuit are charged to a potential intermediate between the potentials of the positive and negative terminals of the common battery 10, the potential of the test-thimble being dependent upon the relative resistances between the point of connection with the test-thimble and either terminal of the battery 10. The point of connection 45 of the conductor 43 with the common battery 10 is made such that the potential of a testing tip-contact of a calling-plug will be only slightly different from that of the test-thimbles 18 of a busy line, in which a closed circuit, such as that previously described, through the telephone apparatus at a substation has been completed. On account of this relatively small difference of the testing tip-contact and the test-thimble the disturbance or click produced in the subscriber's receiver may be made comparatively insignificant, whereby the annoyance due to the exceedingly loud click produced in systems of the prior art is avoided. After having made a busy test, as described, to ascertain whether or not the line leading to substation B is busy the operator upon learning that the line is not in use inserts her calling-plug 22 within one of the line-jacks 19 and manipulates her ringing-key to connect the ringing-generator 40 in bridge of the cord-strands leading to the called line. The insertion of the calling-plug within the line-jack 19 at once causes the closure of a circuit through the winding 11 of the differential cut-off relay, whereby the same is energized to cause the attraction of its armature 15, whereby the sleeve-contacts 18 are connected directly with the limb 4 of the called line, and whereby the connection between the limb 4 through the differential relay-winding 14 and the line-relay 13 with the negative pole of the battery 10 is broken. In order that the interruption of the circuit through the differential relay-winding 11 due to the manipulation of the ringing-key may not break the circuit through this winding 11 to cause the retraction of the armature 15, a conductor 41 is provided, whereby upon the manipulation of the ringing-key a circuit may be traced, through the conductor 41, from the negative pole of the battery 10 and the tip-strand of the cord-circuit through the winding 11 of the differential cut-off relay to the positive pole of the battery 10. Thus the armature is retained in its attracted position to permit a ringing-current to pass from the sleeve-strand 24, through the contact 17 and armature 15, to the line-limb 4, leading to substation B. In answering the calling-signal the subscriber at substation B removes his receiver 2 from the switch-hook 1, thereby causing the closure of a circuit through the supervisory relay 29, whereby the same is energized to cause the attraction of its armature 34, whereupon the previously-completed circuit through the supervisory signaling-lamp 36 is interrupted to cause its extinction. The connected subscribers having completed their conversation, the replacement of either of the receivers upon its switch-hook causes an interruption in the continuity of the circuit through the associated supervisory relay 28 or 29, as the case may be. The consequent deenergization of a supervisory relay causes the retraction of the associated armature, whereby the supervisory signaling-lamp is caused to glow, thereby notifying the operator that the associated connected subscriber has finished his conversation. The operator thereupon removes the cord connecting-plugs from the jacks, whereupon the circuit through the supervisory controlling-relay 39 is broken and the armature 38 is retracted to cause a break in the circuit supplying current to the supervisory signaling-lamps. The removal of the cord connecting-plugs from the line-jacks also causes the deenergization of the differential cut-off relays, whereby the armatures 15 are retracted to their normal position.

It has heretofore been attempted to reduce the click in a subscriber's telephone-receiver upon testing a busy line by introducing resistance into the test-circuit or otherwise cutting down the flow of current upon making a test. I have found that the reduction of this disagreeable click is much more effectively attained by the provision of means whereby

the difference in potential between the test-contact and the test-thimble is made comparatively small. In the system herein described the potential of the test-thimble of a busy line on which the receiver has been removed from its hook is never less than a certain limiting minimum value, depending upon the relative resistances of the relay-windings and the high-impedance windings in the circuit.

The potential of the test-thimble of a busy line on which the receiver has been removed from its hook may be somewhat greater than this minimum value, an amount dependent upon the resistances in the line-circuit. With metallic lines of ordinary length this limiting minimum value of the potential of the test-thimble of a busy line is never very greatly exceeded. In accordance with my invention I provide means whereby the potential of the test-contact before making a test connection is charged to a potential preferably slightly lower than the limiting minimum value of the potential of the test-thimble of a busy line on which the receiver has been removed from its hook. In practice I have found it desirable where the limiting minimum potential of the test-thimble is twenty volts above that of the earth to make the potential of the testing-contact approximately eighteen or nineteen volts.

This may be accomplished by connecting the conductor 43 to an element 45 of the battery 10 eighteen or nineteen volts removed in potential from the positive grounded terminal of the battery 10.

It will be apparent that the testing system herein described may be equally well applied to other telephone-exchange systems, and I do not, therefore, wish to limit myself to the precise disclosure herein set forth; but,

Having described my invention, I claim as new and desire to secure by Letters Patent—

1. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a test-thimble normally disconnected from said source, cord connecting apparatus at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes connection of said test-thimble with said source, a test-contact connected to a point in said source of current intermediate in potential between the potentials of the terminals of said source of current, and a signal-receiving device adapted upon application of the charged test-contact to the test-thimble, to indicate the condition of the tested line.

2. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line,

a test-thimble normally disconnected from said source, cord connecting apparatus at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes connection of said test-thimble with said source, a test-contact associated with said cord connecting apparatus, connected to a point in said source of current intermediate in potential between the potentials of the terminals of said source of current, and an operator's telephone set inductively associated with the test-circuit, whereby a click is produced in the operator's receiver, upon the application of the charged test-contact to the test-thimble of a busy line.

3. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a test-thimble normally disconnected from said source, cord connecting apparatus at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes connection of said test-thimble with said source, a test-contact connected to such a point in said source of current intermediate in potential between the potentials of the terminals of said source of current that the test-contact is charged to a potential only slightly different from the potential of the test-thimble of a busy line, and a signaling device adapted, upon application of the charged test-contact to the test-thimble, to indicate the condition of the tested line.

4. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a common battery at the exchange for supplying talking and signaling currents to said line, cord connecting apparatus at the exchange for connecting said line with another for conversation, a test-thimble normally disconnected from said battery, means whereby the connection of said cord connecting apparatus with said line having a conductively-completed circuit through a substation-transmitter causes said test-thimble to be connected with said battery and charged to a potential intermediate between the potentials of the terminals of said common battery, a test-contact forming the tip-contact of the calling-plug associated with said cord connecting apparatus connected through an impedance-coil, to an intermediate element in said common battery such that the test-contact will be charged to a potential only slightly different from the potential of the test-thimble of a busy line, and an operator's telephone set inductively associated with the test-circuit, whereby a click is produced in the operator's receiver upon the application of the charged test-contact to the test-thimble of a busy line.

5. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a plurality of test-thimbles for said line normally disconnected from circuit, cord connecting apparatus at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes said test-thimbles to become charged by said source, a test-contact adapted to be connected to a point in said source of current intermediate in potential between the potentials of the terminals of said source, and a signal-receiving device adapted upon application of the charged test-contact to a charged test-thimble to indicate the condition of the tested line.

6. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling current to said line, a plurality of test-thimbles for each line normally disconnected from circuit, a cord-circuit at the exchange for connecting said line with another for conversation, means whereby the connection of said cord-circuit with said line causes said test-thimbles to be charged by said source, a test-contact for said cord-circuit, an operator's listening-key for said cord-circuit, actuation of said key causing said test-contact to be connected to an intermediate point in said source, and an operator's telephone set connected in circuit upon actuation of said key for receiving the signal upon application of the charged test-contact to a charged test-thimble.

7. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, a plurality of test-thimbles for said line normally disconnected from circuit, a cord-circuit at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes said test-thimbles to be charged by said source, a test-contact for said cord-circuit normally connected with a terminal of said source, an operator's listening-key, actuation of said listening-key serving to disconnect said test-contact from the terminal of said source and to connect said contact with an intermediate point of said source to charge the test-thimble to a slightly

different potential from the charged test-thimbles, and an operator's telephone set adapted for connection in circuit upon actuation of said key for receiving the signal upon application of the charged test-contact to a charged test-thimble.

8. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange, a test-thimble for said line normally disconnected from circuit, a cord-circuit at the exchange for connecting said line with another for conversation, means whereby the connection of said cord connecting apparatus with said line causes said test-thimble to be charged from said source, a test-contact for said cord-circuit normally disconnected from but adapted to be connected to an intermediate point of said source to be charged to a potential slightly different from the potential of the charged test-thimble, and signal-receiving means for indicating the condition of the tested line upon application of a charged test-contact to the test-thimble.

9. In a telephone-exchange system, the combination with a telephone-line extending by its limbs from a substation to an exchange, of a source of current at the exchange for supplying talking and signaling currents to said line, cord connecting apparatus at the exchange for connecting said line with another for conversation, a test-thimble normally disconnected from said line, but adapted upon the connection of said cord connecting apparatus with said line to be connected with said line, means whereby the connection of said cord connecting apparatus with a line having a conductively-completed circuit through a substation-transmitter, causes said test-thimble to be charged to a potential intermediate between the potentials of said source of current, a test-contact associated with said cord connecting apparatus, means for charging said test-contact to a potential intermediate between the potentials of the terminals of said source of current but different from the potential of the test-thimble of a busy line, and a signaling device adapted upon application of the charged test-contact to the test-thimble to indicate the condition of the tested line.

In witness whereof I hereunto subscribe my name this 15th day of April, A. D. 1903.

HARRY G. WEBSTER.

Witnesses:

LYNN A. WILLIAMS,
JOHN STAHR.