(No Model.) 3 Sheets—Sheet 1.

J. J. O'CONNELL.

TELEPHONE EXCHANGE APPARATUS.

No. 417,271. Patented Dec. 17, 1889.

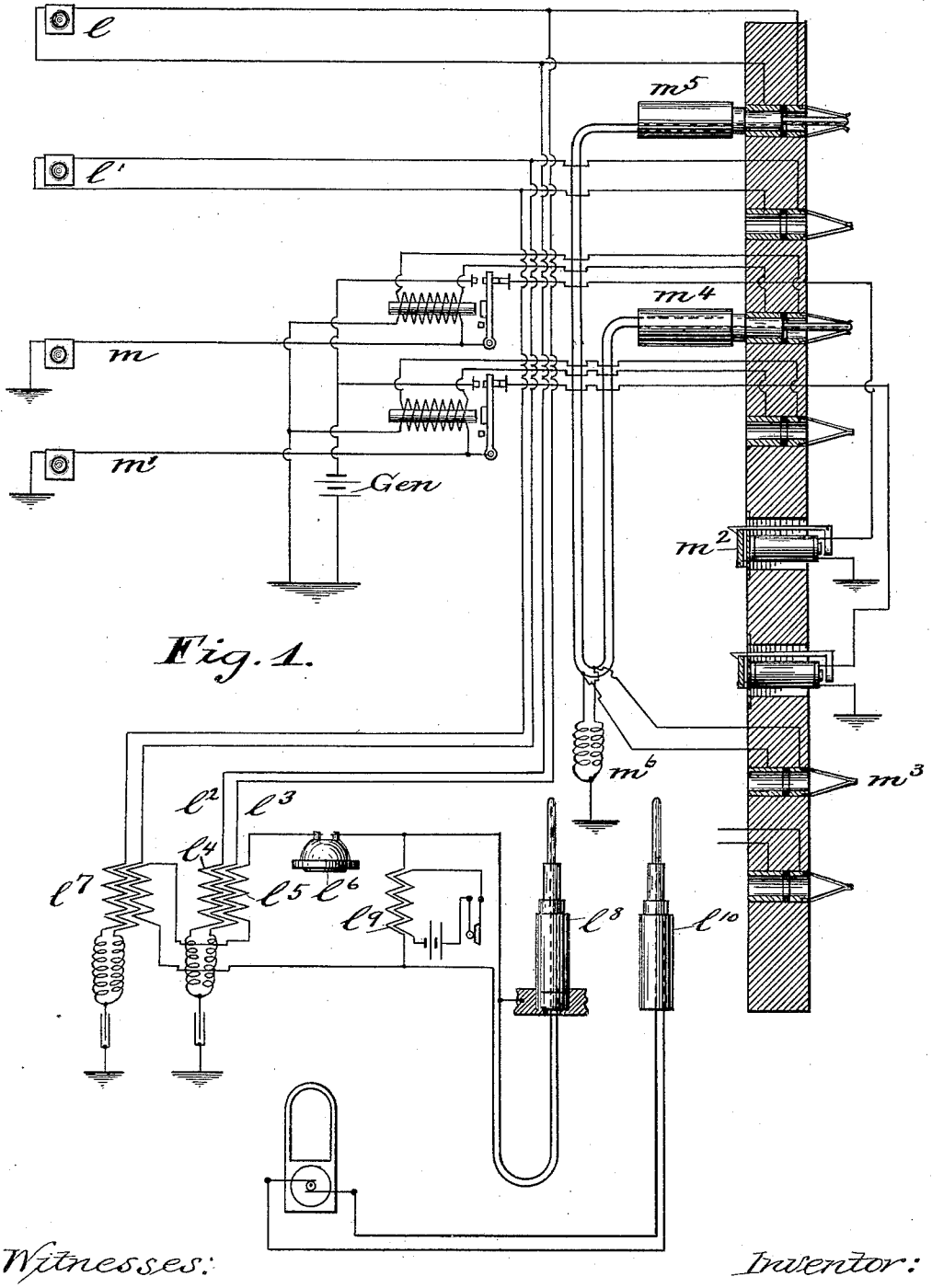

Fig. 1.

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(No Model.) 3 Sheets—Sheet 2.

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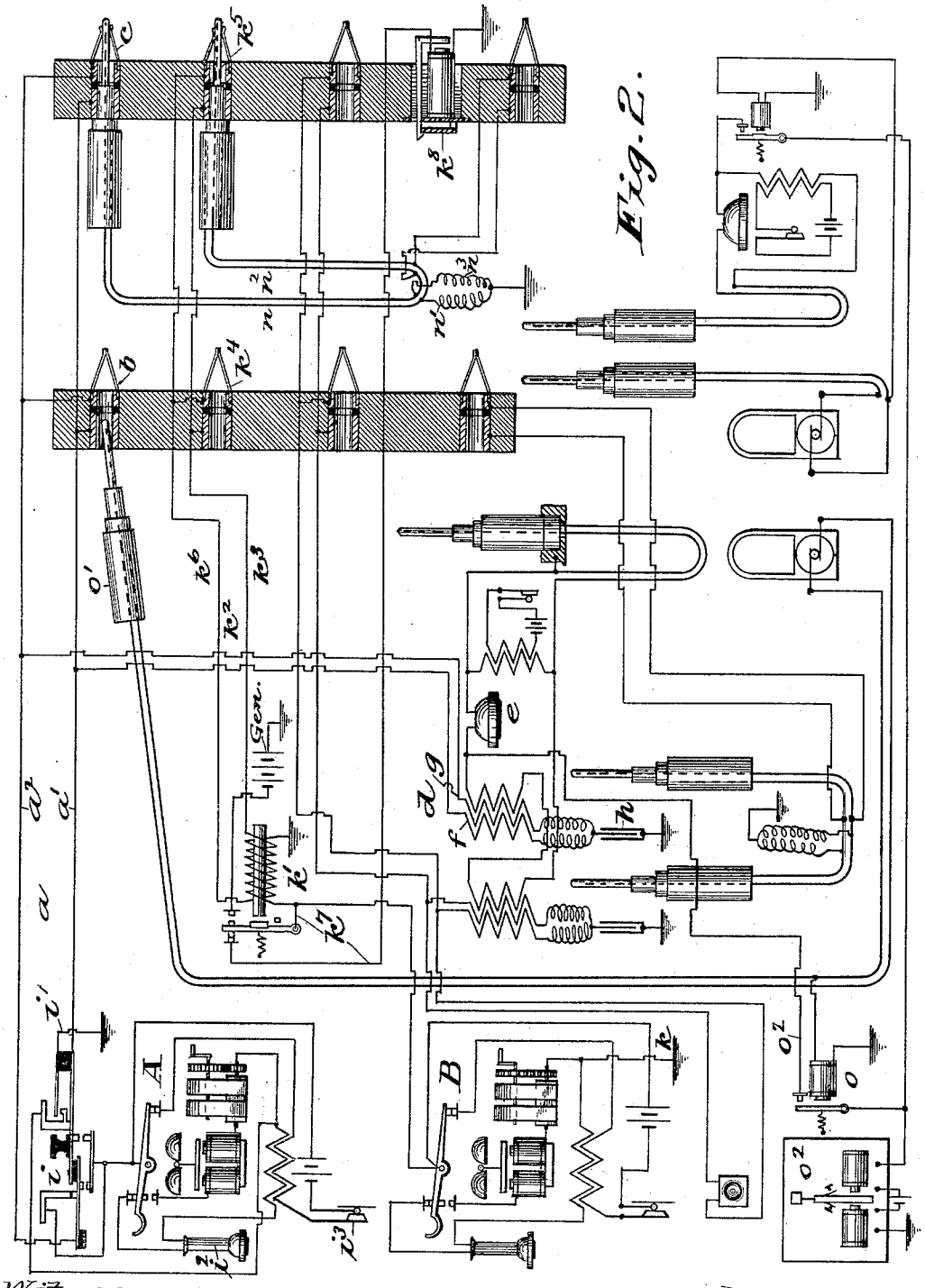

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(No Model.) 3 Sheets—Sheet 3

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TELEPHONE EXCHANGE APPARATUS.

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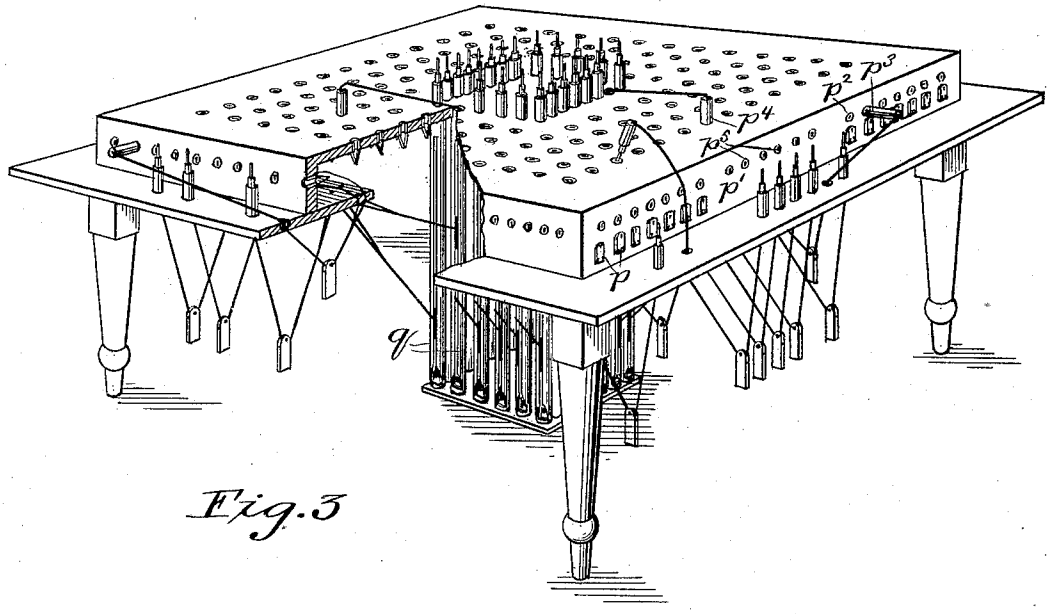

Fig. 3.

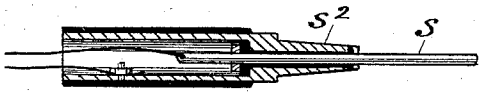

Fig. 4.

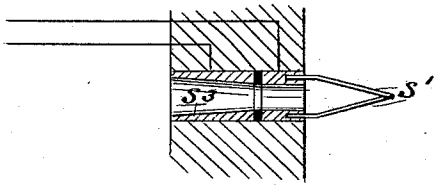

Fig. 5.

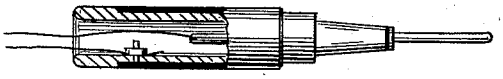

Fig. 6.

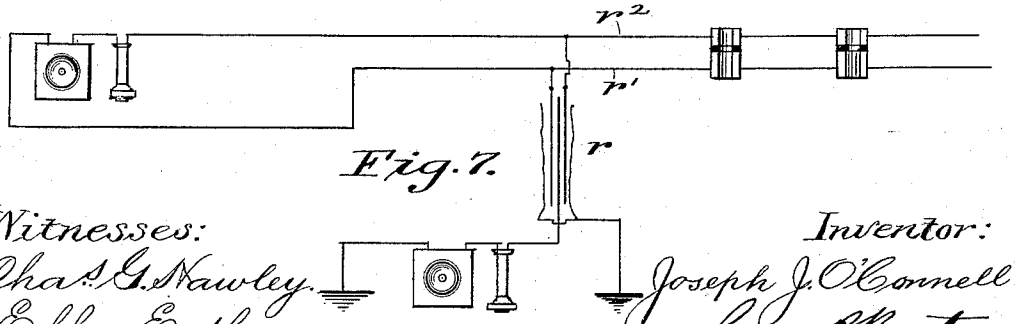

Fig. 7.

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UNITED STATES PATENT OFFICE.

JOSEPH JOHN O'CONNELL, OF CHICAGO, ILLINOIS.

TELEPHONE-EXCHANGE APPARATUS.

SPECIFICATION forming part of Letters Patent No. 417,271, dated December 17, 1889.

Application filed January 2, 1889. Serial No. 295,126. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH JOHN O'CONNELL, 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 Apparatus, (Case 6,) of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to telephone-exchange circuits and apparatus.

Heretofore in telephone-exchange systems subscribers have been provided with a special signaling-circuit in addition to their telephone-lines, several subscribers being grouped upon the same signal-circuit, after the manner of the American district signal system. Such a system was in the early days of the telephone used in New York city and known as the "Law" system. At the present time the same system is used in St. Louis and Philadelphia. A feature of this system is that the subscriber simply takes down his telephone and speaks directly to the listening operator to give his order. This system possesses features of simplicity in operation which do not obtain in systems in which the subscribers call the central office over their own telephone-lines, as is the case in all other telephone-exchanges with which I am familiar.

The principal reason why the system of speaking directly to the listening operator has not found favor is due to the fact that a special signal-circuit was required, and whenever there was trouble on this special circuit the whole group of subscribers thereon would be cut off from the exchange. When the number of subscribers' lines in the exchange were comparatively few, the liability of the special circuit to become disabled or inoperative was much less than now. Therefore it has become of the greatest importance that each subscriber's means of communication with the central office should be independent of the other subscribers' means of communication, in order that trouble upon one circuit may not affect more than one subscriber.

The objects of my invention, briefly stated, are, first, to enable subscribers having metallic circuits to speak directly to the listening operator at the central office over their individual telephone-lines, respectively; second, to provide metallic circuits and single-wire circuits for different subscribers so arranged that the different subscribers may call up the central office and be connected with one another, as desired; third, to provide an answering loop-plug in connection with the listening operator's telephone-set so arranged that the secondary of the induction-coil will be shunted except when the plug is lifted from its socket; fourth, to provide in multiple-switch-board systems for the use of metallic circuits and single or grounded circuits upon the same switch-board, with a busy test of the same character for both classes of lines; fifth, to provide a loop containing one coil of the magnet of a relay in connection with a special generator so arranged at the central office in connection with the grounded line, which includes another winding of said relay, that voice currents will be induced between said loop and the grounded line, while on the closing of the relay the generator will send current over the grounded line; sixth, to provide a switch-board table with connecting cords and plugs and switching devices arranged to facilitate the work of the operators; seventh, to provide a guide for the weights of the cords to prevent the cords hanging under the table from becoming tangled, and, eighth, to provide a double terminal socket and a loop-plug adapted to be inserted therein so constructed that the contacts formed will be positive and reliable.

My invention consists in the circuits and apparatus, hereinafter described, whereby these objects are accomplished.

In the drawings, which are illustrative of my invention, Figure 1 is a diagram illustrative of four telephone-lines, two metallic and two grounded, connected with a switch-board at the central office, together with the operator's outfit. Fig. 2 is a diagram showing three telephone-lines, two metallic and one single, connected with two switch-boards at the central office according to the multiple plan, together with the operator's apparatus at the switch-board, the subscriber's outfit of one of the metallic circuits and the outfit of the subscriber of the grounded circuit being shown in detail. Fig. 3 is a perspective view of the

form of switch-board which I preferably use. Fig. 4 is a detailed sectional view of one of my loop-plugs. Fig. 5 is a detailed view of one of the double sockets adapted to receive the same. Fig. 6 is a detailed sectional view of a loop-plug provided with a metallic heel connected with the sleeve thereof, which is the form I preferably use as an answering-plug. Fig. 7 is a diagram showing a condenser with two of its plates connected with different sides of a metallic circuit, which may be used, if desired, in place of the three-coil induction-coils shown in Figs. 1 and 2.

I will first describe my invention with reference to Fig. 2.

The subscriber's station A is connected with the central office by the metallic circuit a, which consists of two branches a' a^2. Branch or side a' is permanently connected with the front or test portion of each of the sockets b c on the different switch-boards. Branch or side a^2 is connected with the other portion of said sockets b c. These two sides or limbs of the circuit a are provided each with a different branch connected through different differential windings of an induction-coil d. This differential coil is provided with a third winding, which includes the operator's receiving-telephone e. Thus from limb a' there is a connection through winding f of the induction-coil, and from limb a^2 there is a connection through the winding g of said induction-coil d. These coils f g may be considered as the primary of the induction-coil, and each, after passing through suitable resistance, is united with the other. A condenser h is placed in the branch which extends to ground from between the two coils f g. These coils f g are wound upon the induction-coil in the same direction. Therefore, if a voice-current be sent through both of these coils connected in multiple, a corresponding current will be induced upon the secondary coil, which includes the telephone e. If, however, the voice-current is sent through coils f g, connected in series, the currents passing through the two coils at the same time will be neutralized with respect to their effect upon the secondary, and therefore no sound will be heard in the telephone e.

I provide a key i at station A, so arranged that when depressed the two limbs a' a^2 will be united to a ground branch i', including the telephone i^2. The subscriber at station A thus, on taking down his telephone and depressing key i, will speak over the circuit a as a single line, the voice-currents dividing between the different limbs a' a^2 and being sent in the same direction through the coils f g and the condenser h to ground. These voice-currents will induce corresponding voice-currents in the secondary winding, which includes the telephone e. Thus the subscriber at station A, on taking down his telephone i^2 and depressing key i, may speak into his transmitter i^3, thus sending currents in the same direction through the coils f g and condenser h to ground, thereby inducing corresponding currents in the telephone e—that is to say, the subscriber having a metallic circuit connected as described may speak directly to the listening operator at telephone e.

I will now describe the single or grounded telephone-line and its connections.

Station B shows the subscriber's outfit of a single line. This grounded line k, as shown, may be traced from ground through the secondary of the telephone induction-coil, through the telephone, the telephone-switch, and thence through a winding of the induction-coil k' to ground at the central office. A metallic loop k^2 connects with the other winding of this induction-coil k'. Side k^3 of this loop connects with the front or test portion of socket k^4 on the first board, and also with the front or test portion of socket k^5 on the second board. The side or limb k^6 of this loop k^2 is connected with the rear portion or terminal of socket k^4 and also with the rear portion of the socket k^5 on the second board. Thus the sides k^3 k^6 of the loop are connected with the different portions of sockets k^4 k^5 of the different boards in the same manner that limbs a' and a^2 of circuit a are connected, respectively, with the different portions of socket b and socket c of the same boards in the multiple system. I have, then, with each of the different grounded circuits k a loop k^2 at the central office, the line k and the loop k^2 each including a different coil of a converter k', so that voice-currents sent over the wire k will be induced upon the loop k^2, and currents over the loop will be induced upon the line k. The subscriber at station B, in order to call up the central office, operates his generator before the telephone is removed from the switch, thus sending current from line k through one winding of the converter k'. With the armature-lever of this magnet is connected the annunciator branch k^7, which extends through the individual annunciator k^8 of the line of station B to ground. When, therefore, current is sent by the generator of station B over wire k, the annunciator k^8 will be thrown down by the current sent over the derived annunciator circuit or branch k^7. Subscribers thus provided with single lines may call the central office in the manner now most commonly employed—that is to say, by turning a generator, thus sending current to line to operate an annunciator at the central office. Where multiple switch-boards are employed, I preferably arrange the circuits so that the annunciators of the single-circuit lines will be grouped upon the same switch-board or upon as many switch-boards as may be required. When a single board only is used of the form illustrated in Fig. 3, the calls of the subscribers having grounded lines may always be answered by the same operator sitting at a particular side of said board or table.

In Fig. 1 metallic circuits l l' are shown,

each connected with a different socket upon the switch-board, the same as heretofore described with respect to circuit *a* of station A of Fig. 2. The circuit *l* is provided with branches l^2 and l^3 from the different sides thereof, each branch including a different winding of the two equal parallel coils of the converter l^4. The third winding l^5 of this converter is included in the circuit of the operator's telephone l^6. Branches from the different sides of circuit *l'* extend through coils of the converter l^7, and the third winding of said converter is included in circuit with telephone l^6, the same as described with respect to converter l^4. The answering-plug l^8 is used more especially in talking with single-circuit subscribers. The heel of this plug is metallic, and the strand of the cord which connects with the tip of the plug is connected with this socket. Thus the secondary winding l^9 of the transmitter of the induction-coil is short-circuited or shunted when the plug l^8 is resting in its socket, as shown. The loop-plug l^{10} is connected with a generator. By inserting this plug in the socket of a line, current will be sent over this line to call up the subscriber thereon.

Lines *m m'* are single-circuit lines, each being connected at the central office with a different loop. Current between the grounded portion of the circuit and the loop is induced through the medium of a converter, the converter being preferably the magnet of a relay, the armature of the relay being in a branch which includes the individual annunciator of the line. A generator-connection is preferably provided, so that when the armature of a relay is attracted connection will be made between the grounded line and the generator. A single subscriber's outfit is illustrated in detail at B on line *k*, Fig. 2, and, the single telephone-line circuit *k*, together with its connections at the central office, having been fully described, detailed descriptions of connections with lines *m m'* of Fig. 1 will not be necessary.

We will suppose subscriber of line *m* wishes connection with subscriber of metallic circuit *l*. The annunciator m^2 of line *m* is first thrown down. The operator inserts answering-loop plug l^8 in socket m^3 and plug m^4 in the socket of line *m* upon the switch-board. The operator at telephone l^6 is thus in communication with the subscriber over line *m*. The order being given for connection with line *l*, the other plug m^5 of the pair is inserted in socket of said line *l*, as shown, and the two lines are connected. When the subscriber of line *m* is left to call up the subscriber of line *l*, I provide a generator at the subscriber's station. As a part of the outfit of each subscriber I therefore, preferably, provide a generator, so that one subscriber may call another, as desired. The generator at the central office may, however, be connected with any line wanted by inserting the loop-plug l^{10} in the socket of the line or into the socket m^3 of a pair of cords having one of the terminal plugs thereof inserted in the switch or socket of the line. The resistance m^6 in the different ground branches of the strands of the cord connecting plugs m^4 m^5 should be, say, one thousand ohms. These ground-connections from the different strands of the pairs of loop-plugs are utilized in making the tests when multiple switch-boards are employed, as shown in Fig. 2. Thus stations A and B are shown connected together upon the last board at sockets *c* k^5. The strand *n*, connecting the tips of the plugs, is branched to ground through resistance *n'*, while the strand n^2, connecting together the sleeves of the plugs, is branched to ground through resistance n^3. This resistance *n'* and n^3 may be of one thousand ohms. A high-resistance relay *o* is shown connected with one of the strands of the cord connecting with generator loop-plug *o'*, the connection in this instance being with the strand between the sleeve of the plug and the generator. The rheotome o^2 is of the usual construction and so arranged that when current is sent through the relay *o* the rheotome will be connected by wire o^3 with the operator's telephone *e*. Immediately, therefore, on inserting one of the pair of loop-plugs into the socket of a line upon any board—as, for example, socket *c*—the busy test will be indicated if the tip of a test-plug or generator-plug *o'* is applied to the test portion of a socket of the line, as socket *b* upon another board. Thus, as shown in Fig. 2, beginning at ground, the circuit may be traced through the coil of relay *o*, and thence through the generator to the tip of plug *o'*, thence to limb *a'*, and thence through strand n^2 to ground through resistance n^3. Relay *o* will thus be closed, so as to connect circuit o^3 with rheotome o^2. The capacity of the circuit, including the telephone *e*, will be such that whenever the circuit is closed between branch o^3 and the rheotome the hum of the rheotome will be heard in the telephone *e*.

The coils n^3 and *n'* should be self-induction coils of the same size. The coil *n'* is connected with the branch *n* in order that there may be a balance between the two sides of a metallic circuit when the different strands n^2 and *n* form a portion of said metallic circuit.

The switch-board table (shown in Fig. 3) is so constructed that operators may sit upon different sides thereof. The table shown may be considered as provided with sockets upon the top for all the lines of the exchange. The pairs of plugs are arranged so that one plug of each pair will be supported in its socket in the leaf or shelf on one side and the corresponding plug will be near the center of the top of the board. Thus, as shown, each operator is provided with six pairs of connecting-cords with terminal plugs. In case a portion of the lines are single or grounded, the annunciators *p* of these lines may be placed upon one side of the board, as upon the vertical panel *p'*. The telephone-

lines will be preferably grouped between the operators in such manner that each operator will answer the calls of particular lines. By providing answering spring-jacks p^2, one in each of the lines, the work of the operators is facilitated—that is to say, the lines assigned to one operator would each be provided with an answering spring-jack p^2 in the panel in front of said operator. The operator then on receiving a call would insert a loop-plug, as p^3, in the answering spring-jack of the calling subscriber. Having received the order, she will insert the other plug of the pair, as plug p^4, in the regular switch or socket of the called subscriber, as shown. In each pair of cords is preferably provided a cord-socket. (For detail see m^3, Fig. 1.) These cord-sockets may be arranged upon the table in the panels, as indicated at p^5.

I have provided tubes q, which serve as guides for the cord-weights and prevent the cords from becoming tangled. These tubes are slotted, as shown, and preferably enlarged at the lower portion, so as to permit of the ready removal of a weight when desired.

In Fig. 7 I have shown a condenser r, which might be used in place of the induction-coils. I preferably, however, use the induction-coils, as induction-coil d. My system would, however, be successfully operative with the different branches or sides r' and r^2 connected with different plates of the condenser r, as shown, the telephone of the operator being connected with an intermediate plate.

The induction-coil d, or the condenser r, speaking generally, may be termed "differential converters," since when the line connected with one of them, as shown, is grounded at the subscriber's station current sent over the line will induce corresponding currents upon the operator's telephone, while if the telephone-line is in use as a metallic circuit the currents sent over the circuit will be in different directions in the differential portions of the converter, and thus there will be no current induced in the telephone connected with the intermediate plate of the condenser or the third winding of the induction-coil, as the case may be.

The connecting loop plugs and sockets are preferably of the form shown in Figs. 4, 5, and 6, the tip s of the plug being adapted to be inserted between the springs s' of the rear portion of the socket, while the sleeve s^2 of the plug is preferably made tapering, so as to conform to the interior of the outer or test portion s^3 of the socket. When the plug is inserted, a connection is made between the tip s and the springs s', while the sleeve s^2 is connected with the outer portion s^3.

My invention admits of various other modifications that would readily suggest themselves to those skilled in the art, and I therefore do not limit myself to the constructions shown.

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

1. A telephone-line extending from a subscriber's station to the central office, and a switch for closing said line at the subscriber's station to ground to include the subscriber's telephone-line therein, said telephone-line being provided with two branches connected to different portions of a converter, in combination with a telephone connected with another portion of said converter, whereby when the line is grounded at the subscriber's station the subscriber may talk to the listening operator, while on disconnecting the line from said ground any currents over the line will be neutralized at the converter, being sent in opposite directions through different portions of the same.

2. A metallic-circuit telephone-line grounded at the subscriber's station through a branch including the subscriber's telephone, branch wires, one from each side of said circuit at the central office through different differential portions of a converter, and the operator's telephone included in a third portion of said converter, whereby the subscriber may speak to the operator, substantially as and for the purpose specified.

3. A telephone-line extending from ground through a subscriber's outfit and thence to the central office, in combination with a loop at the central office, a relay having two windings, one included in the grounded circuit-wire and the other included in the loop, a branch from said grounded wire through the relay-armature and an individual annunciator to ground, a loop-plug socket consisting of two insulated portions upon the switch-board—one portion for each side of said loop—and an operator's telephone included in said loop, whereby the subscriber may signal the central office, and the operator having connected her telephone into the loop the subscriber and operator are brought into communication, substantially as and for the purpose specified.

4. The combination, with a grounded telephone-line, of one winding of a relay included therein, a loop with its different ends connected with different parts of a loop-plug socket on the switch-board, said loop including the other winding of said relay-coils, a branch from the grounded circuit to the armature of said relay, and a generator with which said relay-armature is adapted to be closed when the magnet of the relay is excited, substantially as and for the purpose specified.

5. The combination, with metallic-circuit telephone-lines each connected through a differential converter with a listening-operator's telephone, of single-line circuits each connected through the medium of a relay-coil with a different loop at the central office, the loops of the different single lines and the metallic circuits being each connected with a different switch or double socket upon the same switch-board, and switching apparatus

for uniting any metallic circuit with the loop of any single line, substantially as and for the purpose specified.

6. The combination, with the different differential windings of an induction-coil, of a metallic circuit to the different sides of which said coils are respectively connected, a condenser in a ground branch connected between said coils, high resistance between each coil and the condenser, and a telephone included in circuit with a third winding of said induction-coil, whereby currents sent over the two sides of said telephone-circuit when connected in multiple are induced upon the telephone-circuit, while currents sent over said telephone-circuit when used as a metallic circuit are neutralized, substantially as and for the purpose specified.

7. A telephone included in circuit with the third winding of each of two or more induction-coils, the two other windings of each of said coils being differential and including connections each with a different side of a metallic telephone-circuit, whereby subscribers may each speak directly to the listening operator.

8. An operator's receiving-telephone included in circuit with the secondary coil of the induction-coil and a transmitter and battery in a local circuit, including the primary coil of said induction-coil, in combination with a shunt around said induction-coil and a switching device for opening said shunt when the transmitter is brought into use.

9. The combination, with the answering loop-plug l^8, of the socket therefor, strands of a flexible cord connected with different sides of the secondary coil of a telephone-set and with different terminals of the plug, and a connection between the socket and one of said strands, whereby the secondary is shunted while the plug rests in the socket, said shunt being opened on the lifting of the plug.

10. The combination, with metallic telephone-circuits and single telephone-circuits, each connected with two or more switch-boards according to the multiple system, of an individual annunciator for each single line and connection from different sides of each metallic circuit with a listening operator's telephone through the medium of a differential converter and switch and testing apparatus, whereby any subscriber of one line may call for connection with the line of any other subscriber, a line called for tested, and the connections made between them, substantially as and for the purpose set forth.

11. The combination, with a telephone-line k, extending from ground at a subscriber's station through a winding of a coil of relay k' to ground, of the armature of said relay, a generator-connection to which the armature is adapted to be closed when the relay-magnet is excited to attract said armature, and a loop including another winding of said relay-magnet, whereby when current is sent over said loop the generator is closed to the ground-wire k, substantially as and for the purpose specified.

12. A switch-board table provided with switches on the upper portion thereof—one for each telephone-line—in combination with pairs of plugs and cords for the operators, said plugs and cords being in pairs and one plug of each pair being near the central portion of the top of said table, while the other plug is placed near the edge on one side thereof, answering-switches for the different lines placed upon the vertical panels and distributed on the different sides, and sockets, one in each pair of cords, with which the answering-plugs and generator-plugs are adapted to be connected, substantially as and for the purpose specified.

13. The combination, with the flexible conducting-cord, of a pulley-weight suspended thereon, and a tube in which said weight is suspended from the cord, and a slot in the tube through which the cord passes, the cord being raised and lowered in this slot.

In witness whereof I hereunto subscribe my name this 28th day of December, A. D. 1888.

JOSEPH JOHN O'CONNELL.

Witnesses:
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GEORGE P. BARTON.