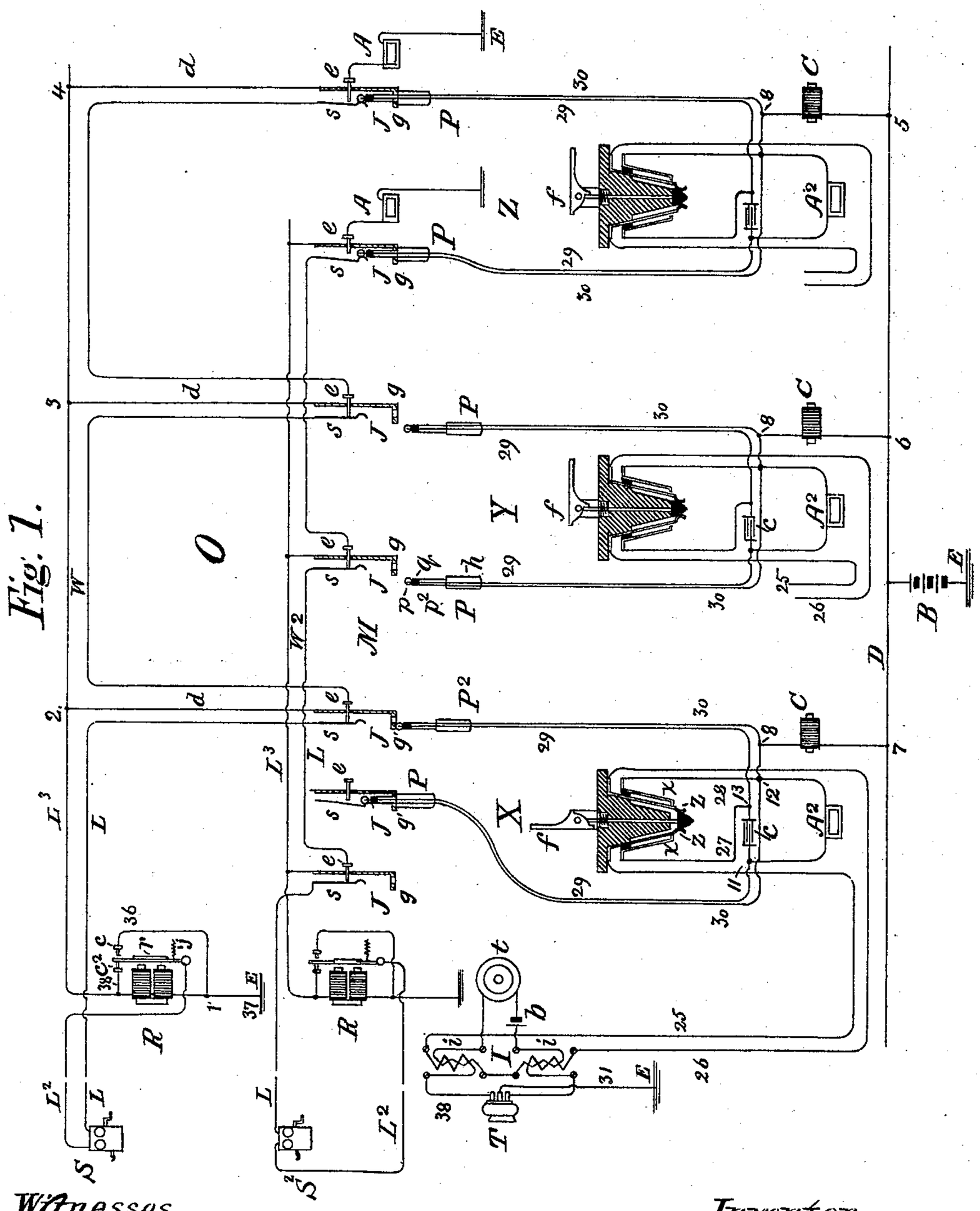
(No Model.) 2 Sheets—Sheet 1.

J. L. McQUARRIE.

MULTIPLE SWITCHBOARD BUSY TEST CIRCUIT AND APPARATUS.

No. 487,853. Patented Dec. 13, 1892.

Fig. 1.



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(No Model.) 2 Sheets—Sheet 2.

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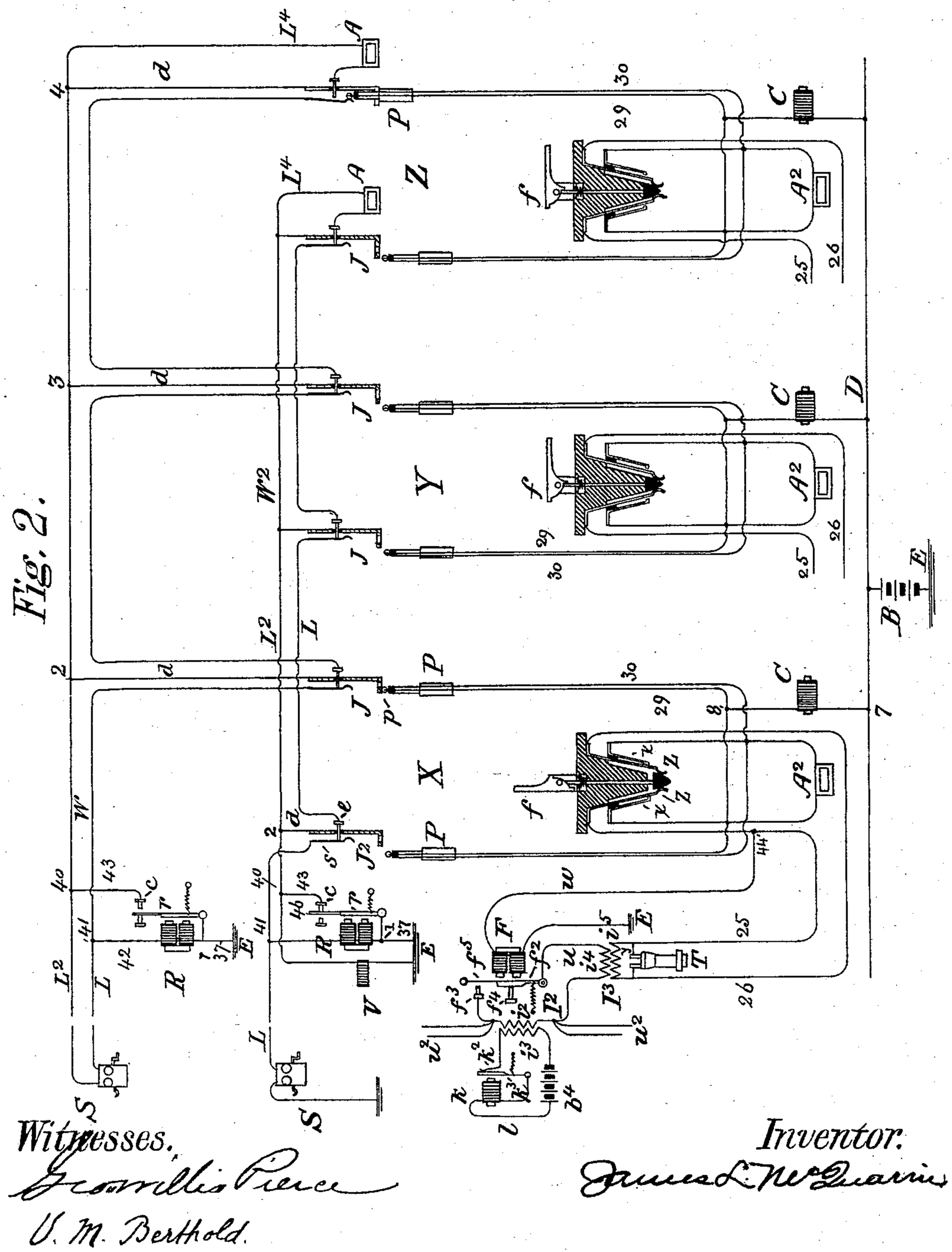
Fig. 2.



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UNITED STATES PATENT OFFICE.

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MULTIPLE-SWITCHBOARD BUSY-TEST CIRCUIT AND APPARATUS.

SPECIFICATION forming part of Letters Patent No. 487,853, dated December 13, 1892.

Application filed April 7, 1892. Serial No. 428,205. (No model.)

To all whom it may concern:

Be it known that I, JAMES L. McQUARRIE, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain Improvements in Multiple-Switchboard Busy-Test Circuits and Apparatus, of which the following is a speicfication.

This invention relates to multiple switchboards and to busy-test apparatus and circuits for use in connection therewith. Multiple switchboards are now extensively employed in central telephone exchanges, and of course require at each section some form of busy-test appliance whereby an operator at such section may at any time be enabled to ascertain whether a given line called for is at liberty or is already in use at another section of the switchboard. It is now customary, in order that inductive disturbance may be avoided, to construct metallic telephone-circuits. The ordinary busy-test which has in practice been found most convenient is to touch the frame of the desired plug-socket for an instant with the tip of the plug-connector which is to be inserted and at the same instant to listen in the supervisory telephone. A click heard in the telephone or the absence of sound in the telephone (as may previously be arranged) upon making the above test denotes that the line is at liberty and that the connection may be proceeded with—that is to say, in some organizations it is understood that if on making the test a clicking sound be heard in the telephone the tested line is already busy and that if there be silence the line is at liberty, while in other exchanges it is understood that if no such click be heard the line is busy, while the occurrence of the click indicates that the line is at liberty. It is not difficult to arrange apparatus for either mode of testing. In metallic circuits the several socket-frames have been permanently in connection with one side of the metallic telephone circuit; and it has in practice been found with many such metallic circuits on applying the plug for tests that a false signal has been received, a click being observed in the telephone when the conditions should have called for its absence. Investigation of the subject has shown that such false signals are attributable to the presence of a charge upon the affected metallic-circuit lines, which parallel or are adjacent to electric railways or to the wires of some electric-light systems, which charge upon the application of the test-plug discharges through the testing operator's telephone in the form of a current, thereby producing in the said telephone a sound which is not easily distinguishable from the true busy-test click.

The object of my invention is to provide a system of test appliances for metallic circuits which shall entirely avoid this liability to give false test signals and to effect this desirable result without any unnecessary complication in circuits or apparatus.

My invention is based on the principle that if the test-wire uniting the several plug-socket frames or test-contacts is normally severed from the line-circuit or made local in the central station in other ways—such as by attaching a dead-earth connection to it—a false test will be prevented. Accordingly I provide for each affected line a relay, which normally maintains the said desired localization of the test-wire and contacts of such line and which may be connected with two contacts for its armature and arranged to ground the test-wire through its own electro-magnetic helices and also to maintain a dead-earth connection upon the return-line from the sub-station or which alternatively may have its armature provided with a single electrical contact and arranged to ground the main conductor from the sub-station through the electro-magnet and to apply a dead-earth to the return and test wires and contacts. The former arrangement gives the positive signal in the operator's telephone when the line is busy and the latter gives the positive signal when the line is not busy. The former plan is perhaps to be preferred in that the positive signal to indicate a busy line is the more familiar and most frequently used mode of operation, while the latter has an advantage in that the continuity of the circuit does not depend upon the perfection of one of the relay-contacts. In both the test-wire is normally cut off by the interposition of a dead-earth from the outside line, and in both the insertion of a plug-connector in any socket of the circuit acts by energizing the electro-magnet of the relay to

disconnect the said dead-earth connection and to establish the continuity of the return-line conductor through the plug-socket frames and also makes such a change in the electrical condition of the said frames that when the test-plug is applied to any one of them a test indicating the present status of the line is indicated with certainty.

In the drawings which accompany and form a part of this specification, Figure 1 is a diagram illustrative of that exemplification of my invention in which the helices of the relay are included between the test-line connecting the plug-socket frames and earth; and Fig. 2 is a like diagram illustrative of the modification in which the test-line is absolutely and directly earthed, the relay-helices being in a branch from the direct main conductor to earth.

In Fig. 1, O is a central station, to which any number of metallic circuits W, extending from sub-stations S S^2, &c., converge, and M is a multiple telephone-switchboard divided as usual into sections, to which all lines loop and at which the said lines are represented by spring-jack plug-sockets J. The line L of each circuit passes through its series of jack-contacts and also through the helices of its call-annunciator A, these being apportioned in a manner well understood between the several sections, so that at each section all circuits are accessible for connections and a given number have their calls answered. The direct line of each metallic sub-station circuit I have, as already intimated, designated by the letter L, the return-line by L^2, and the extension of the latter through the switchboard by L^3.

R is a relay, which in practice has been wound to about five hundred ohms and which is constructed to have a high self-induction coefficient, so that its impedence to currents which have a high frequency of change—such as telephone-currents—is very considerable.

X Y Z indicate the several operators' sections of the multiple switchboard M, and at each are a number of plug-and-cord connectors each having a listening-key *f* in its circuit, whereby the operators' telephones can be connected or disconnected at will in a bridge-circuit between the two conductors of the connecting-cord.

In the drawings for the avoidance of complication the telephones are carried out at section X only. For each connecting-link at each section there is a disconnecting or clearing-out annunciator A^2, which also is bridged between the two conductors of its cord.

B is a test-battery or other suitable electric generator, which may be common to the entire switchboard and which has one pole connected with the earth at E. Its other pole connects with an omnibus-wire D, from which at suitable points 5, 6, and 7 branches extend through retardation-coils C to connections at 8 with the flexible-cord conductor 30, which terminates in that conducting-surface of the plug-connector that connects with the metallic jack-frame. Each spring-jack or plug-socket J consists of a conducting frame or socket *g*, which receives the plug, a contact-spring *s*, and a resting contact-pin or anvil *e* therefor, on which the spring *s* normally rests, but from which it is separated by the insertion of a plug within its socket, as is shown at section Z. Each connecting-plug P has a non-conducting handle *h*, a sleeve or shank conducting-surface p^2, adapted to make contact with the spring-jack frames *g*, a tip-conducting piece *p*, adapted to make contact with the jack-springs, and separating-insulation *q*. The tip-contacts of the two plugs of a pair are united by cord conductor 29, and the sleeve-contacts are united by cord conductor 30.

The telephone outfit in practice consists, as shown, of a receiving-telephone T and a transmitter *t*, the latter being in circuit, as usual, with a local battery *b* and the primary helix of an induction-coil I, the secondary helix of the said induction-coil being arranged for the sake of perfectly balancing the circuit in two parts *i*, one on each side of the receiver. The receiving-telephone T has a connection 31 run from the central point of its helix to earth at E. The two wires 25 and 26, extending as a loop from the telephones, connect with the two inner springs *z* of the listening-key *f* and are thus discontinuous in the recumbent portion of the key and connect with their companion spring *x* in the elevated position thereof, the said springs *x* being in turn united by wires 27 and 28, respectively, to the cord conductors 29 and 30 at the points 13 and 12, thus providing the before-mentioned bridge-circuit for the telephone.

A condenser *c* is interposed in the circuit of the tip-uniting cord conductor 29 for the purpose of preventing misleading sounds in the telephone, while permitting the free passage of the voice-currents. If this were not added, a current from the test-battery would circulate through the testing-circuit part of the telephone-helix as soon as the listening-key *f* is placed in the position to connect the telephones, and in that event the operation of making the busy-test would cause a redistribution of such current and produce a signal in the telephone whether the tested line were busy or not. I have hereinbefore indicated the course through the switchboard of the direct-circuit conductor L. The return-conductor L^2, entering from the sub-station, terminates at the armature-lever *r*, with which it is electrically connected. This is normally retracted by a counter-spring *j* against its back contact *c*, from which a wire 36 leads by way of the junction *l* to an earth connection 37, and the return-conductor is thereby normally connected directly to earth. The electro-magnet of the relay or electro-magnetic instrument R is connected in the circuit of a continuation L^3 of the said return-conductor, which starts from the earth connection at 37 and, after passing through the

said magnet, extends through the switch-board, having its other end discontinuous and having at each switchboard-section a branch *d*, extending to the proper socket-frame or test-ring, these, also, being normally discontinuous. It will now be evident from what has been stated that the normal or resting condition of each circuit is that the direct line L, coming in from the sub-station, passes through the separable contacts of a series of spring-jacks and through an annunciator at one section to earth; that the return-line L^2, coming in, is grounded direct through the relay-armature lever and back contact, and that its continuation extends from earth through the relay-coils and switchboard, being discontinuous and having branches, one to each of its own spring-jack frames. The insertion of a plug-connector P at any section (shown at Z) closes the current of the test-battery B through the relay-coils and the armature *r* is attracted. breaking the direct-earth connection of L^2 and uniting L^2 through the armature-lever *r*, its front contact-stop c^2, and the wire 38 electrically with its extension L^3, thus completing a metallic talking-circuit, to which, however, is attached an earth branch through the relay R. This, being of high resistance and high electro-magnetic retardation, may be neglected in practice.

In the drawings it is assumed that some circuit having its call-annunciator at section X has called for circuit W and that the operator is applying the test-plug P^2 to ascertain whether W is busy or at liberty. Circuit W is, as we know, in connectiom with circuit W^2 at section Z and its relay-armature is attracted forward, as shown. Being so connected, its jack-spring *s* is by the plug-stem raised from its contact *e*, and the annunciator A and terminal earth are disconnected. The sleeve-contact surface p^2 of the plug being in connection through its conductor 30, its retardation-coil C, the junction 5, and the bus-wire D with test-battery B, it is obvious that the circuit of said battery is closed through the relay R by way of socket-frame *g*, branch line *d*, junction 4, conductor L^3, relay R, and to earth, and that the relay holds its armature forward. This battery connection also raises the potential of the several jack-frames of the same circuit, they being all in connection with the line L^2 by their branches *d*, and when at any section the test-plug is applied, as shown at section X, a portion of the current of the test-battery is diverted from the test-frame *g* under test, through the operator's receiving-telephone by way of plug-tip *p*, cord conductor 29, junction-point 13, wire 27, key-springs *x* and *z*, (the cam-key being first turned up,) wire 25, induction-coil conductor *i*, wire 38, and through one-half of the receiver-helix to earth. The current suddenly passing the moment this circuit is closed by the application of the plug-tip to the socket-frame, a sharp click is heard in the telephone and denotes that the line is busy.

The several retardation-coils C in the different cord circuits of the test-battery prevent short-circuiting and also permit the use of a grounded test-battery without thereby introducing disturbance from the earth connection. The more important part of the busy-test concerns itself, however, with the testing of circuits where silence resulting from a test is required to have significance, since it is apparent that an additional sound in the telephone to the required signal-sound is immaterial, while the occurrence of a sound when no sound should be heard is at once a deceptive signal and does not truly indicate the condition of the circuit. To illstrate this, let it be supposed that the plug P is not inserted into the socket at Z, that circuit W is therefore at liberty, and that the armature-lever *r* of its relay is therefore at rest against its back contact *c*. This condition being assumed, no true busy-signal could be heard in the telephone for the reason that there being no plug-connector in any of the sockets of the circuit the test-battery B has no connection with any of the test-frames, and hence the application of the test-plug to any of the said frames does not and cannot determine the passage of a current through the testing-telephone T, and the legitimate busy-signal is therefore not heard. Were it not for the severance of the continuation-line L^3 from the main return L^2, or of the interposed earth connection, a click which would be mistaken for the true busy-signal would in case of a charge on the metallic circuit be heard; but these conditions being present, it is obvious that no false busy-signal due to the above cause can be received, since in the first place the application of the test-plug simply provides the testing-telephone with an earth connection through the relay by way of socket-frame *g*, branch wire *d*, junction 2, conductor L^3, and relay R, and not with a charged line, while in the second place the main return-line L^2, being connected with the earth direct by the armature-lever *r*, contact *c*, and wire 36, is constantly drained of its charge.

In Fig. 2 I show a modification in which the test-battery B is connected through the usual retardation-coil C with the tip-uniting conductor 29 of the pairs of plugs. In this case, while the main-line circuits and circuit connecting and supervising apparatus is arranged generally in the same way as in Fig. 1, the connections of the relay R are different. Two line-circuits are here shown, W being a metallic and W^2 an earth-completed circuit. The metallic circuit, entering from the sub-station by wire L, passes through the several spring-jack contacts from the spring *s* to the anvil-contacts *e*, and then through the annunciator A and by wire L^4 to the return-conductor L^2, which leads back to the sub-station, branching, however, by wires *d* to each spring-jack frame or test-ring. The earth-completed sub-station circuit W^2 is arranged much in the same way, except that the single-

line conductor L is grounded at the sub-station S and that the return-conductor through the switchboard L^2 is also connected to earth at a point external to the switchboard, a balancing-resistance V being included in its circuit. The electro-magnet of the relay R in this case is in a branch 42, leading to earth from a point 41 on the main or direct-circuit conductor L, and as when the circuit is idle no current traverses its coils its armature *r* is normally retracted by its counter-spring and the lever thereof, which is connected directly to earth, is held against its back-stop *c*, from which a wire 43 is led to any point 40 on the test or return wire L^2. By this arrangement all the test-frames of the line under consideration are in connection normally with earth direct and the main or spring contact side of the circuit is in connection with the earth through the relay-coils. I preferably provide an arrangement of apparatus in connection with this mode of busy test which gives a specialized signal. An electro-magnet F is included in a branch circuit *w*, which extends to an earth terminal from any point 44 on the telephone-conductor 25. When the listening-key cam *f* is turned to the position shown at section X and its spring-contacts *x* and *z* thereby brought together, the magnet F is energized by a current from test-battery B, which finds a closed circuit through it, attracting the armature f^2 to a forward position. The lever of said armature has a resilient reed extension f^5, suitably weighted, so that when it is retracted by its counter-spring it not only comes to a solid and permanent rest upon its back-stop f^4, but also makes on its backward movement a snap or brief contact with the auxiliary back-stop f^3, thereby closing for a moment a short circuit *u*, which includes the secondary helix i^2 of one induction-coil I^2 and the primary helix i^4 of a second induction-coil I^3, whose secondary i^5 forms a circuit *y*, including the operator's telephone T. The primary helix i^3 of the first induction-coil I^2 is in circuit with an automatic circuit-breaking vibrator *k*, which rapidly makes and breaks the circuit *l* of a battery b^4, and thus inductively through the two induction-coils I^2 and I^3 makes a buzzing sound in the telephone T when the snap-contact between the reed f^5 and its contact-stop f^3 occurs. The vibrator *k* may be common to the entire central station, and connections to other switchboard-sections are indicated by the wires u^2. The resistance of secondary helix i^5 of the induction-coil I^3 must be sufficiently high that the telephone T will not be short-circuited through it.

In testing if we suppose the line tested to be at liberty—as, for example, is W^2—the armature-lever of its relay R will rest against stop *c*, as shown. The operator, having turned up the cam *f* to bring the telephone T into circuit and to energize magnet F, bringing the armature f^2 forward, touches the socket-frame J^2 with the tip-contact of the testing-plug P. The line being at liberty, as stated, the testing-battery B is momentarily short-circuited by way of conductor D, point 7, retardation-coil C, point 8, tip-conductor 29, plug-tip *p*, test-frame *g* of jack J^2, wire *d*, point 2, wire L^2, point 40, wire 43, stop *c*, armature *r*, and wire 37. The result of the establishment of such a short circuit is that the current is drained from the magnet F and its armature-reed falls back, making a snap-contact on the stop f^3, causing an intermittent current to circulate for a moment through the short circuit *u* and producing a momentary buzz in the telephone T, which is inductively connected therewith. This buzz indicates the circuit wanted to be at liberty, and is an unmistakably-true test, for it is impossible that any discharge from the line can take place through the telephones in view of the earth connection 37 at the relay. If the line wanted be busy—as is line W, for instance, which has a plug inserted at section Z—no short circuit can be established upon touching the test-frame with the plug-tip, for the reason that the act of inserting the plug at section Z has already closed the circuit through the direct line L and relay-coils R of main circuit W, and has consequently by the attraction of the relay-armature, as shown, separated the points *c* and 46. Hence in this case the magnet F of the test apparatus continues to hold its armature forward and the vibrator cannot produce a signal in the telephone. Silence in the telephone, therefore, in this instance, denotes that the line is already busy.

I claim—

1. In a busy-test system and apparatus for multiple switchboards, the combination of the main circuit having plug-sockets at the several switchboard-sections, plug-and-cord connectors for uniting the sockets of any two lines, a test-battery, a normally-open circuit therefor capable of being closed by the insertion of said plug-connectors in the socket of any main circuit, a relay or electro-magnetic device connected with the main line and included in the circuit of a conductor common to said main circuit and said normally-open local circuit, a direct-earth branch normally connected with one side of the main circuit through the armature of said relay and adapted to be disconnected when the said relay is energized by the insertion of a plug-connector in any plug-socket of the main circuit, and a busy-test circuit in which the telephone is directly or inductively included as an indicating-instrument and which is localized and prevented from giving false test-signals by the normal connection of the said relay-controlled earth branch, substantially as described.

2. In a multiple switchboard, the combination, with each main-line circuit, of an earth branch normally connected therewith at a point external to the said switchboard, an electrical generator, a normally-open local

circuit therefor leading through the plug-sockets of said line and adapted to be closed by the insertion of a plug-connector in any of said sockets, and a relay included in such circuit and controlling the continuity of said earth branch, substantially as described.

3. The combination, with a multiple switch-board, main-line circuits connected therewith, each having a direct conductor extending through a series of spring-jack contacts, and a return or test conductor branching to the insulated conducting test frames or rings of the said spring-jacks, a branch extending from a point on said test-conductor external to the spring-jacks to earth direct, and a relay controlling the said earth branch by means of its armature and itself included in an earth branch from the direct main-line conductor, of a plug and connecting-cord therefor at any switchboard-section, whereby any two spring-jacks may be connected, a test-battery connected with the conductor leading from the tip of such plug, and a normally-open circuit therefor adapted to be closed through the relay for the purpose of opening the earth branch upon the insertion of a plug in its jack, a telephone associated with a pair of cord-connected plugs at a second switchboard-section, connected inductively with a vibratory circuit-breaker, an electro-magnet in a derived circuit of the test-battery controlling the continuity of said inductive connection, maintaining the same open when its armature is attracted and momentarily closing the same, and thereby producing a signal in the telephone when its armature is retracted, and connections whereby on the application of the test-plug to the test-frame of any spring-jack the said electro-magnet may be short-circuited through the direct-earth branch of the line tested, when the said line is at liberty and the signal thereby given in the telephone, substantially as described.

In testimony whereof I have signed my name to this specification, in the presence of two subscribing witnesses, this 31st day of March, 1892.

JAMES L. McQUARRIE.

Witnesses:

GEO. WILLIS PIERCE,

V. M. BERTHOLD.