J. F. TOOMEY.

TESTING AND ADJUSTING APPARATUS FOR CORD CIRCUITS.

APPLICATION FILED MAY 3, 1917.

1,361,928.

Patented Dec. 14, 1920.

3 SHEETS—SHEET 1.

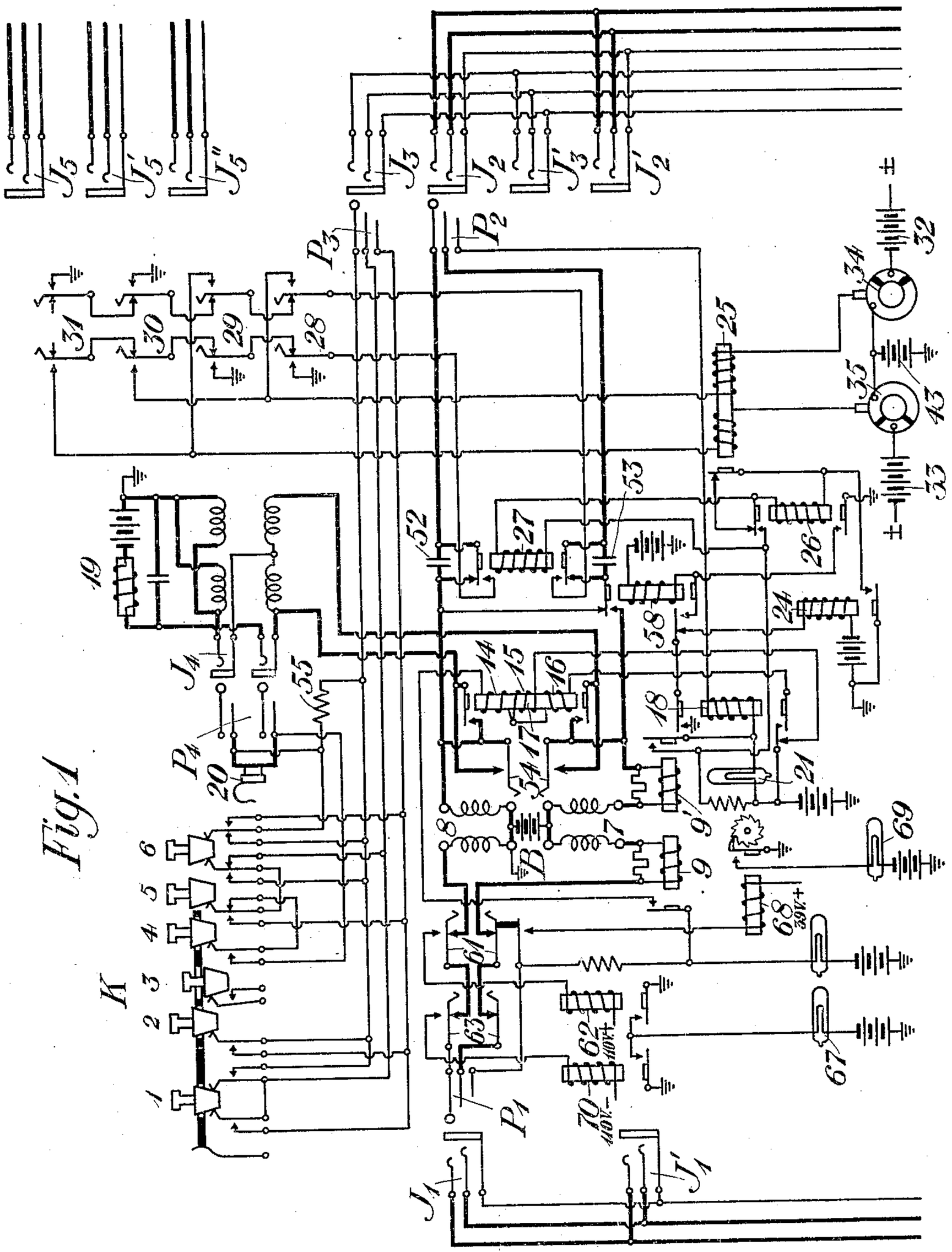

Fig. 1

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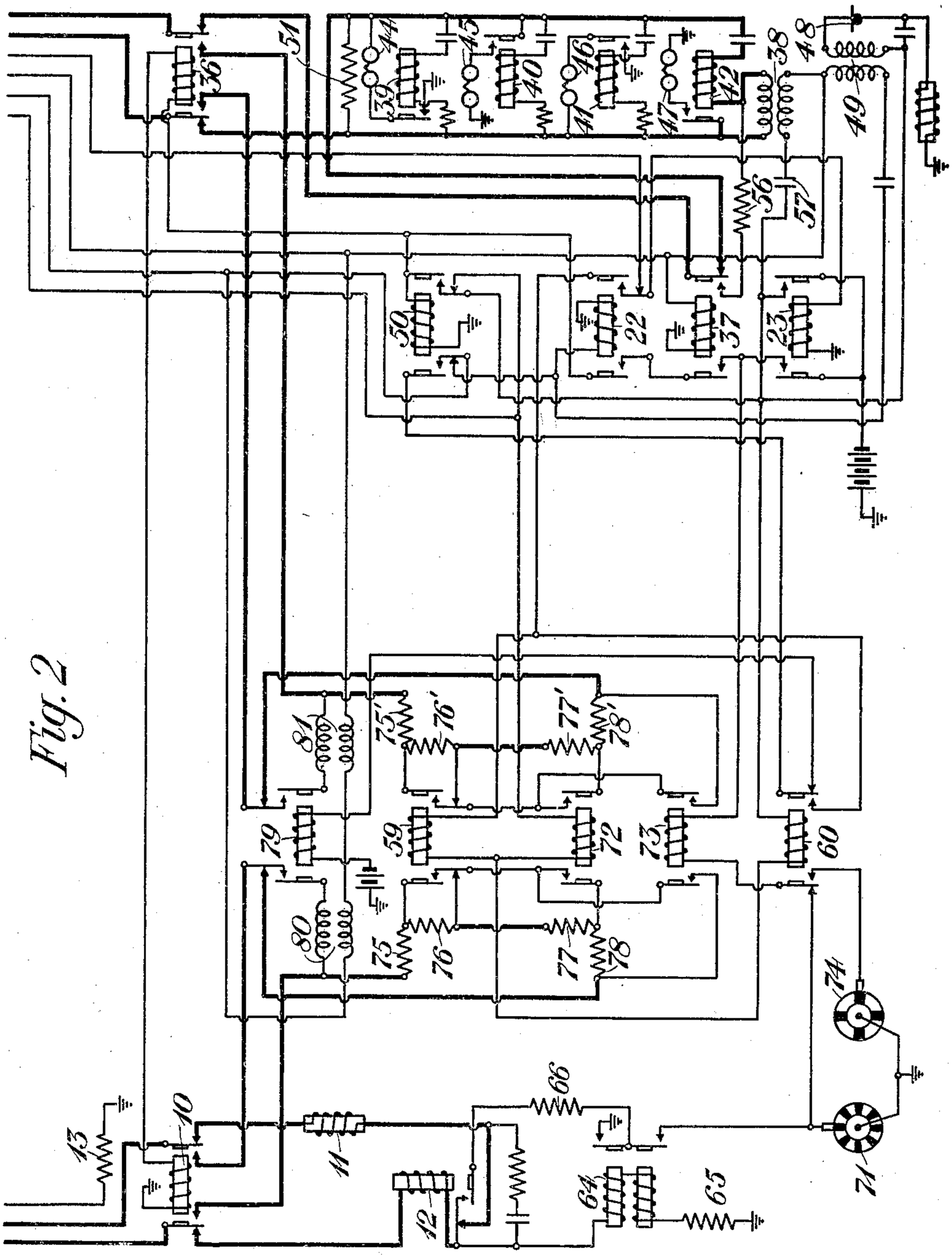

Fig. 2

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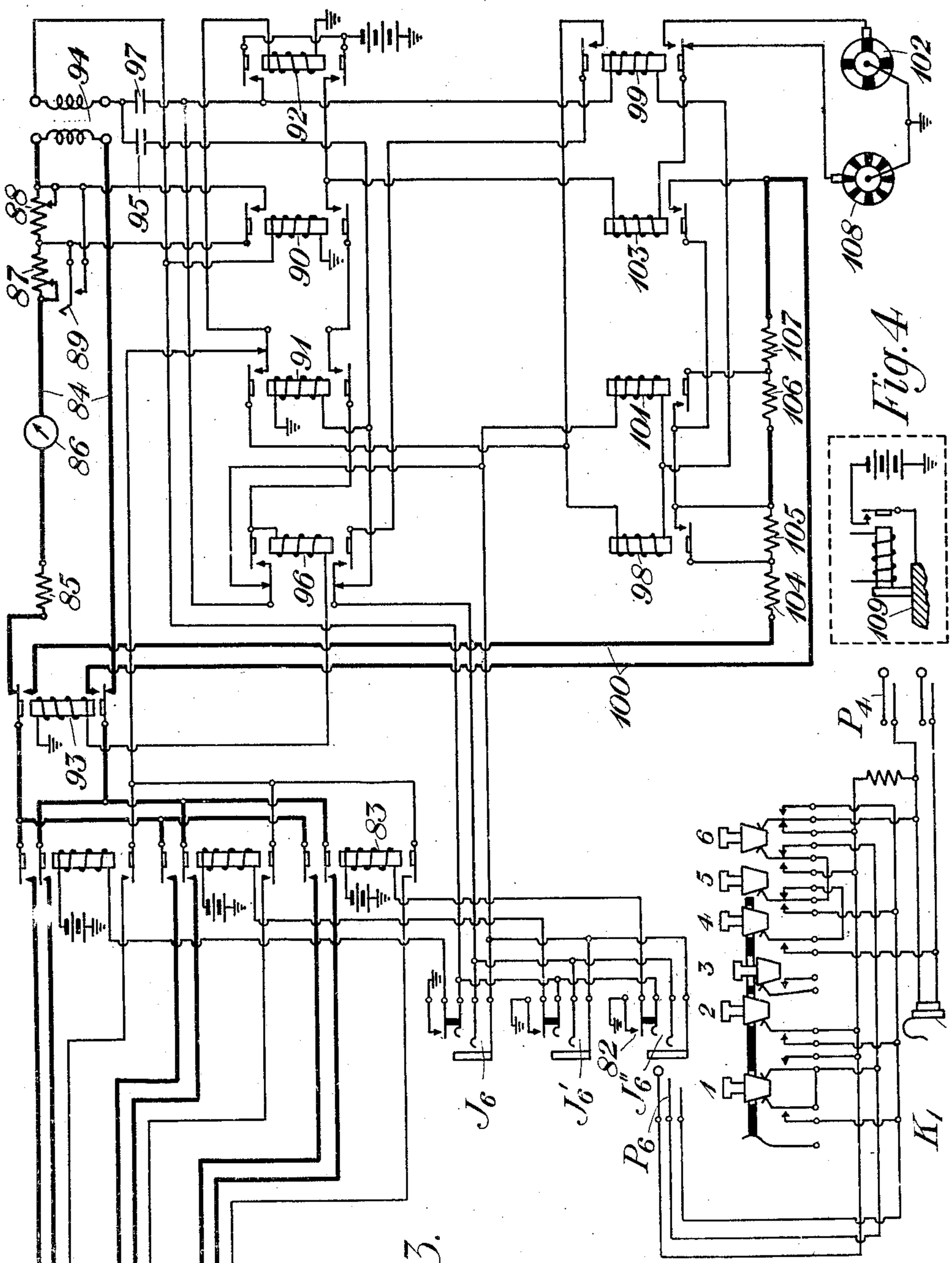

Fig. 4.

Fig. 3.

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TESTING AND ADJUSTING APPARATUS FOR CORD-CIRCUITS.

1,361,928. Specification of Letters Patent. Patented Dec. 14, 1920.

Application filed May 3, 1917. Serial No. 166,249.

To all whom it may concern:

Be it known that I, JOHN F. TOOMEY, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Testing and Adjusting Apparatus for Cord-Circuits, of which the following is a specification.

This invention relates to testing apparatus and more particularly to equipment for testing and adjusting the various apparatus associated with an operator's cord circuit.

It is one of the objects of this invention to provide a testing equipment which, when associated with a cord circuit, will determine whether the apparatus for automatically connecting and disconnecting the operator's set is functioning properly, whether the automatic ringing apparatus is properly set into operation, whether a tone is transmitted to the calling line while ringing over the called line, and if selective ringing is employed, whether the proper ringer is selected. Means are also provided to indicate the action of the apparatus which cuts off the ringing current when a subscriber responds, and to test the action of such apparatus under the severest service conditions.

A further object of the invention is the provision of means to test the action of the coin collect, coin return and message register equipment of the cord circuit.

Another object of the invention is the provision of means to indicate whether or not the supervisory relays of the answering and calling ends of the cord circuit operate satisfactorily under conditions more severe than are experienced over any of the lines entering the office. Means are also provided to determine whether the operator's cords are noisy.

A still further object of the invention is the provision of an adjusting equipment whereby the supervisory relays and the relay which controls the automatic disconnection of ringing current from the called line may be adjusted to meet proper operating conditions.

Other and further objects of the invention will appear from the following description taken in connection with the accompanying drawing, Figures 1, 2 and 3 of which, when arranged with Fig. 2 below and Fig. 3 to the right of Fig. 1, embody a circuit diagram of the testing and adjusting equipment of the invention, while Fig. 4 is a view of a structural detail.

In Fig. 1 is illustrated a diagram of a standard operator's cord circuit terminating in the usual answering and calling plugs P_1 and P_2 which are adapted for insertion into calling and answering jacks (not shown) of the switchboard. In addition to the usual calling and answering jacks, special answering jacks J_1, J_1', etc., and special calling jacks J_2, J_2', etc., are multiplied at each switchboard section, whereby the operator's cord circuit may be associated with the testing circuits of Fig. 2. Another set of jacks J_3, J_3', etc., for controlling purposes are multiplied at each switchboard section, and into these jacks a plug P_3 of a key set K may be inserted for making the various tests in connection with a cord circuit. The key set K is also provided with a twin plug P_4 for insertion in a jack J_4 of the operator's set.

A still further set of jacks J_5, J_5' and J_5'' leading to an adjusting circuit may be provided at each operator's section, and as each cord is tested, if it is found that any of the relays thereof are not functioning properly, said cord may be plugged into an idle one of these adjusting circuit jacks, and thereby associated with the adjusting circuit arrangement of Fig. 3. As here shown there are three jacks at each section leading to the adjusting circuits, but as many jacks may be provided as are found necessary. Each of these jacks has a corresponding control jack J_6, J_6', J_6'' whereby upon inserting a plug P_6 of a key set K_1 into a particular one of said jacks the corresponding adjusting circuit jack is automatically connected to the adjusting circuit, it being understood that the adjusting circuit is common to all of the adjusting circuit jacks. The controlling jacks J_6, J_6', etc., are located in a position convenient to the supervisory relays of the cord circuit, which in practice are grouped at some point distant from the operator's boards. Consequently if a relay is defective and the corresponding cord is plugged into one of the adjusting circuit jacks at the switchboard, by plugging the key set into the proper controlling jack adjacent to the de-

fective relay, said relay may be adjusted until it functions properly.

The key sets K and K_1 are portable sets, indentical in construction, and in practice a single set may suffice. Each set (if there are more than one) comprises six keys 1, 2, 3, 4, 5 and 6, keys 5 and 6 being non-locking and keys 1, 2, 3 and 4 being of the well known locking type whereby any key when depressed is locked and automatically restores a key previously locked. Key 3 controls no circuits, its function being merely to restore any key which is locked up. The other keys control contacts whereby the various testing and adjusting circuit changes are made.

Testing automatic listening apparatus.

With this general description in mind the invention may be fully understood from the description of the operation. Assuming that it is desired to test the cord circuit shown in Fig. 1 the answering plug P_1 is inserted in jack J_1 whereby a circuit is closed from the grounded battery B of the cord circuit, through a winding of the induction coil 7, winding of relay 9, ring contacts of plug P_1 and the jack J_1, right hand contact of relay 10, impedance coil 11, back contact of relay 12, winding of said relay, left hand contact of relay 10, tip contacts of jack J_1 and plug P_1, left hand winding of induction coil 8 to ground. Relay 12 and supervisory relay 9 are energized, the latter closing a circuit from ground (Fig. 2), resistance 13, sleeve contacts of the jack and plug, contact of relay 9, windings 14 and 15 of relay 17, lower normal contact of relay 18 to battery. Relay 17 is energized and connects the operator's set 19 to the cord circuit. The key set K includes a receiver 20 and by inserting plug P_4 of the key set into jack J_4 of the operator's set the tester may now listen in on the cord circuit. Relay 12 acts as a buzzer to interrupt its own circuit thereby impressing a tone upon the talking circuit which the tester hears in the receiver 20, thus indicating that relay 17 has functioned to connect the operator's set to the cord.

Plug P_2 is now inserted in the answering jack J_2 of the testing circuit thereby closing a circuit over the sleeve contacts from battery through lamp 21, relay 18, sleeve contacts of plug P_2 and jack J_2, normal right hand contact of relay 22, winding of relay 23 to ground. Relays 18 and 23 are now energized. The former opens its lower normal contact and closes its front contact, thereby opening the circuit through windings 14 and 15 of listening relay 17, and closing a circuit from ground through resistance 13 and over the circuit previously traced to winding 14 of relay 17, and thence through windings 14 and 16 of said relay in series, and over lower front contact of relay 18 to battery. Windings 14 and 16 are differential so that relay 17 deënergizes and disconnects the operator's set, a fact which is indicated to the tester by the cessation of the tone from buzzer relay 12.

Testing automatic ringing apparatus.

Relay 18 at its upper front contact closes a circuit for relay 24, which in turn closes a circuit from ground, contact of relay 24, back contact of ringing cut off or tripping relay 25, upper back contact of relay 26, winding of ringing relay 27 to battery. Relay 27 connects the leads from the ringing keys to the outgoing circuit. The tester may now determine whether ringing current is applied properly by depressing one of the ringing keys 28, 29, 30 or 31 together with key 4 of the key set K, the plug P_3 of the key set being inserted in controlling jack J_3. Assuming that ringing key 30 is depressed, ringing current flows from the ringing generator, through negative battery 32, interrupter 34, right hand winding of relay 25, left hand make contact of key 30, normal left hand contacts of keys 29 and 28, front contact of relay 27, tip contacts of plug P_2 and jack J_2, right hand back contact of relay 36, right hand back contact of relay 37, through ringing relays 39, 40 and 41 in parallel with relay 42 and the primary of induction coil 38, left hand back contact of relay 36, ring contacts of jack J_2 and plug P_2, lower front contact of relay 27, normal contacts of keys 28 and 29 and make contact of key 30 to ground. During the interruptions of the ringing current by commutator 34 direct current from battery 43 is applied through the winding of relay 25 over the same circuit. During ringing intervals the relays 39 to 42 inclusive, operate in response to ringing current to connect ringers 44 and 45 to one side of the line and ringers 46 and 47 to the other side, whereby the ringing current flows over the circuit previously traced to the terminals of ringers 44 and 45 and then through said ringers to ground, and as the ringers are polarized only ringer 45 should respond. The ringers are mounted within a sound proof compartment within which is arranged a telephone transmitter 48 whose circuit extends from battery, right hand contact of relay 23, primary of induction coil 49, transmitter 48 to ground through a choke coil. The sound from the ringer which is being operated is impressed upon the transmitter 48 and transmitted through the induction coil 49 to the receiver 20 of the key set over a circuit as follows:

From the lower terminal of the secondary of induction coil 49, normal left hand contact of relay 50, ring contacts of jack J_3 and plug P_3, left hand normal contact of key 6, normal contact of key 5, make contact of key 4, receiver 20, right hand normal contact of key 6, tip contacts of plug P_3

and jack J_3 to the upper terminal of the secondary of induction coil 49. The operator may now determine from the sound in his receiver whether ringing current has been applied and whether the right bell is being rung, and by the continuance of the ringing whether the ringing cut-off apparatus under control of tripping relay 25 acts prematurely. Relay 25 should be so adjusted that it is not energized by ringing current through the high resistance of the substation ringing apparatus, but pulls up upon the closing of a low resistance shunt through the substation talking set upon response by the called subscriber. Should it operate prematurely the ringing current will either not be applied or will prematurely cease. A resistance 51 of 10,000 ohms is bridged across the ringing circuit so as to give a sufficient line leak to simulate the severest conditions under which ringing would occur in practice.

To determine whether a ringing induction tone is being transmitted through condensers 52 and 53 to the calling party; key 4 should be released by operating key 3 and the emergency listening key 54 of the cord circuit should be operated, thereby bridging the receiver 20 across the calling side of the cord circuit with respect to the condensers 52 and 53, so that the induced tone, if any, may be heard.

If the tripping relay of the cord does not operate prematurely the next test is to determine whether it will operate satisfactorily when the called party removes the receiver from the hook. Key 6 is therefore depressed closing a circuit from battery over right hand contact of relay 23, right hand normal contact of relay 50, sleeve contacts of jack J_3 and plug P_3, right hand make contact of key 6, resistance 55, tip contacts of plug P_3 and jack J_3, winding of relay 37 to ground. Relay 37 is energized and at its right hand contact disconnects the ringing apparatus and substitutes a low resistance path over the ringing circuit previously traced to the right hand back contact of relay 36, thence over right hand front contact of relay 37, resistance 56, primary winding of induction coil 38, to left hand contact of relay 36, and thence to ground over the contact of the depressed ringing key. The resistance of the winding of induction coil 38 is equal to that of the low resistance path through a substation talking set, while the resistance 56 is equal to the resistance of the longest line over which the tripping relay will have to operate. If the tripping relay 25 operates over this circuit its adjustment is therefore satisfactory. To determine whether the tripping relay operates and to detect any sluggishness in its action, key 4 should be depressed at the time key 6 is operated whereby the ringing current applied to the line, if it is not immediately cut off by the action of the tripping relay, will be transmitted through induction coil 38 to the receiver 20 over the following circuit:

From left hand terminal of the secondary of induction coil 38, through the condenser 57, right hand normal contact of relay 50, sleeve contacts of jack J_3 and plug P_3, right hand make contact of key 6, receiver 20, make contact of key 4, normal contact of key 5, left hand make contact of key 6, tip contacts of plug P_3 and jack J_3 to the right hand terminal of induction coil 38.

In case the tripping relay 25 of the cord is properly adjusted, it will pull up over the low resistance circuit above traced through resistance 56 and at its contact open the short circuit normally existing around the winding of relay 26, whereby relay 26 pulls up over a circuit from ground, contact of relay 24, winding of relay 26, winding of relay 27, to battery. Relay 26 is at once energized and at its upper front contact closes a short circuit about the winding of relay 27, whereby relay 27 is deënergized and disconnects the ringing current from the line. At the same time relay 26 is locked up over a circuit from ground, contact of relay 24, winding of relay 26 and upper front contact of said relay to battery. At its lower contact relay 26 closes a circuit for relay 58 which at its upper contact opens the normal short circuit across the line conductors of the cord circuit and closes the break normally existing in said circuit. At its lower contact relay 58 breaks the circuit of relay 24 and locks itself over the upper contact of relay 18. Relay 24 upon being deënergized opens the circuit of relay 26 which restores to normal. The circuits are now in talking condition.

If it is desired to test the tripping relay 25 and ringing apparatus several times the ringing apparatus may be restored to normal by depressing key 5. A circuit is thereby closed from battery, right hand contact of relay 23, normal right hand contact of relay 50, sleeve contact of jack J_3 and plug P_3, make contact of key 5, left hand normal contact of key 6, ring contacts of plug P_3 and jack J_3, left hand normal contacts of relay 50, winding of relay 22 to ground. Relay 22 is energized and at its right hand front contact opens the sleeve conductor of the calling jack, thereby deënergizing relay 18 of the cord circuit, which relay in turn opens the locking circuit of relay 58 so that the ringing apparatus is restored to normal. While key 5 is depressed relay 23, which is normally held energized over the sleeve contacts of the cord circuit, is locked over a circuit from ground, winding of relay 23, right hand front contact of relay 22, winding of relays 59 and 60, and over right hand contact of relay 23 to battery. The ringing apparatus of the cord circuit being now re-

stored, the tester may release key 5 and repeat the ringing tests.

Testing coin control and register apparatus.

To test coin collect apparatus of the cord circuit the coin collect key 61 should be operated, thereby applying positive potential of 110 volts to the tip strand of the cord over a circuit from 110 volt source, winding of relay 62, upper make contact of key 61, upper normal contact of key 63, tip contacts of plug P_1 and jack J_1 left hand normal contact of relay 10, winding of relay 12, winding of polar relay 64, resistance 65 to ground. If the high potential source was properly applied, relay 12 will pull up and relay 64 will close its upper contact, whereby a shunt about the winding of relay 64 will be closed over back contact of relay 12, resistance 66 and contact of relay 64 to ground. This shunt is of such resistance that the flow through the winding of relay 62 is increased sufficiently to energize this relay, which is marginal, and said relay closes a circuit through lamp 67 to indicate that proper current has been connected to the line to operate a coin collect apparatus.

If the cord is provided with message register apparatus, the operation of key 61 closes a circuit from a 39 volt source through the winding of message register magnet 68, lower make contact of key 61, sleeve contacts of plug P_1 and jack J_1 and through resistance 13 to ground. Resistance 13 is of such value that if the current source is of proper value to operate a coin register, the register magnet 68 will be energized and close a circuit through lamp 69 to indicate that it has functioned properly.

If the coin return key 63 is operated a 110 volt negative source is applied to a circuit through winding of relay 70, upper make contact of key 63, tip contacts of plug P_1 and jack J_1, left hand normal contact of relay 10, windings of relays 12 and 64 and through resistance 65 to ground. If the source is of proper potential relay 12 is energized and polar relay 64 is energized to close its lower contact, whereby a shunt about relay 64 is intermittently closed through interrupter 71, so that marginal relay 70 is intermittently energized, thereby causing lamp 67 to flash, which indicates that the coin return apparatus has functioned properly.

Testing supervisory relays.

After the ringing tests have been completed, the circuits may be prepared for supervisory relay tests by depressing key 1, whereby a circuit is closed from battery over right hand contact of relay 23, normal right hand contact of relay 50, sleeve contacts of jack J_3 and plug P_3, to left hand make contact of key 1, where the circuit divides, one branch continuing over the ring contacts of plug P_3 and jack J_3, left hand normal contact of relay 50 winding of relay 22 to ground and the other branch extending over right hand make contact of key 1, tip contacts of plug P_3 and jack J_3 and through winding of relay 37 to ground. Relays 22 and 37 are energized, thereby closing a circuit from battery, left hand contact of relay 23, left hand contacts of relays 37 and 22 in series, winding of relay 50 to ground, and in parallel with winding of relay 50, through windings of relays 36 and 10 to ground. Relays 50, 36 and 10 are energized and locked up over a circuit from battery, right hand contact of relay 23, right hand front contact of relay 50, and through winding of relay 50 in parallel with windings of relays 36 and 10 to ground. Relays 50, 36 and 10 will now remain energized until the plug P_3 is withdrawn from jack J_3 thereby deënergizing relay 23. The relays 36 and 10 operate to disconnect the answering and calling jacks of the testing circuit from the listening testing circuit and the ringing testing circuits respectively and to connect said jacks to the supervisory relay testing circuit.

The energization of relay 22 at its right hand contact disconnected relay 23 from the sleeve conductor of the cord and connected it to a locking circuit already traced through relays 59 and 60. Relay 50 upon energizing, however, at its left hand contact opens the circuit of relay 22, which deënergizes and restores the original circuit of relay 23. Relay 50 at its right hand contact opens a short circuit normally existing around the windings of relays 60 and 72, so that said relays are energized over a circuit from battery, right hand contact of relay 23, windings of relays 60 and 72 in series, sleeve contacts of jack J_3 and plug P_3, make contacts of key 1, tip contacts of plug P_3 and jack J_3, winding of relay 37 to ground. Relay 60 at its right hand contact closes a circuit whereby a part of the current flowing from battery over the right hand contact of relay 23, winding of relay 60 to the winding of relay 72 is diverted from the comparatively high resistance winding of relay 72 through low resistance winding of relay 59, front right hand contact of relay 60, front left hand contact of relay 50, ring contacts of jack J_3 and plug P_3, right hand make contact of key 1, tip contacts of plug P_3 and jack J_3 winding of relay 37 to ground. Relay 72 is deënergized and relay 59 energized by the current thus diverted. Relay 60 at its left hand contact intermittently energizes relay 73 over a circuit from ground through slow interrupter 74, front left hand contact of relay 60, winding of

relay 73, left hand contact of relay 23 to battery. The result of the actuation of relay 73 will hereinafter appear.

The supervisory relays 9 and 9′ of the cord circuit are normally in series with resistances 75, 76, 77, 78 and 75′, 76′, 77′, 78′ respectively, the circuit of relay 9 extending from battery B, through winding of relay 9, lower talking strand of the cord circuit, ring contacts of plug P_1 and jack J_1, right hand front contact of relay 10, normal left hand contact of relay 79, resistances 78, 77, 76 and 75, left hand front contact of relay 10, tip contacts of jack J_1 and plug P_1, upper strand of the cord circuit to grounded side of battery B. Similarly the circuit of relay 9′ extends from battery B through winding of said relay, upper front contact of relay 58, back contact of relay 27, ring contacts of plug P_2 and jack J_2, left hand front contact of relay 36, right hand back contact of relay 79, resistances 78′, 77′, 76′ and 75′ in series, right hand front contact of relay 36, tip contacts of jack J_3 and plug P_3, upper back contact of relay 27, to grounded side of battery B. Each time the relay 73 is energized however, resistances 76, 77 and 78 and 76′, 77′ and 78′ respectively are shortcircuited over the front contacts of relays 59 and 73 so that only resistances 75 and 75′ are in series with supervisory relays 9 and 9′ respectively. Resistances 75 and 75′ are of such value that the supervisory relays receive a saturating current. Each time relay 73 deënergizes the short circuits are opened and the four resistances are included in the supervisory relay circuit, said resistances being of such value as to reduce the current sufficiently to deënergize the supervisory relays if the latter are properly adjusted. The fact that the relays have satisfactorily met this test is indicated by the flashing of the supervisory lamps.

A still further test of the supervisory relays may be made by depressing key 2, thereby releasing key 1 and opening at the right hand contact of key 1 the circuit previously traced for relay 59, which relay accordingly is deënergized. Key 2 by the closing of its contact establishes a circuit from battery over right hand contact of relay 23, windings of relays 60 and 72 in series, sleeve contacts of jack J_3 and plug P_3, make contact of key 2, tip contacts of plug P_3 and jack J_3, winding of relay 37 to ground. Relays 60 and 72 are energized, the latter shortcircuiting resistances 77 and 77′ and the former at its left hand contact closing the intermittent circuit previously traced for relay 73 through interrupter 74. Each time relay 73 is energized resistances 78 and 78′ as well as resistances 77 and 77′ are shortcircuited over the contacts of said relay and the contacts of relay 72. During the energization of relay 73 supervisory relay 9 has in series therewith resistances 75 and 76 only, while relay 9′ has in series therewith resistances 75′ and 76′. These resistances are of such values that a current of normal operating strength flows through the relays. During the periods of deënergization of relay 73, resistances 75, 76, 78 and 75′, 76′, 78′ are in series with relays 9 and 9′ respectively, these resistances reducing the current to the normal value for holding the relays energized. If the relays are properly adjusted to meet the operating and holding requirements, the supervisory lamps should glow steadily as the relays should not fall off when relay 73 is deënergized.

A still further test of the supervisory relays may be made by operating key 3 which restores key 2, thereby opening the energizing circuit previously traced for relays 60 and 72. Relay 72 upon restoring opens the short circuits previously traced around resistances 77 and 77′. Upon the deënergization of relay 60 a circuit is closed from ground over high speed interrupter 71, left hand back contact of relay 60, winding of relay 73, left hand contact of relay 23 to battery. Relay 73 is rapidly energized and deënergized. Normally all four resistances are in series with the supervisory relays, but during the energized periods of relay 73, resistances 77, 78 and 77′, 78′ respectively are shortcircuited over normal contacts of relay 59 and front contacts of relay 73. With resistances 75, 76 and 75′, 76′ in circuit with relays 9 and 9′ respectively, said relays receive their normal operating current, while with all four resistances in circuit the current is reduced to such value that the relays should deënergize. If the relays properly respond to this test, the supervisory lamps should flash rapidly in response to interrupter 71. If the supervisory relays meet all three tests satisfactorily they may be considered properly adjusted.

Testing for noisy cords.

To determine whether the cords are noisy key 4 should be depressed whereupon a circuit will be established from battery through the winding of relay 79, right hand back contact of relay 60, left hand front contact of relay 50, ring contacts of jack J_3 and plug P_3, left hand normal contact of key 6, normal contact of key 5, make contact of key 4, receiver 20, right hand normal contact of key 6, tip contacts of plug P_3 and jack J_3 and winding of relay 37 to ground. Relay 79 is now energized to disconnect the testing resistance from the cord circuit and to bridge the primaries of induction coils 80 and 81 across the talking circuits leading to the cord. The secondaries of said induction coils are bridged across the circuit just

traced through receiver 20. If now the insulation of the cords is defective, by shaking them a scratching noise will be heard in the receiver 20 as currents will be induced in the secondary of coil 80 or 81 or both, said currents flowing through receiver 20 over a path from secondary winding of induction coil 80, ring contacts of jack J_3 and plug P_3, normal contacts of keys 6 and 5, make contact of key 4, receiver 20, normal contact of key 6, tip contacts of plug P_3 and jack J_3, and then through primary windings of induction coil 81 to the primary of induction coil 80.

Adjustment of ringing cut off or tripping relay.

In the manner above described the various cord circuits may be tested and any cords the tripping or supervisory relays of which are found defective may be plugged into an idle adjusting jack J_5, J_5', etc. If both supervisory relays of a cord need adjustment, or if the answering supervisory relay and the tripping relay of a cord are defective, both ends of the cord should be inserted in adjacent adjusting jacks. After the cords have been tested the tester may proceed with the adjustment of the relays of the defective cords by inserting the plug P_6 of key set K_1 into a controlling jack, say J_6'' adjacent to the relay to be adjusted and corresponding to a jack J_5'' into which the plug of a defective cord is inserted. Contact 82 is thereby closed and an energizing circuit for relay 83 is completed. Relay 83 upon operating switches the three conductors leading from jack J_5'' into connection with the tripping relay testing circuit 84. This circuit includes a fixed line resistance 85 equal to the resistance of the longest line over which ringing will occur, a current measuring instrument 86, and variable resistances 87 and 88, the latter of which may be shortcircuited by the contacts of a key 89 or a relay 90.

When relay 83 was energized a circuit was completed, (assuming plug P_2 to be inserted in jack J_5''), from battery through the winding of relay 18, sleeve contacts of plug P_2 and jack J_5'', lower contact of relay 83, upper normal contact of relay 91, winding of relay 92 to ground, thereby energizing relays 18 and 92. When the plug P_2 of the cord circuit was inserted in jack J_5'', assuming that the tripping relay needed adjustment, some one of the ringing keys 28 to 31 inclusive was depressed and upon the energization of relay 18 the ringing relay 27 is set into operation in a manner already described and ringing current is periodically applied through tripping relay 25 to the tip and ring contacts of jack J_5'', said current flowing from the tip contact over upper contact of relay 83, upper back contact of relay 93, resistance 85, instrument 86, resistances 87 and 88, primary of induction coil 94, lower back contact of relay 93, middle contact of relay 83 to the ring of the jack. During the silent interval between ringing, direct current is applied over said circuit from battery 43. Resistances 87 and 88 may now be adjusted during the silent interval so that the current as indicated by the instrument 86 with resistances 85, 86, 87, 88 and primary of induction coil 94 in circuit will be insufficient to operate a normal tripping relay, while with key 89 closed and only resistances 85, 86, 87 and primary of induction coil 94 in circuit, the current will be increased by the amount necessary to operate a normal tripping relay in actual practice. When the resistances are thus adjusted they need not be changed for each cord tested but should be checked from time to time to see that the current values are correct.

With the resistances thus set the operator may determine whether ringing current is being applied by depressing key 4 of the key set, whereupon the ringing current will be transmitted through induction coil 94 to the receiver 20 over a circuit from the secondary of said induction coil, condenser 95, lower normal contact of relay 96, ring contacts of jack J_6'' and plug P_6, normal left hand contacts of key 6 and key 5, make contact of key 4, receiver 20, normal right hand contact of key 6, tip contacts of plug P_6 and jack J_6'', and back to the secondary of induction coil 94. If the tester hears ringing current over this circuit the tripping relay has not responded to its non-operating current and its adjustment in this respect is proper. If no ringing is heard the relay should be adjusted and then retested as hereinafter described.

Assuming that the tripping relay does not pull up on the non-operating current key 6 is depressed, key 4 still remaining locked in operated position. A circuit is now closed from battery, upper contact of relay 92, upper normal contact of relay 96, sleeve contacts of jack J_6'' and plug P_6, right hand make contact of key 6, receiver 20, make contact of key 4, normal contact of key 5, left hand make contact of key 6, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. Relay 90 is energized over this circuit and at its upper contact short circuits resistance 88 so that the current flowing in circuit 84 is increased to a value such that the tripping relay 25 should operate if properly adjusted. At the same time that the circuit just traced from relay 90 was established a circuit through receiver 20 is closed in order that the tester may determine whether the ringing current is cut off. This circuit extends from the lower terminal of the secondary of induction coil

94, through condenser 97, upper normal contact of relay 96, sleeve contact of jack J_6'' and plug P_6, right hand make contact of key 6, receiver 20, make contact of key 4, normal contact of key 5, left hand make contact of key 6, tip contacts of plug P_6 and jack J_6'', to the upper terminal of the secondary of induction coil 94. If the tripping relay does not energize upon the application of full operating current, such fact would be indicated by the continuance of ringing current in the receiver 20, and the tester may adjust the relay. The relay may now be retested by depressing key 5 to restore the cord circuit to normal and again testing as above described. The operation of key 5 closes a circuit from battery, upper contact of relay 92, upper normal contact of relay 96, sleeve contacts of jack J_6'' and plug P_6, make contact of key 5, left hand normal contact of key 6, ring contacts of plug P_6 and jack J_6'', lower normal contact of relay 96, winding of relay 91 to ground. Relay 91 is energized and at its upper contact opens the circuit over the sleeve contact of plug P_2 and jack J_5'' thereby deënergizing relay 18 to restore the cord circuit to normal in a manner already described. While this circuit is opened relay 92 is locked up over a circuit from ground, winding of said relay, upper front contact of relay 91, windings of relays 98 and 99 in series, upper contact of relay 92 to battery. The ringing test may now be repeated and the tripping relay adjusted until its operation on both operating and non-operating current is satisfactory.

If the tripping relay did not need adjustment the tests and adjustments just described would be omitted and the tester would proceed at once to the adjustment of the supervisory relays. When it is desired to adjust the supervisory relays, either after having adjusted the tripping relay, or without adjusting said relay where such adjustment is unnecessary, key 1 will be depresed. A circuit is now closed from battery, upper contact of relay 92, upper normal contact of relay 96, sleeve contacts of jack J_6'' and P_6 to the left hand make contact of key 1 where the circuit divides, one branch proceeding over ring contacts of plug P_6 and jack J_6'', lower normal contact of relay 96, winding of relay 91 to ground, the other branch continuing over right hand make contact of key 1, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. Relays 90 and 91 are energized and a circuit is now closed from battery over lower contacts of relays 92, 90 and 91 and thence through windings of relays 96 and 93 to ground. Relays 93 and 96 are now locked up over a circuit from battery, upper contact of relay 92, upper front contact of relay 96, windings of relay 96 and 93 to ground. Relay 93 operates to disconnect adjusting jack J_6'' from circuit 84 and connect it to supervisory relay adjusting circuit 100, and as relay 93 is locked up the jack will remain connected to this circuit until plug P_6 is withdrawn, thereby breaking the circuit of relay 83 which in turn breaks the circuit of relay 92, upon the deënergization of which the locking circuit above traced is broken.

The operation of relay 96 at its upper contact also breaks a short circuit normally existing around the windings of relays 99 and 101 so that these relays are energized over a circuit from battery, upper contact of relay 92, windings of relays 99 and 101 in series, sleeve contacts of jack J_6'' and plug P_6, make contacts of key 1, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. Relay 99 upon energizing, at its upper contact closes a circuit which diverts part of the current flowing through the high resistance of relay 101 to the low resistance winding of relay 98 as follows: from battery, upper contact of relay 92, winding of relay 99, winding of relay 98, upper contact of relay 99, lower front contact of relay 96, ring contacts of jack J_6'' and plug P_6, right hand make contact of key 1, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. Sufficient current is diverted through the low resistance winding of relay 98 to energize said relay and deënergize relay 101. Relay 99 at its lower front contact closes an intermittent circuit from ground through low speed interrupter 102, lower front contact of relay 99, winding of relay 103, lower contact of relay 92 to battery. Relay 103 is intermittently energized with a result to be presently described.

Normally four resistances 104, 105, 106 and 107 are in series with the supervisory relay of the cord circuit but each time the relay 103 is energized resistances 105, 106, 107 are shortcircuited over the contact of relays 98 and 103. The resistances are so proportioned that the supervisory relay alternately receives a saturating current through the resistance 104, and a weak current through all four resistances in series. The relay should therefor deënergize upon the latter current and should follow the operation of relay 103. If it does not do so it may be adjusted until it properly meets the requirements of this test.

Key 2 may now be depressed thereby restoring key 1 which opens the circuit of relays 98 and 99. Key 2 closes a circuit from battery, upper contact of relay 92, windings of relays 99 and 101 in series, sleeve contacts of jack J_6'' and plug P_6, make contact of key 2, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. Relays 99 and 101 are energized the former at its lower contact closing an intermittent circuit from ground, interrupter 102, lower

front contact of relay 99, winding of relay 103, lower contact of relay 92 to battery. Relay 101 shortcircuits resistance 106 so that normally the supervisory relay is in series with resistances 104, 105 and 107 and receives a current which should hold it operated when it has been once energized. Each time relay 103 is energized resistance 107 is also shortcircuited over the contacts of relays 101 and 103, so that the supervisory relay is in circuit with resistances 104 and 105 only and receives a current of normal operating strength. If the supervisory relay meets this test properly it will be energized by the latter current and will remain energized when the current is reduced to its holding value, so that the supervisory lamp will glow continuously. The supervisory relay if defective may be adjusted to meet the requirements of this test. When the supervisory relay is so adjusted key 3 may be depressed, thereby restoring key 2 so that relays 99 and 101 deënergize. A circuit is then closed from ground through high speed interrupter 108, lower back contact of relay 99, winding of relay 103, lower contact of relay 92 to battery. All four resistances are normally in circuit with the supervisory relay, and each time relay 103 is energized it shortcircuits resistances 106 and 107 so that the supervisory relay receives normal operating current. If the relay meets this test it will cause the supervisory lamp to flash rapidly. If it does not meet the test it may be adjusted until its operation is satisfactory.

When a supervisory relay has been adjusted it may be desirable to know whether it still operates satisfactorily after the cover has been put on. This may be done by placing the lower sleeve contact of plug P_4 of the key set in contact with the cover of the relay. The arrangement of a supervisory relay is indicated schematically in Fig. 4. When the relay is energized its armature connects battery to the frame 109, a part of which is shown in section. When the cover is in place it is in contact with the frame, and by placing the plug P_4 in contact with the cover as above described, each time the supervisory relay is energized in response to the action of interrupter 108 and relay 103, a current flows from battery, front contact of the supervisory relay, frame and cover of the relay, lower sleeve contact of plug P_4, receiver 20, right hand normal contact of key 6, tip contacts of plug P_6 and jack J_6'', winding of relay 90 to ground. The proper actuation of the relay will thus be indicated by a succession of clicks in the receiver 20.

It will now be clear that by this invention a simple, convenient and economical arrangement of circuits has been devised whereby any cord may be plugged into a convenient testing jack, and, by the manipulation of a simple portable key set adapted for connection with a corresponding control jack at the switchboard, the various apparatus associated with the cord may be tested; moreover, if any apparatus is found deficient upon such test, the cord may be plugged into a jack leading to an adjusting circuit, whereby when the same key set or a similar key set has been plugged into a control jack adjacent to the apparatus to be adjusted, said adjusting circuit may be so controlled by the keys of the set as to determine when the deficient apparatus is properly adjusted.

While the invention has been disclosed as embodied in certain specific organizations and arrangements it is to be understood that this embodiment may be widely varied without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. A testing system comprising an operator's cord circuit, an operator's set, a transmission circuit with which the cord circuit may be associated, means responsive to the association of the cord circuit with said transmission circuit to automatically connect the operator's set to the cord circuit, and means associated with said transmission circuit and operative in response to the association of the cord circuit therewith to transmit a signal from the transmission circuit to the cord circuit to indicate the operative connection of the operator's set with the cord circuit.

2. A testing system comprising an operator's cord circuit, an operator's set, a testing circuit, means associated with said cord circuit to automatically connect the operator's set thereto upon associating the cord circuit with said testing circuit, and electro-responsive means to indicate that the operator's set is so connected.

3. A testing system comprising an operator's cord circuit, an operator's set, a testing circuit, means associated with said cord circuit to automatically connect the operator's set thereto upon associating the cord circuit with said testing circuit, and means in said testing circuit automatically operating to transmit a tone to the cord circuit when the latter is associated with the testing circuit.

4. A testing system comprising an operator's cord circuit, an operator's set, a pair of testing circuits, means associated with said cord circuit to automatically connect the operator's set thereto when the cord circuit is associated with one of said testing circuits and to disconnect the set upon association of the cord circuit with the other testing circuit, and electro-responsive means to indicate such connection and disconnection.

5. A testing system comprising an operator's cord circuit, a testing circuit, means operative in response to the association of the cord circuit with said testing circuit to apply signaling current to the latter, and means responsive to the flow of signaling current in the testing circuit to indicate the same.

6. A testing system comprising a cord circuit, a plurality of sources of signaling current, means associated with said cord circuit for selecting any one of said sources, a testing circuit, a plurality of indicating devices associated therewith and responsive to different signaling currents, means operative upon associating said cord circuit with said testing circuit to apply the selected current to said testing circuit, and means to indicate that the proper current responsive device responds thereto.

7. A testing system comprising an operator's cord circuit, a testing circuit, means operative in response to the association of the cord circuit with the testing circuit to apply ringing current to the latter, controlling means for said testing circuit operative at will to cause the disconnection of the ringing current from the testing circuit, and means responsive to ringing current to indicate the application and disconnection of the ringing current.

8. A testing system comprising an operator's cord circuit, a testing circuit, a testing set including controlling means and indicating means, means to associate the cord circuit with the testing circuit, means to associate the testing set with the testing circuit, means operative in response to the association of the cord circuit with said testing circuit to apply ringing current to the latter, means operative in response to actuation of said controlling means of the testing set to disconnect the ringing current from the testing set, and means to actuate said indicator to indicate the application and disconnection of ringing current.

9. A testing system comprising an operator's cord circuit, ringing apparatus associated with said cord circuit including means to control the application and disconnection of ringing current, a testing circuit, a testing set including an indicating means and a plurality of circuit controlling means, means to associate the cord circuit with the testing circuit, means to associate the testing set with the testing circuit, means operative in response to the association of the cord circuit with said testing circuit to actuate said first mentioned controlling means to cause the application of ringing current to the testing circuit, means operative in response to the actuation of one of said circuit controlling means to actuate said first mentioned controlling means to cause disconnection of said ringing current, means to actuate said indicator to indicate the application and disconnection of ringing current, and means responsive to the actuation of another of said circuit controlling means to restore the ringing apparatus of the cord circuit to normal, whereby ringing current will again be applied to the test circuit.

10. A testing system comprising an operator's cord circuit, a plurality of testing circuits, a portable testing set including a plurality of circuit controlling devices, circuit terminals normally associated with one of said testing circuits for associating said cord circuit with said testing circuits, switching means to associate said portable testing set with said testing circuits, and means responsive to the actuation of one of said circuit controlling devices to associate said terminals with another testing circuit.

11. A testing system comprising an operator's cord circuit, a testing circuit, a portable testing set comprising circuit controlling means, means for associating said cord circuit with said testing circuit, and switching means for associating said portable testing set with said testing circuit whereby said testing circuit may be controlled by said circuit controlling means.

12. A testing system comprising a cord circuit at an operator's position, a supervisory relay in said cord circuit, a testing circuit remote from said operator's position, means associated with said testing circuit operative from the operator's position to control the amount of current flowing through said relay.

13. A testing system comprising a cord circuit at an operator's position, a supervisory relay in said cord circuit, a testing circuit remote from said operator's position, variable resistance in said testing circuit, and means operative from the operator's position for varying said resistance at will to control the current flow through said relay.

14. A testing system comprising a cord circuit, a supervisory relay in said cord circuit, a testing circuit, a portable testing set independent of said testing circuit, means in said testing circuit to regulate the current flow through said relay, and means in said testing set for controlling said current regulating means.

15. A testing system comprising a cord circuit, a supervisory relay in said cord circuit, a testing circuit, resistance elements in said testing circuit, relay means to variably shunt certain of said resistance elements and thereby vary the current flow through said supervisory relay, and means to periodically operate said relay means.

16. A testing system comprising a cord circuit, a supervisory relay in said cord circuit, a testing circuit, means to associate the supervisory relay with the testing circuit, resistance elements in said testing cir-

cuit, relay means to variably shunt certain of said resistance elements, and a portable testing set including controlling means for said relay means.

17. A testing system comprising a cord circuit at an operator's position, a supervisory relay in said cord circuit, a testing circuit, means to associate the supervisory relay with said testing circuit, resistance varying means operative from the operator's position to control the current flow in said testing circuit, indicating means, and means to variably operate said indicating means under different conditions of current flow in said testing circuit.

18. A testing system comprising a plurality of cord circuits, a testing circuit, a plurality of switching terminals over which the cord circuits may be associated with the testing circuit, and means controllable from a point distant from said switching terminals for associating the test circuit with a desired cord circuit connected with one of said switching terminals.

19. A testing system comprising a plurality of cord circuits, a testing circuit, and switching means controllable from a point distant from said cord circuits for selectively associating said testing circuit with a desired cord circuit.

20. A testing system comprising a plurality of cord circuits, a testing circuit, a plurality of testing jacks with which said cord circuits may be connected, a controlling set, a plurality of controlling jacks one for each testing jack, and switching means operating when the controlling set is associated with a controlling jack to connect the testing circuit to the corresponding testing jack.

21. A testing system comprising a cord circuit, a marginal relay in said cord circuit, a testing circuit, means to associate said relay with said testing circuit, a portable controlling circuit independent of said testing circuit and means in said testing circuit and operative over said controlling circuit to vary the current flow through said relay to determine its margin of operation.

22. A testing system comprising a cord circuit, a marginal relay in said cord circuit, a testing circuit, means to associate said relay with said testing circuit, a portable controlling circuit independent of said testing circuit, means in said testing circuit and operative over said controlling circuit to vary the current flow through said relay to determine its margin of operation, and means to indicate the action of the relay.

23. A testing system comprising a cord circuit, a marginal relay in said cord circuit, a testing circuit, means to associate said relay with said testing circuit, means to adjust the current flow in said testing circuit to the normal marginal values at which the relay should not operate, means controllable from a distant point for increasing the current to normal operating value at will, and means to indicate the operation of said relay.

24. A testing system comprising a cord circuit, a switchboard, a testing circuit terminating at said switchboard, a supervisory relay individual to said cord circuit located at a point distant from the switchboard, controlling terminals for said testing circuit adjacent to the relay, a testing set including an indicator and having terminals for coaction with said controlling terminals and an independent terminal for said indicator, means in said testing circuit and under the control of said testing set for supplying variable current to said supervisory relay at will, and means for completing a circuit through said indicator at each actuation of the supervisory relay when the indicator terminal is in contact with the metal structure of the relay.

25. A testing system comprising operator's cord circuits, a switchboard, a testing circuit terminating in multiple testing jacks at each position of the switchboard whereby any cord may be plugged into a testing jack for testing purposes, said testing circuit also having controlling jack terminals multiplied at each position of the switchboard, and a testing set comprising means to control the various testing operations and terminating in a plug for coöperation with said controlling jack terminals.

26. A testing system comprising operator's cord circuits, each provided with auxiliary apparatus, a switchboard, a preliminary testing circuit terminating in multiple testing jacks at each position of the switchboard whereby any cord may be plugged into a testing jack for preliminary test purposes, said preliminary testing circuit also having controlling jack terminals multiplied at each position of the switchboard, a testing set comprising means to control various testing operations and terminating in a plug for coöperation with controlling jack terminals, a final testing circuit also terminating in multiple testing jacks at each position of the switchboard so that defective cord circuits may be plugged into said jacks for further testing, said final testing circuit also having controlling jack terminals located adjacent to the auxiliary apparatus of the cord circuits whereby the testing set may be plugged into said latter terminals to control the final testing operations.

In testimony whereof I have signed my name to this specification this 27 day of April, 1917.

JOHN F. TOOMEY.