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METHOD OF OPERATION
CORD CIRCUIT

Testing - Primary And Secondary - Local Test Desk - Full Mechanical Power Driven System.

GENERAL DESCRIPTION:

1. This circuit is used at a local test desk for testing and locating trouble on line and trunk circuits, in a full mechanical power driven system. It is associated with a sender for use when the line to be tested is automatically selected. In this case it is used with an incoming selector whose sleeve is normally grounded through a maximum resistance of 578 ohms which is reduced to a maximum resistance of 53 ohms when the selection of the desired line has been completed. This circuit may also be used for establishing connections with subscribers' lines over test lines to a zero position, a sender monitoring position, a position at a toll or local switchboard, or the main distributing frame. In this case no automatic features are involved. These test lines have their sleeves grounded through a maximum resistance of 53 ohms. Two testing circuits are provided, a primary and secondary. The primary testing circuit is used in making routine tests and those tests requiring the use of a volt-milameter and Wheatstone bridge. The secondary circuit is used in making those tests which require a considerable length of time and do not require the use of these instruments.

2. The testing circuits are equipped with the following plugs and cords:

1. A primary test cord for connecting the primary test circuit to the line under test.
2. A secondary test cord for connecting the secondary test circuit to the line under test.
3. A relay and sounder cord for use where it is necessary to leave the relay and sounder connected for some time to the line under test.

3. The wire chief can establish a talking connection over either test cord.

4. An automatic connection to a subscriber's line is established by the wire chief inserting the plug of either cord in an incoming selector jack and writing up the call on recording keys in the usual manner. The primary or secondary cord is connected to the sender circuit by the operation of the proper key in the sender circuit. The sender functions to connect the test cord to the subscriber's line through an incoming and final selector.

5. The insertion of the plug of either cord in the incoming selector jack closes a circuit through the winding of the P M G or S M G relay from battery over the lead 50 or 53, depending on whether the primary or secondary cord is used. The P M G or S M G relay does not operate at this time owing to the high resistance in the sleeve circuit. Failure of the P M G or S M G relay to operate prevents the connection of the testing apparatus to the circuit beyond the associated plug and permits the connection of the sender to that plug when the wire chief writes up the desired number on its recording keys (not shown). When selection of the subscriber's line has been completed, the sleeve resistance of the incoming selector circuit is reduced sufficiently to allow the P M G or S M G relay to operate.

6. The P M G or S M G relay operated, lights the associated supervisory lamp, and operates the PMG-1 or SMG-1 relay. The PMG-1 or SMG-1 relay operated disconnects the sender circuit from the associated plug and connects the plug to the testing apparatus. When the receiver at the called station is removed from the switchhook, the PS or SS relay (depending on the cord used) operates, extinguishing the associated supervisory lamp by placing a 40 ohm shunt around it. When the subscriber replaces the receiver on the switchhook the PS or SS relay releases, removing the shunt and permitting the associated supervisory lamp to relight as a disconnect signal. When the plug of the test cord is removed from the jack, the PMG or SMG relay releases, extinguishing the corresponding supervisory lamp and releasing the PMG-1 or SMG-1 relay.

7. When the plug of a test cord is inserted in the jack of a test line (which does not require the use of a sender) the PMG or SMG relay operates at once in turn operating the PMG-1 or SMG-1 relay. The plug is therefore connected at once to the testing circuit and disconnected from the sender circuit. Otherwise the circuit functions as before.

THE TESTING KEY EQUIPMENT OF THE PRIMARY TESTING CIRCUIT IS AS FOLLOWS:

8. The testing key equipment of the primary testing circuit is as follows:

1. A reversing key "REV (PRIM)" which is used to reverse the tip and ring sides of the primary testing circuit with respect to all apparatus connected back of the ringing keys.

2. A grounding key "G (PRIM)" used to ground one side of the line under test.

3. A repeating coil cut in key "RCCI" used when it is necessary to apply talking battery to the circuit through the #25-A repeating coil, PS relay and milammeter winding of the volt-milammeter, to enable common battery subscribers to talk when called up for test.

4. A talking key "T (PRIM)" used for connecting the wire chief's telephone circuit to the primary testing circuit.

5. A transmission test key "TMT" used for connecting the wire chief's telephone circuit and articifial cable to the line under test when determining the degree of transmission of the line.

6. A key "FEMF" used for disconnecting the volt-milammeter from the testing battery and connecting it to ground for measuring foreign potentials.

7. A monitoring key "M (PRIM)" used to connect the wire chief's telephone circuit across the tip and ring side of the testing circuit for monitoring purposes.

8. A volt-milammeter reversing key "VM REV" which, when operated, reverses the voltmeter winding of the volt-milammeter with respect to the line under test when the battery is cut off. It may be used for measuring the voltage of the 100 volt and 20 volt testing batteries when the proper keys are operated, and also for measuring earth potentials.

9. A scale change key "20000 ohm" used to disconnect the 100000 ohm winding of the volt-milameter and the 100 volt testing battery from the testing circuit and to connect the 20,000 ohm winding of the volt-milammeter in series with the 20 volt testing battery to the testing circuit.

10. A "1000 ohm" scale change key used in a manner similar to the "20,000 ohm" key but connecting the 1000 ohm winding of the volt-milammeter in series with the 20 volt battery.

11. A coin collect "CC" key and a coin return "CR" key, for testing coin boxes.

12. A special line insulation test key (#491-A) used for testing the insulation resistance of the line under test.

9. The testing key equipment of the secondary testing circuit is as follows:

1. A reversing key, "REV(SEC)" used in a manner similar to the reversing key "REV(PRIM)".

2. A grounding key "G (SEC)" used to ground one side of the line under test.

3. A repeating coil cut out key, "RCCO", used for disconnecting the talking battery from the testing circuit while testing for crosses between lines.

4. A relay key "S" which when operated connects battery through the winding of a relay (not shown on this drawing) over the lead A to the ring side of the line under test. The relay controls a sounder in a local circuit (not shown on this drawing).

5. A talking key "T (SEC)" used for connecting the wire chief's telephone circuit to the testing circuit.

6. A howler key "H" used for connecting a graduated tone to the line under test for attracting the attention of subscribers in case of failure to replace the receiver on the switchhook after a conversation.

7. A monitoring key "M (SEC)" used in a manner similar to the monitoring key "M (PRIM)".

8. A dial test key "DT" used for checking up the speed of the dial of a subscriber's set under observation in comparison with a known standard.

10. In addition to the above keys an interchange key "X" common to both testing circuits is provided which, when operated, connects the primary testing equipment to the secondary test cord and vice versa. The howler circuit alone cannot be transferred. The howler circuit remains open if the interchange key is operated.

11. The various operations and tests that may be accomplished by means of this circuit in connection with common battery circuits are as follows:

1. Talking to a subscriber.
2. Ringing.
3. Tests for grounds.

4. Tests for short circuits.
5. Continuity tests.
6. Tests for crosses with lines carrying current.
7. Tests for crosses with other lines.
8. Ballistic tests.
9. Breakdown tests.
10. Transmission tests.
11. Monitoring.
12. Miscellaneous tests.

12. The methods to be employed in performing these various tests and operations may be briefly outlined as follows:-

TALKING TO A SUBSCRIBER:

13. The wire chief's telephone set is normally disconnected from the testing circuit. Therefore to talk over a subscriber's line which is connected to the primary testing circuit by means of a test line or incoming and final selectors, it is necessary for the wire chief to operate the primary talking key "T (PRIM)". The repeating coil cut in key "RCCI" must also be operated to supply talking battery to the subscriber's telephone set. In all cases when talking to a subscriber it is necessary that all keys in the testing circuit except those noted above be in their normal position. To talk over a subscriber's line connected to the secondary cord circuit the secondary talking key "T (SEC)" only, is operated.

RINGING:

14. This circuit is arranged to be used with a separate ringing circuit for connecting ringing current to the line under test.

TESTS FOR GROUNDS:

(a) With the voltmeter scale of the volt-milammeter.

15. To test for a ground on the ring side no keys need be operated since the 100 volt testing battery is connected to the ring side in series with the 100,000 ohm winding of the volt-milammeter. The volt-milammeter should show no deflection or at most a very small one if the line is clear except in the case of a grounded line or a party line where the bells are rung with grounded return, and no condensers are in series with the ringer. In this case the resistance to ground may be determined as explained later under "Tests for Short Circuits". If the deflection is in excess of 100 volts it indicates that the ring side of the line is crossed with the office battery. To test on the tip side operate the reversing key and proceed as above.

16. To measure a high resistance ground, the 100 volt testing battery is used. On account of the high resistance of the 120 volt winding of the volt-milammeter the needle will be deflected a greater distance than would be the case if the 20 volt testing battery were used thereby giving a larger deflection and a more accurate reading. For measuring small resistances the 20 volt battery should be used.

(b) With the 0-480 milammeter scale of the volt-milammeter.

17. To test with the milammeter operate the repeating coil cut in key, "RCCI". This connects the milammeter winding of the volt-milammeter to the ring side of the circuit in series with the PS relay and central office battery. If the line is clear no deflection will occur. To test on the tip side operate the reversing key "REV(PRIM)" in addition to the repeating coil cut in key.

(c) With the relay.

18. When the voltmeter indicates a swinging ground of apparently so high a resistance as to be negligible it is always desirable to supplement the foregoing test by a test with the relay. To test with the relay, have all keys in their normal positions and operate the relay key "S". This will connect a relay (not shown on this drawing) to the ring side of the testing circuit in series with battery. This relay will operate if there is a ground on that side, or a short circuit on the line. The operation of the relay in turn operates a sounder in a local circuit (not shown on this drawing). To test on the tip side operate the reversing key and proceed as above.

TESTS FOR SHORT CIRCUITS:

(a) With the voltmeter scale of the volt-milammeter.

19. Tests for short circuits are made by operating the ground key. In the case of a short circuit the voltmeter needle will show a deflection which will be unchanged when the reversing key is operated. The smaller the resistance of the short circuited line the greater will be the delfection. In all cases the voltmeter reading bears the same ratio to the voltmeter resistance as the difference between this reading and the testing battery voltage bears to the external resistance.

20. The line resistance may be calculated by dividing the difference between the testing battery voltage and the voltmeter reading, by the voltmeter reading and multiplying this quotient by the resistance of the voltmeter coil. For example, if the voltmeter coil has a resistance of 100,000 ohms and the testing battery is 100 volts and a reading of 40 volts is obtained on the line, the resistance of the line is $\frac{100 - 40}{40} \times 100000$ ohms = 150,000 ohms.

21. If the wire chief wishes to obtain some further idea of the size of the "short", he operates the scale change key which connects that winding of the volt-milammeter into the circuit which is most nearly equal in resistance to that of the "short" to be measured, for, under these conditions voltmeter resistance measurements are most accurate.

(b) With the milameter scale of the volt-milammeter.

22. To test with the milameter, operate the repeating coil cut in and the ground keys. A deflection will result if the line is short circuited and the milammeter needle will return to zero when the ground key is restored to normal.

CONTINUITY TESTS.

23. Continuity tests are made in the same manner as test for short circuits.

In the case of lines equipped with standard common battery subscribers' sets which have a condenser in series with the ringer no permanent deflection will occur unless the receiver is removed from the switchhook at the subscriber's station. If it is not convenient to have the receiver removed a fairly satisfactory test for continuity may be made by operating the reversing key quickly back and forth several times. This will result in a momentary deflection of the voltmeter needle due to the charge and discharge of the condenser if the line is continuous. A test for continuity should always be proceded by a test for ground.

TESTS FOR CROSSES WITH LINES CARRYING CURRENT.

24. When it is desired to test a line for foreign battery the battery cut-off key "FEMF" is operated. This connects the voltmeter to the ring side of the circuit in series with ground. If the external potential is of a polarity such as to give a negative reading the voltmeter reversing key "VM.REV". is also operated, thereby reversing the voltmeter connections with respect to the line. To test on the tip side, operate the reversing key "REV(PRIM)".

TEST FOR CROSSES WITH OTHER LINES.

25. To test for a cross between two lines, connect one of them to the primary testing circuit and the other to the secondary testing circuit. Ground the tip or ring side of the secondary testing circuit by operating the secondary ground and reversing keys and test the line connected to the primary testing circuit for ground as described above.

BALLISTIC CAPACITY TESTS.

26. These tests are made to determine approximately the value of the capacity of the line or attached condensers. This circuit is arranged for "grounded" capacity tests only unless the Wheatstone bridge circuit is equipped, in which case tests for "mutual" capacity may be made by operating a Wheatstone bridge key (not shown) which cuts the ground off the testing battery. When testing a line for grounded capacity operate the ground key and then operate the reversing key quickly back and forth. This will give a deflection proportional to the capacity on the ring side when the reversing key is returned to normal and proportional to the capacity on the tip side when the reversing key is operated away from normal.

27. Extension bells if placed in series with the bell of the subscriber's set will cause a slight reduction in the deflection of the needle. If they are placed in series with separate condensers and bridged across the line the deflection will be increased. Party lines employing alternating current relays or magneto lines having bells bridged across the line in series with the condenser will give an increased throw for each added instrument.

28. Party lines having the bell connected to ground on either side of the line will give a deflection for the bells on the tip side of the line when the reversing key is operated away from its normal position, and a deflection for the bells on the ring side of the line when the reversing key is returned to its normal position. Grounded lines or grounded bells give about one-half of the deflection for bridged bells on a metallic line since in the one case it measures only the current for charging the condensers from a discharged state.

BREAKDOWN TESTS.

29. When the insulation breakdown test key is operated the following sequence of operation occurs:-

(a) The spring of the impulse wheel "A" make, operating the BT relay, which in turn operates the CC relay. The operation of the BT relay connects the ring side of the line direct to ground. The operation of the CC relay connects the tip side of the line to ground through 96,000 ohms. This is to prevent any condensers on the line from discharging quickly and thereby causing bell taps.

(b) The springs of impulse wheel, "B" operate, removing the ground from the 96,000 ohm resistance and connecting the 200 volt break down potential in series with the 96,000 ohm resistance and the milammeter winding of the volt-milammeter to the tip side of the line, the ring side of the line remaining connected directly to ground.

(c) The springs of impulse wheel "C" operate, short circuiting the 96,000 ohm resistance and connecting the breakdown potential direct to the tip of the line through the milammeter winding of the volt-milammeter. By gradually charging the line condensers in this manner bell taps are avoided. A reading of more than .020 ampere usually indicates a breakdown.

(d) The springs of impulse wheel "C" release, again impressing the 200 volt potential on the line through the 96,000 ohm resistance.

(e) The springs of impulse wheel "B" release, disconnecting the 200 volt battery and connecting ground to the tip side of the line through the 96,000 ohm resistance to gradually discharge the line, the ring side of the line remaining connected to ground.

(f) The springs of impulse wheel "A" release, releasing the BT relay, which in turn releases the CC relay, restoring the circuit to normal.

TRANSMISSION TESTS.

30. These tests are made for testing the grade of transmission on a line. The operation of the transmission test, and repeating coil cut in keys and a key in a rheostat circuit (not shown on this drawing) normally shunting the rheostat out of the circuit, connects the subscriber's line to the wire chief's telephone circuit through an artificial line. The rheostat key is then operated and the current through the transmitter varied by adjusting the special rheostat.

MONITORING.

31. In order that the wire chief can listen in on the circuit when the subscriber attempts to signal the operator, a monitoring key is provided. The operation of the monitoring key frees the tip and ring wire of the test set from all bridge, ground and battery connections. The monitoring key connects the wire chief's receiver across the test circuit. The monitoring key is also used for listening in on toll lines or on any other circuit where it is desirable to cause a minimum transmission loss.

32. The operation of the secondary monitoring key "M(SEC)" connects ground to the sleeve of which every cord is connected to the secondary circuit. This causes the operation of the PMG or SMG relay and permits monitoring on the listening jack of such of the test lines as have their listening jack sleeves open. The PMG or SMG relay in turn operates the PMG-1 or SMG-1 relay.

MISCELLANEOUS TESTS.

(A) Coin Collect and Return.

33. To test the operation of coin boxes on a subscriber's line the "coin collect, "CC" or coin return "CR" key is operated. The operation of the "CC" key operates the CC and D relays. The operation of the CC and D relays connects 110 volt positive battery to the tip and ring sides of the line through the milammeter winding, properly poled, of the volt-milammeter. The wire chief can then check the amount of current that flows over the line for coin collection. When the "CC" key is restored to normal the CC and D relays release. The operation of the "CR" key causes the CR and D relays to function in a manner similar to that explained above, but connecting 110 volt negative battery to the tip and ring sides of the line through the milammeter winding of the volt-milammeter which is poled in the opposite direction from what it was poled by the CC relay. The coin collect and return battery can be regulated by operating a rheostat key in a rheostat circuit (not shown on this drawing) and adjusting the rheostat. The D relay is made slow in releasing for permitting the line and coin magnet to discharge through the 2 M F condenser and 2200 ohm resistance. This protects the test circuit, and the insulation of the wiring of the subscriber's multiple at the selector frames from puncture by the high potential discharge.

(B) Howler.

34. When the plug of the secondary cord is inserted in the jack of a test line or the jack of an incoming selector whose switch has advanced to the testing position, the SLG relay operates in turn operating the SMG-1 relay. If the receiver is off the switchhook on the line to which the cord is connected the SS relay operates, preventing the associated supervisory lamp from lighting. Under this condition a circuit is closed through the make contacts of the SMG and SS relays, operating the H relay. When the wire chief operates the howler key "H", a circuit is closed through the make contact of the H relay which closes a howler circuit not shown on shown on this drawing. A graduated tone is then applied to the line. When the receiver is replaced on the switchhook, the SS relay releases, lighting the supervisory lamp and releasing the H relay. The wire chief then resotres the "H" key to normal, disconnecting the howler circuit. When the plug of the cord is removed from the jack the SLG relay releases, in turn releasing the SMG-1 relays, restoring the circuit to normal.

(C) Dial Tests.

35. The dial test feature is used for checking up the speed of the dial of a subscriber's set under observation in comparison with a known standard. The operation of the dial test key, "D T", connects the winding of the DT relay in series with the impulse springs of the subscriber's dial. The impulses from the subscriber's dial alternately operate and release the DT relay, causing an arm in the dial testing device to rotate in synchronism with these impulses, while at the same time another arm rotates at a known speed. The relative positions of these arms at the end of the period of observation gives an indication of the speed of the dial under test.

CIRCUIT REQUIREMENTS

	OPERATE	NON-OPERATE	RELEASE
B1 (PS) or (SS)	Through 750 ohms bridged across tip and ring of cord at 20 volts. After a soak of approximately .3 amp: Test .019 amp. Readj. .016 amp.		Through 10,000 ohms after operation through 550 ohms at 28 volts. After a soak of approximately .3 amp: Test .003 amp. Readj. .005 amp.
NOTE:- In multi-office districts where the trunk loops exceed 750 ohms the adjustment for this relay when desired by the Telephone Company shall be:			
	After a soak of approximately .3 amp: Test .016 amp. Readj. .015 amp.		After a soak of approximately .3 amp: Test .0048 amp. Readj. .005 amp.
E54 (PMG-1) & (SMG-1)	Test .029 amp. Readj. .020 amp.	Test .015 amp. Readj. .016 amp.	
E64 (H)	Test .064 amp. Readj. .035 amp.	Test .026 amp. Readj. .028 amp.	
E106 (BT)	Test .032 amp. Readj. .026 amp.	Test .019 amp. Readj. .020 amp.	
E192 (D)	Test .034 amp. Readj. .032 amp.	Test .022 amp. Readj. .024 amp.	
E411 (DT)	Test .018 amp. Readj. .017 amp.	Test .011 amp. Readj. .012 amp.	
E845 (CC) & (CR)	Test .030 amp. Readj. .022 amp.	Test .013 amp. Readj. .014 amp.	

CIRCUIT REQUIREMENTS

	OPERATE B.	NON-OPERATE	RELEASE
E1010 (PMG) & (SMG)	Through relay: Readj. .069 amp. When applied to sleeve: Test .089 amp. Readj. .082 amp.	Through relay: Readj. .047 amp. When applied to sleeve: Test .053 amp. Readj. .056 amp.	

ENG.--WJT-VL.
7/22/21.

CHK'D.--CWP.

AAPPROVED C.L. SLUYTER.