DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TM 11-2114

STEPPING-SWITCH TEST SET

STEP-BY-STEP DIAL CENTRAL OFFICE EQUIPMENT

DEPARTMENT OF THE ARMY *JUNE 1949*

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TM 11–2114, Stepping-switch Test Set (Step-by-step Dial Central Office Equipment), is published for the information and guidance of all concerned.

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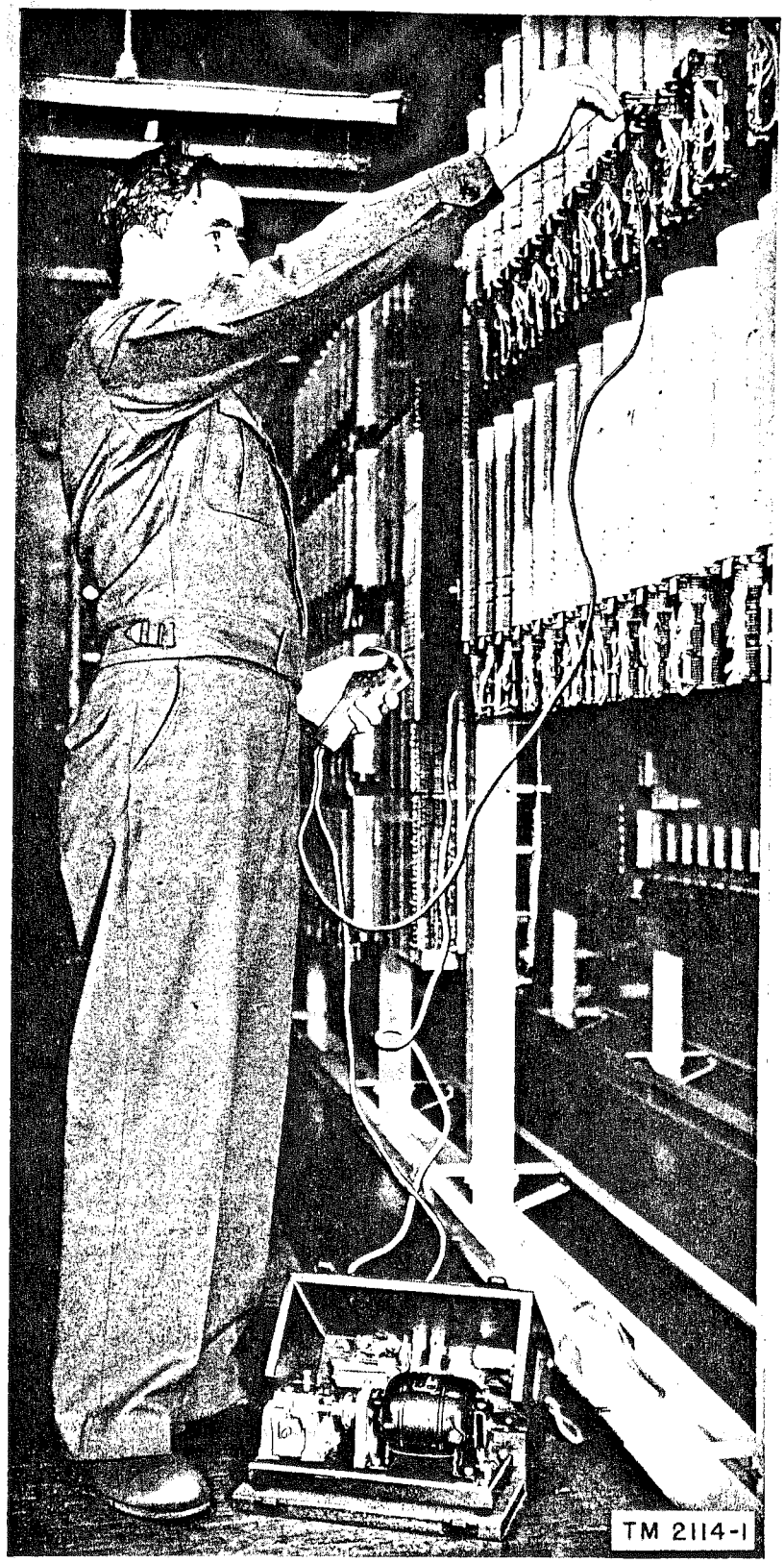

Figure 1. Stepping-switch test set in use.

CHAPTER I

INTRODUCTION

Section I. GENERAL

1. Purpose

This manual is published for the information and guidance of personnel to whom this equipment is issued. It contains basic maintenance information required by maintenance personnel who are making routine tests of step-by-step central office equipment.

2. Scope

This manual contains operating instructions for the stepping-switch test set and testing procedures for use with selectors, connectors, and pulse repeaters. Information on PM (preventive maintenance), adjustment, and repair is included.

3. References

Appendix I contains a list of current references, including supply catalogs, technical manuals, and other available publications applicable to the matériel.

Section II. DESCRIPTION

4. General

a. The stepping-switch test set (Auto Elec D–55165–B), also known as the *varying machine, impulse testing machine, interrupter machine, dial pulse generator, or test-pulse machine,* is an automatic interrupter providing simulated dial pulses for use in testing the operation of step-by-step dial central office switching equipment, with simulated conditions of telephone line loop resistance and leakage. This test set permits making periodic PM tests of the vertical stepping of selectors, of the vertical and rotary stepping of connectors, and of the operation of the incoming selectors and repeaters used for trunking between offices. Throughout this manual the *stepping-switch test set* will be called the *test set,* to avoid unnecessary repetition of the longer name, and since only one reference to another test set will be made.

b. The test set consists of an electric motor, a reduction gearbox, an interrupter assembly, a relay, and wire-wound resistors, all of which are housed in a wooden cabinet. There is an extension-switch box outside the cabinet. The motor operates on energy supplied by the central office battery.

5. Electrical Characteristics

a. When the test set is connected to the central office battery, the motor starts. The battery voltage, as indicated on the power board voltmeter, must be between 48.5 and 50 v (volts) for proper operation of the test set. The test set transmits pulses to the unit under test when either the LOOP or the SHUNT push-switch on the extension-switch box is operated. When one of these switch buttons is operated (depressed), the interrupter assembly transmits a group of 9 pulses to the equipment under test at a rate of 14 pulses per second; pauses; and again sends a ground of 9 pulses. Groups of pulses are transmitted as long as one of these switches is held operated.

b. The following tests are made with test set:

(1) Test of selectors, connectors, and pulse repeaters over a loop of 0 ohm resistance with 15,000 ohms leakage.

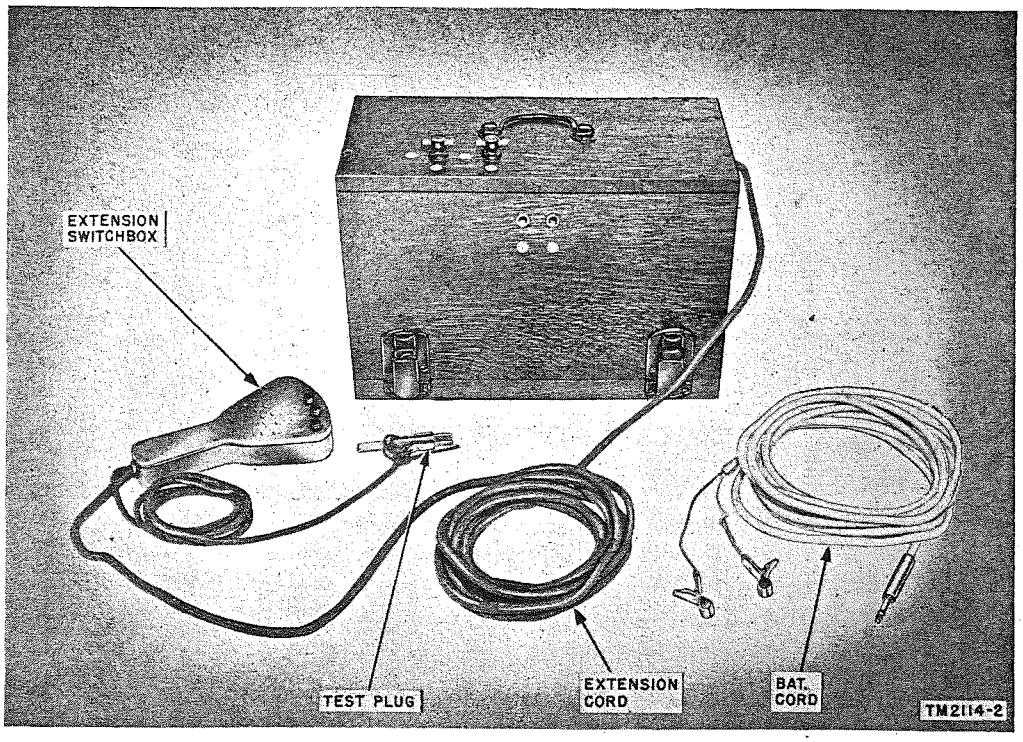

Figure 2. Stepping-switch test set, components.

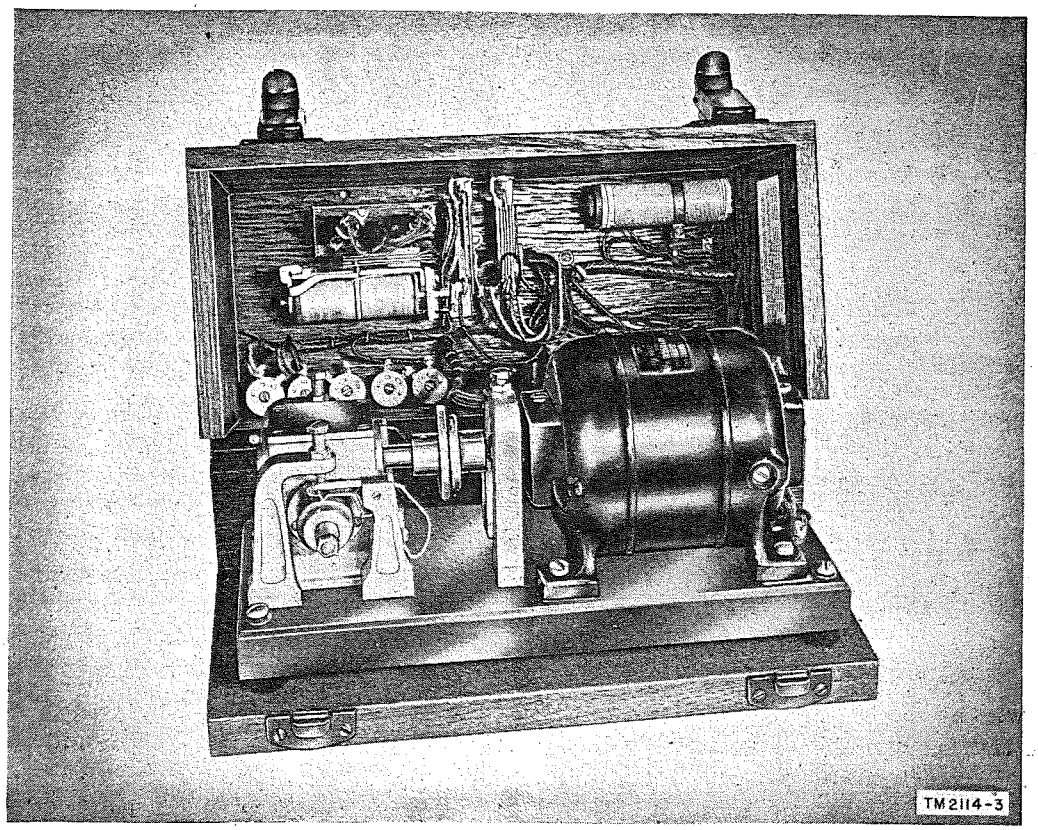

Figure 3. Stepping-switch test set, cover open.

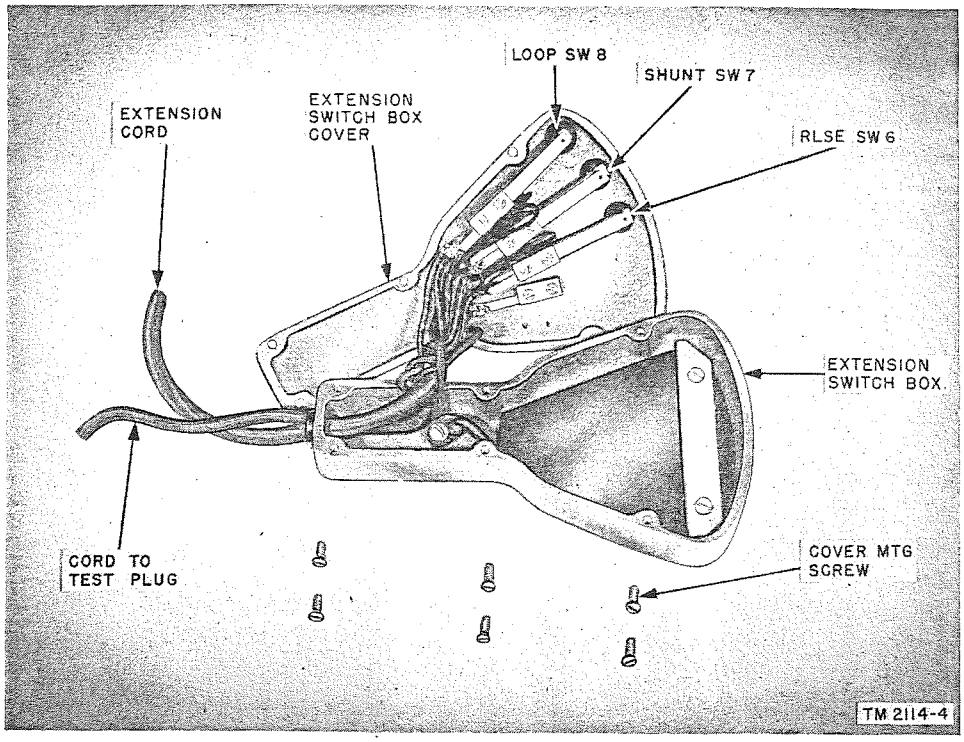

Figure 4. Extension-switch box, cover removed.

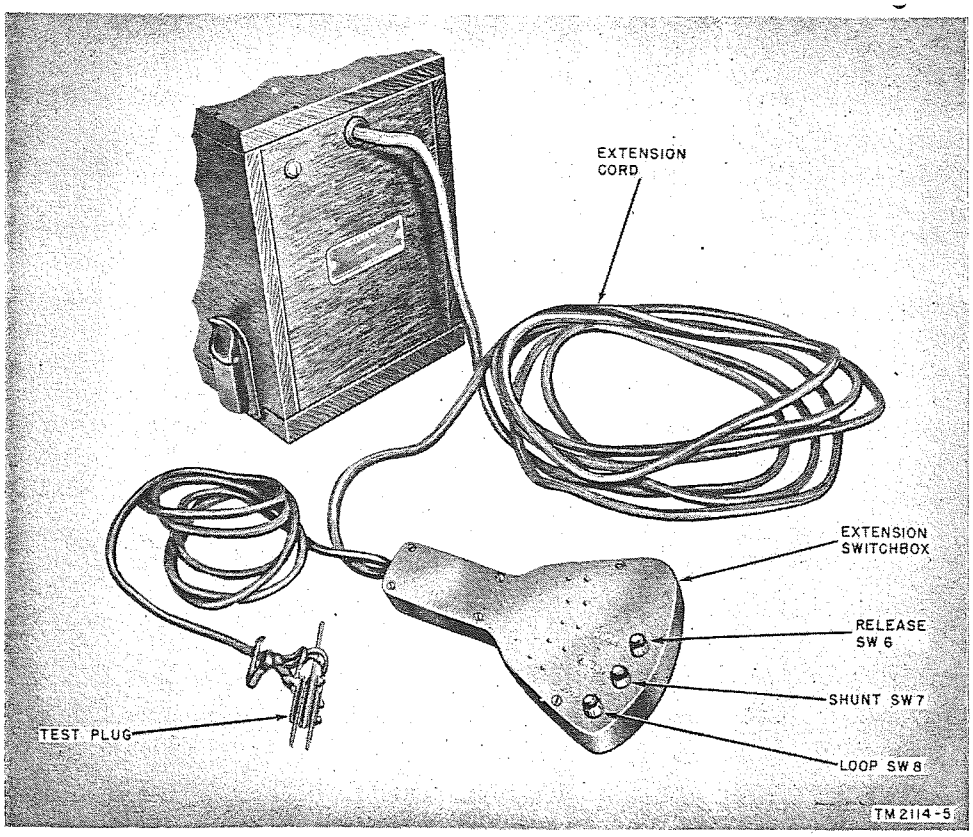

Figure 5. Extension-switch box and test plug.

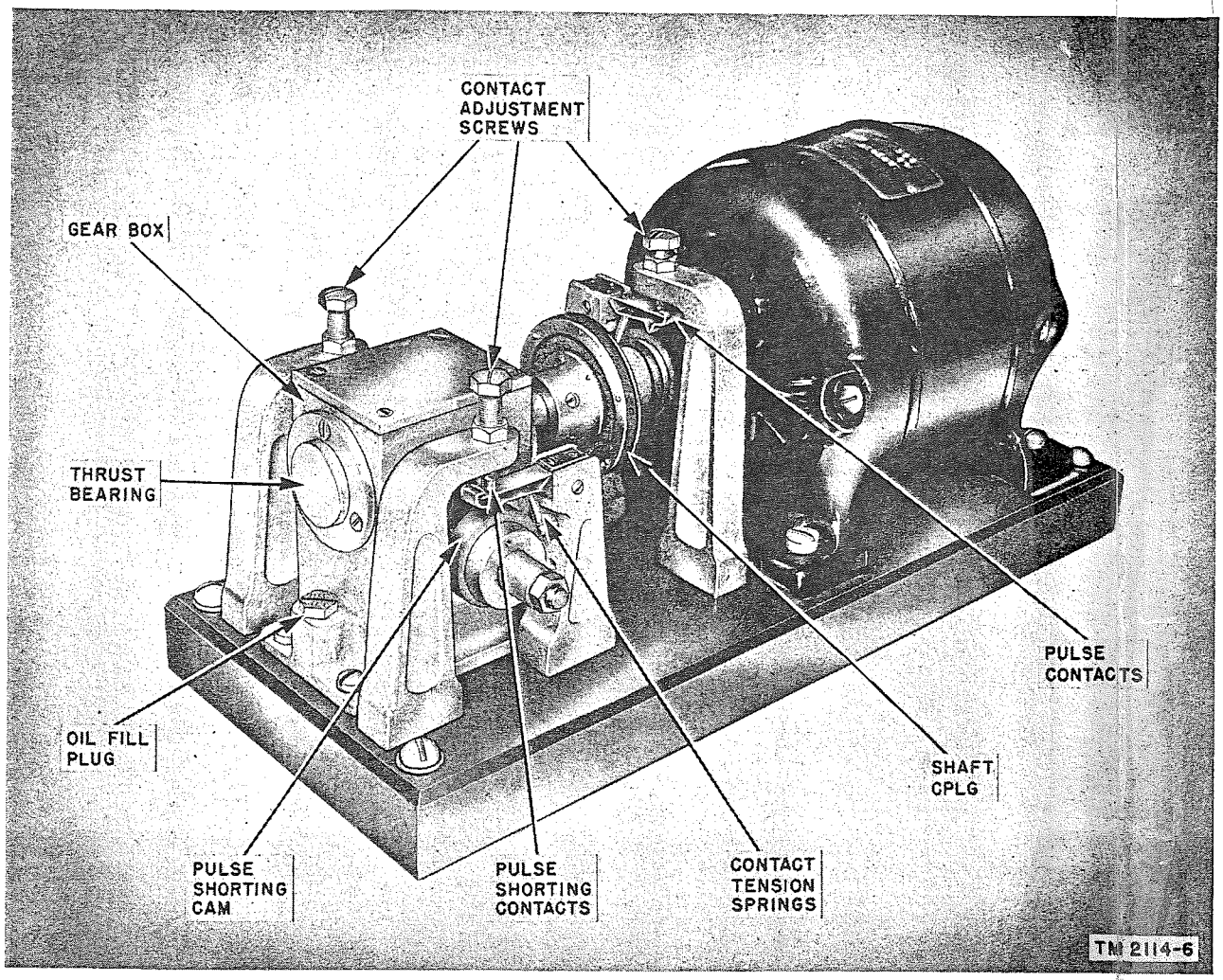

Figure 6. Motor and interrupter assembly.

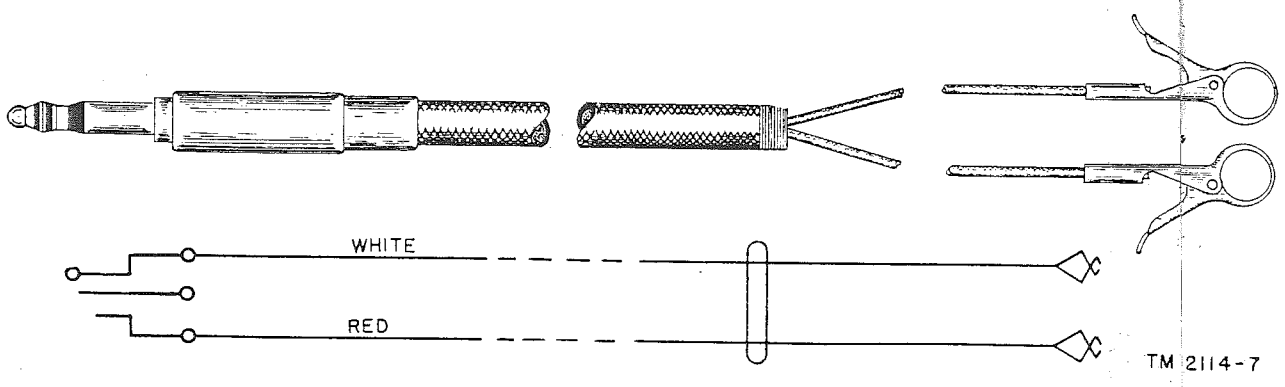

Figure 7. Battery cord.

(2) Test of selectors, connectors, and pulse repeaters over a loop of 1,000 ohms resistance with no leakage.

(3) Release of equipment under test.

(4) Test of the release of relay B in the equipment under test.

6. List of Components

Quantity	Component	Dimensions (in.)		
		Height	Width	Length
1	Cabinet	8⅝	6⅜	13⅛
1	Extension-switch box, with:	1 3/16	4	6¾
1	Extension cord			170
1	Test cord with test plug			69
1	Battery cord (Auto Elec D–57067–A)			178

Note. This list is for general information only. See appropriate publications for information pertaining to requisition of spare parts.

7. Description of Components

a. CABINET. The test set is housed in a natural-finished, sturdy, wooden cabinet. The cabinet has two metal catches, a piano-type hinge, and a carrying handle. The bottom panel of the cabinet serves as a mounting board for the motor and the interrupter assembly. All other parts are mounted on the inside of the hinged cover. A laced flexible cord connects the motor and interrupter assembly to the associated parts mounted on the cover. The rotary switches for the test of relay B, and for series loop selection, are located on the top of the cover. The switch positions are lettered on white plastic disks inlaid on the top of the cover. The external battery power cord is connected to the test set circuit by means of the BAT jack mounted on the front cover. The CTJ jack (connector test jack) is not used during ordinary operation of the test set; it is used, however, when the test set is used in conjunction with other test equipment. The jacks are designated by lettered white plastic disks inlaid in the cover directly below the jacks. On the right side of the cover is an entrance hole for the extension-switch box cord which connects to a terminal strip within the cover. The hinged cover is secured by two latch-type fasteners when the box is closed.

b. EXTENSION-SWITCH BOX. The extension-switch box is made of brass; it contains the release, shunt, and loop resistance push-switches. The switches are mounted under the extension-switch box cover, and the cover is fastened to the box by six machine screws. The switch box extension cord and the test plug cord are connected to the terminals on the switches within the extension-switch box. The conductors in the switch box extension cord have telephone-type cord-tip terminals at the external end, and are secured at the terminal strip in the test set by machine screws.

c. BATTERY CORD. The battery cord has a three-conductor telephone plug (WECo 110) on one end, for insertion in the battery jack of the test set, and two spring clips (WECo 59) on the other end for connection to the fuse panel of the equipment to be tested. These leads are color-coded, with red for connection to ground (+ battery) and white for connection to minus (—) battery.

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CHAPTER 2

OPERATING INSTRUCTIONS

Section I. GENERAL OPERATION

8. Use of Controls

a. CABINET. Two 2-position *turn keys* or rotary switches are located on the top of the cabinet which houses the test set (fig. 8). The loop resistance switch, marked MIN LP-MAX LP, short-circuits the series resistance in the loop test circuit when the switch is operated to the MIN LP (minimum loop) position. This switch, however, is rarely used; it is operated to the MAX LP (maximum loop) position for all ordinary uses of the test set. The other switch, the relay B test switch, marked B RY TST — NOR (B relay test, and normal), is used to test for the release of relay B in the equipment under test when the switch is operated to the B RY TST position. This switch is operated to the NOR position for test pulse transmission.

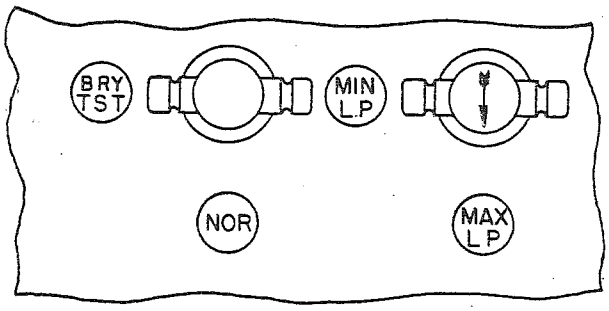

Figure 8. Relay B and LOOP resistance switches.

b. EXTENSION-SWITCH BOX. Three push-switches, marked RLSE, SHUNT, and LOOP, are located in the extension-switch box. These switches are operated to perform the tests on the equipment.

(1) *LOOP switch.* Operating the LOOP push-switch provides a test of the operation of selectors, connectors, and pulse repeaters by supplying them with current pulses over a line having 1,000 ohms loop series resistance.

(2) *RLSE switch.* Operating the RLSE push-switch permits the unit under test to release.

(3) *SHUNT switch.* Operating the SHUNT push-switch provides a test of the operation of selectors, connectors, and pulse repeaters by supplying them with current pulses over a line having negligible loop series resistance, and 15,000 ohms leakage (shunt) resistance.

9. Operating Procedures

a. CABINET. Place the test set near the shelf of the switching equipment to be tested, in such a position that all the test jacks on the shelf can be reached with the test cord of the test set (fig. 1). Be certain that the B RY TST — NOR switch on the cabinet is operated to the NOR position; and that the MIN LP — MAX LP switch is operated to the MAX LP position (fig. 8).

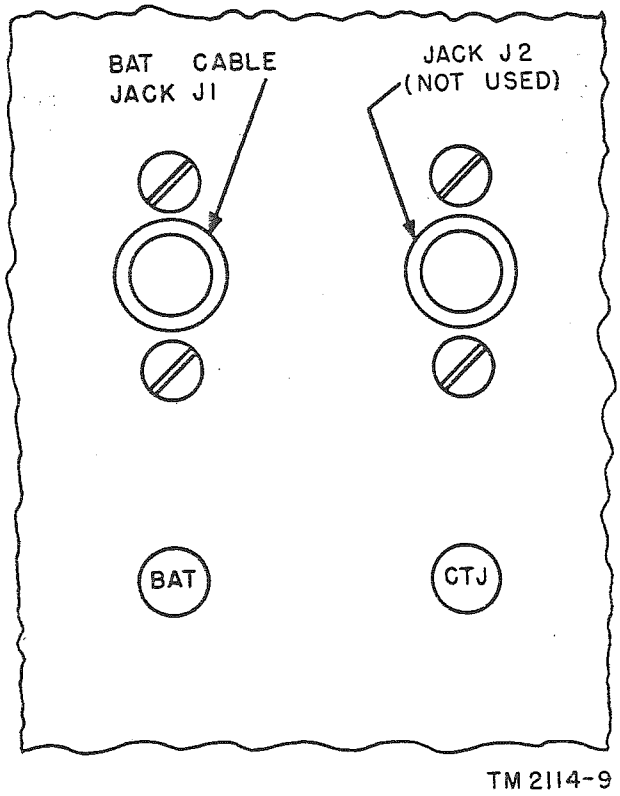

Figure 9. Battery jack and CTJ jack.

b. BATTERY CORD. The battery cord is used to supply the test set with energy from the battery. Before the battery cord is connected, read the voltage at the power panel; this voltage must be 48.5 to 50 volts for the motor of the test set to operate properly.

(1) Insert the plug of the battery cord (fig. 7) in the BAT jack on the cabinet of the test set (fig. 9).

(2) Connect the alligator clips, on the other end of the cord, to battery and ground, at the fuse panel of the equipment under test (fig. 10); attach the clip on the red lead to ground (+ battery) and attach the clip on the white lead to one of the 5-amp (ampere) fuses on the fuse panel of the shelf to be tested (— battery).

Caution: Do not connect the test set in series with a fuse of less than 3 amperes rating, since the motor starting current may approximate 3 amperes. When the battery cord is connected, the motor of the test set will start, and it will continue to operate until the battery cord is disconnected. To obtain best results, allow the test set to operate for one-half hour (warm-up period) before starting equipment tests.

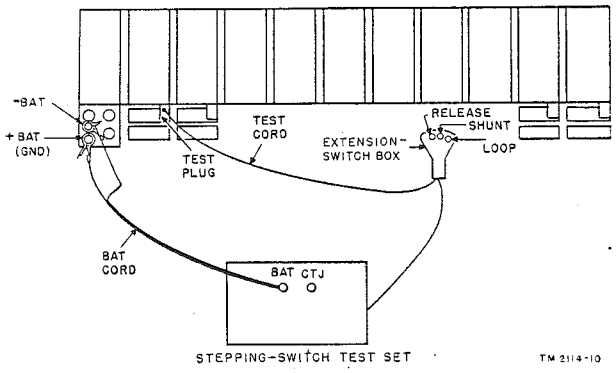

Figure 10. Connections for operation of stepping-switch test.

c. EXTENSION-SWITCH BOX AND TEST PLUG.

(1) Hold the extension-switch box in the left hand.

(2) Insert the test plug into the test jack of an idle unit of the equipment to be tested, and note the response of the unit when the following tests are made:

(a) LOOP test. Operate the LOOP push-switch; this transmits pulses from the test set to the unit under test, over a 1,000-ohm resistance loop. Determine whether the stepping action of the unit is satisfactory. Release the LOOP switch, and operate the RLSE push-switch to permit the unit under test to return to normal.

(b) SHUNT test. Operate the SHUNT push-switch; this transmits pulses from the test set to the unit under test, over a loop of negligible resistance with 15,000-ohm shunt leakage. Determine whether the stepping action of the unit is satisfactory. Release the SHUNT switch, and operate the RLSE push-switch to permit the unit under test to return to normal.

(c) Relay B test. Check the release of the B relay in the switching unit under test. Perform this test by operating the B RY TST — NOR switch, on the cabinet of the test set, to the B RY TST position and then operating either the LOOP or the SHUNT push-switch on the extension-switch box. Operating either of these two switches opens and closes the loop circuit through the pulse short-circuiting springs, thus causing the A relay to operate and release. Relay B of the unit under test should release during the interval in which the loop circuit is open — that is, while the A relay is in the released position and before the circuit again is closed to the shorting relay in the test set.

(d) After testing one unit, move the test plug to other idle units; do not connect to units that are busy. Test the units that were busy after they become idle. All switches that respond to the test pulses are considered satisfactory. Failure of a switch to step in response to the test pulses indicates need for adjustment. Refer to TM 11-2103 for procedure in servicing equipment.

10. Testing Connectors

a. When testing a 200-line connector, hold the LOOP or SHUNT push-switch operated until the test set has sent 3 groups of 9 pulses to the connector, and observe whether the connector responds. The first group of pulses selects the 200-group bank-contact wipers. The second group controls the vertical mechanism, stepping the contact wipers to the ninth level. The third group controls the rotary mechanism, stepping the wipers to the ninth contact. This completes the circuit to No. 299, the test number for the 200-group of lines, terminating in a test jack on the connector bay. After observing the stepping action of the connector, operate the RLSE switch and proceed to the next connector.

b. When testing 100-line connectors, only 2 groups of 9 pulses are required, one group for vertical stepping and one group for rotary stepping. The test number for 100-line connectors is No. 99.

11. Testing Selectors

a. When local first and regular second selectors are tested, only one group of nine pulses is used, since the rotary stepping of a selector is not dial-controlled. When the selector contact wipers have been stepped to the ninth level, the rotary mechanism automatically steps the wipers to the first idle trunk. If all trunks are busy, or if the ninth level is vacant, the selector will automatically rotate its wipers to the eleventh step.

b. When the selector under test serves as an incoming selector on an interoffice trunk, disconnect the trunk from the selector before testing. (This avoids operating the incoming selector at the distant office.)

12. Testing Pulse Repeaters

When the pulse repeaters associated with the interoffice trunks are to be tested, conduct the tests in conjunction with a testman at the distant office in which the trunks terminate. (The incoming selectors in each exchange must be tested first.) Set up a talking circuit over one of the trunks, and then insert the test plug into the test jack on each repeater in turn, operating the LOOP, SHUNT, and RLSE push-switches as described in paragraph 9*c*; the man at the remote office observes the stepping action of his incoming selectors. After the repeaters in one office have been tested, the repeaters in the other office should be tested in the same manner.

CHAPTER 3

MAINTENANCE

Section I. PREVENTIVE MAINTENANCE

13. Tools and Materials

The following PM tools and materials are required:

Sig C stock No.	Item
6R41065C	Burnisher, contact: WECo 265–C.
6R4603	Pliers, TL–103: diagonal cutting, 5″.
6R24617	Soldering Iron, TL–117: 70/100 w (watt).
	Gage, thickness: 9 leaf, Auto Elec H–46795.
	Brush, artist's: sable #4.
6N1636	Cloth, cotton: unbleached, 36″ wd.
6Z7500–0000	Sandpaper: flint, #0000.
6G1517	Polish: cord plug, Auto Elec 184–D.
6R4626	Pliers, TL–126: 6″, straight.
	Screw driver, cabinet: 3½″, Auto Elec 95.
6N7531	Solder, M–31: rosin-core, 1-lb spool.
6G184.4	Carbon tetrachloride: gal can.
	Toothpicks.
	Spring balance: WECo 158–A.
	Tachometer: Jaeger 4840.

14. Procedures

a. GENERAL. Clean relays, plugs, jacks, and switches as specified in TM 11–2103.

b. CABINET. Clean dirt and rust from the inside and outside of the cabinet, touch up all scratches on the wooden surface, and proceed as specified in TM 11–2103.

c. MOTOR. The motor operates on 48.5 to 50 volts dc (direct current). The normal speed must not be less than 840 rpm (revolutions per minute) at 48.5 volts input. The speed is considered normal if the rate of pulse transmission can be adjusted to 14 per second with normal battery voltage. (See par. 19*a*.)

(1) Inspect the commutator, brushes, and brush holders. Replace the brushes if they are worn to less than three-eighths inch in length. The brush holders should clear the commutator by not less than one thirty-second inch, nor more than three-sixteenths inch.

(2) Tighten the mounting screws of the motor, the setscrews in the shaft coupling, and the screws in the frame of the motor.

(3) Clean the commutator, using a piece of wood with canvas duck cloth attached, as directed in TM 11–2103. Clean the exterior of the motor and remove any excess oil.

(4) Lubricate in accordance with instructions in paragraphs 15 and 16.

d. INTERRUPTER ASSEMBLY. The interrupter assembly (fig. 11) includes three contact spring assemblies, three cams, a gearbox, and a motor shaft coupling. Inspect all operating components carefully.

(1) Inspect the cams for tightness on the shafts, and for proper position as indicated in figure 12.

(2) Inspect the bearing surface of the cams for the presence of dirt, or other foreign substances, and for proper lubrication.

(3) Inspect the cam springs and tension springs; be sure the tension holds the cam spring against the bearing surface of the cam through the complete revolution of the cam.

(4) Inspect the contact points for signs of corrosion or pits.

(5) Check the space between contacts in the open position (fig. 12). Make sure that the space between the contact spring and the end of the cam spring, when the contacts are closed, is equal to the contact spacing when the contacts are open.

(6) Inspect the motor shaft coupling for tightness and for signs of wear or play.

(7) Tighten the cam setscrews, the shaft coupling screws, and the contact screw

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locknuts. Tighten the screws and nuts on the gearbox. Tighten the tension spring, if necessary.

(8) Clean the contact points in the same manner as specified for relay contacts. Clean the bearing surface of the cams.

(9) Adjust the cams and the contact points.

(10) Lubricate in accordance with instructions in paragraphs 15 and 16.

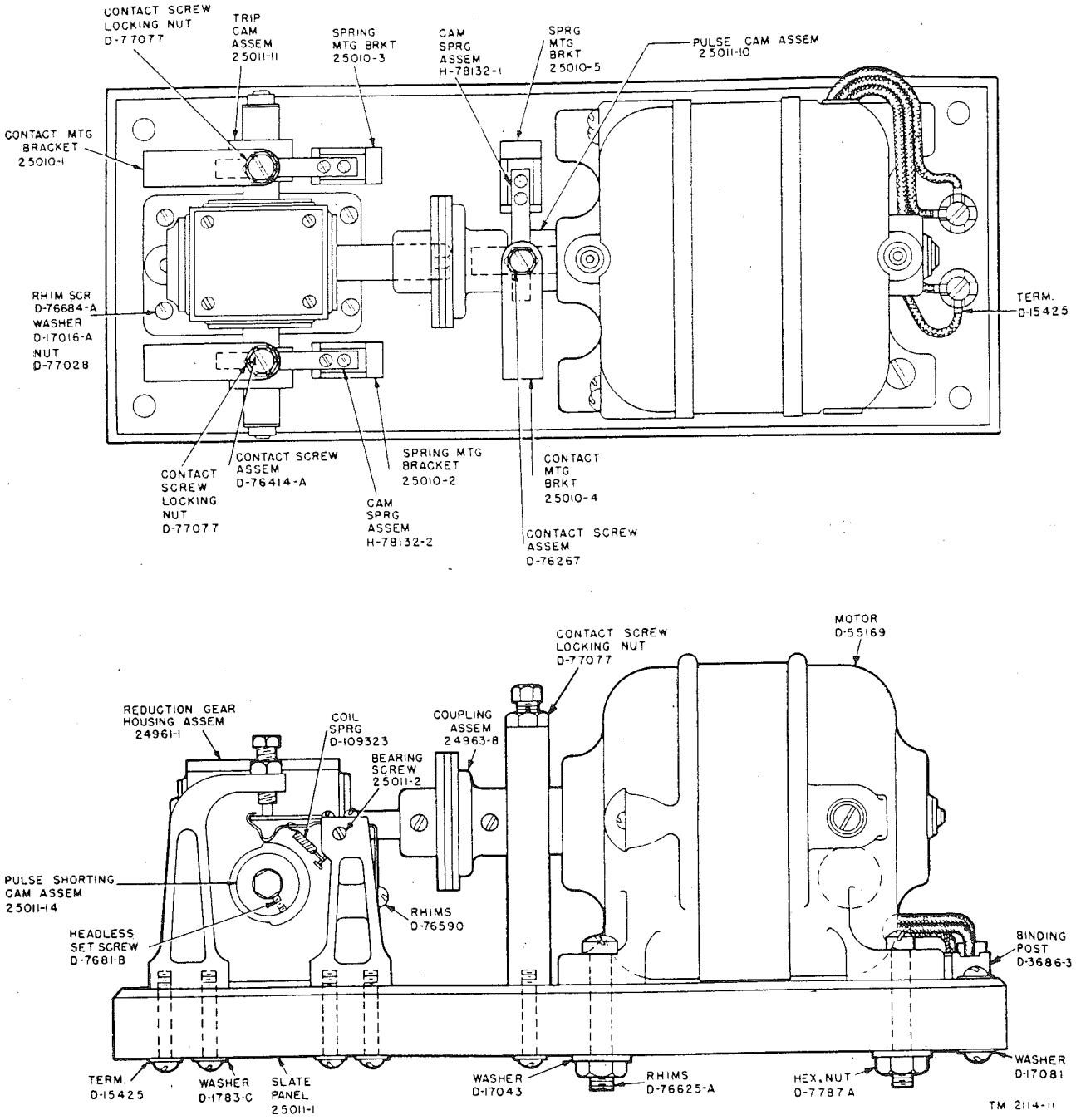


Figure 11. Interrupter assembly, with manufacturer's part numbers.

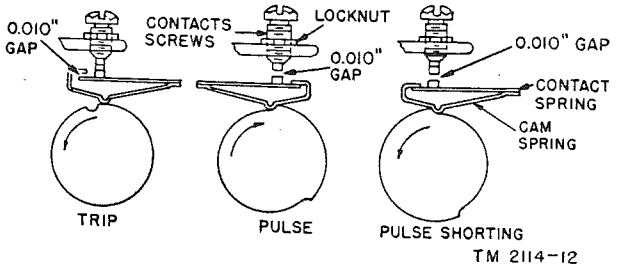


Figure 12. Position of interrupter cams at start of first pulse.

15. General

a. Since the test set is used only during periodic PM checking of the central office switching equipment, it does not require frequent lubrication. The proper interval for lubrication must be determined on the basis of actual operating time. Lubricate the test set before placing it in operation (par. 16). Inspect the lubrication points (fig. 13) monthly; lubricate when necessary. *Do not overlubricate.*

b. The following lubricants are used:

(1) Motor bearings — Oil, lubricating, Auto Elec Grade C, spec No. 5223.

(2) Interrupter cams — Oil, lubricating, spindle, Auto Elec spec 5231; WECo KS–6232.

(3) Interrupter gears — Oil, lubricating, Auto Elec Grade C, spec No. 5223.

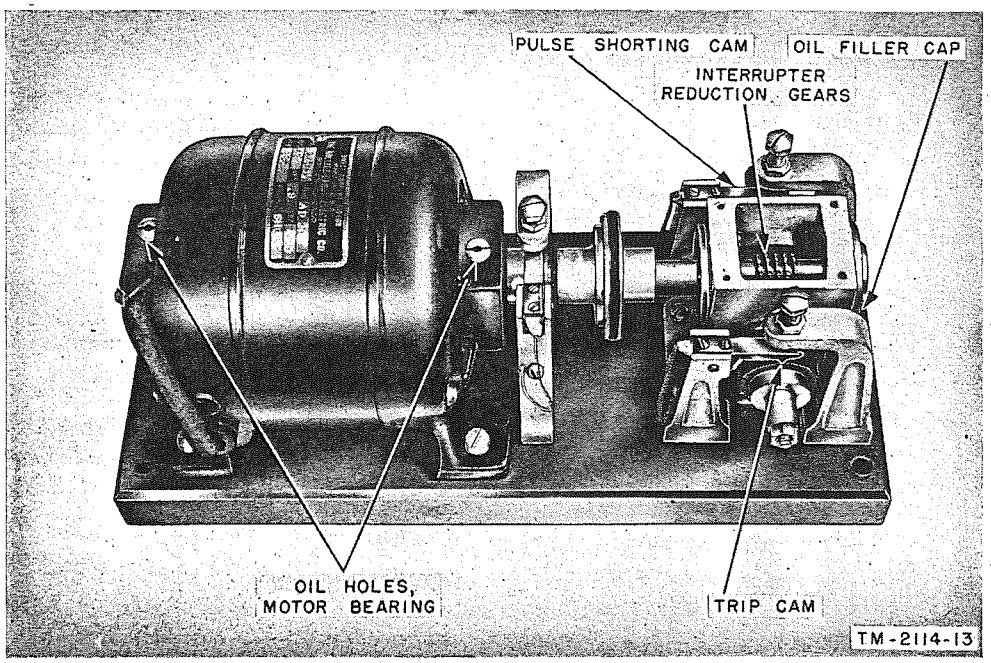


Figure 13. Lubrication points for stepping-switch test set.

16. Specific Instructions

a. Lubricate each bearing of the motor by placing 10 drops of oil, grade C, in each oilhole. Lubricate every 6 months, reducing this interval if necessary.

b. Lubricate the interrupter reduction gears with oil, grade C, by filling the case to within one-eighth inch of the top of the oil filler hole.

c. Lubricate the bearing surface of the interrupter cams with spindle oil, by distributing one *dip* of oil to the three cams (TM 11–2103).

d. Lubricate the hinges and catches on the cabinet with a small amount of light machine oil.

CHAPTER 4

REPAIR

Section I. THEORY OF EQUIPMENT

17. General

a. EFFECT OF LINE LOOP RESISTANCE UPON EQUIPMENT PFRFORMANCE. Periodic tests of the switching equipment of a dial central office are necessary for proper maintenance. The test set must simulate the conditions of resistance and leakage of the outside lines or loops. Figure 14–A represents a dial telephone substation connected through to step-by-step dial central office switching equipment over a line having infinite leakage resistance and a rather high series (loop) resistance. If there were no line resistance, pulsing relay A of the switching equipment would operate almost instantly when the dial contacts close, and relay A would release almost instantly when the dial contacts open. When relay A closes, it sends current to slow-acting relay B; when relay A releases, it sends a pulse of current to the vertical magnet. Too much loop resistance and too little line leakage reduces the current through the coil of relay A to a point at which relay A will be slow to operate, and will release too quickly on dial pulses because of insufficient magnetization. This gives relay B too little current to hold it operated between pulses and gives the vertical magnet too long a pulse, sometimes called a *heavy* pulse.

b. EFFECT OF LINE LEAKAGE UPON EQUIPMENT PERFORMANCE. Figure 14–B represents a line having low loop resistance and low insulation resistance. The high leakage current, flowing across the line, will hold relay A partially magnetized, even when the dial has opened the line circuit. Relay A will thus release too slowly and operate too fast in response to the dial pulses. The shunt line leakage will tend to maintain relay A operated too long, and the vertical magnet will get too short a pulse. High capacitance between one side of the line and the other, represented by the capacitor in figure 14–B, further adds to the effect of the low shunt resistance.

c. APPLICATION OF STEPPING-SWITCH TEST SET. The test set is designed to test central office switching equipment for operation at simulated practical working limits of line loop resistance and leakage. It has a motor-driven interrupter to supply simulated dial pulses of standard rate and duration. If the stepping action of the switching equipment in the central office is satisfactory when checked by the test set, it is considered that the equipment will operate well under normal line conditions and that no adjustments are necessary. The theory of the switching equipment is covered in other technical manuals (par. 3) and is not discussed in further detail in this manual. See figure 19 for a circuit schematic diagram. The following paragraphs outline the theory of the test set.

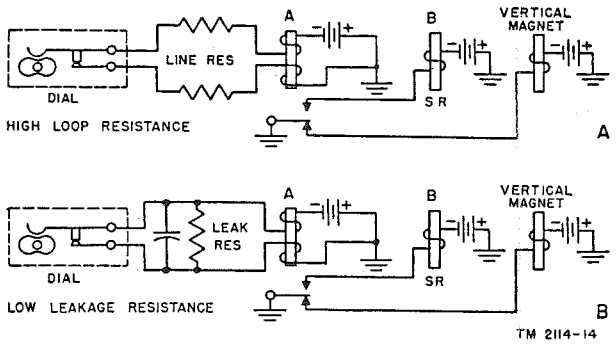


Figure 14. Effect of line resistance and leakage on pulsing of step-by-step equipment.

18. Battery Cord

The battery cord (Auto Elec D–57067–A) is a two-conductor rubber-covered cord, terminating in a three-conductor telephone plug at one end and specially shaped spring clips at the other end. (Note that the middle conductor of the telephone plug is unused (fig. 7).) The leads of the cord are color-coded; the red conductor is connected to the sleeve of the plug, and the white conductor is connected to the tip of the plug. To put the equipment in operation, connect the clip on the red lead to ground or + battery and the clip on the white lead to the equipment side of the fuses on the fuse panel of the switching equipment to be tested.

This connects + battery to terminal 8 on the terminal board of the test set, and — battery to terminal 1 (fig. 19).

19. Motor

a. The motor used to drive the interrupter assembly is a Holtzer-Cabot type AD motor, size 20, 1/60 hp (horsepower), with counterclockwise rotation. The motor connects to the battery terminal Nos. 1 and 8 on the terminal strip TS–1, with adjustable resistor R–8 in series with the + lead. When the battery cord is connected, the motor starts and continues to operate until the battery cord is disconnected. Adjust resistor R–8 to control the motor speed. With the central office battery voltage between 48.5 and 50 volts, the speed should be adjusted so that the pulses have a rate of 14 pulses per second, ± one-third pulse per second. Use a tachometer to determine motor speed. A tachometer cannot be used on the motor shaft, but it can be used on the cross shaft. This shaft turns at one-twentieth the speed of the motor; therefore a tachometer reading of 42 rpm (on the cross shaft) indicates a motor speed of 840 rpm, and so a pulse rate of 14 per second.

b. The interrupter assembly consists of a gearbox with 20 to 1 reduction, and three sets of contact springs, each operated by a cam. A flexible shaft coupling connects the driving shaft of the gearbox to the motor shaft. The driven shaft of the gearbox operates the cams for the pulse short-circuiting contacts and the trip contacts.

20. Relay

When battery and ground are connected to the BAT jack and the motor is running, the lower or starting winding of relay A (fig. 19) is energized through the contact springs SW–7 (shunt) or SW–8 (loop). Relay A operates, closing the circuit to its holding winding through contacts 1 and 2 of the relay, and through the trip contacts SW–3. Contacts 3 and 4 place a short circuit across the line contacts R and T in the test plug PL–1. This prevents transmission of pulses to the equipment being tested until the relay is released by operation of one of the test switches SW–7 or SW–8.

21. Pulse Contacts (SW–5)

The pulse spring contact assembly is mounted over the motor shaft, and the pulse cam operates at motor speed. The pulse cam is designed to close the pulse contacts for one-third revolution and to open the contacts for two-thirds revolution. At a motor speed of 840 rpm the pulse contacts supply pulses at a rate of 14 per second (each pulse with a nominal 61 percent open period).

22. Pulse Short-circuiting Contacts (SW–4)

The pulse short-circuiting contacts are mounted beside the gearbox, and the pulse short-circuiting cam is operated by the reduction gears at one-twentieth motor speed. When operated, the pulse short-circuiting contacts short-circuit the pulse contacts. The cam is designed to allow the pulse short-circuiting contacts to open for nine complete pulses.

23. Trip Contacts (SW–3)

The trip contacts, normally closed, are in series with the holding winding of relay A. When SW–7 or SW–8 is operated, the next operation of the trip cam opens the trip contacts momentarily. This permits relay A to release and to open the short circuit across the T and R contacts of the test plug during the interval when the pulse short-circuiting contacts are closed.

24. Series or LOOP Test

When the LOOP push-switch (SW–8) is operated, two of its contacts open the shunt around resistors R–5 (E) and R–6 (F), placing them in series with the test circuit, and the other two contacts open the circuit to the lower or starting winding of relay A. (Note that figs. 15, 18, and 19 show a third resistor, R–7 (G), in series with resistors R–5 (E) and R–6 (F), but permanently shunted; under special circumstances, the shunting strap may be opened, increasing the total resistance by 200 ohms.) Relay A remains operated through its holding winding. At the next operation of the trip contacts (SW–3), the circuit to the holding winding of relay A is opened and the relay releases, removing the short circuit across the line through its

contacts 3 and 4. The line is now short-circuited through the pulse short-circuiting contacts (SW–4). When the pulse short-circuiting cam opens SW–4, a group of 9 pulses is transmitted by the pulse contacts to the T and R contacts of the test plug, in series with 1,000 ohms. If SW–8 is released, relay A operates at the next operation of the pulse short-circuiting contacts (SW–4), and the test line is again short-circuited by relay contacts 3 and 4. When SW–8 is held operated, the test set continues to send pulses in groups of nine until SW–8 is released. This simulates dialing from a substation, over a line of 1,000 ohms resistance and no leakage.

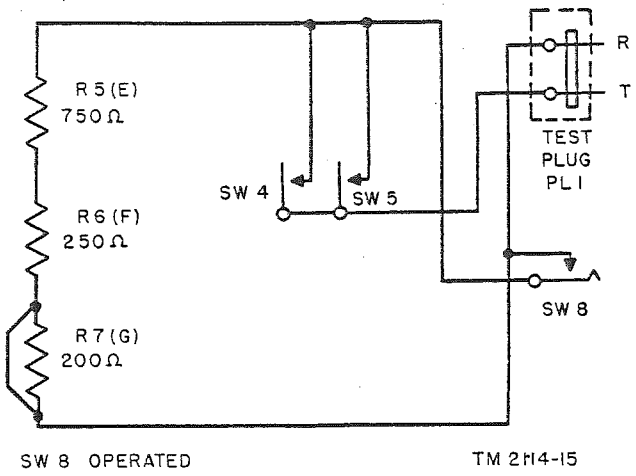


Figure 15. Functional diagram, LOOP test.

25. SHUNT Test

When the SHUNT push-switch (SW–7) is operated, two of its contacts open the circuit to the starting winding of relay A, and the next operation of SW–3 and SW–4 permits pulses to be transmitted to the R and T contacts of the test plug. The other two contacts close the circuit to R–1 (A), R–2 (B), and R–3 (C) in shunt with the R and T contacts. The test set now simulates dialing from a substation, over a loop with negligible series resistance and 15,000 ohms leakage resistance. (Note that a fourth resistor, R–4 (D), shown permanently shunted in figures 16, 18, and 19 may be used to increase the leakage resistance to 20,000 ohms if the shunting strap is opened.)

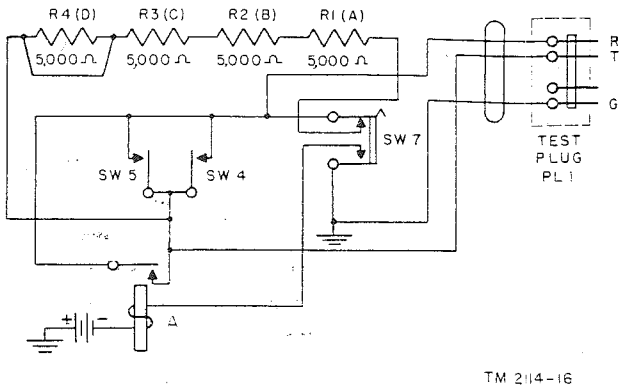


Figure 16. Functional diagram, SHUNT test.

26. Release

After release of the LOOP push-switch (SW–8) or the SHUNT push-switch (SW–7), operate the RLSE push-switch (SW–6). Relay A again operates, preventing any further test pulses from reaching the equipment under test, and SW–6 opens the circuit to the T and R contacts of the test plug, permitting the equipment under test to release.

27. Relay B Test

Relay B of step-by-step switching equipment is slow-release, remaining operated during the dialing sequence. Operation of the B RY TST—NOR switch (SW–2) to its B RY TST position opens the circuit to the pulse contacts (SW–5). Consequently no pulses are sent during the interval that the pulse short-circuiting contacts (SW–4) are open, and the circuit to R and T of the test plug remains open long enough to permit release of relay B in the equipment under test, if relay B is functioning properly.

Section II. TROUBLE-SHOOTING PROCEDURES

28. Fault Location

a. COMMON FAULTS. Faulty operation of the stepping-switch test set may be caused by failure of the loading resistors, the motor, or the interrupter assembly. Faulty operation of the shunt resistors R–1, R–2, R–3, and R–4 will not be as easily apparent as faulty operation of the loop series resistors R–5, R–6, and R–7.

Faults in the shunt resistors must be located by resistance tests.

b. INTERRUPTER ASSEMBLY. When uncertain whether the interrupter assembly is functioning properly, check the positions of the cams and the contact spacing. Figure 12 shows the proper position of the cams at the start of a group of pulses. Note that the trip contacts (SW–3) open just before the pulse short-circuiting contacts (SW–4), and close at the time the pulse short-circuiting contacts open. Also note that the pulse short-circuiting contacts begin to open at the moment when the pulse contacts (SW–5) are closed. Faulty operation may be due to slipping of the cams on the driving shafts, or slipping of the motor shaft coupling. Do not readjust the cams unless it is certain that the sequence of operation is incorrect. Check the cam positions through several sequences, operating the motor shaft by hand.

c. CIRCUIT SCHEMATIC AND WIRING DIAGRAM. Figure 19, circuit schematic diagram, and figure 18, wiring diagram, are included in this manual to aid in understanding the circuit of the test set.

29. Trouble-shooting Chart

Symptom	Probable fault
Motor does not start.	Battery cord improperly connected or failure of cord. Adjustable resistor R–8 open. Defective or worn motor brushes. Defective motor. Shelf power circuit open.
No pulses transmitted to the equipment under test when LOOP switch (SW–8) is operated.	Test plug not making proper contact. Relay B test switch (SW–2) set in wrong position or contacts not making. Open or short-circuited conductors in cords. Resistors R–5 or R–6 open. Relay A fails to release. SW–7 lower contacts do not make. SW–8 contacts do not open. Contacts of SW–3, SW–4, or SW–5 do not open.
No pulses transmitted to the equipment under test when SHUNT switch (SW–7) is operated.	Test plug not making proper contact. Open or short-circuited conductors in cord. Relay B test switch (SW–2) set in wrong position or contacts not making. Relay A fails to release. Contacts of SW–8 do not make. Break contacts SW–7 do not open. Contacts of SW–3, SW–4, or SW–5 do not open.
Pulses are transmitted when SW–7 or SW–8 is not operated.	Contacts on SW–7 or SW–8 do not make. Relay A fails to operate. Contacts on relay A do not make properly. Break contacts on J–2 (CTJ) open.
Pulses are not sent in groups of nine.	Cams improperly adjusted. Slipping of cams or motor shaft coupling. Pulse short-circuiting contacts (SW–4) do not make.

Section III. REPAIRS AND ADJUSTMENTS

30. Replacement of Parts

a. Since the test set is not in constant service, repairs necessitated by wearing out of the apparatus will be uncommon. Most of the faults occurring in service can be corrected by adjustments. Should failure of any part occur, replace it instead of attempting repair, except when necessary to keep the equipment in operation while a replacement part is being obtained.

b. All replaceable parts in the test set are easily accessible and are secured to the cabinet by wood screws. When replacing any part, remove the mounting screws and unsolder the wiring leads. Carefully tag each lead as it is removed from its terminal for reference in rewiring. Install the new part in the same location, using the original mounting screws. In soldering the leads, do not apply excessive heat to the terminals; this may damage the equip-

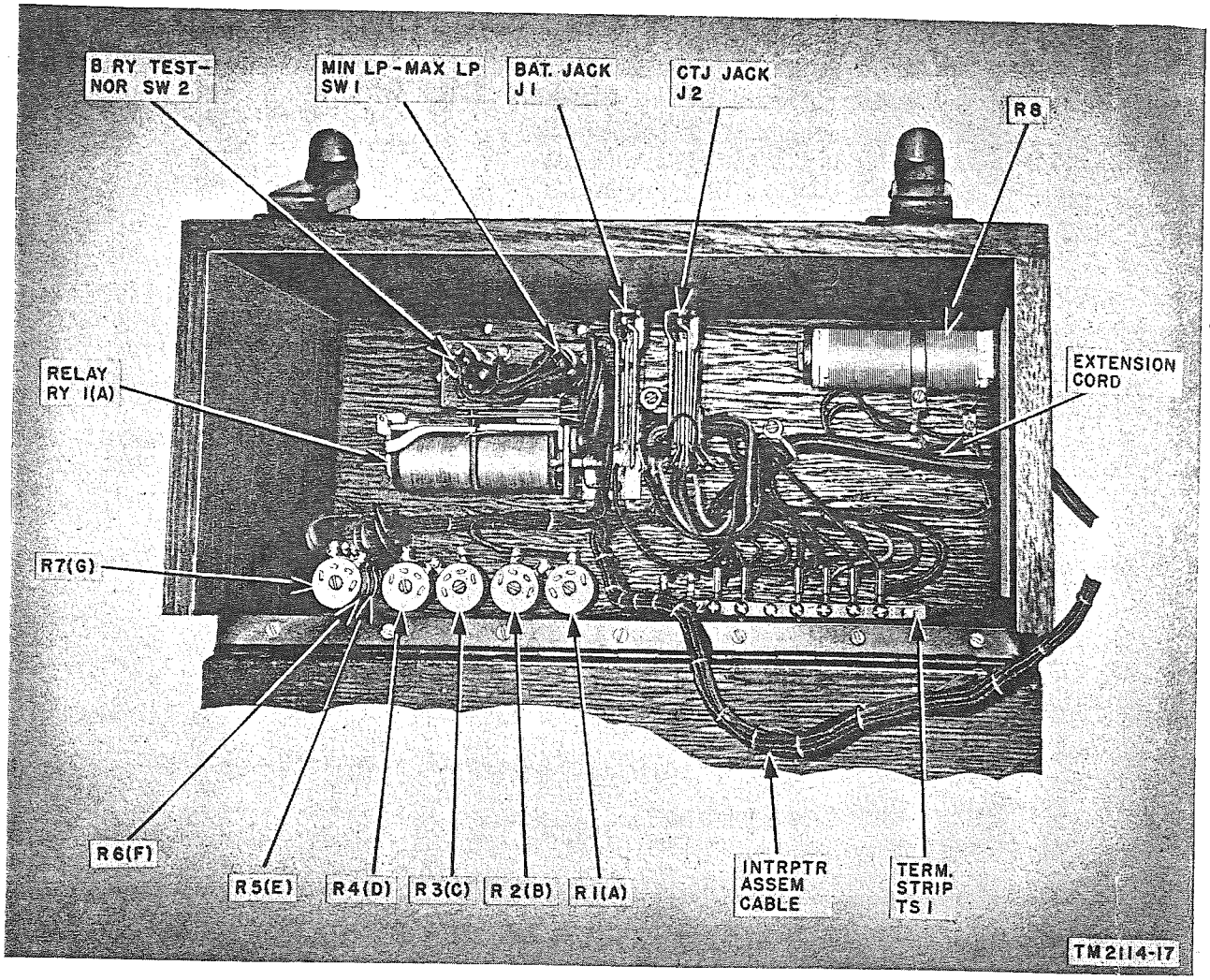


Figure 17. Cabinet-mounted parts of stepping-switch test set.

ment. Refer to figure 17 when replacing parts mounted in the cabinet, and to figure 11 when replacing parts in the interrupter assembly. Figure 18 is the wiring diagram of the test set.

c. When contacts of the relay, switches, or jacks do not make reliably, refer to TM 11–2103 for procedure in cleaning and burnishing contacts and adjusting contact springs. Standards for adjustment of relay and switch contact springs are given in paragraph 31.

31. Adjustments

a. RELAY ADJUSTMENTS. Use the *current-flow test set* when testing and adjusting relay A in the stepping-switch test set. Refer to TM 11–2103 for relay adjustment procedure.

(1) Connect the battery leads of the *current-flow test set* to (+) and (—) central office battery in the usual manner. Do not connect the battery cord to the stepping-switch test set. Connect the OUT TEST leads of the current-flow test set to the terminals on the BAT jack (J–1) inside the stepping-switch test set.

(2) Adjust the relay to the values in the following table:

Armature residual gap: 0.0015″	Armature stroke: 0.010″	Armature gagging for contact make: 0.006″
Operate (adjust value): 3,200 ohms 0.0110 amp	Nonoperate (adjust value): 3,600 ohms 0.0100 amp	*Note.* Insulate the trip spring contacts of SW–3 so that only the No. 1 winding of relay A is energized.
Operate (test value): 2,800 ohms 0.0121 amp	Nonoperate (test value): 4,100 ohms 0.0090 amp	

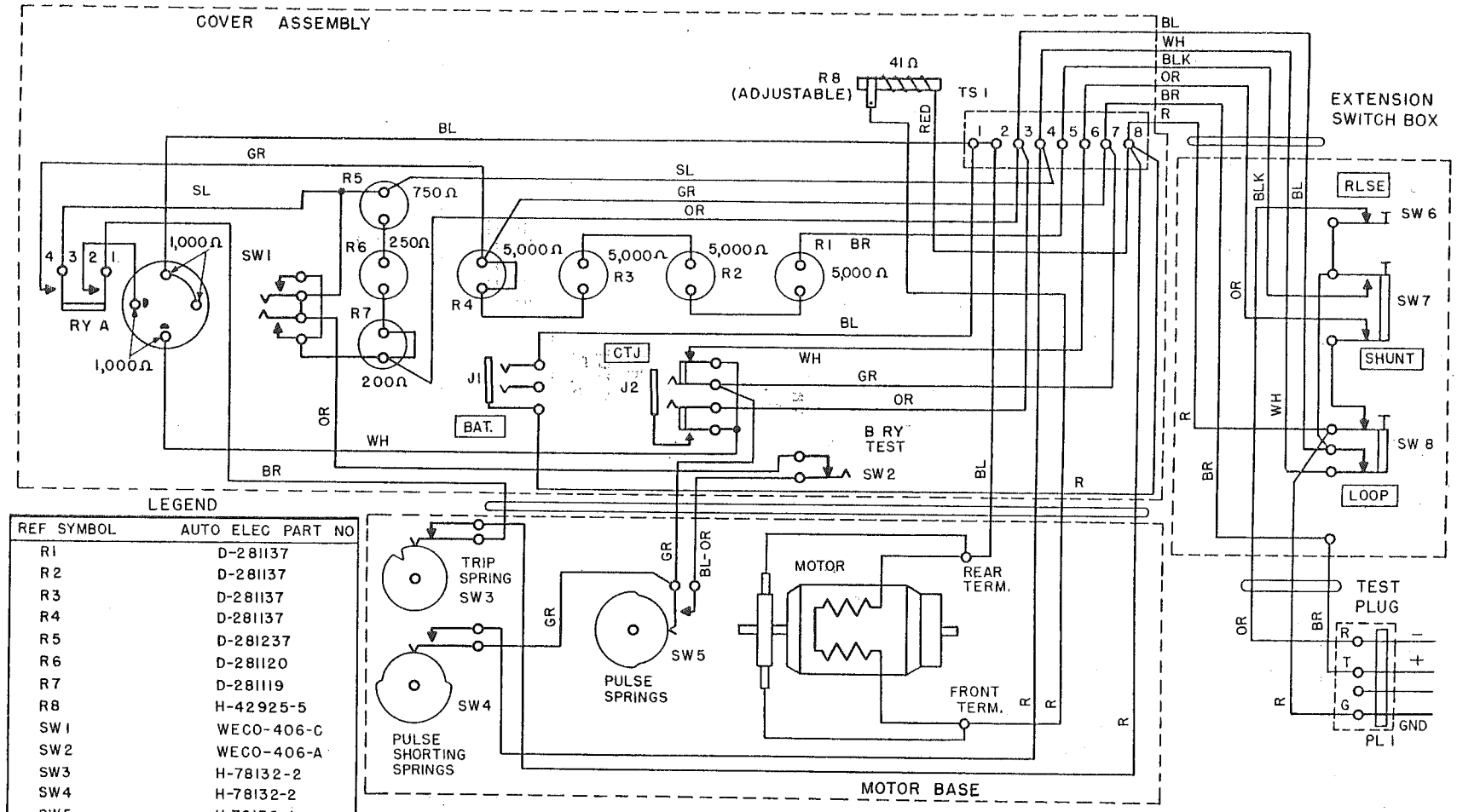
b. INTERRUPTER CONTACT ADJUSTMENT. The contact adjustment values are shown in figure 12. The correct spacing between contacts when open is 0.010 inch for the trip, pulse, and pulse short-circuiting contacts. When the contacts are closed, there must be a gap between the end of the contact spring and the cam spring equal to the contact spacing (0.010 inch). Adjust the contacts by loosening the contact screw locknut (fig. 11), by turning the contact screw until the spacing is correct, and then by tightening the locknut.

c. INTERRUPTER CAM ADJUSTMENT. Adjust the pulse short-circuiting cam so that nine full operations are made by the pulse contacts (SW–5) during the interval that the pulse short-circuiting contacts are open. After the ninth contact break, the pulse contacts must again make before the pulse short-circuiting contacts make. Adjust the trip cam so that the trip contacts open just before the pulse short-circuiting contacts open. Adjust one cam at a time by loosening the setscrew securing it to the shaft, turning the motor shaft by hand until the cam position is correct, and then tightening the setscrew.

d. PUSH-SWITCH ADJUSTMENTS. Adjust the push-switches in accordance with the procedure shown in TM 11–2103. The first contact springs on the SHUNT, LOOP, and RLSE switches must hold the push buttons firmly in place. The contact follow of make contacts must not be less than one thirty-second inch. The contact separation of make contacts must not be less than 0.010 inch or more than 0.035 inch with the push button not operated. The contact separation of break contacts, with the push button fully operated, must be 0.030 inch. If a spring balance that reads in grams is available, the combined tension of all contact springs, as indicated on the balance, must not be less than 500 grams or more than 1,000 grams.

e. ROTARY SWITCH ADJUSTMENTS. Adjust the rotary switches (turn keys) in the same manner as the push-switches. The minimum contact separation in the nonoperated position must be 0.010 inch and there must be perceptible contact follow when the contacts make.

f. MOTOR. The motor speed is adjusted by means of variable resistor R–8. When the voltage applied to the motor is 48.5 volts, the motor speed should be at least 840 rpm; when the applied voltage is 52 volts, the motor speed should not exceed 952 rpm. A tachometer may be used to determine motor speed (par. 19*a*). This test need not be made unless the motor is removed for repair, or known not to be operating properly. Replace the motor brushes when worn to a length less than three-eighths inch. New brushes should be five-eighths inch long, not including the spring. The motor shaft should turn freely in the bearings. Excessive noise and vibration when running, or overheating or sparking at the brushes, are indications of motor trouble that require major repair or replacement of the motor. Under normal conditions, the motor should operate satisfactorily throughout the life of the test set.

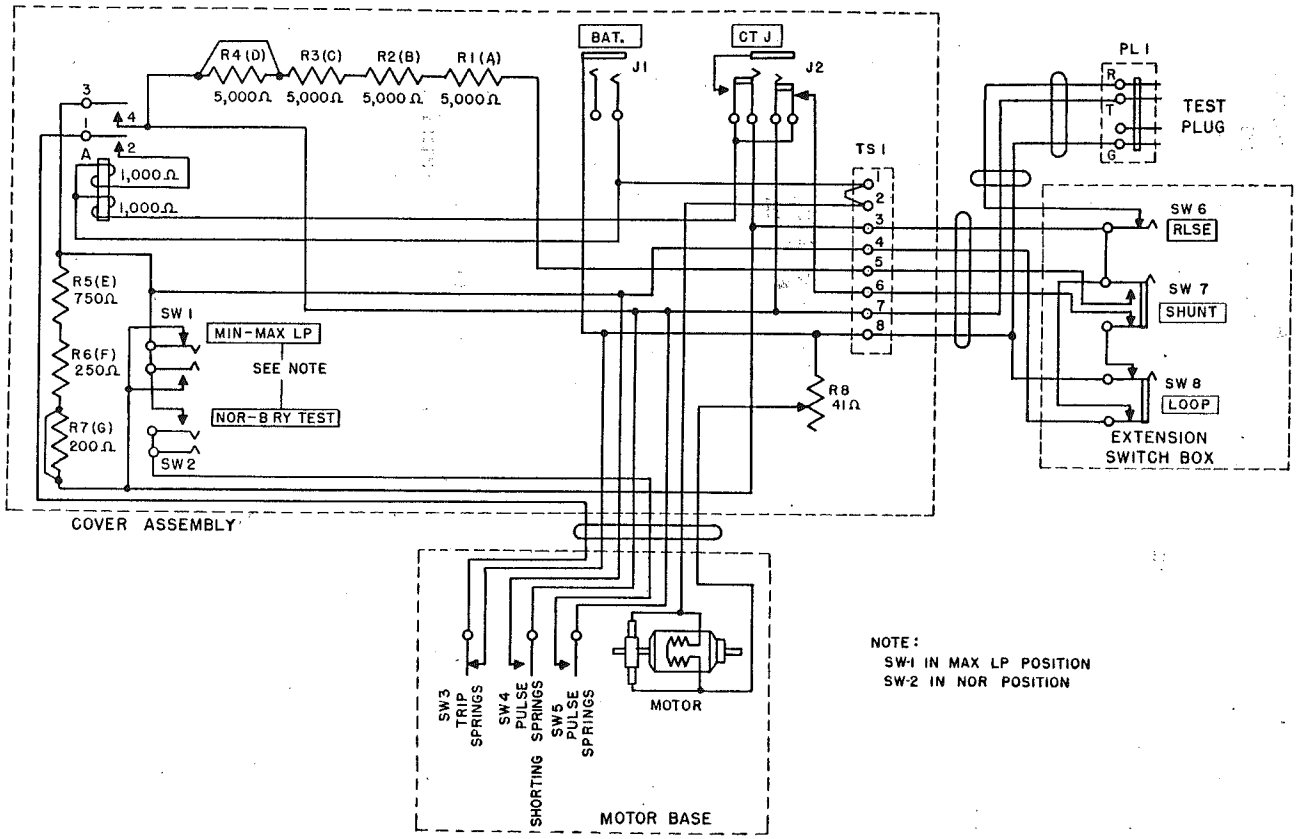


LEGEND

REF SYMBOL	AUTO ELEC PART NO
R1	D-281137
R2	D-281137
R3	D-281137
R4	D-281137
R5	D-281237
R6	D-281120
R7	D-281119
R8	H-42925-5
SW1	WECO-406-C
SW2	WECO-406-A
SW3	H-78132-2
SW4	H-78132-2
SW5	H-78132-1
SW6	D-320149
SW7	D-320149
SW8	D-320149
J1	WECO-238-B
J2	WECO-243-B
PL 1	D-576308240A
TS 1	D-310161
MOTOR	D-55169
RELAY A	R-363-B1

TM 2114-18

Figure 18. Wiring diagram, stepping-switch test set.



LEGEND

REF SYMBOL	AUTO ELEC PART NO.
R1(A)	D-281137
R2(B)	D-281137
R3(C)	D-281137
R4(D)	D-281137
R5(E)	D-281237
R6(F)	D-281120
R7(G)	D-281119
R8	H-42925-5
SW1	WECO-406-C
SW2	WECO-406-A
SW3	H-78132-2
SW4	H 78132-2
SW5	H-78132-1
SW6	D-320149
SW7	D-320149
SW8	D-320149
J1	WECO-238-B
J2	WECO-243-B
PL1	D-5763 OR 240A
TS1	D-310161
MOTOR	D-55169
RELAY A	R-363-B1

Figure 19. Circuit schematic, stepping-switch test set.

APPENDIX I

REFERENCES

Note. For availability of items listed, consult FM 21–6 and Department of the Army Supply Catalog SIG 1. Also see the latest issue of FM 21–6 for applicable technical bulletins, supply bulletins, modification work orders, and Changes.

1. Supply Publications

SIG 1, Introduction and Index.
SIG 3, List of Items for Troop Issue.
SIG 4–1, Allowances of Expendable Supplies.
SIG 4–2, Allowances of Expendable Supplies for Tactical Organizations, Training Centers, Boards, and Fixed Installations.
SIG 5, Stock List of All Items.
SIG 7 & 8, Organizational and Higher Echelon Spare Parts.
SB 11–76, Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.

2. Technical Manuals on Test Equipment

TM 11–2017, Test Set TS–26/TSM.
TM 11–2019, Test Set I–49.
TM 11–2036, Test Set I–181.
TM 11–2613, Voltohmmeter I–166.

3. Packaging and Packing Instructions

a. JOINT ARMY-NAVY PACKAGING SPECIFICATIONS.
JAN–D–169, Desiccants, Activated.
JAN–P–100, General Specification.
JAN–P–106, Boxes, Wood, Nailed.
JAN–P–116, Preservation, Methods of.
JAN–P–125, Barrier Material, Waterproof.
JAN–P–131, Barrier Material, Moisture-Vaporproof, Flexible.

b. U. S. ARMY SPECIFICATIONS.
100–2E, Marking Shipments by Contractors (and Signal Corps Supplements thereto).

c. SIGNAL CORPS INSTRUCTIONS.
720–7, Standard Pack.
726–15, Interior Marking.

4. Other Publications

TM 1–455, Electrical Fundamentals.
TM 11–453, Shop Work.
TM 11–458, Common Battery Telephone Equipment.
TM 11–486, Electrical Communication Systems Engineering.
TM 11–498, Fundamentals of Telephony and Manual Telegraphy.

5. Forms

WD AGO Form 468 (Unsatisfactory Equipment Report).
AF Form 54 (Unsatisfactory Report).

APPENDIX II

IDENTIFICATION TABLE OF PARTS

Note. The fact that an item appears in this manual is not sufficient basis for requisitioning the part. Requisitions must cite an authorized basis, such as T/O&E, T/A, T/BA, SIG 6, SIG 7 & 8, SIG 7–8–10, SIG 10, list of allowances of expendable material, or another authorized supply basis. For an index of available supply catalogs in the Signal portion of the Department of the Army Supply Catalog, see the latest issue of SIG 1, Introduction and Index.

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
TS–1	BOARD, terminal: binding post strip for control box cords; 8 straight cylindrical term (AE Part No. D–310161).	Interconnects the test set circuits, and connects test set with equipment under test.	
	CORD, battery: 2 tinsel cond, color-coded red and white; alligator clips (WECo #59) on one end and one plug (WECo #110) on other end (AE Part No. 57067A).	Supplies test set with energy from battery.	
J–1	JACK, telephone: for 2 cond plug, cont arranged J–2; WECo type #238–B (WECo Part No. 238–B).	Connects battery cord to test set.	
J–2	JACK, telephone: for 2 cond plug cont arranged J–2–1A1B (WECo Part No. 243–B).	May be used to connect test set with other test equipment; *normally not used.*	
	MOTOR: Holtzer-Cabot type AD, size 20, 1/60 hp; counterclockwise rotation (AE Part No. D–55169).	Drives interrupter assembly.	
PL–1	PLUG, test (AE Part No. D–5763 or 240A).	Connects test set to equipment to be tested.	
Relay A	RELAY, two-winding: contacts arranged 2A, rated 3 amp, dual wound coil 46 vdc (AE Part No. R–363–B1).	Controls transmission of pulses to equipment under test.	
R–8	RESISTOR, adjustable: 41 ohms, 1 adjustable slide (AE Part No. H–42925–5).	Controls the speed of the motor.	
R–7	RESISTOR, fixed: WW, noninductive, 200 ohms (AE Part No. D–281119).	May be used to provide additional series loop resistance; *normally strapped out.*	
R–6	RESISTOR, fixed: WW, noninductive, 250 ohms (AE Part No. D–281120).	Provides series loop resistance.	
R–1, R–2, R–3, R–4	RESISTOR, fixed: WW, noninductive, 5000 ohms (AE Part No. D–281137).	Provides leakage (shunt) resistance; *R–4 normally strapped out.*	
R–5	RESISTOR, fixed: WW, noninductive, 750 ohms (AE Part No. D–281237).	Provides series loop resistance.	

Ref. symbol	Name of part and description	Function of part	Signal Corps stock No.
SW–1	SWITCH: two-position, rotary; marked MIN LP—MAX LP (WECo–406–C).	Controls series resistance of loop test circuit.	
SW–2	SWITCH: two-position, rotary; marked B RY TST—NOR (WECo–406–A).	Tests release of relay B in equipment under test.	
SW–3	SWITCH: trip (AE Part No. H–78132–2).	Controls flow of energy to holding winding of relay A.	
SW–4	SWITCH: pulse short-circuiting; cam operated (AE Part No. H–78132–2).	Short-circuits the pulse contacts, and controls the number of pulses transmitted to the equipment under test.	
SW–5	SWITCH: pulse; cam operated (AE Part No. H–78132–1).	Opens and closes circuit that transmits pulses to equipment under test.	
SW–6	SWITCH, push: marked RLSE (AE Part No. D–320149).	Releases the equipment under test.	
SW–7	SWITCH, push: four contacts; marked LOOP (AE Part No. D–320149).	Places R–1, R–2 and R–3 in parallel with the test circuit, and controls flow of energy to starting winding of relay A.	
SW–8	SWITCH, push: four contacts; marked SHUNT (AE Part No. D–320149).	Places R–5 and R–6 in series with the test circuit, and controls the flow of energy to the starting winding of relay A.	

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