

# TM 11-2111

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

---

TOOLS  
TESTING EQUIPMENT  
AND COMMON SUPPLIES  
STEP-BY-STEP DIAL  
CENTRAL  
OFFICE EQUIPMENT

---

DEPARTMENT OF THE ARMY • MAY 1950

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

TM 11-2111

---

TOOLS  
TESTING EQUIPMENT  
AND COMMON SUPPLIES  
STEP-BY-STEP DIAL  
CENTRAL  
OFFICE EQUIPMENT

---



DEPARTMENT OF THE ARMY

MAY 1950

---

United States Government Printing Office

Washington: 1950

DEPARTMENT OF THE ARMY  
WASHINGTON 25, D. C., 10 May 1950

TM 11-2111 is published for the information and guidance of all concerned.

[AG 300.7 (29 Nov 49)]

By ORDER OF THE SECRETARY OF THE ARMY:

OFFICIAL:

J. LAWTON COLLINS  
*Chief of Staff, United States Army*

EDWARD F. WITSELL  
*Major General, USA*  
*The Adjutant General*

DISTRIBUTION:

Tech Sv (2) except 11 (50); Arm & Sv Bd (1); AFF Bd (ea Sv Test Sec) (1); AFF (5); OS Maj Comd (5); Base Comd (3); MDW (5); A (5); CHQ (2); FC (2); Sch (2) except 11 (10); Gen Dep (2); Dep 11 (5); Tng Ctr (2); PE (10), OSD (2); Lab 11 (2); 4th & 5th Ech Maint Shops 11 (2); Two (2) copies to each of the following T/O&E's: 11-47; 11-107; 11-127; 11-500 GA,GB,GC, GD,GE,GH; 11-587; 11-592; 11-597; SPECIAL DISTRIBUTION.

For explanation of distribution formula, see SR 310-90-1.

# CONTENTS

	<i>Paragraph</i>	<i>Page</i>
<b>CHAPTER 1. INTRODUCTION</b>		
<i>Section I. General.</i>		
Scope .....	1	1
Forms and records .....	2	1
References .....	3	1
<i>II. Description and Data of Test Equipment.</i>		
General .....	4	1
Type 1 test desk .....	5	1
Test sets supplied by the manufacturer .....	6	2
Other test equipment supplied by the manufacturer .....	7	5
Signal Corps standard test equipment .....	8	6
Dial speed and pulse ratio test set .....	9	7
Type 31 portable dial speed test set .....	10	8
Buzzer test set .....	11	9
Test stand .....	12	10
<b>CHAPTER 2. OPERATING INSTRUCTIONS AND THEORY OF OPERATION FOR TEST EQUIPMENT.</b>		
Test handset .....	13	11
Test lamp .....	14	12
Dial speed and pulse ratio test set .....	15	13
Type 31 portable dial speed test set .....	16	17
Buzzer test set .....	17	19
Test stand .....	18	19
<b>CHAPTER 3. MAINTENANCE TOOLS AND MATERIALS.</b>		
Maintenance tools, materials, and supplies .....	19	20
Maintenance spare parts .....	20	29
<b>CHAPTER 4. DEMOLITION OF MATÉRIEL TO PREVENT ENEMY USE.</b>		
General .....	21	30
Methods of destruction .....	22	30
Destruction of components .....	23	30
<b>APPENDIX. REFERENCES</b> .....		31

# CHAPTER 1

## INTRODUCTION

---

### Section I. GENERAL

#### 1. Scope

These instructions are published for the information and guidance of personnel to whom this equipment is issued. They contain basic information on the special tools, test equipment, and common supplies required by operating and maintenance personnel in a *typical* step-by-step dial central office. They list and describe briefly the special tools, test sets, installation materials, and maintenance spare parts supplied initially by the manufacturer, as well as the common tools, standard test sets, and general maintenance materials obtained through regular supply channels.

#### 2. Forms and Records

a. The following forms are used in reporting receipt, operation, and maintenance of the equipment:

- (1) NME Form 6 (Report of Damaged or Improper Shipment) for equipment used by Army Field Forces and technical services will be filled out and forwarded in accordance with SR 745-45-5 or AF'R 71-4, when equipment is received in a damaged condition or when it is necessary to report unsatisfactory preservation, packaging, packing, marking, loading, unloading, and handling of supplies.
- (2) DA AGO Form 468 (Unsatisfactory Equipment Report) for equipment used

by the Army will be filled out and forwarded through channels to the Office of the Chief Signal Officer, Washington 25, D. C., when trouble occurs more often than is normal, as determined by qualified repair personnel.

- (3) AF Form 54 (Unsatisfactory Report) for equipment used by the Air Force will be filled out and forwarded to Commanding General, Air Matériel Command, Wright-Patterson Air Force Base, Dayton, Ohio, in accordance with AF Regulation 15-54.

b. Use other forms and records as authorized.

#### 3. References

This manual is one of a series of 15 technical manuals dealing with the equipment which comprises a typical step-by-step dial central office. Detailed information on the operation, maintenance, and installation of this central office equipment is given in the other manuals of the series, listed in the appendix. The appendix also contains a list of current references, including supply catalogs, technical manuals, packaging specifications, and other available publications. In addition, it lists the forms required for use by using personnel in the performance of prescribed operations. General maintenance procedures and routines involving the use of tools, test sets, and supplies described in this manual are covered in TM 11-2103.

### Section II. DESCRIPTION AND DATA OF TEST EQUIPMENT

#### 4. General

Most step-by-step dial central offices are equipped with a type 1 wire chief's test desk, which provides centralized testing facilities for the maintenance of both the central office and outside plant equipment, and with several portable test sets for routine testing of the central office switching equipment. These test sets include a connector routine test set, a current-flow test set, and a test handset. Other test equip-

ment, sometimes required by dial central office maintenance men or by outside plant repairmen, can be obtained through regular supply channels.

#### 5. Type 1 Test Desk

The wire chief's test desk is the major center for fault location and equipment tests in a typical step-by-step dial central office. Although additional test sets are used in the central office, most basic tests

can be performed from the test desk. Detailed information and operating instructions on the type 1 test desk are given in TM 11-2110. Other tools and test equipment used in dial central office maintenance are described in TM 11-372 and TM 11-487. The following test equipment components and circuits comprise the type 1 test desk:

a. **VOLT-OHM-MILLIAMMETER.** This multirange meter has ranges of 0-15, 0-150, and 0-600 volts, 0-150 and 0-600 milliamperes, and 0-5,000, 0-50,000 and 0-500,000 ohms. It is used primarily as a continuity tester in determining the nature and extent of electrical faults within the central office.

b. **WHEATSTONE BRIDGE.** The Wheatstone bridge is a precision resistance bridge which has a range of 1 ohm to 10 megohms. It is used to make general-purpose resistance measurements and to detect cable faults in the outside plant equipment.

c. **DIAL SPEED AND PULSE RATIO TEST SET.** This test set measures dial speeds in pulses per second and the percent make (pulse ratio) of dial pulse spring contacts.

d. **HOWLER AND INSULATION BREAK-DOWN TEST CIRCUIT.** The howler circuit provides a loud tone to signal a telephone user when a handset is left off the cradle and no call is in progress. The insulation break-down test circuit is used to test telephone lines for break-down of insulation upon the application of a high potential.

e. **TEST CORD AND TEST TRUNK CIRCUITS.** The test cord circuits connect the test desk to the desired test trunks. The test trunk circuits permit direct connection for test purposes from the test desk to any telephone line of the central office.

f. **NIGHT ALARM CIRCUIT.** The night alarm circuit provides an audible alarm, or buzzer sound, on incoming calls during night service or periods when the test desk is unattended.

g. **IN-CALL AND OUT-CALL WIRE CIRCUITS.** These call-wire circuits permit intercommunication between two or more test desks or between a test desk and an information center, repair center, or switchboard.

## 6. Test Sets Supplied by the Manufacturer

a. **CONNECTOR ROUTINE TEST SET.** The connector routine test set (fig. 1) is used for the routine testing of the regular connectors, PBX (Private Branch Exchange) connectors, and reverting-call switches in a typical step-by-step dial central office. Detailed

theory of operation and operating instructions for the connector routine test set are covered in TM 11-2113. This test set checks the following functions of connectors and reverting-call switches:

- (1) *Connector functions tested.* The connector routine test set tests the following functions of connectors:
  - (a) Vertical and rotary stepping from pulses over a high-resistance loop.
  - (b) Vertical and rotary stepping from pulses over a loop having low leakage resistance.
  - (c) Returning busy tone when stepped to a busy line.
  - (d) Extension of ringing current to the called line and ring-back tone to the calling line when the wipers are stepped to an idle line or trunk.
  - (e) Completion of the talking circuit over an idle line or trunk.

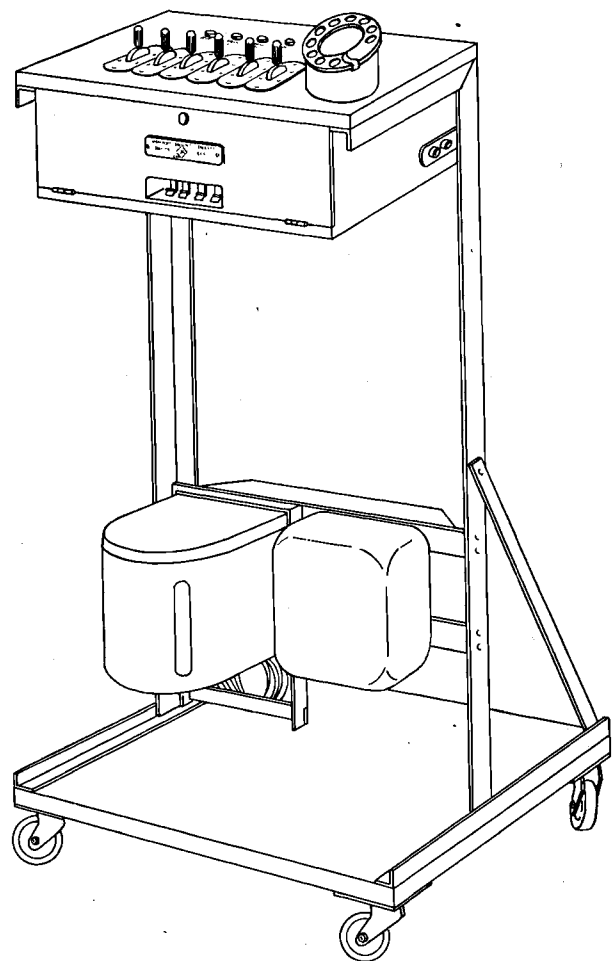


Figure 1. Connector routine test set.

TM 2111-1

- (f) Release of the connector when the last (calling or called) party hangs up.
- (2) *Reverting-call switch functions tested.* The following functions of reverting-call switches are checked by the connector routine test set:
- (a) Pulsing over a loop which has a resistance higher than normal to seize a reverting-call switch.
  - (b) Reverting-call ringing over a line which has a higher than normal resistance.
  - (c) Ringing cut-off when called party answers.
  - (d) Release when the last party hangs up.
- b. CURRENT-FLOW TEST SET.
- (1) *Application.* Relays used in step-by-step dial central office equipment are tested and adjusted in accordance with electrical performance requirements by a current-

flow test set. This test set measures the *electrical operate* value, or specified minimum current through the relay windings to operate the relay, and the *electrical nonoperate* value, or the maximum current flow through the windings without operating the relay. It consists of sets of adjustable resistance banks, a milliammeter, and suitable operating controls. The resistance banks are adjusted until the marginal *operate* and *nonoperate* current-flow values are indicated on the milliammeter, in accordance with circuit requirement tables or relay adjustment sheets prepared by the manufacturer. The operate and nonoperate test, performed with the current-flow test set, gives an accurate indication of the operating efficiency of relays. When readjusting a relay, using the current-flow test set, the relay contact springs are ten-

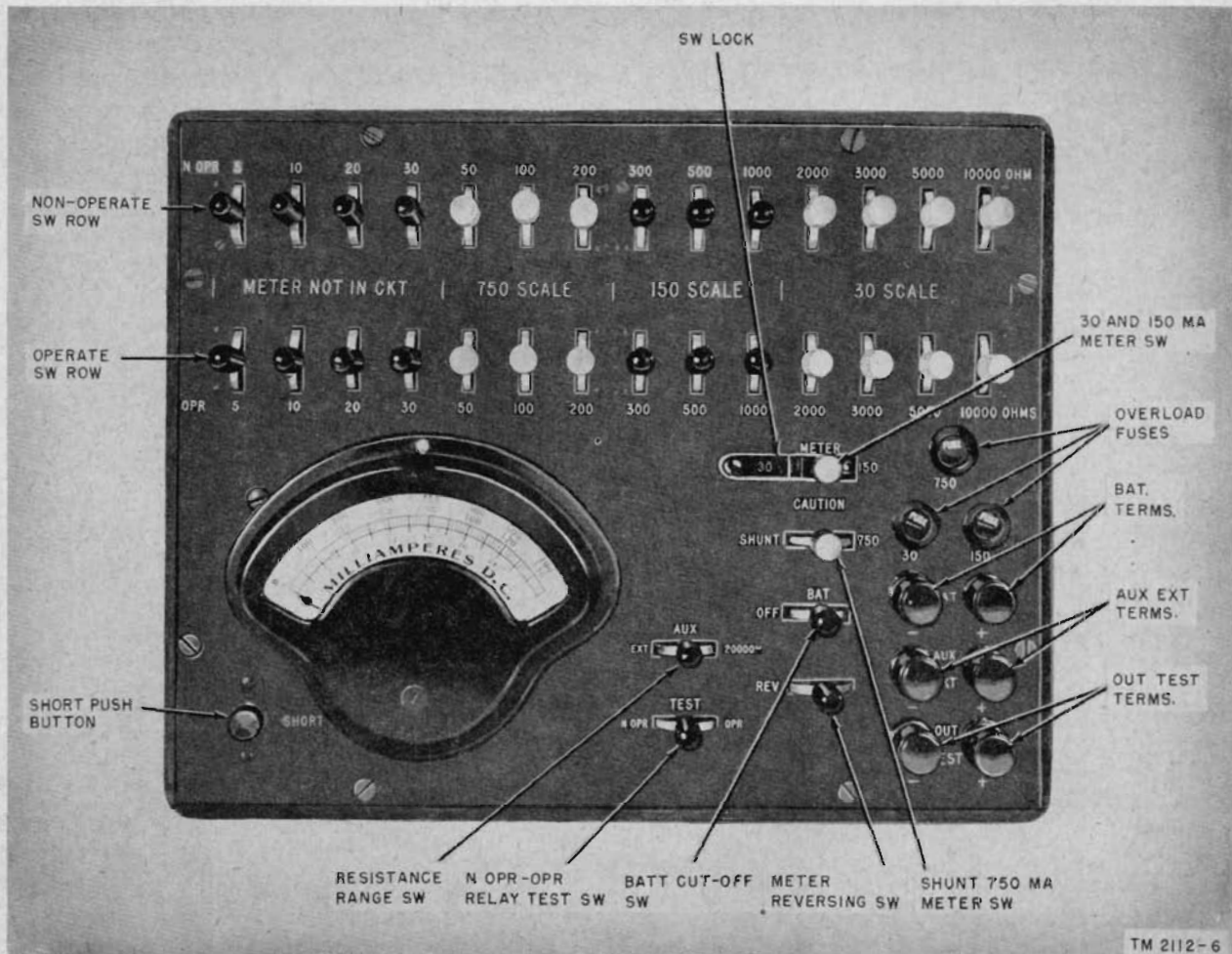


Figure 2. Current-flow test set.

sioned and adjusted until the relay meets the operate and nonoperate current-flow requirements. This operation is sometimes called *margining*.

- (2) *Typical current-flow test set.* A typical current-flow test set used in many step-by-step dial central offices is illustrated in figure 2. The milliammeter of this test set covers current-flow ranges of 0-30, 0-150, and 0-750 milliamperes; the resistance banks are adjustable in 5-ohm steps from 5 to 22,215 ohms. An auxiliary 20,000-ohm resistor increases the resistance range to 42,215 ohms. Provision is made also for connecting external resistors of any desired resistance value in series with the resistance banks. Lever switches (keys) control the resistance value and milliammeter ranges. Special test cords for connecting the test set to the contact springs of relays are usually included with the current-flow test set. TM 11-2112 describes the operation and use of the current-flow test set.

*Note.* Standard Current-flow Test Set I-181 (par. 8b (8)), which can be obtained through regular supply channels, may be used instead of the current-flow test set furnished by the manufacturer.

c. *STEPPING-SWITCH TEST SET.* This test set is an automatic interrupter which generates pulses for use in testing the vertical stepping of selectors, the vertical and rotary stepping of connectors, and the action of pulse repeaters, all under simulated loop resistance and leakage conditions. The stepping-switch test set (fig. 3) is also called *impulse testing machine*, *varying machine*, *interrupter machine*, *dial pulse generator*, and *test pulse machine* in the manufacturer's literature, specifications, and drawings. In relatively large step-by-step dial central offices, this test is used widely for fast and accurate routine testing on selector and connector switch shelves, thereby eliminating the necessity for dialing test digits for each switch tested. This saves time when large numbers of switches must be tested, since three digits are required for testing 200-point connectors with test sets, such as the test handset (par. 7a), which require dialing to produce test pulses. In smaller step-by-step dial central offices, however, this test set generally is not used for routine testing. In this case, the connector routine test set is preferred by repairmen for checking the stepping action of connectors while the test handset is preferred for checking the stepping action of selectors. Use of the stepping-switch test set in smaller offices is limited to the repair or readjustment of the

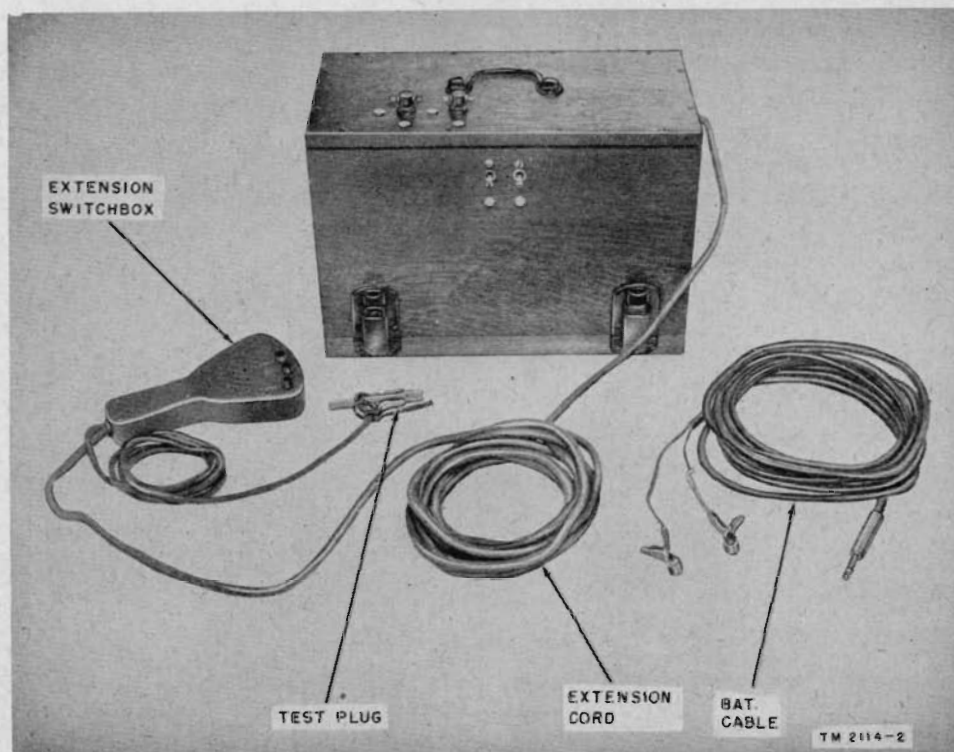
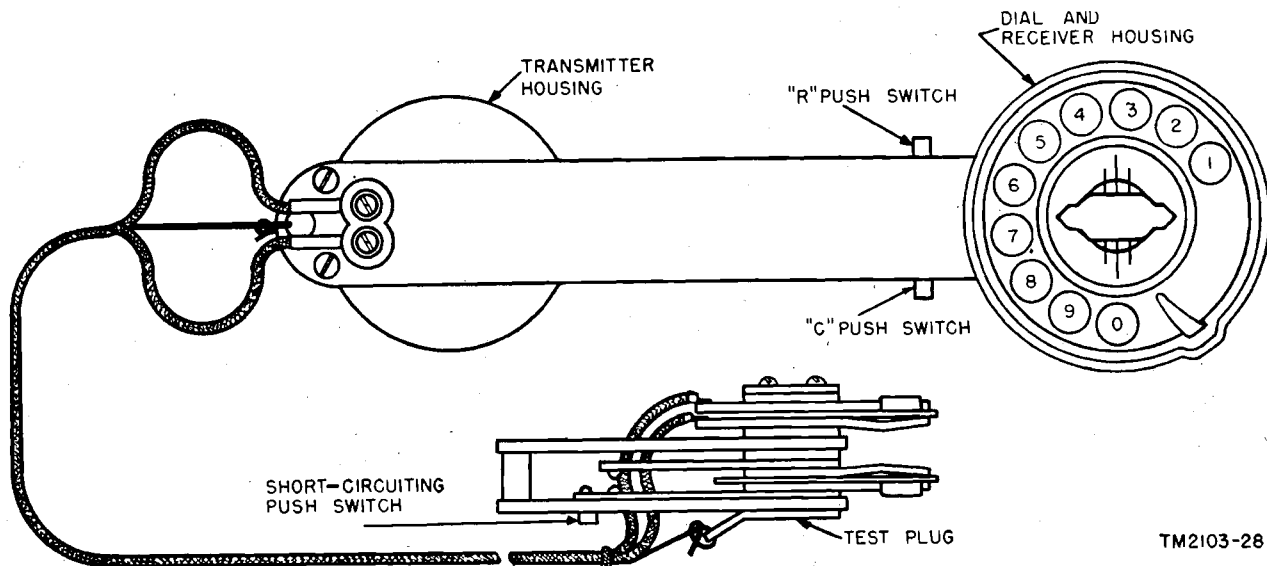


Figure 3. Stepping-switch test set.





TM2103-28

Figure 4. Test handset.

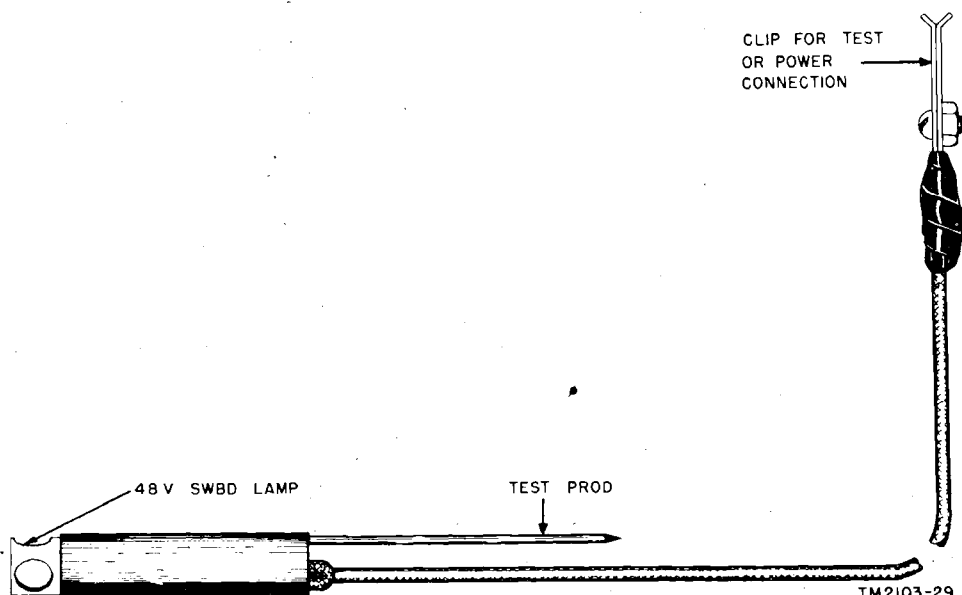
stepping mechanism of the selectors and connectors. TM 11-2114 describes the application, functioning, and operating procedure of the stepping-switch test set.

## 7. Other Test Equipment Supplied by the Manufacturer

*a. TEST HANDSET.* The test handset (fig. 4) is a test telephone having a transmitter at one end and a receiver and dial mounted back to back at the other end. It is used for dialing, monitoring, and

talking tests on the switching equipment of a typical step-by-step dial central office. There are two push switches (push buttons), marked C and R on the handle of the handset, which are located just below the dial and receiver. The test handset is also equipped with a test cord and special test plug which mates with the test jack terminals of the switch to be tested.

*b. TEST LAMP.* A small test lamp (fig. 5) for continuity testing is provided with the step-by-step dial central office maintenance tools supplied by the



TM2103-29

Figure 5. Test lamp.

manufacturer. The unit consists of a lampholder, a test prod, and a 6-foot test cord with a special clip for connecting to the relay contact springs. A 48-volt telephone switchboard-type lamp is ordinarily used in this test unit. The lamp filament resistance, when cold, is 185 ohms and, when hot, varies between 1,260 and 1,500 ohms.

## 8. Signal Corps Standard Test Equipment

Additional items of test equipment, which are not supplied by the manufacturer, may sometimes be required in the maintenance and repair of step-by-step dial central office equipment or the outside plant equipment. For additional information on this test equipment, which is usually obtained through regular supply channels, refer to TM 11-487 and TM 11-372. The standard test sets which are obtainable from regular supply channels and which are used most commonly in the maintenance of the equipment of a typical step-by-step dial central office are listed below.

a. **TEST SET TS-190/U.** This is a high-resistance test receiver, having a headband and a three-conductor test cord. The test receiver has a 1,000-ohm impedance. An external 50,000-ohm resistor normally is connected in series with the receiver. A switch cuts out this resistor when it is not required. The test set is equipped with a three-conductor test cord, an alligator clip, and a test prod for probing in a circuit. Test Set TS-190/U is used for making trouble location tests, for continuity testing, and for checking circuits for the presence of negative battery or ground. The 50,000-ohm resistor protects the user against loud clicks when testing for potentials in circuits, and provides a high-impedance monitoring circuit to bridge across circuits without affecting performance. The test receiver may be used when identifying cable pairs, since its high resistance will not operate or restore any relays in the equipment. For details concerning the use of Test Set TS-190/U in the maintenance of equipment in a typical step-by-step dial central office, refer to TM 11-2103.

b. **PORTABLE TEST SETS.** The following portable test sets, when available, are used frequently in the maintenance and repair of step-by-step dial central office equipment:

(1) *Volt ohmmeter I-166.* This test set is a portable self-contained multirange volt-ohmmeter for measuring a-c and d-c voltages and resistances. Operating instruc-

tions for this instrument are given in TM 11-2613.

- (2) *Test Set TS-26/TSM.* This instrument is a portable, fault-locating test set, which contains a 45-volt test battery. It measures d-c voltages and resistances. Operating instructions for Test Set TS-26/TSM are contained in TM 11-2017.
- (3) *Test Set TS-27/TSM.* This test set is a form of Wheatstone bridge used for line tests, but is equipped, in addition, with a vacuum-tube oscillator which supplies 20-cycle current for capacitance tests and fault location. Operating instructions for Test Set TS-27/TSM are outlined in TM 11-2057.
- (4) *Test Set I-49.* This instrument is a portable, self-contained Wheatstone-bridge test set, especially adapted for locating faults in communication circuits. It differs slightly from the Wheatstone bridge which is part of the type 1 test desk used in many step-by-step dial central offices. Refer to TM 11-2019 for operating instructions and fault-locating procedures for Test Set I-49.
- (5) *Test Set I-48-B.* This instrument is a portable insulation-resistance test set with a range from 0 to 1,000 megohms. Operating instructions for Test Set I-48-B are given in TM 11-2050.
- (6) *Test Sets I-61-A, I-61-B, and I-61-C.* These test sets are portable, self-contained, transmission-measuring units, incorporating an audio oscillator for sending, an amplifier for receiving, and a power-level meter. Test Sets I-61-B and I-61-C also include a local-battery Telephone EE-8-B. Operating instructions for these test sets are found in TM 11-346.
- (7) *Cable fault-locating equipment.* Refer to TM 11-372 and TM 11-487 for information on Test Set I-51, WEC Co Test Set 62-A, WEC Co Test Handset 1011-BW, Test Set TS-420/U, and other equipment used in the testing of outside plant equipment.
- (8) *Test Set I-181.* This portable, standard current-flow test set is used in testing and adjusting relays of step-by-step dial central office switching equipment, in accordance with the manufacturer's electrical

specifications. Its continuously variable resistance range makes this test set especially suited for precision testing and adjusting of relays, since the current-flow test set furnished by the manufacturer (par. 6b) has its resistance range in 5-ohm steps. Two control knobs in each resistance path of this standard test set provide a coarse setting and a fine adjustment which permit accurate measurement of the marginal current-flow requirements. For details concerning the operation and use of Test Set I-181, refer to TM 11-2036. Test cords and connecting tools, as listed in TM 11-2036, are required for use with Test Set I-181, but are not provided as part of the test set.

(9) *Test Sets I-142 and I-142A.* These test sets incorporate a number of relatively independent test circuits for measuring the electrical characteristics of step-by-step dial central office equipment. Detailed information on Test Sets I-142 and I-142A is contained in TM 11-2062. It includes the following test circuits:

- (a) *Measuring circuit.* A variable-range, vacuum-tube type volume indicator is used for measuring the electrical output of telephone transmitters or receivers.
- (b) *Capacitor test circuit.* A relaxation-type oscillator is used to check the leakage resistance of capacitors.
- (c) *Generator test circuit.* This test circuit is used for checking the electrical rating of generators used in central offices.
- (d) *Ringer test circuit.* This circuit consists of a hand-operated generator and resistors arranged to supply minimum operating currents of approximately 16-2/3 cps (cycles per second) to ringers of three different impedances.
- (e) *Insulation resistance test circuit.* This test circuit measures resistances of 1 megohm or less.
- (f) *Dial test circuit.* This test circuit measures the speed of the dial pulse spring contacts and the percentage of the total pulse period during which the dial pulse spring contacts are closed (*pulse ratio*, or *percent make*, of the dial pulse spring contacts).

- (g) *Continuity test circuit.* A buzzer and lamp are provided in this test circuit for making point-to-point tests for electrical continuity.
- (h) *Instrument test circuits.* These circuits are provided for testing the efficiency of common- and local-battery telephones.

## 9. Dial Speed and Pulse Ratio Test Set

A portable dial speed and pulse ratio test set (fig. 6) is used by installation and maintenance men to check the speed and pulse ratio, or percent make (ratio of the time the dial pulse spring contacts are closed to the length of the pulse period), of dials of telephone sets. This test set usually is included with the installation tools which are furnished by

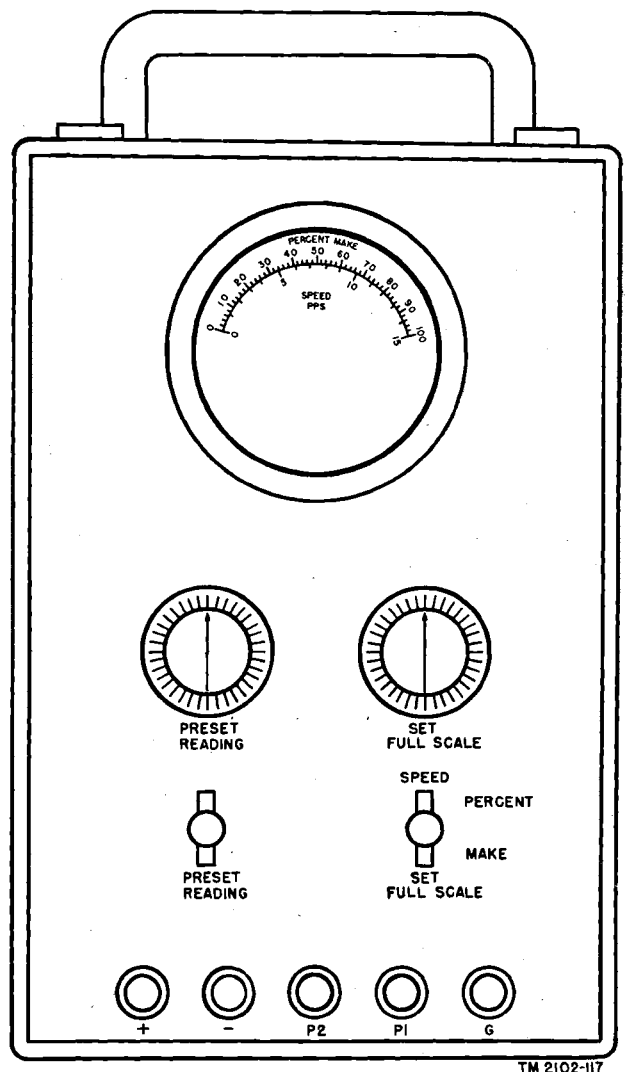


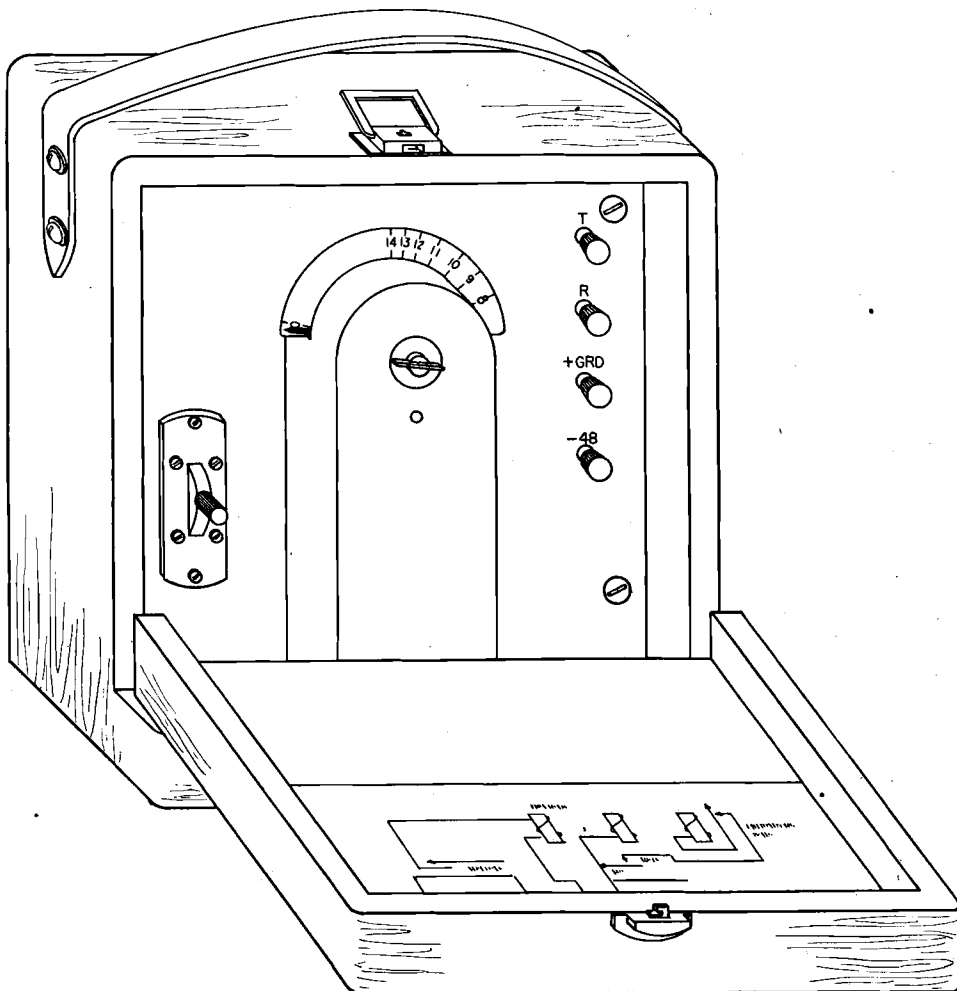
Figure 6. Dial speed and pulse ratio test set.

the manufacturer with the dial central office equipment. It may be used to make dial tests at the point of installation, but it is more adaptable for use at test and repair benches. The speed of dials must be within certain limits to assure proper functioning of stepping switches which are actuated by dial pulses. A dial speed of 10 pulses per second is considered ideal, while extreme test limits for dial speeds are 8 and 14 pulses per second. Normal percent make, or pulse ratio, of dial pulse spring contacts is approximately 38½ per cent. The test set also can be used to make rapid approximations of the pulse ratio of a short series of dial pulses (par. 17c(3)). A millimeter on the front panel of the test set registers both dial speeds and percent make of a series of pulses. This millimeter has two scales, one for dial speeds, calibrated from 0 to 15 pulses per second and the other for pulse ratios,

calibrated from 0 to 100 percent make. The dial speed and pulse ratio test set (fig. 6) is set normally for percent make tests. To use the test set as a dial speed indicator, SPEED-SET FULL SCALE switch must be operated to the SPEED position.

### 10. Type 31 Portable Dial Speed Test Set (fig. 7)

a. GENERAL. For efficient operation of the switching equipment in a step-by-step dial central office, the speed of rotation of telephone dials must be kept at approximately 10 pulses per second. Therefore, test equipment for the accurate determination of dial speeds is required by dial central office maintenance men. Thus, wire chief's test desks in newer central offices are equipped with dial speed and pulse ratio testing equipment which can



TM 2111-4

Figure 7. Type 31 dial speed test set.

be used both as a dial speed indicator and a dial pulse ratio (percent make) test set. A portable dial speed and pulse ratio test set (par. 9) is also furnished initially by the manufacturer with the newer dial central office equipment. The type 31 portable dial speed test set (fig. 7) is used in some older central offices. The components of this test set are incorporated in older models of the type 1 test desk, used in some earlier step-by-step dial central offices. It consists of two relays, a stepping magnet, a circuit-breaker, a single-throw, locking-type lever switch, and a spring-driven timing mechanism which moves the pointer from left to right on the indicator scale. The test set is mounted on a laminated panel which is faced and backed with bakelite. The unit is mounted in a wooden carrying case by means of four wood screws. The dial speed indicator, the lever switch, and four binding posts (marked T, R, +GND and -48) are mounted on the front of this panel. The two relays, equipped with individual dust covers, and a 3-ampere, cartridge-type fuse are mounted on the rear of this panel. The type 31 dial speed test set operates from an external 48-volt battery supply, connected to the two lower binding posts (+GND and -48) on the front of the panel.

b. APPLICATION. Type 31 dial speed test set is used as a portable testing unit for repairing or ad-

justing dial mechanism of dial telephone sets. It is furnished as part of the installation tools provided by the manufacturer. When used at a repair or testing bench, the test set is useful in making dial speed tests on dial telephone sets prior to installation. It is used by installer-repairmen to check and test dials. It may be used also for completing dial tests at the attendant's switchboard if the installation of the test desk has not been completed.

## 11. Buzzer Test Set

A portable buzzer test set (fig. 8) operated by two 1½-volt, dry-cell batteries (BA-23), usually is included with the installation tools which are furnished by the manufacturer. The buzzer and the batteries are contained in a wooden case. The buzzer test set is used during cabling and wiring of the step-by-step dial central office equipment to identify cable conductors and to test and verify the wiring after the installation is completed. A buzzer test set similar to that illustrated in figure 8 is a necessary item in step-by-step dial central office maintenance. If not available, buzzer test sets can be constructed locally. The buzzer test set and a switchboard plug are used in making continuity tests on switchboard multiple cables during installation.

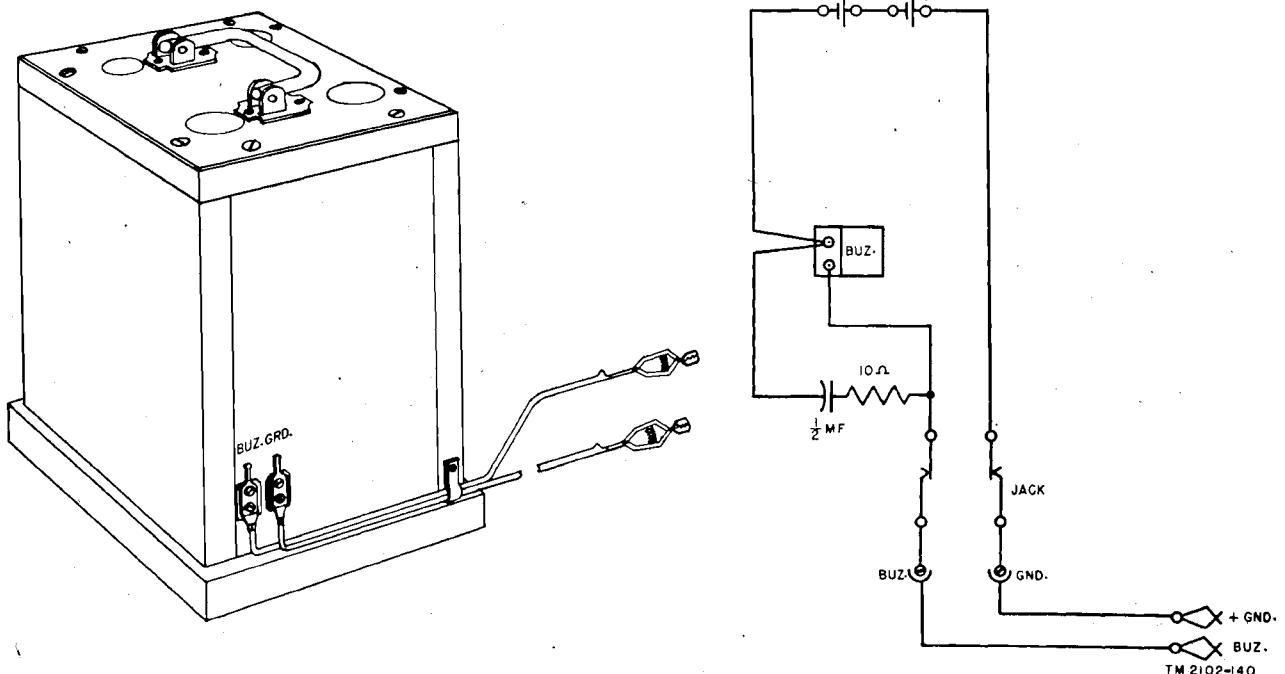


Figure 8. Buzzer test set.

## 12. Test Stand

A special test stand (fig. 9) is supplied with the step-by-step central office maintenance tools furnished by the manufacturer. The test stand is used to support two-motion stepping switches when removed from the shelf positions for adjustment or repair. A 24-terminal test jack is included on the

test stand for making connections to negative battery and ground. This permits operating tests to be made on stepping switches while mounted on the test stand. Bayonet pins in the upright members of the test stand support switching units which have a large mounting base. Smaller mounting bases are supported on the test stand by screws inserted in tapped holes in the upright members.

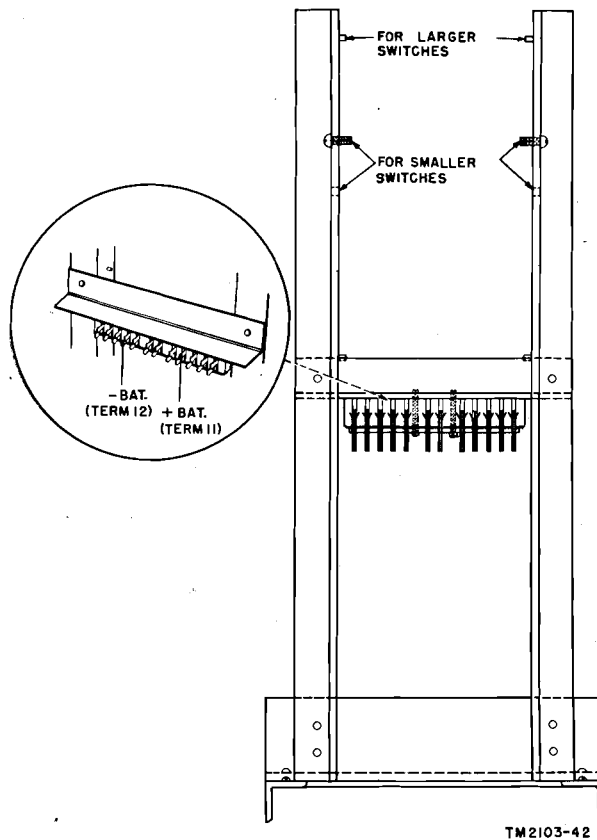


Figure 9. Test stand.

## CHAPTER 2

### OPERATING INSTRUCTIONS AND THEORY OF OPERATION FOR TEST EQUIPMENT

---

#### 13. Test Handset (figs. 4 and 10)

##### a. OPERATING INSTRUCTIONS:

(1) *Linefinder operation test.* Perform routine testing of linefinders with the test handset as follows:

- (a) Plug the handset test cord into the two bottom springs of the test jack associated with the *A* group of linefinders. Note that one of the linefinders in the *A* group steps its wipers to the contacts on its banks which correspond to the test line (No. 29).
- (b) Listen to the test handset receiver for dial tone.
- (c) On hearing dial tone, hold push switch *R* operated and dial any digit corresponding to a vacant, or unused, selector bank level, as shown on the central office cabling diagram, or on the selector terminal assembly drawing. Listen for busy tone. Release push switch *R*.
- (d) Operate push switch *C* on the handle of the test handset. The linefinder which was seized previously ((a) above) releases upon operation of switch *C*.
- (e) Release push switch *C* on the test handset handle. The next idle linefinder should step its wipers up to the contacts on its banks which correspond to the test line (No. 29).
- (f) To test all other idle linefinders in the *A* group, repeat steps described in (a) through (e) above.
- (g) When all idle linefinders in group *A* have been tested, operate the group relay busy lever switch (key) of the *A* group.
- (h) Restore the group relay busy switch of the linefinders *A* group.
- (i) Make a similar operation test of each idle linefinder in the *B* group of linefinders from the *B* group test jack by repeating steps described in (a) through (f) above.

(j) After testing all idle linefinders in the *B* group, momentarily operate the group relay busy switch of the *B* group. Then restore the *B* group busy switch to transfer back to the *A* group of linefinders. Make sure that the linefinder equipment transfers both ways, from the *A* to the *B* group and then back to the *A* group.

(2) *Selector trunk test.* Test selectors in groups of ten with the test handset as follows:

- (a) Insert the handset test plug in the two top selector test jack springs.
- (b) Hold push switch *R* operated and dial any test digit. Observe whether the selector steps its wipers up to the dialed level and around to the contacts of the first idle trunk.
- (c) Rapidly open and close the VON (vertical off-normal) springs and note that the selector shaft steps its wipers around to each trunk on the dialed level. If an open trunk is encountered, the shaft will fail to rotate.
- (d) Listen for busy tone each time the selector wipers reach the eleventh rotary step.
- (e) Test each selector bank level in a similar manner. On vacant levels, the selector wipers should rotate to the eleventh rotary step and return busy tone.
- (f) Test all trunks on all selector levels, using a different group each time the test is made, so that ultimately all groups will be tested.

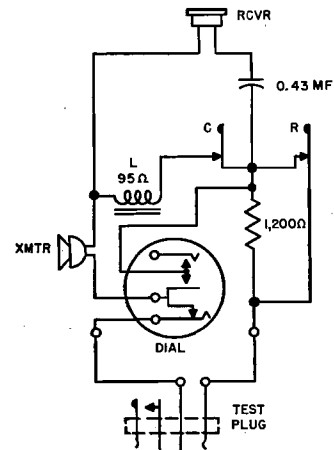
(3) *Selector cut-in and release test.* Perform this selector test using the test handset as follows:

- (a) Plug the handset test cord into the two top test jack springs of a selector.
- (b) Holding push switch *R* of the test handset operated, dial a digit which will cause the selector to step its wipers up to the bank level being tested.
- (c) Observe that the selector wipers cut in properly and rotate to the first idle trunk on the dialed bank level.

- (d) Dial the digit 1 to insure that the line switching relay of the selector has operated properly. Failure of the line switching relay will be indicated by a vertical *kick* of the shaft when the second digit is dialed. Release test handset push switch R.
- (e) Observe that the selector releases properly upon disconnection.
- (f) Test a different bank level at each inspection to insure that the selector wipers will be tested ultimately on all bank levels.
- (4) *Two-way repeater trunk test.* Test each two-way repeater with the test handset as follows:
- (a) Plug the test handset into the top and bottom test jacks of the repeater and operate push switch C on the handset. Monitor the trunk to determine whether the trunk is idle.
- (b) Holding push switch R of the handset operated, dial the reverse battery number in the distant central office and listen for a click in the handset receiver.
- (c) When the reverse battery click is heard, proceed to the next repeater. Test repeaters to manual central offices by dialing the operator.
- (d) Release push switch R and operate push switch C of the test handset. This permits the trunk equipment to release.
- (e) Busy out any repeater which fails to meet the test outlined in the steps described in (a) through (d) above, and notify the distant central office of the trunk in trouble.
- (f) Make a note of all busy trunks and test each one when it becomes idle.

b. **THEORY OF OPERATION.** The test handset circuit (fig. 10) consists of a telephone transmitter, receiver, dial, an induction coil, a 0.43-microfarad capacitor, a 1,200-ohm resistor, and push switches C and R. Plugging the test handset into the test jack of a stepping switch closes the loop to that switch, making the switch busy to other calls and preparing it for dialing or talking tests. Push switch C, when in the unoperated (closed-contact) position, normally short-circuits the 0.43-microfarad capacitor. When held operated, however, push switch C opens the transmitter circuit and forms a

listening circuit through the capacitor and receiver in series. This permits the testman to monitor on busy equipment. To talk with a called party on the loop, the testman releases push switch C, thereby closing the transmitter circuit again. Similarly, push switch R normally short-circuits the 1,200-ohm resistance. When the testman holds push switch R operated, the short circuit is removed and the resistance is connected in series with the loop. This provides a standard 1,200-ohm test loop over which dial pulses from the test handset dial may be sent to test the stepping action of the stepping switch under test. The 1,200-ohm resistance in series with the loop simulates the extreme limit of loop resistance for test purposes. The test handset may be adapted for other tests by disconnecting the special plug from the test cord, and using test clips, terminal lugs, or standard telephone plugs, which permit connection of the handset to other equipment.



TM 2103-11

Figure 10. Test handset, schematic diagram.

## 14. Test Lamp (fig. 5)

a. **OPERATING INSTRUCTIONS.** Make continuity tests with the test lamp on relay circuits of the step-by-step dial central office switching equipment as follows:

- (1) To test the continuity of a relay circuit which is connected to ground, but not to negative battery, connect the test clip of the test lamp to a negative-battery source and make point-to-point exploratory tests with the test prod. Lighting of the test lamp will indicate the presence of ground in the circuit.
- (2) When the relay circuit under test is connected to negative battery, but not to



ground, connect the test clip to ground and make continuity tests with the test prod. The presence of negative battery in the circuit is indicated by lighting of the test lamp.

- (3) If the relay circuit is not connected to negative battery, or ground, connect the test clip in series with the central office battery and perform continuity tests with the test prod.

b. **THEORY OF OPERATION.** The test lamp circuit, used in point-to-point localization tests, consists of a lamp with a thin metal probe, or test prod, at one end, and a length of flexible cable terminating in a test clip at the other end. The test clip is connected to known ground or negative battery, while the test prod is used in tracing circuits point by point. The presence of ground or negative battery in a given circuit under test is shown by the lighting of the test lamp. When the test prod touches each point in a circuit connected to ground, it completes the lamp circuit from ground through the lamp to negative battery thus lighting the lamp. Similarly, negative battery can be traced from point to point in any circuit. In each case, a continuous circuit is required to light the test lamp. Failure of the lamp to light indicates an open circuit.

## 15. Dial Speed and Pulse Ratio Test Set (figs. 6 and 11)

a. **OPERATING INSTRUCTIONS FOR DIAL SPEED TESTS.** To use the dial speed and pulse ratio test set as a dial speed indicator, proceed as follows:

- (1) Connect the dial telephone set being tested to the P1 and G binding posts of the test set (fig. 6). Connect a jumper wire between the negative (—) and P2 binding posts of the test set.
- (2) Connect the 48-volt battery supply of the central office to the positive (+) and negative (—) binding posts of the test set (fig. 6 and A in fig. 11). When using the test set at an outside telephone set which has no battery supply available, connect the telephone line to the positive and negative binding posts, and request the central office testman to supply negative battery over the line. If the test set is being used at the central office for dial tests over the telephone lines, connect the line which is being tested to the P1 and G binding posts.

- (3) To calibrate the test set initially for dial speed tests, operate the SPEED-SET FULL SCALE lever switch to the SPEED position (fig. 6) and adjust the SET FULL SCALE control knob until the meter registers an average dial speed reading of 10 pulses per second.
- (4) Dial, or instruct the telephone user or the repairmen at the distant dial telephone set to dial, the digit zero (0).
- (5) Read the speed of the dial under test directly on the meter scale (fig. 6). A meter reading of 8 pulses per second or lower indicates a slow dial speed; a meter reading of 14 pulses per second or higher indicates a fast dial speed. When readjusting dials, try to obtain a dial speed reading of 9 to 11 pulses per second.

b. **PERCENT MAKE TEST.** To perform pulse ratio, or percent make, tests with the dial speed and pulse ratio test set, proceed as follows:

- (1) To calibrate the test set initially for percent make tests, operate the SPEED-SET FULL SCALE switch temporarily to the SPEED position and adjust the SET FULL SCALE control knob for full-scale deflection of the meter pointer.
- (2) Hold the PRESET READING lever switch operated temporarily, and adjust the PRESET READING control knob until the meter pointer reaches full-scale deflection.
- (3) Release the PRESET READING lever switch.
- (4) Dial, or request the telephone user or the repairman at the distant dial telephone set to dial, the digit zero. The meter will now register the percent make of the dial pulse spring contacts.

c. **THEORY OF OPERATION.**

- (1) *Pulse ratio, or percent make, test.* During initial calibration of the dial speed and pulse ratio test set, operation of SPEED-SET FULL SCALE switch SW-2 to the SET FULL SCALE position and adjustment of variable resistors R-6 (SET FULL SCALE control) and R-7 (initial calibration) for full-scale deflection of the meter pointer completes a circuit to the meter. This initial meter circuit extends from ground, through fixed resistor R-3 and variable re-

sistor R-7 in series, and through SET FULL SCALE make contacts of switch SW-2, to a parallel circuit, one branch of which is connected through fixed resistors R-2 and R-1 to negative battery which is in series with fuse F-1 and the negative meter terminal; the other branch of which is connected through variable resistors R-6 and R-8 in series, to the positive meter terminal. After calibration, switch SW-2 is returned to its normal position (fig. 11). This opens the initial meter circuit. At the beginning of this test (b(1) above) PRESET READING switch SW-1 is held operated momentarily while PRESET READING control knob (variable resistor R-9) is adjusted to give full-scale meter deflection. Operation of switch SW-1 completes the operating circuit of relay B from ground, through make contacts of switch SW-1, and the winding of relay B, to negative battery. Operation of relay B completes a second circuit to the meter from ground, through variable resistor R-9 (PRESET READING control) and fixed resistor R-5 in series, through make contacts 2 and 3 of relay B, and SET FULL SCALE break contacts of switch SW-2, to the parallel circuit consisting of resistors R-6 and R-8, which is connected in series with the positive meter terminal, and of resistor R-2, which is connected in series with negative battery, resistor R-2, fuse F-1, and the negative meter terminal. When relay B operates, it locks itself in the operated position by completing its own holding circuit through its own make contacts 6 and 7 and break-after-make contacts 2 and 3 of relay C, to ground. This holding circuit enables relay B to remain operated after the release of PRESET READING switch SW-1 (b(3) above) and causes the operating circuit of relay B to be opened. Relay B, when operated, also partially completes the operating circuit of relay C. When the handset of the dial telephone set under test is removed from the cradle, the loop is closed through the dial pulse springs (at normal) and the winding of relay A, completing the operating circuit of relay A. Relay A operates. Dialing of the test

digit zero (b(4) above) causes the dial pulse springs to open and close alternately 10 times, alternately opening and closing the loop to relay A. This causes relay A to restore and reoperate as the loop is opened and closed, respectively, in response to each pulse. When the relay A operates after the first pulse, it completes the operating circuit of relay C from ground, through make contacts 4 and 5 of relay B (operated), its own make contacts 1 and 2, and the winding of relay C, to negative battery. Operation of relay A also partially completes a pulsing circuit through its own make contacts 4 and 5 and break contacts 1 and 2 of relay B, to the meter and negative battery. Relay C operates and causes its contact 1 to make with contact 3 before its contact 2 breaks with contact 3. A new locking ground is thus connected to the winding of relay B through make-before-break contacts 1 and 3 of relay C before the initial locking ground of relay B is disconnected by the opening of break-after-make contacts 2 and 3 of relay C. Relay B thus remains operated because of the completion of this new holding circuit which passes through its own make contacts 6 and 7, make-before-break contacts 1 and 3 of relay C (operated), make contacts 1 and 2 of relay A (operated), and through its own make contacts 4 and 5, to ground. When relay A restores during the first pulse, it opens the operating circuit of relay C and the new holding circuit of relay B by returning its make contacts 1 and 2 to normal. Relay C, however, being slow-releasing, remains operated momentarily after its operating circuit is opened. But relay B restores immediately after locking ground is disconnected from its winding upon restoration of relay A. The slow-release feature of relay C is provided to prevent relay C from restoring simultaneously with relay B, thus eliminating the possibility of having relay B operate again after the first dial pulse. After the second dial pulse and after all subsequent pulses, relays B and C do not reoperate; relay A, however, continues to restore during, and to reoperate after, each pulse. After each pulse fol-

lowing the first dial pulse, the operation of relay A completes a pulsing circuit to the milliammeter. This meter circuit extends from ground, through resistors R-3 and R-7, SPEED break contacts of switch SW-2, make contacts 4 and 5 of relay A (operated), break contacts 1 and 2 of relay B (unoperated), back through SET FULL SCALE break contacts of switch SW-2, through resistors R-6 and R-8, to the positive milliammeter terminal, and also through resistor R-2, connected in parallel with resistors R-6 and R-8, to negative battery via series resistor R-1, and also the negative milliammeter terminal via fuse F-1. When relay A restores during each dial pulse after the first pulse, it opens this meter circuit. Similarly, relay A restores and reoperates in response to subsequent dial pulses, and, in turn, opens and closes the circuit to the milliammeter. Dial pulses are thus transmitted to the milliammeter. Since the meter has been adjusted previously for full-scale reading when its circuit is completed, it will indicate the percent make of the dial pulse spring contacts. 300-microfarad capacitor, C-3, is connected from one side of resistor R-2 of the meter circuit to negative battery. Variable resistor R-6 in the meter circuit compensates for battery voltage variations. After the tenth, or last, pulse, relay A reoperates and is held operated until the handset is replaced on the cradle at the completion of the test.

- (2) *Dial speed test.* In initial calibration of the test set prior to this test, SPEED-SET FULL SCALE switch is operated manually to the SPEED position and SET FULL SCALE control knob (variable resistor R-6) is adjusted until the meter shows a reading of 10 pulses per second. A circuit is thus completed from negative battery, through resistor R-1 and resistors R-2, which is connected in parallel with fuse F-1, the milliammeter, and variable resistors R-6 and R-8, through SET FULL SCALE break contacts of switch SW-2, break contacts 1 and 2 of relay B (unoperated) to capacitor C-2. Capacitor C-2, being connected to ground at switch SW-2, through resistor R-4, SPEED make

contacts of switch SW-2, break contacts 3 and 4 of relay A (unoperated), is thus charged. Throughout the dial speed test, SPEED-SET FULL SCALE switch SW-2 is left in the SPEED position. When the dial to be tested is connected to the test set (a(1) and (2) above) and the handset is lifted from the cradle, relay A operates. Dialing of the test digit zero causes relay A to restore and reoperate 10 times in response to the dial pulses. When relay A operates, it opens the initial meter circuit which passed through its break contacts 3 and 4. This causes capacitor C-2 to discharge since it is now disconnected from ground at switch SW-2. At the same time, the operation of relay A completes a new meter circuit from negative battery, through resistor R-1 and resistor R-2, which is connected in parallel with fuse F-1, the milliammeter, and variable resistors R-6 and R-8, through SET FULL SCALE break contacts of switch SW-2, break contacts 1 and 2 of relay B (unoperated), make contacts 4 and 5 of relay A (operated), SPEED make contacts of switch SW-2, and resistor R-4 to capacitor C-1. Since capacitor C-1 is connected directly to ground at switch SW-2 (operated to the SPEED position), it becomes charged. When relay A restores during each dial pulse, its movable contact 4 breaks with contact 5 and makes again normally with contact 3. The meter circuit to capacitor C-1 through make contacts 4 and 5 of relay A is thus opened and the initial meter circuit to capacitor C-2 through break contacts 3 and 4 of relay A is closed when relay A restores. This causes capacitor C-1 to discharge and capacitor C-2 to recharge. Similarly, when relay A operates again after the second and subsequent dial pulses, capacitor C-2 discharges and capacitor C-1 recharges. The frequency of operation of relay A, therefore, determines the amount of current which flows through capacitors C-2 and C-1. The milliammeter indicates this current. Since the meter scale was calibrated originally to give a reading of 10 at a dial speed of 10 pulses per second, its reading at any other pulse speed within



its range will be proportionate. The meter, thus, indicates dial speeds directly in pulses per second. Resistor R-4 is used as a spark suppressor to reduce the tendency toward sparking across contacts of relay A when capacitors C-1 and C-2 are charging or discharging. After the tenth, or last, pulse, relay A reoperates and remains operated, restoring only when the handset is replaced on the cradle at the completion of the test.

- (3) *Pulse ratio test on a short series of pulses.* To perform the pulse ratio (percent make) test for a short series of dial pulses, the procedure outlined in *b* above is followed with this exception: With the test set connected, as described in *a*(1) and (2) above, to the dial telephone being tested, PRESET READING lever switch SW-1 is operated momentarily while PRESET READING control knob (variable resistor R-1) is adjusted so that the meter gives the approximate percent make reading expected (later upon dialing), instead of merely full-scale deflection as in the case of the regular percent make test for a long series of pulses (*b* above). With this exception, the theory of operation for the percent make test on a short series of pulses is identical with that for the regular percent make test, described in (1) above. The PRESET READING control knob (variable resistor R-9) permits the test set to make more rapid measurement of the pulse ratio (percent make) of a short series of dial pulses, since the meter ordinarily requires a time interval before it stabilizes at a true reading.

## 16. Type 31 Portable Dial Speed Test Set

*a. OPERATING INSTRUCTIONS.* To perform a dial speed test, proceed as follows:

- (1) Connect the positive and negative leads from the central office battery to the +GND and -48 binding posts on the test set front panel (fig. 7).
- (2) Connect the cord of the dial telephone set under test to the T and R binding posts on the front of the test set panel (fig. 7).
- (3) Set the dial speed indicator (fig. 7) for operation by winding its handle (fly nut)

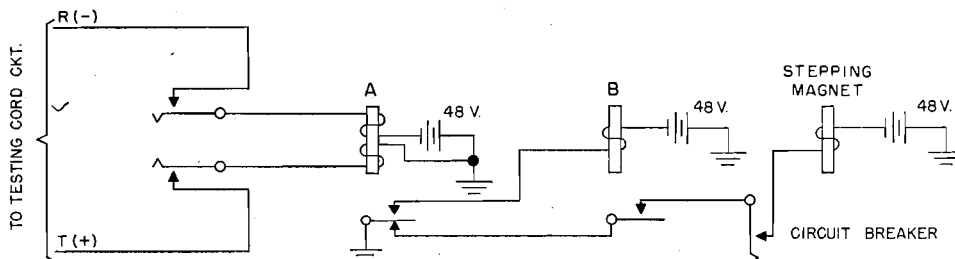
counterclockwise, or to the left, as far as it can be turned. The pointer of the indicator should now be at the zero mark on the scale.

- (4) Turn the handle clockwise, or to the right, as far as it will go.
- (5) Operate the lever switch.
- (6) Dial, or request the telephone user or testman at the dial telephone being tested to dial, the test digit zero.
- (7) Read the speed of the dial under test directly on the indicator scale by observing the position on the scale at which the pointer stops. The dial scale is calibrated from 14 to 8 pulses per second. Thus, if the pointer comes to rest at 10, it indicates that the rate of speed at which the dial under test is transmitting pulses is 10 pulses per second. A dial speed of 10 pulses per second is considered ideal. A dial speed reading of 8 pulses per second or lower is considered slow, while a reading of 14 pulses per second or higher is considered fast.
- (8) When the dial speed test is completed, replace, or ask the telephone user or testman to replace the handset on the cradle. Then restore the lever switch.

*b. THEORY OF OPERATION.* Figure 12 is a schematic diagram of the type 31 dial speed test set. Turning the dial speed indicator handle counterclockwise (*a*(3) above) to its extreme limit winds the spring and sets the indicator pointer at zero on the scale. Turning the handle clockwise (*a*(4) above), as far as it will go, closes the circuit-breaker springs (fig. 10). Operation of the lever switch (*a*(5) above) connects the dial telephone set under test through the T and R leads to the two windings of relay A. Lifting the handset from the cradle closes the loop through the dial pulse springs of the telephone set, completing the operating circuit of relay A from ground through the lower winding of relay A, the lower make contacts of the lever switch (operated), over the T, or positive, lead, through the dial pulse springs (at normal), back over the R, or negative, lead, the upper make contacts of the lever switch (operated), and the upper winding of relay A, to negative battery. Relay A operates and closes the operating circuit to slow-release relay B from ground, through its own make-after-break contacts and the winding of relay B, to negative battery. Relay B operates and partially

completes through its own make contacts the operating circuit of the stepping magnet, thereby preparing the circuit to the dial speed indicator for subsequent operation in response to dial pulsing. Dialing of the test digit zero (*a*(6) above) causes the dial pulse springs of the dial under test to interrupt the loop 10 times, opening and closing the operating circuit of relay A each time. Relay A, therefore, restores momentarily during each dial pulse and reoperates after each pulse. Each time relay A restores, it opens the operating circuit of relay B. But since relay B is slow-releasing, it does not restore when its operating circuit is opened, but is held operated throughout the pulsing period. Thus, each time relay A restores in response to dial pulsing, it completes the operating circuit of the stepping magnet, which moves a geared wheel at the same rate of speed as the dial is transmitting pulses. This operating circuit of the stepping magnet extends from ground, through break-before-make contacts of relay A (unoperated), make contacts of relay B (held operated), the closed spring contacts of the circuit breaker (operated), and through the winding of the stepping magnet, to negative battery. On the first pulse, the spring-driven timing mechanism which controls the dial speed indicator pointer is released, allowing the pointer to return clockwise to normal at its own preset, constant speed of 10 pulses per second. The speed of the pointer is not effected by dial pulses. The stepping magnet operates 10 times for the test digit zero. On the tenth, or last, dial pulse of the test digit, the stepping magnet operates a tripping device which stops the pointer. After the tenth dial pulse has been received, relay A comes to rest in the operated position, remaining operated as long as the handset of the dial telephone set being tested is off the cradle. This opens the circuit to the indicator and stepping magnet, causing the pointer to stop. Note that 10 dial pulses are required to op-

erate the tripping mechanism which stops the indicator pointer. Thus, if any test digit, other than zero, is dialed, the tripping device will not be actuated and the pointer will, therefore, continue all the way to the right (clockwise) before coming to rest. The position on the indicator scale at which the pointer comes to rest, after completion of the tenth dial pulse, indicates the rate of speed, in pulses per second, of the dial under test. If, for example, the pointer stops at 9, it indicates that the dial being tested is rotating and transmitting pulses at the rate of 9 per second. While the speed of the indicator pointer is constant (10 pulses per second) and independent of the speed of the dial under test, the starting and stopping of the pointer are controlled by the dial being tested. Thus, the pointer movement starts on the first dial pulse and stops after the tenth, or last pulse. If the speed of the dial under test is too fast, the pointer will come to rest before it reaches 10 on the indicator scale; if the speed of the dial is too slow, the point will come to rest at some point after 10; if the dial speed is standard (10 pulses per second), the pointer will stop at 10. Since the scale of the dial speed indicator is calibrated in pulses per second, the position on the scale at which the pointer stops after the tenth pulse indicates the required dial speed. On completion of the dial speed test, the handset of the telephone being tested is restored on the cradle, opening the loop through the dial pulse springs, and thereby opening the operating circuit of relay A. Relay A restores and opens the operating circuit (by disconnecting ground from the winding) of relay B. Relay B restores. The lever switch is now restored to normal (*a*(8) above) to disconnect the telephone set from the T and R leads of the test set. On each subsequent test with the dial speed test set, the operating instructions outlined in *a* above must be repeated.



TM 2111-3

Figure 12. Type 31 dial speed test set, schematic diagram.

## 17. Buzzer Test Set (fig. 8)

*a. OPERATING INSTRUCTIONS.* To make continuity tests on switchboard multiple cables with the buzzer test set (fig. 8) proceed as follows:

- (1) Connect one lead of the buzzer (fig. 8) to the tip contact of the end jack in the multiple under test.
- (2) Connect the other lead of the buzzer to the tip contact on a switchboard plug.
- (3) A continuous circuit is indicated by the sounding of the buzzer. An open circuit or reversed connection is indicated by failure of the buzzer to sound after insertion of the switchboard plug in any of the switchboard jacks associated with the multiple being tested.
- (4) Test ring and sleeve contacts of each multiple under test with the buzzer test set by applying the procedure outlined in (1) through (3) above to the ring and sleeve, respectively.

*b. THEORY OF OPERATION.* The buzzer test set is a continuity tester which gives an audible signal upon completion of its operating circuit by the multiple being tested. Thus, if the circuit between the end jack and the switchboard plug is continuous, current will flow through the buzzer, causing it to sound. Likewise, the buzzer will not sound when the circuit is open or when connections are reversed.

## 18. Test Stand (fig. 9)

*a. OPERATING INSTRUCTIONS.* To use the test stand as a support for two-motion stepping switches which have been removed from a switch shelf for repair or adjustment, proceed as follows:

- (1) Mount the test stand (fig. 9) on a well-lighted, properly equipped repair bench.
- (2) If the stepping switch to be repaired or adjusted has a large mounting base, mount it on the bayonet pins in the upright members of the test stand.
- (3) If the stepping switch has a smaller mounting base, mount it on the test stand with screws inserted in the tapped holes in the upright members.
- (4) Connect terminal 11 of the 24-terminal test jack on the test stand to the positive, or grounded, terminal, and terminal 12 to the negative terminal of the central office battery supply.

*b. THEORY OF OPERATION.* The test stand serves as a convenient support for two-motion stepping switches removed from their shelf positions for adjustment or repair. The 24-terminal test jack on the test stand enables the repairman to connect battery supply to each switch and thus, to perform operation tests on each switch.

## CHAPTER 3

### MAINTENANCE TOOLS AND MATERIALS

#### 19. Maintenance Tools, Materials, and Supplies

a. The special tools listed below are supplied by the manufacturer for use in maintenance, adjustment, and repair of the equipment of a typical step-by-step dial central office. The manufacturer

does not supply common tools which do not have special design features applicable to step-by-step dial central office equipment. Additional tools, required in most offices, are available from regular supply channels. Tools supplied with the central office equipment are illustrated in figures 13 to 17, inclusive.

*Special Maintenance Tools Supplied by the Manufacturer*

Ref fig. No.	Sig C stock No.	Auto Elec part No.	Article and description
13 (1)	4D20777	H-20777	Adjuster, spring, double-end, $\frac{1}{32}$ " slots, for relay make contact springs.
13 (1)	6R41572	H-42873	Adjuster, spring, double-end, same as H-20777 except 0.018" slots, for relay lever contact springs.
13 (2)	6R41574	H-14769	Adjuster, spring, double-end, step-cut slot at each end, $\frac{1}{32}$ " to $\frac{1}{64}$ ", for relay armature back stop.
13 (3)	6R41578	H-14768	Adjuster, spring, for bending relay armatures.
14 (11)	4D7067	H-7067	Adjuster, spring, for bending stepping switch detents (dogs).
13 (4)	4D20179	H-20179-1	Adjuster, spring, for rotary switch wipers and relay contact springs.
13 (6)	6Q187-5	H-47202	Adjuster, spring, for bending teeth of normal post cam on selectors and line-finders.
13 (8)	6Q188	H-88385	Adjuster, spring, for contact springs of lever switches and type 27 manual relays.
13 (5)	6Q188-2	H-88504-1	Adjuster, spring, for type 57 relay contact springs.
13 (5)	6Q188-3	H-88504-2	Adjuster, spring, for type 57 relay contact springs.
14 (9)	6Q188-5	H-88503-1	Adjuster, spring, for relay armature, type 57 twin-contact relays.
13 (7)	6Q188-4	H-88502-1	Adjuster, spring, for type 57 twin-contact relay armatures.
14 (10)	6Q188-1	H-56518	Adjuster, spring, for type 10 a-c relay armatures.
14 (12)	6R141065C	-----	Burnisher, WEC0 265-C, pocket-type with clip, includes burnisher blades, for relay contacts.
14 (13)	6M213	-----	Brush, bank cleaning (switch banks) WEC0 389-A, wood handle, curved brush.
14 (14)	-----	D-730370	Bracket, for test handset.
14 (15)	4D16590-1	H-16590-1	Cleaner, switch bank contact, used with sleeving Auto Elec part D-542539A, for cleaning stepping switch line banks.
14 (15)	4D16590-2	H-16590-2	Cleaner, switch bank contact, same as Auto Elec part H-16590-1 except thickness, used on control banks.
15 (16)	6Q18018	H-46556	Case, tool, container for maintenance tools.
15 (18)	-----	D-15455	Clip, for busying switches. -
17 (39)	-----	MP-4425	Extractor, designation strip and lamp cap.
16 (26)	6R41353A	-----	Extractor, lamp, WEC0 553-A, for removing telephone switchboard lamps.
17 (40)	6R41119	-----	Extractor, lamp cap, WEC0 319-A, plier-type, for removing lamp caps from panels.
	6Q45726	-----	Gage, thickness, 26-leaf, Lufkin 123, Starret 66, for general purpose checking and adjusting.
15 (17)	6R41570	H-46795-1	Gage, thickness, key-ring type, for adjusting Auto Elec relay residual screws 9-leaf, with hole in one end of each leaf.
6	6Z6941-1	H-16339-1	Light, test, with 48-volt switchboard-type lamp, test prod and 6-foot test cord, for continuity testing.
15 (20)	6R40858	-----	Pliers, heat coil extractor, for WEC0 heat coils.
16 (24)	-----	H-44514	Pliers, heat coil extractor, for heat coils, Auto Elec part D-68181.
15 (21)	4D16290	H-16290-7	Pliers, adjuster, for switch contact springs and dial mechanism.



*Special Maintenance Tools Supplied by the Manufacturer—Continued*

Ref fig. No.	Sig C stock No.	Auto Elec part No.	Article and description
15 (22)	6R4607	-----	Pliers, TL-107, side cutting.
15 (23)	6R4603	H-22945	Pliers, diagonal cutting, 5" long.
16 (25)	6R4735-5	H-50620	Pliers, duck-billed, 5 $\frac{3}{4}$ " long, for adjusting switch contact springs.
15 (19)	6R4626	H-50619	Pliers, TL-126, 6", straight, long-nosed, knurled handle.
16 (27)	6R4741-5A	311	Pliers, flat-nosed, smooth, for adjusting relay contact springs.
15 (19)	6R4770-6	-----	Pliers, spring adjuster, 6", round-nosed.
	6Z8165	D-542539-A	Sleeving, cotton (75' long), 0.290" ID x 0.015" thk wall, for bank cleaning tools.
16 (31)	6R18339	H-21766	Screw driver, offset, double-end, bits $\frac{1}{4}$ " wide.
16 (30)	6R16011	H-24664	Screw driver, cabinet, 6 $\frac{1}{2}$ " blade, 10 $\frac{1}{4}$ " lg over-all, wooden handle.
16 (28)	6R16095	-----	Screw driver, 6" blade, 8 $\frac{1}{2}$ " lg over-all, round shank, bit $\frac{1}{8}$ " wide x $\frac{1}{32}$ " thick, plastic Amberyl handle.
16 (29)	6R4084/1	95	Screw driver, cabinet, 3 $\frac{1}{2}$ " blade, 7 $\frac{1}{2}$ " lg over-all, Yankee #95.
12	-----	H-15799	Stand, test, for switch repairing, bench mounting, with shelf connector.
16 (32)	4D26917	H-26917	Tool, dial escutcheon, for removing dial from dial telephone sets.
17 (32A)	6R55507-8	H-7062	Wrench, open-end, for relay residual screw locknuts, $\frac{13}{64}$ " one end, $\frac{7}{32}$ " other end, 15° angle offset.
17 (33)	6R57210-12-1	H-7063	Wrench, open-end, double-ended, $\frac{5}{16}$ " and $\frac{3}{8}$ ", 3 $\frac{1}{2}$ " lg, flat, 15° offset each end.
17 (34)	6R57407-1	H-46440-1	Wrench, socket, $\frac{7}{32}$ ", T-handle, for bearing pin clamping screws.
17 (35)	-----	H-46437-1	Wrench, socket, $\frac{3}{16}$ ", T-handle, for wiper setscrews.
17 (37)	4D23865	H-23865	Wrench, open-end, for adjusting rotary switch armature screws.
17 (38)	6R57697-2	M-6656-1	Wrench, special socket, for switchboard jack strip fasteners.
17 (36)	6Q48541	M-6656-2	Wrench, special, used to hold jack strip fasteners while using jack strip wrench.
	NSN	H-14315	Fuse repair kit, for telephone-type indicator alarm fuses, contains the following items: (1) Fuse wire, 5 amp, Auto Elec spec 5129, 10 ft. spool. (2) Fuse wire, 3 amp, Auto Elec spec 5129, 10 ft. spool. (3) Fuse wire, lamp, Auto Elec spec 5129, 10 ft. spool. (4) Sandpaper, #0, 1 sheet, 2 $\frac{3}{4}$ " x 4 $\frac{1}{2}$ ". (5) Soldering flux, Auto Elec spec 2003, 2-dram bottle. (6) Solder, hard, Auto Elec spec 2001, 2-ounce roll.

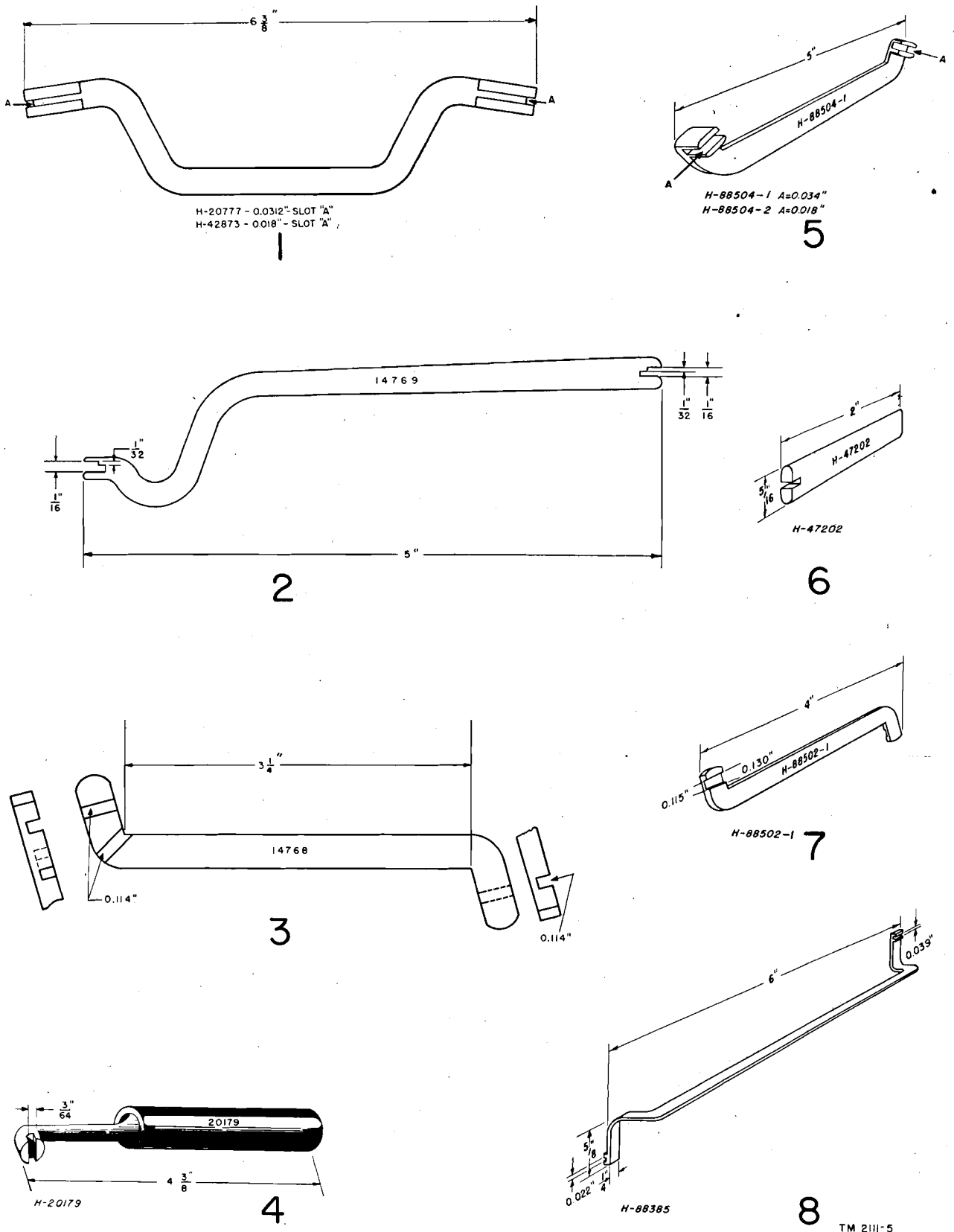
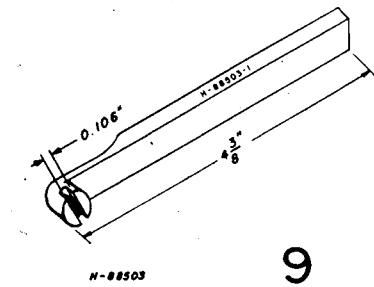
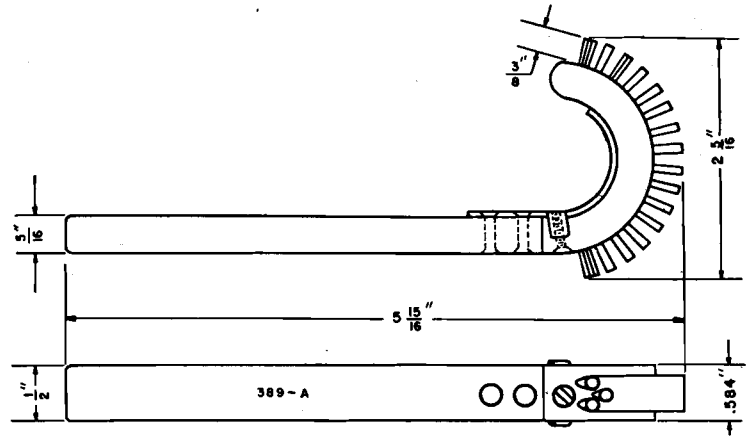


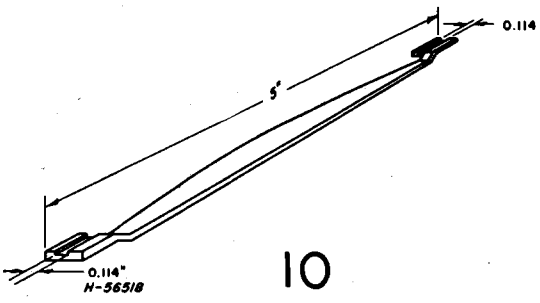
Figure 13. Special maintenance tools supplied by the manufacturer.



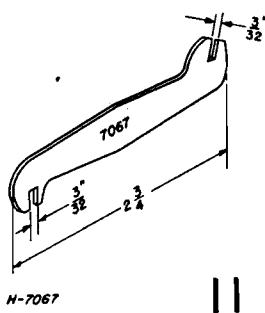
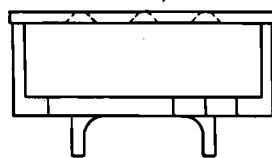
9



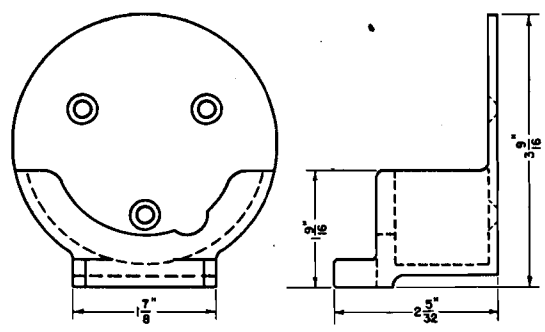
13



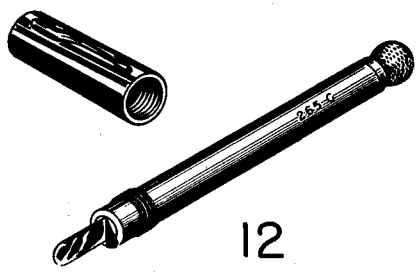
10



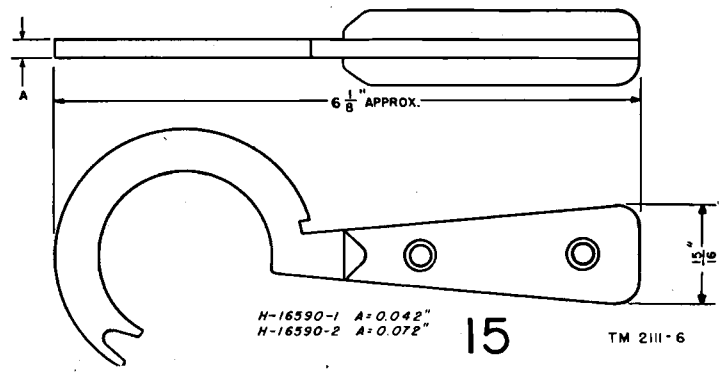
11



14



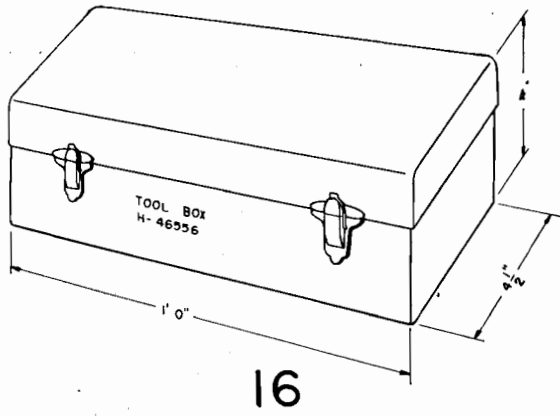
12



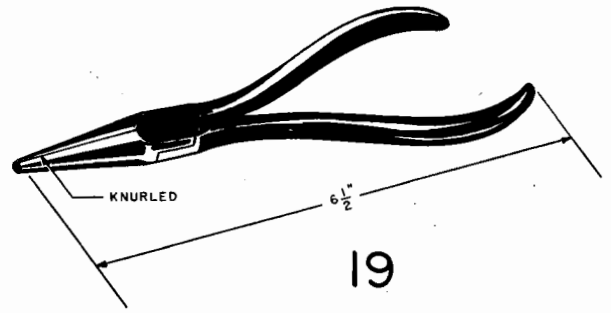
15

TM 2111-6

Figure 14. Special maintenance tools supplied by the manufacturer.



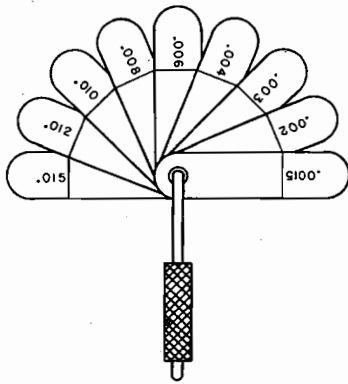
16



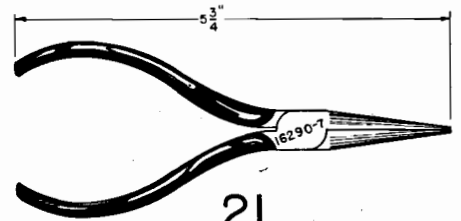
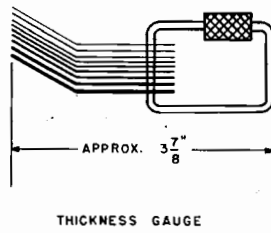
19



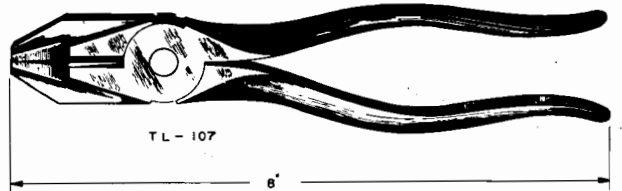
20



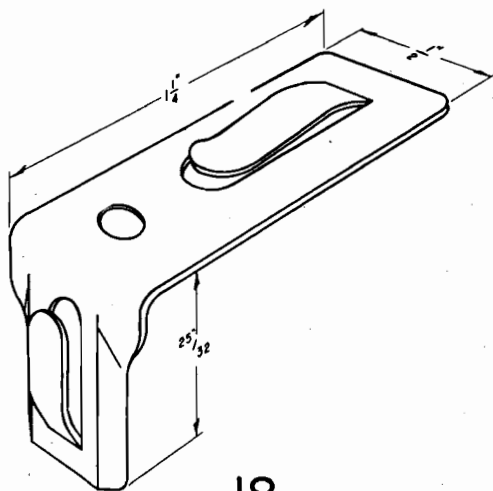
17



21

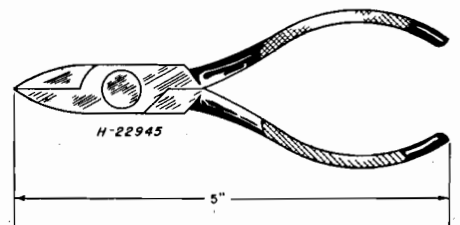


22



18

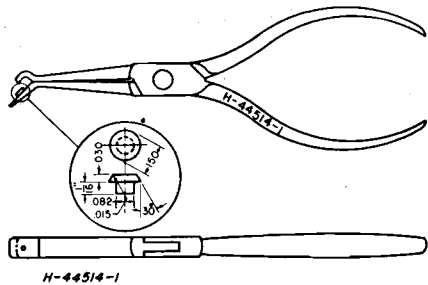
D-15455



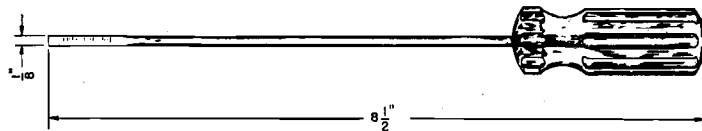
23

TM 2111-7

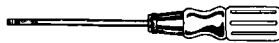
Figure 15. Special maintenance tools supplied by the manufacturer.



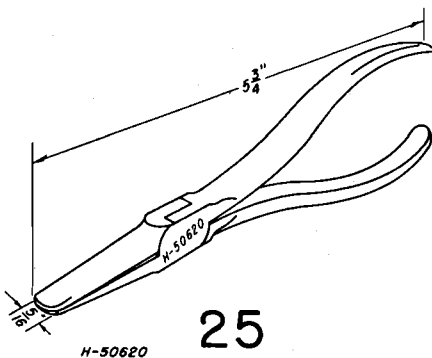
24



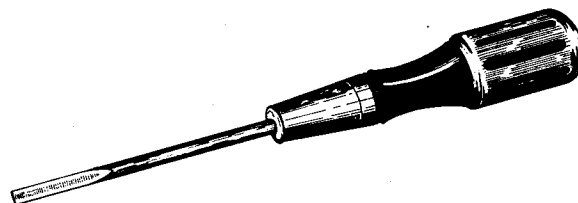
28



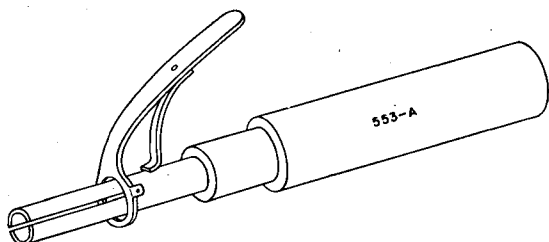
29



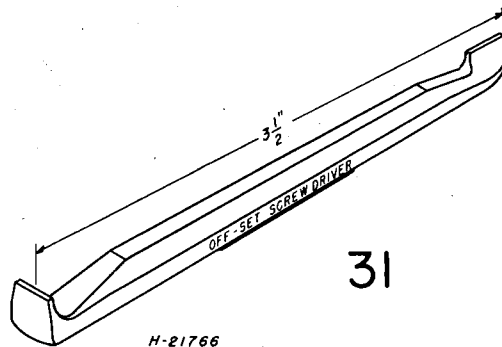
25



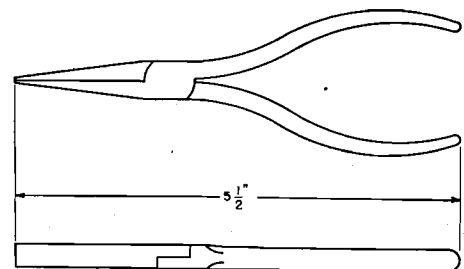
30



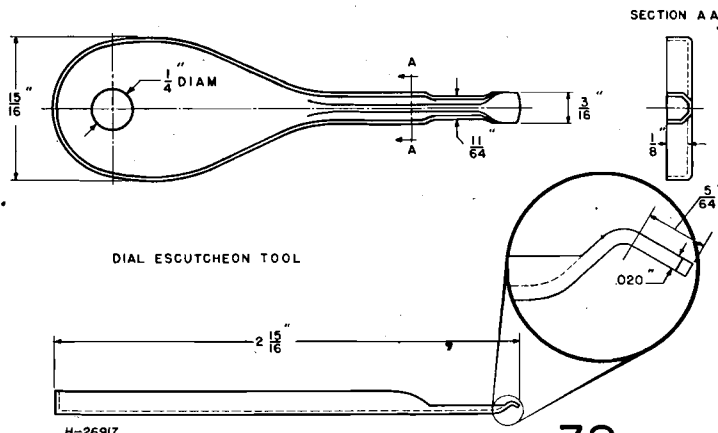
26



31



27



32

TM 2111-8

Figure 16. Special maintenance tools supplied by the manufacturer.

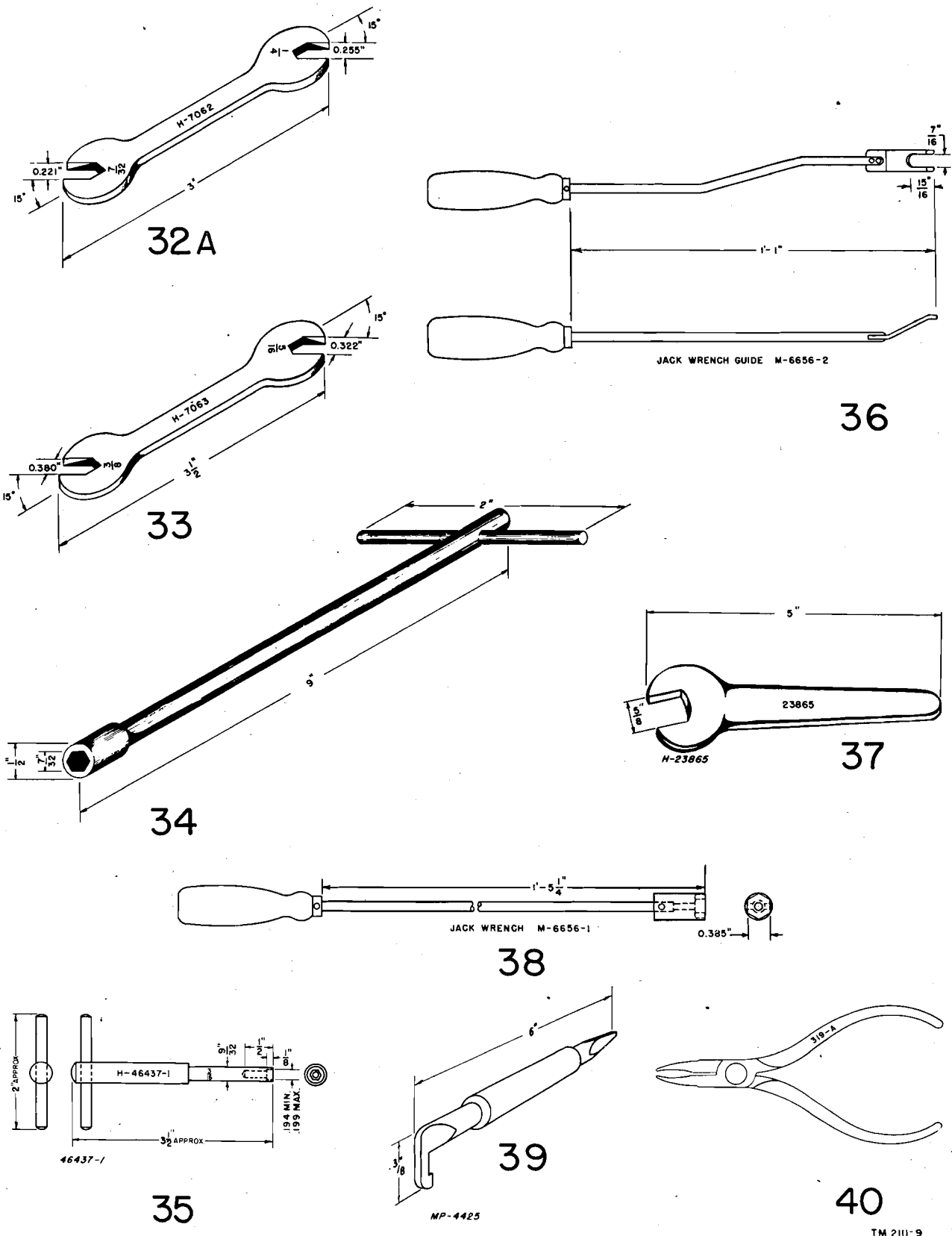


Figure 17. Special maintenance tools supplied by the manufacturer.

b. Additional common hand tools and materials, which are not supplied by the manufacturer but are needed for maintenance of a typical step-by-step dial central office, may be obtained through regular supply channels. These tools are listed below:

*Additional Maintenance Tools Obtainable Through Regular Supply Channels*

Sig C stock No.	Article and description
6Z2000	Abrasive, crocus cloth (for commutator cleaning tools).
6Z1372	Brush TL-72, 1/2", camel-hair.
6Z1402	Brush, camel-hair, 2".
6Z1428	Brush, dusting, 8".
6Z1419	Brush, cleaning, steel wire.
6R41065C	Burnisher, contact, WECO 265-C, for relay contacts (this provides a spare).
6Z1989	Cheesecloth, 36" wide (for general cleaning).
6Q19095	Chest CH-77, steel, tool, w/tray.
6Q19804	Chisel, cold, tool steel, 1/4"
6Z18806	Chisel, cold, tool steel, 3/8".
6Z26804	Clamp, machinist's, C, 4" opening.
6Q34813	Drill, TL-374/U, 110 v, all-angle head.
6Q36908	Extractor set, Ezy-out 15-A.
6Q37110	File TL-10, flat, bastard, 6".
6Q38033-6	File, flat, 2d cut, 6".
6Q37104-2	File, flat, 1/4" wide, jeweler's, WECO KS-2622.
6Q38120-8	File, half-round, bastard, 8".
6Q38500-10	File, round, bastard, 10".
6Z4002	Flashlight TL-122.
6Q45300	Gage, screw and wire, Browne & Sharpe 700.
6Q45735	Gage, screw pitch, Lufkin 74-C.
6R40870-D	Gram tension gage, WECO 70-D.
6R40870-E	Gram tension gage, WECO 70-J.
6Q41002	Hacksaw frame, adjustable, 8" to 12".
6Q49708	Hammer, machinist's, ball peen, 8 oz.
6Q49716	Hammer, machinist's, ball peen, 1 lb.
6Q49804	Hammer, soft-face, 4 oz., Sears 9F3821.
6Q60229	Knife TL-29.
6Z7072	Mirror, dental, WECO 376-A.
6Z7301-1	Oiler, 1 oz., 4" spout.
6Z7360	Orange stick, WECO KS-6320 (for inspecting switch wipers).
6Z7942	Padlock MC-92.
6R4724	Pliers, cord repairing, WECO KS-7139.

Sig C stock No.	Article and description
6R4726-6	Pliers, curved-nosed, 6", Klein 302-6.
6R4603	Pliers, TL-103, diagonal cutting, 5".
6R4625	Pliers, TL-125, gas, 8".
6R7513-4	Punch, drift, 1/4" point, 12" long.
6R7580	Punch, prick, 3/8" diam., 5" long, Stanley 635.
6R9502	Rule, 2 ft., 4 fold.
6R9906	Rule, steel, 6".
6Z7500-0000	Sandpaper, flint, #0000.
6R38005/1	Scissors, electrician's, 5".
6R40909.1	Screw driver, cord repair, WECO KS-2348.
6R19040.4	Screw driver, jeweler's, 3 1/2" over-all, Starrett 555C.
6R24617	Soldering iron TL-117, 70/100 w.
6R24620	Soldering iron TL-120, 200 w, 110 v.
6R24641	Soldering iron holder, Vulcan #2100.
6W8583	Tape TL-83, 3/4".
3F4316.1	Test Unit TS-190/U, WECO special D-173231 (test receiver).
6R55004	Wrench, 1/2" capacity, 4", Crescent A-14.
6R55006	Wrench TL-111, Crescent A-16, Adjustable, single-end, 6".
6R55010	Wrench TL-112, 10", 1 1/8" capacity, Crescent A-110.
6R55502	Wrench set, midget, J. H. Williams 1285P, in steel case.

c. No general maintenance materials supplied by the manufacturer are furnished with the step-by-step dial central office equipment. These maintenance materials usually are obtained through regular supply channels. Some items of the installation materials supplied with the equipment may be used for maintenance, if any unused quantities remain. A list of typical lubricants, a list of some suggested maintenance materials available through regular supply channels, and a list of the installation materials supplied by the manufacturer follow.

(1) Below are listed the lubricants required for the maintenance of step-by-step dial central office equipment. Detailed lubrication instructions are given in TM 11-2103.

*Recommended Lubricants*

Product symbol	Standard nomenclature	Spec or Sig C stock No.
PL-Special	Oil, lubricating, preservative, special	US Army spec No. 2-120 JAN-L-644.
OCW	Oil, clock and watch	US Army spec No. 2-47B.
P-38	Oil, instrument	Sig C stock No. 6G1398.7
	Oil, lubricating, graphited	Auto Elec grade A, spec 5232 Sig C stock No. 6G1837.
OE-10	Oil, engine	US Army spec No. 2-104B (Amend. 5).
GL	Grease, lubricating, special	US Army spec No. 2-134.

- (2) Following is a list of general maintenance materials which may be ordered through regular supply channels:

*General Maintenance Materials Obtainable  
Through Regular Supply Channels*

Sig C stock No.	Item and description
6Z2000	Abrasive, sheet, crocus cloth.
6N702	Beeswax compound IC-2.
6Q8112-18	Blade, hacksaw, 10", 18 teeth per inch.
6G184.4	Carbon tetrachloride, gal can.
8A805	Cheesecloth, bleached, 36" wide.
3B921	Clip TL-110, battery, steel-lead.
6N1636	Cloth, cotton, unbleached, 36" wide.
6Z2000-0	Cloth, emery, #0.
6Z2000-000	Cloth, emery, #000.
1B132X	Cordage, #18, AWG, GE, yellow.
6Z7500-00	Paper, sand, flint, #00.
6Z7500-1	Paper, sand, flint, #1.
6G1517	Polish, cord plug, Auto Elec 184-D.
6N7531	Solder M-31, resin core, 1-lb. spool.
6N8583	Tape TL-83, friction, 3/4", 1/2-lb. rolls.
6N8692	Tape TL-192, rubber, 3/4", 15-ft. rolls.
6Z8653-B	Thread, linen, #40.
6Z8813	Twine RP-13, linen, 6-cord, waxed, 1-lb. spool.
6Z8815	Twine RP-15, cable lacing, 12-cord, 1-lb. spool.

- (3) The following installation materials supplied by the manufacturer are furnished with a typical step-by-step dial central office:

*Installation Materials Supplied by the Manufacturer*

Quantity	Item and description
6	Battery BA-23, 1 1/2-volt, dry-cell.
25	Beeswax, #1, yellow, 1-lb. cake.
6	Brush, paint, 1 1/2".
4	Brush, paint, 2 1/2".
2	Buzzer, test, 5-ohm, Lungen 15, size 3.
12	Cloth, emery, medium, sheet.
3	Compound, Sarco (for cords), 1-lb. can.
1	Fuse wire, 1-amp, 1/4-lb. spool.
1	Fuse wire, 5-amp, 1/4-lb. spool.
1	Fuse wire, 10-amp, 1/4-lb. spool.
6	Oil, lubricating, graphited, per Auto Elec spec 5232, 2-dram bottle, Auto Elec 78612-8.
6	Oil, lubricating, mineral, per Auto Elec spec 5231, 2-dram bottle, Auto Elec 78612-4.
1	Paint, black asphaltum, 1-qt. can.
3	Paint, enamel, gray, Murphy 613, 1-gal. can.
6	Reducer, Xylol, for enamel, 1-pt. can.
12	Sandpaper, medium, sheet.
1	Solder bar, 1-lb.
7	Solder, wire, resin core, 5-lb. spool.
2	Solder, wire, solid, 5-lb. spool.
8	Tape, friction, 3/4", gray, 1/2-lb. roll.
5	Tape, linen, waxed, 3/4", 1-lb. roll.
6	Tape, rubber, 3/4", 1/2-lb. roll.
12	Twine, lacing, 8-ply, gray, 1-lb. ball.
12	Twine, lacing, 11-ply, gray, 1-lb. ball.
3	Wire, copper, #22 AWG, black cotton cover, 1-lb. spool, Auto Elec 22-64-BLK.
12	Wire, copper, #24 AWG, green cotton cover, 1-lb. spool, Auto Elec 24-68-GR.
6	Wire, copper, #24 AWG, red cotton cover, 1-lb. spool, Auto Elec 24-68-RED.
3	Wire, copper, #24 AWG, tinned, 1-lb. spool.
6	Wire, copper, #24 AWG, white cotton cover, 1-lb. spool, Auto Elec 24-68-WH.



## 20. Maintenance Spare Parts

Following is a list of the maintenance spare parts, supplied initially by the manufacturer, which are furnished with the equipment for a typical step-by-step dial central office.

### Maintenance Spare Parts Supplied Initially by the Manufacturer

Signal C stock No.	Auto Elec part No.	Quantity	Part and description
	R-7948-A4B	10	Line and cut-off relay.
3Z6020-247	D-281410-A	8	Resistor, suppressor, 200-ohm.
3C1121-32	D-281455	4	Release magnet coil.
3C1121-33	D-281530	3	Rotary and vertical magnet coil.
4D46088	D-46088	2	Shaft, for selector.
4D46099A	D-46099-A	2	Shaft, for linefinder.
4D46176	D-46176	2	Shaft, for 200-point connector.
4D46218	D-46218-A	2	Shaft, for 100-point connector.
4D46270A	D-46270-A	5	Contact wiper, for line banks of 200-point stepping switch, with cord holder.
4D46271A	D-46271-A	3	Contact wiper, for vertical banks of 100-point stepping switch.
4D46273A	D-46273-A	5	Contact wiper, for control banks of 100-point selectors.
4D46274A	D-46274-A	6	Contact wiper, for line banks.
3E4057-4.75	D-542281-A	6	Cord, for bank contact wipers.
	D-542282-A	5	Cord, for bank contact wipers.
3E4057-7.5	D-542283-A	5	Cord, for bank contact wipers.
3E4057-9	D-542284-A	5	Cord, for bank contact wipers.
3E4057-11.25	D-542285-A	5	Cord, for bank contact wipers.
4D71262A	D-71262-A	2	Armature, for relay.
3Z381-1	D-71163	2	Armature, for relay.
3Z381-2	D-71164	2	Armature, for relay.
4D71166	D-71166	2	Armature, for release magnet.
4D71169	D-71169	2	Armature, for rotary stepping magnet.
4D71250	D-71250	2	Armature, for rotary stepping magnet.
4D71343A	D-71343-A	2	Armature, for vertical stepping magnet.
3Z9580-6.25	D-735002	2	Contact assembly, rotary interrupter springs.
3Z9580-6.26	D-735004	2	Contact assembly, cam springs.
3Z9580-6.29	D-735022	2	Contact assembly, cam springs.
3Z9580-6.18	D-735066	2	Contact assembly, rotary interrupter springs.
3Z9580-6.19	D-735114	2	Contact assembly, vertical interrupter springs.
4C1914	MC-67704-A	2	Lens, indicator light, white (lamp cap).
4C1915	MC-67705-A	2	Lens, indicator light, red (lamp cap).
4C1916	MC-67706-A	2	Lens, indicator light, green (lamp cap).
3G1838-42.21	D-44670	20	Insulator (for protector blocks).
	D-44671	20	Insulator (for protectors).
	D-44674	20	Insulator.
	D-44866	20	Insulator.
	D-67166	20	Block, protector (carbon).
	D-67167	20	Block, protector (carbon).
	D-68181-B	20	Heat coil (2.7-ohm).
	D-108088	5	Spring (for protectors).
	D-108091	5	Spring (for protectors).
	D-108092	10	Spring (for protectors).
	D-108093	5	Spring (for protectors).
	D-108094	5	Spring (for protectors).
	D-108096-A	5	Spring (for protectors).

## CHAPTER 4

### DEMOLITION OF MATÉRIEL TO PREVENT ENEMY USE

---

#### 21. General

The demolition procedures outlined in paragraphs 22 and 23 will be used to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished *only* upon order of the commander.

#### 22. Methods of Destruction

- a. *Smash.* Use sledges, axes, handaxes, pickaxes, hammers, crowbars and heavy tools.
- b. *Cut.* Use axes, handaxes, and machetes.
- c. *Burn.* Use gasoline, kerosene, oil, flame throwers and incendiary grenades.
- d. *Explosives.* Use firearms, grenades, and TNT.
- e. *Other.* Use anything immediately available for destruction of this equipment.
- f. *Disposal.* Bury in slit trenches, fox holes, and other holes. Throw in streams. Scatter.

#### 23. Destruction of Components

a. *Smash* the test desk, test sets, tools, tool kits, meters, supplies, spare parts, relays, lever switches, resistors, capacitors, etc.

b. *Cut* all wires and cables.

c. *Burn* cables, wires, technical manuals, circuit diagrams, manufacturer's drawings, blueprints, specifications, and all forms and records.

d. *Bury or scatter* the above items after smashing, cutting, and burning, in addition to all remaining parts of tools, test equipment and supplies.

e. *Destroy everything.*

## APPENDIX

### REFERENCES

---

#### 1. Other Technical Manuals on Step-by-step Dial Central Office Equipment

TM 11-2100	Fundamentals (Step-by-step Dial Central Office Equipment).
TM 11-2102	Installation Instructions (Step-by-step Dial Central Office Equipment).
TM 11-2103	Basic Maintenance Practices (Step-by-step Dial Central Office Equipment).
TM 11-2104	Linefinder Equipment (Step-by-step Dial Central Office Equipment).
TM 11-2105	Selectors and Connectors (Step-by-step Dial Central Office Equipment).
TM 11-2106	Miscellaneous Switching Equipment (Step-by-step Dial Central Office Equipment).
TM 11-2107	Attendant's Switchboard (Step-by-step Dial Central Office Equipment).
TM 11-2108	Power, Ringing, and Supervisory Equipment (Step-by-step Dial Central Office Equipment).
TM 11-2109	Distributing Frames and Line and Trunk Assignments (Step-by-step Dial Central Office Equipment).
TM 11-2110	Test Desk Equipment and Techniques (Step-by-step Dial Central Office Equipment).
TM 11-2112	Current-Flow Test Set (Step-by-step Dial Central Office Equipment).
TM 11-2113	Connector Routine Test Set (Step-by-step Dial Central Office Equipment).
TM 11-2114	Stepping-Switch Test Set (Step-by-step Dial Central Office Equipment).
TM 11-2115	Crash and Conference Equipment (Step-by-step Dial Central Office Equipment).

#### 2. Supply Publications

SB 11-76	Signal Corps Kit and Materials for Moisture- and Fungi-Resistant Treatment.
----------	---

#### 3. Technical Manuals on Test Equipment

TM 11-346	Test Sets I-61-A, I-61-B, and I-61-C.
TM 11-2017	Test Sets TS-26/TSM.
TM 11-2019	Test Set I-49.
TM 11-2036	Test Set I-181.
TM 11-2050	Test Set I-48-B.
TM 11-2057	Test Set TS-27/TSM.
TM 11-2062	Test Set I-142 and Test Set I-142-A (Telephone).
TM 11-2613	Voltohmmeter I-166.

#### 4. 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, Flexible.
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.  
720-15 Interior Marking.

## 5. Other Publications

TB SIG 123 Preventive Maintenance Practices for Ground Signal Equipment.  
TM 1-455 Electrical Fundamentals.  
TM 11-372 Telephone Cable Splicing.  
TM 11-486 Electrical Communication Systems Engineering.  
TM 11-487 Electrical Communication Systems Equipment.  
TM 11-684 Local Battery Switchboards.  
TM 11-685 Common Battery Switchboards.  
TM 11-757 Principles of Line Fault Location.  
TM 11-4301 Tactical Switchboards and Long Lines Equipment—Repair Instructions, General Requirements.  
TM 11-4302 Tactical Switch Boards and Long Lines Equipment—Repair Instructions, Apparatus Requirements.  
TM 11-4700 Electrical Indicating Instruments and Test Sets, Repair Instructions.

## 6. Forms

AF Form 54 (Unsatisfactory Report.)  
DA AGO Form 468 (Unsatisfactory Equipment Report.)  
NME Form 6 (Report of Damaged or Improper Shipment.)

## 7. Glossary

Refer to the glossary in the appendix of TM 11-2100 and to the list of abbreviations in the appendix of TM 11-2103.