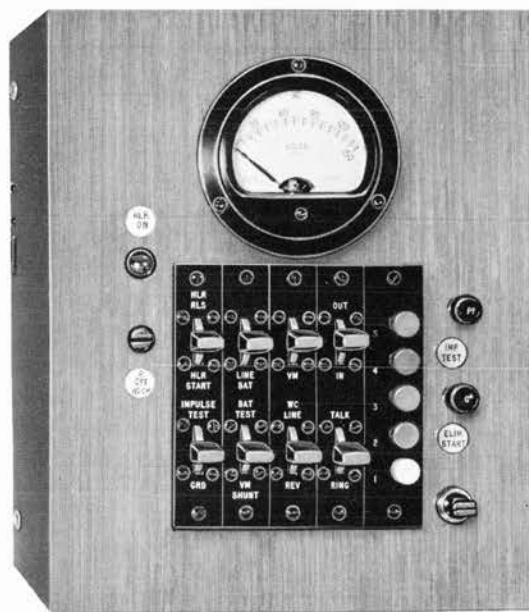


# WIRE CHIEF'S TEST UNIT TYPE 22



Technical  
bulletin **476**

***AUTOMATIC ELECTRIC***

Subsidiary of

**GENERAL TELEPHONE & ELECTRONICS**





*Factory, development laboratories, and general office at Northlake, Illinois, U.S.A.*

AUTOMATIC ELECTRIC COMPANY is an organization of designing, engineering, and manufacturing specialists in the fields of communication, electrical control, and allied arts. For more than sixty years the company has been known throughout the world as the originator and parent manufacturer of the Strowger Automatic Telephone System. Today Strowger-type equipment serves over 75% of the world's automatic telephones. The same experience and technique that have grown out of the work of Automatic Electric engineers in the field of telephone communication are also being successfully applied on an ever-increasing scale to the solution of electrical control problems in business and industry.

## PRINCIPAL PRODUCTS

**Strowger Automatic Telephone Systems**—Complete automatic central-office equipment for exchange areas of any size, from small towns to the largest metropolitan networks.

**Community Automatic Exchanges**—Unattended automatic units for small rural or suburban areas, with facilities for switching into attended exchanges.

**Automatic Toll Boards**—An adaptation of Strowger principles to toll switching, resulting in simplification of operators' equipment and greater economy of operating and toll-circuit time.

**Private Automatic Exchanges**—Available in various capacities, with or without central-office

connections, and with facilities for special control services to meet the needs of the user.

**P.B.X. Switchboards**—A complete range of cordless and cord types for the modern business.

**Telephone Instruments**—Modern designs for automatic or manual exchanges, including the Monophone—the world's most attractive and efficient handset telephone.

**Exchange Accessory Equipment**—Auxiliary exchange and substation equipment, including manual desks, testing apparatus, transmission equipment, and all accessories needed for the operation and maintenance of the modern telephone exchange.

Makers also of electrical control apparatus for industrial, engineering, and public utility companies, telephone apparatus for railroads and pipe-line companies, private telephone systems of all types, electrical and communication devices for aircraft and airways control, and special communication apparatus for military and naval departments.

# CONTENTS

	Page
1. GENERAL . . . . .	1
2. FEATURES . . . . .	1
3. EQUIPMENT DETAILS . . . . .	1
3.1 General Design . . . . .	1
3.2 Test Equipment . . . . .	1
3.2.1 Voltmeter . . . . .	2
3.2.2 Keys . . . . .	2
3.2.3 Miscellaneous test equipment . . . . .	4
4. CONNECTING CIRCUITS AND ASSOCIATED EQUIPMENT . . . . .	5
4.1 Test Cord . . . . .	5
4.2 Ringing Supply . . . . .	5
4.3 Howler . . . . .	5
4.4 Dial Speed Indicator . . . . .	5
4.5 Line Equipment . . . . .	5
4.6 Extension Ringer . . . . .	5
4.7 Telephone . . . . .	5
4.8 Test Battery . . . . .	6
4.9 Ringing Machine . . . . .	6
5. METHOD OF OPERATION . . . . .	6
5.1 Incoming Calls - Via Connector Terminals (Figure 7) . . . . .	6
5.2 Outgoing Calls - Via Line Equipment . . . . .	6
5.3 Voltmeter Test on Lines and Trunks . . . . .	6
5.3.1 Reading test battery voltage . . . . .	6
5.3.2 Loop test - no battery on voltmeter . . . . .	6
5.3.3 Switchboard test . . . . .	6
5.3.4 Loop test with battery on voltmeter . . . . .	6
5.3.5 Capacitance test . . . . .	7
5.3.6 Test for ground on ring . . . . .	7
5.3.7 Test for ground on tip . . . . .	7
5.3.8 Measurement of foreign potential . . . . .	8
5.3.9 Line leaks . . . . .	8
5.3.10 Voltmeter shunt . . . . .	9
5.3.11 Test for crosses between lines . . . . .	9
5.4 Operational Tests . . . . .	10
5.4.1 Talking . . . . .	10
5.4.2 Monitoring . . . . .	10
5.4.3 Straight line ringing . . . . .	10
5.4.4 Harmonic ringing . . . . .	10
5.4.5 Superimposed ringing . . . . .	11
5.4.6 Dial speed test . . . . .	11
5.4.7 Electronic howler . . . . .	11



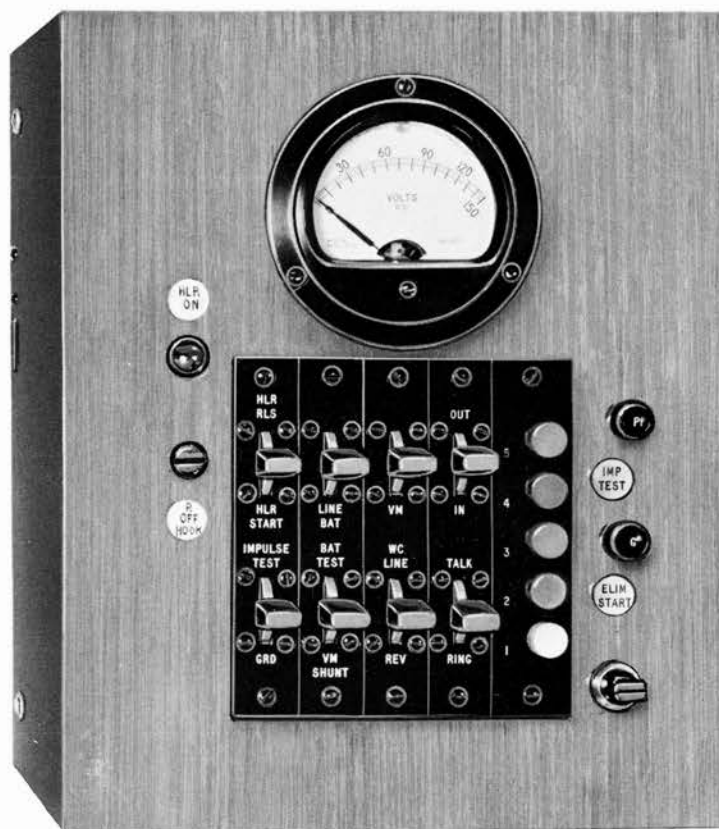


Figure 1. Type 22 wire chief's test unit (H-73435-A), general view.

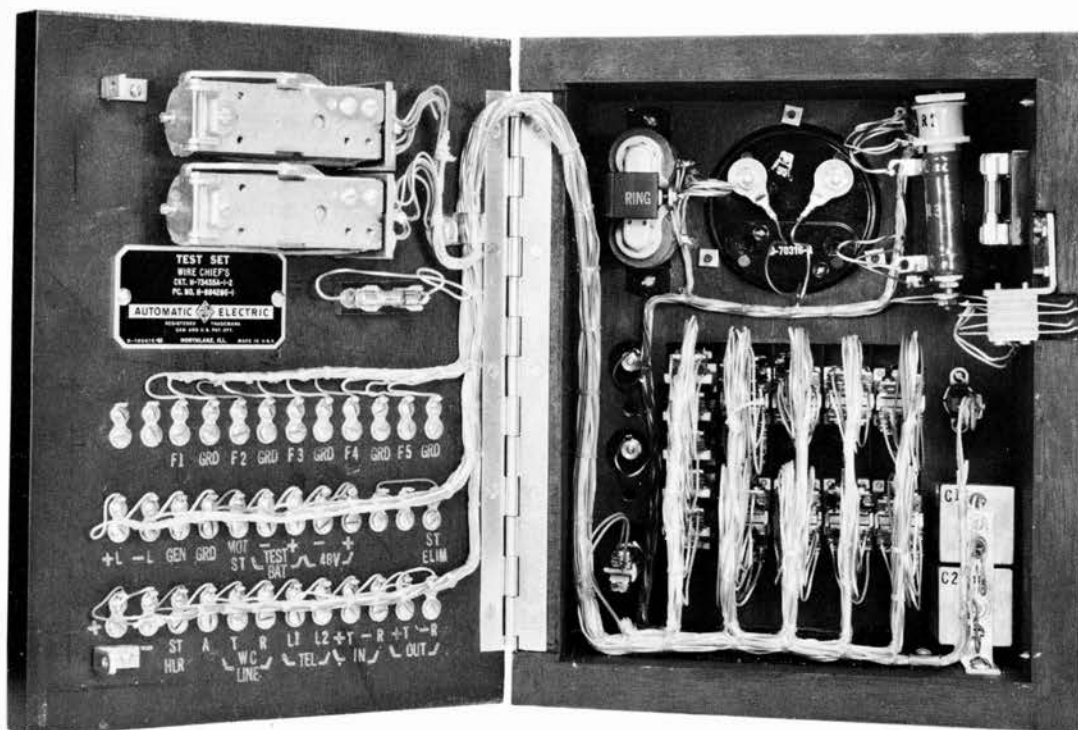


Figure 2. Type 22 wire chief's test unit, (H-73435-A) interior view.

# TYPE 22 WIRE CHIEF'S TEST UNIT

## 1. GENERAL

The type 22 wire chief's test unit provides means for performing tests and locating trouble on subscriber lines, interoffice trunk circuits and associated central office equipment.

It is particularly designed for use in small exchanges (up to 400 lines) not equipped with test connectors; automatic or manual, local battery or central office battery, and in unattended community dial offices.

This test unit is a portable wire chief's test desk which may be located on any convenient wall, desk, or table; on a main distributing frame column, or in a manual exchange at one end of the switchboard.

This bulletin provides information concerning the present (circuit H-73435-A) and former (circuit H-73435) type 22 test units which are basically the same. However, when a difference occurs between models it will be called out in a note.

## 2. FEATURES

The type 22 wire chief's test unit has facilities for performing ordinary line tests and for detecting general nonstandard operating conditions. This test unit is arranged for the following functions:

- a. To receive and originate regular two way service calls between a test attendant in the exchange and subscribers, inspectors, installers, or others outside the exchange. This feature is independent of the test circuit and is accomplished via regular automatic line equipment and a connector terminal, or via manual line equipment and switchboard interposition trunks. See sections 5.1 and 5.2.
- b. To perform routine operational tests on the station equipment of a line. These tests are done without the use of the voltmeter. See section 5.4.
- c. To perform routine voltmeter tests determining:

- (1) Whether a line or trunk is free of shorts, grounds, and crosses with exchange battery, outside lines, or foreign potentials.
- (2) That the continuity of the line is complete.
- (3) That the capacity of the line, corresponding to the number of stations connected to the line, is correct.
- (4) That the insulation resistance of the line is satisfactory.

Tests for these conditions are done by the operation of applicable keys. See section 5.3.

## 3. EQUIPMENT DETAILS

### 3.1 General Design

The type 22 wire chief's test unit (figure 1), is enclosed in a cabinet 10-1/2 inches high, 8-1/2 inches wide, and 5-1/4 inches deep. The cabinet is usually made of mahogany, finished in dull, insulating, black lacquer enamel. The weight of the type 22 wire chief's test unit is 9 pounds.

The rear cover of the cabinet is hinged, providing access to the interior of the case (figure 2). All wiring is connected to a terminal strip on the rear cover. The exterior circuits, such as battery, ground, test cords, ringing supply, line equipment, test attendant's telephone, etc. are carried through a cable hole to be drilled in the cabinet (at a suitable location at the time of installation) by the installer or customer and connected to the terminal strip in accordance with the designated terminals. (Figure 3).

NOTE. Figure 4 shows the terminal strip for previous test units.

### 3.2 Test Equipment

The test equipment consists of a voltmeter, keys, test jack, buzzer, retardation coils, capacitors and resistors.

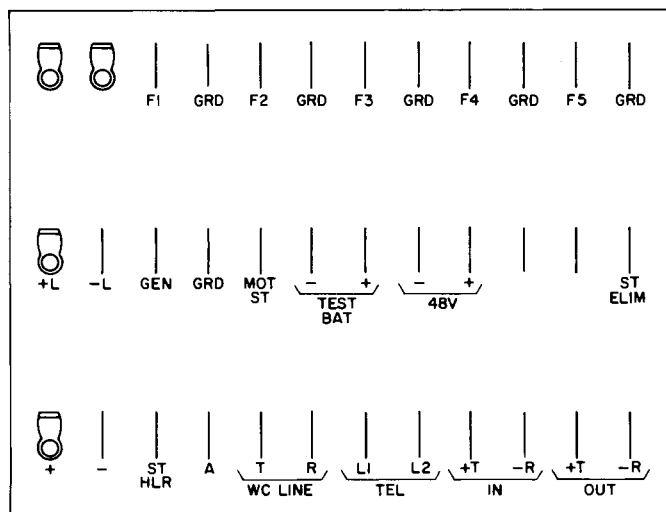


Figure 3. Terminal strip for test unit H-73435-A.

### 3.2.1 Voltmeter.

The basic test circuit for locating and measuring faults consists of a separate 150 volt insulated test battery or 150 volt battery eliminator and a 100,000 ohm Weston Model 301-57 dc single scale voltmeter with a scale of 0-150 volts. The voltmeter is associated with a shunt resistor for measuring low resistance values. The internal resistance of the voltmeter is 100,000 ohms.

NOTE. Previous models used a voltmeter with a scale of 0-100 volts.

### 3.2.2 Keys.

All test circuits are key ended, with keys located in the front panel of the test unit (figure 1). Figure 5 shows the location and designation of each key.

NOTE. The key panel for previous models, when wired for a Lorain electronic howler, is identical to figure 5 except that the battery eliminator start (ELIM START) and RING OFF HOOK keys are not present. Figure 6 shows the key panel of the previous models when wired for an A. E. Co. howler.

The keys, their operating positions, and their functions are as follows:

#### a. BAT TEST/VM SHUNT key.

BAT TEST (battery test) - a locking key position for reading the voltage of the test battery.

VM SHUNT (voltmeter shunt) - a locking key position for connecting the 1010 ohm shunt resistor R1 across the voltmeter when measuring low resistance values (49,000 ohms - 150 volt insulated test bat-

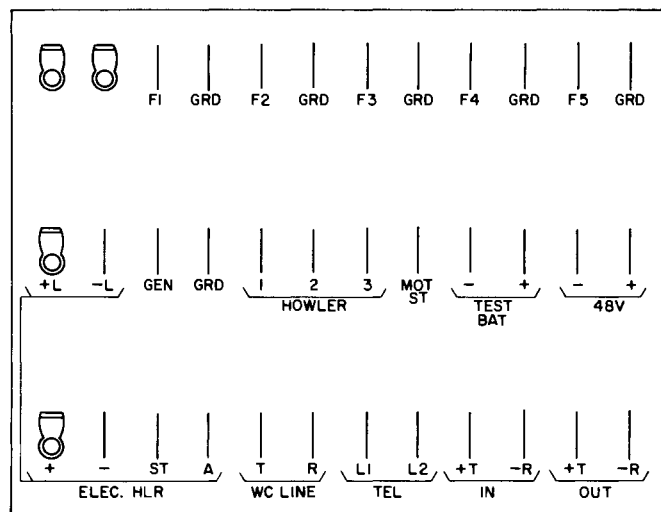


Figure 4. Terminal strip for previous test unit H-73435.

tery or battery eliminator). This reduces the voltmeter resistance from 100,000 to 1,000 ohms.

NOTE. With the previous test unit (circuit H-73435) using 24 or 48 volt test battery, operate the VM SHUNT key when measuring resistance values under 23,000 ohms for 24 volt test battery and under 47,000 ohms for 48 volt test battery.

#### b. VM key.

VM (voltmeter) - a locking key used for connecting test battery in series with the voltmeter and extending the voltmeter to the ring side of the line or trunk. This arrangement is used on loop tests, line leak tests, tests for ground on the ring or tip side of the line, tests for crosses between lines, and tests for capacitance.

#### c. LINE BAT key.

LINE BAT (line battery) - a locking key position which furnishes battery and ground through retardation coil B (figure 16) as talking battery to the telephone of a subscriber or testman outside the exchange.

NOTE. On previous test units equipped with an A. E. Co. howler this key is the HLR/LINE BAT key (figure 6). The HLR (howler) position is used to connect the test unit (figure 18 "X" wiring and apparatus) to an A. E. Co. howler box for receiver off-hook signaling.

#### d. IMPULSE TEST/GRD key.

IMPULSE TEST - a locking key position which connects the test circuit to a portable dial speed indicator for checking the pulsing speed of subscriber dials in an automatic

exchange. The dial speed indicator is not furnished with the test unit except when specified. It can be added at any future time.

GRD (ground) – a locking key position used on voltmeter tests with insulated test battery. The operation of this key, in conjunction with the operation of the VM key, connects ground to the positive terminal of test battery when making the following voltmeter tests: leak tests, test for ground on the ring or tip side of the line, tests for crosses between lines, and tests for capacitance on the ring or tip side of the line.

This key, in the GRD position, is also used with the voltmeter independently of the VM key when making tests for foreign negative (battery) potential on the ring or tip side of the line.

e. TALK/RING key.

TALK – a locking key position which furnishes battery and ground through retardation coil A (figure 16) as talking battery to the telephone associated with the test unit. This key also connects the telephone of the test unit through a capacitor bridge to the outside line or trunk.

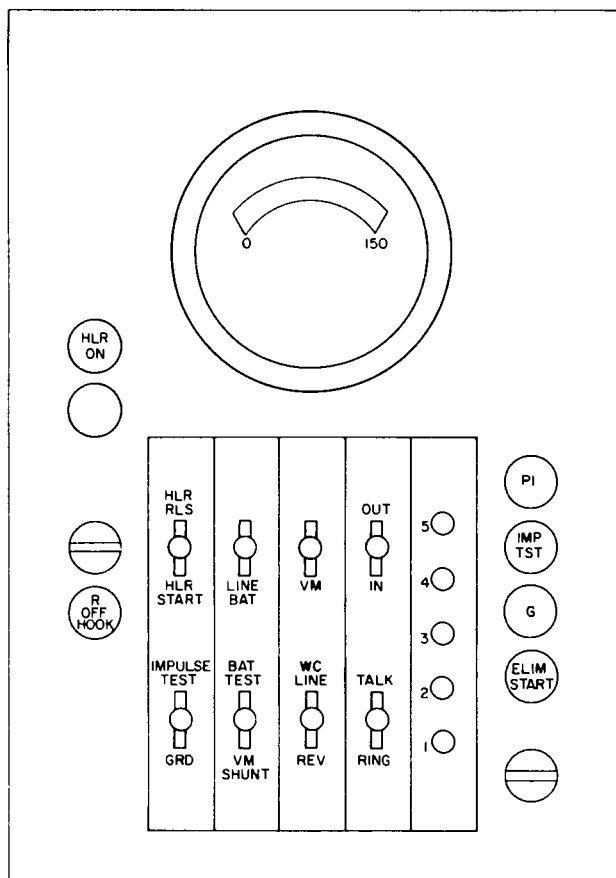


Figure 5. Key location for test unit H-73435-A.

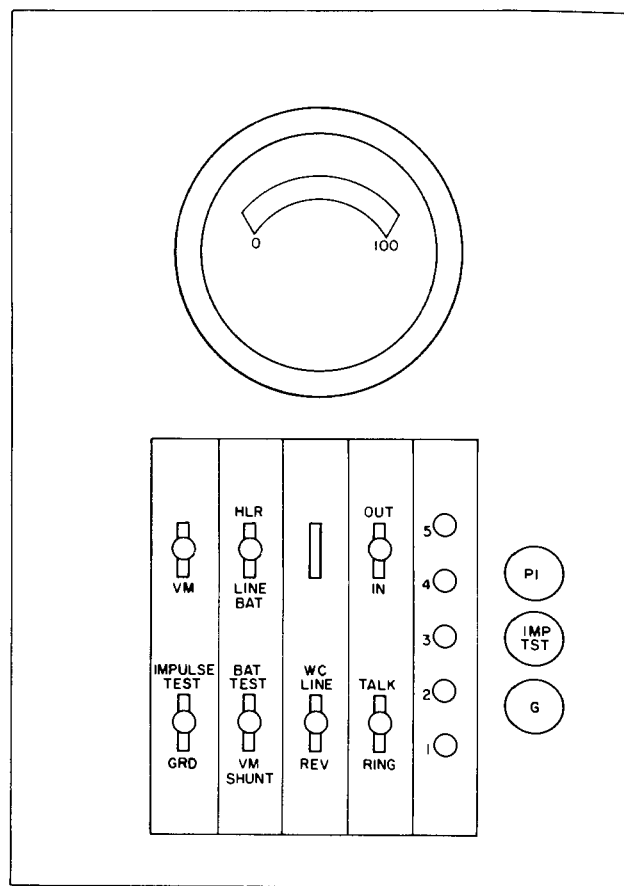


Figure 6. Previous test unit key location when equipped with an A. E. Co. howler (H-73435).

This key, when operated to the TALK position, permits the test attendant to monitor a line or trunk to verify an idle or busy condition before proceeding with routine tests.

RING – a non-locking key position for connecting ringing current to a line or trunk plugged up for test. This key permits the test attendant to signal or recall a repairman located on an outside line or trunk.

f. WC LINE/REV key.

WC LINE (wire chief's line) – a locking key position used for connecting the test attendant's telephone to the regular assigned line circuit for answering incoming calls to the test position or for originating outgoing calls from the test position via the regular exchange switch train. This key remains normal when working on lines and trunks plugged up for test.

REV (reverse) – a locking key position for reversing tip and ring connections to the line or trunk plugged up for test. This key is used when making voltmeter tests as follows:



- (1) Tests for foreign potential across the line.
- (2) Tests for line leak.
- (3) Tests for ground on the ring or tip side of the line.
- (4) Tests for crosses between lines.
- (5) Tests for capacitance.
- (6) Tests for foreign negative potential on the line. In the REV position this key is also used in conjunction with the TALK/RING key in the TALK position for tip side party line ringing.

g. HLR RLS/HLR START key.

HLR RLS (howler release) – a non-locking key position used in conjunction with the Lorain Model B electronic howler. When operated, the HLR RLS key breaks the circuit to the electronic howler box, thereby stopping the howler and extinguishing the HLR ON lamp.

HLR START (howler start) – a non-locking key position used to connect the test unit to an external Lorain Model B electronic howler for receiver off-hook signaling. When the HLR START key is momentarily operated it supplies a ground to operate a relay in the electronic howler box. This relay operates and locks. Contacts of this relay connect howler tone to the + and - lines and on out to the receiver which is off-hook; also, contacts of this relay close a circuit to light the HLR ON lamp located at the type 22 wire chief's test unit. Wiring is provided for the howler, but the electronic howler box is not furnished with the test unit except when specified. It can be added at any future time.

NOTE. This key and its associated HLR ON lamp, is also present on former test unit models (figure 18 "Y" wiring and apparatus) wired for a Lorain electronic howler.

h. OUT/IN key.

OUT – a locking key position used for tests on a line or trunk plugged up for test through a test cord. The operation of the OUT/IN key to the OUT position splits the line or trunk circuit, disconnecting the switchboard end of the circuit and extending the outside line through to the test unit for the performance of tests.

IN – a locking key position used for tests on a line or trunk plugged up for test through

a test cord. The operation of the OUT/IN key to the IN position splits the line, disconnecting the outside line and extending the inside or switchboard end of the circuit through to the test unit for the performance of tests.

i. Harmonic or superimposed ringing push keys 1, 2, 3, 4, and 5.

Harmonic ringing push keys are locking type keys used in conjunction with the TALK/RING key in the RING position when harmonic party-line ringing is used. The operation of a harmonic ringing key furnishes ringing current of a particular frequency to ring a station ringer connected to the ring side of the line. The WC LINE/REV key is operated to the REV position when ringing a party connected to the tip side of the line.

When superimposed ringing is required, push keys 1 and 2 are wired to -GEN and +GEN respectively (figure 17 and 18).

Wiring is provided for the harmonic or superimposed ringing keys, but the keys are not furnished with the test unit unless specified.

j. ELIM START key.

ELIM START (eliminator start) – a turn key used to start the 150 volt battery eliminator. This key must be operated before attempting any tests.

NOTE. This key was not needed on former models as they used 48 or 24 volt exchange battery or separate insulated test battery up to 100 volts.

k. RING OFF HOOK key.

RING OFF HOOK – a turn key provided to permit ringing off-hook telephones when the howler tone is ineffective (on R.E.A. endorsed installations, only).

NOTE. This key is not provided on former models (circuit H-73435).

### 3.2.3 Miscellaneous test equipment.

- a. Test Jack. A test jack located on the side of the cabinet is provided to permit the use of a portable handset as a test attendant's telephone instead of a standard telephone.
- b. Buzzer. An a-c buzzer is provided as an audible signal when ringing on a line or trunk plugged up for test.



- c. Binding posts (IMP TEST). Two binding posts designated P1 and G are provided to permit the use of a portable external dial speed indicator circuit with the test unit.

#### 4. CONNECTING CIRCUITS AND ASSOCIATED EQUIPMENT

##### 4.1 Test Cord

The leads designated "To Test Cord" (figures 17 and 18) allow the connection of subscriber lines and trunk circuits to the test unit. These leads may be cabled to the MDF, or wherever required. At the MDF, these leads terminate either in four-conductor patching cords or in twin jacks located in suitable jack boxes. The patching cords and the plugging up cords for use with the jack boxes, are equipped on one end with test shoes for establishing connection to the main frame protectors of the particular line or trunk to be tested. The plugging up cords are equipped on the opposite end with a twin plug for insertion in the twin jack boxes.

This arrangement loops the outside line or trunk circuit through contacts of either position of the IN/OUT key to the switchboard side of the line. This connects the test circuit to the line or trunk to be tested without splitting until such time as the test man desires to separate the line (i. e., disconnecting the outside line from the inside line equipment for the performance of tests).

In a manual exchange, test connections may be established at the manual switchboard by connecting a switchboard test cord to the test unit leads designated "To Test Cord". In this case a switchboard operator may make all the necessary tests for the wire chief when he is outside the exchange.

##### 4.2 Ringing Supply

The test unit is supplied with ringing current from the exchange ringing equipment. Provision is made for either multifrequency, single frequency, or superimposed ringing.

Five frequencies of ringing current may be connected to the test unit. Ten party ringing is accomplished by using the harmonic ringing keys and the WC LINE/REV key in the REV position, in combination. The test unit may be furnished for straight line or code ringing, without the harmonic or superimposed ringing keys, in which case the latter may be added at any future time.

##### 4.3 Howler

The test unit is arranged for connection to an external Lorain Model B electronic howler, via leads designated "To Electronic Howler"

(figure 17). The howler is used for receiver off-hook signaling (section 5.4.7). Wiring is provided, but the howler is not furnished except when specified. It may be added at any future time.

NOTE. Former models used A. E. Co. or Lorain howlers. When wired for an A. E. Co. howler, connection is made via leads designated "To Howler Circuit" (figure 18).

##### 4.4 Dial Speed Indicator

The test unit is arranged for connection, via leads designated "To Impulse Test Set" (figures 17 and 18), to an external portable dial speed indicator for testing subscriber dials in automatic exchanges. Wiring is provided but the dial speed indicator is not furnished with the test unit except when specified. It can be added at any future time.

##### 4.5 Line Equipment

Connection is made to a regular subscriber line circuit via leads designated "To Line Eqpt" (figures 17 and 18). Either an automatic or manual switchboard line circuit may be used. This line circuit is used for calls into the test unit and for originating calls from the test unit.

##### 4.6 Extension Ringer

An extension ringer with a capacitor connected in series with the ringer coils is connected to leads designated "To Extension Ringer" (figures 17 and 18) to serve as an incoming signal. The ringer box should be located within audible distance of the test position, preferably underneath the desk, table or work bench on which the test unit is located. This ringer is not furnished as part of the test unit but is supplied by the customer.

##### 4.7 Telephone

Leads L1 and L2 designated "To Auto. Tel." (figures 17 and 18), connect the test attendant's telephone to the test circuit for talking and dialing on regular calls via the line equipment. This is done by operating the WC LINE/REV key to the WC LINE position. All outgoing and incoming calls are originated and received over the test telephone.

When the test circuit is used with a line or trunk plugged up for test via a test cord, the WC LINE key remains normal and connection to the test attendant's telephone is established by operation of the TALK/RING key to the TALK position. A telephone is not furnished with the test unit unless specifically requested. In automatic exchanges, a portable handset is entirely suitable and can be readily plugged into the test unit TEST JACK (figures 17 and 18). Where no handset is available, any standard type of telephone may be used.

## 4.8 Test Battery

The test unit is arranged for use with 150 volt insulated test battery or a 150 volt battery eliminator.

NOTE. Previous models (circuit H-73435) of the test unit were arranged for use with either 48 volt or 24 volt exchange battery or with a separate insulated test battery up to 100 volts.

## 4.9 Ringing Machine

When performing outside tests on lines or trunks, ringing may be required. Therefore the OUT position of the OUT/IN key is provided with a make contact (figures 17 and 18) to start the ringing convertor, ringing interrupter, and tone generator equipment in small offices where such equipment operates only while a call is in progress.

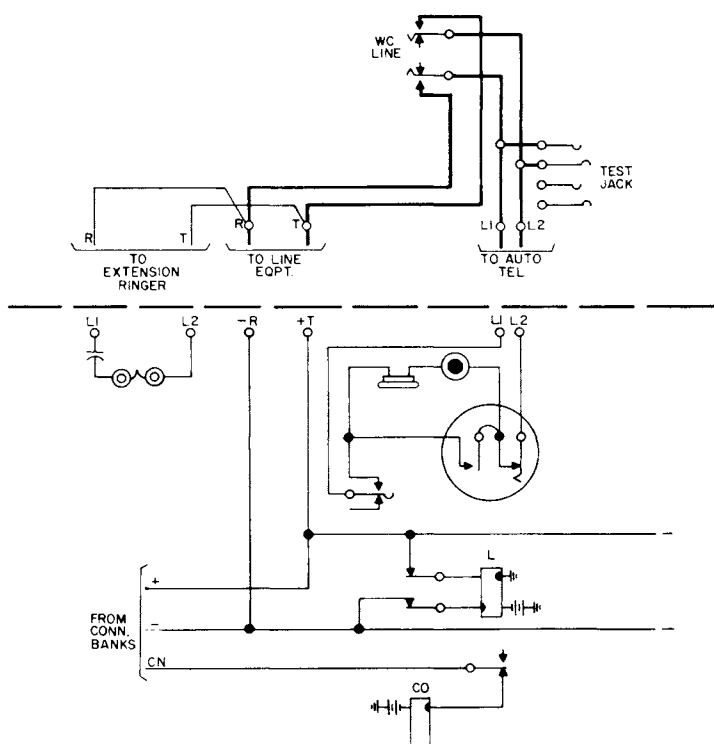


Figure 7. Connection to line equipment.

## 5. METHOD OF OPERATION

NOTE. When test battery is a 150 volt battery eliminator, key ELIM START (eliminator start) must be operated before making any tests.

### 5.1 Incoming Calls - Via Connector Terminals (Figure 7)

To answer an incoming call lift the receiver of the test unit telephone and operate the WC LINE/REV key to the WC LINE position. To release the call, restore the WC LINE key.

### 5.2 Outgoing Calls - Via Line Equipment

To initiate an outgoing call operate the WC LINE/REV key to the WC LINE position. Lift the receiver and dial the number. Release the connection by restoring the WC LINE key.

### 5.3 Voltmeter Test on Lines and Trunks

Connect the line or trunk to be tested as described in section 4.1. Operate OUT/IN key to OUT position.

NOTE. There may be a momentary deflection of the voltmeter needle; do not test until needle is steady.

#### 5.3.1 Reading test battery voltage.

The voltage of the test battery or battery eliminator should be checked before attempting any voltmeter measurement test on a line loop, short circuited line, or resistances to ground; by operating the BAT TEST/VM SHUNT key to the BAT TEST position. The voltmeter will give a voltage reading of the test battery.

#### 5.3.2 Loop test - no battery on voltmeter.

Operate the OUT/IN key to the OUT position. The voltmeter will indicate whether the line under test is connected to battery (figure 8). The voltmeter will also indicate positive potential if external battery is on ring side of line.

NOTE. If voltmeter deflects off scale, operate the WC LINE/REV key to the REV position and the proper voltage deflection may be read.

The tests in sections 5.3.1 and 5.3.2 must be made before making any voltmeter tests, as an external or foreign voltage will affect all voltmeter testing.

#### 5.3.3 Switchboard test.

To connect to switchboard operate the OUT/IN key to IN and make desired tests (figure 9).

#### 5.3.4 Loop test with battery on voltmeter.

Operate the OUT/IN key to the OUT position and operate the VM key. A steady deflection of the voltmeter indicates a closed or short-circuit condition. The amount of deflection indicates whether a short, a ground, or insulation resistance is being measured (figure 10). If exchange battery is used operate WC LINE/

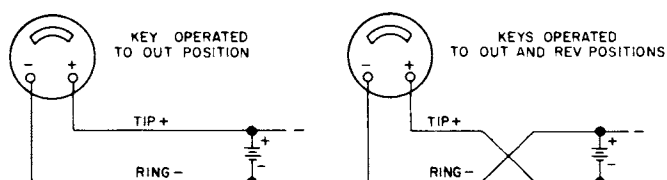


Figure 8. Loop test - no battery on voltmeter.

REV key to the REV position. The voltmeter will continue to show a deflection for a shorted line, and no deflection for a grounded ring.

The voltage indicated by the deflection can be used to determine the resistance of the loop through the short circuit. This resistance may be read from Table I, II, III, IV, V, or VI or calculated by the following formula:

$$X = \frac{E-V}{V} R$$

Where X is the resistance of the loop; E is the voltage of test battery; V is the voltmeter reading, and R is the resistance of the voltmeter.

The same method may be used to measure the normal loop resistance of a subscriber line when the circuit is closed by the removal of the receiver at the subscriber station or to measure any other resistance when it is connected across the TO and RO leads of the test cord.

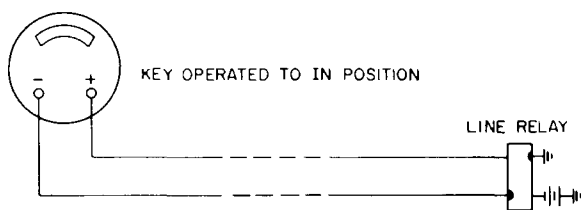


Figure 9. Testing line equipment.

#### 5.3.5 Capacitance test.

Operate the OUT/IN key to the OUT position and the VM key. If capacitors are bridged across the line or connected between the ring side of the line and ground, a steady deflection or a deflection and return to zero of the voltmeter needle will be noticed. The amount of deflection indicates an approximate measurement of the capacitance.

- a. Capacitance across line – insulated test battery only (figure 11). The OUT/IN key will remain operated to the OUT position and the VM key will remain operated. There should be a momentary deflection of the voltmeter needle. Then, alternately operate and release the WC LINE/REV key to the REV position. There should be a corresponding “kick” of the voltmeter needle due to charge and discharge of the capacitor under test. If the REV key is operated and restored rapidly the deflection of the needle will remain steady and the capacitance of the capacitor under test may be compared with a capacitor of known value.
- b. Capacitance from ring to ground (figure 11). Operate the IMPULSE TEST/GRD key to the GRD position. Operate the OUT/IN key to the OUT position. Rapidly operate and

release the VM key. The needle of the voltmeter should remain steadily deflected in order to compare the capacitance of the capacitor under test with a capacitor of known value.

- c. Capacitance from tip to ground (figure 11). Operate WC LINE/REV key to REV position. Perform remainder of test as in b. above.

NOTE. If the line is open, there will be no kick of the needle in either case. If one side of the line is open there will be no deflection of the needle when testing that side of the line. If there are no telephones connected to the sides of a party line with grounded ringing, there will be little or no capacitance deflection. In the case of long lines there may be a slight deflection due to the capacitance of the line.

#### 5.3.6 Test for ground on ring.

To initiate a test for ground on ring, operate the OUT/IN key to the OUT position. Operate the VM key and the REV key. If exchange battery is used, the voltmeter may show a deflection of the needle. If a deflection of the needle is indicated, there is a short or ground on the ring side of the line. If a short is indicated, the VM key is left operated, and the IMPULSE TEST/GRD key is operated to the GRD position (figure 12a). With the GRD key operated, a deflection of the voltmeter needle indicates ground on the ring side of the line. No deflection of the needle indicates the condition is caused by a shorted line. This test holds true for insulated test battery as well as exchange battery.

#### 5.3.7 Test for ground on tip.

To test for ground on the tip side of the line the VM key is operated as are the IMPULSE TEST/GRD and OUT/IN keys to the GRD and OUT position, respectively. The WC LINE/REV key is operated to the REV position (figure 12b). A deflection of the voltmeter

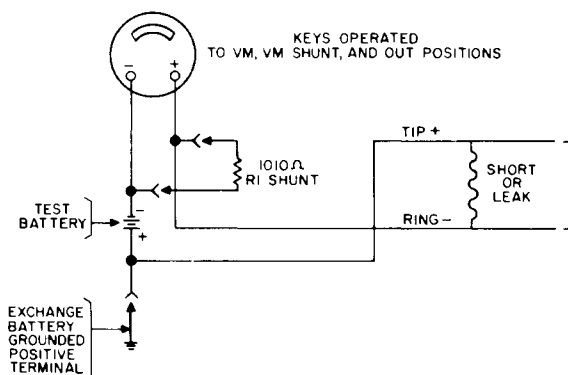


Figure 10. Loop test with battery on voltmeter.

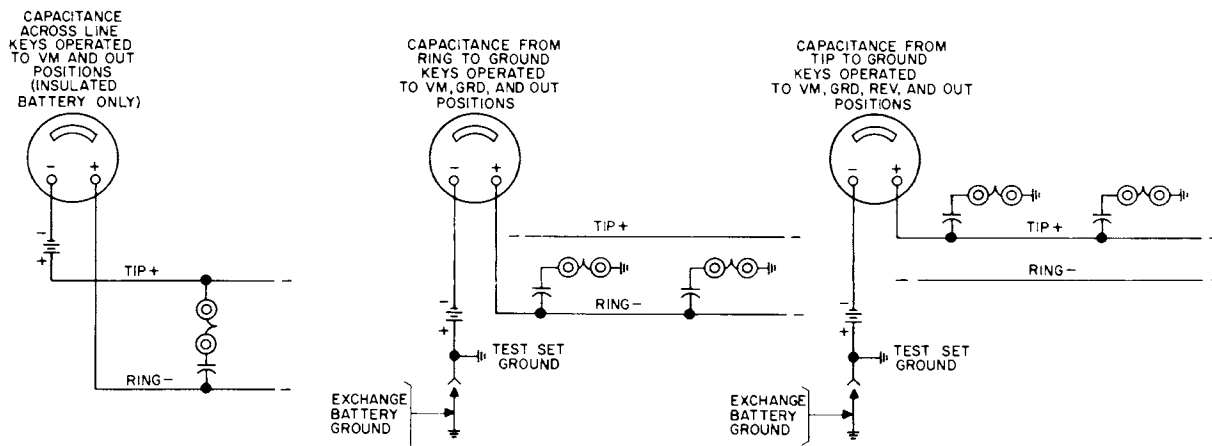


Figure 11. Capacitance tests.

needle indicates a ground on the tip side of the line. The resistance of either side of the line to ground is measured by the deflection of the voltmeter needle. It can be calculated by the formula below:

$$X = \frac{E-V}{V} R$$

#### 5.3.8 Measurement of foreign potential.

A foreign potential is any current other than the regular test battery supply. This voltage may be caused by a cross between conductors of two telephone lines; current carrying conductors of telegraph, police, and fire alarm systems; radios, etc.; and in some cases by ac power and lighting circuits paralleling telephone lines.

NOTE. Caution must be used in making measurements of external voltages to prevent damage to the voltmeter.

- Test for negative potential on ring (figure 13). Establish a test connection as in section 4.1. Operate the IMPULSE TEST/GRD and OUT/IN keys to the GRD and OUT positions, respectively. A deflection of the voltmeter needle indicates a negative potential on the ring side of the line (figure 13).
- Test for negative potential on tip side of the line. Operate the WC LINE/REV key to the REV position, leave other keys operated as in a. above. A deflection of the voltmeter needle indicates a negative potential on the tip side of the line (figure 13).

#### 5.3.9 Line leaks.

The voltage of the test battery makes it unnecessary, when making normal tests, to consider ground potentials, since the error introduced in the reading of the voltmeter is

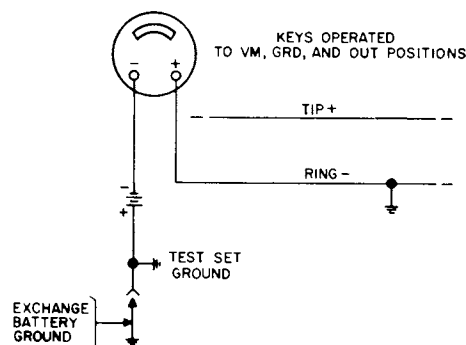


Figure 12a. Test for ground on ring.

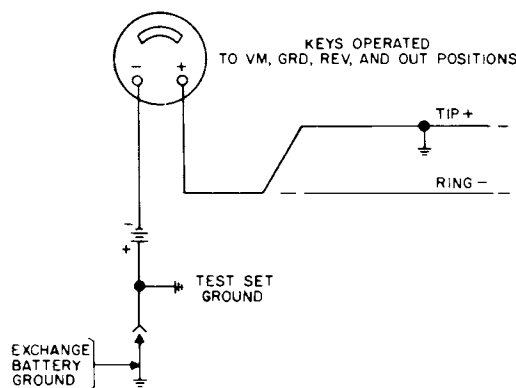


Figure 12b. Test for ground on tip.

comparatively small. If the looptest described in section 5.3.4 shows a steady deflection when the VM key is operated, a line leak condition is indicated. The insulation between conductors and from each conductor to ground should be measured.

- Leak across tip and ring (figure 14). A measurement of insulation resistance between the tip and ring conductors of a line is accomplished in the same manner as for a loop test with battery on the voltmeter, as described in section 5.3.4.



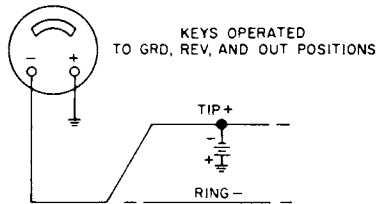
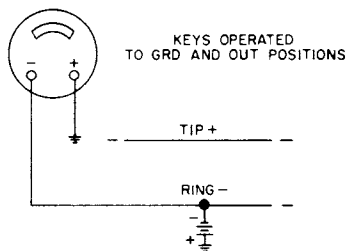


Figure 13. Test for foreign negative potential on ring or tip.

- b. Leak from ring to ground (figure 14). Operate the OUT/IN key to the OUT position and the VM key. Also operate the IMPULSE TEST/GRD key to the GRD position. A steady voltmeter deflection indicates a ground leak on the ring side of the line. This voltage reading can be used to determine the resistance of the leak by reference to Tables I, II, III, IV, V, and VI or by calculation from the formula:

$$X = \frac{E - V}{V} R$$

- c. Leak from tip to ground (figure 14). Operate the WC LINE/REV key to the REV position in addition to the keys operated in b. above. A deflection of the voltmeter needle indicates a ground leak on the tip side of the line.

### 5.3.10 Voltmeter shunt.

To reduce meter sensitivity for the purpose of accurate measurement of low resistance faults, operate the BAT TEST/VM SHUNT key to the VM SHUNT position (figure 10).

### 5.3.11 Test for crosses between lines.

Physical crosses between conductors of two separate telephone lines may be caused by poor insulation, sagging line wires, line wires breaking and falling across another circuit, bullet holes, burns in cables due to lightning, etc. Tests for such conditions may be accomplished as a test for ground on the ring (negative) line or ground on the tip (positive) line, as described in sections 5.3.6 and 5.3.7 (figure 15).

Figure 15a shows a method of testing for a cross between the ring side of one line and the tip side of a second line. In this case line 1 is plugged up for test and a temporary ground is connected to the tip of line 2 at the distributing frame or at the switchboard line jack. A test for ground on the ring of line 1 is made and deflection of the voltmeter indicates a cross between the conductors of two lines.

Figures 15b, 15c, and 15d represent crosses between tip to tip conductors, ring to ring conductors and tip to ring conductors. Tests for these conditions are made in a manner similar to the preceding ring to tip test except it will be necessary to operate the WC LINE/REV key to the REV position when making tests for crosses to the tip conductor of line 1.

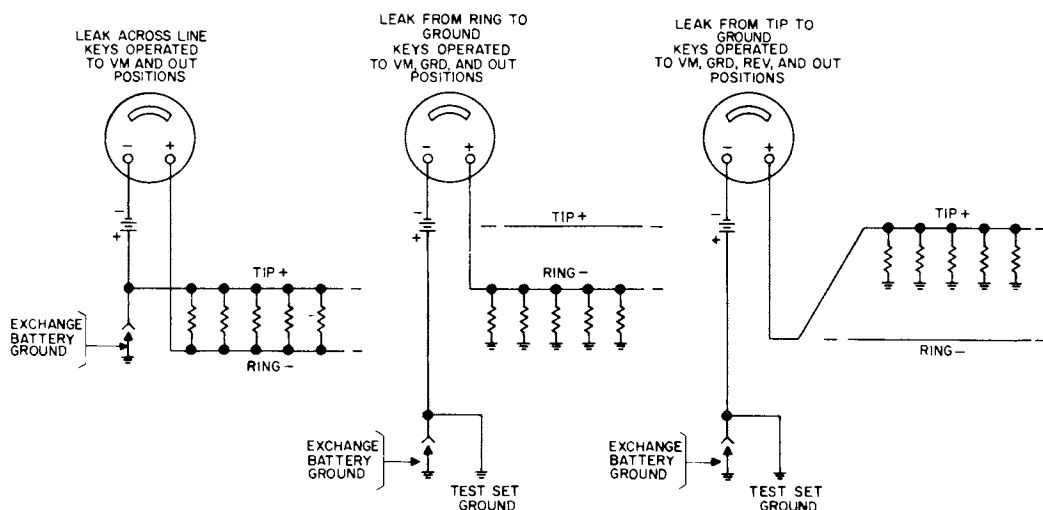
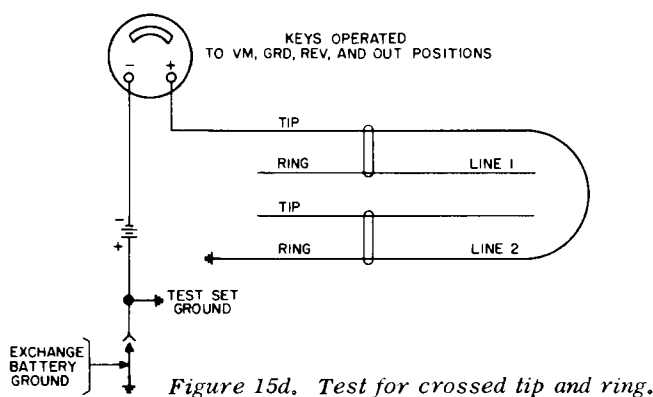
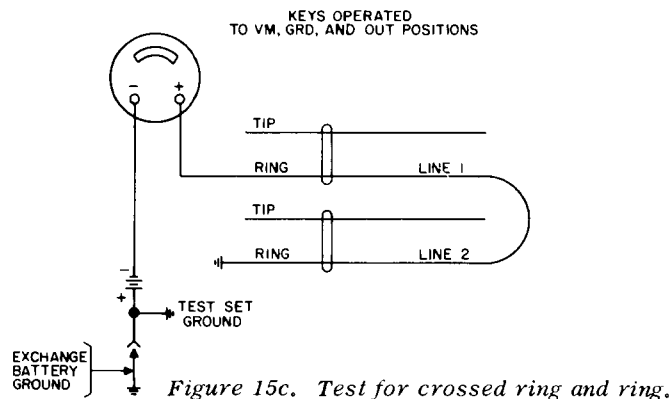
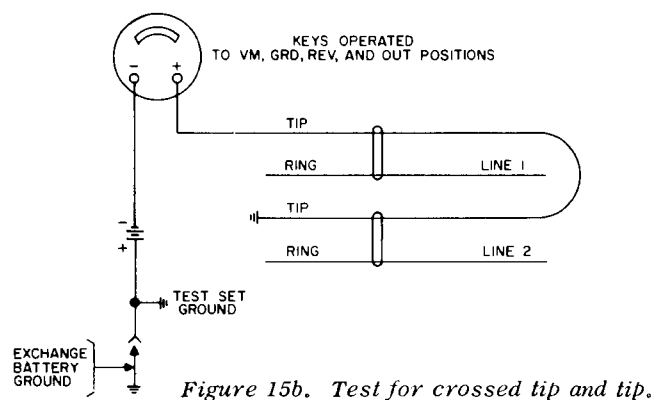
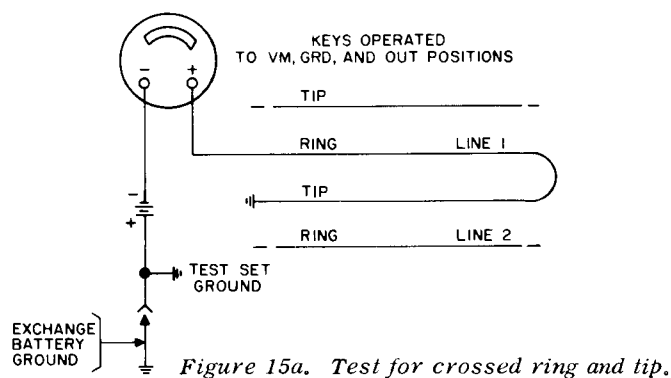


Figure 14. Line leak tests.

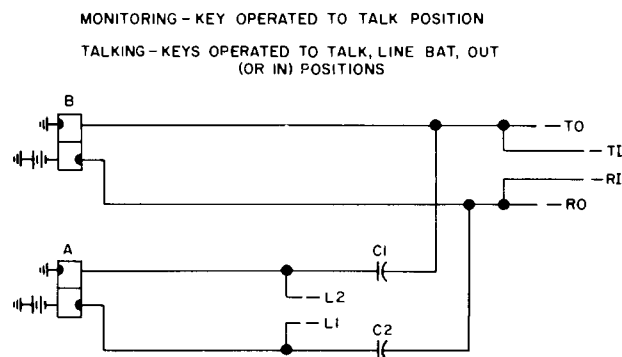


## 5.4 Operational Tests

The wire chief's test unit is equipped with facilities for checking the condition and operation of subscriber station equipment. These tests do not involve the use of the voltmeter.

### 5.4.1 Talking.

To establish a talking circuit operate the TALK/RING and OUT/IN keys to the TALK and OUT positions (figure 16). Operate the LINE BAT key unless the line is equipped with local battery telephones.



### 5.4.2 Monitoring.

The test attendant is able to monitor or listen in to determine if a line or trunk plugged up for test is idle or busy before proceeding with tests. The test attendant may also monitor to determine whether a subscriber is dialing correctly, for quality of transmission, etc. (figure 16). To monitor a line or trunk remove the handset of the telephone and operate the TALK/RING key to the TALK position.

### 5.4.3 Straight line ringing.

When a line is plugged up for test, the test attendant may ring on the line by operating the TALK/RING key to the RING position. If ringing a party line arranged for divided ringing with station ringers connected from tip to ground, operate the WC LINE/REV key to the REV position before operating the RING key.

### 5.4.4 Harmonic ringing.

When harmonic ringing is desired, frequency key 1, 2, 3, 4, or 5 is depressed prior to the operation of the TALK/RING key to the RING position. This operation connects the particular ringing frequency over lead F1, F2, F3, F4, or F5 and generator ground over lead G1, G2, G3, G4, or G5 to the GEN and GRD leads respectively of the test circuit. The operation of the TALK/RING and WC LINE/REV keys to

the RING and REV positions extends ringing current to the line in the same manner as for single frequency ringing.

The following table shows a typical arrangement for the frequency of ringing current connected to the harmonic ringing keys when multiple or nonmultiple harmonic party line ringing is used.

Harmonic Ringing Push Key	Party	Frequency Multiple	Frequency Non-Multiple
1 - White	1 and 6	33-1/3 cycles	30 cycles
2 - Black	2 and 7	50 cycles	42 cycles
3 - Green	3 and 8	66-2/3 cycles	54 cycles
4 - Red	4 and 9	16-2/3 cycles	66 cycles
5 - Blue	5 and 10	25 cycles	20 cycles

During the time ringing current is applied to the line, the a-c buzzer operates, providing an audible indication that the line being signaled is closed, or normal.

The 900 ohm noninductive resistance is connected in parallel with the buzzer so that circuit conditions during the ringing period are the same as when subscriber lines are signaled over the regular automatic switch train. This arrangement enables an installer or inspector to make subscriber station bell adjustments under actual operating conditions.

#### 5.4.5 Superimposed ringing.

Use keys 1 and 2 of the ringing frequency keys. Operate the TALK/RING key to the RING position and press key 1 to operate the ringer for one party and the RING key and key 2 for the other party. When four-party lines are used, operate the WC LINE/REV key to the REV position to ring the other side of the line.

#### 5.4.6 Dial speed test.

After setting up a connection to a line to be tested, the speed of dial pulses sent by the dial of the telephone tested may be measured. This is done by operating the IMPULSE TEST/GRD and OUT/IN keys to the IMPULSE TEST

and OUT positions, plus the key of the external dial pulse speed test circuit. The TALK/RING key to the TALK position, and LINE BAT key are also operated to permit two way conversation with the subscriber station.

The test attendant requests the party at the telephone under test to dial the digit zero. The operation of the dial causes the dial pulsing

springs to open and close the circuit to the pulse test set. These pulses operate and release a pulsing relay in the pulse test set, to give a meter reading in pulses per second.

#### 5.4.7 Electronic howler.

If, after setting up a connection to the line, the attendant suspects the receiver has been left off-hook, the Lorain Model B electronic howler may be connected. Operate the HLR RLS/HLR START and OUT/IN keys to the HLR START and OUT positions. The HLR ON lamp will light. When the user replaces the handset, the circuit to the howler is broken and the howler releases; thereby extinguishing the HLR ON lamp. The howler box should be located beyond the audible range of the test attendant, so that tone produced by the howler will not cause a disturbance. If the attendant wishes to release the howler the HLR START/HLR RLS key is momentarily operated to the HLR RLS position; this breaks the circuit to the howler and extinguishes the HLR ON lamp.

NOTE. In previous models using an A. E. Co. howler, the howler is connected by operating keys HLR/LINE BAT and OUT/IN to the HLR and OUT positions. Since no supervision is furnished on these howlers, the howler is disconnected by restoring the HLR/LINE BAT key.

RESISTANCE TABLE I  
24 VOLT TEST BATTERY  
WITHOUT EXTERNAL SHUNT  
RESISTANCE

TEST BATTERY VOLTAGE

Def. of Needle	22	22.5	23	23.5	24	24.5	25	25.5	26
1	2,100,000	2,150,000	2,200,000	2,250,000	2,300,000	2,350,000	2,400,000	2,450,000	2,500,000
2	1,000,000	1,025,000	1,050,000	1,075,000	1,100,000	1,125,000	1,150,000	1,175,000	1,200,000
3	633,333	649,999	666,666	683,333	700,000	716,666	733,333	749,999	766,666
4	450,000	462,500	475,000	487,500	500,000	512,500	525,000	537,500	550,000
5	340,000	350,000	360,000	370,000	380,000	390,000	400,000	410,000	420,000
6	266,666	274,999	283,333	291,666	300,000	308,333	316,666	324,999	333,333
7	214,286	221,428	228,571	235,714	242,857	249,999	257,142	264,285	271,428
8	175,000	181,250	187,500	193,750	200,000	206,250	212,500	218,750	225,000
9	144,444	149,999	155,555	161,110	166,666	172,221	177,777	183,332	188,888
10	120,000	125,000	130,000	135,000	140,000	145,000	150,000	155,000	160,000
11	100,000	104,545	109,090	113,635	118,181	122,726	127,272	131,817	136,363
12	83,333	87,499	91,666	95,833	100,000	104,166	108,333	112,499	116,666
13	69,230	73,076	76,923	80,769	84,615	88,461	92,308	96,154	100,000
14	57,135	60,710	64,286	67,857	71,428	74,999	78,571	82,142	85,714
15	46,666	49,999	53,333	56,666	60,000	63,333	66,666	69,999	73,333
16	37,500	40,625	43,750	46,875	50,000	53,125	56,250	59,375	62,500
17	29,411	32,352	35,294	38,235	41,176	44,117	47,059	50,000	52,941
18	22,222	24,999	27,777	30,555	33,333	36,110	38,888	41,666	44,444
19	15,800	18,426	21,053	23,684	26,315	28,947	31,579	34,210	36,842
20	10,000	12,500	15,000	17,500	20,000	22,500	25,000	27,500	30,000
21	4,761	7,142	9,523	11,904	14,285	16,666	19,048	21,428	23,809
22	0	2,272	4,545	6,817	9,090	11,363	13,636	15,908	18,181
23		0	0	2,174	4,348	6,521	8,695	10,869	13,043
24				0	0	2,082	4,165	6,249	8,333
25						0	0	2,000	4,000
26								0	0



RESISTANCE TABLE II  
24 VOLT TEST BATTERY  
WITH EXTERNAL SHUNT  
RESISTANCE

TEST BATTERY VOLTAGE

Def. of Needle	22	22.5	23	23.5	24	24.5	25	25.5	26
1	21,000	21,500	22,000	22,500	23,000	23,500	24,000	24,500	25,000
2	10,000	10,250	10,500	10,750	11,000	11,250	11,500	11,750	12,000
3	6,333	6,499	6,666	6,833	7,000	7,166	7,333	7,499	7,666
4	4,500	4,625	4,750	4,875	5,000	5,125	5,250	5,375	5,500
5	3,400	3,500	3,600	3,700	3,800	3,900	4,000	4,100	4,200
6	2,666	2,749	2,833	2,916	3,000	3,083	3,166	3,249	3,333
7	2,142	2,214	2,285	2,357	2,428	2,499	2,571	2,642	2,714
8	1,750	1,812	1,875	1,937	2,000	2,062	2,125	2,187	2,250
9	1,444	1,499	1,555	1,611	1,666	1,722	1,777	1,833	1,888
10	1,200	1,250	1,300	1,350	1,400	1,450	1,500	1,550	1,600
11	1,000	1,045	1,090	1,136	1,181	1,227	1,272	1,318	1,363
12	833	874	916	958	1,000	1,041	1,083	1,124	1,166
13	692	730	769	807	846	884	923	961	1,000
14	571	607	642	678	714	749	785	821	857
15	466	499	533	566	600	633	666	699	733
16	375	406	437	468	500	531	562	593	625
17	294	323	352	382	411	441	470	500	529
18	222	249	277	305	333	361	388	416	444
19	158	184	210	236	263	289	315	342	368
20	100	125	150	175	200	225	250	275	300
21	47	71	95	119	142	166	190	214	238
22	0	22	45	68	90	113	136	159	181
23		0	0	21	43	65	86	108	130
24				0	0	20	41	62	83
25						0	0	20	40
26								0	0

RESISTANCE TABLE III  
48 VOLT TEST BATTERY  
WITHOUT EXTERNAL SHUNT  
RESISTANCE

Def. of Needle	TEST BATTERY VOLTAGE								
	46	46.5	47	47.5	48	48.5	49	49.5	50
1	4,500,000	4,550,000	4,600,000	4,650,000	4,700,000	4,750,000	4,800,000	4,850,000	4,900,000
2	2,200,000	2,225,000	2,250,000	2,275,000	2,300,000	2,325,000	2,350,000	2,375,000	2,400,000
3	1,433,333	1,450,000	1,466,666	1,483,333	1,500,000	1,516,666	1,533,333	1,550,000	1,566,666
4	1,050,000	1,062,500	1,075,000	1,087,500	1,100,000	1,112,500	1,125,000	1,137,500	1,150,000
5	820,000	830,000	840,000	850,000	860,000	870,000	880,000	890,000	900,000
6	666,666	675,000	683,333	691,666	700,000	708,333	716,666	725,000	733,333
7	557,143	564,285	571,428	578,571	585,713	592,856	600,000	607,142	614,285
8	475,000	481,250	487,500	493,750	500,000	506,250	512,500	518,750	525,000
9	411,111	416,666	422,222	427,777	433,333	438,888	444,444	449,999	455,555
10	360,000	365,000	370,000	375,000	380,000	385,000	390,000	395,000	400,000
11	318,181	322,726	327,818	331,818	336,363	340,908	345,454	350,000	354,545
12	283,333	287,500	291,666	295,834	300,000	304,166	308,333	312,500	316,666
13	253,846	257,692	261,538	265,384	269,230	273,076	276,923	280,769	284,615
14	228,571	232,142	235,714	239,285	242,857	246,428	250,000	253,571	257,142
15	206,666	210,000	213,333	216,666	220,000	223,333	226,666	230,000	233,333
16	187,500	190,625	193,750	196,875	200,000	203,125	206,250	209,375	212,500
17	170,588	173,529	176,470	179,411	182,352	185,293	188,235	191,176	194,117
18	155,555	158,333	161,111	161,888	166,666	169,444	172,222	175,000	177,777
19	142,105	144,736	147,368	150,000	152,631	155,262	157,894	160,525	163,157
20	130,000	132,500	135,000	137,500	140,000	142,500	145,000	147,500	150,000
21	119,047	121,428	123,809	126,190	128,571	130,952	133,333	135,714	138,095
22	109,090	111,363	113,636	115,900	118,181	120,454	122,727	125,000	127,272
23	100,000	102,174	104,348	106,522	108,696	110,869	113,043	115,217	117,391
24	91,666	93,750	95,833	97,917	100,000	102,083	104,167	106,250	108,334
25	84,000	86,000	88,000	90,000	92,000	94,000	96,000	98,000	100,000
26	76,923	78,846	80,769	82,692	84,615	86,538	88,461	90,384	92,307
27	70,370	72,222	74,074	75,926	77,777	79,629	81,481	83,333	85,185
28	64,285	66,071	67,857	69,643	71,428	73,214	75,000	76,785	78,571
29	58,621	60,340	62,069	63,793	65,517	67,241	68,965	70,689	72,413
30	53,334	55,000	56,666	58,334	60,000	61,667	63,334	65,000	66,666
31	48,387	50,000	51,612	53,225	54,838	56,451	58,064	59,677	61,290
32	43,750	45,312	46,875	48,437	50,000	51,562	53,125	54,687	56,250
33	39,393	40,908	42,424	43,939	45,454	46,969	48,484	50,000	51,515
34	35,294	36,764	38,235	39,795	41,176	42,646	44,117	45,587	47,058
35	31,428	32,856	34,285	35,703	37,142	38,571	40,000	41,428	42,857
36	27,777	29,166	30,555	31,944	33,333	34,722	36,111	37,500	38,888
37	24,324	25,675	27,027	28,378	29,729	31,080	32,432	33,783	35,135
38	21,052	22,368	23,684	25,000	26,315	27,631	28,947	30,262	31,578
39	17,948	19,230	20,512	21,694	23,076	24,358	25,641	26,923	28,205
40	15,000	16,250	17,500	18,750	20,000	21,250	22,500	23,750	25,000
41	12,195	13,414	14,634	15,853	17,073	18,292	19,512	20,731	21,951
42	9,523	10,713	11,904	13,094	14,285	15,475	16,666	17,856	19,047
43	6,976	8,139	9,302	10,465	11,627	12,790	13,953	15,116	16,279
44	4,545	5,681	6,818	7,954	9,090	10,226	11,363	12,500	13,636
45	2,222	3,333	4,444	5,555	6,666	7,777	8,888	9,999	11,110
46	0	1,087	2,174	3,261	4,347	5,434	6,521	7,608	8,695
47		0	0	1,064	2,127	3,191	4,255	5,319	6,383
48				0	0	1,041	2,083	3,124	4,166
49						0	0	1,020	2,040
50								0	0

RESISTANCE TABLE IV  
48 VOLT TEST BATTERY  
WITH EXTERNAL SHUNT  
RESISTANCE

Def. of Needle	TEST BATTERY VOLTAGE								
	46	46.5	47	47.5	48	48.5	49	49.5	50
1	45,000	45,500	46,000	46,500	47,000	47,500	48,000	48,500	49,000
2	22,000	22,250	22,500	22,750	23,000	23,250	23,500	23,750	24,000
3	14,333	14,500	14,667	14,833	15,000	15,167	15,333	15,500	15,667
4	10,500	10,625	10,750	10,875	11,000	11,125	11,250	11,375	11,500
5	8,200	8,300	8,400	8,500	8,600	8,700	8,800	8,900	9,000
6	6,667	6,750	6,833	6,917	7,000	7,083	7,167	7,250	7,333
7	5,571	5,643	5,714	5,786	5,857	5,929	6,000	6,071	6,143
8	4,750	4,812	4,875	4,937	5,000	5,062	5,125	5,187	5,250
9	4,111	4,167	4,222	4,278	4,333	4,389	4,444	4,500	4,556
10	3,600	3,650	3,700	3,750	3,800	3,850	3,900	3,950	4,000
11	3,182	3,227	3,273	3,318	3,364	3,409	3,455	3,500	3,545
12	2,833	2,875	2,917	2,958	3,000	3,042	3,083	3,125	3,167
13	2,538	2,577	2,615	2,654	2,692	2,731	2,769	2,808	2,846
14	2,286	2,321	2,357	2,393	2,429	2,464	2,500	2,536	2,571
15	2,067	2,100	2,133	2,167	2,200	2,233	2,267	2,300	2,333
16	1,875	1,906	1,937	1,969	2,000	2,031	2,062	2,094	2,125
17	1,706	1,735	1,765	1,794	1,824	1,853	1,882	1,912	1,941
18	1,556	1,583	1,611	1,639	1,667	1,694	1,722	1,750	1,778
19	1,421	1,447	1,474	1,500	1,526	1,553	1,579	1,605	1,631
20	1,300	1,325	1,350	1,375	1,400	1,425	1,450	1,475	1,500
21	1,190	1,214	1,238	1,262	1,286	1,310	1,333	1,357	1,381
22	1,091	1,114	1,136	1,159	1,182	1,205	1,227	1,250	1,273
23	1,000	1,022	1,043	1,065	1,087	1,109	1,130	1,152	1,174
24	917	937	958	979	1,000	1,021	1,042	1,062	1,083
25	840	860	880	900	920	940	960	980	1,000
26	769	788	808	827	846	865	885	904	923
27	704	722	741	759	778	796	815	833	852
28	643	661	679	696	714	732	750	768	786
29	586	603	621	638	655	672	690	707	724
30	533	550	567	583	600	617	633	650	667
31	484	500	516	532	548	565	581	597	613
32	437	453	469	484	500	516	531	547	562
33	394	409	424	439	455	470	485	500	515
34	353	368	382	398	412	426	441	456	471
35	314	328	343	357	371	386	400	414	429
36	278	292	306	319	333	347	361	375	389
37	243	257	270	284	297	311	324	338	351
38	211	224	237	250	263	276	289	303	316
39	179	192	205	217	231	243	256	269	282
40	150	162	175	187	200	212	225	237	250
41	122	134	146	159	171	183	195	207	220
42	95	107	119	131	143	155	167	179	190
43	70	81	93	105	116	128	140	151	163
44	45	57	68	80	91	102	114	125	136
45	22	33	44	56	67	78	89	100	111
46	0	11	22	33	43	54	65	76	87
47		0	0	11	21	32	43	53	64
48				0	0	10	21	31	42
49						0	0	10	20
50								0	0

RESISTANCE TABLE V  
FOR  
MODEL 301 WESTON VOLTMETER  
WITHOUT 1010 OHM EXTERNAL SHUNT  
RESISTANCE

Def. of Needle	TEST BATTERY VOLTAGE								
	138	139.5	141	142.5	144	145.5	147	148.5	150
3	4,500,000	4,550,000	4,600,000	4,650,000	4,700,000	4,750,000	4,800,000	4,850,000	4,900,000
6	2,200,000	2,225,000	2,250,000	2,275,000	2,300,000	2,325,000	2,350,000	2,375,000	2,400,000
9	1,433,333	1,450,000	1,466,666	1,483,333	1,500,000	1,516,666	1,533,333	1,550,000	1,566,666
12	1,050,000	1,062,500	1,075,000	1,087,500	1,100,000	1,112,500	1,125,000	1,137,500	1,150,000
15	820,000	830,000	840,000	850,000	860,000	870,000	880,000	890,000	900,000
18	666,666	675,000	683,333	691,666	700,000	708,333	716,666	725,000	733,333
21	557,143	564,285	571,428	578,571	585,713	592,859	600,000	607,143	614,285
24	475,000	481,250	487,500	493,750	500,000	506,250	512,500	518,750	525,000
27	411,111	416,666	422,222	427,777	433,333	438,888	444,444	449,999	455,555
30	360,000	365,000	370,000	375,000	380,000	385,000	390,000	395,000	400,000
33	318,181	322,727	327,272	331,818	336,363	340,908	345,454	350,000	354,545
36	283,333	287,500	291,666	295,834	300,000	304,166	308,333	312,500	316,666
39	253,846	257,692	261,538	265,384	269,230	273,076	276,923	280,769	284,615
42	228,571	232,142	235,714	239,285	242,857	246,429	250,000	253,571	257,142
45	206,666	210,000	213,333	216,666	220,000	223,333	226,666	230,000	233,333
48	187,500	190,625	193,750	196,875	200,000	203,125	206,250	209,375	212,500
51	170,588	173,529	176,470	179,411	182,352	185,294	188,235	191,176	194,117
54	155,555	158,333	161,111	163,888	166,666	169,444	172,222	175,000	177,777
57	142,105	144,737	147,368	150,000	152,631	155,263	157,894	160,526	163,157
60	130,000	132,500	135,000	137,500	140,000	142,500	145,000	147,500	150,000
63	119,047	121,428	125,809	126,190	128,571	130,952	133,333	135,714	138,095
66	109,090	111,363	113,636	115,900	118,181	120,454	122,727	125,000	127,272
69	100,000	102,174	104,348	106,522	108,696	110,870	113,043	115,217	117,391
72	91,666	93,750	95,833	97,917	100,000	102,084	104,167	106,250	108,334
75	84,000	86,000	88,000	90,000	92,000	94,000	96,000	98,000	100,000
78	76,923	78,849	80,769	82,692	84,615	86,538	88,461	90,384	92,307
81	70,370	72,222	74,074	75,926	77,777	79,640	81,481	83,333	85,185
84	64,285	66,071	67,857	69,643	71,428	73,214	75,000	76,786	78,581
87	58,621	60,345	62,069	63,793	65,517	67,241	68,963	70,689	72,413
90	53,334	55,000	56,666	58,334	60,000	61,666	63,334	65,000	66,666
93	48,387	50,000	51,612	53,225	54,838	56,451	58,064	59,677	61,290
96	43,750	45,213	46,875	48,437	50,000	51,563	53,125	54,687	56,250
99	39,393	40,908	42,424	43,939	45,454	46,969	48,484	50,000	51,515
102	35,294	36,764	38,325	39,795	41,176	42,646	44,117	45,587	47,058
105	31,424	32,846	34,285	35,703	37,142	38,660	40,000	41,418	42,857
108	27,777	29,166	30,555	31,944	33,333	34,722	36,111	37,500	38,888
111	24,324	25,675	27,027	28,378	29,729	31,081	32,432	33,783	35,135
114	21,052	22,368	23,684	25,000	26,315	27,631	28,947	30,263	31,578
117	17,498	19,130	20,512	21,694	23,076	24,258	25,641	26,823	28,205
120	15,000	16,250	17,500	18,750	20,000	21,250	22,500	23,750	25,000
123	12,195	13,414	14,634	15,853	17,073	18,291	19,512	20,731	21,961
126	9,523	10,713	11,904	13,094	14,285	15,475	16,666	17,856	19,047
129	6,976	8,139	9,302	10,465	11,627	12,790	13,953	15,116	16,279
132	4,545	5,681	6,818	7,954	9,090	10,226	11,363	12,500	13,636
135	2,222	3,333	4,444	5,555	6,666	7,777	8,888	9,999	11,110
138	0	1,087	2,174	3,261	4,347	5,434	6,521	7,608	8,695
141		0	0	1,064	2,127	3,191	4,255	5,319	6,383
144				0	0	1,041	2,083	3,125	4,166
147						0	0	1,020	2,040
150								0	0



RESISTANCE TABLE VI  
FOR  
MODEL 301 WESTON VOLTMETER  
WITH 1010 OHM EXTERNAL SHUNT  
RESISTANCE

TEST BATTERY VOLTAGE

Def. of Needle	138	139.5	141	142.5	144	145.5	147	148.5	150
3	45,000	45,500	46,000	46,500	47,000	47,500	48,000	48,500	49,000
6	22,000	22,250	22,500	22,750	23,000	23,250	23,500	23,750	24,000
9	14,333	14,500	14,667	14,833	15,000	15,167	15,333	15,500	15,667
12	10,500	10,625	10,750	10,875	11,000	11,125	11,250	11,375	11,500
15	8,200	8,300	8,400	8,500	8,600	8,700	8,800	8,900	9,000
18	6,667	6,750	6,833	6,917	7,000	7,083	7,167	7,250	7,333
21	5,571	5,643	5,714	5,786	5,857	5,929	6,000	6,071	6,143
24	4,750	4,812	4,875	4,937	5,000	5,062	5,125	5,187	5,250
27	4,111	4,167	4,222	4,278	4,333	4,389	4,444	4,500	4,556
30	3,600	3,650	3,700	3,750	3,800	3,850	3,900	3,950	4,000
33	3,182	3,227	3,273	3,318	3,364	3,409	3,455	3,500	3,545
36	2,833	2,875	2,917	2,958	3,000	3,042	3,083	3,125	3,167
39	2,538	2,577	2,615	2,654	2,692	2,731	2,769	2,808	2,846
42	2,286	2,321	2,387	2,393	2,429	2,464	2,500	2,536	2,571
45	2,067	2,100	2,133	2,167	2,200	2,233	2,267	2,300	2,333
48	1,875	1,906	1,937	1,969	2,000	2,031	2,062	2,094	2,125
51	1,706	1,735	1,765	1,794	1,824	1,853	1,882	1,912	1,941
54	1,556	1,583	1,611	1,639	1,667	1,694	1,722	1,750	1,778
57	1,421	1,447	1,474	1,500	1,526	1,553	1,579	1,605	1,631
60	1,300	1,325	1,350	1,375	1,400	1,425	1,450	1,475	1,500
63	1,190	1,214	1,238	1,262	1,286	1,310	1,333	1,357	1,381
66	1,091	1,114	1,136	1,159	1,182	1,205	1,227	1,250	1,273
69	1,000	1,022	1,043	1,065	1,087	1,109	1,130	1,152	1,174
72	917	937	958	979	1,000	1,021	1,042	1,062	1,083
75	840	860	880	900	920	940	960	980	1,000
78	769	788	808	827	846	865	885	904	923
81	704	722	741	759	778	796	815	833	852
84	643	661	679	696	714	732	750	768	786
87	586	603	621	638	655	672	690	707	724
90	533	550	567	583	600	617	633	650	667
93	484	500	516	532	548	565	581	597	613
96	437	452	469	484	500	516	531	547	562
99	394	409	424	439	455	470	485	500	515
102	353	368	383	398	412	426	441	456	471
105	314	328	343	357	371	387	400	414	429
108	278	292	306	319	333	347	361	375	389
111	243	257	270	284	297	311	324	338	351
114	211	224	234	250	263	276	289	303	316
117	179	191	205	217	231	243	256	268	282
120	150	162	175	187	200	212	225	237	250
123	122	134	146	159	171	183	195	207	220
126	95	107	119	131	143	155	167	179	190
129	70	81	93	105	116	128	140	151	163
132	45	57	68	80	91	102	114	125	136
135	22	33	44	56	67	78	89	100	111
138	0	11	22	33	43	54	65	76	87
141		0	0	11	21	32	43	53	64
144				0	0	10	21	31	42
147						0	0	10	20
150								0	0





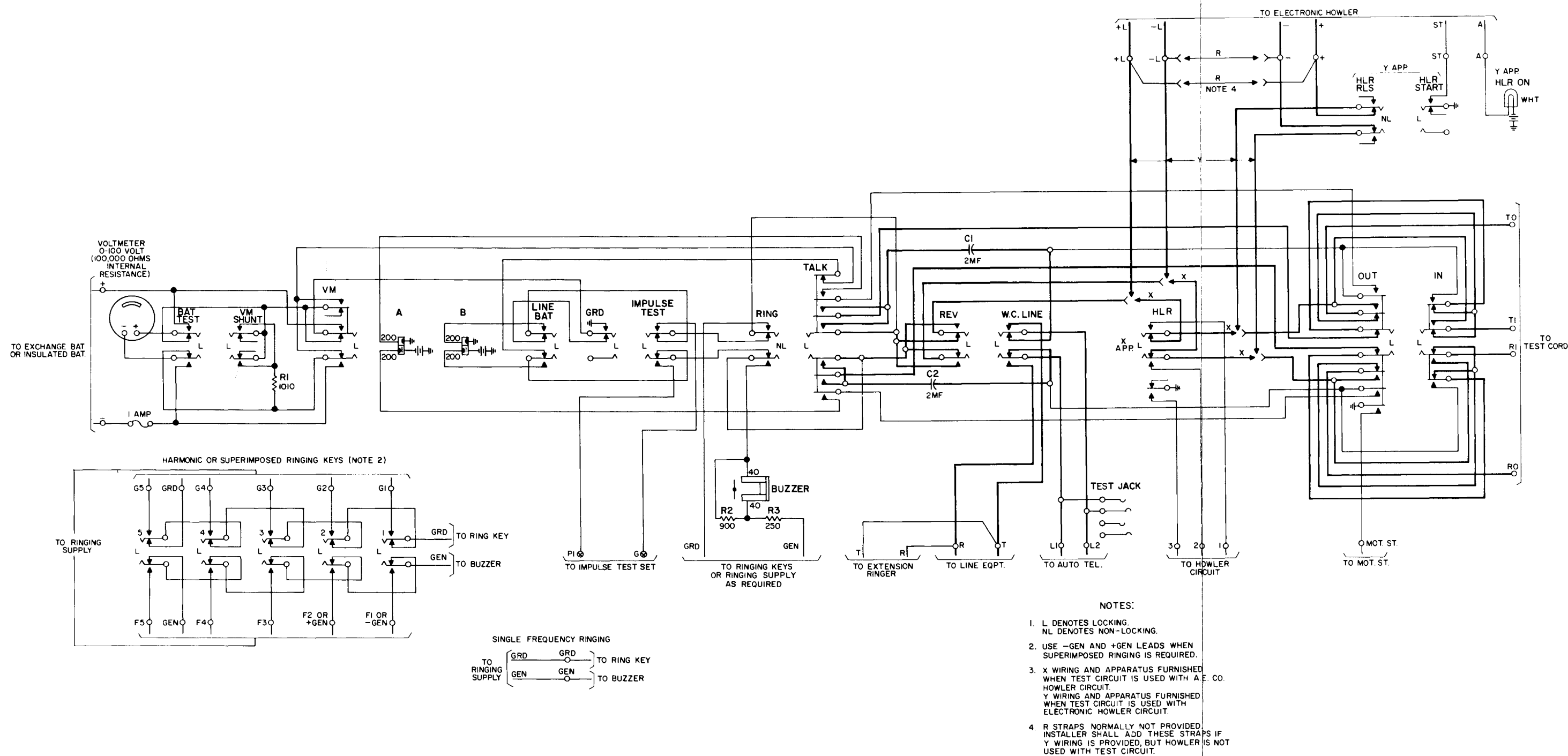


Figure 18. Schematic, Type 22 wire chief's test unit (H-73435).



*Printed in U.S.A. by Edward Keogh Printing Co.*

# **AUTOMATIC ELECTRIC**



Subsidiary of

## **GENERAL TELEPHONE & ELECTRONICS**

*Makers of Telephone, Signaling, and Communication Apparatus . . . Electrical Engineers, Designers, and Consultants*

Factory and General Offices: Northlake, Illinois, U.S.A.

### **ASSOCIATED RESEARCH AND MANUFACTURING COMPANIES**

Automatic Electric Laboratories, Incorporated - - - - - Northlake, Illinois, U. S. A.  
Automatic Electric (Canada) Limited - - - - - Brockville, Ontario, Canada  
Automatique Electrique, S.A. - - - - - Antwerp, Belgium  
Automatic Electric, S.p.A. - - - - - Milan, Italy

### **DISTRIBUTOR IN U.S. AND POSSESSIONS**

#### **AUTOMATIC ELECTRIC SALES CORPORATION**

Northlake, Illinois, U.S.A.  
*Sales Offices in All Principal Cities*

### **GENERAL EXPORT DISTRIBUTOR**

#### **AUTOMATIC ELECTRIC INTERNATIONAL**

INCORPORATED  
Northlake, Illinois, U.S.A.

### **REGIONAL DISTRIBUTING COMPANIES**

Automatique Electrique, S.A.  
Boomgaardstraat—  
Antwerp, BELGIUM

Automatic Electric, S.p.A.  
Via Bernina 12  
Milan, ITALY

Automatic Electric do Brasil, S.A.  
Caixa Postal 9212  
São Paulo, BRAZIL

General Telephone & Electronics  
International, S.A. de C.V.  
Apartado 20735  
México 6, D.F., MEXICO

Automatic Electric Sales (Canada) Ltd.  
185 Bartley Drive  
Toronto 16, Ontario, CANADA

Cia. General de Telefonía y Electrónica, S.A.  
Apartado 1896  
Panamá, REPUBLICA DE PANAMA

Automatic Electric de Colombia, S.A.  
Apartado Aéreo 3968  
Bogotá, COLOMBIA

General Telephone & Electronics  
International, Inc.  
P.O. Box 12251  
Santurce, PUERTO RICO

Automatic Electric de Colombia, S.A.  
Casilla Postal 1388  
Quito, ECUADOR

Automatic Electric International, Inc.  
40, Rue du Rhone  
Geneva, SWITZERLAND

Automatic Electric International, Inc.  
Apartado Postal 313  
San Salvador, EL SALVADOR

Automatic Electric International, Inc.  
730 Third Avenue  
New York 17, New York, U.S.A.

General Telephone & Electronics  
International, Inc.  
1103 Central Building  
HONG KONG

Automatic Electric de Venezuela, C.A.  
Apartado 9361  
Caracas, VENEZUELA

*Sales Representatives and Agents Throughout the World*

Wire Chief's Test Unit Type 22 476  
ISSUE 2