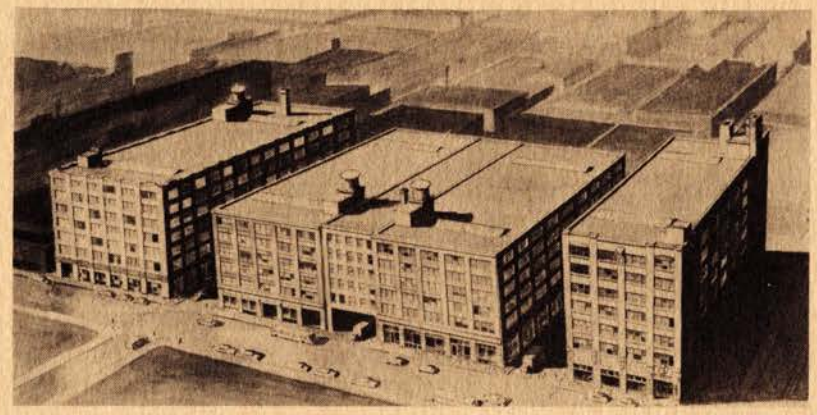
TYPE 22
WIRE CHIEF'S
TEST UNIT

Bulletin 476

AUTOMATIC ELECTRIC

ORIGINATORS OF THE AUTOMATIC DIAL TELEPHONE



Factory and General Offices of Automatic Electric Company, Chicago, 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.

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Factory and General Offices: 1033 West Van Buren Street, Chicago 7, U.S.A.

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TYPE 22 WIRE CHIEF'S TEST UNIT

1. GENERAL APPLICATION

1.1 Purpose of Wire Chief's Test Unit

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

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

This test unit is primarily 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.

2. PRINCIPAL FEATURES

The type 22 wire chief's test unit has all the essential facilities for performing ordinary line tests and for detecting practically all general non-standard operating conditions. This test unit is arranged for the following functions: (1) two way calls via the regular exchange switching train, (2) tests on station equipment, (3) voltmeter tests on lines and trunks.

2.1 Regular Calls

The test unit is arranged to receive and originate regular two way service calls between a test attendant in the exchange and subscribers, inspectors, installers, or other company employees 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 inter-position trunks. This feature is controlled by operation of the WC LINE key.

2.2 Equipment Tests

The test unit is arranged to perform routine operational tests on the station equipment of a line. Tests for the following conditions are accomplished, in conjunction with, or independent of, the voltmeter by operation of the following keys:

Test	Keys Operated
Talking	TALK, LINE BAT, OUT
Monitoring	TALK
Ringing	RING, REV, OUT
Dial Speed	IMPULSE TEST, LINE BAT, TALK, OUT
Howler	HOWL, OUT

2.3 Voltmeter Tests

The test unit is arranged to perform routine voltmeter tests to determine whether a line or trunk is free of shorts, grounds, and crosses with exchange battery, outside lines, or foreign potentials; that the continuity of the line is complete; that the capacity of the line, corresponding to the number of stations connected thereto, is correct, and that the insulation resistance of the line is satisfactory. Tests for these conditions are accomplished by the operation of the following keys:

Test	Keys Operated
Reading Test Battery Voltage	BAT TEST
Loop Test - No Battery on Voltmeter	REV, OUT
Switchboard Test	IN
Loop Test With Battery on Voltmeter	VM, REV, OUT
Capacitance Test	VM, OUT
Capacitance Across Line	VM, REV, OUT
Capacitance From Ring to Ground	VM, GRD, OUT
Capacitance From Tip to Ground	VM, GRD, REV, OUT
Test For Ground on Ring	VM, GRD, OUT
Test For Ground on Tip	VM, GRD, REV, OUT
Test For Negative Potential on Ring	GRD, OUT
Test For Negative Potential on Tip	GRD, REV, OUT
Leak Across Tip and Ring	VM, OUT
Leak From Ring to Ground	VM, GRD, OUT
Leak From Tip to Ground	VM, GRD, REV, OUT
Voltmeter Shunt	VM SHUNT
Test For Crosses Between Lines	VM, GRD, REV, OUT

3. EQUIPMENT DETAILS

3.1 General Design

The type 22 wire chief's test unit, as shown in Fig. 1, consists of a cabinet 10 inches high, 7-1/2 inches wide, and 5 inches deep. The cabinet is usually made of birchwood, finished in ebony, presenting an attractive appearance. The weight of the type 22 wire chief's test unit is 9 pounds.

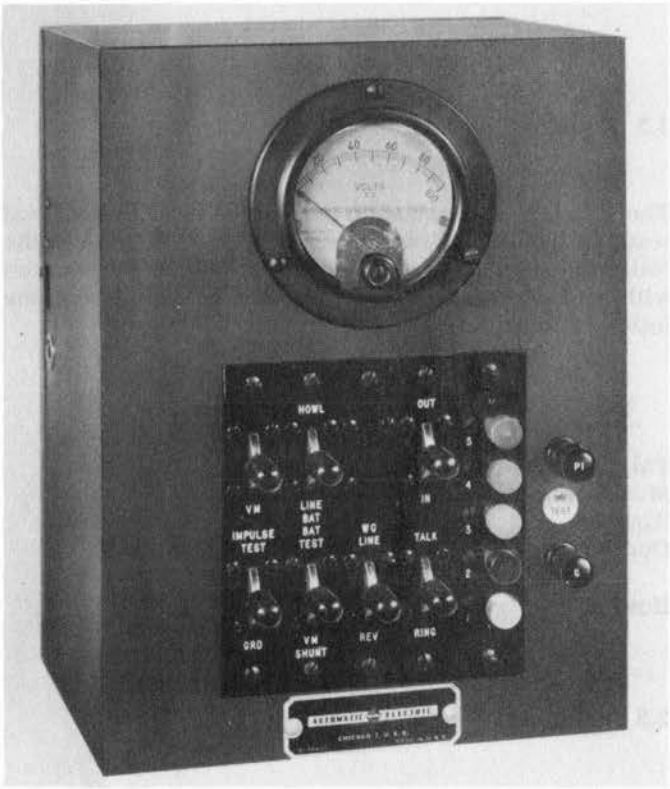


Fig. 1. Type 22 Wire Chief's Test Unit, General View

The rear panel is hinged, providing ready access to the interior of the case. 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 this terminal strip in accordance with designated terminals. (Fig. 2)

3.2 Test Equipment

The test equipment consists of a voltmeter, keys, test jack, buzzer, retardation coils, condensers and resistors. Tests are made by operating keys to provide the required conditions.

a. Voltmeter.

The basic test circuit for locating and measuring faults consists of either a separate insulated battery or 48 volt or 24 volt exchange battery and a 100,000 ohm Weston type Model 301 d.c. single scale voltmeter with a scale of 0-100 volts. The voltmeter is associated with a shunt resistor for measuring low resistance values. The internal resistance of the Model 301 voltmeter is 100,000 ohms.

b. Keys

All circuits are key ended, with keys located in the front panel of the test unit as shown in Fig. 1. The keys furnished and their functions are as follows.

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

VM SHUNT (Voltmeter Shunt) - a locking key, for connecting a 1010 ohm shunt resistor R1 across the voltmeter when measuring low resistance values (47,000 ohms - 48 volt test battery), (23,000 ohms - 24 volt test battery). This shunt reduces the voltmeter resistance from 100,000 to 1,000 ohms.

VM (Voltmeter) - a locking key, for connecting test battery in series with the voltmeter and which also extends 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.

LINE BAT (Line Battery) - a locking key, which furnishes battery and ground through retardation coil B as talking battery to the telephone set of a subscriber or testman outside the exchange.

GRD (Ground) - a locking key, 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.

The GRD key 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.

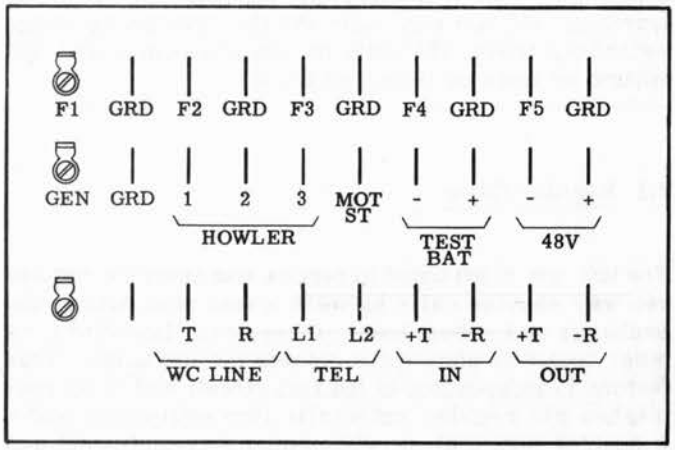


Fig. 2. Terminal Strip Connections For External Circuits

IMPULSE TEST - a locking key, 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 and can be added at any future time.

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

Harmonic Ringing Keys 1, 2, 3, 4, 5 - locking plunger type keys used in conjunction with the RING key when harmonic party-line ringing is used. The operation of a harmonic ringing key furnishes ringing current of a particular frequency for ringing a station ringer connected to the ring side of the line. The REV key is operated when ringing a party connected to the tip side of the line.

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

TALK - a locking key, which furnishes battery and ground through retardation coil A as talking battery to the telephone set associated with the test unit. This key also connects the telephone set of the test unit through a condenser bridge to the outside line or trunk.

This key is also operated to permit the test attendant to monitor on a line or trunk plugged up for test to verify an idle or busy condition before proceeding with routine tests.

REV (Reverse) - a locking key, 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: tests for foreign potential across the line, tests for line leak, tests for ground on the ring or tip side of the line, tests for crosses between lines, tests for capacitance, and tests for foreign negative potential on the line.

The REV key is also used in conjunction with the RING key for tip side party line ringing.

WC LINE (Wire Chief's Line) - a locking key, used for connecting the test attendant's telephone set 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 switching train. This key remains normal when working on lines and trunks plugged up for test.

HOWL (Howler) - a locking key, used for connecting the test unit to an external portable "howler box" for receiver off-hook signalling. Wiring is provided for the howler but the howler box is not furnished with the test unit except when specified and can be added at any future time.

OUT - a locking key, used for tests on a line or trunk plugged up for test through a test cord. The operation of the OUT key 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 used with tests on a line or trunk plugged up for test through a test cord. The operation of the IN key 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.

c. Miscellaneous Test Equipment

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 instrument.

Buzzer

An a.c. buzzer is provided as an audible signal when ringing on a line or trunk plugged up for test.

Binding Posts

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" provide means for connecting subscriber lines and trunk circuits to the test unit. These leads may be cabled to the M.D.F., or wherever required. At the M.D.F., 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 the IN and OUT keys 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., disconnect 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 multi-frequency or single frequency 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 line reverse key in combination. The test unit may be furnished for straight line or code ringing, without the harmonic ringing keys, in which case the latter may be added at any future time.

4.3 Howler

The test unit is arranged for connection, via leads designated "To Howler Ckt.", to an external portable howler box for receiver off-hook signaling. Wiring is provided but the howler is not furnished with the test unit except when specified and may be added at any future time.

4.4 Dial Speed Indicator

The test unit is arranged for connection, via leads designated "To Impulse Test Set", 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 and 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 Equip." 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

A standard subscriber set (ringer box) with a condenser connected in series with the ringer coils is connected to leads designated "To Extension Ringer" 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 Set

Leads L1 and L2 designated "To Auto. Tel." connect the test attendant's telephone set to the test circuit for talking and dialing on regular calls via the line equipment by operation of the WC LINE key. 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 set is established by operation of the TALK key. No telephone is 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. Where no handset is available, any standard type of telephone instrument may be used.

4.8 Test Battery

The test unit is arranged for use with either the exchange 48 volt battery (automatic) or 24 volt battery (manual) or with a separate insulated test battery. In the latter case, a battery eliminator or radio B batteries, connected in series, may provide the test voltage.

4.9 Ringing Machine

When performing outside tests on lines or trunks, ringing may be required. Therefore the OUT key is provided with a make contact 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.

5. METHOD OF OPERATION

5.1 Incoming Calls - Via Connector Terminal - WC LINE Key

The two way access connection consists of a two conductor subscriber line circuit connected to the T (positive) and R (negative) line equipment terminals of the test unit. (Fig. 3)

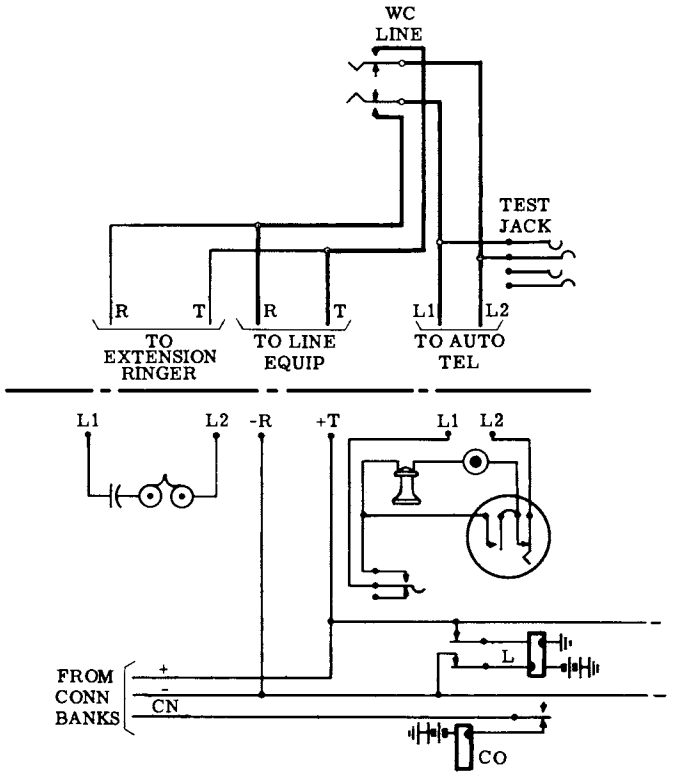


Fig. 3. Connection to Line Equipment

When this special line number is called from another line, a connector circuit seizes the line, or an operator establishes a connection through a cord. Ringing current, from the connector circuit or the cord circuit, operates the extension ringer which is connected across the line equipment terminals.

The test attendant answers the incoming call by removing the receiver of the test unit telephone instrument and operates the WC LINE key which closes the line loop circuit through the telephone set. The completion of this

direct current loop trips ringing and completes a talking circuit. Talking battery is supplied to the telephone of the test unit by the automatic switching train or from the operator's cord circuit.

When the calling party replaces the receiver and the test attendant restores the WC LINE key, the loop is opened to the connector circuit or to the cord circuit, causing the switching train to release or giving the operator a disconnect supervisory signal.

5.2 Outgoing Calls - Via Line Equipment - WC LINE Key

When the test attendant desires to make an outgoing call, the WC LINE key is operated, connecting the test unit telephone set across the T and R leads of a regular line circuit. When the receiver is removed, the line switch extends the connection through to the next switch, or displays a line lamp signal to an operator.

In an automatic exchange, the test attendant receives dial tone and then dials the desired number, causing the automatic switches to complete the connection to the desired line. A connector circuit automatically rings the called line, if it is free, and completes the talking circuit when the called party answers. In a manual exchange, the call is completed by an operator through a cord circuit.

When the called party replaces the receiver and the test attendant restores the WC LINE key or replaces the receiver, the loop is opened to the connector circuit or to the cord circuit, causing the switching train to release, or giving the operator a disconnect supervisory signal.

5.3 Voltmeter Tests On Lines and Trunks - OUT Key

A line or trunk to be tested is connected to the test unit by a patching cord and test shoes as described in par. 4.1 and the OUT key is operated. The completion of this connection may produce a momentary deflection of the voltmeter needle. No voltmeter tests should therefore be made until the needle of the instrument comes to rest, to prevent the introduction of an error in the reading, particularly from a ballistic or capacitance standpoint.

a. Reading Test Battery Voltage - BAT TEST Key

The voltage of the test battery should be checked before making any tests involving voltmeter measurements of a line loop, a short circuited line or resistances to ground to insure accuracy of results.

This voltage check is accomplished by operating the BAT TEST key. The positive and negative terminals of the voltmeter are connected direct to the ground (positive) and negative battery terminals respectively, giving a voltage reading of the test battery.

b. Loop Test - No Battery On Voltmeter - REV, OUT Keys

Referring to Fig. 4, it will be noted that the voltmeter is normally bridged across the TO and RO leads of the test cord, with the positive terminal of the voltmeter connected to the tip (positive) side of the line and the negative terminal of the voltmeter connected to the ring (negative) side of the line.

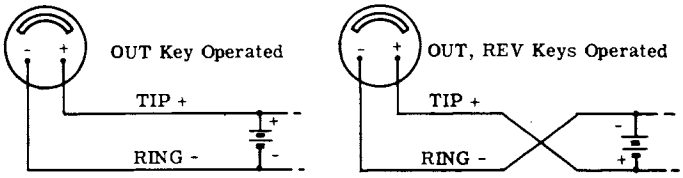


Fig. 4. Loop Test - No Battery on Voltmeter

This arrangement, with all testing keys normal, determines as soon as the test connection is established, whether the line under test is connected to battery. The voltage reading may be taken of a distant battery connected to the test circuit, in the same manner.

The voltmeter now reads the d.c. potential across the line and indicates positive potential of the external battery is connected to the tip side of the line and negative potential is connected to the ring side of the line.

In testing the voltage of battery connected to the distant end of a line or trunk, should the deflection of the voltmeter be in the opposite direction (off scale), the REV key is operated and the proper voltage deflection may be read.

The presence of an external or foreign voltage will affect all voltmeter readings. Therefore, this reading should always be made before making any voltmeter tests.

c. Switchboard Test - IN Key

To test the switchboard side of the plugged up line or trunk circuit for grounds, shorts, etc., or to test the operation of switchboard apparatus associated with the line or trunk, the IN key is operated. This disconnects the line side and connects the switchboard side to the testing circuit. The desired tests may then be performed.

This operation connects the positive and negative terminals of the voltmeter through the TI and RI leads of the test cord to ground on the tip (positive) side of the line circuit and to battery on the ring (negative) side of the line circuit. This connection gives a deflection of the voltmeter as an indication of polarity and continuity of the line equipment. (Fig. 5)

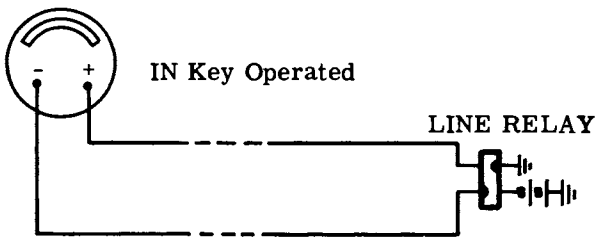


Fig. 5. Testing Line Equipment

d. Loop Test With Battery On Voltmeter - VM, REV, OUT Keys

The operation of the VM key connects negative potential of test battery to the negative terminal of the voltmeter, and connects the positive terminal of the voltmeter through the RO lead of the test cord to the ring (negative) side of the line. At the same time, positive potential of test battery is connected through the TO lead of the test cord to the tip (positive) side of the line. (Fig. 6)

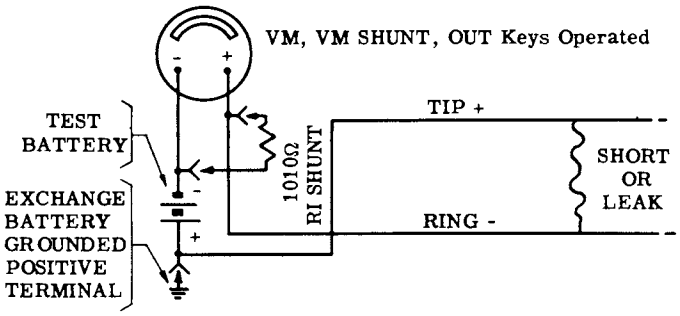


Fig. 6. Loop Test With Battery on Voltmeter

A steady deflection of the voltmeter needle indicates a closed or short circuited condition. The amount of deflection indicates whether a short, a ground or insulation resistance is being measured.

If exchange battery (grounded positive terminal) is used, this test also indicates ground on the ring side of the line. Therefore, while the VM key is operated, the REV key should be operated to determine whether this deflection is caused by a shorted line or by ground on the ring. The meter will continue to show a deflection in the case of 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 or IV or calculated by the following formula:

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

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.

e. Capacitance Test - VM, OUT Keys

If, when the VM key is operated, the needle of the voltmeter is deflected and returns to zero or a steady deflection value after a short interval, it indicates condensers are bridged across the line or connected between the ring side of the line and ground. The consequent deflection of the voltmeter is an approximate measurement of the capacitance connected between the ring side of the line and ground, or across the line. To determine the nature of the capacitance, the following tests are made.

f. Capacitance Across Line - VM, REV, OUT Keys (Insulated Test Battery Only)

With the OUT key operated, the operation of the VM key connects the negative terminal of test battery to the negative terminal of the voltmeter. The positive terminal of test battery is connected to the tip side of the line and the ring side of the line is connected to the positive terminal of the voltmeter. This arrangement charges the ringer condenser, producing a momentary deflection of the meter needle. (Fig. 7)

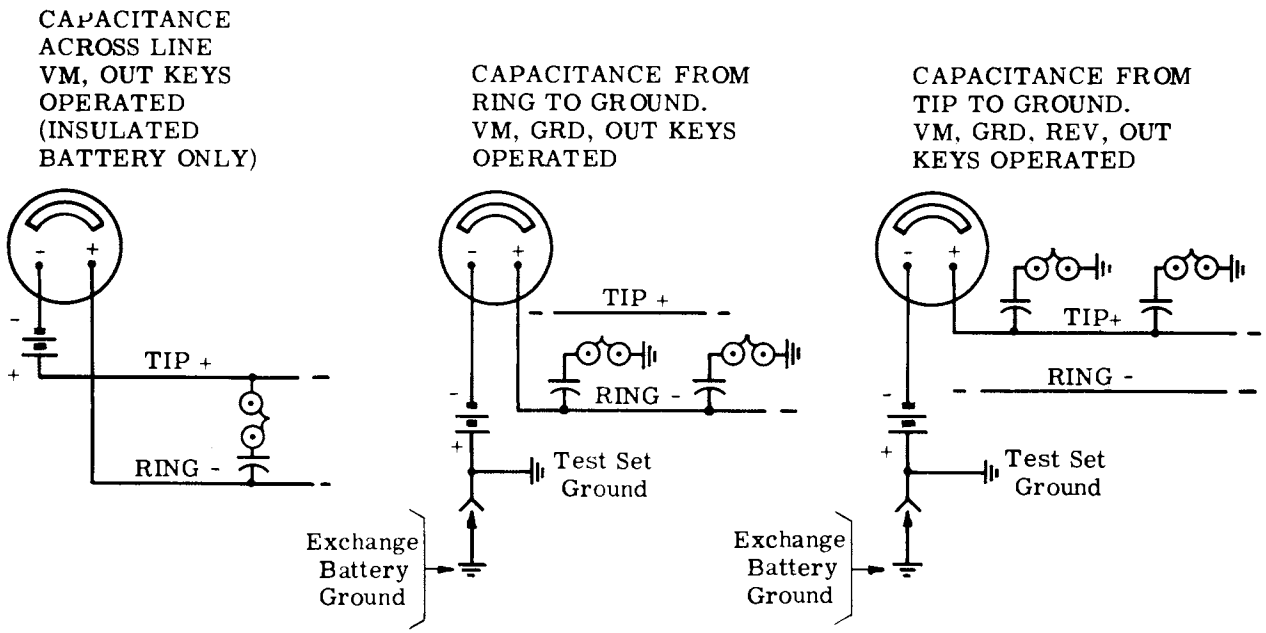


Fig. 7. Capacitance Tests

By alternately operating and releasing the REV key, the connections of the voltmeter and test battery are reversed to the tip and ring sides of the line, in turn reversing the polarity to the condenser across the line. This operation results in a charge and discharge of the condenser, causing a deflection or "kick" of the meter needle, amounting to several scale divisions. If the REV key is operated and released rapidly, the voltmeter needle will remain deflected during the test. It is then possible to determine the capacitance by comparison with the amount of deflection from a condenser of known value in microfarads.

g. Capacitance Test From Ring to Ground - VM, GRD, OUT Keys

To determine if capacitance exists from the ring side of the line to ground, the GRD key is operated in addition to the OUT and VM keys. The operation of the GRD key connects ground to the VM key and disconnects the tip side of the line from the voltmeter. With the VM key operated, ground is connected to the positive terminal of test battery. The negative terminal of test battery is connected through the operated VM key to the negative terminal of the voltmeter. The positive terminal of the voltmeter is connected through the operated VM key to the ring side of the line, charging the ringer condenser. (Fig. 7)

The VM key is then released, which transfers the ring side of the line from the positive to the negative terminal of the voltmeter and replaces test battery on the negative terminal of the voltmeter with ground on the positive terminal of the voltmeter. This reversal of connections at the voltmeter discharges the ringer condenser to ground through the voltmeter, causing a deflection or "kick" of the meter needle, amounting to several scale divisions.

By alternately operating and releasing the VM key, the condenser is charged and discharged, causing corresponding "kicks" of the voltmeter needle. If the VM key is operated rapidly, the voltmeter needle will remain deflected during the test.

h. Capacitance Test From Tip to Ground - VM, GRD, REV, OUT Keys

To test for capacitance connected between the tip side of the line and ground, the REV key is operated in addition to the operation of keys VM, GRD and OUT. The operation of the REV key transfers the positive terminal of the voltmeter from the ring to the tip side of the line. The amount of capacitance is determined by operating and releasing the VM key as described for test of capacitance on the ring side of the line. (Fig. 7)

Open Line - 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 kick of the needle when testing that particular side of the line.

If no telephone sets are connected to the sides of a party line with grounded ringing, there will be little or no capacity kick. In the case of long lines, there may be a slight kick due to the capacity of the line itself.

i. Test For Ground On Ring - VM, GRD, OUT Keys

In case there is a deflection of the voltmeter needle when the VM and REV keys are operated, (and exchange battery is used) par. 5.3d, indicating a short or a ground on the ring (negative) side of the line, the VM key is left operated and the GRD key is operated. (Fig. 8)

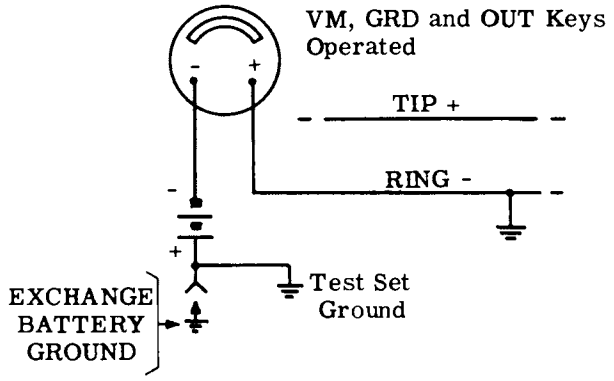
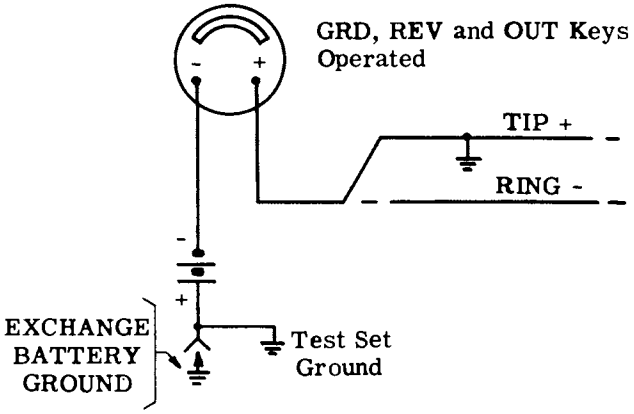


Fig. 8. Test For Ground on Ring

The operation of the GRD key opens the tip side of the line from the positive terminal of test battery and connects ground to the positive terminal of test battery. A deflection of the voltmeter needle indicates ground on the ring side of the line. No deflection of the voltmeter needle indicates that the previous deflection, occurring when the VM key was first operated, was caused by a shorted line.

j. Test For Ground On Tip - VM, GRD, REV, OUT Keys

To determine whether there is ground on the tip (positive) side of the line, the VM, GRD, and OUT keys remain operated and the REV key is operated. This operation opens the ring side of the line from the positive terminal



Test For Ground on Tip

of the voltmeter and connects the tip side of the line to the positive terminal of the voltmeter. (Fig. 8) A deflection of the voltmeter needle indicates ground on the tip side of the line.

The resistance in either side of the line to ground is measured by the deflection of the voltmeter needle. It can be calculated by using the formula

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

k. Measurement of Foreign Potentials

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

CAUTION - must be exercised in making measurements of external voltages to avoid injury to the voltmeter.

l. Test For Negative Potential On Ring - GRD, OUT Keys

To test a line for foreign negative potential (battery) on the ring side of the line, a test connection is established as described in par. 4.1 and the GRD and OUT keys are operated. The operation of the GRD key opens the tip side of the line and connects direct ground to the positive terminal of the voltmeter. The negative terminal of the voltmeter is connected to the ring side of the line. A deflection of the voltmeter needle indicates a negative potential on the ring side of the line. (Fig. 9)

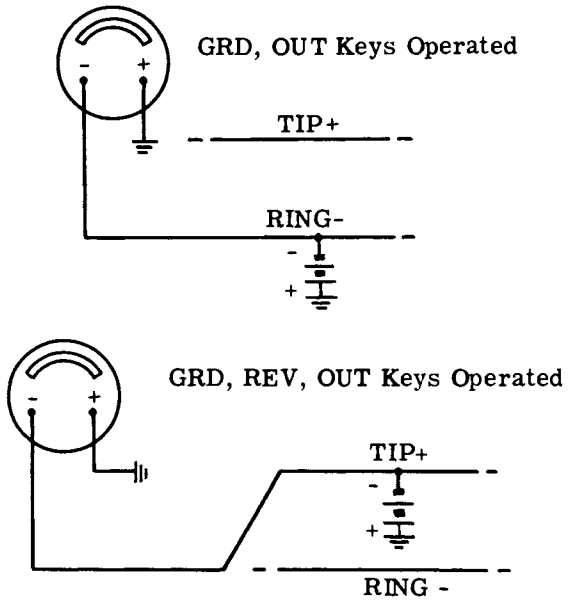


Fig. 9. Test For Foreign Negative Potential on Ring or Tip

m. Test For Negative Potential On Tip - GRD, REV, OUT Keys

To test a line for foreign negative potential (battery) on the tip side of the line, a test connection is established as described in par. 4.1 and the GRD, REV, and OUT keys are operated. The operation of the REV key disconnects the negative terminal of the voltmeter from the ring side

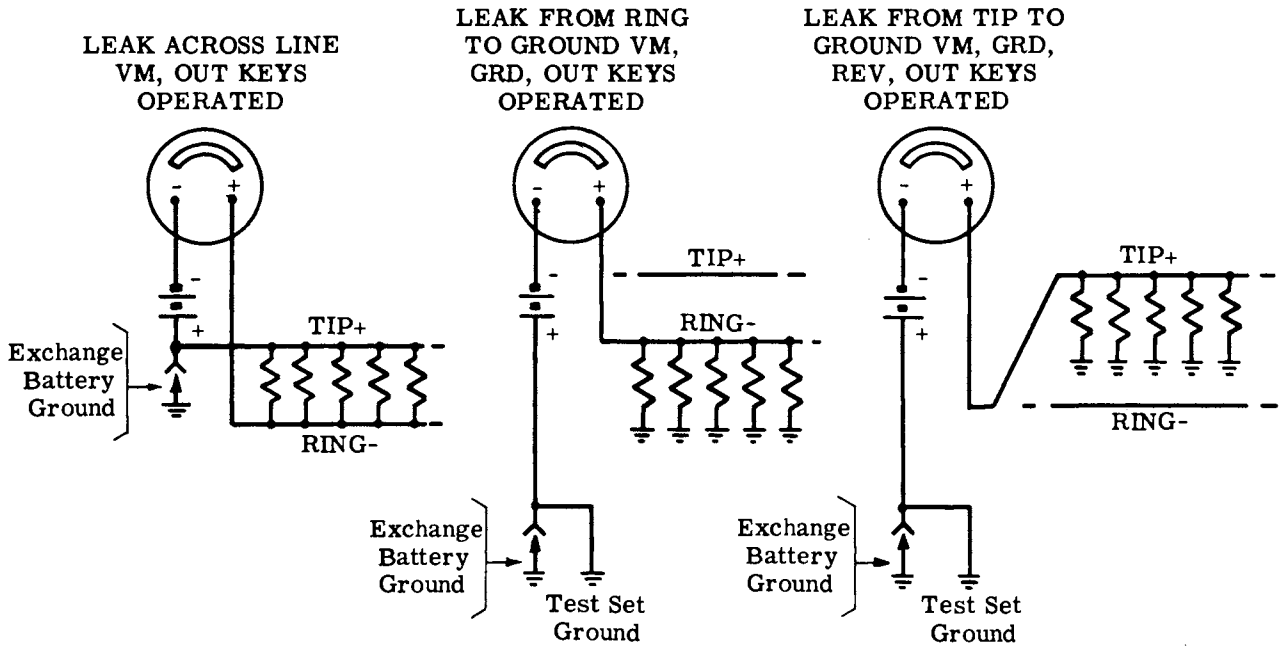


Fig. 10. Line Leak Tests

of the line and connects it to the tip side of the line. A deflection of the voltmeter needle indicates a negative potential on the tip side of the line. (Fig. 9)

n. Line Leaks - VM, GRD, REV, OUT Keys

It is necessary to have subscriber lines and trunks well insulated to prevent loss of current as leakage between conductors, and to ground. In order to decrease leakage effect, particularly in wet weather, the resistance of insulation material must be as high as possible.

The voltage of the test battery makes it unnecessary, in the course of ordinary testing, for the test attendant to be much concerned with ground potentials when making measurements of insulation resistance between a line and to ground where earth potentials exist, since the error introduced in the reading of the voltmeter is comparatively small.

If the loop test with battery on the voltmeter as described in par. 5.3d shows a steady deflection value when the VM key is operated, a line leak condition is indicated. The insulation resistance between conductors and from each conductor to ground should be measured. (Fig. 10)

o. Leak Across Tip and Ring - VM, OUT Keys

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 par. 5.3d.

p. Leak From Ring to Ground - VM, GRD, OUT Keys

The operation of the VM and GRD keys connects grounded test battery to the negative terminal of the voltmeter with the positive terminal of the voltmeter connected to the ring side of the line. The operation of the GRD key disconnects the tip side of the line from the test circuit.

With a ground leak on the ring of the line, the voltmeter shows a steady voltage deflection. This voltage reading can be used to determine the resistance of the leak by reference to Tables I, II, III and IV or by calculation from the formula

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

q. Leak From Tip to Ground - VM, GRD, REV, OUT Keys

The resistance of a ground leak on the tip side of the line is measured in a similar manner by the additional operation of the REV key.

The operation of the REV key disconnects the positive terminal of the voltmeter from the ring side of the line and connects it to the tip side of the line. A deflection of the voltmeter needle indicates a ground leak on the tip side of the line.

r. Voltmeter Shunt - VM SHUNT Key

The operation of the VM SHUNT key connects the R1 1010 ohm resistor across the terminals of the voltmeter to form a shunt across the meter coil, thereby reducing the meter sensitivity to permit more accurate measurements of low resistance faults. (Fig. 6)

s. Test For Crosses Between Lines - VM, GRD, REV, OUT Keys

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 pars. 5.3i and 5.3j. (Fig. 11)

Fig. 11A

TEST FOR CROSSED
RING AND TIP
VM, GRD, OUT KEYS OPERATED

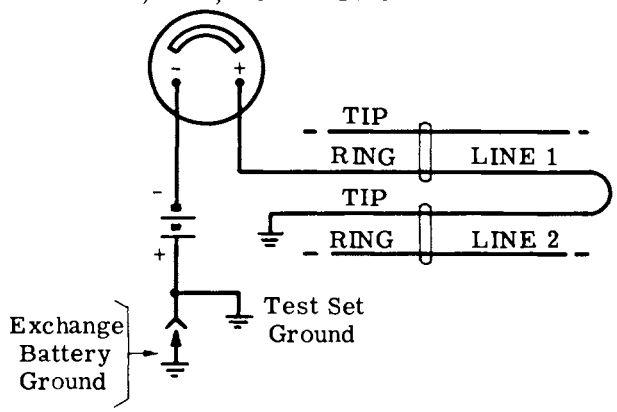


Fig. 11A shows a method of testing for a cross between the ring side of one line and the tip side of a second line. In this case line 1 is plugged up for test and a temporary ground is connected to the tip of line 2 at the distributing frame or at the switchboard line jack. A test for ground

Fig. 11B

TEST FOR CROSSED
TIP AND TIP
VM, GRD, REV, OUT KEYS OPERATED

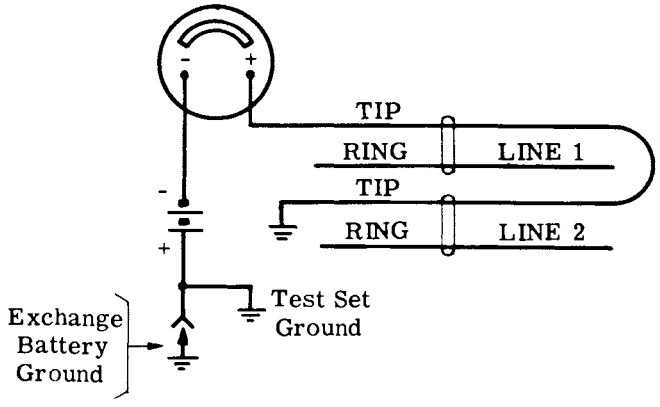
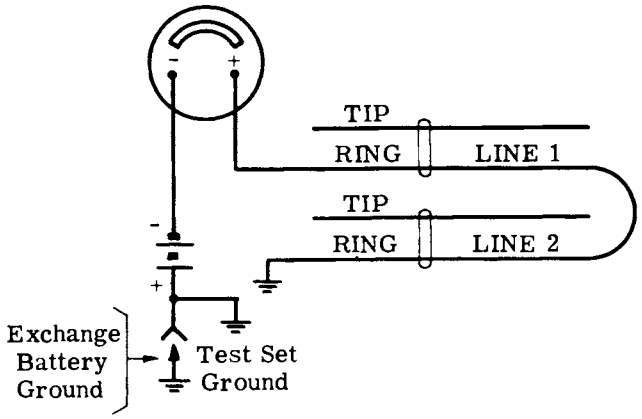


Fig. 11C

TEST FOR CROSSED
RING AND RING
VM, GRD, OUT KEYS OPERATED

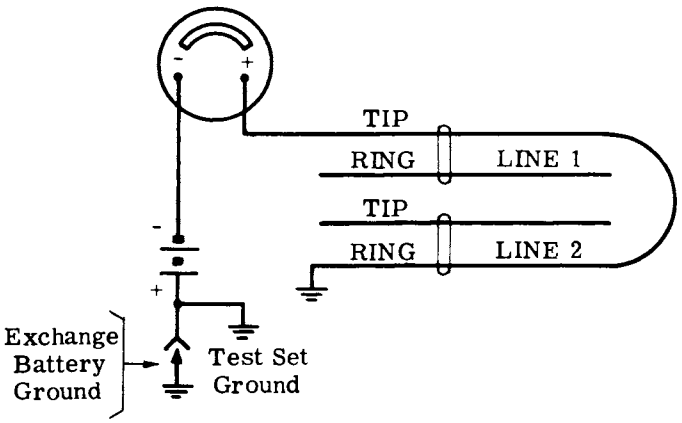


on the ring of line 1 is made and a deflection of the voltmeter indicates a cross between the conductors of the two lines.

Figs. 11B, 11C and 11D 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 REV key when making tests for crosses to the tip conductor of line 1.

Fig. 11D

TEST FOR CROSSED
TIP AND RING
VM, GRD, REV, OUT KEYS OPERATED



5.4 Operational Features

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.

a. TALKING - TALK, LINE BAT, OUT Keys

After setting up a connection to a line to be tested, a talking circuit may be established with a subscriber, installer or outside testman. This is accomplished by operating the TALK and OUT keys. (Fig. 12)

The operation of the TALK key connects ground and battery through the windings of retardation coil A and contacts of the OUT key via leads L1 and L2 to the telephone set of the test position.

It is also necessary to operate the LINE BAT key, unless the line under test is equipped with local battery instruments, in order to furnish talking battery to the subscriber, installer, or outside testman. Operation of the LINE BAT key connects ground and battery through the windings of retardation coil B and contacts of the OUT key via the TO and RO leads to the line under test.

MONITORING - TALK Key Operated
TALKING - TALK, LINE BAT, OUT (Or IN)
Keys Operated

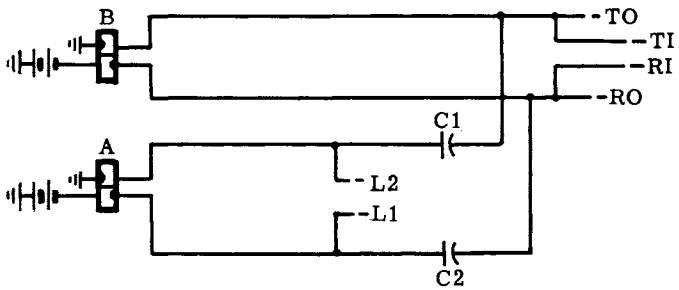


Fig. 12. Talking and Monitoring

The C1 and C2 condensers are connected through contacts of the TALK key as a condenser talking bridge between the telephone set of the test position and the line under test.

b. MONITORING - TALK Key

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. (Fig. 12)

This feature is accomplished by removing the handset of the telephone and operating only the TALK key. The OUT and IN keys remain normal to prevent splitting the line and cutting off a busy connection. This operation connects the telephone set via the L1 and L2 leads, condensers C1 and C2, contacts of the TALK key to the TO, RO and TI, RI leads of the test cord and to the line or trunk under test. By leaving the TALK key operated during the dialing period, the call may be monitored without interference to dialing.

c. RINGING - RING, REV, OUT Keys - Harmonic Ringing Keys

When a line is plugged up for test, the test attendant may ring on the line by operating the RING key. The operation of the RING key, with harmonic frequency keys 1, 2, 3, 4, and 5 normal, connects straight line ringing current from the ALT and G leads, through back contacts of the frequency keys to the GEN and G leads of the test circuit.

Ringing current is connected to the ring side of the line through the windings of an a.c. buzzer in parallel with the R2 resistor. Generator ground is connected to the tip side of the line. This ringing arrangement rings subscriber stations with ringers connected across the line (bridged ringing), party lines with ringers connected from the ring side of the line to ground (divided ringing), and toll and rural lines.

If the line under test is a party line arranged for divided ringing with station ringers connected from the tip side of the line to ground, the reverse key REV is operated prior to the operation of the RING key. This connects ringing current to the tip side of the line and generator ground to the ring side of the line.

d. Harmonic Ringing - when harmonic ringing is desired, frequency key 1, 2, 3, 4, or 5 is depressed prior to the operation of the RING key. 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 RING and REV keys 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 currents connected to the harmonic ringing keys when multiple or non-multiple harmonic party line ringing is used.

Harmonic Ringing 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

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

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

e. DIAL SPEED TEST - IMPULSE TEST, LINE BAT, TALK, OUT Keys

After setting up a connection to a line to be tested, the speed of dial pulses sent by the dial of a telephone may be tested. This is accomplished by operating the IMPULSE TEST and OUT keys and also the key of the external dial pulse speed test circuit. The TALK and LINE BAT keys are also operated to permit two way conversation between the test attendant and a subscriber station.

The operation of the IMPULSE TEST key transfers the loop circuit of the line to the pulse test set over leads P1 and G and also removes battery and ground fed through the windings of retardation coil B to the line. The TALK key may remain operated since the C1 and C2 condensers prevent interference with dial pulses.

The test attendant requests the party at the telephone under test to dial digit zero. The operation of the dial at the telephone under test causes the dial pulsing springs to open and close the circuit to the pulse test set ten times by interrupting the loop through the telephone. These dial pulses release and re-operate a pulsing relay in the pulse test set, giving a meter reading in pulses per second.

f. HOWLER - HOWL, OUT Keys

After setting up a connection to a line, the howler may be connected if the test attendant suspects the receiver has been left off the hook. This is accomplished by operating the HOWL and OUT keys. The external howler box equipment should be located beyond the audible range of the test attendant so that the tone produced by the howler interrupter will not cause a disturbance.

The howler circuit is arranged to give a preliminary tone at a lower level than the final howler tone. Upon connection to the line, the preliminary tone is first applied to the line and continues for approximately 2 seconds. This feature warns a person, if the receiver should be held to the ear, of the presence of howler tone before the full volume of tone is sent out. The howler tone at full volume is very shrill and piercing, and will, under ordinary conditions, be audible some distance from the receiver which has been left off the switchhook. Since no supervision is furnished, the test attendant disconnects the howler by restoring the HOWL key and re-tests the line for the off-hook condition.

RESISTANCE TABLE I
24 VOLT TEST BATTERY
WITHOUT EXTERNAL SHUNT
RESISTANCE

Def. of Needle	TEST BATTERY VOLTAGE								
	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

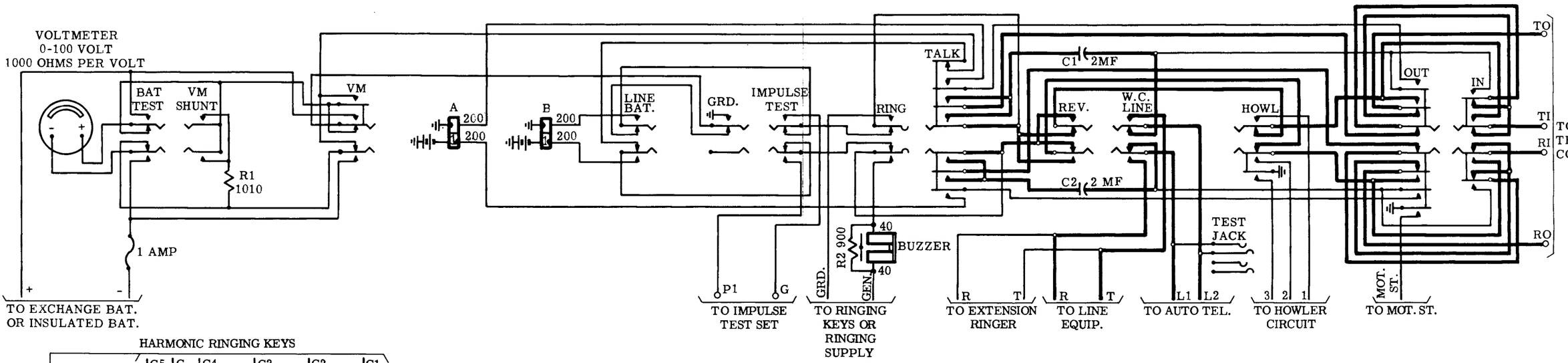
Def. of Needle	TEST BATTERY VOLTAGE								
	22	22.5	23	23.5	24	24.5	25	25.5	26
1	21,000	21,500	22,000	22,500	23,000	23,500	24,000	24,500	25,000
2	10,000	10,250	10,500	10,750	11,000	11,250	11,500	11,750	12,000
3	6,333	6,499	6,666	6,833	7,000	7,166	7,333	7,499	7,666
4	4,500	4,625	4,750	4,875	5,000	5,125	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

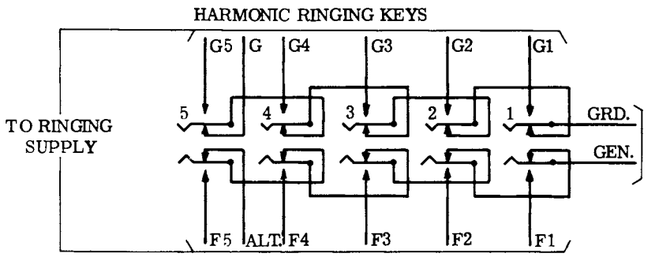
RESISTANCE TABLE III
48 VOLT TEST BATTERY
WITHOUT EXTERNAL SHUNT
RESISTANCE

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	327,272	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	163,888	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	855	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





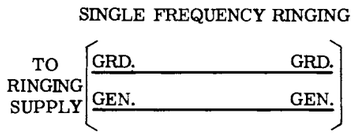


Fig. 13: Schematic, Type 22 Wire Chief's Test Unit

H-73435

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