HARRIS CORPORATION DRACON DIVISION
Plant Series

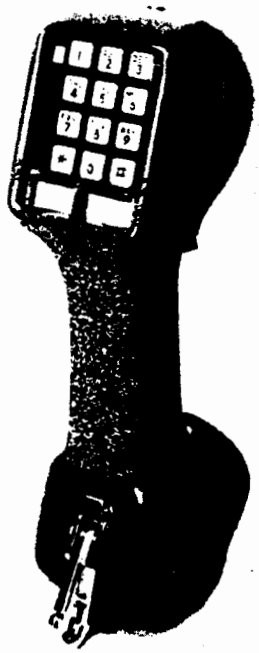
SECTION DRCN-10-802
Issue 1, June 1984

TS21 LINEMAN'S TEST SET

IDENTIFICATION, OPERATION, AND MAINTENANCE

MODELS

21800-010
21800-011
21800-012
21800-020
21800-021
21800-023
21800-024
21800-025
21800-027



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TS21 LINEMAN'S TEST SET

CONTENTS PAGE

1. GENERAL

1.01 This section provides identification, description of apparatus, method of operation, functional description and maintenance information for the TS21 Lineman's Test Set manufactured by the Dracon Division of the Harris Corporation, Camarillo, California 93010.

1.02 Information in this section was formerly contained in Section DRCN-10-800 and Section DRCN-10-801 which are hereby cancelled.

1.03 The Dracon TS21 Lineman's Test Set (Fig. 1) is a modern self-contained line-powered combination handset used by installers, repairmen, linemen, and other telephone personnel for line testing and for temporary communications.

1.04 The TS21 employs the latest in solid-state circuit design to provide either a Touch Tone® or rotary-dial output from the built-in keypad. It contains many other features not found in conventional test handsets and is a direct replacement for the Western Electric 1013A or equivalent.

®Touch Tone is a registered service mark of the AT&T Co.

2. IDENTIFICATION

PURPOSE

- To provide a modern lineman's test set incorporating several new features.
- To provide a test handset combining both rotary-dial and Touch Tone® capability.
- To provide additional testing capabilities.

Fig. 1—TS21 Lineman's Test Set

APPLICATION

- Outside plant installation and repair.
- Central office frame and switchtrain testing.
- PABX and station equipment installation and troubleshooting.
- All other applications presently employing a conventional lineman's test handset.

DESIGN FEATURES

- Equipped with built-in pushbutton dial.
- Provides both rotary and tone dialing.
- Dialing mode is switch-selectable.
- Keypad may be switched in or out of circuit.
- Operates in either talk or monitor mode.
- Permits checking telephone line polarity.
- Comes with insulation-piercing alligator clips.
- Crystal-controlled, integrated-circuit design.
- Low-consumption line-powered circuitry.
- Unaffected by polarity reversal of the line.
- Contains non-slip pad for handsfree use.
- High-impact case with spring-loaded belt clip.

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OPTIONAL FEATURES

- Mute switch for use in noisy locations.
- Ground-start feature for testing PABX trunks.
- Cord with 346A plug for CO applications.
- Cord with resistor to simulate long loops.
- Cord with alligator clips in combination with bed-of-nails.

ELECTRICAL CHARACTERISTICS

- Refer to Table A for the TS21 operating parameters and signaling specifications.

DIMENSIONS AND WEIGHT

- The set is 9-11/16" (24.60 cm) long, 2- 11/16" (6.82 cm) wide and 3-11/16 (9.36 cm) high.
- The maximum weight is 21 oz (600 gm).

ORDERING GUIDE

- Refer to Table B to select the model containing the desired features and the appropriate cord.

TABLE A

ELECTRICAL SPECIFICATIONS

PARAMETER	WORKING LIMITS
Max. Loop Resistance	2000 ohms at 48v dc
Minimum Loop Current	20 mA
Typical Talk Impedance	150 ohms*
Min. Monitor Impedance	100K ohms at 1kHz
DIAL PULSE OUTPUT	
Pulsing Rate	9.5 pps to 10.5 pps
Percent Break	61% ±2%
Interdigital Interval	800 ms typical
Leakage During Break	400uA max. at 54v dc
DTMF OUTPUT	
Tone Frequency Error	±1% maximum
Level per Tone Pair	-9 dbm to +2 dbm
Amplitude Difference	3 dB maximum

Note: Specifications are subject to change without notice.
*Equivalent to the WECo 1013A and the BECo 801.

TABLE B

ORDERING GUIDE

MODEL NO.	CORD ASSEMBLY				MUTE SWITCH	GROUND START SWITCH	TWO-TONE BLUE	OCHRE AND BLUE
	TYPE	LENGTH	LEADS	TERMINATION				
21800-010	STD	5 Feet	2	Alig. Clips	●			●
21800-011	SP	1 Foot	2	346A Plug	●			●
21800-012	SBN	5 Feet	2	Alig. Clips with Bed-of-Nails	●			●
21800-020	STD	5 Feet	2	Alig. Clips			●	
21800-021	STD	5 Feet	2	Alig. Clips	●		●	
21800-023	SP	1 Foot	2	346A Plug			●	
21800-024	SP	1 Foot	2	346A Plug	●		●	
21800-025	SPR	1 Foot	2	346A Plug*			●	
21800-027	3W	5 Feet	3	Alig. Clips	●	●	●	

*Equipped with switchable 1500-ohm resistor for simulating long loop conditions.

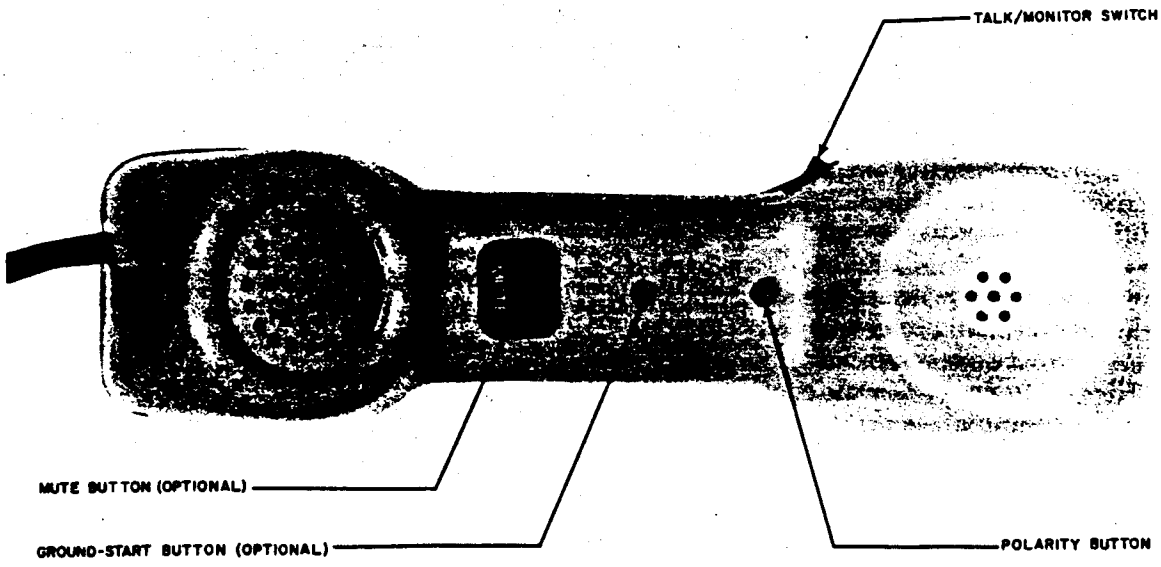


Fig. 2—TS21 Handset Assembly—Transmitter and Receiver Side

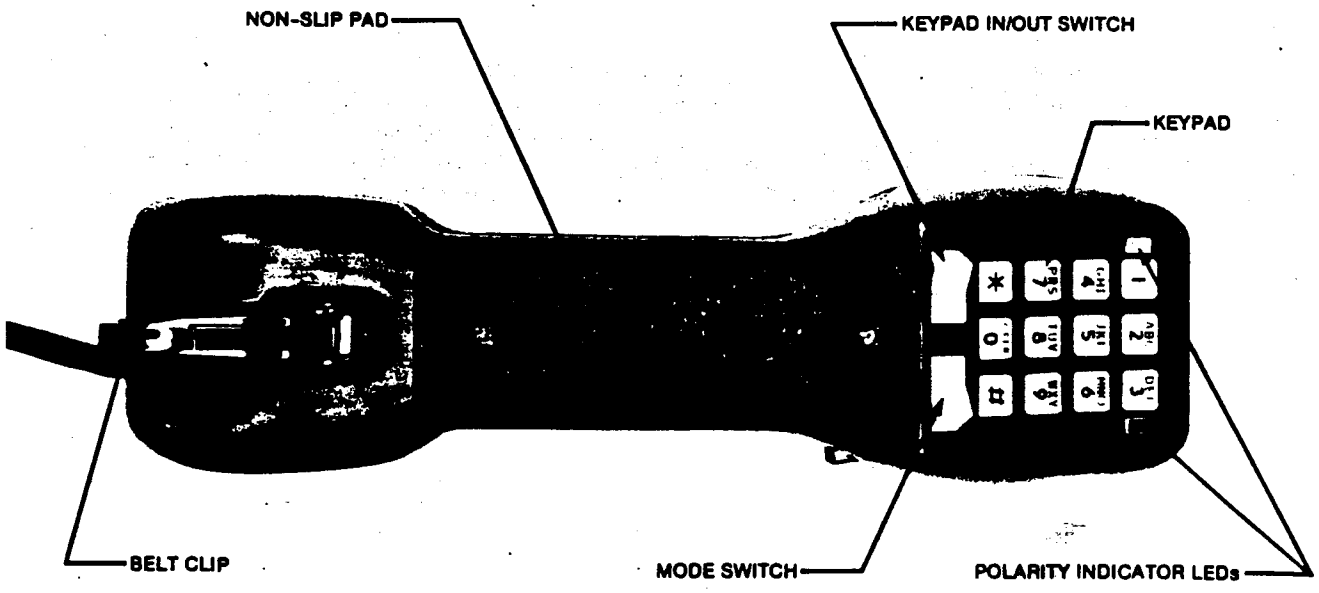


Fig. 3—TS21 Handset Assembly—Dial Side

DESCRIPTION OF APPARATUS

DSET ASSEMBLY

The TS21 Lineman's Test Set (Fig. 2 and 3) has a two-piece case made of high-impact tic. It is specially contoured to fit the shoulder is equipped with a non-slip pad to facilitate dsfree use. The set is two-tone in color, either and light blue or ochre and blue (see Table B), contains a heavy-duty spring-loaded belt clip he transmitter end of the case. The keypad,)s and associated switches are located on the of the handset at the receiver end of the case. itional switches are mounted on the side and de of the handgrip. Electronic components are nted on a single printed circuit board located le the handset case.

D ASSEMBLIES

Standard Cord (STD): This cord is approximately five-feet long and consists ne red and one black fabric-covered tinsel ductor. Each conductor is fitted with an gator clip which is offset 20 degrees to imize clip shorting. The thumb handle and of each clip is covered with an insulating erial. The clips contain insulation-piercing es. See Fig. 4 (a).

Ground Start Cord (3W): This cord is approximately five-feet long and consists ne red, one black and one green fabric-covered el conductor. Each conductor is fitted with an gator clip of the same type found on the ndard cord. Pressing the optional ground-start on connects the green (ground) conductor to red (ring) conductor inside the test set. Fig. 4 (b).

Plug Cord (SP): This cord is approximately one-foot long and is fitted h a 346A male plug. This allows the test set to used with a variety of different test cords ipped with a matching 471A female connector. Fig. 4 (c).

Plug and Resistor Cord (SPR): This cord is approximately one-foot long l is fitted with a 346A male plug and a tchable 1500-ohm resistor. When switched in, resistor is inserted in series with the ring side the cord to simulate a long loop condition. Fig. 4 (d).

3.06 *Standard Cord with Bed-of-Nails (SBN):* This cord is identical to the standard cord except that each alligator clip is equipped with a bed-of-nails in addition to the insulation-piercing spike, and the clips are not off-set as are the clips on the standard cord. See Fig. 4 (e).

SWITCHES AND INDICATORS

3.07 *Talk/Monitor Switch:* The **TALK/MONITOR** switch is a black rocker switch located on the side of the test set near the receiver (Fig. 2). In the **T (TALK)** position, it establishes an off-hook condition for dialing and talking. In this mode, the test set performs as a common battery telephone. In the **M (MONITOR)** position, the switch removes the transmitter from the circuit and provides a high-impedance coupling to the line. This allows monitoring of the line without disrupting a conversation in progress or a data or signaling transmission.

3.08 *Mode Switch:* The **MODE** switch is a white rocker switch located on the bottom right of the keypad bezel (Fig. 3). This switch selects either tone or pulse dialing. In the **TONE** position, the switch selects the DTMF output. In the **PULSE** position, it selects the dial pulse output.

3.09 *Keypad Switch:* This is a white rocker switch located in the bottom left corner of the keypad bezel (Fig. 3). When the switch is set to the **IN** position, the test set operates as a modern electronic telephone instrument. The **IN** position is used for all normal communications functions. Set to the **OUT** position, the switch bypasses the electronics including the keypad. In this mode, dialing is not possible and the test set operates at much lower voltages, functioning much like the older mechanical dial test sets. The **OUT** position is recommended when testing at or near the loop limit or testing on dry circuits. The **OUT** position is also useful when the test set is used for local communications with another craftsperson when talk battery is supplied by a local battery source such as that provided by "TONES" or other types of installer test equipment.

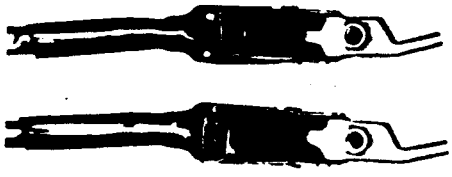
3.10 *Keypad:* The keys on the keypad are used for dialing. There are twelve keys on a bezel which is recessed into the receiver end of the case to provide both physical protection to the keypad and to prevent accidental key operation (Fig. 3). The actual mode of dialing, either tone or pulse, is determined by the setting of the **MODE** switch described in paragraph 3.08.

3.11 ***Polarity Switch and LEDs:*** The **POLARITY** switch is a small black button located on the inside of the handgrip, just under the receiver (Fig. 2). The polarity indicators consist of a yellow LED located in the upper lefthand corner of the keypad bezel and a red LED in the upper righthand corner. The **POLARITY** switch and the LEDs are used to determine the polarity of a telephone line.

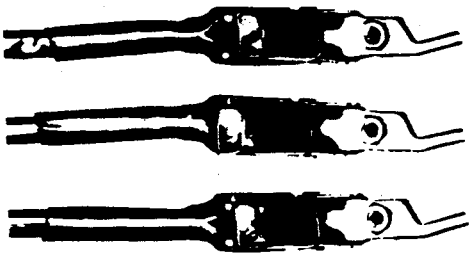
Note: The Dracon TS21 is not polarity sensitive. It will function normally regardless of the polarity of the line.

3.12 ***Mute Switch (Optional):*** The optional **MUTE** switch is located on the inside of the handgrip, just above the transmitter (Fig. 2). When pressed, this switch shunts the transmitter to improve the reception in noisy locations.

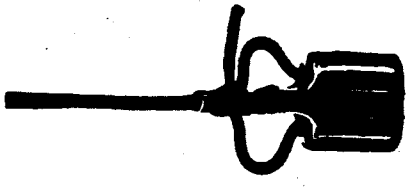
3.13 ***Ground Start Switch (Optional):*** The **GROUND START** switch is located midway between the **MUTE** and the **POLARITY** switches. Pressing this switch connects the green lead (ground) to the red lead (ring), initiating a ground-start seizure of a trunk.



(a) STANDARD CORD (STD)

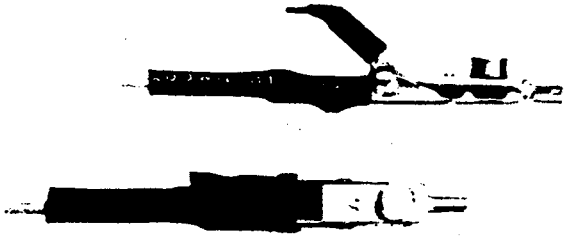


(b) GROUND START CORD (3W)



(c) PLUG CORD (SP)

(d) PLUG AND RESISTOR CORD (SPR)



(e) ALLIGATOR CLIPS WITH BED-OF-NAILS (SBN)

Fig. 4—TS21 Cord Assemblies

4. METHOD OF OPERATION

ORIGINATING A CALL

4.01 To place a call:

(1) Position the **TALK/MONITOR** switch to **M**.

(2) Connect the black test clip to the tip and the red test clip to the ring of the circuit to be used.

(3) Listen in the handset to ensure that the selected line is idle.

(4) Position the **KEYPAD** switch to **IN**.

(5) Set the **MODE** switch for the desired type of dialing, **TONE** for DTMF or **PULSE** for dial pulse.

(6) Position the **TALK/MONITOR** switch to **T** and listen for dial tone (where furnished).

(7) When dial tone is received, key in the desired telephone number on the keypad.

Note: When dial-pulse dialing is selected, the number may be keyed in at any speed. Digits will automatically outpulse at the correct rate.

(8) Upon termination of the call, return the **TALK/MONITOR** switch to the **M** position.

CALLING OVER A GROUND START TRUNK

4.02 To place a call over a ground start trunk:

(1) If your test set is equipped with the ground start option, connect the green wire to a ground.

(2) Perform steps (1) to (6) of paragraph 4.01 (no dial tone will be heard at this time).

(3) Press the **GROUND START** button on the TS21 and hold it down. (If the TS21 is not equipped with a **GROUND START** button, apply a temporary ground to the ring side of the line cord with a piece of wire).

(4) As soon as dial tone is heard, release the **GROUND START** button (or remove the temporary ground).

(5) Perform steps (7) and (8) of paragraph 4.01.

CHECKING POLARITY

4.03 To determine the polarity of the telephone line:

(1) Position the **TALK/MONITOR** switch to **M**, with **KEYPAD** and **MODE** switches in any position.

(2) Connect the test clips to the tip and ring of the circuit to be checked and ensure it is idle.

(3) Press the **POLARITY** button:

The red LED will light if the red test clip is connected to tip (+) and the black to ring (-).

The yellow LED will light if the red test clip is connected to ring (-) and the black to tip (+).

MONITORING AND TESTING

4.04 To monitor or test a line:

(1) Position the **TALK/MONITOR** switch to **M** with **KEYPAD** and **MODE** switches in any position.

(2) Connect the test clips to the circuit under test.

(3) Proceed to monitor or test the line. In this high-impedance mode, traffic will not be disrupted.

OPERATING OVER LONG OR DRY LOOPS

4.05 To use the test set on low-voltage or dry loops:

(1) Position the **KEYPAD** switch to **OUT**.

(2) Position the **TALK/MONITOR** switch to **M**, with the **MODE** switch in any position.

(3) Connect the test clips to the tip and ring of the circuit and listen to ensure that it is idle.

(4) Position the **TALK/MONITOR** switch to **T** for testing or two-way communications.

Note: Dialing is not possible in this mode. The electronic circuitry has been bypassed to increase the loop limit of the set. All other functions perform normally.

OPERATING IN NOISY LOCATIONS

4.06 Reception in noisy areas can be improved by operating the **MUTE** switch when listening and releasing it when talking. This switch shunts the transmitter to eliminate background noise.

5. FUNCTIONAL DESCRIPTION

5.01 The TS21 Lineman's Test Set provides the means for communications and testing in the central office as well as in the field. The various models offer a variety of options to meet different operating conditions. A detailed circuit schematic of all the models is shown in Fig. 8.

5.02 The TS21 provides three distinct modes of operation. They are the monitor mode for listening and testing without disturbing a conversation in progress, talking and dialing for normal communications, and the long- or dry-loop mode for use when the telephone line voltage is too low to power the electronic circuitry of the set. In the latter mode, dial pulse or tone dialing is not possible.

MONITOR MODE

5.03 *Monitor Circuit (Fig. 5):* When the TALK/MONITOR switch is placed in the M position, the transmitter is disconnected from the line, and a high-impedance transmission path is established from the tip and ring conductors to the receiver via monitor transformer T1 in conjunction with capacitor C1, section B of the TALK/MONITOR switch in the M position and capacitor C6. The primary impedance of T1 is 150K ohms, while the secondary is 150 ohms. C1 is a dc blocking capacitor to prevent the seizure of the central office while the set is in the monitor mode. The settings of the KEYPAD IN/OUT and MODE switches have no effect on the operation of the set in this mode.

5.04 *Polarity Indicator:* The polarity of the telephone line can be determined by pressing the POLARITY switch, connecting the two LEDs across tip and ring. If DS1 (yellow LED) lights, ground is on the tip and battery is on the ring. If DS2 (red LED) lights, battery is connected to tip and ground to ring. Resistor R1 limits current flow to protect the LEDs. The polarity test can be performed in any mode.

TALKING AND DIALING MODE

5.05 With the TALK/MONITOR switch in the T position and the KEYPAD IN/OUT switch in the IN position, the TS21 is in the normal talking mode and the electronic circuitry is enabled to permit tone or pulse dialing.

5.06 *Transmission Path (Fig. 6):* In the T position, the TALK/MONITOR switch establishes a transmission path from the telephone line under test, via the tip conductor, one side of diode bridge BR1, the collector-emitter path of transistors Q6 and Q7 in series, section B of the KEYPAD IN/OUT switch in the IN position, to the receiver and transmitter, returning via sections A and C of the KEYPAD IN/OUT switch, diode bridge BR1, section A of the TALK/MONITOR switch in the T position to the ring conductor to the telephone line. VR3 is a silicon-carbide varistor used to limit the maximum output level of the receiver and prevent acoustic shocks to the user. C6 passes voice signals to the receiver, but blocks dc which could damage the receiver's permanent magnet. Resistor R11 provides a dc path for the transmitter, while limiting the current flow and providing the proper impedance to the loop.

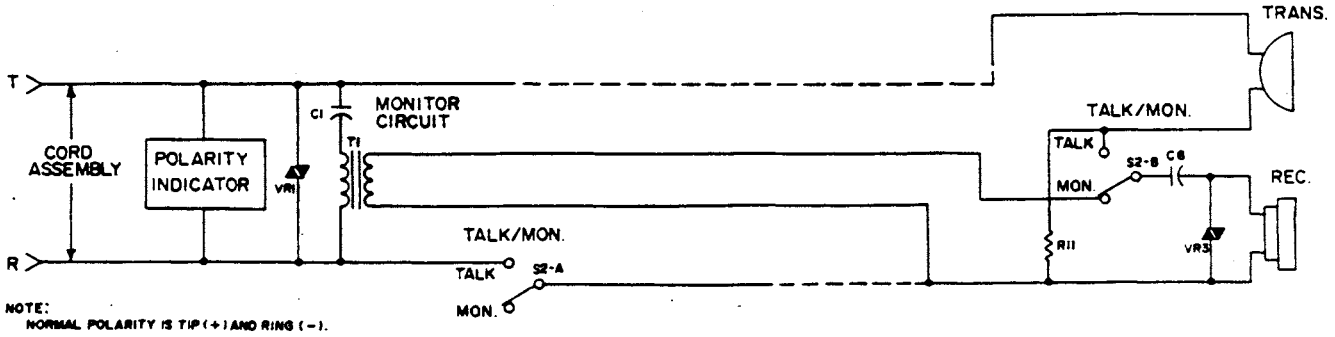


Fig. 5—Condensed Functional Schematic of TS21 Test Set (Monitor Mode)

5.07 ***Ground Start Switch (Optional):*** The **GROUND START** switch and three-conductor cord are optional and are used to facilitate the testing of ground start trunks in a PBX. When placing an outgoing call from the PBX, the **GROUND START** switch is pressed, connecting ground to the ring side of the trunk. As soon as the central office recognizes the ground start signal and returns dial tone, the **GROUND START** switch can be released.

5.08 ***Mute Switch (Optional):*** The **MUTE** switch is used in noisy locations. When depressed, it shunts the transmitter via resistor R12. Background room noise is no longer able to pass from the transmitter to the receiver as sidetone, improving reception of the distant party's conversation. The **MUTE** switch is pressed while listening and released for talking.

5.09 ***Power Supply (Fig. 8):*** Polarity guard BR1 is a 400 PIV diode bridge used to assure that the correct voltage polarity is always applied to the power supply and other electronic circuitry in the set. Varistor VR1 with a breakdown voltage of approximately 190 volts dc is used to absorb voltage transients which could damage the electronic circuitry. Resistors R2, R3, and R4, diode CR1, zener diode VR2, and transistors Q1 and Q2 comprise a 5.1v regulated supply to power the set's electronic circuitry. Capacitors C2 and C3 filter the supply voltage and store energy to operate the set during momentary line interruptions and during the break intervals of dial pulsing.

5.10 ***Keypad:*** The keypad comprises twelve nonlocking pushbuttons with two make contacts each, and is used for entering the digits to be dialed. Each time a button is depressed, a "column" signal and a "row" signal are transmitted in "2-out-of-7" code to both the dial pulse and the dual tone integrated circuits.

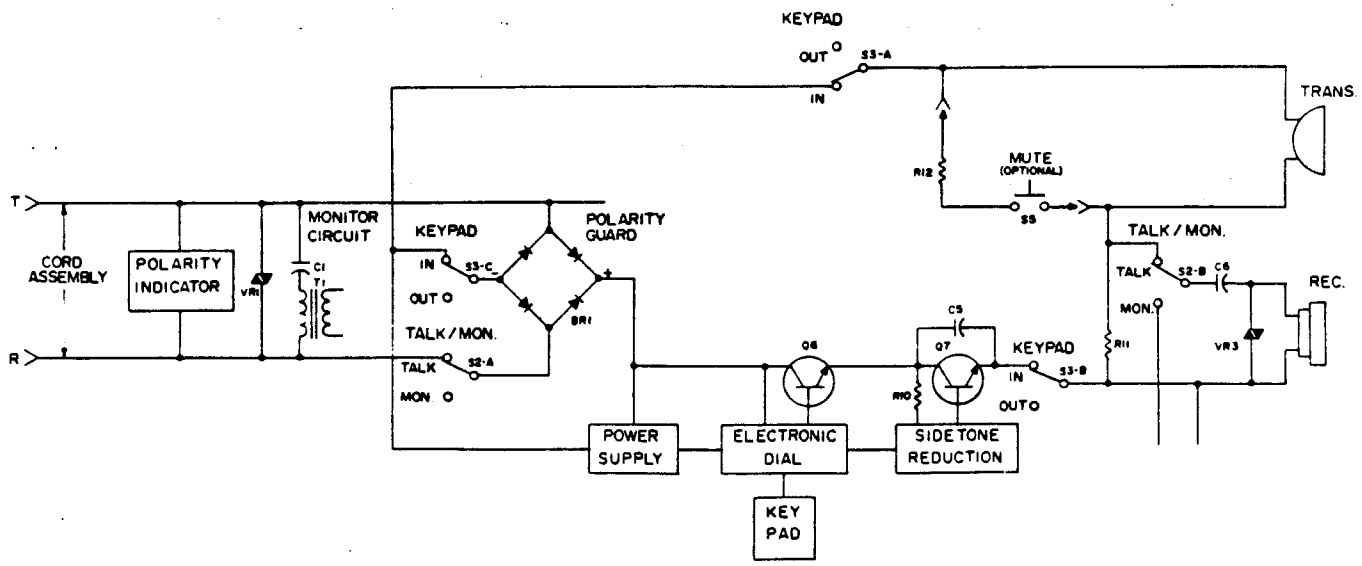


Fig. 6—Condensed Functional Schematic of TS21 Test Set (Talking and Dialing Mode)

5.11 ***Dual Tone Generator:*** U1 is a DTMF generator IC. Y1 is a 3.579545 MHz crystal providing U1 with a stable and accurate frequency source. The DTMF generator is enabled when the **MODE** switch is placed in the **TONE** position. Each time a button on the keypad is depressed, the corresponding signal is received on two of the seven inputs to U1. U1 transmits the two selected tones via coupling capacitor C7 to the base of driver transistor Q3. Q3 amplifies the tones and applies them via resistor R6 to the base of Q4. Q4 then modulates the line with the DTMF signals. C4 is a feedback capacitor for reducing distortion. Resistor R15 biases transistor Q3, while resistors R5 and R7 supply the bias for transistor Q4.

5.12 ***Dial Pulse Generator:*** U2 is a dial pulse generator. In conjunction with Y2, a 480 kHz ceramic resonator, U2 is capable of generating accurately spaced and timed pulses for rotary dialing. U2 has a storage capacity of 17 digits, allowing digits to be entered at any rate for subsequent outpulsing with the proper spacing and interdigital timing. Diodes CR3 through CR9 isolate IC U2 from IC U1. IC U2 is enabled and IC U1 is disabled when the **MODE** switch is in the **PULSE** position. When a button on the keypad is depressed, a signal appears at two of the seven IC inputs where it is converted to the corresponding digit. U2 then transmits a series of pulses via transistor Q10 and resistor R9 to the base of driver transistor Q5. Q5 inverts the pulses and applies them to the base of Q6. Transistor Q6 acts as a switch, interrupting the telephone loop, and repeating the digit to the central office. Resistors R18 and R8 bias transistors Q10 and Q5, respectively.

5.13 ***Sidetone Reduction:*** During either tone or pulse dialing, the receiver is shunted to reduce sidetone and prevent loud tones or clicks from being heard in the receiver. During pulse dialing, U2 transmits an inhibit signal to transistor Q11 which drives the base of FET Q8. In the tone dialing mode, U1 drives the base of Q8 directly. Q8 maintains the loop closure via an alternate path while turning off Q7. Q7 opens the normal loop path via the transmitter. Capacitor C5 allows a small amount of the dialing signal to be heard in the receiver. As soon as dialing ceases, the circuit reverts to the original loop path.

LONG OR DRY LOOP MODE

5.14 The electronic circuitry of the TS21 will not function beyond the TS21's normal loop limit of 2000 ohms, due to the low voltage. It then becomes necessary to bypass the electronic circuits by operating the **KEYPAD IN/OUT** switch to the **OUT** position. The **TALK/MONITOR** switch and **MODE** switch may be in either position. In this mode, the TS21 operates much like a conventional test handset, with the transmission loop limit extended to 2500 ohms. It also allows subjective testing of dry circuits by allowing inductive noise to be heard. In this mode, neither DTMF nor pulse dialing is possible.

5.15 ***Transmission Path (Fig. 7):*** With the **KEYPAD IN/OUT** switch in the **OUT** position and the **TALK/MONITOR** switch in the **T** position, a talking path is established from the tip conductor via section A of the **KEYPAD IN/OUT** switch directly to the transmitter and receiver circuits, returning via section B of the **KEYPAD IN/OUT** switch and section A of the **TALK/MONITOR** switch to the ring conductor.

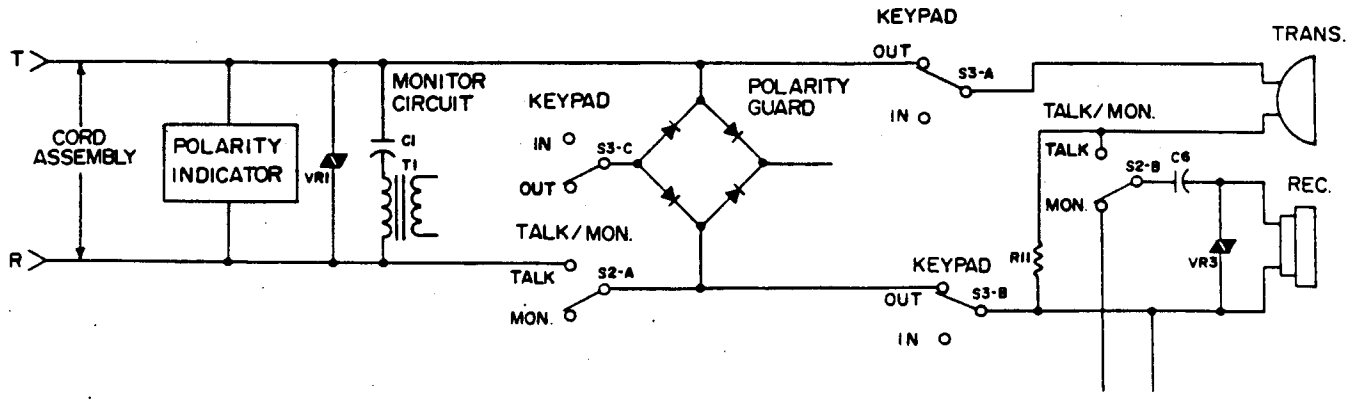
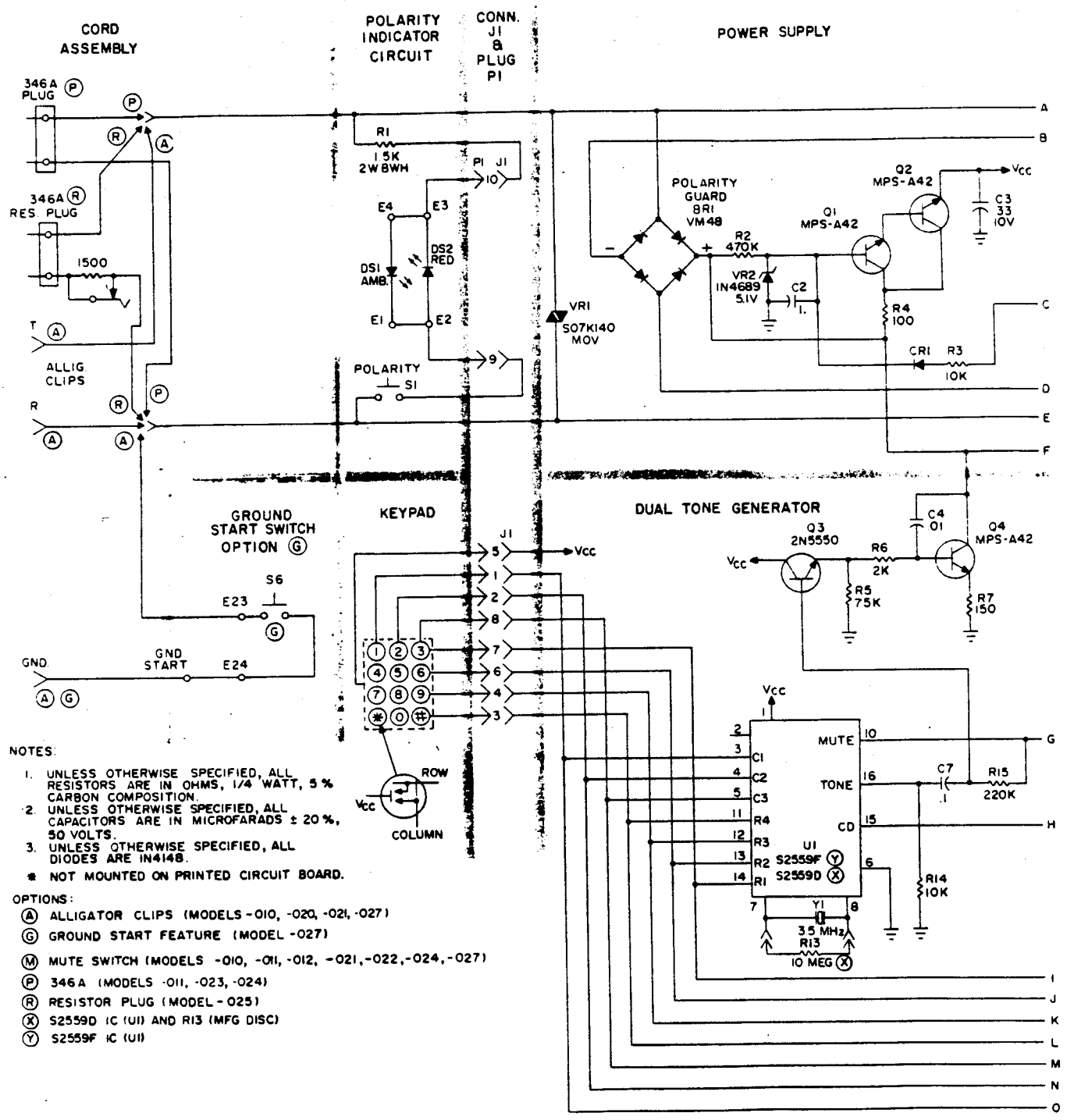


Fig. 7—Condensed Functional Schematic of TS21 Test Set (Long or Dry Loop Mode)



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE IN OHMS, 1/4 WATT, 5% CARBON COMPOSITION.
2. UNLESS OTHERWISE SPECIFIED, ALL CAPACITORS ARE IN MICROFARADS ± 20%, 50 VOLTS.
3. UNLESS OTHERWISE SPECIFIED, ALL DIODES ARE IN4148.

* NOT MOUNTED ON PRINTED CIRCUIT BOARD.

OPTIONS:

- (A) ALLIGATOR CLIPS (MODELS -010, -020, -021, -027)
- (G) GROUND START FEATURE (MODEL -027)
- (M) MUTE SWITCH (MODELS -010, -011, -012, -021, -022, -024, -027)
- (P) 346A (MODELS -011, -023, -024)
- (R) RESISTOR PLUG (MODEL -025)
- (X) S2559D IC (U1) AND R13 (MFG DISC)
- (Y) S2559F IC (U1)

Fig. 8—Schematic, TS21 Lineman's Test Set (Sheet 1 of 2)

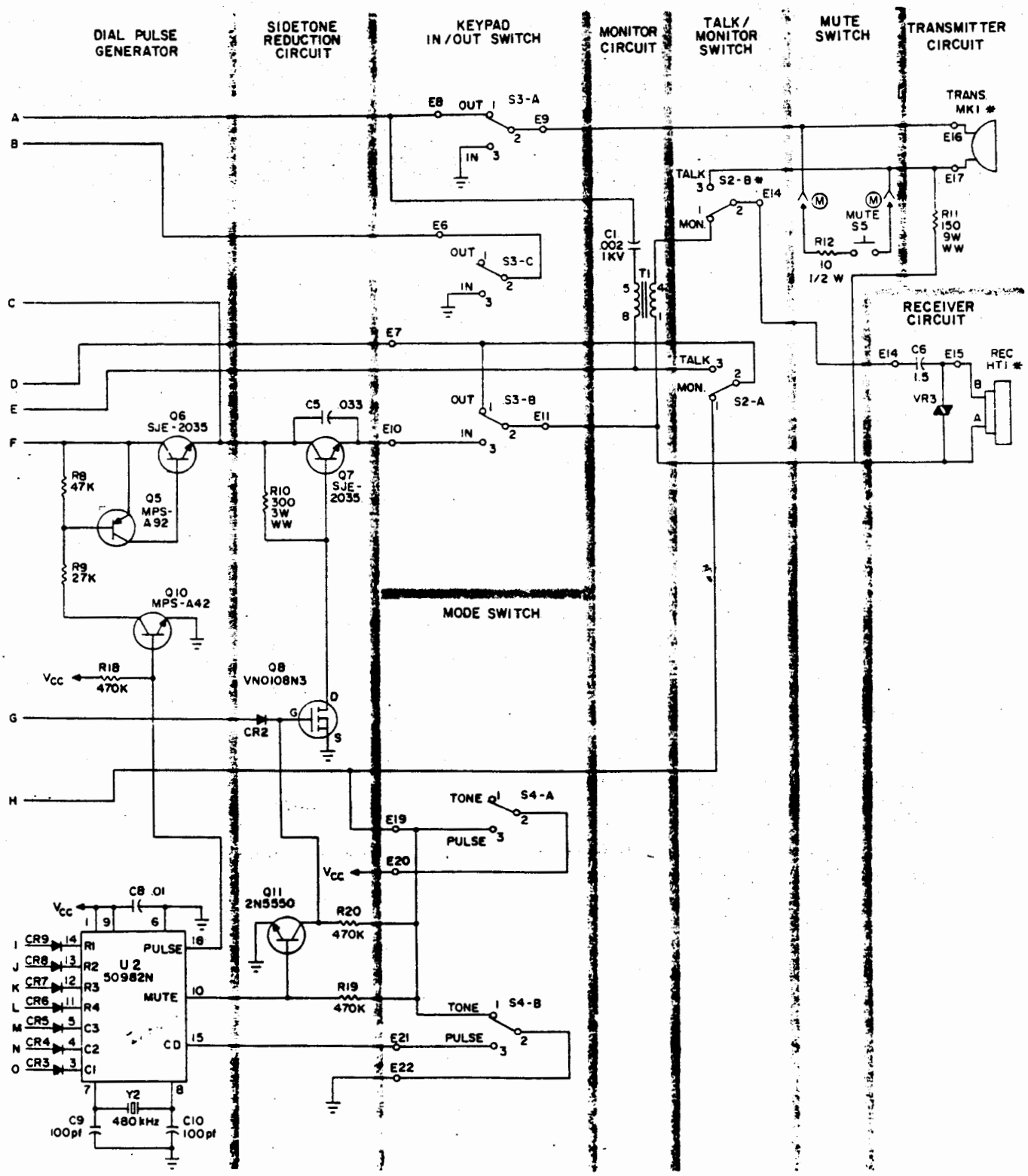


Fig. 8—Schematic, TS21 Lineman's Test Set (Sheet 2 of 2)

6. CIRCUIT TESTS

6.01 Circuit testing information is provided as an aid in diagnosing and locating trouble in the TS21 Lineman's Test Set. The tests are also used to verify that the TS21 set is performing according to specification. Analysis of the reported trouble may be helpful in narrowing the search for the source of trouble. Otherwise it will be necessary to conduct all of the circuit tests until the trouble is encountered.

6.02 Once the particular area of malfunction has been identified, it will be necessary to test the individual circuit components to locate the source of the trouble. For detailed information on component tests, refer to part 7 of this practice.

DISASSEMBLY

6.03 It is not necessary to disassemble the test set to perform routine circuit tests, but disassembly is necessary to locate and replace defective components. To disassemble the TS21 Lineman's Test Set, proceed as follows:

6.04 To open the housing:

(1) Remove the five screws that hold the front and rear housing together. (See Fig. 9).

(2) Separate the front and rear housing and place them as shown in Fig. 10.

Caution: The front part of the housing may bind around the* TALK/MONITOR *switch. Use gentle pressure to free it.

Note: Arranging the two parts of the case as shown in Fig. 10 reduces the risk of accidentally pulling loose the receiver or transmitter wires.

6.05 To free the printed circuit board:

(1) Remove the screws that fasten the line cord leads to the printed circuit board.

6.06 To remove the line cord:

(1) Remove the screw that fastens the line cord strain-relief braid to the rear housing.

(2) Lift the circuit board slightly and pull the cord leads and strain-relief braid out of the housing.

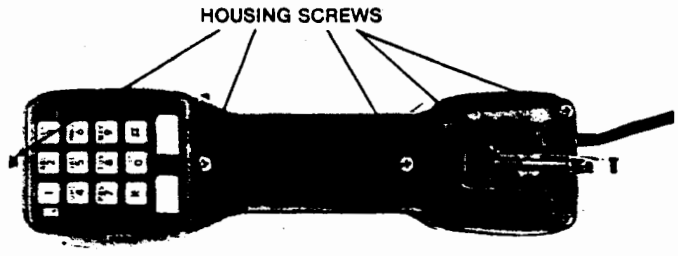


Fig. 9—Location of Housing Screws

6.07 To remove the transmitter:

(1) Remove the three phillips-head screws from the transmitter's plastic retainer.

(2) Remove the plastic retainer.

(3) Remove the transmitter.

(4) Remove and inspect the large rubber washer. (Replace the washer if necessary.)

6.08 To remove the receiver:

(1) Loosen the receiver terminal screws and disconnect the spade terminals from the receiver.

(2) Remove the three phillips-head screws from the receiver's plastic retaining ring.

(3) Remove the retainer ring.

(4) Remove the receiver.

TESTS

6.09 The following tests are required to ensure the proper operation of the lineman's test set and to locate the portion of the circuitry containing a malfunction:

- Loop Test
- DTMF Test
- Pulse Test
- Transmitter Test
- Polarity Test.

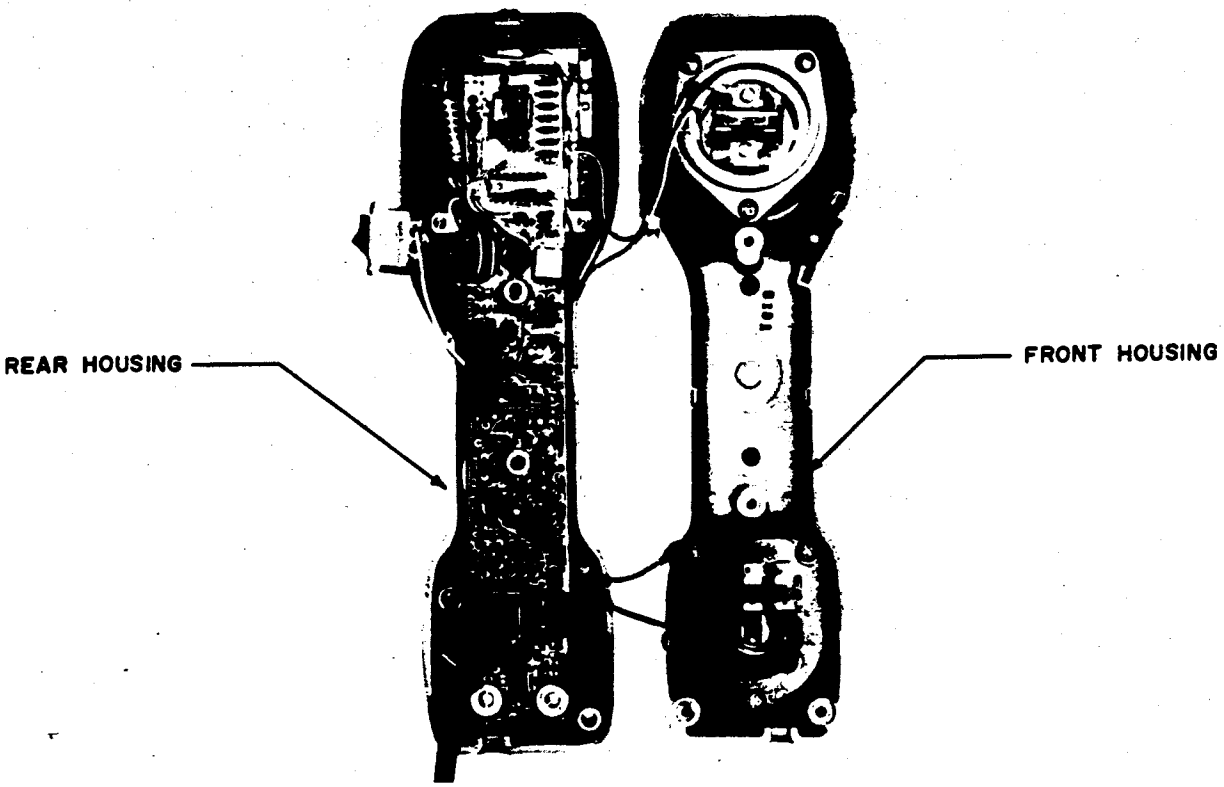


Fig. 10—TS21 Lineman's Test Set Shown Disassembled

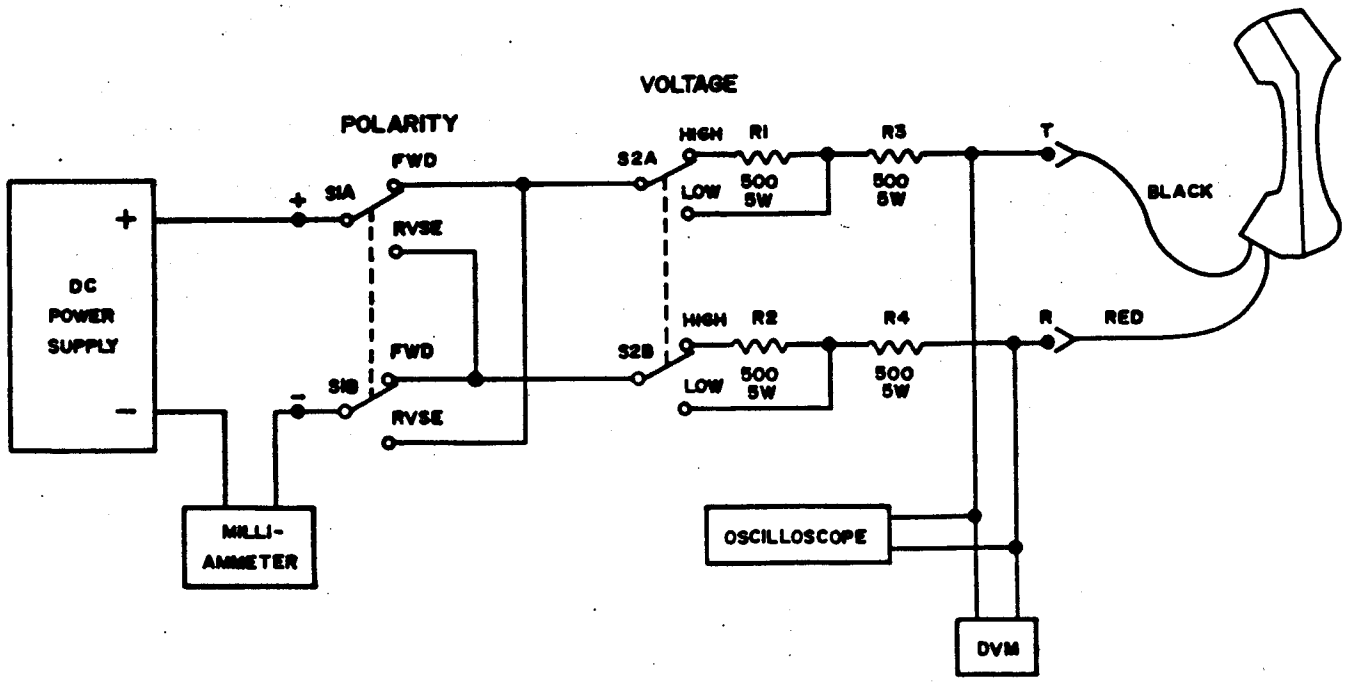


Fig. 11—Test Equipment Connections for Circuit Tests

6.10 Test Apparatus: The following test equipment is required for these tests:

- Digital voltmeter (DVM)
- Milliammeter
- Oscilloscope with a 1X (non-attenuating) probe.
- Variable power supply capable of supplying 20v dc to 120v dc and up to 1.5 amperes
- Oscillator with a 600-ohm output impedance and a capability of supplying a 1 kHz tone at a level of -10 dBm
- Magnavox X183 Telecoupler or equivalent
- Four 500-ohm, 5-watt wirewound resistors
- Two double-pole, double-throw toggle switches.

6.11 ***Preparation:*** To perform any of the following tests, it is first necessary to wire up a test fixture in accordance with Fig. 3. Proceed as follows:

(1) Wire the four resistors and the two switches as shown in Fig. 11.

(2) Label the switches and terminal points as shown in Fig. 11.

(3) Connect the dc power supply, switch S1 and the milliammeter as shown in Fig. 11.

(4) Connect the red and black test clips of the TS21 to the points designated (T) and (R).

(5) Also connect the oscilloscope and the DVM to the points designated (T) and (R).

6.12 To check that the test fixture is working properly, proceed as follows:

(1) Turn the power supply on and set it for an output of 30 ±0.5 volts.

(2) Position text fixture switch S1 to **FWD** and switch S2 to **LOW**.

(3) Select the 200-volt dc scale on the DVM.

(4) Place the TS21's **TALK/MONITOR** switch in the **M** position.

(5) The DVM should read 30 ±.05 volts.

(6) Press the **POLARITY** button on the TS21. The yellow LED should light.

(7) Position test fixture switch S1 to **RVSE**.

(8) Press the **POLARITY** button on the TS21 again. This time the red LED should light.

(9) If the wrong LEDs light, the labeling of switch S1 is reversed.

(10) If an LED fails to light and the DVM shows less than 30 ±0.5 volts, the test setup is incorrect.

(11) If an LED fails to light with the DVM reading 30 ±0.5 volts, the TS21 may be defective.

6.13 ***Loop Test:*** The loop test is required to measure the TS21 power consumption and to check the voltage at the set's input. An improper voltage or current reading is indicative of a malfunction and its possible cause. Proceed with the loop test as follows:

(1) Set the power supply voltage to 30 ±0.5 volts.

(2) Position test fixture switch S2 to **LOW**.

(3) Select the 200-volt dc scale on the DVM.

(4) Select the 200mA scale on the milliammeter.

(5) Connect the TS21 to the test fixture terminals as shown in Fig. 11.

(6) Position the TS21 **TALK/MONITOR** switch to **M**.

(7) The DVM should read 30 ±0.5 volts.

(8) The milliammeter should not indicate more than 12 microamperes.

(9) Position the TS21 **TALK/MONITOR** switch to **T**.

(10) The DVM should read between 5 and 10 volts.

(11) The milliammeter should indicate between 21 and 23 milliamperes.

6.14 In the event that the TS21 failed to pass the loop test, a defective component may be the cause. For detailed testing of suspected components, refer to part 7 of this practice and for a parts index, see part 8. If the loop test provided an improper reading on the milliammeter or voltmeter, the cause may be one of the following:

(a) Low or no current—broken wire from the **TALK/MONITOR** switch to the circuit board.

(b) Higher-than-specified voltage—rectifier bridge BR1 may be defective.

(c) Lower-than-specified voltage—bridge BR1 may be defective, or the transmitter resistance may be high (see paragraph 7.11).

6.15 *DTMF Test:* The dual tone test is required to check the DTMF circuitry for proper tone frequency, waveform and dual-tone operation. Proceed with the test as follows:

(1) Position the TS21 TALK/MONITOR switch to T.

(2) Position the TS21 MODE switch to TONE.

(3) Position the TS21 KEYPAD switch to IN.

(4) Set the power supply output to 30 ±0.5 volts.

(5) Position test fixture switch S2 to LOW.

(6) The milliammeter should indicate between 21 and 23 milliamperes.

(7) Set channel 1 of the oscilloscope for 1v ac per division and 1 ms sweep per division.

(8) Ensure that a 1X probe is being used.

(9) Position the ground-level scope trace to the center of the screen.

(10) Set the DVM to read ac voltage.

(11) Press the keypad (#) key and hold it down.

(12) The DVM should indicate a minimum of 0.4v.

(13) The oscilloscope should show the clean and non-distorted waveform of Fig. 12.

(14) Adjust the scope trigger and time base to display a single waveform.

(15) Repeat steps (11) through (13) for every keypad key in sequence.

(16) Each key shall produce a waveform similar to that of Fig. 12.

(17) Waveforms similar to those shown in Fig. 13 are unacceptable for the reasons indicated.

(18) Position test fixture switch S1 to RVSE to reverse the polarity of the test fixture.

(19) Repeat steps (11) to (17) above. The same results should be obtained.

6.16 If one or more digits fail to pass the dual-tone test, as indicated by an improper or intermittent waveform or by the absence of one or both tones, one or more of the following components may be defective: crystal Y1, IC's U1 or U2, diodes CR3 through CR9, the keypad, the MODE switch or the KEYPAD IN/OUT switch. These components may be tested in accordance with the test procedures for components described in part 7 of this practice.

DUAL TONES

Fig. 12—Proper Dual-Tone Waveform

ONE TONE ABSENT

BOTH TONES ABSENT

DUAL TONES WITH CLIPPED PEAKS AND/OR NOISE

Fig. 13—Improper Dual-Tone Waveforms

6.17 *Pulse Test:* The pulse test checks the amplitude and the make and break intervals of the dial pulses generated by the TS21 during pulse dialing. The test is required to ensure that the dial pulses are adequate to operate the switching equipment in the central office over the longest loop permitted by the TS21 specifications. Proceed with the dial-pulse test as follows:

(1) Position the TS21 MODE switch to PULSE.

(2) Set the power supply for an output of 20 volts.

(3) Position test fixture switch S2 to LOW.

(4) Set channel 1 of the oscilloscope for 5v dc per division and 10 ms sweep per division.

(5) Position the ground-level scope trace to the bottom of the screen.

(6) Press the key for the digit (1) on the keypad.

(7) The scope should indicate a pulse amplitude of 17 to 20 volts during the break interval.

(8) During the make and non-dialing intervals, the scope should show a dc level of 5 to 7 volts.

(9) The break interval should be 59% to 63% of one cycle and 57 to 63 ms in duration.

(10) The make interval should be 37% to 41% of one cycle and 38 to 42 ms in duration.

(11) Fig. 14 shows the waveform and amplitude of a proper train of dial pulses.

(12) Repeat steps (6) through (10) for all other digit keys on the TS21 keypad.

(13) Set the power supply for an output of 120 volts.

(14) Position test fixture switch S2 to **HIGH**.

(15) Set channel 1 of the oscilloscope for 20 volts per division.

(16) Repeat steps (5) through (12). The dial pulses should meet the same requirements.

(17) Position test fixture switch S1 to **RVSE** to reverse the power supply polarity.

(18) Repeat steps (2) through (16). The test results should be the same as before.

6.18 If the dial pulses fail to meet the foregoing requirements, are intermittent, or if certain keys fail to generate digits or if no pulses are generated, one or more of the following components may be defective: resonator Y2, IC U2, diodes CR3 through CR9, the ribbon cable, the keypad, the **KEYPAD IN/OUT** switch or the **MODE** switch. Refer to part 7 for component tests and part 8 for a parts list.

6.19 ***Polarity Test:*** The Polarity test is required to check the polarity sensing function of the TS21 and the operation of the LED's. Proceed with the polarity test as follows:

(1) Set the power supply output for 30 ±0.5 volts.

(2) Position test fixture switch S2 to **LOW**.

(3) Position test fixture switch S1 to **FWD**.

(4) Press the TS21 **POLARITY** switch. The yellow LED should light.

(5) Position test fixture switch S2 to **RVSE**.

(6) Press the TS21 **POLARITY** switch again. This time the red LED should light.

(7) If either LED fails to light, check the LED. If both LEDs fail to light, check the line cord, the TS21 **POLARITY** switch and both LEDs. Refer to part 7 for testing components and part 8 for the parts index.

6.21 ***Transmitter Test:*** The transmitter test is required to verify that the voltage output of the transmitter meets the minimum requirements when energized with a known sound-pressure level. Proceed with the transmitter test as follows:

(1) Set the power supply for an output of 120 volts.

(2) Position the test fixture switch S2 to **HIGH**.

(3) Connect the oscillator to the acoustic coupler as specified by the coupler manufacturer.

(4) Place the TS21 Lineman's Test Set in the acoustic coupler's handset cradle.

(5) Set the oscillator output for 1 kHz at a level of -10 dBm.

(6) Set the digital voltmeter to read ac voltage.

(7) The DVM should indicate 0.1 volts ac or more.

(8) Set the power supply output for 30 ±0.5 volts.

(9) Position the test fixture switch S2 to **LOW**.

(10) The digital voltmeter indication should continue to meet the requirements of step (7).

6.22 If there is no voltage indication, check for broken wires from the transmitter to the printed circuit board. If the reading of the digital voltmeter is less than 0.1 volt ac, check that the output voltage of the power supply is between 3.5v and 4.1v dc at 22mA. If the power supply voltage is correct, test the transmitter in accordance with the instructions contained in part 7.

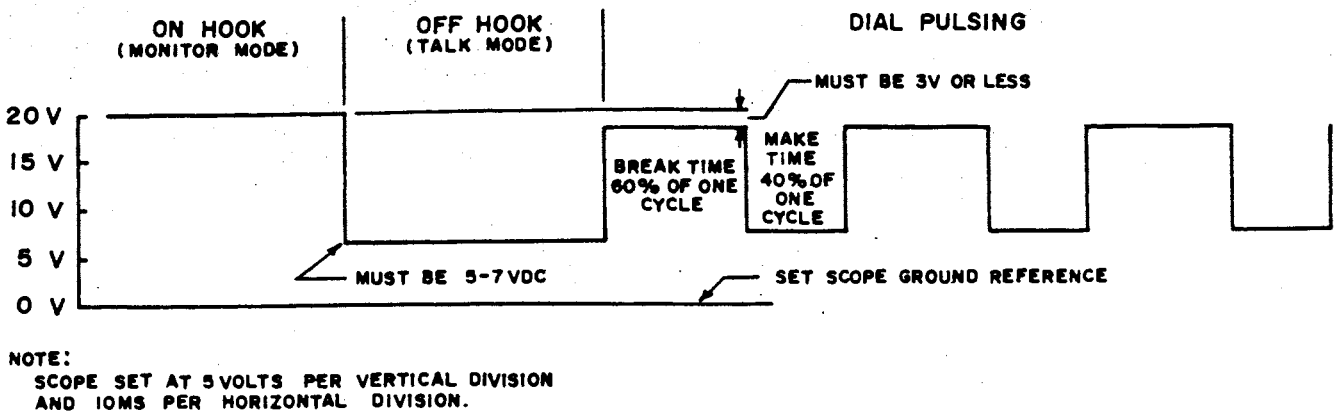


Fig. 14—Proper Waveform for Dial Pulses

7. COMPONENT TESTS

7.01 Test procedures for the major components of the TS21 test handset are included to assist in identifying defective elements and clearing trouble. For those components which are not considered, standard test procedures should be used. The components to be tested are those pertaining to that portion of the circuitry identified through the circuit testing of part 6 as malfunctioning. A complete parts index listing all components is provided in part 8 of this practice.

7.02 *Tests:* Test procedures are provided for the following component parts of the TS21 test handset:

- Rectifier Bridge BR1
- Varistor VR3
- Diodes CR1 through CR9
- Keypad
- LEDs
- Line Cord and Test Leads
- Transmitter
- Receiver
- All Switches
- Integrated Circuits U1 and U2
- Crystal Y1
- Resonater Y2.

7.03 *Test Apparatus:* The following test equipment is required for these tests:

- Digital voltmeter (DVM)
- Ohmmeter
- Oscilloscope with a 1X (non-attenuating) probe
- Variable power supply capable of supplying 0 volts to 120 volts dc.
- Small soldering iron suitable for soldering on printed circuit boards containing ICs.
- Desoldering tool suitable for removing components from printed circuit boards.

7.04 *Preparation:* For component testing, the TS21 will have to be disassembled as described in paragraph 6.03. The TS21 shall be disconnected from the test fixture except for those tests requiring that the TS21 be powered.

> ***Caution: When removing components from the printed circuit board, first remove the silicon rubber coating, then completely desolder the leads; otherwise the metal feed-throughs may be pulled loose. All coating must be replaced with Dow Corning 3-6550 Dispersion or an equivalent material.***

7.05 *Rectifier Bridge BR1 Test:* This test is required to determine if there is an open or short circuit in rectifier bridge BR1. To perform the test, first set the TS 21 TALK/MONITOR switch to M. Then test the elements of the bridge with an ohmmeter in accordance with Table C. The results should correspond to the last column of the table.

TABLE C

RECTIFIER BRIDGE OHMMETER TEST

STEP	PLACEMENT OF POSITIVE PROBE	PLACEMENT OF NEGATIVE PROBE	METER READING
1	BR1 (+)	(R) Terminal on PC board	open
2	BR1 (+)	(T) Terminal on PC board	open
3	BR1 (-)	(R) Terminal on PC board	approx. 600 ohms
4	BR1 (-)	(T) Terminal on PC board	approx. 600 ohms
5	(R) Terminal on PC board	BR1 (+)	approx. 600 ohms
6	(R) Terminal on PC board	BR1 (-)	open
7	(T) Terminal on PC board	BR1 (+)	approx. 600 ohms
8	(T) Terminal on PC board	BR1 (-)	open

7.06 ***Varistor VR3 Test:*** This test is required to determine if varistor VR3 is shorted. To perform the test, set the ohmmeter to the high-resistance scale and apply it across the varistor. The meter should indicate an open circuit.

7.07 ***Diodes CR1 Through CR9 Test:*** This test is required to determine if there is an open or a short circuit in any of the diodes. Proceed with the diode test as follows:

(1) Disconnect the diode from the circuit.

(2) Set the ohmmeter to the R x 1000 scale.

(3) Apply the ohmmeter across the diode with the negative probe on the banded side of the diode.

(4) The meter should read approximately 600 ohms.

(5) Reverse the test probes and place the positive probe on the banded side.

(6) The meter should read open on the R x 1000 and any higher scale.

7.08 ***Keypad Test:*** This test is required to determine if the keypad is not functioning properly. Proceed with the keypad test as follows:

(1) Set the TS21 **TALK/MONITOR** switch to **T**.

(2) Set the TS21 **KEYPAD** switch to **IN**.

(3) Set the TS21 **MODE** switch to **PULSE**.

(4) Press each keypad digit key in sequence.

(5) Dial pulses should be transmitted in each case.

(6) Set the TS21 **MODE** switch to **TONE**.

(7) Press each keypad key in sequence.

(8) A dual tone signal should be generated each time.

(9) Check the ribbon cable for scratches across the conductors.

(10) If the trouble has not been located, replace the keypad with one that is known to be good.

(11) Repeat steps (1) to (8) with the new keypad.

7.09 ***LED Test:*** This test is required to determine if either LED is open or shorted. Proceed with the LED test as follows:

(1) Disconnect the LED from the circuit.

(2) Apply 2 to 3 volts dc through a 150-ohm series resistor in both forward and reverse polarity.

(3) The LED should light in forward polarity only.

Note: The LEDs should not illuminate in reverse polarity on less than 5 volts dc.

(4) Set the ohmmeter to a high-ohms scale.

(5) Apply the meter across the LED in both polarities.

(6) The meter should read open in one polarity and at least 1.5K ohms in the other.

7.10 ***Line Cord Test:*** The line cord test is required to determine if there is an open, high-resistance or intermittent condition in the line cord. Proceed as follows:

(1) Apply an ohmmeter across each conductor and make sure the resistance is zero.

(2) Check for an intermittent condition by wiggling each conductor and observing the ohmmeter.

(3) Set the power supply to 50v dc.

(4) Connect one line cord test clip to one of the power terminals.

(5) Tap the other test clip to the other power terminal.

(6) A loud click should be heard in the TS21 receiver each time the terminal is tapped.

7.11 ***Transmitter Test:*** This test is required to check the transmitter element. Measure the transmitter resistance with an ohmmeter. It should read between 200 and 500 ohms.

7.14 ***Receiver Test:*** This test is required to determine if the receiver element is defective. Proceed with the test as follows:

(1) Replace the receiver with a known good receiver and test its operation.

(2) If the line cord is known to be good, test the receiver per steps (3) to (6) of paragraph 7.10.

(3) If the receiver fails to function check for broken wires and also check transistors Q5, Q6 and Q7.

7.13 ***Switch Test:*** Switches can be checked for proper operation by measuring their contact resistance while power is removed from the TS21. Switches should also be checked for accumulations of oil, dirt, moisture and mechanical obstructions.

7.14 ***Mode Switch Test:*** This test is required to determine if there is a malfunction in the **MODE** switch. Perform the test as follows:

(1) Set the TS21 **TALK/MONITOR** switch to **T**.

(2) Press a keypad digit key and at the same time rock the **MODE** switch back and forth.

(3) A dual tone should be heard each time the switch is in the **TONE** position.

(4) A single tone or absence of both tones is an indication of probable intermittent switch operation.

7.15 ***Tone Generator IC Test:*** This test is required to determine if there is a failure in IC U1. Proceed with the test as follows:

(1) Connect the DVM across pins 1 and 6 of U1.

(2) The DVM should show a Vcc voltage of 3.8 ±.3v dc.

(3) Connect the oscilloscope across pins 16 and 6 of U1.

(4) Set the **MODE** switch to the **TONE** position.

(5) Press any keypad key. The scope should show a dual waveform of 3.6 ±.5v ac peak and a dc level of 1.5v ±0.2v dc.

7.16 ***Pulse Generator IC Test:*** This test is required to determine if IC U2 is bad. Proceed as follows:

(1) Connect the DVM across pins 1 and 6 of U2.

(2) The DVM should show a Vcc voltage of 3.8 ±.3v dc.

(3) Connect the oscilloscope across pins 16 and 6 of U2.

(4) Set the **MODE** switch to the **PULSE** position.

(5) Press any keypad key. The scope should show a .5v dc pulse.

7.17 ***Tone Crystal Test:*** This test is required to determine if tone crystal Y1 is defective. Proceed with the test as follows:

(1) Connect the oscilloscope across the terminals of Y1.

(2) Set the **MODE** switch to the **TONE** position.

(3) Press any keypad key and observe a 3.57 MHz waveform on the scope.

7.18 ***Pulse Resonator Test:*** This test is required to determine if pulse resonator Y2 is bad. Proceed as follows:

(1) Connect the scope across pins 7 and 6 of IC U2.

(2) Set the **MODE** switch to the **PULSE** position.

(3) Press any keypad key and observe a 455 MHz waveform on the oscilloscope.

8. PARTS INDEX

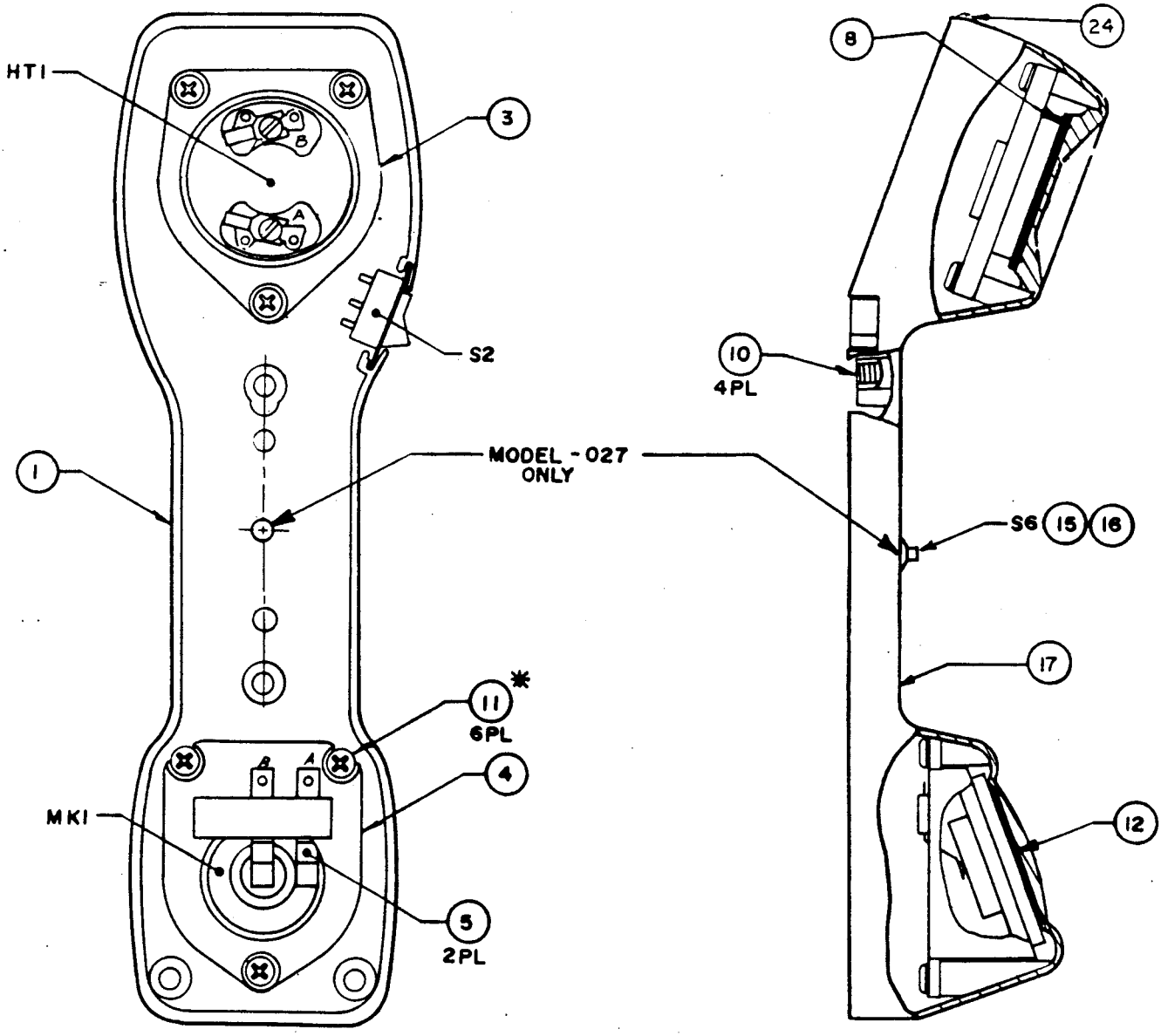
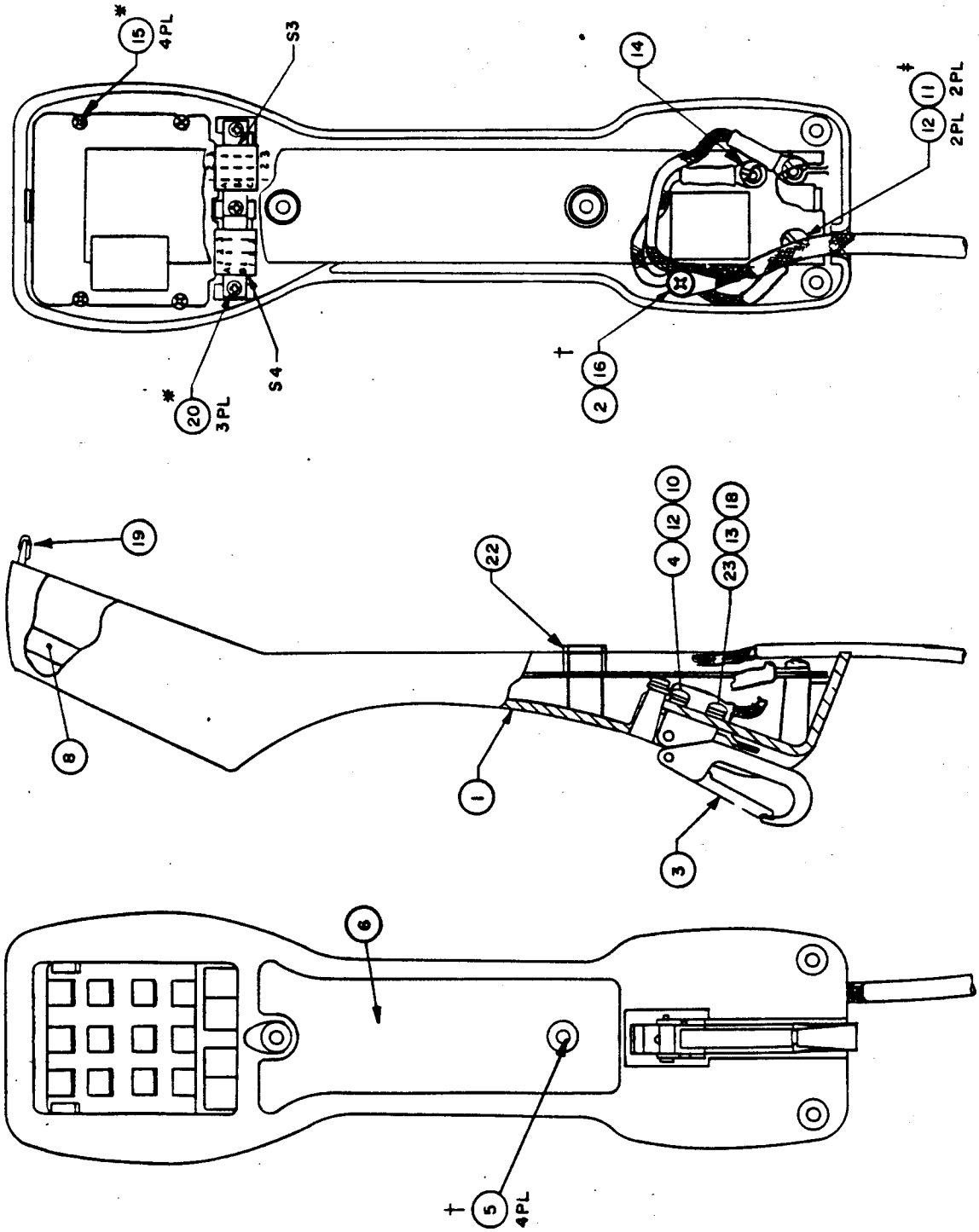


Fig. 15—Front Housing and Components

TABLE D

PARTS LIST—FRONT HOUSING ASSEMBLY

FIGURE REFERENCE	DESCRIPTION	DRACON STOCK NO.
①	Front Case Assembly (Models -010, -011, and -012 only)	028-721862-001
①	Front Case Assembly (Models -020 -021, -023, -024, and -025 only)	024-721862-001
①	Front Case Assembly (Model -027 only)	024-721862-003
③	Retainer, Receiver	035-721837-001
④	Retainer, Transmitter	035-721836-001
⑤	Terminal, Spring	020-721841-001
HT1	Receiver, Telephone	091-020085-053
MK1	Transmitter, Telephone	091-020085-052
⑧	Washer, Receiver	036-721835-001
S2	Switch, DPDT	034-020062-995
⑪	Screw, Type 25, Pan Head, Cr Rec, Cad Zinc Plated, #6-20 x 1/2	025-020256-208
⑫	Washer, Transmitter	036-721861-001
S6	Switch Assy (Model -027 only)	034-020062-260
⑮	Decorative Press Nut (Model -027 only)	025-020234-001
⑯	Pad, Insulator (Model -027 only)	036-020056-232
⑰	Label M73-1 (Model -010 only)	023-720000-562
⑰	Label M74-1 (Model -011 only)	023-720000-563
⑰	Label M86-1 (Model -012 only)	023-720000-575
⑰	Label M75-1 (Model -020 only)	023-720000-564
⑰	Label M76-1 (Model -021 only)	023-720000-565
⑰	Label M78-1 (Model -023 only)	023-720000-567
⑰	Label M79-1 (Model -024 only)	023-720000-568
⑰	Label M80-1 (Model -025 only)	023-720000-569
⑰	Label M82-1 (Model -027 only)	023-720000-571
㉔	Screw, Oval Head, Slotted 6-32 x 3/8"	025-020004-206



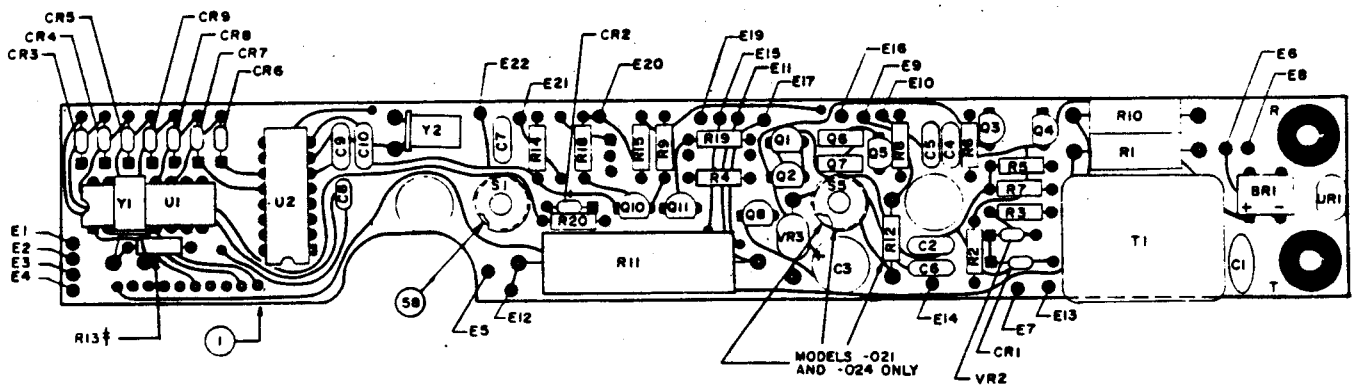
NOTES:
‡ TIGHTENED SCREWS TO 6 IN-LBS. MAX.
† TIGHTENED SCREWS TO 10 IN-LBS. MAX.
* TIGHTENED SCREWS TO 3 IN-LBS. MAX.

Fig. 16—Rear Housing and Components

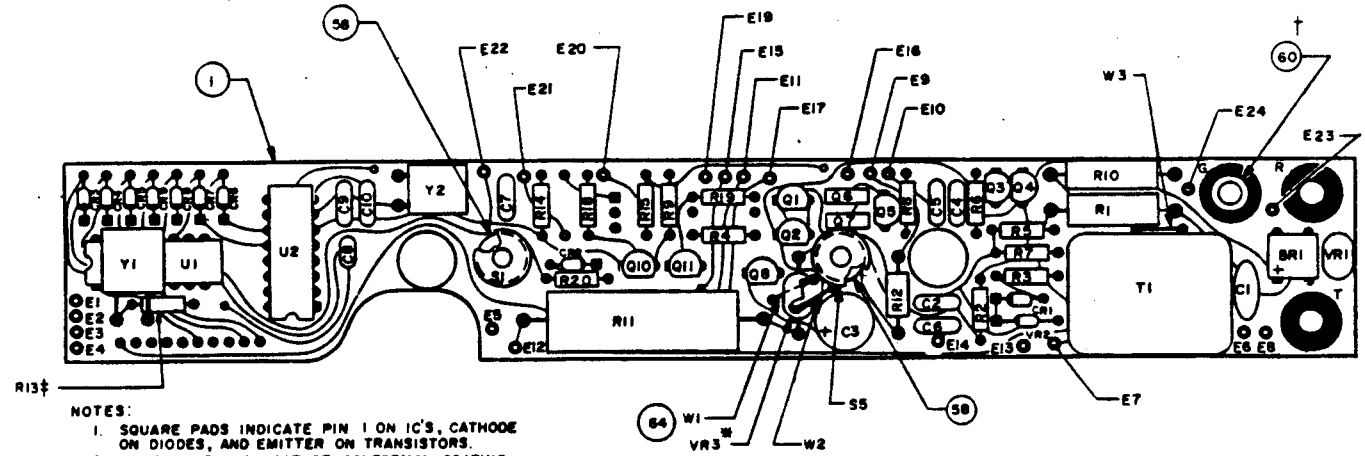
TABLE E

PARTS LIST—REAR HOUSING ASSEMBLY

FIGURE REFERENCE	DESCRIPTION	DRACON STOCK NO.
(1)	Rear Case Assembly (Models -010, -011, and -012 only)	024-721863-001
(1)	Rear Case Assembly (Models -020, -021, -023, -024, -025, and -027 only)	024-721863-002
(2)	Washer, Flat #6	025-020016-020
(3)	Clip, Belt	024-721887-001
(4)	Washer, #4	025-020284-042
(5)	Screw, Type G, Combo Pan Head, #6-32 x 1"	025-020235-216
(6)	Friction Pad	027-721802-001
(8)	Keypad Assembly	024-721875-001
S4	Switch, DPDT, BBM, ON-ON Mode 523-8500 12-001	~~034-020062-999~~
S3	Switch, 3PDT, ON-ON Keypad 523-8500 09-001	~~034-020062-998~~
(10)	Screw, Pan Head, Cr Rec, #4-40 x 5/16"	025-020186-205
(11)	Screw, Pan Head, Combo, #4-40 x 3/8"	025-020235-106
(12)	Washer, Internal Tooth, #4	025-020138-002
(13)	Washer, Internal Tooth, #8	025-020138-004
(14)	Screw, Pan Head, #4-40 x 1/4" (Model -027 only)	025-020001-104
(15)	Screw, Type 25 Pan Head, Cr Rec, Cad Zinc Plated, #2 x 3/8"	025-020256-006
(16)	Screw, Type 25, Pan Head, Cr Rec, Cad Zinc Plated, #6-20 x 1/2"	025-020256-208
(18)	Screw, Pan Head, Cr Rec, #8-32 x 5/16"	025-020186-405
(19)	Fastener, Self-Retaining	025-020316-001
(20)	Screw, Type 25, Pan Head, Cr Rec, Cad Zinc Plated, #2 x 1/4"	025-020256-004
(22)	Tubing, Neoprene	025-020305-524
(23)	Washer, #8	025-020284-166
	Cord Assembly, Standard (STD) (Models -010, -020, and -021 only)	087-721806-001
	Cord Assembly, Ground Start (3W) (Model -027 only)	087-721806-004
	Cord Assembly, Plug Cord (SP) (Models -011, -023 and -024 only)	087-721806-002
	Cord Assembly, Plug and Resistor Cord (SPR) (Model -025 only)	087-721806-008
	Cord Assembly, Standard with Bed-of-Nails (SBN) (Model -012 only)	087-721806-013



ALL MODELS EXCEPT -027



NOTES:
1. SQUARE PADS INDICATE PIN 1 ON IC'S, CATHODE ON DIODES, AND EMITTER ON TRANSISTORS.
2. BOARD HAS ONE COAT OF CONFORMAL COATING.
* VR3 IS POSITIONED ABOVE W1 AND W2.
† NUT INSTALLED ON FAR SIDE..
‡ R13 IS OMITTED ON CURRENT MODELS.

MODEL - 027

Fig. 17—Printed Circuit Board Layouts

TABLE F

PARTS LIST—PRINTED CIRCUIT BOARD

FIGURE REFERENCE	DESCRIPTION	DRACON STOCK NO.
①	Board, Printed Circuit, (All Models except -027)	010-721848-001
①	Board, Printed Circuit (Model -027 only)	010-721849-002
U1	IC, Tone-Dial Generator, S2559F	586-830000-001
U2	IC, Dial-Pulse Generator, 50982N	076-020212-998
T1	Transformer	080-721801-001
Y1	Crystal, 3.579545 MHz	086-020032-999
Y2	Resonator, Ceramic, 480 kHz	086-020116-026
BR1	Rectifier, Bridge, VM48	074-020135-053
Q1, Q2, Q4, Q10	Transistor, MPS-A42	084-020260-043
Q3, Q11	Transistor, 2N5550	084-020260-055
Q3, Q11	Transistor, 2N5551 (Alternate Part)	584-000001-002
Q5	Transistor, MPS-A92	084-020255-032
Q6, Q7	Transistor, SJE-2035	084-020260-089
Q8	Transistor, VN0108N3 VFS 013	084-020115-998
CR1-CR9	Diode, Signal, IN4148	074-020017-120
VR1	Varistor, MOV, S07K140	074-020140-007
VR2	Diode, Zener, IN4689 4.9v -5.1v	074-020141-997
VR3	Varistor, SG1045/1	067-020134-009
S1	Switch, Pushbutton, Momentary	034-020062-259
S5	Switch, Pushbutton, Momentary, (-021, -024 and -027 only)	034-020062-224
C1	Capacitor, Ceramic, .002uf, ±20%, 1KV	059-020018-118
C2	Capacitor, Ceramic, 1uf, ±20%, 50V	059-020018-090
C3	Capacitor, Tantalum, 33uf, ±10%, 10V	059-020128-126

TABLE F (Cont)

PARTS LIST—PRINTED CIRCUIT BOARD

FIGURE REFERENCE	DESCRIPTION	DRACON STOCK NO.
C4	Capacitor, Ceramic, .01uf, ±5%, 100V	059-020018-181
C5	Capacitor, Ceramic, .033uf, ±20%, 50V	059-020018-140
C6	Capacitor, Ceramic, 1.5uf, ±20%, 50V	059-020018-180
C7	Capacitor, Ceramic, .1uf, ±20%, 50V	059-020018-097
C8	Capacitor, Ceramic, .01uf, ±20%, 50V	059-020018-095
C9, C10	Capacitor, Ceramic, 100pf, ±20%, 50V	059-020018-150
R1	Resistor, Wirewound, 1.5K ohms, 5%, 2 Watts	062-021504-044
R2, R18, R19, R20	Resistor, Carbon Comp., 470K ohms, 5%, 1/4-Watt	060-004706-041
R3, R14	Resistor, Carbon Comp., 10K ohms, 5%, 1/4-Watt	060-001005-041
R4	Resistor, Carbon Comp., 100 ohms, 5%, 1/4-Watt	060-001003-041
R5	Resistor, Carbon Comp., 7.5K ohms, 5%, 1/4-Watt	060-007504-041
R6	Resistor, Carbon Comp., 2K ohms, 5%, 1/4-Watt	060-002004-041
R7	Resistor, Carbon Comp., 150 ohms, 5%, 1/4-Watt	060-001503-041
R8	Resistor, Carbon Comp., 47K ohms, 5%, 1/4-Watt	060-004705-041
R9	Resistor, Carbon Comp., 27K ohms, 5%, 1/4-Watt	060-002705-041
R10	Resistor, Wirewound, 300 ohms, 5%, 3 Watts	062-023003-045
R11	Resistor, Wirewound, 150 ohms, 5%, 9 Watts	062-021503-047
R12	Resistor, Carbon Comp., 10 ohms, 5%, 1/2-Watt (Models -021, -024 and -027 only)	060-001002-042
R15	Resistor, Carbon Comp., 220K ohms, 5%, 1/4-Watt	060-002206-041
(58)	Pad, Transistor	036-020056-232
	Conformal Coating	095-020093-997
(60)	Nut, Self-Clinching, 4-40 (Model -027 only)	025-020191-002
W1	Wire, 22 AWG, Solid, 1/2" (Model -027 only)	003-020156-001
(64)	Sleeving, Teflon, 22-Ga., Clear (Model -027 only)	003-020164-005