TM 11-6625-369-12

TECHNICAL MANUAL

OPERATOR AND ORGANIZATIONAL MAINTENANCE MANUAL FOR INDICATOR, STANDING WAVE RATIO AN/USM-37A (NSN 6625-00-814-8357)

HEADQUARTERS, DEPARTMENT 0F THE ARMY

SEPTEMBER 1977

WARNING

HIGH VOLTAGE

is used in the operation of this equipment

DEATH ON CONTACT

may result if personnel fail to observe safety precautions.

Learn the areas containing high voltage in each piece of equipment. Be careful not to contact high-voltage connections when installing or operating this equipment.

Before working inside the equipment, turn power off and ground points of high potential before touching them.

WARNING

The fumes of trichloroethane are toxic. Provide thorough ventilation whenever used. DO NOT use near an open flame. Trichloroethane is not flammable, but exposure of the fumes to an open flame or hot metal surface converts them to highly toxic phosgene gas. Inhalation of this gas could result in serious injury or death.

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HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, 9 September 1977

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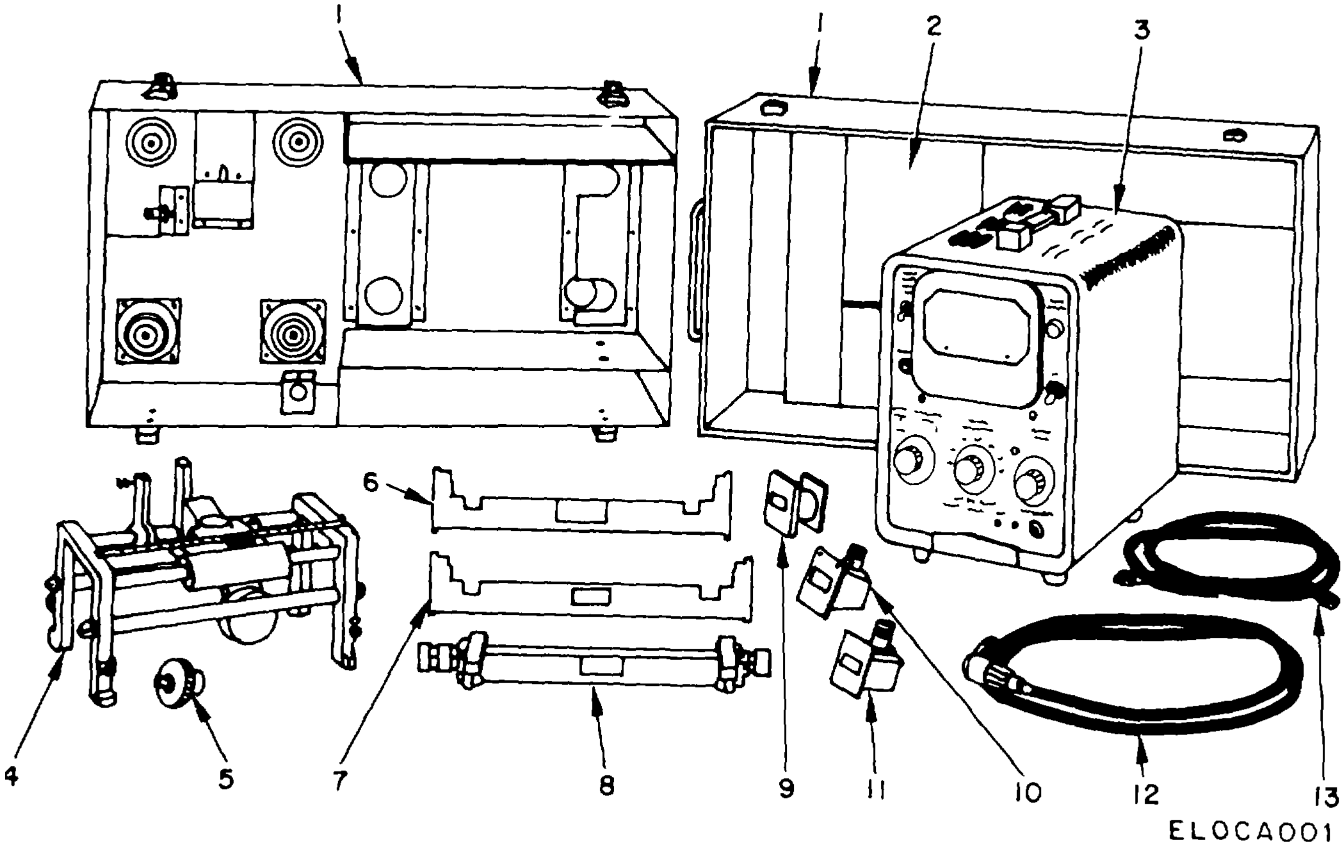
REPORTING OF ERRORS

You can improve this manual by recommending improvements using DA Form 2028-2 (Test) located in the back of the manual. Simply tear out the self-addressed form, fill it out as shown on the If there are no blank DA Forms 2028-2 (Test) in the back of your manual, use the standard DA sample, fold it where shown, and drop it in the mail.
Form 2028 (Recommended Changes to Publications and Blank Forms) and forward to the Commander, US Army Electronics Command, ATTN: DRSEL-MA-Q, Fort Monmouth, New Jersey
In either case a reply will be furnished direct to you.

LIST OF ILLUSTRATIONS



1.Case, Indicator CY-2964/USM-37A
2 Technical Manual
3 Indicator, Standing Wave Ratio IM- 157/USM-37
4 Carriage, Probe MS-1545/USM-37
5 Probe, waveguide MX-1546/USM-37
6 waveguide Assembly CG-1106/USM-37
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12 Cord CG-92D/U
13 Cord CG-409/U

Figure 1-1. Indicator, Standing Wave Ratio AN/USM-37A with Equipment Supplied

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Scope

This manual describes the operation of Indicator, Standing Wave Ratio AN/USM-37A as well as the operator and organizational maintenance required. A Maintenance Allocation Chart will be found in Ap- pendix C.

1-2. Indexes of Publications

a *DA Pam 310-4* Refer to the latest issue of DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

b. DA Pam 310-7 Refer to DA Pam 310-7 to determine whether there are modification work orders (MWO's) pertaining to the equipment

1-3. Forms and Records

a. *Reports of Maintenance and Unsatisfactory Equipment* Maintenance forms, records, and reports which are to be used by maintenance personnel at all maintenance levels are listed in and prescribed by TM 38-750

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Packaging Improvement Report) as prescribed in AR 700-58/NAVSUPINST 4030 29/AFR 71-13/MCO P4030 29A, and DSAR 4145.8.

c. Discrepancy In *Shipment Report (DISREP (SF 361)* Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38/NAPSUPINST 4610 33AIAFR 75-181MCO P4610.19B and DSAR 4500 15

1-4. Destruction of Army Materiel

Destruction of Army materiel to prevent enemy use shall be as prescribed m TM 750-244-2.

1-5. Administrative Storage

For procedures, forms and records, and inspections required during administrative storage of this equipment refer to TM 740-90-1

1-6. Reporting Equipment Improvement Recommendations (EIR)

EIR's will be prepared using EA Form 2407, Maintenance Request. Instructions for preparing EIR's are provided in TM 38-750, The Army Maintenance Management System EIR's should be mailed direct to Commander, US Army Electronics Command, ATTN DRSEL-MA-Q, Fort Monmouth, NJ 07703 A reply will be furnished directly to you

Section II. Description and Data

1-7. Purpose and Use

a. Indicator, Standing Wave Ratio AN/USM-37A is a laborate quality test set for use m making accurate standing-wave measurements m waveguide and coaxial systems over the frequency range from 3 0 to 12 4 GHz.

b Standing-wave measurements are the customary means of investigating the impedance and/or impedance match of transmission systems, various types of terminations such as antennas and loads, and other devices such as attenuators, connectors, transitions, etc.

1-8. Description Indicator, Standing Wave Ratio AN/USM-37A (fig 1-1) consists of a standing wave ratio indicator, two precision slotted wavegiude sections, a slotted coaxial section, a voltage sampling probe, a probe holder, adapters and cables The equipment is housed in a metal transit case, CY-2964/USM-37A

a Standing Wave Ratio Indicator IM- 157/ USM-57, the major component of the ANIUSM- 37A, is a high-gain, selective amplifier which has an indicating meter as its output. The meter is calibrated both in voltage-standing-wave ratio and m decibels.

b. The two slotted waveguide sections are designated as Waveguide Assemblies CG-1106/USM-37 and CG- 1107/USM-37 The former is designed for use over the frequency range from 7.05 to 10.0 gigahertz and mates with UG-51/U (RG-51/U size waveguide). The CG-1107/USM-37 is designed for use from 8 2 to 12.4 gigahertz and mates with UG-39/U (RG-52 size waveguide)

c The IM-100/USM-37 slotted coaxial section is designed for use over the frequency range from 3 to 12 GHz Impedance is 50 ohms to match flexible coaxial cables Included with the section are two shorting cor nectors, one male and one female for phase measure ments

d. The three sections described above are designee so that each can be used with Probe Holder MX-1545/USM-37. This carriage can also accommo date Voltage-Sampling Probe MX- 1546/USM-37.

e. Waveguide Probe MX-1546/USM-37 is ar ranged so that the penetration of the probe antenna m to the waveguide slot is adjustable In addition, four different lengths of probe antennas are supplied to facilitate certain types of standing-wave measure ments

f. Miscellaneous components include three adapt ers, UG-1389/U, UG-1053/U, and UG-1054/U to facilitate connections to signal sources Two coaxial cables are also supplied Cord CG-92D/U connects the coaxial output of a signal source to the waveguide to coax adapters Cord CG-409/U connects the output of the voltage-sampling probe to the voltage indicator.

1-9. Tabulated Data for the IM-157/ USM-37

Frequency 1,000Hz +/- 2%

Bandwidth	30 Hz (nominal)
Sensitivity	0 1 uV at a 200 ohm level for f full scale deflection
Noise level	Less than 0 03 uV ref. to input o operated from a 200 ohm resistor at room temperature
Amplifier Q	25 + 5
Calibration	Square law, meter indicates swr, dB
Range	70 dB, input attenuator provides 60 dbm 10 dB steps, accuracy + 0 1 dB per 10 dB steps, maximum cumulative error + 02 dB
Input	
BOLO (200Q)	Bias provided for 8 7 mA bolometer,1/100 amp fuse, or 4 3 mA low current bolometer
XTAL (200Q)	200 ohms for crystal rectifier
XTAL (200Q)	High impedance for crystal rectifier as null detector
Power	115/230 volts + 10%, 60 Hz, 55 watts

1-10. Items Comprising an Operable Equipment

Items comprising an operable AN/USM-37A are listed in table 1-1
.

Table 1-1. Items Comprising an Operable Equipment

NSN	Item	Qty	Dimensions(In) Height	Depth	Width (lbs.)	Weight
6625-00-814-8357	Indicator, Standing Wave Ratio ANIUSM-37A consisting of					
	NOTE The part number is followed by the 5-digit Federal Sup-ply Code for Manufacturer (FSCM) which is used to iden-tify the manufacturer, distributor, or Government agency, etc. , and is identified In SB 708-42					
6625-00-682-4493	Indicator, Standing Wave Ratio IM-157/USM 37 415B,98734	1	9	12	9	14
6625-00-820-4300	Probe WaveguideMX-1546/USM-37 44A,98734	1	2	1 1/4		
6625-00-304-7213	Carriage, Probe MX,-1545/USM-37:809B;98734	1	7 1/2	11/4	8	6
6625-00-752-5724	Waveguide Assembly CG-11061IJSM-37 H810B. 98734	1	1 7/8	2 1/2	10 1/4	
6625-00-752-5723	WaveguldeAssemblyCG-11071USM-37 X810B.98734	1	1718	21/2	101/4	
6625-00-284-7494	Slotted LmineIM-100/USM-37 806B,98734	1	1 /16	21/2	9314	2
5985-00-752-5826	AdapterUG-13981u HX292B,98734	1	17/8	17/8	33/8	1
6625-00-834-4880	Adapter, Coaxial to Waveguide UG-1053/U X281A,98734	1	23/8	17/8	13/4	1
5985-00-870-4299	Adapter, Coaxial to Waveguide UG-1054fU H281A, 98734	1	2 1/8	15/8	19/16	1
5995-00-561-9211	CordCG-92DfU 11500A,98734	1		72(lg.)		
5995-00-504-7185	Cord CG-4091U	1		120(lg.)		
6625-00-834-4884	Case, Indicator CY-2964/USM-37A	1	12	22	12	

CHAPTER 2

SERVICE UPON RECEIPT AND INSTALLATION

Section I. SERVICE UPON RECEIPT OF MATERIAL

2-1. Site and Shelter Requirements

The only requirement for the siting of the ANI USM-37A is that it be installed on a flat surface with liberal working space, convenient to a 115 volt electrical outlet, a signal source, and the device whose SWR is to be measured.

2-2. Unpacking

The AN/USM-37A is packed in a carton lined with corrugated spacers Refer to figure 2-1 when unpacking the equipment

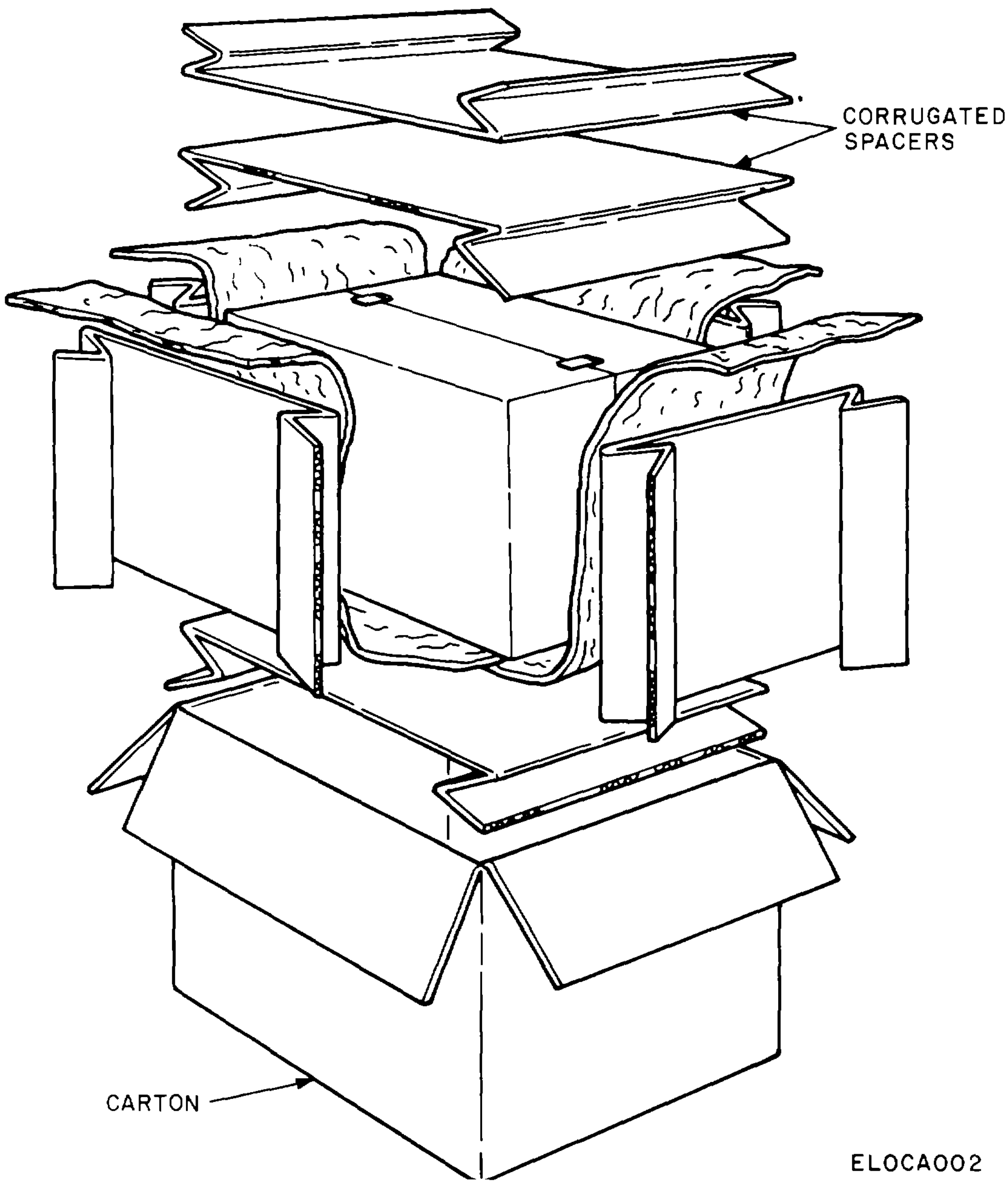

Figure 2-1. Packing Diagram for Indicator, Standing Wave Ratio AN/USM-37A

2-3. Checking Unpacked Equipment

a. Inspect the equipment for damage incurred during shipment. If the equipment has been damage report the damage on DD Form 6 (para 1-3).

b. Check the equipment against the component list (table 1-1) and the packing slip to see if the shipment is complete Report all discrepancies in accordance with the instructions contained in TM 38-750 equipment should be placed m service even though a minor_assembly or part that does not affect proper functioning is missing

c. Check to see whether the equipment has been modified. Equipment which has been modified have the MWO number on the front panel near the nomenclature place. Check to see whether all currently applicable MWO's have been applied (Current MWOs applicable to the equipment are listed in DA PAM 310-7)

2-4. Auxiliary Equipment

The following items are required to extend or increase the capability of the test set Specific application of' these items is covered in chapter 3.

(1) Signal Generator
(2) RF Attenuator.
(3) Filter.
(4) Telephone Jack
(5) 1500 ohm + 10%, 1/4 watt Resistor

Section II. INSTALLATION INSTRUCTIONS

2-5. General

All components of Indicator, Standing Wave Ratio ANI/USM-37A are housed within Indicator Case CY-2964JUSM-37A. When the cover of the case is raised, Standing Wave Ratio Indicator IM-157/ USM-37 (SWR indicator) is free to be removed from the case Below the IM-157/USM-37 is the coaxial connecting cable CG-409/U. The three slotted sections and Cord CG-92D/U are fastened to the cover of the case Probe Carnage MX-1545/ USM-37 (probe carnage) is fastened to the floor of the case by four shock mounts. All adapters are mounted on the bottom of the case

2-6. Assembly of Equipment

a. Remove the SWR indicator (fig 2-2) from the case and connect it to a 115-volt electrical outlet b

Assemble the probe carnage as follows' **CAUTION**

Probe Carriage MX-1545/USM-37 is a precision instrument It is designed for extremely accurate probe positioning and very smooth motion of traveling parts Handle gently. *Do not* bump or twist.

(1) Remove probe carnage from case by unscrewing the center of the shock-mounts from the probe carriage mounting feet *Do not* turn the probe carnage mounting feet

(2) Select the slotted sections and adapter that will be required for the equipment under test.

(3) Position the slotted section under the probe carriage with slot side up

CAUTION

During assembly, protect the probe carriage and slotted sections from damage. Scratches, dents, burns, etc. cause RF leakage, discontinuities, which could degrade performance

(4) Carefully raise the slotted section into the probe carriage recesses.

(5) Thread the thumb screws on the probe car- riage end frames into the slotted section mounting holes evenly and by hand. *Do not* overtighten the screws or permit the slotted section to bind in the probe carriage.

(6) Move the traveling carriage from end to end, it should move evenly and freely with no binding and parallel to the top surface of the probe carriage. If the movement of the carnage is not parallel, check the mounting of the slotted section to be sure it is not tilted.

(7) Adjust the four mounting feet so that each' foot provides equal support for the probe carriage. If additional sections of waveguide are to be fastened to the slotted section, they should have their own source of support or else they will apply strains that may impair the accuracy of measurements.

c. Install an appropriate sized tip extension on the waveguide probe. When used with the slotted sections included m the AN/USM-37A, the two shorter lengths (1/4 in and , min.) Will suffice for most measurements. The longer tips (3/, m. and '/,e m.) may be used when investigating the characteristics of a null or when additional pick-up is required.

d. Place the wave-guide probe in the probe carriage. Adjust the probe to the desired depth of penetration and lock it in place.

NOTE

Check that the probe tip has adequate clearance on both sides of the slot by looking down the inside of the slotted section and moving the traveling carnage and probe along the slot. If the probe carriage and slotted section have been assembled properly, centering will automatically be correct.

e. Attach Cord CG-409/U between the waveguide probe and the INPUT connector of the SWR indicator.

NOTE

The signal source to be used with the SWR Indicator must operate in the frequency range from 3 0 to 12 4 GHz and must have either a type N coaxial output terminal or a wave- guide output that matches one of the wave- guide sizes included in the AN/USM-37A To keep re-reflections to a minimum, the internal impedance of the source should be nominally 50 ohms When objectionable harmonics appear in the signal generator output, a low-pass filter may be connected between the signal generator and the pad to minimize or eliminate these harmonics The cut-off frequency of the filter should be just above the highest frequency used The signal source must be capable of 1,000 Hz square-wave modulation and should produce at least 0 1 milliwatts of power

f Attach Cord CG-92D/U between the signal source and the coaxial slotted section or the wave- guide-to-coaxial adapter mounted on the waveguide slotted section

g Attach the load to be tested to the right-hand side of the probe carriage

h Refer to figure 2-3 for a typical test setup using components of the ANIUSM-37A

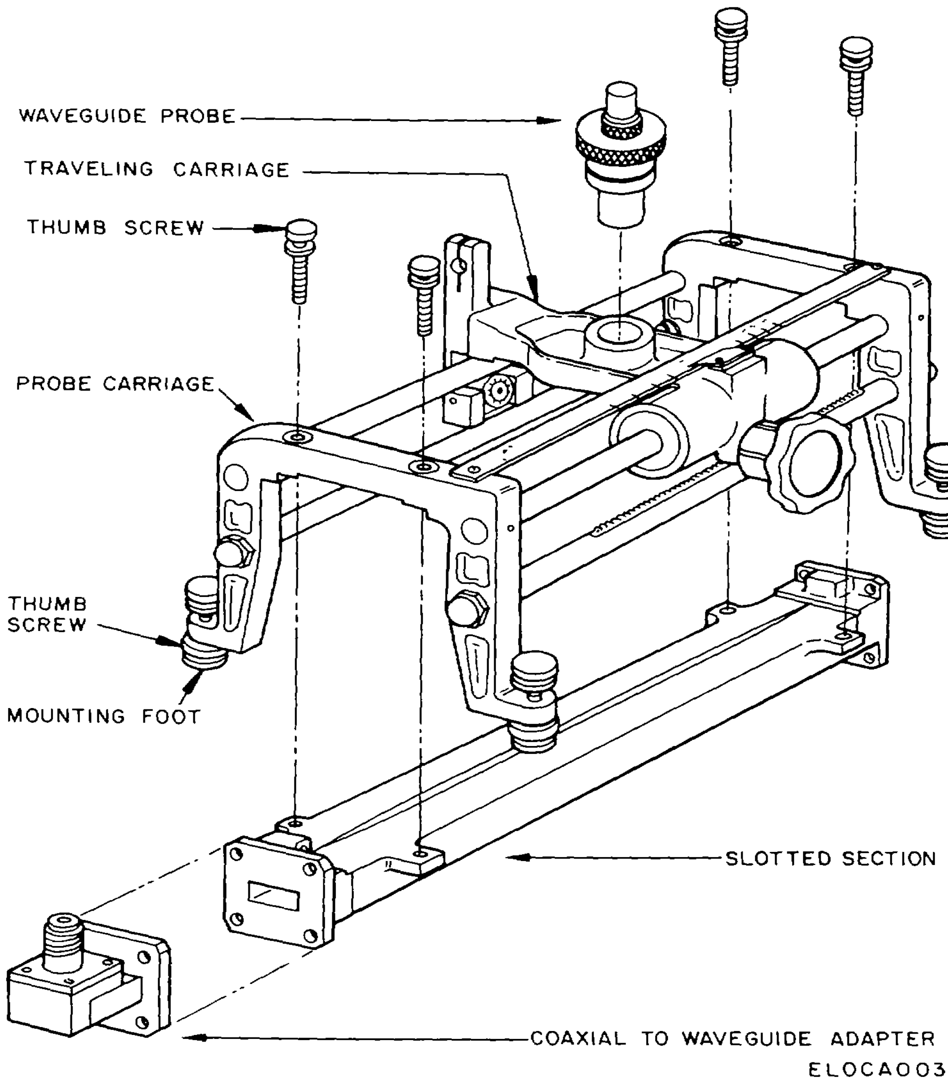

Figure 2-2. Probe Carriage MX-1545/USM-37 and Slotted Section, Assembly Diagram

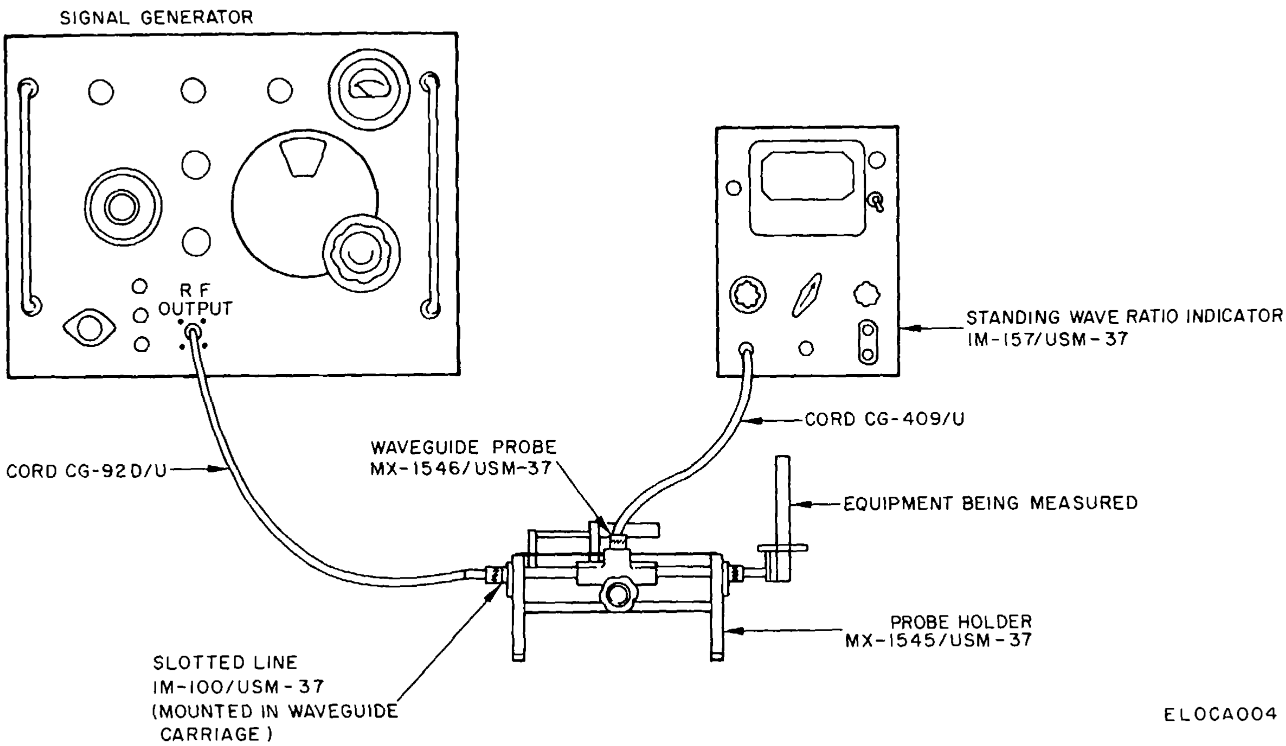

Figure 2-3. Typical Test Setup for Making SWR Measurements

CHAPTER 3

OPERATING INSTRUCTIONS

Section I. CONTROLS AND PRELIMINARY PROCEDURES

3-1. Controls and Indicators

a. To avoid damage to the SWR Indicator and associated equipment, the operator should be thoroughly familiar with the location and function of the controls and indicators

b. Refer to figure 3-1 for the location of the controls and indicators of Standing Wave Ratio Indicator IM-157/USM-37.

c 3-1 describes the function of each control and indicator of the IM-157fUSM-37.

Table 3-1. Operator's Controls

Control, indicator or connector	Function
Ac power switch LINE POWER indicator	ON (up) applies power Off (down) removes power Visual indication of power application
INPUT SELECTOR (3 position rotary switch)	Selects appropriate input for the type of detector to be used Swr Pos — Detector Used BOLO 200Ω — Bias provided for 8 7 mA bolometer, 1/100 amp fuse, or 4 3 mA low current bolometer XTAL 200Ω — Crystal rectifier XTAL 200 KΩ — Crystal rectifier used as null detector
INPUT connector	BNC type coaxial connector to receive input signal
RANGE (SWR or DB) (7-position rotary switch)	Selects meter sensitivity for the signal level being indicated
GAIN and VERNIER controls	Adjust meter reading to full scale or other convenient reading
SWR meter	Indicates SWR directly on the following scales SWR 1-4, SWR 3-10, EXPANDED SWR 1-1 3, DB 0-10, EXPANDED DB 0-2
METER SCALE	Adjusts meter for measurements on expanded scales or normal scales, or shafts meter down-scale by 5 dB
MONITOR connector	Connects an external milliammeter to monitor the bias applied to an external barretter
RECORDER connector	Provides signal current corresponding to meter indication for connection of high-impedance instrument such as oscilloscope (Requires external 1500 ohm load for use)
BOLO BIAS CURRENT	(2-position toggle switch) Selects bolometer bias current of either 4 3 (LOW) or 8 7 (HIGH) mlliamperes

3-2. Precautions When Using Crystal Detectors

a Whenever a crystal detector with a matched load resistor is used, the INPUT SELECTOR switch must be set at the XTAL-200KQ position to obtain accurate square-law response With an unloaded crystal, select the input impedance which gives maximum sensitivity. Usually the XTAL-200Q position will give the best sensitivity. However, some crystal diodes may give higher output m the XTAL-200KQ position. Maximum sensitivity is desirable so probe penetration in the slotted line can be kept to a minimum

b There are precautions to be observed concerning all crystal detector elements Crystal diodes exhibit a departure from the ideal square-law response which the SWR Indicator is calibrated This departure tends to occur when the rf power level exceeds a few microwatts which corresponds to a reading of approximately full scale on the 30-db range of the IM-157[USM-37 with the gain controls set to maximum

Section II. OPERATION

3-3. Operating Procedures

With the equipment properly assembled as described in para 2-6, refer to a below when making low SWR **(10** or below) measurements or to b below when making high SWR (above 10) measurements.

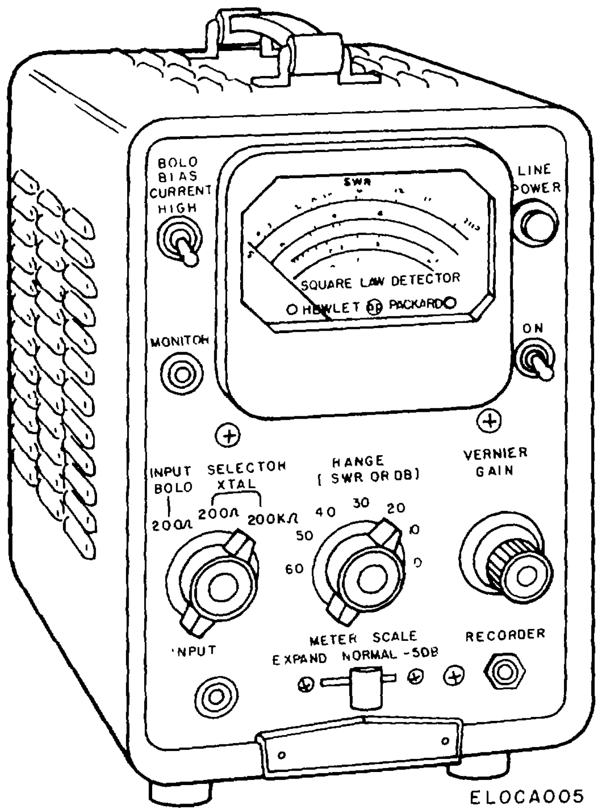

Figure 3-1. Front Panel of Standing Wave Ratio Indicator IM-157/USM-37

NOTE

Both MONITOR and RECORDER jacks on the front panel of the IM-1571USM-37 receive the three-terminal 1/4 in diameter "tip-ring-sleeve" phone plug supplied with the instrument Do not use the standard single- circuit phone plug in these jacks. In both jacks the sleeve connection is grounded to the instrument chassis and is not used as part of the output circuit, the ring and tip provide the connections to the appropriate signal circuit and must not be grounded externally (Refer to fig. 3-9)

a. Low SWR Measurements (10 or below)

(1) Turn ac power switch ON For maximum stability, allow approximately 10 minutes for equipment warm up.

(2) Set INPUT SELECTOR switch to XTAL 200Q

(3) Connect the detector cable to INPUT jack.

(4) Set GAIN and VERNIER controls to approx.-mately 3/4 maximum.

(5) Set RANGE switch to 30 dB or 40 dB position Adjust probe penetration to obtain an on-scale meter indication.

(6) Peak the meter by adjusting modulation frequency of the signal source, If adjustable Reduce probe penetration to keep meter on scale

(7) Peak the meter by moving the probe carriage along the line Reduce probe penetration to keep meter on scale.

(8) Adjust GAIN and VERNIER controls and or output power from the signal source to obtain an exactly full-scale meter indication.

(9) Move the probe carnage along the hne to obtam a minimum meter indication

(10) If the meter indication on the top scale is greater than 3, set RANGE switch to the next (40 dB or 50 dB) position and read the indication on the second (3-10) SWR scale If the RANGE switch is changed by two positions, use the top SWR scale and multiply all indications on this scale by 10.

(11) If the SWR is 1 3 or less, it can be measured on the EXPANDED SWR scale by setting the METER SCALE switch to EXPAND and repeating steps (6), (7), and (8) In the EXPANDED position, set the RANGE switch to the next (40 or 50 dB) position and readjust GAIN control to obtain a full-scale indication at the voltage maximum.

(12) The standing wave ratio may also be expressed m decibels. If the SWR measures between 5 and 10 on the DB scale, set the METER SCALE switch to - 5 DB and set the RANGE switch to the next lower (CCW) position To obtain a true measurement, sub- tract 5 dB from the indication on the DB scale

(13) If the SWR is 2 2 dB or less it can be read on the EXPANDED DB scale by performing step (10).

(14) A graph of SWR in decibels vs. standing wave ratio is shown in figure 3-2.

(15) For accurate measurements, take several readings with different amounts of probe penetration to detect any probe loading error in the standing wave pattern

NOTE

At high SWRs, probe loading will cause erroneous meter indications By using the method described in b below, the effects of probe loading will be overcome.

b. High SWR Measurements (above 10).

(1) The straightforward measurements of SWR with conventional methods is generally applicable when measuring normal SWR's up to 10, but at higher SWR's special techniques are desirable

(2) When the SWR is high, probe coupling must be increased if a reading is to be obtained at the volt age minimum However, at the voltage maximum this high coupling may result m a deformation of the pattern, with consequent error in reading. In addition to this error caused by probe loading, there is also danger of error resulting from the change in detector characteristics at higher rf levels.

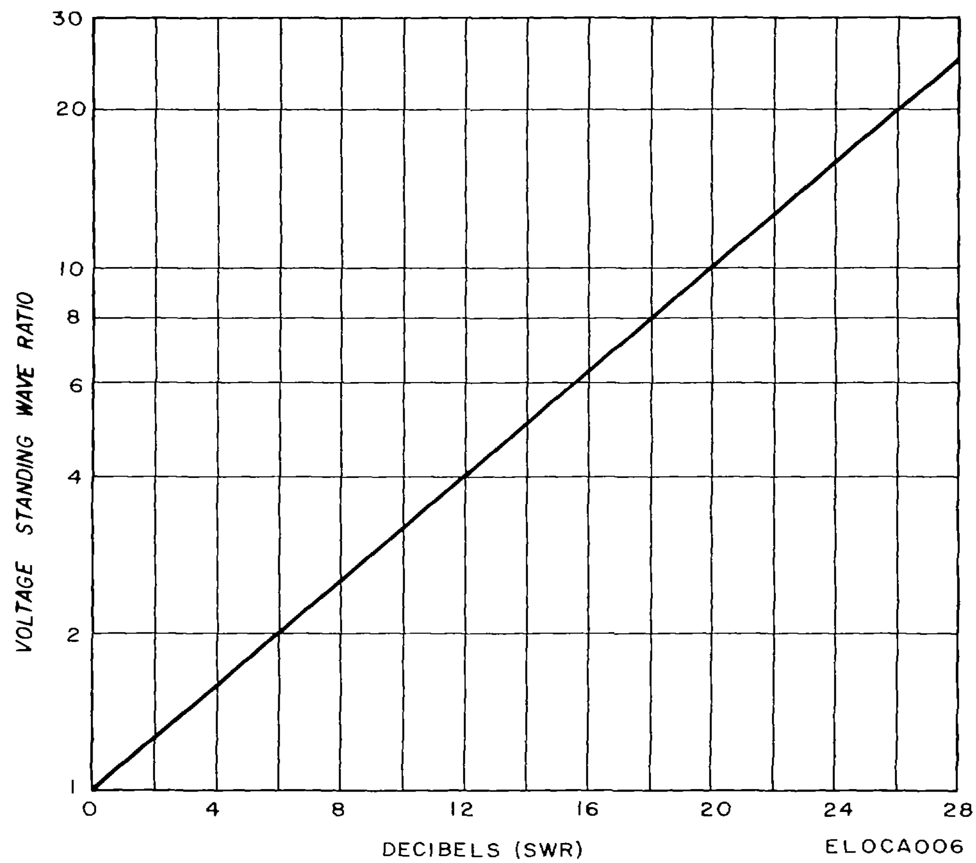

Figure 3-2. Standing wave ratio in decibels versus SWR

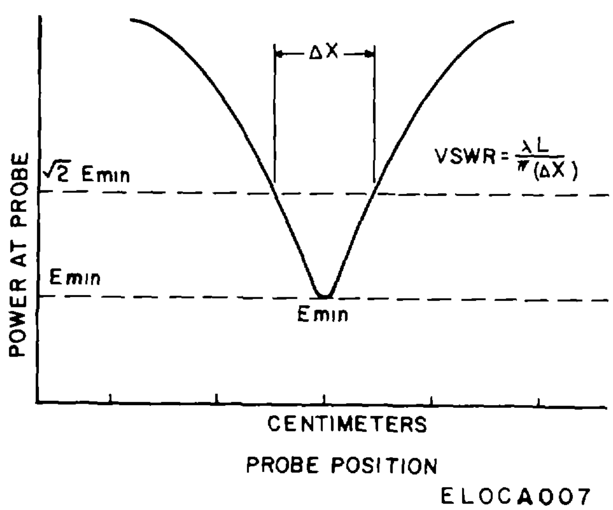

Figure 3-3. Graph showing double minimum method for computing SWR.

c. Double minimum method. In the double minimum method, it is necessary to establish the electrical distance between the points where the output is double the minimum (See figure 3-3)

(1) Repeat steps a(l) through a(7) above

(2) Move the probe carnage to obtain a minimum meter indication and note the carriage position.

(3) For reference adjust GAIN controls to obtain an indication of 3 0 dB

(4) Move the probe carriage to obtain a full scale ("0") indication on the DB scale on each side of the minimum obtained In step (2) above. Note these two carriage positions

(5) Record as dl and d2 the probe positions noted in step (4) above

(6) Short the line and measure the distance between successive minima Twice this distance is g, the guide wavelength.

(7) Compute SWR according to the following formula

$$SWR = \frac{\lambda g}{\pi (d_1 - d_2)} = \frac{\lambda g}{\pi (\Delta X)}$$

Where λg is the guide wavelength and d, and $_{d2}$ are the locations of the twice-minimum points

NOTE

This method overcomes the effect of probe loading since the probe Is always set around a voltage minimum where larger probe loading can be tolerated. However, it does not overcome the effect of detector characteristics

d Calibrated Attenuator Method. Another method for measuring high SWR's is to use a calibrated variable rf attenuator between the signal source and the slotted line. Adjust the rf attenuator to keep the recti- fied output of the crystal diode equal at the voltage minimum and voltage maximum points The SWR in dB is the difference m the attenuator settings

(1) Repeat a(1) through a(7) above

(2) Move the probe carnage along the line for a voltage minimum, adjust the rf attenuator to give a convenient indication on the meter, and note the rf attenuator setting

(3) Move the probe carriage along the line to a voltage maximum, adjust the rf attenuator to obtain the same indication on the meter as established in step (2) and note the rf attenuator setting

(4) The SWR may be read directly (in dB) as the difference between the first and second readings

NOTE

While this method overcomes the effect of detector variations from a square-law characteristic, the effect of probe loading still remains Always use minimum probe penetration-

3-4. Checking of Square-Law Response

a The square-law response of either a crystal diode or bolometer is easily checked with slotted line equipment.

b . A simple method of calibrating a detector is by increasing the power level in the slotted line in known steps and noting the detector response on the IM-157/USM-37

c. Another method for calibrating a detector is to use a load having unity reflection coefficient (usually a short circuit) This load will then set up an electric field between adjacent minima in the slotted line closely approximating half a sine wave, thus giving a relative voltage that is a known function of the probe carriage position

d . Any new crystal being used for the first time should be checked, as there is often a significant varation between crystals Data should be taken m both XTAL positions on the SWR Indicator so that the better setting may be determined for any individual crystal diode

3-5. Location of Voltage Maximum or Voltage Minimum

From the discussion on probe loading it has shown that it is more desirable to locate the voltage minimum than the voltage maximum since the effect of probe loading is less at the minimum. However, the location of a voltage minimum by a single measurement, par- ticularly on low SWR, is usually inaccurate because of Its broadness, thus making the true minimum position hard to determine. An accurate method of locating the voltage minimum is to obtain the position of the probe carriage at two equal output readings on either side of the minimum and then averaging these two readings

3-6. Precautions with Signal Sources

a Signal sources can introduce at least three undesirable characteristics that will affect slotted line measurements These include presence of rf harmonics, frequency modulation, and spurious signals Signal sources used for standing wave measurements should have relatively low harmonic content in their output

b The standing wave ratio at a harmonic fre- quency may be considerably higher than at the fundamental Spurious frequencies In the signal source are also undesirable, for, unless very slight, they will obscure the minimum points at high SWR values Figure 3-4 shows the plot of an SWR pattern made with this signal source producing unwanted FM

c Instances are common where the presence of rf harmonics has led to very serious errors in SWR meas-

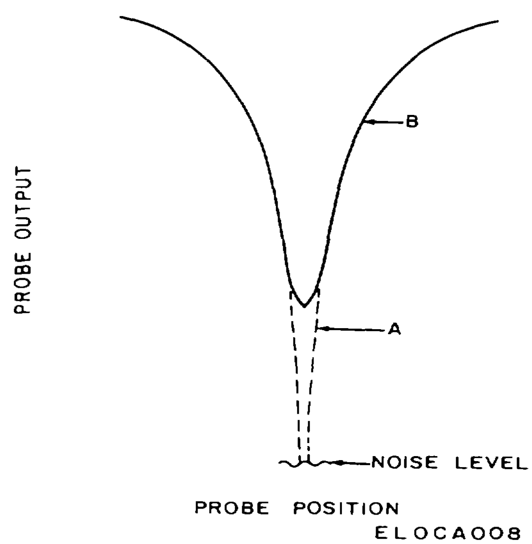

Figure 3-4. High Standing Wave Ratio Pattern.
(a) Free of Fm
(b)With Moderate FM

urements Such harmonics are usually present to an excessive degree only m signal sources that have coaxial outputs Coaxial pickups of a broad-band type will often pass harmonic frequencies with greater effi- ciency than the fundamental In waveguide systems, signal sources such as internal cavity Klystron have a more or less fixed coupling and in addition do not have pickups extending into the tuned cavity to cause per- turbations of the cavity fields Consequently, the har- monic problem is generally limlted to coaxial systems d

Harmonics become especially troublesome when the reflection coefficient of a load at a harmonic fre- quency is much larger than at the fundamental fre- quency-a common condition When the harmonic content of the signal source is high, the large reflection coefficient of the load at the harmonic frequency can cause the harmonic standing wave fields to be of the same order of magnitude as the fields at the funda- mental frequency

e Thus, a device having a SWR of 2.0 at the fundamental frequency will often have a SWR of 20 or more at the second harmonic frequency If such a device is driven from a signal source having, say 15% second harmonic content, the peaks of the standing waves of second harmonic will be about one-fourth the ampli- tude of the peaks at the fundamental frequency Figure 3-5 shows a typical SWR pattern obtained when the rf signal contains harmonics

3-7. Impedance Measurement Rules

a. The shift in the minimum when the load is short ed is never more than + one quarter wavelength b

. If shorting the load causes the minimum to move toward the load, the load has a capacitive component

c If shorting the load causes the minimum to shift toward the generator, the load has an inductive com- ponent.

d If shorting the load does not cause the minimum to move, the load is completely resistive and has a value Z_0/swr

e If shorting the load causes the minimum to shift exactly one-quarter wavelength, the load is completely resistive and has a value of Z_o x SWR

f When the load is shorted, the minimum will al- ways be a multiple of a half-wavelength from load. Shifts m voltage minima resulting from various types of loads are illustrated m figure 3-6

3-8. Impedance Measurement Procedure

a. Connect the load under test to the slotted section and measure the SWR and the position of the minimum in the standing wave pattern.

b Replace the load with a short at the load end of the slotted line.

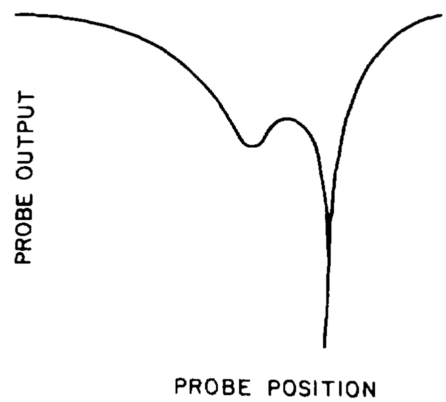

Figure 3-5. Typical Pattern of High SWR Spurious Frequencies in the Signal Source

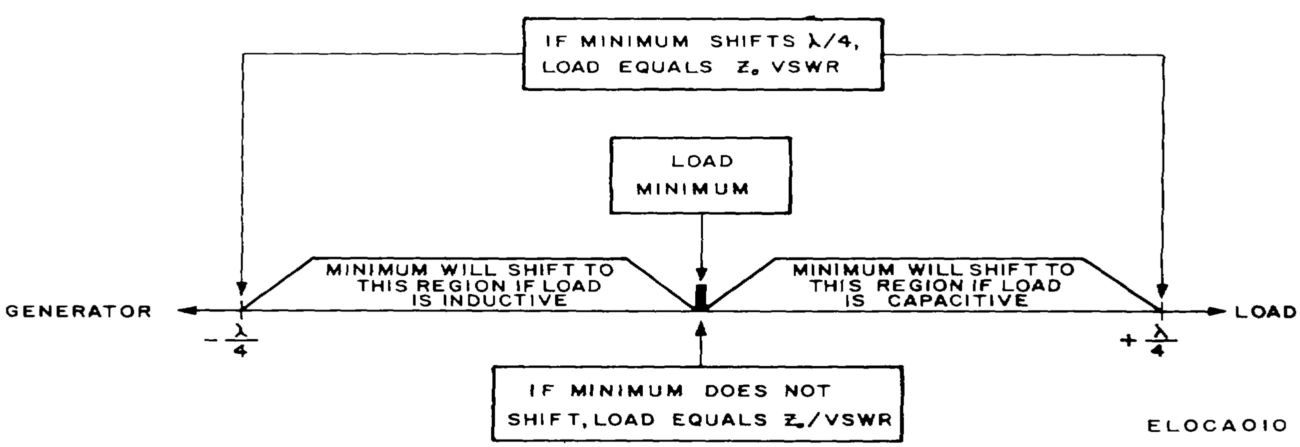

Figure 3-6. Summary of Rules for Impedance Measurement

c. Determine the new minimum position with the line shorted.

d. The normalized load impedance may be computed by the formulas below. Refer to figure 3-7

$$ZL = \frac{I - j\,(SWR)\,Tan\,X}{(SWR) - j\,Tan\,X}$$

$$\text{Where } X = \frac{180°(+/-\Delta)}{\lambda g/2}$$

And +/- Δ d = Shift in centimeters of the minimum point when the short Is applied
d takes a positive (+) sign when the mimmum shifts toward the load
d takes a negative (-) sign when the minimum shifts toward the generator

$\lambda_2 g$ = One-half hne or guide wavelength It is the distance in centimeters as measured between two adjacent minima

NOTE

These calculations are based upon the assumption that no losses occur in the transmission system For laboratory setups where the line lengths are short this assumption is customary It is also assumed that the Zo for the lines is entirely resistive

3-9. Impedance Measurement and the Smith Chart

a. When data is obtained from slotted line measurement, impedance may be determined by the use of the Smith Chart This chart represents an impedance coordinate system so arranged that the variable quanti- ties m impedance relationships are conveniently dis- played for the solution of transmission line problems

b. Figure 3-8 illustrates a Smith Chart with an example situation presented below to aid in the use of the chart

c The values of resistance and reactance are based on a normalized value obtained by dividing the actual value by the characteristic impedance, Zo of the line Thus if Z = 5 + 25j ohms and if Z_0 = 50 ohms then Zn = 0 1 + j 0.5 On the Smith Chart the circles which are tangent to the bottom of the chart are for a con- stant normalized resistance, lines curving to the right from the center are the normalized positive reactance, components, lines curving to the left from center are the normalized negative reactance components, the straight line forming the vertical diameter is a line of zero reactance, the lower half of the zero reactance line (marked 1 through 50) also represents the standing wave radio line.

3-10. Procedure for Smith Chart Calculations

a General. Use of the Smith Chart for calculating impedance is outlined below . Following the generalized procedure is a numerical example Other methods are possible for first entering the Smith Chart, but the method suggested here is practical and easy to use

b. Procedures

(1) Determine the guide wavelength λg, as explained m paragraph 3-c.

(2) Measure SWR using the method described m paragraph 3-3c or d.

(3) Locate a convenient minimum with the load still in place . Record the probe carriage reading

(4) Replace the load with a short; relocate the minimum and record the probe carriage reading. Determine Δd, the difference between this reading and the one from step (3) Note whether the mimmum was moved toward the load or toward the generator.

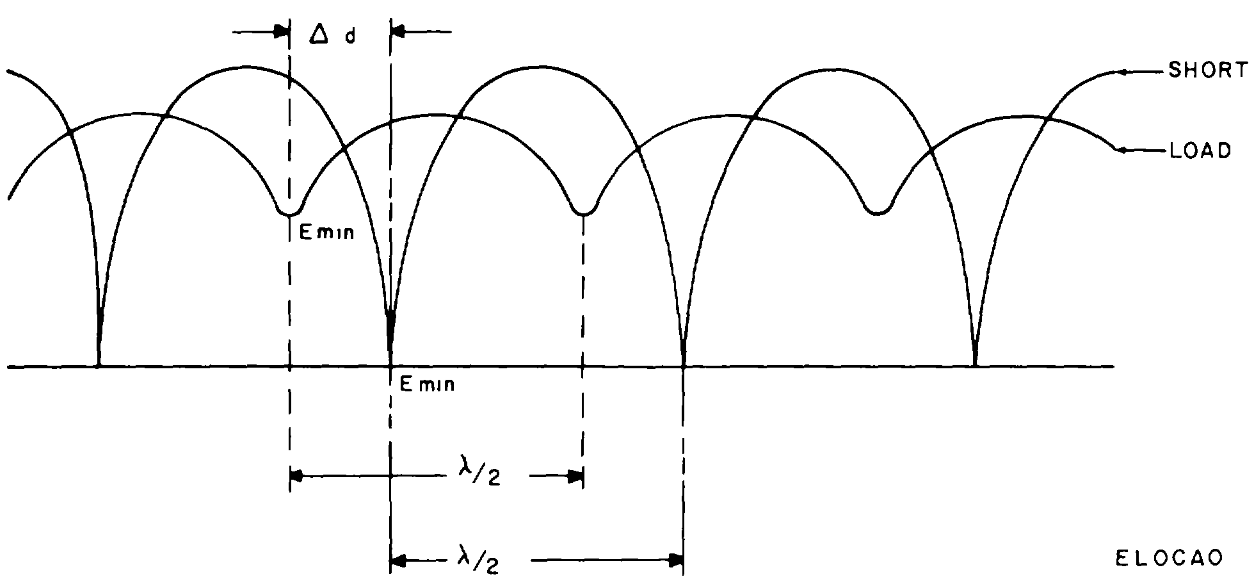

Figure 3-7. Graph showing standing wave patterns with a load and short.

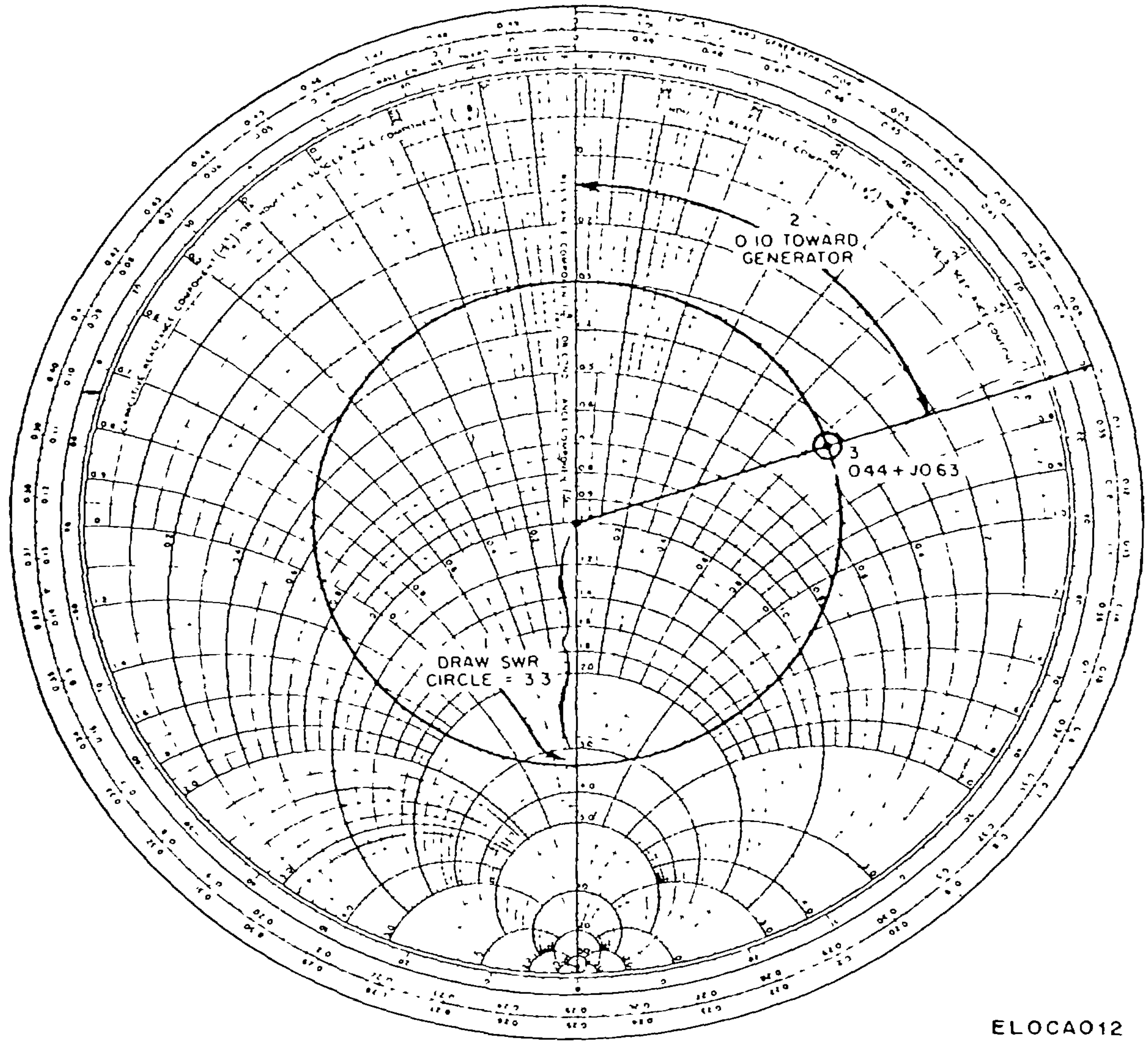

Figure 3-8. Smith Chart

(5) Calculate the shift of the minimum, in terms of wavelength Δλ=Δd
λg

(6) Start at the center of the Smith Chart and draw a circle with a radius equal to the SWR

(7) Enter the Smith Chart at the top, move in the direction of the probe noted m step (4) and a distance AA, computer in step (5) Use wavelength scale at the periphery of the Smith Chart

(8) Draw a line from the Δλ point to the center of the chart

(9) Locate the normalized impedance at the intersection of the SWR circle and the line drawn m step (8)

(10) The actual impedance is the product of the normalized impedance from step (8) and Zo, the line characteristic impedance

NOTE

The convention of entering the Chart in step (7) applies only if the minimum is located first, when the load is connected to and relocated when the line is shorted If it is necessary to first establish the shorted minimum point, the direction of Δλ would be opposite to the direction of probe movement required to relocate the minimum point with the load initially connected.

c Example The following example may be used to clarify the above procedures

(1) The assumed characteristic impedance is 50 ohms

(2) The distance between adjacent minima is 15 cm, therefore λg = 30 cm

(3) The SWR is measured as 3.3

(4) A minimum is located at 22 cm

(5) The line is shorted and the minimum shifts from 22 cm to 19 cm, toward the generator

Ad= 22cm - 19cm= cm AA = Ad = 3 cm = 01wavelength
Ag 30 cm

(6) Referring to figure 3-8, a circle for SWR = 3 3 is drawn

(7) A line is drawn from the 0. 1A point (toward the generator) to the center of the chart.

(8) The normalized impedance at the intersection of the circle and the line is 0 44 + j0.63. The impedance of the load (for Z_o = 50Q) is then 50Q (O 44 + j0.63) = 22 + j31 5 ohms.

3-11. Using the Test Set with an Oscilloscope

a. With the RECORDER jack at normal there is a 1500-ohm resistor (R37) across the tip and ring leads of the jack With a plug m the jack, R37 is open. For proper operation of the SWR Indicator, it is necessary to connect a 1500-ohm resistor across the tip and ring of the plug when connecting the SWR Indicator to a high-impedance instrument like an oscilloscope

b. Use a three-conductor plug, such as a Switchcraft No 60, and connect a 1500-ohm 1/4 watt resistor across the tip and ring terminals (see figure 3-9) Be sure the resistor is not connected across the tip and sleeve (ground), if the external 1500-ohm resistor is connected to ground, part of the meter feedback circuit will be shunted to ground

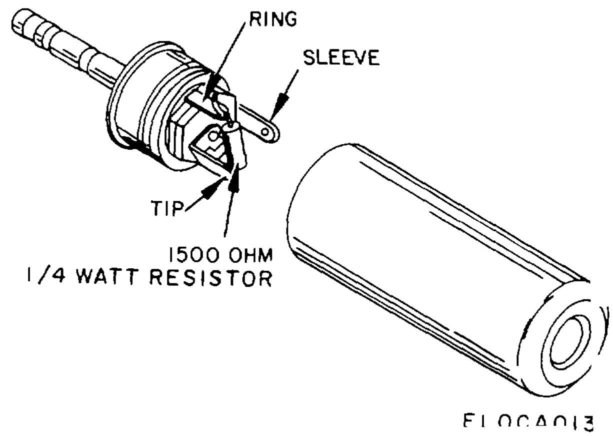

Figure 3-9. Three conductor plug connections

3-12. Stopping Procedure

a. To de energize the standing wave ratio indicator, place the ac power switch in the off (down) position.

b. Disconnect all input and output cables

c Disconnect the indicator from its power source

d. Disassemble the probe carriage and slotted section

e Replace all components in their respective slots in the transit case.

CHAPTER 4

OPERATOR AND ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

4-1. General

To insure that the AN/USM-37A is always ready for operation, it must be inspected systematically so that defects may be discovered and corrected before they result in serious damage or failure The necessary preventive maintenance checks and services to be performed are listed and described m tables 4-1 through 4-4. The item numbers indicate the sequence of minimum inspection required. Defects discovered during operation of the unit will be noted for future correction to be made as soon as operation has ceased. Stop operation immediately If a deficiency is noted during operation which would damage the equipment Record all deficlencles together with the corrective action taken as prescribed m TM 38-750.

4-2. Instructions for the Performance of Preventive Maintenance Checks and Services

a Table 4-1 lists those items which must be inspected by the operator on a daily basis (or weekly if equipment is in standby condition)

b Table 4-2 lists items to be inspected by organizational maintenance personnel on a weekly basis

c. Organizational monthly checks and services are listed in table 4-3

d Refer to table 4-4 for items to be inspected quar terly by organizational maintenance personnel

Table 4-1. Operator's Preventive Maintenance Checks and Services

D-Daily
Total time required :0.6

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	COMPLETENESS See that equipment is complete (table 1-1)	0.1
2	EXTERIOR SURFACES Clean the exterior surfaces,including the panel and meter Check the indicator lens for scratches Replace faulty lens	0.1
3	CONNECTORS Check the tightness of all connectors	0.1
4	CONTROLS AND INDICATORS While making the operating checks (sequence No 5) observe that the mechanical action of each knob, dial,and switch is smooth and free of external or internal binding, and that there is no excessive looseness Replace broken knobs and faulty lamps	
	OPERATION During operation be alert for any unusual performance or condition	0.3

Table 4-2. Organizational Weekly Preventive Maintenance Checks and Services

W-Weekly
Total Time Required: 0.7

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	CABLES Inspect cords, cables and wires for chafed, cracked, or frayed insulation Replace connectors that are broken,arced, stripped, or worn excessively	0.3
2	HANDLES AND LATCHES Inspect handles and latches for looseness Tighten as necessary	0.2
3	METAL SURFACES Inspect exposed metal surfaces for rust and corrosion Clean and touchup paint as required	0.2

Table 4-3. Organizational Monthly Preventive Maintenance Checks and Services

M-Monthly

Total time required: 0.8

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	PLUCKOUT ITEMS Inspect seating of pluckout items Make certain that tube clamps grip tubes tightly	01
2	JACKS Inspect jacks for snug fit and good contact	0 1
3	TRANSFORMER TERMINALS Inspect terminals on power transformer for dirt or corrosion All nuts securing the transformer must be tight	0 2
4	TERMINAL BLOCKS Inspect terminal blocks for loose connections and cracked or broken insulation	02
5	RESISTORS AND CAPACITORS Inspect resistors and capacitors for cracks, blistering, or other defects	0 2

Table 4-4. Organizational Quarterly Preventive Maintenance Checks and Services

Q-Quarterly

Total time required: 0.4

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	PUBLICATIONS Check to see that all publications are complete, serviceable, and current (DA Pam 310-4)	0.1
2	MODIFICATIONS Check DA Pam 310-7 to determine whether new applicable MWO's have been published All URGENT MWO's must be applied immediately and all NORMAL MWO's must be scheduled Reporting of accomplished MWO's will be submitted (see TM 38-750)	0.1
3	SPAREPARTS Check all spare parts for general condition and method of storage No overstock should be evident, and all shortages must be on valid requisitions	0.2

Section II. MAINTENANCE OF THE AN/USM-37A

4-3. General

a. Organizational maintenance of the AN/ USM-37A shall be limited to those functions list- ed in the maintenance chart in Appendix C. Any maintenance function that is beyond the scope of organizational maintenance personnel shall be referred to a higher maintenance category

b. Tools and test equipment required for the performance of orgamizational maintenance are listed in Section III of Appendix C of this manual

4-4. Cleaning

Inspect the exterior surfaces of the indicator; they must be free of dirt, grease, and fungus

a. Remove dust and loose dirt with a clean, soft cloth

WARNING

The fumes of trlchloroethane are toxic Provide thorough ventilation whenever used. **DO NOT USE NEAR AN OPEN FLAME** Trichloroethane is not flammable, but exposure of the fumes to an open flame or hot metal forms highly toxic phosgene gas

b. Remove grease, fungus, and ground-in dirt from the transit case and indicator cabinet; use a cloth dampened (not wet) with trichloroethane.

c. Remove dirt from plugs and jacks with a brush.

d. Clean front panel and control knobs, use a soft clean cloth.

e. Clean the meter's glass face with a solution of mild soap and water CAUTION To protect the glass, do not apply heavy pressure when cleaning the meter.

4-5. Paint and Finishes

When the AN/USM-37A requires repainting, refinish- ing, or touchup painting refer to Federal Standard No 595A for a matching color SB 11-573 lists the tools and miscellaneous supplies required for painting

4-6. Touchup Painting Instructions

a Refer to TB 43-0118 for instructions on painting and preserving Electronics Command equipment. In touchup painting a perfect match with the exact shade of the original paint may not be possible The preven- tion of corrosion and deterioration is the most impor- tant consideration in touchup painting; appearance is secondary.This should not be construed to mean that the appearance of the equipment is unimportant. Touchup painting should be accomplished neatly, and in a professional manner

APPENDIX A

REFERENCES

DA Pam 310-4	Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, and Lubrication Orders
DA Pam 310-7	US Army Equipment Index of Modiflcatlon Work Orders
Federal Standard No 595A	Colors
SB 11-573	Painting and Preservation Supplies available for field use for Electronics Command Equipment.
SB 708-42	Federal Supply Code for Manufacturers - United States and Canada - code to name (Cataloging Handbook H4-2)
TB 43-0118	Field Instructions for Painting and Preserving Electronics Command Equipment including Camouflage Pattern Painting of Electrical Equipment Shelters
TM 38-750	The Army Maintenance Management System (TAMMS)
TM 740-90-1	Administrative Storage of Equipment.
TM 750-244-2	Procedures for Destruction of Electronics Materiel to Prevent Enemy Use.

APPENDIX C

MAINTENANCE ALLOCATION

Section I. INTRODUCTION

C-1. General This appendix summarizes the maintenance operations covered in the equipment literature It authorizes categories of maintenance for specific maintenance functions on repairable items and components, and the tools and equipment required to perform each function

C-2. Maintenance Functions

Maintenance functions will be limited to and defined as follows

a. To determine the serviceability of an item by comparing its physical, mechanical, and/or electrical characteristics with established standards through examination

b Test. To verify serviceability and to detect incip ient failure by measuring the mechanical or electrical characteristics of an item and comparing those charac- teristics with prescribed standards

c . Service Operations required periodically to keep an item in proper operating condition, i e, to clean, preserve, drain, paint, or to replenish fuel/lubri- cants/hydraulic fluids or compressed air supplies

d. Adjust Maintain within prescribed limits by bringing into proper or exact position, or by setting the operating characteristics to the specified parameters

e Align To adjust specified variable elements of an item to about optimum or desired performance

f Calibrate To determine and cause corrections to be made or to be adjusted on instruments or test measuring and diagnostic equipment used in precision measurement Consists of the comparison of two in- struments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy m the accuracy of the instrument being compared

g. Install The act of emplacing, seating, or fixing into position an item, part, module (component or assembly) in a manner to allow the proper functioning of the equipment/system

h Replace. The act of substituting a serviceable like-type part, subassembly, module (component or assembly) for an unserviceable counterpart

i Repair. The application of maintenance services (inspect, test, service, adjust, align, calibrate, replace) or other maintenance actions (welding, grinding, rivet- mg, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, for failure in a part, subassembly, module/component/assembly, end item or system.

j Overhaul That periodic maintenance effort (service/action) necessary to restore an item to a completely serviceable/operational condition as prescribed by maintenance standards (e g, DMWR) m appropriate technical publications Overhaul is normally the highest degree of maintenance performed by the Army Overhaul does not normally return an item to like-new condition

k Rebuild Consists of those services/actions necessary for the restoration of unserviceable equipment to a like-new condition in accordance with original manufacturing standards Rebuild is the highest degree of materiel maintenance applied to Army equipment The rebuild operation includes the act of returning to zero those age measurements (hours, miles, etc.) considered in classifying Army eqmpment/components

C-3. Column Entries

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies and module with the next higher assembly.

b. Column 2, Component/Assembly. Column 2 contains the noun names of components, assemblies, sub- assemblies, and modules for which maintenance is authorized

c Column 3, Maintenance Functions. Column 3 lists the functions to be performed on the item listed m column 2.

d Column 4, Maintenance Category Column 4 specifies, by the listing of a "worktime" figure in the appropriate subcolumn(s), the lowest level of mainte- nance authorized to perform the function listed in col- umn 3 This figure represents the active time required to perform that maintenance function at the indicated category of maintenance If the number or complexity of the tasks within the listed maintenance function vary at different maintenance categories, appropriate "worktime" figures will be shown for each category The number of man-hours specified by the "worktime" figure represents the average time required to restore an item (assembly, subassembly, component, module, end item or system) to a serviceable condition under typical field operating conditions. This time includes preparation tune, troubleshooting time and quality assurance/quality control time in addition to the time required to perform the specific tasks identified for the maintenance functions authorized in the maintenance allocation chart. Subcolumns of column 4 are as follows.

C - Operator/Crew

O – Organizational

F - Direct Support

H - General Support

D - Depot

e. Column 5, Tools and Equipment. Column 5 specifies by code, those common tool sets (not individual tools) and special tools, test, and support equipment required to perform the designated function.

C-4. Tool and Test Equipment Requirements (Section III)

a. Tool or Test Equipment Reference Code The numbers in this column coincides with the numbers used in the tools and equipment column of the MAC The numbers indicate the applicable tool or test equipment for the maintenance functions.

b Maintenance Category The codes in this column indicate the maintenance category allocated the tool or test equipment.

c. Nomenclature This column lists the noun name and nomenclature of the tools and test equipment required to perform the maintenance functions.

d. National/NATO Stock Number This column lists the National/NATO stock number of the specific tool or test equipment.

e. Tool Number. This column lists the manufacturers part number, followed parenthetically by the digit Federal Supply Code for that manufacturer.

SECTION II MAINTENANCE ALLOCATION CHART
FOR
INDICATOR, STANDING WAVE RATIO - AN/USM-37A

(1) GROUP NUMBER	(2) COMPONENT/ ASSEMBLY	(3) MAINT. FUNCT.	(4) MAINTENANCE CATEGORY C	O	F	H	D	(5) TOOLS AND TEST EQUIPMENT
00	INDICATOR, STANDING							
	WAVE RATIO, AN/USW-37A	Inspect		0 5				Visual,15
		Test				1.0		1-10, 12, 13
		Adjust				1.0		1-10, 12, 13
		Repair				1.0		15
		Overhaul					2.0	1-11,13
		Repair1		0.5		15		
01	Indicator Standing Wave							
	Ratio IM-157/USA-37	Inspect		0 5				Visual
		Test				1 0		1-10, 12, 13
		Repair				1 0		1-10, 12, 13
		Overhaul					2.0	1-11, 13
		Repair1		0.2		‘		15
02	Probe, Wave Guide							
	IX-1546/USW-37	Inspect		0 2				Visual
		Inspect				0.5		
		Replace				0 5		13
		Test				0.5		1, 14
		Repair				0.5		13
03	Carriage, Probe)							
	AX-1545/U9W-37	Inspect		0 2				Visual
		Inspect				0.5		
		Repair’				0.5		13
04	Wave Guide Assembly							
	CG-1106/USW-37	Inspect		0 2				Visual
		Inspect				0.5		
		Replace				0 5	13	
05	Wave Guide Assembly							
	CG-1107/USM-37	Inspect		0 2				Visual
		Inspect				0 5		
		Replace				0 5		13
06	Slotted Line DM-100/USM-37	Inspect		0 2				Visual
		Inspect				0 5		
		Replace				0 5		13
07	Adapter UG-1398/u	Inspect		0 2				Visual
		Inspect				05		
		Replace				0 5		13
08	Adapter, Coaxial to Wave							
	Guide 1G0-1053/u	Inspect		0 2				Visual
		Inspect				05		
		Replace				0 5		13
09	Adapter, Coaxial UG-1054/U	Inspect		0 2				Visual
		Inspect				05		
		Replace				0 5		13
10	Case Indicator CT-2964/U,1	Inspect		0 2				Visual
		Inspect				0.5		
		Repair				0.5		13

1.Repair by replacement of knobs, fuses, lamps, etc.

SECTION III TOOL AND TEST EQUIPMENT REQUIREMENTS FOR INDICATOR, STANDING WAVE RATIO AN/USM-37A

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	H,D	Generator, Signal An/URM-44A	6625-00-990-7700	
2	H,D	voltmeter, Electronic ME-264/U	6625-00-967-1504	
3	H, D	Counter, Electronic Digital Readout AN/U-207	6625-00-911-6368	
4	H, D	Attenuator CN-970/U	5985-00-993-1377	
5	H, D	Attenuator CN-112/U	5985-00-957-1860	
6	H, D	Voltmeter, Electronic Er-202/U	6625-00-709-0288	
7	H, D	Oscilloscope AN/U9S281C	6625-00-106-9622	
8	H, D	Generator, Signal AN/U205	6625-00-788-9672	
9	H, D	Altimeter TS-352B/U	6625-00-553-0142	
10	H, D	Transformer, Variable Power CN-16/U	5950-00 688-5722	
11	D	Tube Tester TV-2/U	6625-00-849-5694	
12	H	Tube Tester TV-7?/U	6625-00-820-0064	
13	H, D	Tool Xit TX-100/0	5180-00-605-0079	
14	H, D	Dummy Load, Electrical DA-75/	6625-00-177-1639	
15	0	Tools and Test Equipment available to the organizational technician because of his/her assigned mission.		

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Ft Richardson (ECOM Ofc) (2)
LBAD (14)
SAAD (30)
TOAD (14)
SHAD(3)
Ft Gillem (10)
Sig FLDMS (1)
Units org under fol. TOE'
(1 copy each unit)
11-16
11-97
11-117
11-500 (AA-AC)
32-56
32-57

NG None
USAR None
For explanation of abbreviations used, see AR 310-50

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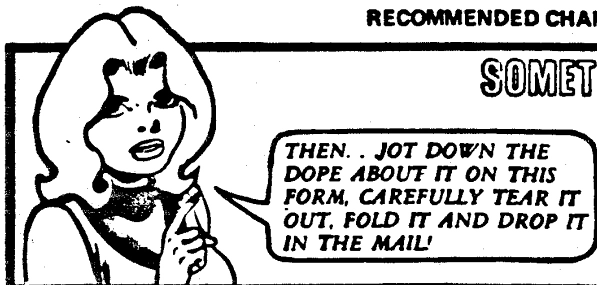

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