TECHNICAL MANUAL

OPERATOR AND ORGANIZATIONAL

MAINTENANCE MANUAL

MEASURING SET, STANDING WAVE RATIO AN/USM-37E

(NSN 6625-00-197-6910)

H E A D Q U A R T E R S , D E P A R T M E N T O F T H E A R M Y

FEBRUARY 1978

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 it is used; avoid prolonged or repeated breathing of vapor. Do not use near an open flame or hot surface; trichloroethane is non-flammable but heat converts the fumes to a highly toxic phosgene gas the inhalation of which could result in serious injury or death. Prolonged or repeated skin contact with trichloroethane can cause skin inflammation. When necessary, use gloves, sleeves and aprons which the solvent cannot penetrate.

Change No. 1

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, *8 August 1983*

Operator and Organizational Maintenance Manual

MEASURING SET, STANDING WAVE RATIO AN/USM-37E

(NSN 6625-00-197-6910)

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5 SAFETY STEPS TO FOLLOW IF SOMEONE IS THE VICTIM OF ELECTRICAL SHOCK

1 DO NOT TRY TO PULL OR GRAB THE INDIVIDUAL

2 IF POSSIBLE, TURN OFF THE ELECTRICAL POWER

3 IF YOU CANNOT TURN OFF THE ELECTRICAL POWER, PULL, PUSH OR LIFT THE PERSON TO SAFETY USING A DRY WOODEN POLE OR A DRY ROPE OR SOME OTHER INSULATING MATERIAL

4 SEND FOR HELP AS SOON AS POSSIBLE

5 AFTER THE INJURED PERSON IS FREE OF CONTACT WITH THE SOURCE OF ELECTRICAL SHOCK, MOVE THE PERSON A SHORT DISTANCE AWAY AND IMMEDIATELY START ARTIFICIAL RESUSCITATION

TECHNICAL MANUAL

No. 11-6625-369-12-1

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(NSN 6625-00-197-6910)

REPORTING ERRORS AND RECOMMENDING IMPROVEMENTS

You can help improve this manual. If you find any mistakes or if you know of a way to improve the procedures, please let us know. Mail your letter, DA Form 2028 (Recommended Changes to Publications and Blank Forms), or DA Form 2028-2 located in back of this manual direct to: Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DR-SEL-ME-MP, Fort Monmouth, New Jersey 07703. In either case, a reply will be furnished direct to you.

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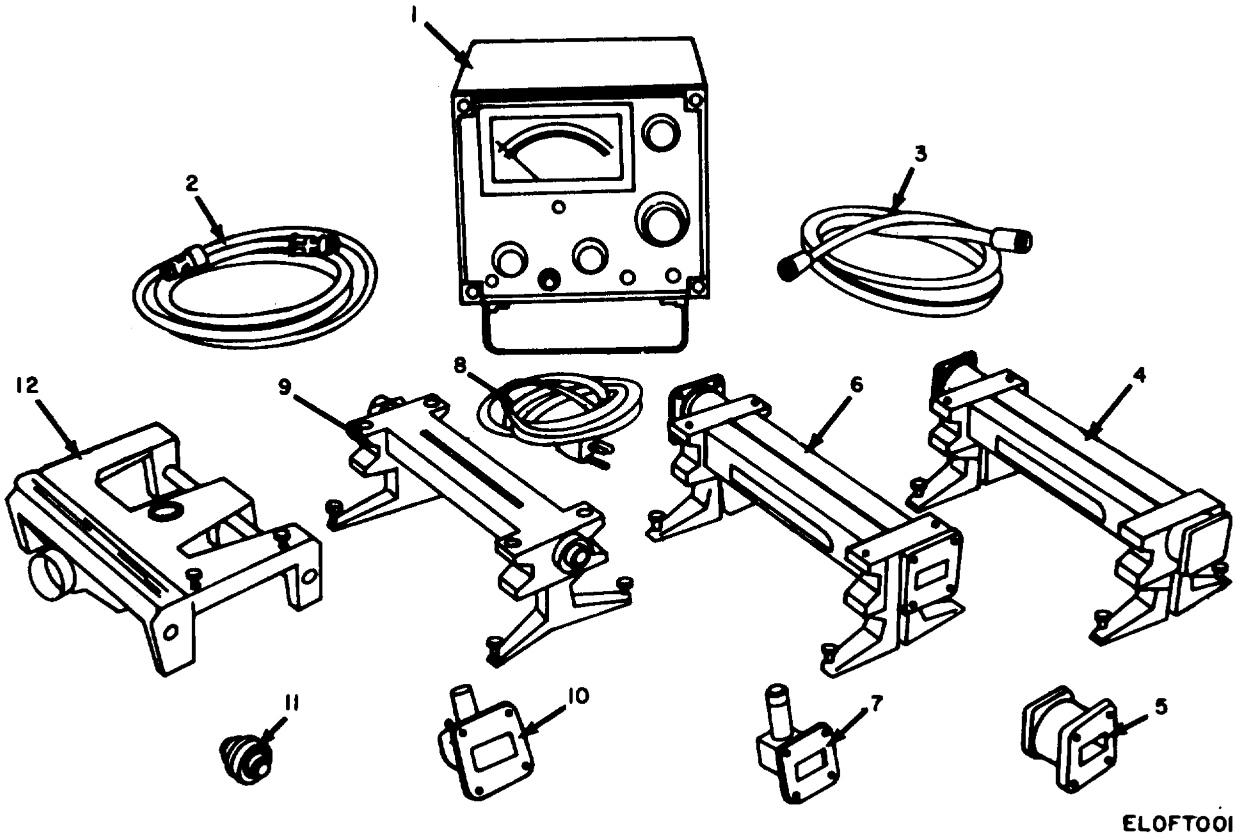

1. Standing Wave Ratio Indicator IM-157E/U
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Figure 1-1. Standing wave ratio measuring set AN/USM-37E.

CHAPTER 1

INTRODUCTION

Section I. GENERAL

1-1. Scope

This manual covers Measuring Set, Standing Wave Ratio AN/USM-37E, and includes a description of the equipment, operating procedures and operator and organizational maintenance. Throughout this manual, the major component of the test set, Standing Wave Ratio Indicator IM-157E/U will be referred to as the SWR Indicator.

1-2. Consolidated Index of Army Publications and Blank Forms

Refer to the latest issue of DA Pam 310-1 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

1-3. Maintenance Forms, Records and Reports

a. Reports of Maintenance and Unsatisfactory Equipment. Department of the Army forms and procedures used for equipment maintenance will be those prescribed by TM 38-750, The Army Maintenance Management System (TAMMS).

b. Report of Packaging and Handling Deficiencies. Fill out and forward SF 364 (Report of Discrepancy (ROD)) as prescribed in AR 735-11-2/DLAR 4140.55/NAVMATINST 4355.73A/AFR 400-54/MCO 4430.3F.

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/NAVSUPINST 4610.33C/AFR 75-18/MCO P4610.19D/DLAR 4500.15.

1-4. Administrative Storage

Administrative storage of equipment issued to and used by Army activities shall be in accordance with TM 740-90-1.

1-5. Destruction of Army Electronics Materiel

Destruction of Army electronics materiel to prevent enemy use shall be in accordance with TM 750-244-2.

1-6. Reporting Equipment Improvement Recommendations (EIR)

If your Measuring Set, Standing Wave Ratio AN/USM-37E needs improvement, let us know. Send us an E IR. You, the user, are the only one who can tell us what you don't like about your equipment. Let us know why you don't like the design. Put it on an SF 368 (Quality Deficiency Report). Mail it to Commander, US Army Communications-Electronics Command and Fort Monmouth, ATTN: DR-SEL-ME-MP, Fort Monmouth, New Jersey 07703. We'll send you a reply.

Section II. DESCRIPTION AND DATA

1-7. Purpose and Use

In high-frequency systems, standing wave measurements are the customary means of investigating the impedance, and/or impedance match of transmission lines, various types of terminations (such as antennas, detectors, and loads) and other devices (such as attenuators, connectors, transitions, etc.). The AN/USM-37E is a complete laboratory-quality test set for making accurate standing-wave measurements in waveguide and coaxial transmission systems over the frequency range of 3.0 to 12.4 gHz.

1-8. Description

The components of the AN/USM-37E are illustrated in figure 1-1, and described below.

a. Indicator, Standing Wave Ratio IM-157E/U. The major component of the AN/USM-37E is the SWR Indicator. It is a solid-state direct-reading instrument for measuring VSWR and attenuation. The instrument is essentially a high-gain low-noise tuned amplifier, feeding an indicator calibrated for signal inputs from either the crystal or bolometer type square-law detectors. The SWR scales on the indicator are calibrated to provide direct VSWR readings. The DB scales provide attenuation readings directly in decibels. Measurements of high accuracy and resolution are obtained by expanding selected portions of the ordinary scales for fullscale presentation. The gain, bandwidth and pass frequency of the amplifier are controlled from the front panel. A rear-panel output jack permits connection of a dc recorder if a permanent record of meter indications is desired. The input signal is obtained from either a crystal or bolometer type detector. Crystal and bolometer detectors produce low-level signal outputs that require the high-gain amplification afforded by the SWR Indicator before being applied to the indicator proper. The instrument can also be used as a high-gain tuned amplifier by making use of its amplifier output terminals on the rear panel. Power requirements are either 115 volts or 230 volts + 10%, 50 to 1,000 Hz. A rear-panel switch permits the selection of 115-volt or 230-volt operation. The SWR Indicator can also be used as a portable instrument with 36 hours of uninterrupted service available from the rechargeable battery pack.

b. Cables CG-1963/U, CG-2651/U, and Power Cable. Three cables are provided with the AN/USM-37E.

The power cable connects the SWR Indicator to the power source. Rf cable CG-1963/U connects the external signal source to the coaxial jack on one of the waveguide-to-coax adapters. Video cable CG-2651/U connects the probe output to the SWR/attenuation meter.

c. Probe, Waveguide MX-1546/USM-37. The probe is a sensitive untuned broadband microwave unit, consisting of a crystal rectifier and probe assembly in a convenient housing that permits penetration to be varied quickly and easily. The detector element is a modified 1N76 silicon crystal, and is suitable for use in standing wave measurements over a wide range of frequencies.

d. Carriage, Slotted Line Coaxial/Waveguide MX-8355/USM-37E. The probe carriage provides the support for a selected slotted line and allows the waveguide probe to be positioned along the longitudinal slot. Three sets of ball bearings, rolling on precision-ground hardened runways, allow smooth and accurate movement of the probe along the slotted section. Knurled thumbscrews are used to level the carriage. Other thumbscrews secure the selected slotted line to the carriage, minimizing the need for hand tools. A precision dial gage may be installed on the rear of the carriage.

e. Slotted Sections IM-214/USM-37E, IM-215/USM-37E, and IM-216/USM-37E. Three slotted sections are provided which allow coverage of frequencies from 3.0 to 12 gHz (coaxial) and 7.05 to 12.4 gHz (waveguide). Coaxial slotted section IM-214/USM-37E provides a measurement capability between 3.0 and 12.0 gHz for coaxial components. Waveguide slotted sections IM-215/USM-37E and IM-216/USM-37E allow measurements from 7.05 to 10 gHz and 8.2 to 12.4 gHz respectively.

f. Adapters UG-1053AIU, UG-397/U and UG-1389/U. Three adapters are provided with the equipment. Waveguide adapter UG-1389/U adapts a UG-136A/U choke flange on RG-67/U size waveguide to a UG-137A/U choke flange on RG-68/U size waveguide. The adapter is provided with a UG-135/U cover flange on one end and a UG-138/U cover flange on the other. The remaining two adapters are both coaxial-to-waveguide adapters which are used to connect a signal source having a coaxial output to the input of the waveguide slotted sections. Adapter UG-1053A is equipped with a UG-135/U cover flange on one end and a female N-type connector on the other end. This adapter connects type RG-52/U or RG-67/U waveguide to 50 ohm coaxial cable. The second adapter, UG-397/U is equipped with a UG-138/U flange on one end and a female N-type connector on the other end. This adapter connects type RG-51/U or RG-68/U waveguide to 50 ohm coaxial cable.

g. Case, Measuring Set CY.6873/USM-37E. During storage or transit, the components of the AN/USM-37E are housed in a drip-proof fiberglass combination test set case. The packed equipment is protected by molded polyurethane cushioning surrounding all components.

1-9. Tabulated Data

NOTE

Items comprising an operable AN/USM-37E are listed in Table 1-1.

SWR Indicator

Power requirements	115V or 230V ±10%, 50-1,000 Hz 2W; optional rechargeable battery for 36 hours of continuous operation.
Input circuit	
Crystal	Unbiased: 100 ohms (low) and 5,000 ohms (high) optimum source impedance; biased IV into 1,000 ohms.
Bolometer current	4.5 mA (low) and 8.7 mA (high) into 200 ohms, adjustable ±3%; positive bolometer protection.
Amplifier	
Bandwidth	15-130 Hz, continuously adjustable.
Center frequency	1,000 Hz, adjustable ±20 Hz.
Sensitivity	0.15 uV rms at maximum bandwidth and 0°-55°C; (7 uV rms on high impedance crystal).
Noise level	7.5 db below full scale sensitivity (0.15 uV at 130 Hz).
Attenuation range	70 db in 10 db and 2 db steps.
Accuracy	±0.05 db/10 db step or ± 0.1 db max cumulative; ±0.2 db linearity on expanded scale.
Dc output	01- V into open circuit, 1,000 ohms at DC OUTPUT jack.
Ac output	0-0.3 V rms (NORM), 0-0.8 V rms (EXPAND) into 10 K ohms min at AMPLIFIER OUTPUT terminals.
Meter	
Calibration	Square law.
Scales	SWR: 1-4, 3.2-10 (NORM), 1-1.25 (EXPAND); DB: 0-10 (NORM), 0-2 (EX-

PAND), Bolometer bias: 4.5 mA, 8.7 mA.

Waveguide Probe

Frequency range .... 2.6 - 18.0 gHz.
Output connector .... BNC female.
Crystal .... 1N76, modified.

Adapters

UG-1053A/U .... Waveguide UG-135/U to coaxial type N, female.
UG-397/U .... Waveguide UG-138/U to coaxial type N, female.
UG-1389/U .... Waveguide UG-138/U to Waveguide UG-135/T.

Slotted Sections

IM-214/USM-37E
Input connector .... Type N, female.
Output connector .... Universal type N, male.
Characteristic impedance .... 50 ohms.
SWR .... 3.0-8.0 gHz, 1.04 max; 8.0-10.0 gHz, 1.06 max; 10.0-12.0 gHz, 1.10 max.

IM-215/USM-37E and IM-216/USM-37E
Connectors .... Waveguide Flange UG-138/U (215); waveguide flange UG-135/U (216).
SWR .... Not more than 1.01 with load SWR of 1.2, slope at 10.0 or 12.4 gHz.

Probe Carriage

Probe travel .... 12.0 cm.
Calibration .... Cm, vernier adjustment to 0.01 mm.

Cables

CG-1963/U
Impedance .... 50 ohms.
Termination .... Type N, male.

CG-2651/U
Impedance .... 50 ohms.
Termination .... UG-88C/U.

Table 1-1. Items Comprising an Operable AN/USM-37U

NSN	Item	Qty	Dimensions (in)			Weight
			Height	Width	Depth	(lbs)
6625-00-484-8654	Indicator, Standing Wave Ratio IM-157E/U	1 ea	7 1/4	8 1/4	11 1/8	10
6625-00-581-5802	Probe, Waveguide MX-1546/USM-37	1 ea				
6625-00-834-4880	Adapter, Waveguide/Coax UG-1053A/U	1 ea	2 1/2	1 5/8	1 1/4	
5985-00-264-9212	Adapter, Waveguide/Coax UG-397/U	1 ea	2 1/2	1 7/8	1 1/2	
	Adapter, Waveguide UG-1389/U	1 ea	1 7/8	1 7/8	1 1/2	
6625-00-484-8656	Slotted Section, Coaxial IM-214/USM-37E	1 ea	3 1/4	5	10	
6625-00-484-8657	Slotted Section, Waveguide IM-215/USM-37E	1 ea	3 7/8	5	10	
6625-00-484-8658	Slotted Section, Waveguide IM-216/USM-37E	1 ea	3 3/4	5	10 1/4	
6625-00-230-3832	Carriage, Slotted Line MX-8355/USM-37E	1 ea	6	2 1/4	6	
5995-00-463-4066	Cable, Rf CG-1963/U	1 ea			72	
5995-00-470-4339	Cable, Rf CG-2651/U	1 ea			72	
6145-00-284-0579	Cable, power	1 ea			84	
6625-00-484-8655	Case, Measuring Set CY-6873/USM-37E	1 ea	9 1/4	19	22	60

CHAPTER 2

SERVICE UPON RECEIPT AND INSTALLATION

2-1. Unpacking

a. Packaging Data. When packaged for shipment the AN/USM-37E is placed in a fiberboard box and packed in a wooden case. A typical packaging diagram is illustrated in figure 2-1.

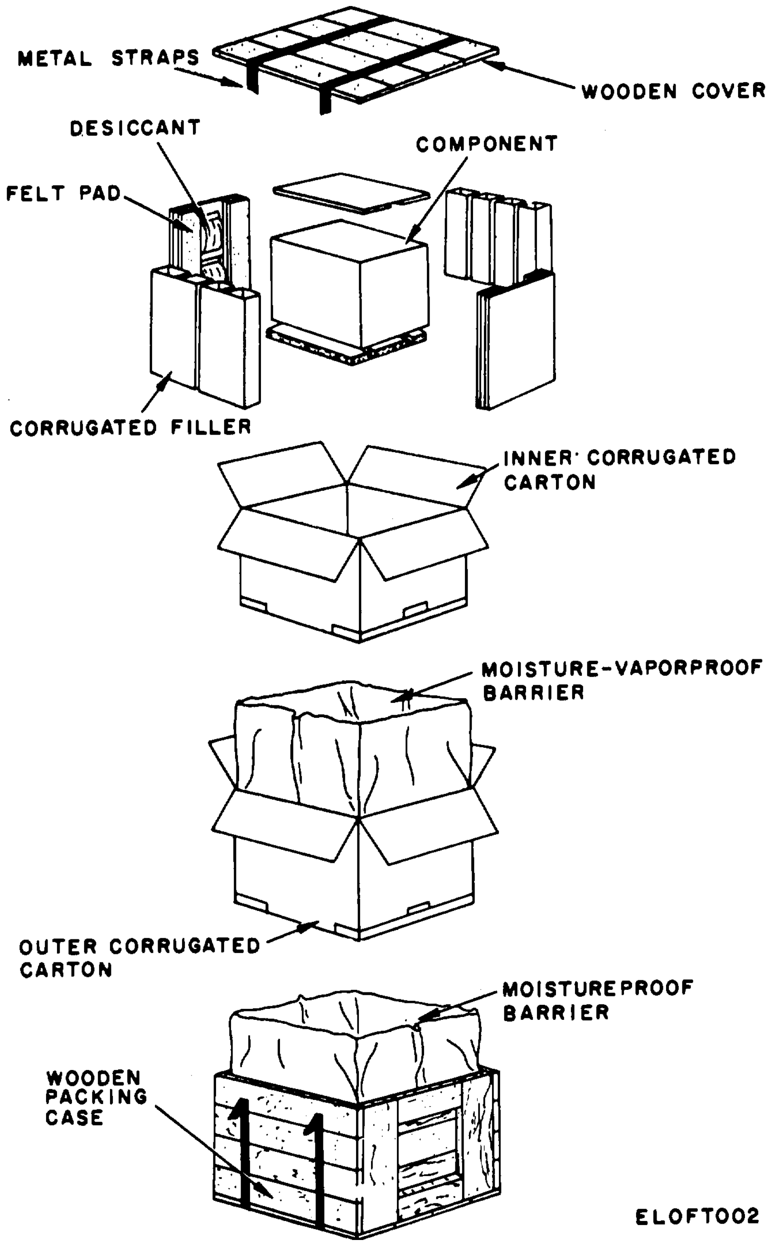


Figure 2-1. Packaging diagram for standing wave ratio measuring set AN/USM-37E.

b. Removing Contents.

(1) Cut and fold back the steel straps and remove the cover of the wooden case.

(2) Remove the fiber padding and pad.

(3) Carefully lift the fiberboard box from the wooden crate.

(4) Open the carton to expose the AN/USM-37E and lift the test set out.

(5) Unscrew relief valve on test set case before opening to relieve pressure.

CAUTION

The components of the AN/USM-37E have been rigidly inspected prior to shipment. When the cover of the test set case is unlatched and raised, the top cushioning pad can be removed to expose all equipment. Handle all components gently since even slight physical damage to critical openings, connectors, or flanges will greatly degrade measurements.

2-2. Checking Unpacked Equipment

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

b. Check the equipment against table 1-1 of this manual and the packing slip to see if the shipment is complete. Report all discrepancies in accordance with the instructions of TM 38-750 (para. 1-3). The equipment should be placed in service even though a minor assembly or part that does not affect proper function is missing.

c. Check to see whether the equipment has been modified. (Equipment which has been modified will have the MWO number on the front panel, near the nomenclature plate.) Check also to see whether all currently applicable MWO have been applied. (Current MWO applicable to the equipment are listed in DAM Pam 310-7.)

2-3. Assembly of Equipment

a. General. The AN/USM-37E is a portable test set designed for bench test use. No tools other than a screwdriver are required for assembly. The slotted waveguide sections are mounted to the carriage by thumbscrews. Waveguide sections and adapters are joined by machine screws, washers, and nuts, or waveguide clamps (not supplied). Installation should be undertaken by persons experienced in handling waveguide equipment. Assemble the test set on a flat surface with liberal working space which is convenient to a 115-volt electrical outlet, a signal source, and the equipment under test. It is important that the operating surface be free of mechanical vibration and shock. When assembling the waveguide carriage and when joining waveguide sections, protect the carriage and waveguide sections from damage; wipe waveguide flanges clean before joining. Scratches, dents, burrs, etc., cause rf leakage discontinuities, and degrade performance.

b. Carriage and Slotted Section.

(1) Select the slotted section and adapters that will be required. Remove these components from the transit case.

(2) Check all joining surfaces to be sure they are clean and free of extraneous particles.

(3) Position the carriage over the slotted section, slot side up, as shown in figure 2-2.

(4) Thread the thumbscrews on the end frames of the carriage into the slotted section mounting holes evenly and not more than finger tight.

(5) Move the traveling carriage from end to end. The carriage should roll evenly and freely with no binding or changing of level. If the carriage does not roll parallel to the top surface, check the mounting of the waveguide section to be sure it is not tilted.

(6) Adjust the thumbscrews of the four mounting feet of the slotted section so that each foot provides equal support of the carriage. If additional sections of waveguide are to be fastened to the slotted section they should have their own support. Do not depend on the coupling flanges for support of adjacent waveguide sections. To do so apply strain that impairs measurement accuracy.

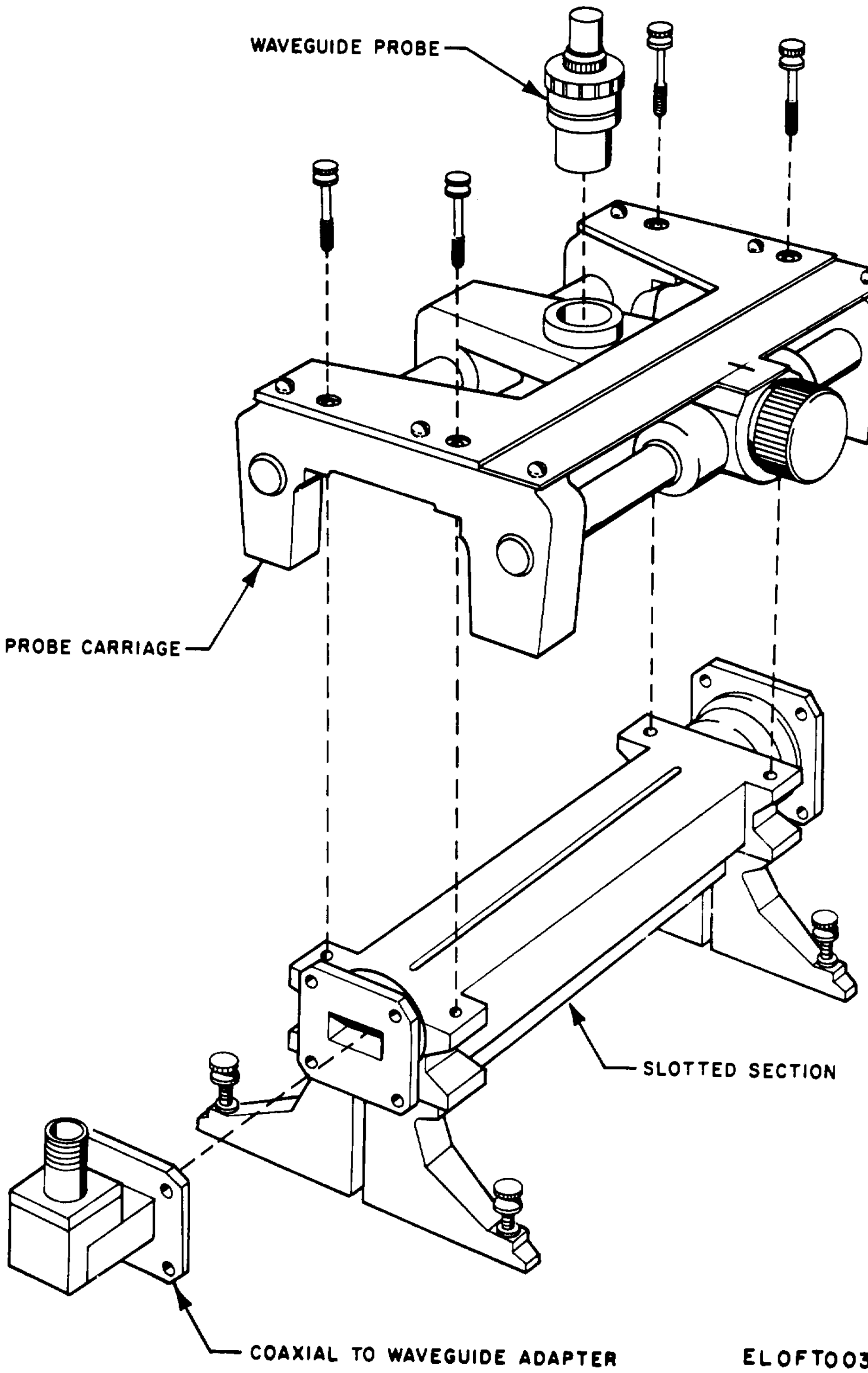


Figure 2-2. Assembly of carriage and slotted section

CHAPTER 3

OPERATING INSTRUCTIONS

Section I. CONTROLS AND PRELIMINARY PROCEDURES

3-1. Operator's Controls

a. A complete listing of all controls and indicators used by the operator may be found in table 3-1. The front panel of the SWR Indicator is illustrated in figure 3-1.

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

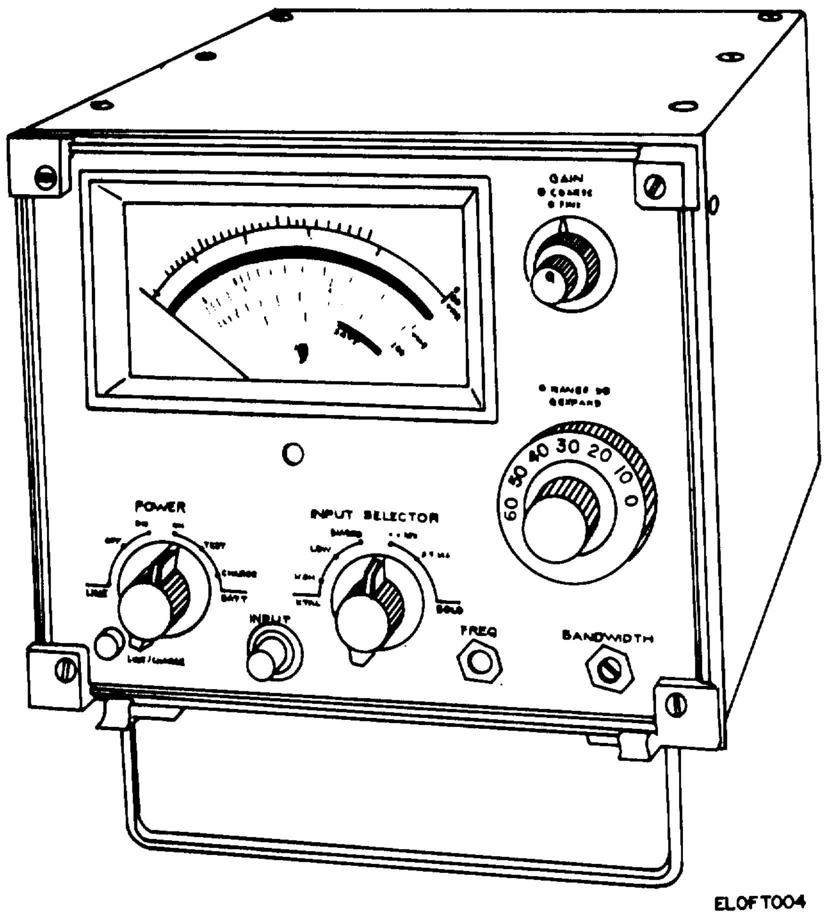


Figure 3-1. Front panel controls and indicators, IM-157E/U.

3-2. Preliminary Starting Procedures

Before commencing operation of the SWR Indicator, proceed as follows:

a. Set the LINE VOLTAGE slide switch (rear panel) to correspond to primary power source (115 or 230 volts ac).

b. Fold down metal stand from underside to insure proper operating position.

c. If battery operation of the SWR Indicator is desired, the Battery Pack must be charged prior to use. To charge the battery:

(1) Set POWER switch (front panel) to BATT CHARGE.

(2) Plug line cord into ac power source.

Table 3-1. Operator's controls

Control, indicator, or connector	Function
	Front Panel
LINE/CHARGE indicator	Lights when POWER selector switch is in the LINE ON or BATT CHARGE position.
POWER selector switch.	
LINE OFF	No power, all circuitry deenergized.
LINE ON	Ac power connected; trickle charge from internal dc power supply applied to battery.
BATT ON	Battery connected.
BATT TEST	Condition of battery is indicated on meter, deflection should be within BATT CHK band
BATT CHARGE	Full charging current from internal dc power supply applied to battery; no other circuitry is energized.
INPUT connector	Provides connection for input signal from waveguide probe.
INPUT SELECTOR switch	Allows instrument to be used with either crystal detector or bolometer mounts of the types indicated.
FREQ adjustment	Varies center frequency of tuned amplifier :20 Hz.
BAN'DWIDTH adjustment	Varies amplifier bandwidth between 15 and 130 Hz.
RANGE DB switch	Varies amplifier gain in 10-db steps from 0-60 db; 60 db setting provides maximum gain.
EXPAND switch	Allows full-scale expansion of 2 db portions of 10 db scale.
GAIN controls COARSE and FINE	Vary amplifier gain continuously within setting of RANGE DB selector switch; allows initial Reference setting on the meter.
Panel Meter	Provides direct reading of VSWR measurements calibrated in SWR and in decibels.
	Rear Panel
METER DAMP INIOUT switch	Provides time constant circuit for meter damping if desired
FUSE 1/16A	Provides overload protection.
LI'E VOLTAGE switch	Allows selection of either 115V or 230V operation.
DC OUTPUT connector	Provides dc output for connection of external recorder.
BOLO BIAS switch	Provides meter indication of bolometer bias current.
AMPLIFIER OUTPUT connector	Provides ac output when equipment is used as a high-gain tuned amplifier.
POWER connector	Provides connection for ac power cable.

(3) Allow battery to charge for 72 hours.

NOTE

The battery can be maintained indefinitely in the charging state at a normal rate of charge without being damaged.

3-3. Signal Source

a. The signal source to be used with the AN/USM-37E, is not supplied with the equipment. Three types of sources are in common use: signal generators, variable-frequency klystrons and backward-wave tubes. To be used with this equipment, the source must operate over the portion of the frequency range from 3.0 to 12.4 GHz that is of interest, have either a type N coaxial output terminal or a waveguide port which matches the sizes contained in the test set, and produce at least 0.1 mW of power. To keep reflections to a minimum, the internal impedance of the source should be matched to the system. Good practice is to connect a well matched 6 db resistive pad or isolator to the generator end of the slotted section, A low pass filter with a cut-off frequency above the highest frequency used is desirable to eliminate any harmonics in the generator output. This filter should be connected between the generator and the pad. For best overall operation, the signal generator should indicate power output and should contain an accurately calibrated output attenuator.

b. The source must also be capable of 1,000-Hz, square-wave modulation and produce at least 01. mW of power. Since microwave oscillator circuits often use reflex klystrons (which are incapable of sinusoidal amplitude modulation without serious frequency modulation), it is common practice to drive the modulating electrode of the klystron from a square-wave generator to obtain 100% square-wave modulation of the signal source. The frequency of the square waves must then be accurately tuned to the acceptance frequency (1,000 Hz) of the standing wave indicator.

3-4. Check of Crystal Detector

Crystal diodes depart from the ideal square-law response for which the standing-wave indicator is calibrated. The effective point of departure depends on the sensitivity of the detector rf power level and the accuracy required of the measurement. The departure tends to occur when the rf power level exceeds a few microwatts, which approximately corresponds to a reading of full scale on the 30-db range of the standing wave indicator with the COARSE GAIN control set to 3/4 maximum (3/4 full setting of the COARSE GAIN control gives rated sensitivity; avoid higher settings when using the lowest db range). If the quality of the crystal detector in the probe is in question, its square-law response may quickly be compared against a signal generator having an accurately calibrated attenuator. The step-by-step procedure for making such a check follows. A new crystal being used for the first time should be thus checked, as there is often a significant variation between crystals. With the equipment connected as described in paragraph 3-3, and indicated in figure 3-2, proceed as follows:

a. Adjust the waveguide probe position for a maximum reading to obtain a full-scale reading on the 30-db range of the standing-wave indicator (COARSE GAIN control set to approximately 3/4 maximum). Keep the penetration of the probe at a minimum.

b. Reduce the output of the signal generator by exactly 10 decibels.

c. Set the RANGE DB switch to 40 db. The meter on the standing-wave indicator should again read full-scale, thereby showing a decrease of 10 decibels. A deviation greater than 0.25-db nominal from full-scale reading indicates a departure from square-law characteristics at the higher level (30-db range).

d. Adjust the COARSE GAIN control on the standing-wave indicator, if necessary, to again obtain a full-scale reading with the RANGE DB switch set to the 40-db range.

e. Again reduce the signal generator output by 10 db.

f. Set the RANGE DB switch to 50 db. The meter should again read full-scale, indicating a reduction of signal strength of 10 db. If the reading differs noticeably from that on the attenuator, use the alternate method of SWR measurement described below.

g. Adjust the output from the signal generator to a few decibels below its maximum rated output. Note the setting of the attenuator.

h. Set the waveguide probe to a maximum in the standing wave pattern.

i. Set the RANGE DB switch on the indicator to one of three ranges (40, 50 or 60 db).

j. Adjust probe penetration for full-scale reading.

k. Move probe to a peak in the standing wave pattern.

l. Reduce the output of the signal generator by increasing the attenuation until the reading of step *j* is obtained on the SWR indicator.

m. Note the setting of the attenuator. The standing wave ratio in db is then equal to the difference in the readings at the two settings of the attenuator.

Section II. OPERATION UNDER USUAL CONDITIONS

3-5. Operating Procedures for VSWR Measurements Using the Slotted Line Technique

a. General. The measurement of VSWR between 1 and 40 GHz is accomplished by the use of a probe which, when inserted into a slotted line, will produce a steady voltage indication on the SWR Indicator meter. Use the minimum probe penetration which picks up an adequate signal to measure since excessive probe penetration will load the transmission line significantly resulting in erroneous measurements. To find out whether a given probe penetration is too deep, measure SWR, then change probe penetration and re-measure SWR. If the second reading differs from the first, probe penetration is too deep, and the transmission line has been loaded.

b. Slotted Line Technique, When measuring VSWR above 1 GHz proceed as follows:

(1) Connect the equipment as indicated in figure 3-2.

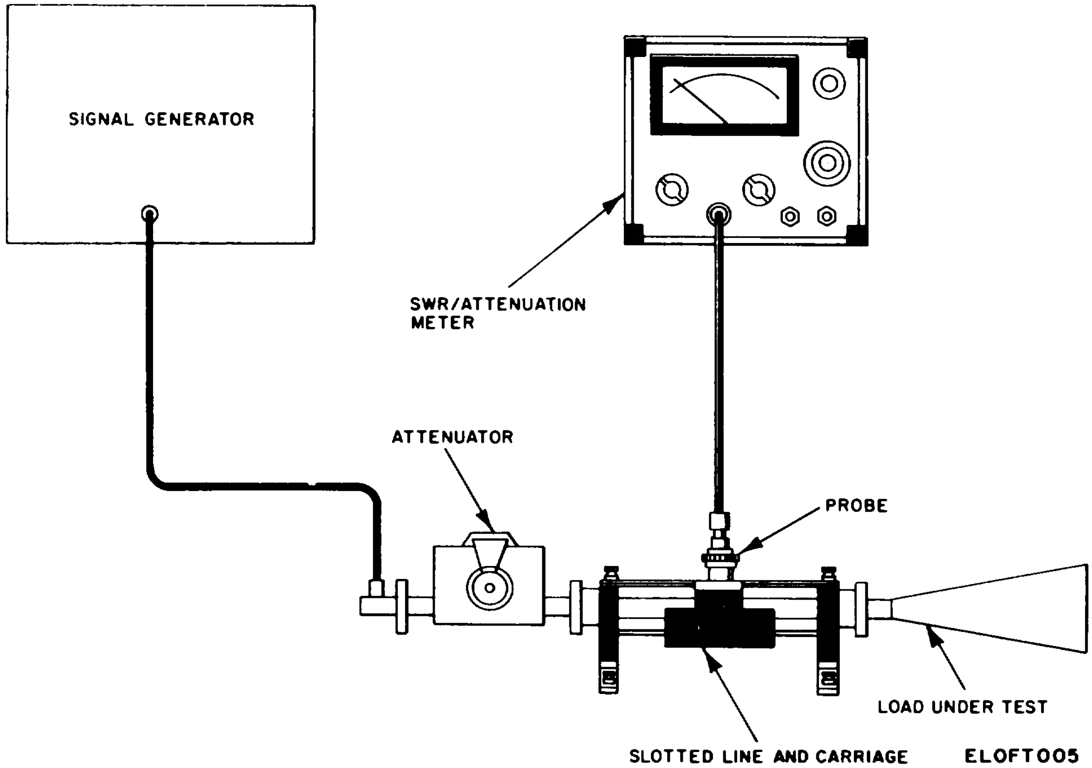


Figure 3-2. Test setup for making VSWR measurements using the slotted line technique

NOTE

To prevent ground loop currents from causing erroneous readings, particularly with low-level signals, keep all instruments in the test setup grounded-with the exception of the SWR Indicator. The input circuits are isolated from power ground and ground loop currents do not normally effect this meter. However, if an output connector on the rear panel (DC OUTPUT OR AMPLIFIER OUTPUT) is grounded by attaching grounded apparatus, then ground loop effects may occur. To detect the presence of these effects connect and disconnect the instrument in question from the SWR Indicator output. If this procedure causes a change in the meter reading, then ground loop effects are present. Ground loops can usually be reduced or eliminated by using either an instrument with a floating input ground or an instrument with a high input impedance (and connecting only the "hot" or signal lead to the SWR Indicator with the power line ground providing the return path). If neither of these type instruments is available, use the highest practical signal level and reduce the SWR Indicator gain to minimize the ground loop effect.

(2) Set the SWR Indicator front-panel controls to the following positions:

(a) POWER switch LINE ON or BATT ON.

(b) COARSE AND FINE GAIN controls-mid-range.

(c) RANGE DB switch 10 DB.

(d) EXPAND switch NORM.

(e) INPUT SELECTOR switch to proper positions for type of detector used.

NOTE

If the front-panel meter is not set at mechanical zero, adjust the mechanical zero-set screw (just below meter) until the meter pointer rests exactly over the 2-db mark of the expanded meter scale. The instrument should be turned off during this procedure.

(3) Energize all other equipment in test setup and allow sufficient time for equipment to warm up and stabilize.

(4) Set the rf signal source for the desired signal frequency with 1,000-hz square-wave modulation (para. 3-3).

(5) Adjust the RANGE DB switch setting and the probe penetration to obtain an on-scale indication on the front-panel meter. If necessary, also adjust GAIN controls.

(6) Move the probe carriage along the slotted line until a maximum indication (maximum deflection to the right) is obtained on the front-panel meter. If necessary, reduce RANGE DB switch or FINE and COARSE GAIN control settings to keep needle indication on scale.

(7) If adjustable, adjust the rf signal source modulation frequency until a maximum indication (maximum deflection to the right) is obtained on the meter. Frequency peaking can also be achieved by adjusting the FREQ adjustment screw on the front panel of the SWR Indicator. If necessary, reduce RANGE DB switch or GAIN control settings to keep needle indication on scale.

NOTE

For most measurements, the BANDWIDTH screwdriver adjustment should be set about mid-range. However, for low signal levels, a narrow bandwidth should be used since this improves the signal-to-noise factor. If the modulation frequency drifts and noise is not a major factor, a wider bandwidth is more desirable.

(8) Adjust the probe insertion for the minimum depth that produces a steady meter indication.

(9) Adjust the COARSE and FINE GAIN controls on the SWR Indicator for a full-scale deflection of the meter needle, i.e., 1.0 VSWR indication on the SWR scale.

NOTE

Do not adjust power output from signal source or GAIN, BANDWIDTH, or FREQ controls on the SWR Indicator during the remainder of this procedure.

(10) Move the probe along the slotted line until a minimum indication (greatest deflection to the left) is obtained on the front-panel meter and read the VSWR directly on its SWR scale. If the meter indication goes off scale, reduce the RANGE DB switch setting by 10 db and read VSWR on the 3.2 to 10) SWR scale, directly below on the meter face.

(11) If the SWR read in step (10) above is less than 3.2 greater reading accuracy can be obtained by using the EXPAND switch. In EXPAND operation, VSWR below 1.25 can be read directly on the EXPAND SWR scale. For VSWR between 1.25 and 3.2 readings are obtained on the EXPAND DB scale calibrated in db; the readings thus obtained have to be converted into VSWR using the formula

$$VSWR = 10^{db/20}$$

or by using the conversion chart in figure 3-3.

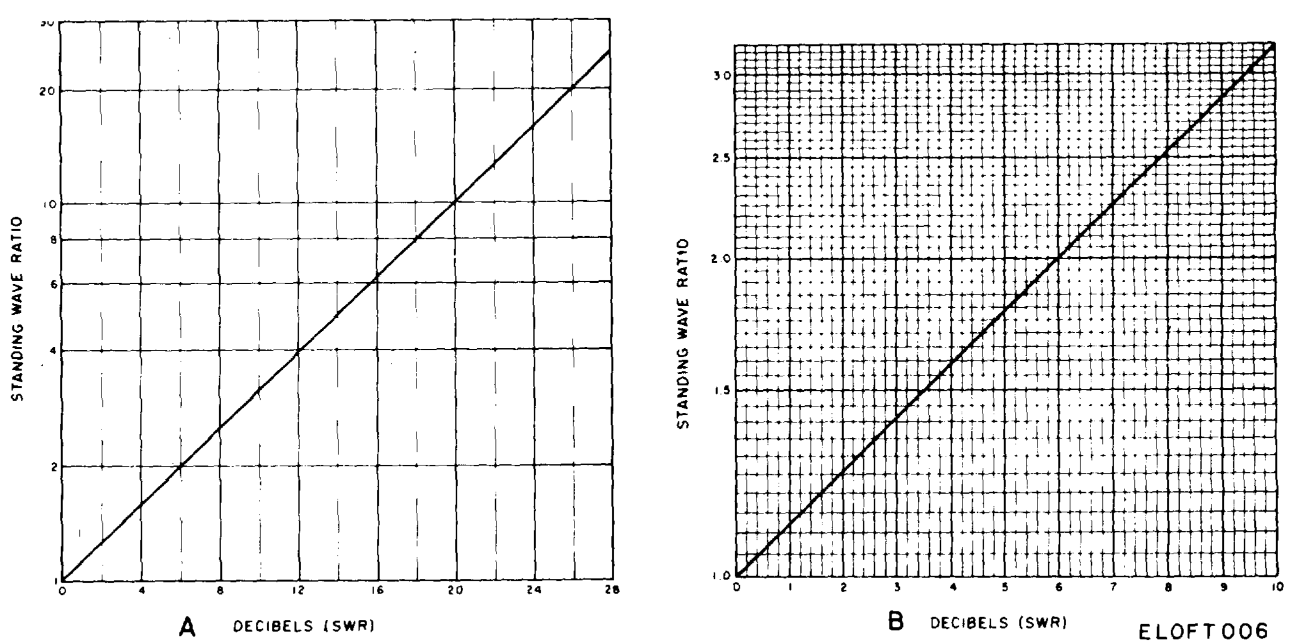


Figure 3-3. Conversion chart decibels (DB) to VSWR.

A. Converting DB to SWR.
B. Expanded section.

(12) If the VSWR reading of step (10) is less than 1.25, set the EXPAND switch to O and read the VSWR

directly on the EXPAND SWR scale.

(13) If the VSWR reading of step (10) is between 1.25 and 3.2 and it is desired to use the EXPAND DB scale and then convert back to VSWR, read the meter indication in db on the 0-10 DB scale. Then set the EXPAND switch to a position which normalizes the proper 2-db segment. Read the meter indication (between 0 and 2 db) on the EXPAND DB scale. The total reading in db is the sum of the EXPAND switch setting and meter indication. To convert this reading to VSWR, use formula of step (11) or the conversion chart in figure 3-3. For example, if meter indication on 0-10 DB scale is 6.2, set EXPAND switch to 6.0 and read 0.2 on EXPAND DB scale. Total reading is 6.0 + 0.2 or 6.2 db which, when converted to VSWR, gives 2.042.

(14) For VSWR readings greater than 10, the meter indication in step (11) will go off scale on the 3.2-to-10 SWR scale. If this occurs, reduce the RANGE DB switch setting by another 10 db (a total reduction of 20 db), read the VSWR on the 1-to-4 SWR scale and multiply each reading by 10.

c. Moderate SWR.

(1) The scales of the SWR Indicator are calibrated for reading standing wave ratio directly from the meter. Set the slotted line probe at a voltage maximum and adjust the gain of the SWR Indicator with the RANGE DB, COARSE, and FINE GAIN controls (EXPAND switch to NORM) for full deflection (1.0 on the 1.0-to-4 SWR scale). Now move the probe toward a minimum. If the meter indication drops below 3.2, rotate the RANGE DB switch one more position clockwise and read on the 3.2-to-10 SWR scale. If the pointer drops below this scale, rotate the RANGE DB switch one more position clockwise, read on the 1.0-to-4 scale, and multiply by 10. This pattern continues for still higher SWR readings.

(2) The db scales can be used for a standing wave ratio measurement by setting the SWR Indicator to a full scale at a voltage maximum, then turning the RANGE DB switch clockwise for an on-scale reading at a voltage minimum and noting the difference in db readings at the maximum and minimum points. A db reading is obtained by adding the RANGE DB switch setting and meter indication.

d. Low SWR. Standing wave ratios between 1.0 and 1.24 can be read quite accurately on the EXPAND scales of the meter when the EXPAND switch is set to any position other than NORM.

e. Moderate SWR High Resolution. The EXPAND and DB scales can be used together with the EXPAND switch to read any SWR with high resolution in db. Figure 3-3 is used to convert db to SWR. The reference level (full-scale meter deflection at a voltage maximum) can be used with the EXPAND switch at NORM (since 0 db NORM and 0 db EXPAND correspond) but greater accuracy is obtained by setting the reference level with the EXPAND switch to 0.

f. High SWR. High standing wave ratios (greater than 30, or sometimes 10) present problems because of excessive probe penetration (to lift the minimum above the noise level) and departure of detector behavior from square law. Both problems are lessened or eliminated by measuring only the standing wave pattern near the voltage minimum, where probe loading effects are least disturbing. Two methods for measuring high SWR are given.

(1) Twice minimum power method. The basis for this method (and the 10 times minimum power method) is the fact that for a high SWR, the standing wave pattern approximates a parabola in the vicinity of a voltage minimum. The slotted line carriage must have a good scale or dial indicator. Measure the distance (ΔX) between positions on the standing wave pattern where the voltage is 3 db above the voltage at the minimum. Also measure the transmission line wavelength λ g (standing wave pattern minima are one-half wavelength apart and the sharp minima resulting from short circuiting the transmission line are easy to locate accurately). Compute the SWR from the following equation:

$$SWR = 1/\pi \ (\lambda g/\Delta X).$$

(2) Ten-times-minimum power method. Another convenient level above minimum method to use for computing SWR is a level 10 db above minimum. The separation (Δ X) between these positions should be put in the following equation:

$$SWR = 3/\pi \ (\lambda \ g/\Delta \ X).$$

For standing wave ratios as low as 15 to 1, the accuracy of this method is within 1% .

3-6. Load Impedance Measurements

a. General. Slotted line techniques provide information to allow calculation of a load impedance. The following rules apply to the indications given by the voltage minimum when the load is replaced by a short. Figure 3-4 summarizes and graphically presents these impedance measurement rules. When the load is replaced by a short, then:

(1) The shift in the minimum is never more than ± 1/4 wavelength.

(2) If the minimum moves toward the load, the load has a capacitive component.

(3) If the minimum moves toward the generator, the load has an inductive component.

(4) If the minimum does not move, the load is completely resistive and has a normalized value of 1/SWR.

(5) If the minimum shifts exactly 1/4 wavelength, the load is completely resistive and has a normalized value equal to the SWR.

(6) The minimum will always be at a multiple of 1/2 wavelength from the load.

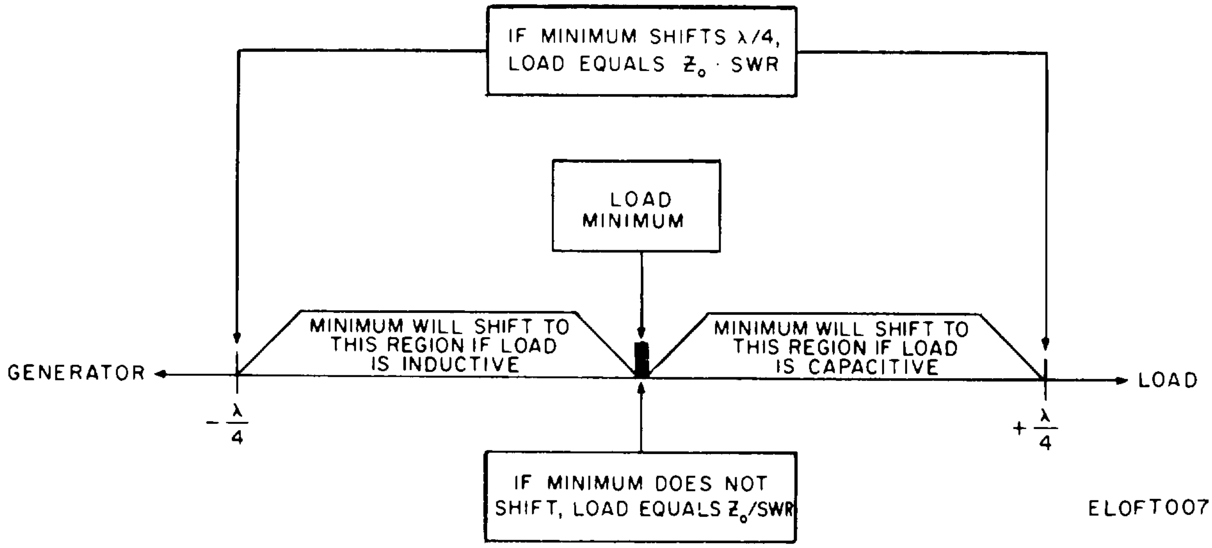


Figure 3-4. Summary of impedance measurement rules

b. Impedance Measurement Procedure. The procedure for performing the actual impedance measurement with a slotted line is as follows:

(1) Connect the load under test to the slotted line section and measure the SWR. Also note the position of the probe carriage at the minimum.

(2) Replace the load under test with a short.

(3) Locate the minimum with the line shorted.

(4) Referring to figure 3-5 and the following equations, compute the normalized load impedance.

$$\text{Normalized } Z_L = \frac{1 - j(\text{SWR}) \tan X}{(\text{SWR}) - j \tan X}$$

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

and: $\Delta \pm$ d = shift in centimeters of the minimum point when the short is used. Δd takes a positive sign (+) if the minimum shifts toward the load. A d takes a negative sign (-) if the minimum shifts toward the generator.

λ g/2 = 1/2 guide wavelength, i.e., the distance in centimets between two adjacent voltage minima.

NOTE

The above calculations are based on the assumption that no losses occur in the transmission line. It is assumed that the characteristic line impedance, Z $_O$, is resistive.

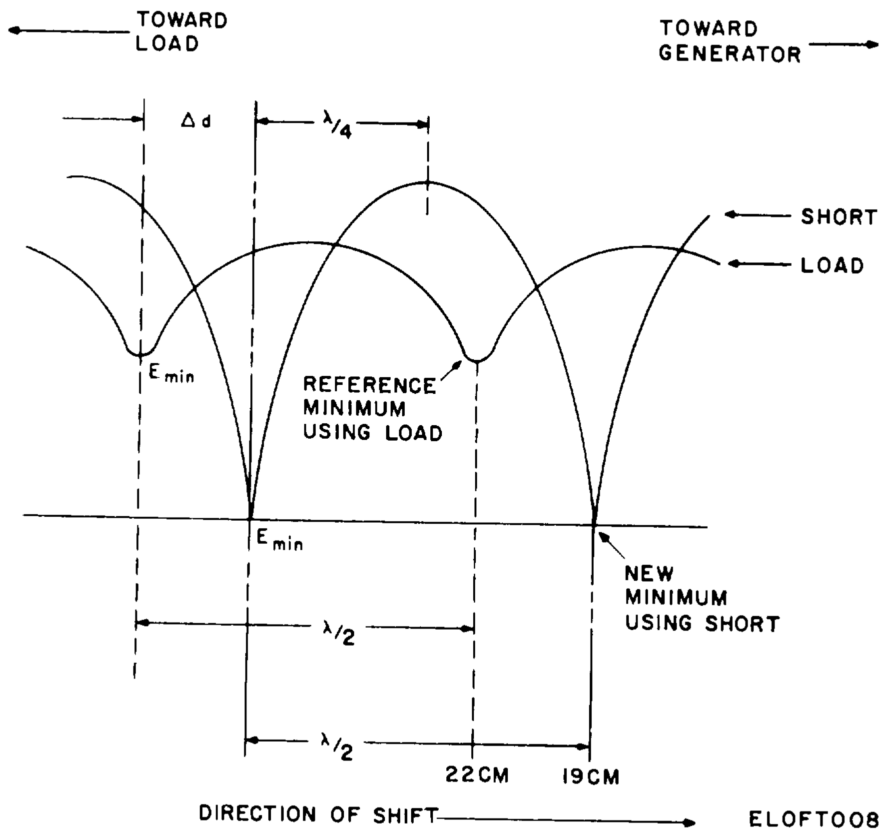


Figure 3-5. Shift of minimum with load and short.

c. Smith Chart Explanation. When data is obtained from a slotted line system, the Smith chart may be used for determining impedance. A Smith chart with an example is shown in figure 3-6. The values of resistance and reactance are based on a normalized value obtained by dividing the actual value by the characteristic impedance, Z_O, of the line. Thus if Z = 5 + 25j ohms and if Z_O = 50 ohms, the Z_N = 0.1 + j0.5. On the Smith chart, the circles which are tangent to the bottom of the chart are for a constant, normalized resistance; lines curving to the right from 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 ratio line.

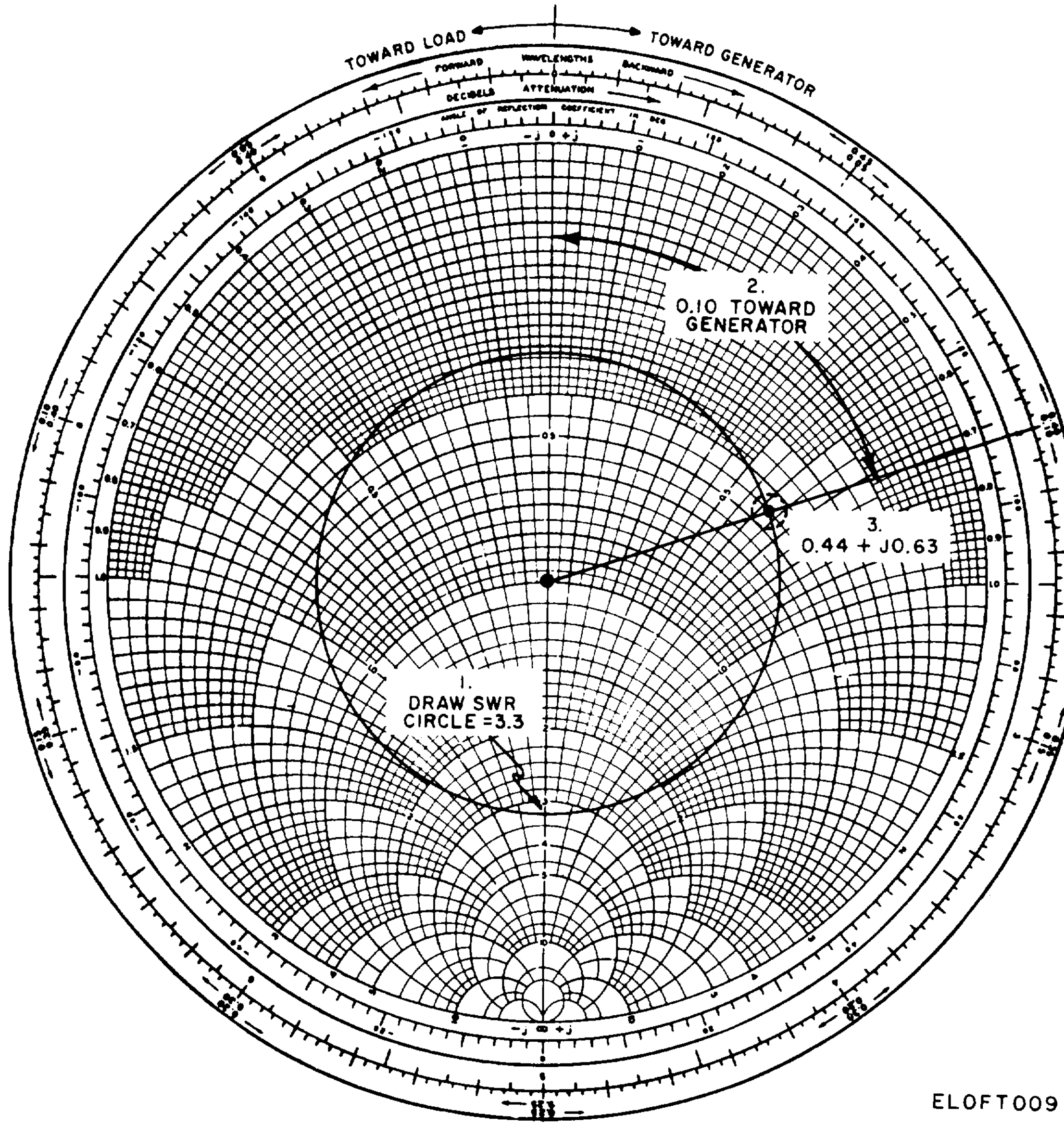


Figure 3-6. Smith Chart

d. Smith Chart Calculations. 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 one suggested here is practical and easy to use.

(1) Determine the guide wavelength, λ g, as explained in paragraph 3-5 *f*(1).

(2) Measure the SWR by the method in either paragraph 3-5*e* or 3-5 *f*(1).

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

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

(5) Calculate the shift of the minimum, in terms of wavelength:

$$\Delta = \frac{\Delta d.}{\lambda g}$$

(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 probe movement noted in step (4) and a distance Δ λ, computed in step (5). Use wavelength scale at the periphery of the Smith chart.

(8) Draw a line from the Δ λ point to the center of the chart.

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

(10) The actual impedance is the product of the normalized impedance from step (9) and Z_O, the line characteristic impedance.

NOTE

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

The following example will clarify the above procedure. Figures 3-5 and 3-6 show the important steps involving the Smith Chart. The assumed characteristic impedance is 50 ohms. The distance between adjacent minima is 15 cm; therefore λg = 30 cm. The SWR is measured as 3.3. A minimum is located at 22 cm. The load is shorted and the minimum shifts from 22 cm to 19 cm, toward the generator.

$$\Delta d = 22 \text{ cm} - 19 \text{ cm} = 3 \text{ cm}$$

$$\Delta\lambda = d/\lambda g = 3 \text{ cm}/30 \text{ cm} = 0.1 \text{ wavelength}$$

(11) The following steps refer directly to figure 3-6.

(a) A circle for SWR = 3.3 is drawn.

(b) A line is drawn from the 0.1 point (toward the generator) to the center of the chart.

(c) The normalized impedance at the intersection of the circle and the line is 0.44 + j0.63.

The impedance of the load (for $Z_O = 50\ \Omega$) is then:

$$50(0.44 + j0.63) = 22 + j31.5 \text{ ohms.}$$

3-7. Operating Procedures for Attenuation Measurements

a. General. Attenuation measurements can be performed by matching the transmission line, after which the SWR Indicator meter is adjusted for full-scale deflection without the unknown attenuator in the RF circuit. The attenuator is then inserted and the attenuation is read directly on the meter in db.

b. Procedures.

(1) Connect equipment as indicated in figure 3-7 and energize all equipment. Allow sufficient time for the equipment to warm up and stabilize.

NOTE

For accurate attenuation measurements, an impedance match must be made between the signal source and the remainder of the test setup.

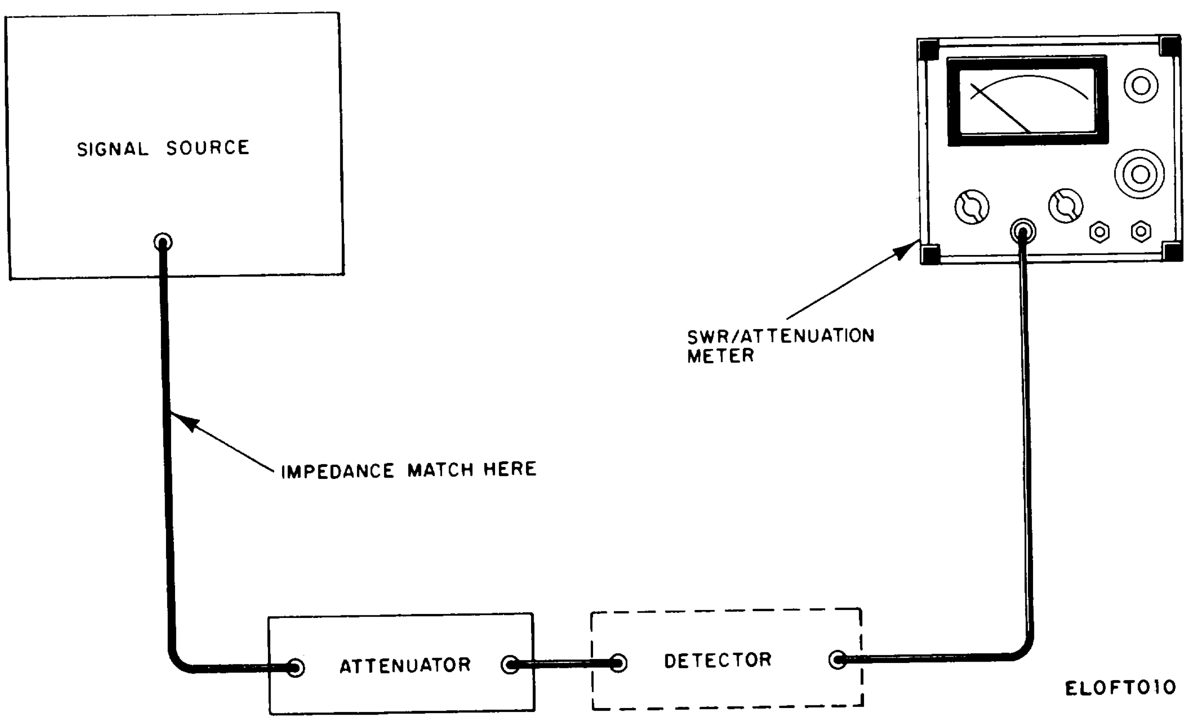


Figure 3-7. Test setup for making attenuation measurements.

(2) With the line properly matched, remove unknown attenuator from the setup and set the SWR Indicator front panel controls as follows:

(a) POWER switch-LINE ON or BATT ON.

(b) RANGE DB switch--30 or other appropriate range setting, depending upon attenuation of unknown.

(c) EXPAND switch-NORM.

(d) INPUT SELECTOR-proper position for type of detector used.

NOTE

If front panel meter is not set at mechanical zero, turn the SWR Indicator off and adjust the zeroing screw until the meter pointer rests exactly over the 2 DB mark of the expanded meter scale.

(3) Setup the rf signal source for the desired signal frequency with 1,000-hz square-wave modulation. Adjust signal source output level for an on-scale indication on the SWR Indicator meter.

(4) If adjustable, adjust the rf signal source modulation frequency until a maximum indication (maximum deflection to the right) is obtained on the meter. Frequency peaking can also be achieved by adjusting the FREQ adjustment screw on the front panel. If necessary, reduce RANGE DB switch or GAIN control settings to keep needle indication on scale.

NOTE

For most measurements, the BANDWIDTH screwdriver adjustment should be set about mid-range. However, for low signal levels, a narrow bandwidth should be used since this improves the signal-to-noise factor. If the modulation frequency drifts, and noise is not a major factor, a wider bandwidth is more desirable.

(5) Adjust the COARSE and FINE GAIN controls for a full-scale indication (0 db reading) on the meter.

NOTE

Do not adjust power output from signal source or GAIN, BANDWIDTH or FREQ controls on the SWR Indicator during the remainder of this procedure.

(6) Insert the unknown attenuator into the test setup and turn the RANGE DB switch clockwise until an on-scale reading is obtained on the 0-10 DB scale of the front-panel meter.

(7) Set the EXPAND switch to the position which selects the 2-db segment of the 0-10 DB scale in which the meter indication of step (6) falls. For example, if reading on 0-10 DB scale is 4 db, set EXPAND switch to 2.

(8) Read the indication on the 0-2 DB scale. The total attenuation of the unknown is the sum of the reading on the 0-2 DB scale, plus the EXPAND switch setting, plus the number of db the RANGE DB switch was turned clockwise in step (6).

3-8. Battery Operation

a. A fully charged battery will provide the SWR Indicator with approximately 36 hours of continuous operation. Twice the operating time has to be allowed for recharge. The battery will not be overcharged when normal charging rates are applied.

CAUTION

Avoid short-circuiting the battery pack terminals. The cells of this battery have a very low internal resistance and will discharge at an extremely high-current level when shorted, resulting in high temperature and possible battery damage.

b. The battery contains individual replaceable cells. If a cell has been replaced, the battery should be charged.

c. The battery can be stored at temperatures of -40° to 120°F, although lower temperatures are preferable. During storage, the battery loses a certain amount of its charge (in direct proportion to the storage temperature). After approximately 90 days in storage, the battery should be charged prior to use. After prolonged storage, the cells may require three to five cycles of charge-discharge to achieve full capacity.

d. While the battery is installed in the instrument, it is charged by setting the POWER selector switch to BATT CHARGE and connecting the line cord to the appropriate primary power source. The LINE/CHARGE indicator should light while the battery is charging. A trickle charge is applied to the battery automatically when the instrument is operating on ac power.

3-9. Additional Applications

SWR Indicator is equipped with outputs which permit applications, in addition to its use as an indicating meter for SWR and attenuation. The instrument can be used as a high-gain amplifier with up to 0.3 volt rms (NORM) or 0.8 volt rms (EXPAND) available across a resistance of at least 10k ohms at the rear panel AMPLIFIER OUTPUT terminals. A DC OUTPUT rear-panel connector provides a means for connection of a recorder for obtaining a permanent record of data. The dc output is 0 to 1 volt with a source impedance of 1,000 ohms.

3-10. Stopping Procedures

Follow the steps below after operating procedures have been completed.

a. Turn POWER selector switch to OFF position and disconnect power cord from primary power source.

b. Deenergize all equipment used with the SWR Indicator and disconnect appropriately.

c. Disassemble carriage and slotted section and replace in AN/USM-37E case.

d. Carefully place all components of the AN/USM-37E in the case and secure the latches.

Section III. OPERATION UNDER UNUSUAL CONDITIONS AND PREPARATION FOR MOVEMENT

3-11. Operation in Arctic Climates

Subzero temperatures and climatic conditions associated with cold weather may hamper the efficient operation of electronic equipment. Instructions and precautions for operation under such conditions follow:

a. Keep the equipment warm and dry. If the equipment is not kept in a heated enclosure, construct an insulated box for its protection.

b. Make certain the equipment has been warmed up sufficiently before use. The set may need several minutes to warm up depending on the temperature of the surrounding air.

c. When equipment which has been exposed to the cold is brought into a warm room, it will sweat until it reaches room temperature. When the equipment has reached room temperature dry it thoroughly.

3-12. Operation in Desert Climates

The main problem with electronic equipment in desert areas is the large amount of sand and dust that lodges in the moving parts and mechanical assemblies. Cleaning and servicing intervals should be shortened according to local conditions.

3-13. Operation in Tropical Climates

In tropical climates, electronic equipment may be installed in tents, huts, or, when necessary, in underground dugouts. When equipment is installed below ground, and when it is set up in swamp areas, danger of moisture damage is more acute than normal in the tropics. Ventilation is usually very poor, and the high relative humidity causes condensation on the equipment whenever its temperature becomes lower than the ambient air. To counteract this condition, place lighted electric bulbs under the equipment.

3-14. Repacking Instructions

NOTE

The components of the AN/USM-37E are extremely delicate and have been machined to critical tolerances. Prepare the AN/USM-37E for storage or transmit as follows:

a. Place each component in its respective slot in the transit case before moving.

b. Secure the latches and tighten the screw on the case cover to seal.

c. Refer to figure 2-2 if shipment of the equipment is required.

CHAPTER 4

ORGANIZATIONAL MAINTENANCE INSTRUCTIONS

Section I. PREVENTIVE MAINTENANCE CHECKS AND SERVICES

4-1. General

a. To insure that the AN/USM-37E 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 in table 4-1 through 4-3. The item numbers indicate the sequence of and 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 which would damage the equipment. Record all deficiencies, together with the corrective action taken, in accordance with TM 38-750.

b. The preventive maintenance checks and services are performed by the organizational repairman to insure proper operation of the equipment.

4-2. Tools and Equipment

Tools and equipment required for organizational maintenance are listed in Appendix C (Maintenance Allocation).

Table 4-1. Operator's preventive maintenance checks and services

D-Daily
Time required: 0.5

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 meter face for scratches. (para 4-4)	0.1
3	CONNECTORS	
	Check the tightness of all connectors. (para 4-3)	
4	CONTROLS AND INDICATORS	
	While making the operating checks (item 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 loose. ness.	
5	OPERATION	
	During operation be alert for any unusual performance or condition.	0.3

Table 4-2. Organizational preventive maintenance checks and services.

W-Weekly
Time required: 0.6

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	CABLES	
	Inspect cords, cables, and wires for chafted, cracked, or frayed insulation. Replace connectors that are broken, stripped or worn excessively.	0.1
2	JACKS	
	Inspect jacks for snug fit and good contact.	0.1
3	HANDLES AND LATCHES	
	Inspect handles and latches for looseness. Tighten or replace as necessary.	0.1
4	METAL SURFACES	
	Inspect metal surfaces for rust and corrosion. Touchup paint as necessary. (par 4-6)	0.3

Table 4-3. Organizational preventive maintenance checks and services.

Q-Quarterly
Time required: 0.3

Sequence number	Item to be Inspected Procedure	Work time (T/H)
1	PUBLICATIONS	
	See that all publications are complete, serviceable, and current.	0.1
2	MODIFICATIONS	
	Check DA Pam 310-7 to determine if new applicable MWO's have been published. All URGENT MWO's must be applied immediately. All NORMAL MWO's must be scheduled.	0.1
3	SPARE PARTS	
	Check all spare parts for general condition and method of storage. There should be no evidence of overstock, and all shortages must be on valid requisitions.	0.1

Section II. TROUBLESHOOTING AND MAINTENANCE OF THE AN/USM-37E

4-3. Visual Inspection

a. When the equipment fails to perform properly, visually check all the items listed below. Do not check fuses with power on.

(1) Power connection.

(2) Setting of the switches and the controls.

(3) Burned out fuses (usually indicates some other fault).

(4) The cables and connections.

(5) Meter for evidence of sticking by tapping the meter.

b. If the above checks do not locate the faults, higher category maintenance is indicated.

4-4. Cleaning

Inspect the exterior of the AN/USM-37E. The exterior surfaces must be free of dirt, grease, and fungus.

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

b. Remove grease, fungus, and ground-in-dirt from the case and cover with a cloth dampened (not wet) with trichlorotrifluoroethane.

c. Remove dirt or dust from jacks with a soft brush.

d. Clean the front panel meter face and controls with water, or for more effective cleaning, use a mild detergent.

CAUTION

To protect the glass, do not apply heavy pressure when cleaning the meter.

WARNING

Adequate ventilation should be provided while using TRICHLOROTRIFLUOROETHANE. Prolonged breathing of vapor should be avoided. The solvent should not be used near heat or open flame; the products of decomposition are toxic and irritating. Since TRICHLOROTRIFLUOROETHANE dissolves natural oils, prolonged contact with skin should be avoided. When necessary, use gloves which the solvent cannot penetrate. If the solvent is taken internally, consult a physician immediately.

e. Clean all cables and power cord with a clean, soft cloth.

4-5. Paints and Finishes

When the AN/USM-37E requires repainting, refinishing, or touchup painting, refer to Federal Standard No. 595a for a matching color. SB 11-573 lists painting 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 surface may not be possible. There are many reasons for this, such as a change in the original pigment because of oxidation and differences as a result of manufacture. The prevention of corrosion and deterioration is the most important consideration in touchup painting; appearance is secondary. This, however, should not be construed to mean that appearance of the equipment is not important. Touchup paint should be accomplished neatly and in a skillful manner. Inspection personnel in the field should make allowances for slight color mismatch where minor touchup has been done, but not for neglect, poor quality of work, or in cases where the need for refinishing is obvious.

b. Remove rust and corrosion from metal surfaces by lightly sanding them with fine sandpaper. Brush two thin coats of paint on the bare metal to protect it from further corrosion.

CHAPTER 5

MATERIEL USED IN CONJUNCTION WITH MAJOR ITEM

5-1. General

The SWR Indicator may be used to measure VSWR measurements between 10 MHz and 2.3 GHz by utilizing a Standing Wave Detector instead of a slotted line and probe. When measuring VSWR using a Standing Wave Detector, a 1,000 Hz modulated test signal is applied to the unknown load. The frequency dial of the Standing Wave Detector is set to correspond with the test signal frequency. The probe knob of the Standing Wave Detector is adjusted to produce a maximum indication on the SWR Indicator. At this point the meter is set for full scale deflection (VSWR = 1). The probe knob is then turned to produce a minimum indication on the SWR Indicator, at which point the VSWR is read directly on the SWR scale of the meter.

5-2. Operational Procedures for Making VSWR Measurements Using the Standing Wave Detector Technique

When measuring VSWR between 10 MHz and 2.3 GHz, proceed as follows:

a. Connect the test equipment as indicated in figure 5-1. Typical equipment covering the frequency range from 10 MHz to 2.3 GHz is listed in table 5-1.

NOTE

To prevent ground loop currents from causing erroneous readings, particularly with low-level signals, keep all equipment in the test setup grounded with the exception of the SWR Indicator. The meter input circuits are isolated from power ground and ground loop currents do not ordinarily affect the SWR Indicator. However, if an output connector on the rear panel (DC OUTPUT or AMPLIFIER OUTPUT) is grounded by attaching grounding apparatus then ground loop effects may occur. To detect ground loop effects disconnect the equipment in question from the SWR Indicator output. If this procedure causes a change in meter reading, ground loop effects are present. Use an instrument with either a floating input ground or a high input impedance (and connecting only the "hot" signal lead to the SWR Indicator with the power line ground providing the return path). If these types of equipment are not available, reduce the SWR gain to minimize ground loop effect.

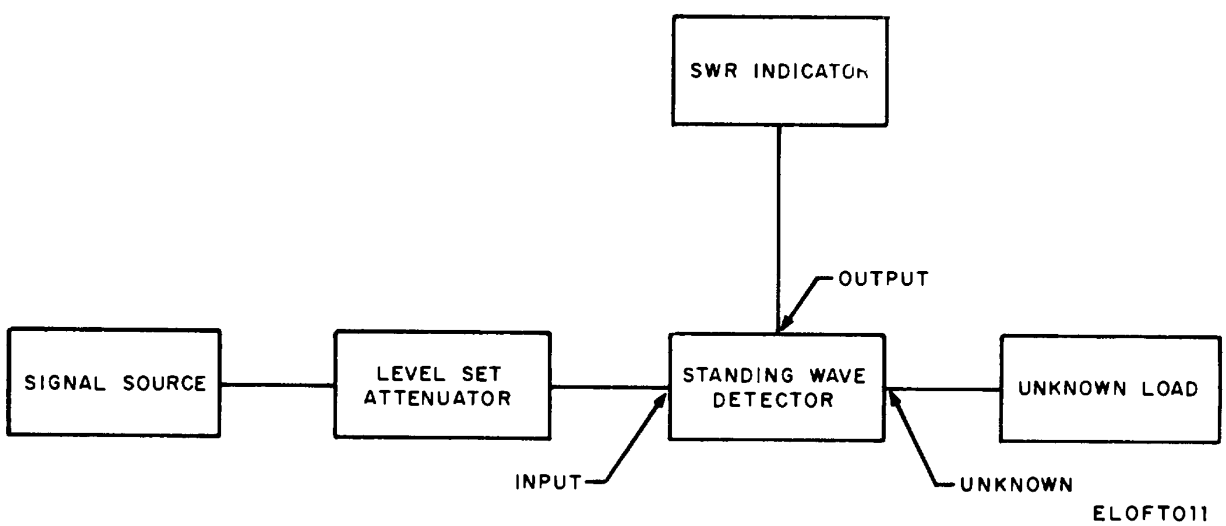


Figure 5-1. Test setup for making VSWR measurements using the standing wave detector technique.

b. Set the SWR Indicator front-panel controls as follows:

(1) POWER switch-LINE or BATT ON
(2) COARSE and FINE GAIN controls-mid-range
(3) RANGE DB switch-10 DB
(4) EXPAND switch-NORM
(5) INPUT SELECTOR-XTAL HIGH

Table 5-1. Equipment required for VSWR measurements Using the standing wave detector technique

Frequency Range in MHz	10-50	50-100	100-250	250-960	960-2300
Signal Source	GR 1211-C	GR 1215-C	GR 1215-C	GR 1209-C	PRD L712A
Filter	LC	LC	LC	PRD 587A	PRD 578B
Standing Wave Detector	PRD 2219-L	PRD 2219-L	PRD 2219-M	PRD 2219-M	PRD 2219-H
SWR Indicator	IM-157E/U	IM-157E/U	IM-157E/U	IM-157E/U	IM-157E/U

NOTE

If the front-panel meter is not set at mechanical zero, adjust the mechanical zero-set screw (just below the meter) until the meter pointer rests exactly over the 2 db mark of the expanded meter scale. The instrument should be turned off during this procedure.

c. Energize the RF signal source and allow sufficient time for the equipment to warm-up and stabilize.

d. Set the rf signal source to the desired frequency with 1,000-hz square-wave modulation.

e. Set the Standing Wave Detector to the same frequency generated by the rf signal source.

f. Adjust RANGE DB switch on the SWR Indicator for an on-scale indication on front-panel meter. If necessary, also adjust GAIN controls.

g. Adjust front-panel FREQ adjustment for peak indication on meter. If necessary, reduce RANGE DB switch or GAIN control settings to keep needle indication on scale.

h. Rotate the probe knob on the Standing Wave Detector until a maximum indication (maximum deflection to the right) is obtained on the meter of the SWR Indicator.

i. If adjustable, adjust the rf signal source modulation frequency until a maximum indication (maximum deflection to the right) is obtained on the meter. Frequency peaking can also be achieved by adjusting the FREQ adjustment screw on the front panel of the SWR Indicator. If necessary, reduce RANGE DB switch or GAIN control settings to keep needle indication on scale.

NOTE

For most measurements, the BANDWIDTH screwdriver adjustment should be set about mid-range. However, for low signal levels, a narrow bandwidth should be used since this improves the signal-to-noise factor. If the modulation frequency drifts, and noise is not a major factor, a wider bandwidth is more desirable.

j. Adjust the COARSE and FINE GAIN controls on the SWR Indicator for a full-scale deflection of the needle, i.e., 1.0 VSWR on SWR scale.

NOTE

Do not adjust power output from signal source or GAIN, BANDWIDTH, or FREQ controls on the SWR Indicator during the remainder of this procedure.

k. Rotate the probe knob until a minimum indication (maximum deflection on the left) is obtained on the SWR Indicator meter and read the VSWR directly on its SWR scale. If the meter indication goes off scale, reduce the RANGE DB switch setting by 10 db and read VSWR on the 3.2-to-10 SWR scale, directly below on the meter face.

l. If the SWR read in step k above is less than 3.2, greater reading accuracy can be obtained by using the EXPAND switch. In EXPAND operation, VSWR below 1.25 can be read directly on the EXPAND SWR scale. For VSWR between 1.25 and 3.2, readings are obtained on the EXPAND DB scale calibrated in db; the readings thus obtained have to be converted into VSWR using the formula

$$\text{VSWR} = 10^{\text{db}/20}$$

or by using the conversion chart in figure 3-3.

m. If the VSWR reading of step k is less than 1.25, set the EXPAND switch to 0.0 and read the VSWR directly on the EXPAND SWR scale.

n. If the VSWR reading of step k is between 1.25 and 3.2 and it is desired to use the EXPAND DB scale and then convert back to VSWR, read meter indication in db on the 0-10 DB scale. Then set the EXPAND switch to a position which normalizes the proper 2-db segment. Read the meter indication (between 0 and 2 db) on the EXPAND DB scale. The total reading in db is the sum of the EXPAND switch setting and the meter indication. To convert this reading to VSWR, use formula of step I or the conversion chart in figure 3-3. For example, if meter indication on 0-10 DB scale is 6.2, set EXPAND switch to 6.0 and read 0.2 on EXPAND DB scale. Total reading is 6.0 + 0.2 or 6.2 db which, when converted to VSWR, gives 2.042.

o. For VSWR readings greater than 10, the meter indication in step k will go off scale on the 3.2-to-10 SWR scale. If this occurs, reduce the RANGE DB switch setting by another 10 db (a total reduction of 20 db), read the VSWR on the 1-to-4 SWR scale and multiply each reading by 10.

APPENDIX A

REFERENCES

DA PAM 310-1	Consolidated Index of Army Publications and Blank Forms.
SB 11-573	Painting and Preservation Supplies Available for Field Use for Electronics Command Equipment.
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 B

COMPONENTS OF END ITEM AND BASIC ISSUE ITEMS LIST

SECTION I. INTRODUCTION

B-1. SCOPE

This appendix lists components of end item and basic issue items for the AN/USM-37E to help you inventory items required for safe and efficient operation.

B-2. GENERAL

The Components of End Item and Basic Issue Items Lists are divided into the following sections:

a. Section II. Components of End Item. This listing is for informational purposes only, and is not authority to requisition replacements. These items are part of the end item, but are removed and separately packaged for transportation or shipment. As part of the end item, these items must be with the end item whenever it is issued or transferred between property accounts. Illustrations are furnished to assist you in identifying the items.

b. Section III. Basic Issue Items. These are the minimum essential items required to place the AN/USM-37E in operation, to operate it, and to perform emergency repairs. Although shipped separately packaged BII must be with the AN/USM-37E during operation and whenever it is transferred between property accounts. The illustrations will assist you with hard-to-identify items. This manual is your authority to request/requisition replacement BII, based on TOE/MTOE authorization of the end item.

B-3. EXPLANATION OF COLUMNS

The following provides an explanation of columns found in the tabular listings:

a. Column (1) - Illustration Number (Illus Number). This column indicates the number of the illustration in which the item is shown.

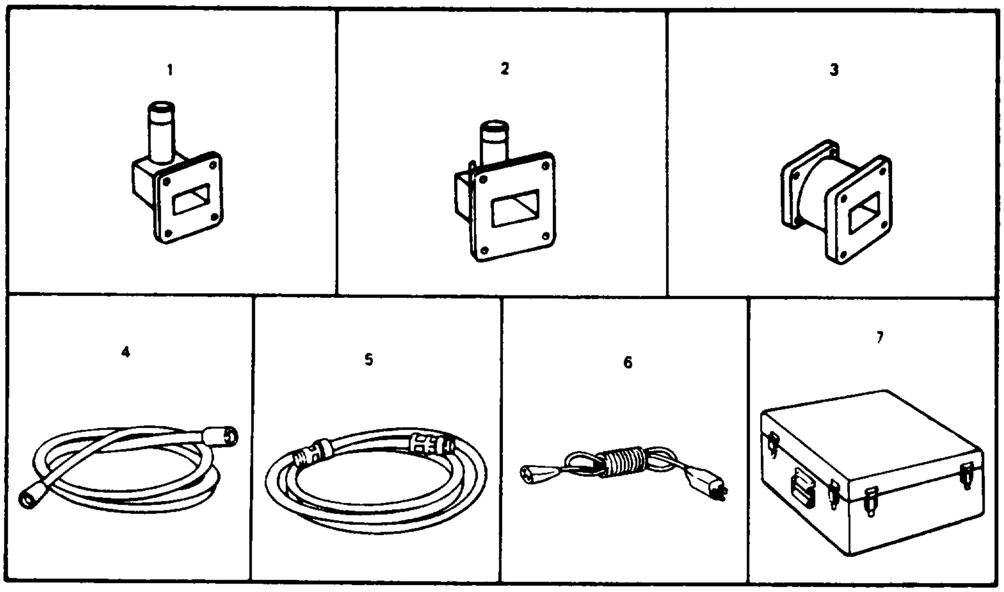
b. Column (2) - National Stock Number. Indicates the National stock number assigned to the item and will be used for requisitioning purposes.

SECTION I. INTRODUCTION - CONTINUED

c. Column (3) - Description. Indicates the National item name and, if required, a minimum description to identify and locate the item. The last line for each item indicates the FSCM (in parentheses) followed by the part number.

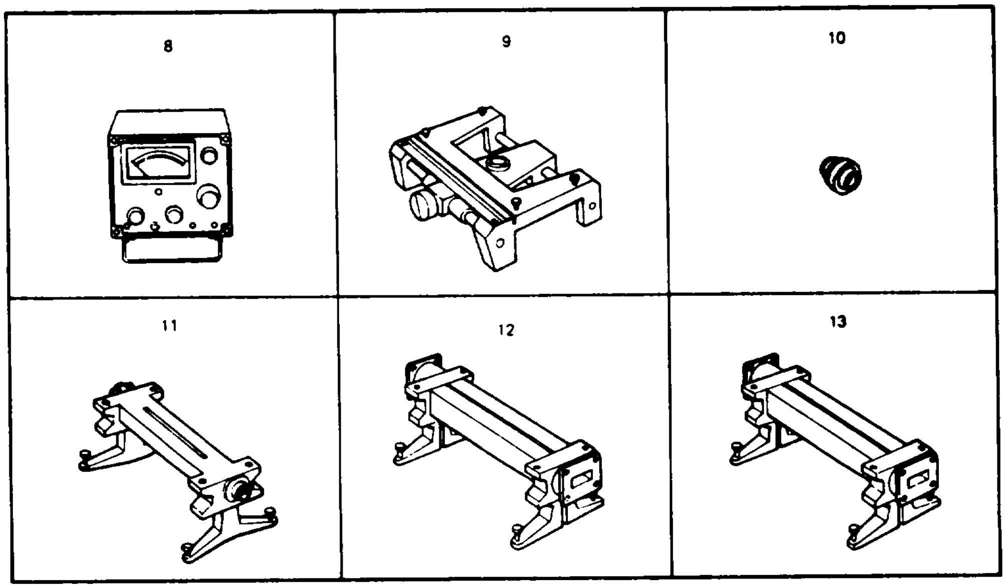
d. Column (4) - Unit of Measure (U/M). Indicates the measure used in performing the actual operational/maintenance function. This measure is expressed by a two-character alphabetical abbreviation (eg., ea., in, pr).

e. Column (5) - Quantity required (Qty rqr). Indicates the quantity of the item authorized to be used with/on the equipment.



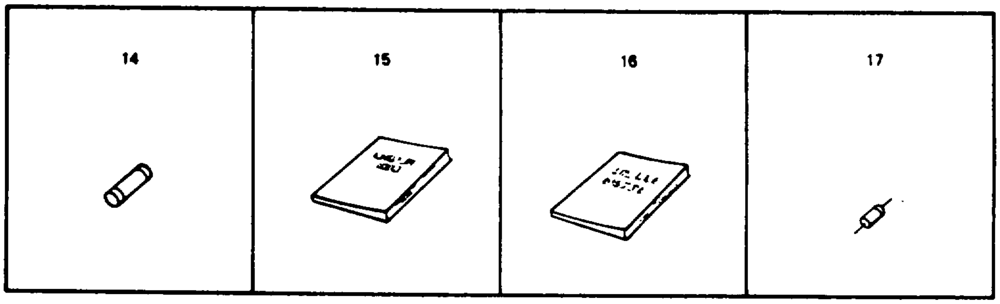
SECTION II. COMPONENTS OF END ITEM

(1) ILLUS NO.	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION (FSCM) AND PART NUMBER / USABLE ON CODE	(4) U/M	(5) QTY REQD
1		ADAPTER, WAVEGUIDE: (in measuring set case) (80058) UG-1053A/U	EA	1
2	5985-00-264-9212	ADAPTER, WAVEGUIDE (in measuring set case) (80058) UG-1054/U	EA	1
3		ADAPTER, H-BAND TO X-BAND WAVEGUIDES (in measuring set case) (80058) UG-1389/U	EA	1
4	5995-00-463-4066	CABLE ASSEMBLY, RADIO FREQUENCY (in measuring set case) (80058) CG-1963/U	EA	1
5	5995-00-470-4339	CABLE ASSEMBLY, RADIO FREQUENCY (in measuring set case) (80058) CG-2651/U	EA	1
6		CABLE ASSEMBLY, POWER (in measuring set case) (16428) 17258	EA	1
7	6625-00-484-8655	CASE, MEASURING SET (80058) CY-6873USM37E	EA	1



SECTION II. COMPONENTS OF END ITEM

(1) ILLUS NO.	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION (FSCM) AND PART NUMBER	USABLE ON CODE	(4) U/M	(5) QTY REQD
8	6625-00-484-8654	INDICATOR, STANDING WAVE RATIO (in measuring set case (80058) IM157E/U		EA	1
9	6625-00-230-3832	PROBE, CARRIAGE (in measuring set case) EA (80058) MX8355USM37E		1	
10	6625-00-581-5802	PROBE, WAVEGUIDE (in measuring set case) (80058) MX1546USM37		EA	1
11	6625-00-484-8656	SLOTTED SECTION, COAXIAL. (in measuring set case) (80058) IM214/USM37E		EA	1
12	6625-00-484-8657	SLOTTED SECTION, WAVEGUIDE (In measuring set case) (80058) IM215USM37E		EA	1
13	6625-00-484-8658	SLOTTED SECTION, WAVEGUIDE (in measuring set case) (80068) IM216USM37E		EA	1



SECTION III. BASIC ISSUE ITEMS

(1) ILLUS NO.	(2) NATIONAL STOCK NUMBER	(3) DESCRIPTION (FSCM) AND PART NUMBER	USABLE ON CODE	(4) U/M	(5) QTY REQD
14	5920-00-080-2558	FUSE, CARTRIDGE: (75915) 313.062		EA	1
15		OPERATING AND MAINTENANCE INSTRUCTIONS FOR SWR/ATTENUATION METER PRD TYPE 277-D, PUBLICATION STOCK NO. 89996300		EA	1
16	6625-00-197-6910	OPERATOR AND ORGANIZATIONAL MAINTENANCE MANUAL FOR MEASURING SET, STANDING WAVE RATIO AN/USM-37E. TM 11-6625-369-12-1		EA	1
17	5961-00-390-5222	SEMICONDUCTOR DEVICE, DIODE: (81349) JAN1N76		EA	1

APPENDIX C
MAINTENANCE ALLOCATION

Section I. INTRODUCTION

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.

2. Maintenance Functions

Maintenance functions will be limited to and defined as follows:

a. Inspect. 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 incipient failure by measuring the mechanical or electrical characteristics of an item and comparing those characteristics 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/lubricants/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 instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in 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 equivalent/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, riveting, straightening, facing, remachining, or resurfacing) to restore serviceability to an item by correcting specific damage, fault, malfunction, or 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) in 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 equipment/components.

3. Column Entries

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

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

c. *Column 3, Maintenance Functions.* Column 3 lists the functions to be performed on the item listed in 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 maintenance authorized to perform the function listed in column 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 time, 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.

4. Tool and Test Equipment Requirements (Section III)

a. *Tool or Test Equipment Reference Code.* The numbers in this column coincide 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
MEASURING SET, STANDING WAVE RATIO, AN/U&S-37E

(1) GROUP NUMBER	(2) COMPONENT ASSEMBLY	(3) MAINTENANCE FUNCTION	(4) MAINTENANCE CATEGORY C	O	F	H	D	(6) TOOLS AND EQUIPMENT
00	MEASURING SET, STANDING WAVE RATIO AN/USM-37E	Inspect		0.5				Visual, 14
		Test				1.0		2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
		Adjust				1.0		2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
		Repair				1.0		2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
		Overhaul					2.0	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
01	Indicator, Standing Wave Ratio IM-157E/U	Inspect		0.5				Visual, 14
		Test				1.0		2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
		Repair				1.0		2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
		Overhaul					2.0	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
02	Case Measuring Set CY-6873/USM-37E	Inspect				0.5		
		Repair				0.5		12
03	Probe, Waveguide MX-1546/U9S37	Inspect				0.5		
		Test				0.5		1, 13
		Repair				0.5		12
04	Cable Assembly, Radio Frequency, CG-1963/U	Inspect				0.5		
		Repair				0.5		12
05	Cable Assembly Radio Frequency, CG-2651/U	Inspect				0.5		12
		Repair				0.5		12
06	Slotted Section, Coaxial IM-214/USM-37E	Inspect				0.5		
		Replace				0.5		12
07	Carriage, Slotted Line Coaxial Waveguide MX:-8355/USM-37E	Inspect				0.5		
		Replace				0.5		12
08	Adapter, Waveguide UG-1389/U	Inspect				0.5		
		Replace				0.5		12
09	Slotted Section, Waveguide IM-215/ USM-37E	Inspect				0.5		
		Replace				0.5		12
010	Slotted Section, Waveguide IM-216/ USM-37E	Inspect				0.5		
		Replace				0.5		12

SECTION III. TOOL AND TEST EQUIPMENT REQUIREMENTS
FOR
MEASURING SET, STANDING WAVE RATIO AN/USM-37E

TOOL OR TEST EQUIPMENT REF CODE	MAINTENANCE CATEGORY	NOMENCLATURE	NATIONAL/NATO STOCK NUMBER	TOOL NUMBER
1	E, 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/USM-207	6625-00-911-6368	
4	H, D	ATTENUATOR - CN-970/U	5895-00-993-1377	
5	H, D	ATTENUATOR - CN-1128/U	5895-00-957-1860	
6	H, D	VOLTMETER, ELECTRONIC - ME-202/U	6625-00-709-0288	
7	H, D	OSCILLOSCOPE, AN/USM-281C	6625-00-106-9622	
8	H, D	GENERATOR, SIGNAL - AN/USM-205	6625-00-788-9672	
9	H, D	VOLTMETER - TS-352B/U	6625-00-553-0142	
10	H, D	TRANSFORMER, VARIABLE POWER - CN-16/U	5950-00-688-5722	
11	H, D	TRANSISTOR TEST SET - TS-1836C/U	6625-00-159-2263	
12	H, D	TOOL KIT - TK-100/G	5180-00-605-0079	
13	H, D	DUMMY LOAD, ELECTRICAL DA-75/U	6625-00-177-1639	
14	O	TOOLS AND TEST EQUIPMENT AVAILABLE TO THE ORGANIZATIONAL TECHNICIAN BECAUSE OF HIS/HER ASSIGNED MISSION		

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Sig Dep (1)
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Units org under fol TOE:
(1 cy each unit)
11-16
11-97
11-117
11-500(AA-AC)
32-56
32-57

NG: None
USAR: None
For explanation of abbreviation used, see AR 310-50.

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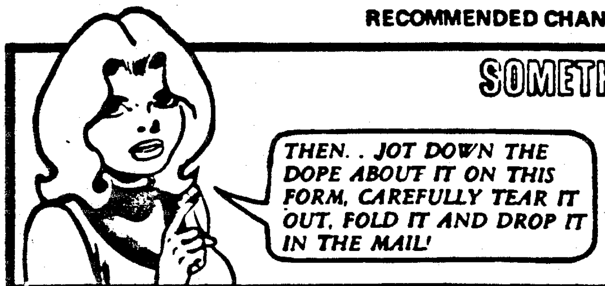

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