INTERIM
INSTRUCTION BOOK
FOR
RADIO FREQUENCY
WATTMETER
TS-118A/AP

693

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LIST OF ILLUSTRATIONS

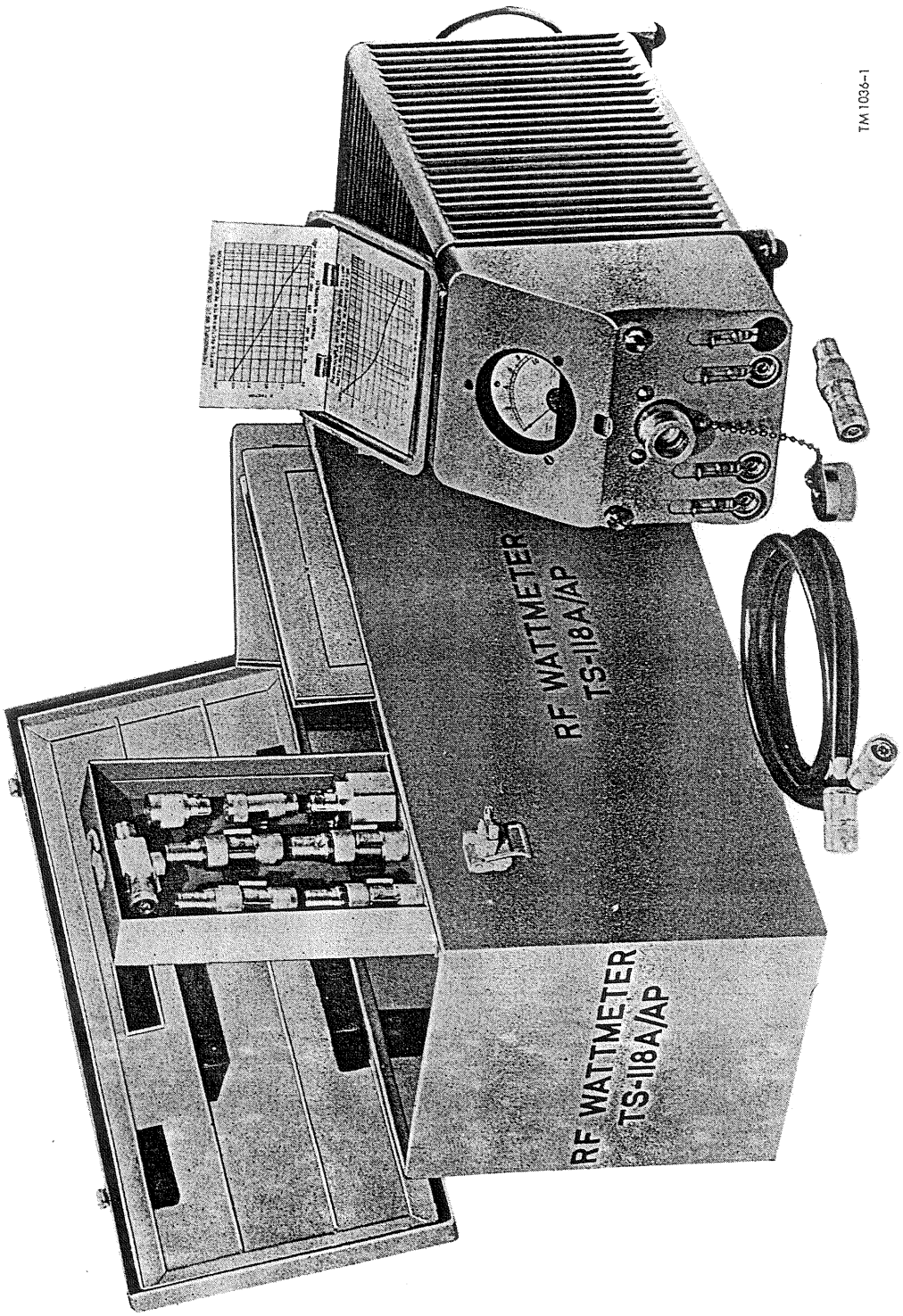

Figure 1. RF Wattmeter TS-118A/AP (photograph)

Chapter I
INTRODUCTION

Section I. GENERAL

1. SCOPE

This instruction book covers the installation, theory, operation and maintenance and repair of RF Wattmeter TS-118A/AP, shown in photograph, Fig. 1.

2. FORMS AND RECORDS

The following forms will be used for reporting unsatisfactory conditions of Army material and equipment.

a. DD Form 6, Report of Damaged or Improper Shipment, will be filled out and forwarded as prescribed in SR 745-45-5 (Army), NAV DEPT SERIAL 85 POO (Navy), and AFR 71-4 (Air Force).

b. DA AGO Form 468, Unsatisfactory Equipment Report, will be filled out and forwarded to the Office of the Chief Signal Officer as prescribed in SR 700-45-5.

c. USAF Form 54, Unsatisfactory Report, will be filled out and forwarded to Commanding General, Air Material Command, Wright-Patterson Air Force Base, Dayton, Ohio, as prescribed in SR700-45-5 and AFR 65-26.

d. DA AGO Form 11-238, Operator First Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form.

e. DA AGO Form 11-239, Second and Third Echelon Maintenance Check List for Signal Corps Equipment (Radio Communication, Direction Finding, Carrier, Radar), will be prepared in accordance with instructions on the back of the form.

f. Use other forms and records as authorized.

Section II. DESCRIPTION AND DATA

3. PURPOSE AND USE

Radio Frequency Wattmeter TS-118A/AP is a portable load-resistor type absorption wattmeter for measuring radio frequency power within the frequency range of 20 to 1400 megacylces per second. The wattmeter is used with a selected thermocouple for making power measurements (determined by means of readings on the millivoltmeter dial) and to facilitate the tuning of transmitters, or may be used without thermocouples as a dummy antenna. In either capacity, the radio transmitter may be operated without radiating energy into space.

4. TECHNICAL CHARACTERISTICS

Frequency Range	20 to 1400 megacycles/second
Power	2 to 500 watts
Circuit Impedance	Coaxial - 50 ohms Nominal
Type of Modulation	CW, AM or FM - Measures average power
Accuracy	±15% of absolute

5. PACKAGING DATA

When packaged for export, RF Wattmeter TS-118A/AP unit and all components of the equipment are placed in the waterproof Transit Case CY-1764/UPM with ample supply of desiccant. This case seals by means of four spring loaded latches at the sides. The Transit Case is nested (with cardboard filler at top and bottom and all sides) in a packing carton fully sealed with Kraft gummed tape. This carton is heat sealed in a waterproof-vaporproof barrier qualified for Class B protection and placed in another carton which is sealed at open seams with pressure sensitive tape. The package is then placed in an approved wooden shipping box and bound with two steel binding straps. Exploded view of this packaging is illustrated in Fig. 2.

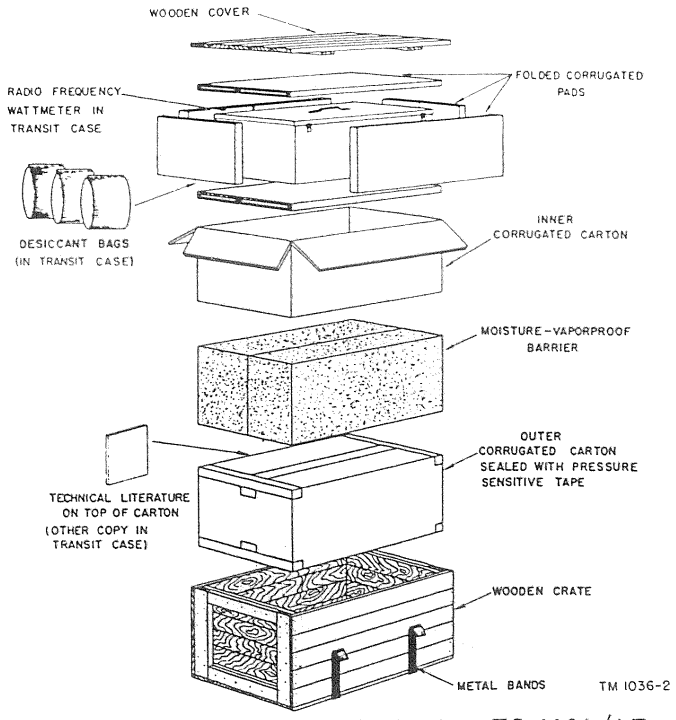

Figure 2. Packing and Packaging, TS-118A/AP

6. TABLE OF COMPONENTS

Component	Req. No.	Length (in.)	Width (in.)	Height (in.)	Volume (cu.ft.)	Weight (lbs.)
RF Wattmeter TS-118A/AP	1	20-13/16	5-15/16	8-3/4	.63	27.5
Thermocouple	8					
MX-1785/U		2-7/8	7/8 D	-	-	4 oz.
MX-1781/U		2-7/8	7/8 D	-	-	4 oz.
MX-1782/U		2-7/8	7/8 D	-	-	4 oz.
MX-1783/U		2-7/8	7/8 D	-	-	4 oz.
RF Adapter UG-999A/U	1	2-1/2	Hex	1-1/2	-	7 oz.
RF Adapter UG-83/U	1	1-3/4	3/4 D	-	-	2 oz.
RF Adapter UG-213A/U	1	1-1/2	7/8 D	-	-	2 oz.
Shunt, Tuning MX-1784/U	1	2-7/8	3/4	1-1/8	-	5 oz.
Cord CG-92 B/U	1	5 ft.	3/4 D	-	-	12 oz.
Calibration Charts (Each card has chart on both sides)	4	5-1/8	3-1/8	-	-	-
Instruction Book	2	1/4	8-3/4	11-1/4	-	4.5 oz.
Transit Case CY-1764/UPM	1	22	8-1/2	9-7/8	1.1	14.2
Total					1.1	45.0

Note: This list is for general information only. See appropriate supply publications for information pertaining to requisition of spare parts.

7. DESCRIPTION

a. Electrical Description

(1) Power is measured under non-radiating conditions, i.e., with the transmitter disconnected from its antenna and feeding into the wattmeter only. The TS-118A/AP is an absorption wattmeter, as distinguished from the other general class of "transmitted power" or "thru" wattmeters.

(2) The wattmeter is built around an accurate coaxial resistor which is the transmitter load element. This resistor terminates 50-ohm coaxial lines so that the standing wave ratio remains below 1.25 to 1.0 over the frequency range of 20 to 1400 megacycles. The transmitter, when loaded by the wattmeter, then operates into a known resistive load, Fig. 13.

(3) Power input to the load resistor is measured by means of a thermocouple connected to the input end of the load resistor (between the transmitter and the load resistor). The d-c voltage developed by the thermocouple is read on a d-c millivoltmeter, with a scale calibrated 0 to 1 in 50 divisions. General theory is that of the I^2R method of RF power measurement. The constant resistance (R) is provided by the load over a wide frequency range. The thermocouple d-c output is proportional to the I^2 (Current squared) and hence to power.

(4) This instrument requires the use of calibration charts to convert the millivoltmeter reading to watts. The charts are retained in the meter cover lid. Four thermocouples are required to cover the power range of 2 to 500 watts. Each thermocouple is color coded to designate its range and the correct calibration chart to use. The color code used is as follows:

Thermocouple	Color Code	Full Scale Power at 400 MC	Symbol
MX-1785/U	Red-Yellow	15 watts	E201
MX-1781/U	Red	40 watts	E202
MX-1782/U	Yellow	120 watts	E203
MX-1783/U	Green	400 watts	E204

In addition, each thermocouple is marked with its own correction or "C" factor. This correction allows for the variation in sensitivity between thermocouples of the same type and should be applied for maximum accuracy of power measurements.

b. Physical Description

(1) The entire equipment is housed in Transit Case CY-1764/UPM. The cover is held watertight with four spring loaded toggle clasps, and is captive to one side. Opening the cover, the long slot at right provides for two copies of the Instruction Book TM-1036, and a 5-foot r-f power cable CG-92B/U. The drawer at the end of the side slot pulls up, and is also captive. It contains the following accessories, which are held in by bronze spring clips:

4 Thermocouples, MX-1785/U, 1781/U, 1782/U and 1783/U (Spares)
1 Connector Adapter UG-999A/U
1 Connector Adapter UG-83/U
1 Connector Adapter UG-213A/U
1 Shunt, Tuning MX-1784/U

These items are all part of, and included in the material of Table of Components, in this Section.

(2) The major unit may be lifted out by use of the retractable captive handle at its top. The radiator is built around a cylindrical tank of hard aluminum tubing upon which the aluminum sheet fins are tightly pressed. This tank houses the electrical load unit and is kept filled with dielectric coolant oil. The function of the dielectric oil is described in Chapter 4, THEORY. The tank may be opened only at the ends, where they are sealed with special synthetic compound fillers. Without removing the load unit, access may be gained to the tank by removal of the cover and expansion diaphragm at the back end of the unit.

(3) The cast aluminum case mounted on the front end of the radiator mounts and protects the d-c millivoltmeter and serves to support the front end of the r-f connector piece. The front of the "LC" Type r-f connector is closed by a sealed dust plug attached by ball chain to the case. The interior of the case is accessible, see Chapter 5, paragraph 31.

(4) The meter face on the slanted front of the cover, is protected by a hinged lid. The lid may be propped back up so that the "K" curve charts are exposed. The cards are held in a special rack which will hold any face of the two cards in position for easy reference while making power measurements. The four thermocouples are held in the respective recesses across the lower face of the cover. A spring at the bottom of the recess will eject any thermocouple unit upon raising the front finger latch.

Chapter 2
OPERATION

Section I. SERVICE UPON RECEIPT OF RADIO FREQUENCY WATTMETER TS-118A/AP

8. UNCRATING, UNPACKING, AND CHECKING NEW EQUIPMENT

Note: For used or reconditioned equipment, refer to paragraph 9.

a. General. Equipment may be shipped in oversea packing cases and, sometimes, in its own carrying cases. When new equipment is received, select a location where the equipment may be unpacked without exposure to the elements and which is convenient to the permanent or semipermanent installation of the equipment. The instructions in subparagraph b. below apply to equipment shipped in export packing cases, and the instructions in subparagraph c. below, to equipment in domestic packing cases. Aside from checking to make sure that all carrying cases are present and that the equipment is undamaged, no special unpacking and uncrating procedures are necessary for equipment shipped in carrying cases.

Caution: Be careful when uncrating, unpacking, and handling the equipment; it is easily damaged. If it becomes damaged or exposed, a complete overhaul might be required or the equipment might be rendered useless.

b. Step-by-step Instructions for Uncrating and Unpacking Export Shipments Fig. 2.

(1) Place the packing case as near the operating position as convenient.

(2) Cut and fold back the steel straps.

(3) Remove the nails with a nail puller. Remove the top and one side of the packing case. Do not attempt to pry off the sides and top; the equipment may be damaged.

(4) Remove the sealed carton and any excelsior or corrugated paper covering the equipment from the packing case. Break the sealing strips from the top of the carton, along the center line and at the ends, then pry open the carton and remove contents.

(5) Strip off the waterproof barrier, and break open the inner cardboard carton.

(6) Remove Transit Case, CY-1764/UPM from the cardboard carton, and open the cover by lifting out the four spring latches at the sides.

(7) Remove the equipment from its transit case and place it on the workbench or near its final location.

(8) Inspect the equipment for possible damage incurred during shipment.

(9) Check the contents of the packing case against the master packing slip.

c. Unpacking Domestic Packing Cases. Radio equipment may be received in domestic packing cases. The instructions given in subparagraph b. above apply also to unpacking domestic shipments. Cut the metal bands if they are used. Open the cartons that protect the equipment; or, if heavy wrapping paper has been used, remove it carefully and take out the components. Check the contents of the packing case against the master packing slip.

Note: Save the original packing cases and containers for both export and domestic shipments. They can be used again when the equipment is repacked for storage or shipment.

9. SERVICE ON RECEIPT OF USED OR RECONDITIONED EQUIPMENT

a. Follow the instructions in paragraph 8 for uncrating, unpacking and checking the equipment; then proceed as outlined in b, c and d below.

b. Check the used or reconditioned equipment for tags or other indications of changes in the design or arrangement of the equipment. If any changes in wiring have been made, note the change in this manual, preferably on the schematic diagram.

c. Check for normal condition of the equipment; that all parts are in place and intact. Check that the meter is undamaged and that the pointer will move freely, and that both calibration cards are in place in the meter housing lid. Observe the radiator (particularly at the ends) for leakage.

d. No lubrication is required on this equipment nor is any servicing necessary at this time.

10. INSTALLATION

a. Portability. The RF Wattmeter TS-118A/AP is essentially a portable test equipment instrument. It should be placed as close as possible to the point at which the power output reading is desired.

b. Optional Fixed Mounting.

(1) The wattmeter may be fastened to a working table, test bench, etc. For this purpose, the four rubber mounting feet may be removed from the bottom of the radiator. These bumpers are fastened to the corners of the radiator feet by #8-32 acorn nuts. Using a suitable wrench the nuts may be readily unscrewed. The 9/32 diam. holes thus exposed will accomodate appropriate 1/4-inch fastenings (with washers and nuts) for mounting the wattmeter. These holes are on a 5-1/8 x 12-17/32 rectangle.

(2) If the wattmeter is to be mounted on rigid structures, which are not shock mounted, use shock mounts under the wattmeter to replace the shock protection afforded by the rubber feet. The central bushings of suitable shock mounts may be attached to the 9/32 diam. holes in the angled feet of the wattmeter and the flanges of the mounts screwed to the foundation surface or to an auxiliary metal plate.

c. Location.

(1) Free circulation of air around the wattmeter is essential. Keep the equipment reasonably in the clear and avoid mounting it on or alongside of heated surfaces.

(2) Where possible, operate in the normal position, feet resting on a horizontal surface, with at least six inches clearance on all sides. The space above the wattmeter should be kept unobstructed to allow for good heat convection. Air cooling is most effective with the wattmeter in this position. This is most important where the power level is above 200 watts.

(3) The wattmeter may be mounted and operated in any position except those in which the load resistor axis is within 60° of the vertical, in a connector up position, or within 45° of the vertical in a connector down position.

Section II. CONTROLS AND INSTRUMENTS

11. GENERAL

Haphazard operation or improper setting of the controls can cause damage to electronic equipment. For this reason it is important to know the function of every control and meter on the equipment. The actual operating instructions are contained in Section III of this chapter.

12. CONTROLS AND THEIR USES, Fig. 3

a. There are no typical operating controls used with the TS-118A/AP. There are four thermocouples to be selected from, depending on the anticipated power value being measured. The ranges and coding of these units is described in Chapter 1, paragraph 7. The thermocouples are only used one at a time, and may be reached by raising the thumb latch just above each opening. The dust cap on the central r-f connector jack must be removed, and the Adapter UG-999A/U attached thereon, for measurements.

b. The meter dial should be kept zero-ed. If the meter does not read zero under no-load conditions, take a small screw driver and slightly turn the slotted head (at the base of the meter dial) until the meter pointer is exactly on zero. The meter dial is under the lid of the meter housing. Lift up the lid and rest it back on the hinge when making readings. The calibrating cards in the meter lid may be flipped up until the one matching the thermocouple being used is exposed. The applicable nomenclature of the calibrating charts appears at the top center of each card, with the color coding described at its right.

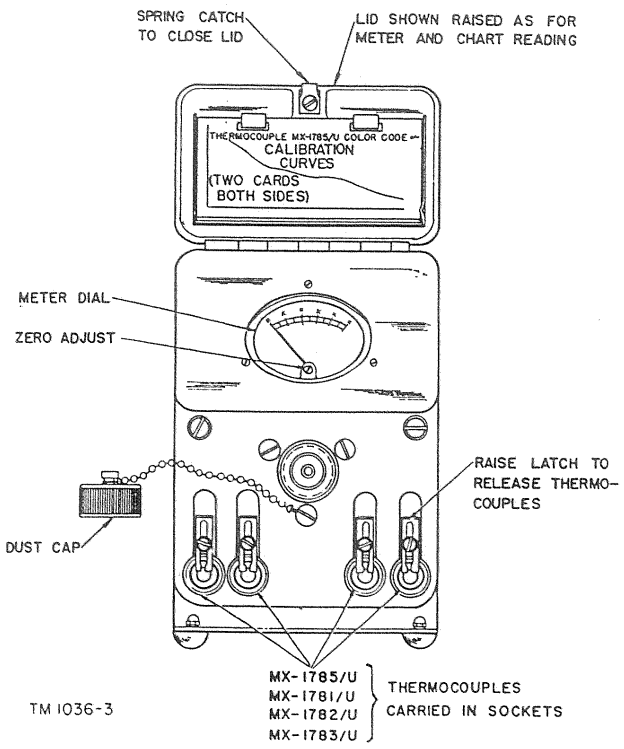

Figure 3. Control View, TS-118A/AP

Section III. OPERATION UNDER USUAL CONDITIONS

13. OPERATING PROCEDURE

a. To Measure Transmitter Power

(1) Locate the wattmeter where the Cord CG-92B/U will connect the transmitter to the wattmeter and where the meter is conveniently readable while adjusting the transmitter.

(2) Connect one end of the Cord CG-92B/U to the transmitter output terminal and the other end to the Shunt Tuning Unit MX-1784/U. This Tuning Shunt is in turn connected to the thermocouple selected and the thermocouple to the wattmeter connector Adapter UG-999A/U. If these units are connected correctly, the sex of the "N" type connectors will mate and adapters or patch cords will not be needed, see Block Diagram, Fig. 4. This is the connection recommended for accurate power measurements.

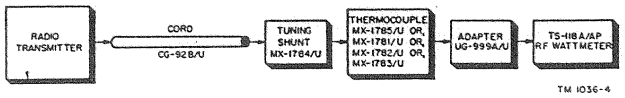

Figure 4. Block Diagram

(3) If the transmitter frequency and power level are known within 20%, consult the calibration charts and select a thermocouple that will provide a mid-scale reading. For example, suppose the transmitter frequency is around 100 megacycles and is known to have a power output in the neighborhood of 200 watts. From the calibration charts, the MX-1782/U has a full scale power indication of 240 watts. This would be the thermocouple to select. If the MX-1781/U were to be selected, which has a full scale power indication of 70 watts at 100 megacycles, the meter reading would be off-scale and probable damage to the MX-1781/U thermocouple would occur.

WARNING - ALWAYS SELECT A HIGHER POWER THERMOCOUPLE AT THE OPERATING FREQUENCY THAN THE POWER IS THOUGHT TO BE. IF NOTHING IS KNOWN ABOUT THE POWER LEVEL, USE THE MX-1783/U FIRST.

(4) After a mid-scale or up-scale reading is obtained, the wattmeter is in a condition to measure the power. A period of one minute after turning the transmitter on is ample time for the transmitter and wattmeter to settle down and obtain a reading. The wattmeter reading will lag slightly behind power level changes. If for some reason the transmitter involved will not reach a steady state of power output in this length of time, follow the instruction book pertaining to the transmitter.

WARNING - OBSERVE SAFETY PRECAUTIONS WHEN ADJUSTING TRANSMITTER.

(5) The power output is determined in the following manner:

(a) Determine the "K" constant at the operating frequency from the appropriate calibration chart for the thermocouple being used.

(b) Read the wattmeter reading. (It will be 1.0 or some even hundredth part of 1.0 such as .60)

(c) Note the correction or "C" factor on the thermocouple.

(d) Calculate the power from the following relation:

Watts = "K" x Meter Reading x "C" Factor

Example: Frequency of transmitter - 100 MC
Meter Reading - .62
Thermocouple Correction - .960
Thermocouple Type - MX-1782/U
"K" of MX-1782/U at 100 MC = 240
Then Watts = 240 x .62 x .960 = 142.85

WARNING - TURN TRANSMITTER OFF BEFORE OPENING RF CONNECTIONS TO THE WATTMETER.

(6) The power indicated by the TS-118A/AP is the power the transmitter will deliver to a 50-ohm resistive load.

(7) When switching the transmitter over from the wattmeter to an antenna, some allowance must be made for the fact that the antenna may have a VSWR as high as 2 to 1. This will require retuning of the transmitter to the antenna for maximum output. Here the instruction book pertaining to the transmitter should be followed.

b. Use as a Dummy Load Only

(1) The load unit of the wattmeter is an excellent termination for 50-ohm coaxial lines in the frequency range of 20 to 1400 megacycles. The load will handle its rated power in this range and can be expected to have a VSWR of better than 1.25 to 1.

(2) To use the Wattmeter TS-118A/AP as a dummy load only the following procedure should be followed: See Fig. 5.

(a) If the r-f line to be loaded terminates in a type "N" connector, connect the line directly to the Adapter UG-999A/U eliminating the Thermocouple and the Shunt Choke Unit E205 from the circuit.

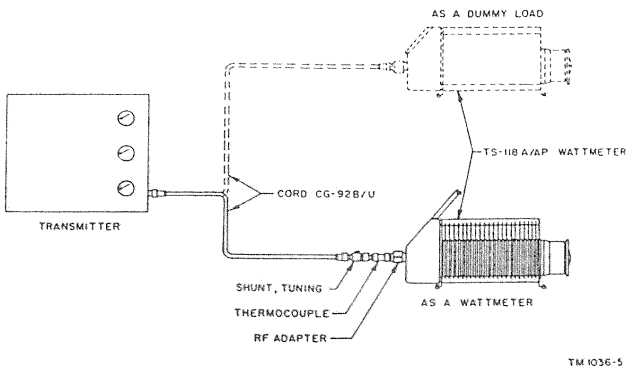

Figure 5. Connections to Wattmeter

(b) If the r-f line to be loaded terminates in an "LC" Type Plug (UG-154/U), unscrew the Adapter UG-999A/U from the wattmeter and connect the line directly to the nosepiece of the r-f load E206.

(c) The same precautions apply concerning air circulation and mounting that apply when used as a wattmeter, see paragraph 10c.

WARNING - DO NOT USE AT FREQUENCIES BELOW 20 MEGACYCLES

c. General Operating Notes.

(1) Regular Operating Precautions

(a) The operator should be careful about the condition of r-f cables and connectors used in the r-f circuit to the wattmeter. Proper assembly of connectors to cables is important for electrical reasons.

(b) Avoid faulty assembly of Type "N" connectors. Misalignment often results in broken center pins.

(c) Patch cord lengths, adapters and connectors should be kept to a minimum. Type "N" or other constant impedance 50-ohm connectors and adapters should be used throughout. The preferred method of connecting the wattmeter is outlined in a(2) above.

(d) Where non-constant impedance connectors must be used, as with transmitters having the output jack Type SO-239, keep them at the transmitter jack only, so that the patch cord will be free from standing waves. In other words, the VSWR will be low on good 50-ohm cables and fittings, from the wattmeter back to the transmitter jack.

(e) Adapters, of any type, should be used at the transmitter end rather than at the wattmeter end.

(f) The Cord CG-92B/U as furnished with the wattmeter should be the only connecting cable used if at all possible. When this is not feasible, the precautions outlined above should be observed.

(g) For special cases where the transmitter may have an output impedance other than 50 ohm, such as 75 ohm, 50-ohm lines should be used right to the ouput jack of the transmitter.

(2) Operator's Test for Accuracy

(a) Operating checks should consist mainly of comparison between wattmeters of this type.

(b) Two thermocouples of each type are furnished with each wattmeter. It is advisable to keep one set of four aside as comparison standards, and the other set of four as working units. In this manner a cross check can be made at any time to determine whether the working units have been damaged or have changed sensitivity. If two or more wattmeters are available the same procedure is advisable.

(c) To cross-check the comparison standards against the working units, the following procedure is recommended:

(1) Connect the transmitter to the wattmeter, as outlined at the beginning of this paragraph, using one of the thermocouples selected as a comparison standard.

(2) Tune the transmitter to full power output using the transmitter instruction book as a guide.

(3) Calculate the power from the wattmeter reading as outlined in subparagraph a(5) of this paragraph.

(4) Note the meter readings of the transmitter.

(5) Turn the transmitter off and substitute the thermocouple selected as the working unit in place of the comparison standard.

(6) Repeat steps (2), (3) and (4) maintaining the same transmitter readings as before. The power now read should agree with the power read in (3) within $\pm 15\%$ (the wattmeter rated accuracy). More than likely the two thermocouples checked will agree within $\pm 5\%$.

(7) Record the data taken and set aside the comparison standard for future reference. The operator now has a standard to refer to if he is ever in doubt about the working thermocouple having changed characteristics during normal use.

(3) Harmonics. The thermocouples of the

TS-118A/AP while operated thermally, are not flat as to sensitivity vs. frequency, see Theory, Chapter 4. The sensitivity increases with frequency and therefore harmonics of considerable amplitude will cause indications higher than the sum of the fundamental and harmonic powers. Harmonic amplitude however, must be quite large to cause appreciable error from this source. In general a rough calculation indicates that 20% of third harmonic is necessary to make the scale reading 2% higher than the sum of the fundamental and harmonic powers.

Section IV. OPERATION UNDER UNUSUAL CONDITIONS

14. GENERAL

The operation of the RF Wattmeter TS-118A/AP should not be unduly difficult under extreme conditions. The unit is designed to be resistant to moisture and humidity. It should maintain technical accuracy of reading (±15%) when operated in ambient temperatures from -4°F to 125°F. No particular precautions need be observed under unusual conditions except as noted in the paragraphs below.

15. OPERATION IN ARCTIC CLIMATES

Care must be taken in these conditions because of congealing of the coolant oil. If the wattmeter has been exposed to sub-freezing temperatures for any length of time, the unit should stand at room temperature for a suitable period before application of r-f power. However if it is desired to accelerate the warming, an r-f power of not more than 20 watts may be applied, and slowly increased over a period of half an hour or more. Care must be used in this case, and the time will depend of course on how deeply frozen the unit has been. After warming, the wattmeter may be readily used at low temperature ranges, as above. The power load rating will of course be somewhat benefited by cold conditions.

16. OPERATION IN TROPICAL AND DESERT CLIMATES

In high temperature conditions, load power value will of course be slightly less than ordinarily. All critical parts of the equipment are sealed against moisture and they should not be disturbed if possibly avoidable. Also, connector parts should be kept protected against the intrusion of sand or blown material.

Chapter 3

ORGANIZATIONAL MAINTENANCE

Section I. ORGANIZATIONAL TOOLS AND EQUIPMENT

17. GENERAL

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from trouble shooting and repair service since its object is to prevent certain troubles from occurring. See AR 750-5.

a. Use No. 000 sandpaper to remove corrosion.

b. Use a clean, dry, lint-free cloth or a dry brush for cleaning.

c. Use a cotton swab stick.

d. If necessary, except for electrical contacts, moisten the cloth or brush with Solvent, dry cleaning (SD); then wipe the parts dry with a cloth.

e. For further information on preventive maintenance techniques, refer to TB SIG 178.

18. TOOLS AND MATERIALS

Tools and materials required for performing preventive maintenance on the radio frequency wattmeter are listed below:

Cheesecloth, bleached, lint-free.
Cotton swab stick.
Paper, sand, flint #000.
Solvent (SD) (Fed. spec. No. P-S-661a)

Section II. PREVENTIVE MAINTENANCE

19. GENERAL PREVENTIVE MAINTENANCE TECHNIQUES

The comparatively rugged and basically mechanical construction of the TS-118A/AP makes its care a relatively simple matter. Its rugged structure will permit this equipment to withstand normally rough treatment, but care is urged in handling. However, the small electrical accessories (particularly the thermocouples) should always be handled with a reasonable degree of caution. Having fine wire internal conductors, accurately suspended, they should not be dropped or subjected to severe shock.

20. USE OF PREVENTIVE MAINTENANCE FORMS

a. The decision as to which items on DA AGO Forms 11-238 and 11-239 are applicable to this equipment is a tactical decision to be made in the case of first echelon maintenance by the communication officer/chief or his designated representative, and, in the case of second and third echelon maintenance, by the individual making the inspection. Instructions for the use of each form appear on the reverse side of the form.

b. Circled items in Figures 6 and 7 are partially or totally applicable to Radio Frequency Wattmeter TS-118A/AP. References in the ITEM column refer to paragraphs in text which contain required detailed or additional maintenance information.

21. PERFORMING PREVENTIVE MAINTENANCE

a. All electrical connectors should be kept as clean as possible. Adapters, cables, thermocouples, shunt choke, etc., should be put away when not in use. Thermocouples, of course, are inserted in the r-f lines only for measurement purposes, so should be kept in their storage receptacles at all other times. The dust cap 0-210 should be kept in place whenever the front connector jack P201 is not engaged.

b. The connectors should be inspected at regular intervals for evidence of contamination; especially if open ends have been left exposed for any length of time. This should include male and female "N" connectors on all thermocouples, and the tuning shunt, two plugs P206 on r-f cable assembly, adapters P201, P203 and P204, the r-f connector jack J201, the d-c connector jack J202 on the unit, and the plug P202 on the d-c meter cable W202. If any of these parts show evidence of dirt, metallic particles, or moisture they should be cleaned with a cotton swab stick dipped in carbon tetrachloride. Use this fluid with restraint to avoid unnecessary exposure to

vapors due to slop or dripping of the carbon tetrachloride liquid. CAUTION - AVOID BREATHING FUMES. Care should be exercised when cleaning r-f connectors not to disturb or damage the spring prongs, particularly the fingers of the center sleeve of a female "N" connector.

c. If available, dry compressed air may be used at a line pressure not exceeding 60 pounds per square inch to remove dust from inaccessible places; be careful, however, or mechanical damage from the air blast may result.

d. For further information on preventive maintenance techniques, refer to TB SIG 178.

OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE | EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

DAILY

NO.	ITEM	CONDITION S	M	T	W	T	F	S
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT *(receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories).* PAR. 9a,b&c							
(2)	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 10c							
(3)	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 21b							
(4)	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 21a							
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.							
6	CHECK FOR NORMAL OPERATION.							

WEEKLY

NO.	ITEM	CONDITION	NO	ITEM	CONDITION
(7)	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS. PAR. 21a		13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.	
(8)	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. PAR. 23a&b		14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.	
(9)	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 13c		(15)	INSPECT METERS FOR DAMAGED GLASS AND CASES. PAR. 25b	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.		18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.	

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA AGO FORM 1 MAY 51 11-238 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

TM 1036-6

Figure 6. DA AGO Form 11-238

SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT

RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

INSTRUCTIONS: See other side

EQUIPMENT NOMENCLATURE	EQUIPMENT SERIAL NO.

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

NO.	ITEM	CONDITION	NO.	ITEM	CONDITION
(1)	COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT (*receiver, transmitter, carrying cases, wire and cable, microphones, tubes, spare parts, technical manuals and accessories*). PAR. 9a, b&c		19	ELECTRON TUBES - INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS: INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; CHECK EMISSION OF RECEIVER TYPE TUBES.	
(2)	LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. PAR. 10c		20	INSPECT FILM CUT-OUTS FOR LOOSE PARTS, DIRT, MISALIGNMENT AND CORROSION.	
(3)	CLEAN DIRT AND MOISTURE FROM ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS, JACKS, PLUGS, TELEPHONES, CARRYING BAGS, COMPONENT PANELS. PAR. 21b		21	INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION.	
(4)	INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: TUBES, LAMPS, CRYSTALS, FUSES, CONNECTORS, VIBRATORS, PLUG-IN COILS AND RESISTORS. PAR. 21a		22	INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALIGNMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.	
5	INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALIGNMENT, POSITIVE ACTION.		23	INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALIGNMENT OF PLATES, AND LOOSE MOUNTINGS.	
6	CHECK FOR NORMAL OPERATION.		24	INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION AND MOISTURE.	
7	CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES, AND CABLE CONNECTIONS.		25	INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT AND LOOSE CONTACTS.	
8	INSPECT CASES, MOUNTINGS, ANTENNAS, TOWERS, AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE.		26	CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, BLOWERS, RELAY CASES, AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE.	
9	INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN.		27	INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS AND BREAKS.	
10	INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.		28	CHECK SETTINGS OF ADJUSTABLE RELAYS.	
11	INSPECT CANVAS ITEMS, LEATHER, AND CABLING FOR MILDEW, TEARS, AND FRAYING.		29	LUBRICATE EQUIPMENT IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.	
12	INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, POWERSTATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS, AND PILOT LIGHT ASSEMBLIES.		30	INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.	
13	INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.		31	CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS.	
14	CLEAN AIR FILTERS, BRASS NAME PLATES, DIAL AND METER WINDOWS, JEWEL ASSEMBLIES.		32	INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING AND OIL-LEAKAGE.	
15	INSPECT METERS FOR DAMAGED GLASS AND CASES.		33	BEFORE SHIPPING OR STORING - REMOVE BATTERIES.	
16	INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.		34	INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.	
17	CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.		35	INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.	
18	CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.		(36)	INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.	
			(37)	MOISTURE AND FUNGIPROOF. PAR. 32 & 33 PAR. 22b	
38	IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.				

DA AGO FORM 1 MAY 51 11-239 REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE. 16—64947-1

TM 1036-7

Figure 7. DA AGO Form 11-239

Section III. LUBRICATION AND WEATHERPROOFING

22. LUBRICATION AND WEATHERPROOFING PROCEDURES AND PRECAUTIONS

a. General. Signal Corps equipment, when operated under severe climatic conditions such as prevail in tropical, arctic and desert regions, requires special treatment and maintenance. Fungus growth, insects, dust, corrosion, salt spray, excessive moisture, and extreme temperatures are harmful to most materials.

b. Tropical Maintenance. A special moistureproofing and fungiproofing treatment has been devised which, if properly applied, provides a reasonable degree of protection. This treatment is explained in TB SIG 13, and TB SIG 72. The equipment is given the moistureproofing and fungiproofing treatment at the factory and it is necessary to use this treatment only when parts are replaced or repaired.

c. Winter Maintenance. Special precautions necessary to prevent poor performance or total operational failure of equipment in extremely low temperatures are explained in TB SIG 66 and TB SIG 219.

d. Desert Maintenance. Special precautions necessary to prevent equipment failure in areas subject to extremely high temperatures, low humidity, and excessive sand and dust are explained in TB SIG 75.

e. Lubrication. No lubrication is required on this equipment.

23. RUSTPROOFING AND PAINTING

a. When the finish on the case has been badly scarred or damaged, rust and corrosion can be prevented by touching up bared surfaces. Use #00 or #000 sandpaper to clean the surface down to the bare metal; obtain a bright smooth finish.

Caution: Do not use steel wool. Minute particles frequently enter the case and cause harmful internal shorting or grounding of circuits.

b. When a touch-up job is necessary, apply paint with a small brush. Remove rust from the case by cleaning corroded metal with solvent (SD). In severe cases it may be necessary to use solvent (SD) to soften the rust and to use sandpaper to complete the preparation for painting. Paint used will be authorized and consistent with existing regulations.

Section IV. TROUBLE SHOOTING AT ORGANIZATIONAL MAINTENANCE LEVEL

24. GENERAL

a. The trouble shooting and repair work that can be performed at the organizational maintenance level (operators and repairmen) is necessarily limited in scope by the tools, test equipment, and replaceable parts issued, and by the existing tactical situation. Accordingly, trouble shooting is based on the performance of the equipment and the use of the senses in determining such troubles as burned-out resistors, broken cords, defective thermocouples or meters, cracked insulators, etc.

25. VISUAL INSPECTION

a. Causes of failure in this instrument are not generally subject to observation by visual inspection. The load unit should be watched for leakage from the radiator tank A203 at either end. Excessive loss of oil from the radiator will cause disturbance of the VSWR of the load resistor, and will also lead to burnout of the resistor if not corrected in time. In any case, where any considerable leakage is observed, the tank should be inspected immediatly, see Field Maintenance, Par. 32b.

b. The millivoltmeter M202 may be stuck or the pointer unseated, which can be observed visually. The internal condition of the meter, and the condition of the other important components of this equipment such as the load resistor R201 and components of the metering circuit C201 and L201 will have to be tested by electrical means, in field maintenance, see paragraph 31 b and c. Also, the thermocouples E201 to E204 and the tuning shunt E205 are not subject to observation checking and should be internally tested per paragraphs 34a and 34b.

Chapter 4
THEORY

26. GENERAL

a. There is very little lumped-constant conventional circuitry in this instrument. Circuit elements are, with few exceptions, of the distributed constant type, machined and fabricated, as in general microwave manufacturing practices.

b. The power dissipated in a resistor is given by the relation $P=I^2R$ where I is the current through the resistance R, illustrated in Fig. 8. One of the oldest methods of measuring transmitter power at low radio frequencies depends upon this relationship. This was generally done by opening the radio frequency line and inserting a thermoammeter. Such a system is probably limited to frequencies below 50 megacycles.

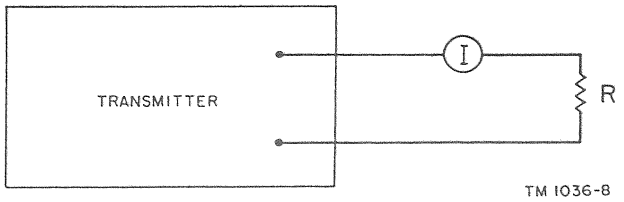

Figure 8. I^2R Method Power Measurements

c. To secure accurate results with the I^2R system two main requirements must be met.

(1) The load resistor must be designed to have a constant impedance over the frequency range to be covered. This constant impedance keeps the standing wave ratio down to a level that makes it possible to insert a thermo-sensitive element in series with the load without the element reading in error because of the variation of the current level with frequency at the point of insertion.

(2) The thermo-sensitive element or thermocouple must be in series with the load resistor in such a fashion as to minimize reflections caused by the thermocouple itself or by the insertion of it. Reflections caused by the thermocouple represent a loss of power that does not reach the wattmeter load and must be absorbed by the transmitter.

d. Since the coaxial lines and fittings for the frequency range covered by this wattmeter are of 50 ohms nominal impedance, the wattmeter has been designed for this load resistance value. This accurately terminates such lines and fittings in their characteristic impedance over the frequency range of 20 to 1400 megacycles.

e. The thermocouples generate a d-c millivoltage almost proportional to the r-f current squared and hence to r-f power. They do however depart somewhat from this function. In order to avoid the necessity of a correction for this error, the scale of the d-c millivoltmeter M201 has been drawn to correct this factor. Comparison of a linear millivolt scale and the actual scale used is illustrated in Fig. 9.

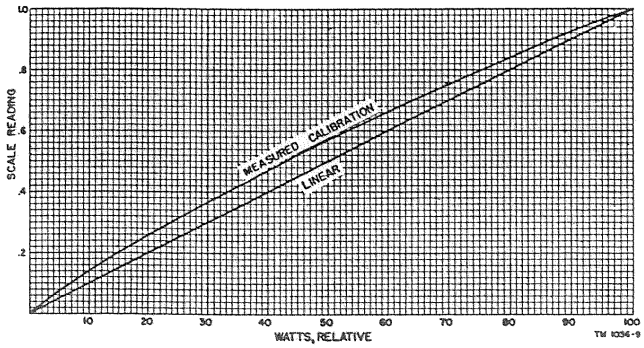

Figure 9. Scale Comparison - Thermocouple vs. Linear

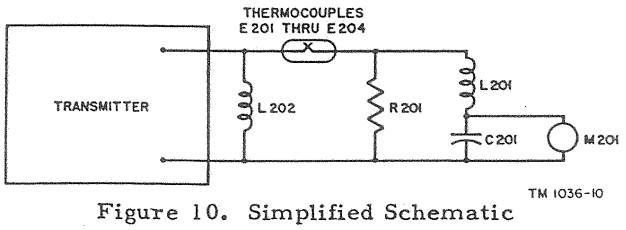

Figure 10. Simplified Schematic

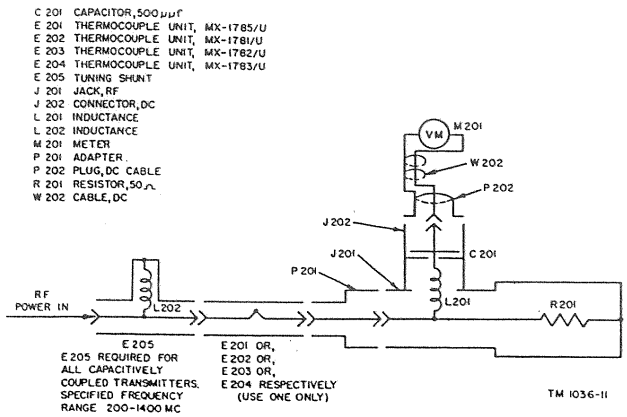

Figure 11. Equipment Schematic

27. CIRCUIT DESCRIPTION (See Fig. 10 and Fig. 11)

The Choke L201 and Capacitor C201 form a filter network that makes it possible to get the d-c thermocouple millivoltage out of the r-f circuitry with minimum effect on the load resistance R201. This network terminates in d-c Jack J202. P202 and W202 make up a cable and plug assembly that connects the d-c Millivoltmeter M201 to the r-f Load R201. The input to the r-f load assembly (Jack J201) is equivalent to a UG-352A/U and mates with "LC" type Plug UG-154/U. E201, E202, E203, and E204 are the four thermocouple units, one to be selected depending upon the power range desired. E205 is an assembly consisting of a short section of 50-ohm coaxial line across which is connected Choke L202. This shunt choke assembly functions as a d-c return for the thermocouple when the wattmeter is used with transmitters that are capacitively coupled.

28. CIRCUIT THEORY (See Fig. 11)

a. Load Resistor

(1) Structure - The Load resistor structure is coaxial, having a characteristic impedance of 50 ohms from the r-f input Jack J201 to a point about two inches behind the large 4-1/2 inch diameter mounting flange, see cut-away view of load resistor, Fig. 12. The load resistance

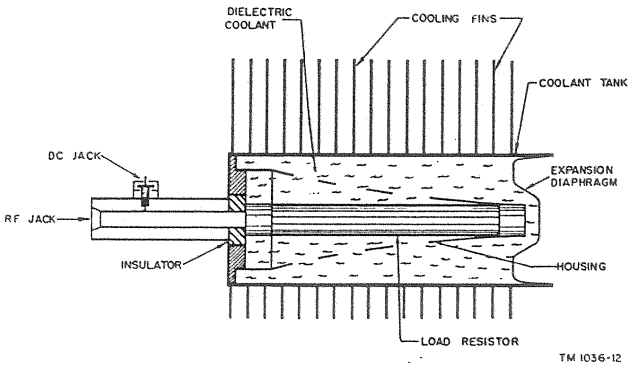

Figure 12. Cut-Away View - Coaxial Load Resistor

proper begins at about this point. The active power dissipating portion of the resistor is the external surface of a cylindrical carbon-film-on-ceramic resistor, which forms the center conductor of the coaxial structure. At the far end of the resistor, the film is connected to a metal shell, which forms the return or outer conductor of the coaxial structure. The constant resistance vs. frequency properties of the assembly are dependent upon the shape of this shell and the distribution of resistance along the length of the film on the resistor. These factors

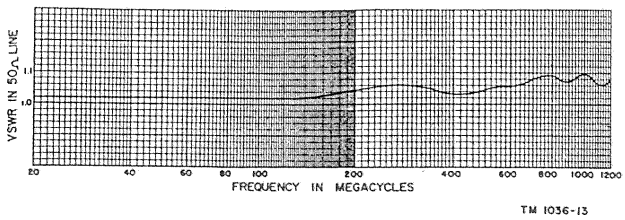

Figure 13. Typical VSWR - Load Choke and Adapter

have either been designed into the instrument or are controlled to meet specified requirements.

(2) RF Load Impedance - Voltage standing wave ratio - Fig. 13 shows the VSWR produced by the load portion of the wattmeter when connected to a 50-ohm coaxial line. This smooth curve is free from the rapid cyclical changes of VSWR with frequency which are typical of lossy line loads. The average curve represents results of measurements made on many loads. All loads will have VSWR's which fall below the "maximum allowable limit" curve. This VSWR curve also includes whatever small effect the choke L201, the capacitor C201 and the adapter P201 may have on the measured VSWR.

(3) Cooling System - To assure full power rating, the cylindrical film resistor R201 is immersed in oil which carries heat by convection through openings in the coaxial metal shell to the inside wall of the enclosing cylinder. From there heat is conducted through the fins and carried away by air convection. The cooling system is conservatively rated. It will handle the stated power (300 watts) continuously without damage, or 500 watts for 20 minute periods, with time in between periods for the load to return to ambient temperature. These power ratings are valid for operation in an ambient temperature range from -4 degrees Fahrenheit to +125 degrees Fahrenheit. The coolant used is a high flash point transformer oil, conforming to Federal Specification VV-0-401. The Load resistor unit must be reasonably full of proper coolant or the r-f input impedance will be changed. The dielectric constant of the coolant is an important factor in determining the input impedance. Careful attention has been given to obtaining a design which is leakproof under service conditions. In order to get both high quality r-f connectors and a leakproof design, teflon insulators compressed as gaskets for the r-f connections and "O" rings of synthetic high temperature resistant rubber are used. Slight leaks are not of too great significance, such as a slight leak around the base of r-f input connector J201.

They will become serious only through cumulative loss of coolant. From this standpoint, a

loss of 10% of the coolant volume has a negligible effect on the input impedance and the power rating. An expansion diaphragm is provided at the rear of the resistor housing. This diaphragm is held in place by a protective cap and "V" ring. The diaphragm is removable and can be replaced if ruptured. The purpose of the diaphragm is to allow for expansion of coolant with raised temperatures.

b. DC Circuitry - The choke L201, the capacitor C201, and the jack J202 constitute the network that serves to withdraw the d-c energy generated by the thermocouple from the r-f circuitry. The choke L201 is wire wound on a Rexolite form, its inductance value being about 5 microhenries. It is entirely suspended in the r-f field and is connected to the center conductor of the 50-ohm air dielectric line that makes up the nosepiece or r-f fitting on the front end of the wattmeter. The capacitor C201 is a 500 micro-micro-farad button mica feed-thru type. It is mounted in the jack J202. The choke L201 and the capacitor C201 are connected together with a short flexible lead wire. This LC combination is a series circuit shunted by the 50-ohm load resistor R201. In the operating range of the wattmeter, 20 to 1400 MC, this network places a very high inductive reactance across the load resistor and has a negligible effect on the r-f properties of the load, see Fig. 10.

WARNING - AT FREQUENCIES BELOW 20 MEGACYCLES DO NOT USE THE WATTMETER IN ANY MANNER WITHOUT DISCONNECTING THE METER M201 AT JACK J202. FAILURE TO DO SO MAY RESULT IN PERMANENT DAMAGE TO THE METER.

The meter M201 is a d-c millivoltmeter. It is of the sealed ruggedized type and cannot be opened for service. It has an external zero adjustment. The scale is marked 0-1 in 50 divisions. The movement is 25 millivolts full scale and the resistance is 50 ohms. The meter is temperature compensated to operate within specifications in a temperature ambient of -4 to +125 degrees Fahrenheit.

29. THERMOCOUPLE DESCRIPTION

a. The thermocouples E201, E202, E203 and E204 are external insertion devices. The four thermocouples cover a full scale power range at 400 megacycles of approximately 15 to 400 watts.

b. The full scale power value of the thermocouple output changes rapidly with frequency. This requires the use of calibration charts, referred to as "K" curves. The full scale power value at 20 megacycles is 22 to 500 watts, the top figure of 500 watts being the maximum power rating of the load. At 1200 megacycles the full scale power range is 11 to 250 watts.

c. Overloads in terms of off-scale readings should be carefully avoided, although the thermocouples will stand about 25% overload for short periods of time without serious damage or change of characteristics.

d. If the frequency of the transmitter to be measured is known but the power level doubtful, always select a thermocouple with a high full scale power value for a preliminary measurement. Then for the final power measurement use the thermocouple which, at this power level, produces a reading on the meter which is well upscale.

e. The thermocouples are calibrated in, and should be used, in a position in the r-f line right at the wattmeter front end. Or in other words, connected to the adapter P201, see Fig. 5. This eliminates the possibility of errors that might be caused by reflections set up in the r-f circuitry between the thermocouple and the load.

f. The d-c millivoltage of the thermocouple is generated in series with the output circuit of the transmitter and with the various r-f fittings in this circuit. There is always the possibility of stray contact and thermal emf's. This hazard can be eliminated by connecting the Choke Shunt Unit E205 in the circuit right next to the thermocouple. (See Fig. 4 and 11) This places the d-c return, necessary for the thermocouple to operate, at the shortest possible point circuit-wise. The Choke Shunt Unit E205 was primarily designed for use with capacitively coupled transmitters in the frequency range of 200 to 1400 megacycles. However, its use is recommended with the lower frequency inductively coupled transmitters for the above stated reason.

g. The sensitivity of the thermocouples or response to a fixed power level will vary somewhat among thermocouples of the same type. This factor is determined and each thermocouple is marked on the plain band of the knurled locking nut with the correction. This correction will vary between .900 and 1.100. The power value obtained from the Wattmeter calibration chart ("K" curve) is multiplied by this factor to obtain maximum accuracy. For quick rough measurements this adjustment may be disregarded, using the "K" curve of the calibration chart only. The thermocouple correction factor is independent of frequency and may be applied at any frequency in the range of the wattmeter.

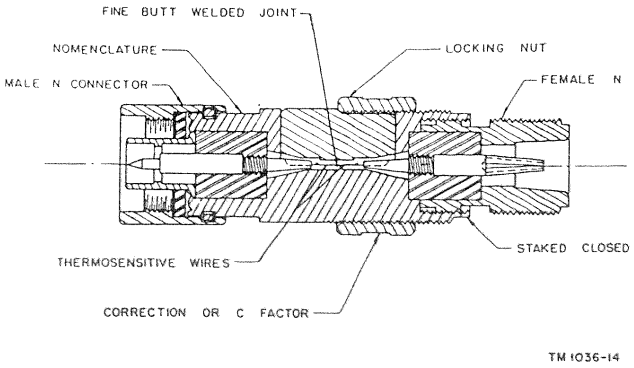

Figure 14. Cross Section of Thermocouple

30. THERMOCOUPLE THEORY

a. Figure 14 shows a cross-section typical of the thermocouples MX-1785/U, MX-1781/U, MX-1782/U and MX-1783/U. These thermocouples have a butt-welded junction of two straight lengths of thermosensitive wire. The composite wire thus formed is connected between the center conductor pins.

b. Throughout the thermocouple, a 50-ohm impedance is maintained, with the exception of the heated composite wire portion. Wire sizes and impractical clearances make it impossible to maintain the diameter ratio necessary for a 50-ohm impedance. The higher diameter ratio at this point in the thermocouple is equivalent to a small lumped inductance.

c. In operation the composite wire is heated by the r-f current, the temperature being considerable at the center where the welded joint is located, and very much less at its ends where the wire joins the contact pins, because of the cooling effect of the large diameter contact pins. A thermo-electric voltage is generated proportional to the temperature difference between the junction at the center of the composite wire and the junctions at the pin ends.

d. The d-c millivoltage thus generated by the thermocouple is almost directly proportional to the r-f current squared and hence to r-f power squared. What departure from the linear that does exist is corrected by the manner in which the d-c meter scale is drawn, see Fig. 9.

e. By keeping the length of the composite wire to a minimum consistent with the sensitivity required, and by adhering as closely as possible to a 50-ohm impedance throughout the thermocouple, the input impedance to the thermocouple-load combination is kept very close to 50 ohms. See Fig. 15. Note that the higher power (or larger composite wire) thermocouples are more nearly the nominal 50-ohm figure. The maximum deviation from 50-ohms is with the MX-1785/U at 1200 MC where the VSWR can be as high as 1.75 to 1. This indicates 7-1/2% of the power is being reflected back to the transmitter by the MX-1785/U thermocouple and the wattmeter load.

f. Since the input impedance of the thermocouple load is practically constant throughout the frequency range of the wattmeter, the calibration charts or "K" curves are essentially the frequency response of the thermocouples.

g. Reference to the calibration charts will show that for all thermocouples the sensitivity increases with frequency. This factor is less pronounced in the MX-1785/U, which has the smallest diameter composite wire. Calculations based on accepted skin-effect theory have shown that the measured "K" curves of the four thermocouples used with this wattmeter, agree with calculated ratios of r-f resistance to d-c resistance very closely.

h. Fig. 9 shows the manner in which r-f power and the d-c millivoltage developed by the thermocouple are related. While the four types of thermocouples supplied with the wattmeter do not have exactly the same response, they are sufficiently alike to use the one correction for all four types. This correction is applied by designing the d-c meter with a scale which departs from the linear insofar as millivoltage is concerned sufficiently to correct for the thermocouple response characteristic.

i. The life expectancy of the thermocouples, while not as good as lower frequency vacuum types, is ample for this application. In general the life is greater for the higher power, larger wire types. The life may be extended for all types if operated somewhat below full scale. Since the thermocouples will be used intermittently rather than continuously with this instrument the life problem is not serious.

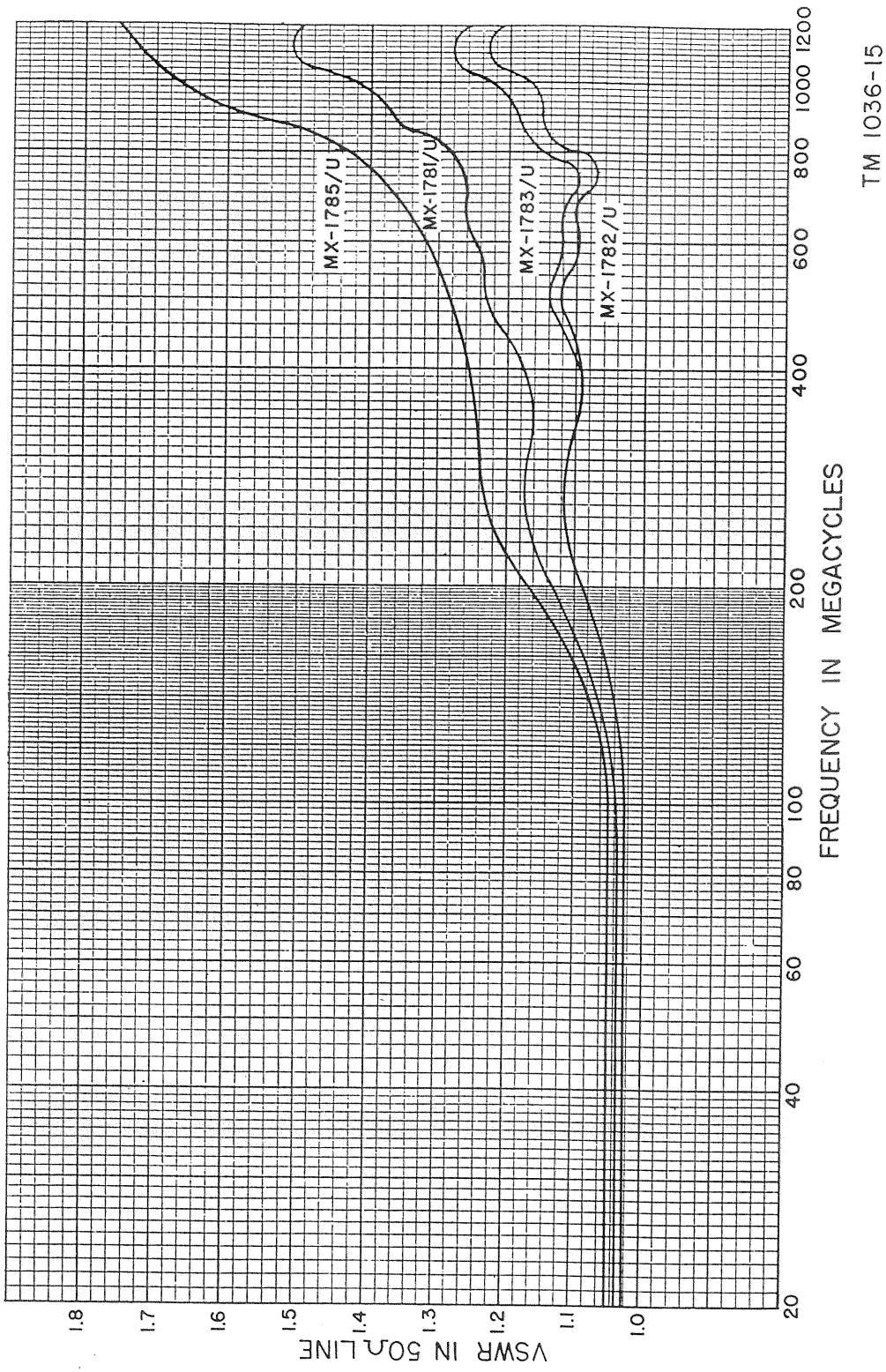

Figure 15. VSWR - Wattmeter (Thermocouples with Load)

Chapter 5

FIELD MAINTENANCE

31. METER REPLACEMENT, Figure 16

a. The millivoltmeter M201 is a sealed ruggedized instrument, and if properly used (protected from overvoltages) should be quite resistant to breakdown. As a hermetically sealed unit, the meter cannot be repaired if damaged, so will require replacement. To change the millivoltmeter, the wattmeter cover A202 must first be removed from the radiator unit A203. Unscrew the dust cover 0210 from the r-f jack J201 at the front of the wattmeter, and also unscrew the three #10-32 truss head screws H207 surrounding the jack. Disengage the two drum head screws (externally relieved) H203 at the front edges of the wattmeter cover A202. When the screws are loose, the cover may be lifted free of the shouldered studs at the four front corners of the radiator A203 against which it is positioned. This will release the cover sufficiently to permit unfastening the d-c cable plug P202 from the d-c jack J202 on the side of the r-f connector nosepiece. The millivoltmeter is attached to the rear of the slanted face of the cover A202 by three #6-32 x 5/8 flat head machine screws by means of nuts and lockwashers behind the meter flange. Unfasten these to remove the meter from the cover box. In changing meters, strip vinyl lacing and tubing away from the terminal lugs on the back, and unsolder the leads of cable W202 and solder the cable on the new meter.

b. If the condition of meter M201 is suspected to be faulty, it may be advisable to check the millivoltmeter by external means. This may be done, but because of the danger of damage in unsuitable circuits, testing of the meter should be attempted only by one familiar with circuits and instruments for testing sensitive d-c millivoltmeters. If so, proceed as follows:

(1) Test the meter as a microammeter in series with a low voltage battery, a variable resistor, and an external meter to read 500 microamps. full scale or well uspscale. A full scale reading on the millivoltmeter should produce 500 microamps. ±10% on the microammeter.

(2) Using a low voltage battery and potentiometer, test the meter as a millivoltmeter in parallel with a sensitive no-load type measuring potentiometer (such as Foxboro type). Full scale on the millivoltmeter should check on the potentiometer within ±2% of 25 millivolts. The second test is to be preferred of the two if equipment is available because of its greater essential accuracy.

c. In case of suspicions that faulty or no readings on the meter may be due to the d-c cable assembly W202, it may be checked. Unsolder from meter M201 and disconnect plug from d-c jack J202. Using an ohmmeter and megger check cable for continuity and leakage. Do not use a worn or old cable without this test. Fig. 17 shows construction of the d-c plug P202, Navy Type CAWY-491859. Fig. 18 shows proper service of RG-58/U cable for these plugs. To remove cable from this plug unscrew bushing and pull cable out. The center conductor of the cable makes tight contact between turns of the coil spring when assembled. Assembly of the RG-58/U cable to d-c plug P202 is as follows:

(1) Slip the bushing, washer, and grommet over end of cable.

(2) Remove outer insulation 9/16 inch from end.

(3) Slip collar over shielding (unbraided).

(4) Fold back braids and trim as illustrated, Fig. 18.

(5) Remove inside insulation to dimension shown.

(6) Flatten end on center conductor to sharp chisel edge, push into d-c plug P202, aligning edge with turns of coil spring.

(7) Push in grommet and washer and screw bushing down snugly.

32. REPLACEMENT OF REAR DIAPHRAGM

a. The diaphragm at the rear end of the unit 0204 is especially designed to withstand any effects of heat or pressure, and is protected at the back against damage from inadvertent outside causes by the strong steel spinning, cover A204. However, if the rubber diaphragm should become torn or ruptured, excessive leakage of coolant oil is certain, and replacement is necessary immediately.

b. To replace the diaphragm 0204, proceed as follows: Stand the radiator assembly A203 vertically, with the back end up. Use box or frame to hold wattmeter radiator in position.

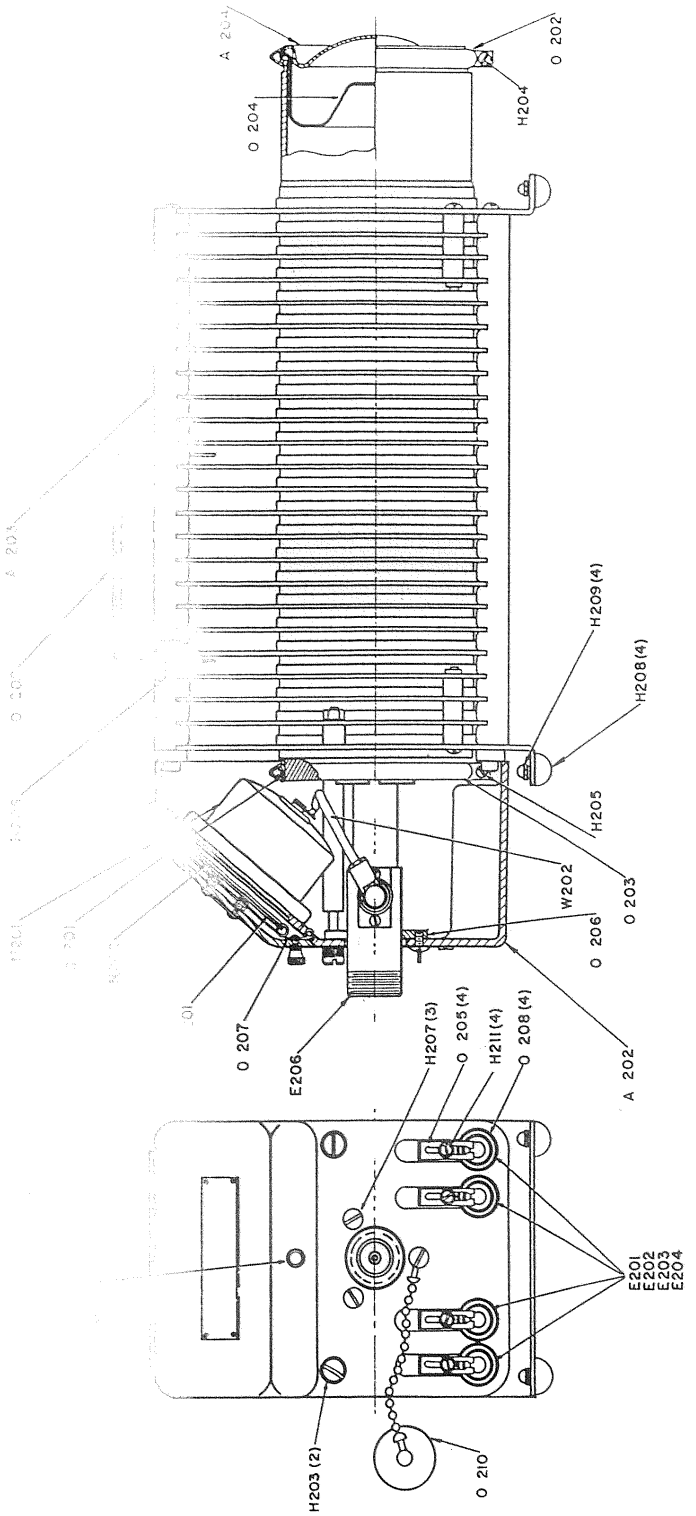

Figure 16. Assembly, Parts Drawing

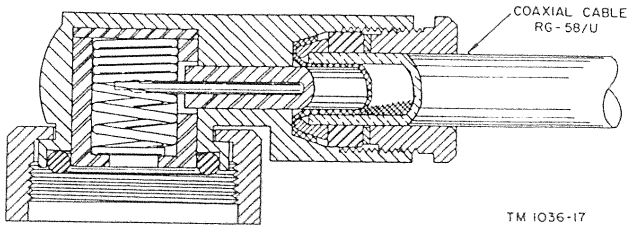

Figure 17. Connector - P202

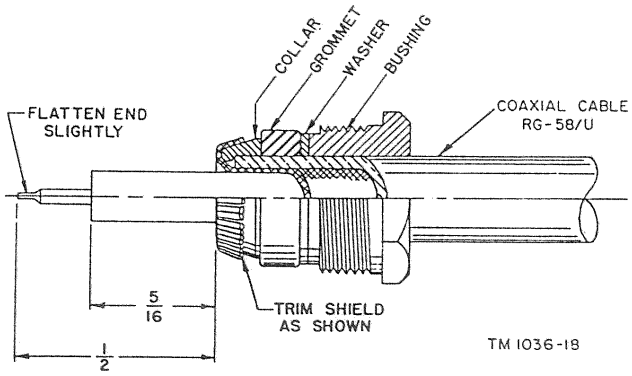

Figure 18. Cable Service for Connector Plug - P202

Loosen clamp screw H204 until the V-band clamp 0202 is released (threaded block is disengaged from shank of screw H204). This release the V-band clamp 0202 and the cover A204, which may be removed; the expansion diaphragm 0204 may now be lifted from the back end of the tank A203. The oil in the tank should be carefully examined, and if there is any evidence of contamination it should be poured out. Refill the tank to within 1-inch of the top with GE 10C Grade Transil (insulating Oil) Fed. Stock No. VV-0-401. Before reassembly of parts, make certain that the mating surfaces are as clean as possible, and the rear face of the tank cylinder should be kept as free of marks or abrasions as good care will permit. Insert replacement diaphragm 0204 and assemble the clamping parts by reversing procedure stated just above. Turn up the clamp screw H204 to a snug tight fit; it is not necessary to pull this up to excessive tension to prevent leakage. The ring-shaped flange on the diaphragm furnishes the tank seal, and the protective cover A204 is especially designed to produce an even and strong lateral pressure on the diaphragm and must always be used.

33. REPLACEMENT OF DUMMY LOAD, E206

If damage to the load resistor R201 is suspected, its d-c resistance should be checked with an accurate measuring instrument such as A-N Type Resistance Bridge ZM-4/U good to 1% or better at 50 ohms (like Leeds and Northrup No. 6305 Test Set). Use low resistance leads, preferably a short piece of RG-8/U cable connected to a UG-21D/U plug. Resistor R201 should read 50.0 ohms ±5% to be in satisfactory condition. The resistance to the center pin of the d-c jack J202 (thru the choke L201) may also be checked with this instrument. This resistance should be 3.0 ohms ±20% from the center pin of the front connector J201 or 53.0 ohms to the body of the unit E206, see Schematic Diagram Fig. 11. If the resistor of the dummy load is found to be faulty, the unit E206 must be replaced. Remove the front cover A202 as described in Paragraph 31 above. Then set the wattmeter vertically with the conector end up. Loosen the clamp screw H205 until the V-band clamp 0203 and the entire dummy load unit E206 may be lifted out of the radiator tank A203. Note - for cleanliness, allow the assembly sufficient time to drain oil into the tank before moving dummy load from over the tank. Inspection will disclose the O-ring gasket 0201 laying just behind the slanted flange on the perimeter of the mounting disc of the dummy load unit E206. This ring 0201 of special synthetic rubber is the seal for the front tank opening. It is recommended to always replace this part with a new one whenever replacing the dummy load unit in the radiator of the r-f wattmeter. Do not reuse these rings unless they are in perfect condition, or under emergency circumstances. Here, as in paragraph 32 above, the face of the tank A203, the o-ring gasket 0201 and the periphery of the mounting disc should be scrupulously clean before replacing the dummy load unit.

34. MISCELLANEOUS FIELD MAINTENANCE ITEMS

a. The thermocouples E201, E202, E203 and E204 are staked closed at the connectors and are not subject to field maintenance. Reference to Fig. 14 shows construction of a typical thermocouple. All four types provided with this equipment are essentially the same, differing mainly in the diameter of the wire used in the leads. Unscrewing the locking nut (with correction factor on band) and sliding it off the body frees the cover, giving access to thermocouple leads. This will only help to give visual evidence of continuity or short circuit. These thermocouples may also be checked externally by resistance measurement, see preceding paragraph. They should show a center conductor d-c resistance of approximately the following values:

MX-1785/U	-	1.0 ohm
MX-1781/U	-	0.6 ohm
MX-1782/U	-	0.2 ohm
MX-1783/U	-	0.05 ohm

If these values are deviated from substantially the thermocouples are in bad order and must be replaced. These pieces may be forwarded to appointed Sig. Corps repair depots for repair. Do not attempt to make repairs on thermocouples, as this can only be accomplished with very special equipment and techniques.

b. The Tuning Shunt E205 should not usually be subject to operational failures, but likewise is not suitable for field maintenance repair. The shunt should of course show negligible d-c resistance along the center conductor. Between the center conductor and the body, see Fig. 11, the d-c resistance should be 1.5 ohms ±20% when accurately measured, with the same procedure as in paragraph 31 of this chapter. If this varies beyond these limits the unit should be replaced as in subparagraph a above.

c. The Adapter Connector P201 for the r-f connector is of special design. The insulator and center conductor unit are inserted at a temperature of well below -40°C while the body is at room temperature. The insulator assembly is therefore under very high compression because of the thermal expansion. It is therefore suggested not to attempt to repair these units. The two adapters UG-83/U and UG-213A/U and the cable assembly CG-92B/U are all composed of standard components and may be serviced according to the regular procedures governing these items.

d. The compression springs 0208 (at the bottom of the four thermocouple storage tubes) may become unserviceable through failure to eject the thermocouples when the rim latch 0205 is raised. To correct this, reach with finger to contact the last two coils of the helical spring and pull straight out. Slight stretching of the turns in pulling out serves to assist extraction. After proper reshaping or replacement, the spring 0208 may be restored to position by pushing in with female end of a thermocouple unit.

The other items identified in the Fig. 16 Assembly, Parts Drawing are not maintenance items and may be serviced by evident mechanical procedures.

35. OPERATOR MAINTENANCE CHECK

a. The principal consideration in this section is a check on wattmeter readings, and care of the thermocouples. The operator should keep one full set of thermocouples (as stored in the drawer of transit case CY-1764/UPM) as reference standards, and not use these for any regular service. They should be saved especially as measurement standards to be compared with the equivalent regular service thermocouple when a unit is suspected of being faulty, see Chapter 2, Paragraph 13c (2). By cross checking when required, deterioration or aging in the service thermocouples will be observed.

b. Any difference in wattmeter readings, or between two wattmeters, if possible, should be watched for carefully by the operator, or checked at regular intervals. If significant differences are noticed, checks should be made. It may be due to faulty thermocouples, as above, or other components off value. If the thermocouples' readings are found to be within ±15% specified accuracy, see Chapter 1, paragraph 4, then the load resistor R201, the meter M201 and choke inductances L201 and L202 should be checked as described in preceding paragraphs 31, 33 and 34. If these are all found to be correct then the trouble may be due to too high a standing wave ratio.

It will be possible to check VSWR in the field with a slotted line, if available, or with a reflection measuring device such as AN Type IM-89/UR Indicator, Standing Wave. If the load unit is discovered to have standing wave ratios in excess of those shown in Fig. 13, the dummy load E206 should be replaced as in paragraph 33 of this section.

There might be cases where the operator would experience difficulty tuning the transmitter. In rare cases this could be due to shorting across the choke coil of Tuning Shunt MX-1784/U (E-205). If testing of the d-c resistance of L202 in this unit, as in Paragraph 34 above, produces a reading substantially below 1.2 ohms then the Tuning Shunt may be at fault and a replacement should be used.

Chapter 6

SHIPMENT AND LIMITED STORAGE AND DEMOLITION TO PREVENT ENEMY USE

Section I. SHIPMENT AND LIMITED STORAGE

36. REPACKING FOR SHIPMENT OR LIMITED STORAGE

Restore all thermocouples to slots provided, replace all accessories in clips in the spare parts drawer. Repack cable and books in slot in transit case. Close down the wattmeter lid and screw on connector cover. Replace wattmeter in transit case and insert desiccant bags in the case. Latch down the case cover tightly. The exact procedure in repacking for shipment or limited storage depends on the materials available and the conditions under which the equipment is to be shipped or stored. Reverse the instructions given in paragraph 8. See Fig. 2.

37. PROTECTIVE PACKAGING

Whenever practicable, place a dehydrating agent, such as silica gel, inside the waterproof barrier. Protect the equipment with a waterproof paper barrier. Seal the seams of the paper barrier with a waterproof sealing compound or tape. Pack the protected box in a padded wooden case, providing at least 3 inches of excelsior padding or some similar material between the paper barrier and the packing case.

Section II. DEMOLITION OF MATERIAL TO PREVENT ENEMY USE

38. GENERAL

Follow the demolition procedures outlined in paragraph 39 to prevent the enemy from using or salvaging this equipment. Demolition of the equipment will be accomplished only upon order of the commander.

39. METHODS OF DESTRUCTION

a. Smash. Smash the coaxial resistor and the meter assemblies, using sledges, axes, handaxes, pickaxes, hammers, or other heavy tools.

b. Cut. Cut the cord and wiring, using axes, handaxes, or machetes.

c. Burn. Burn technical manuals and data obtained with the r-f wattmeter, using gasoline, kerosene, or flame throwers.

d. Bend. Bend the housing, using a heavy tool.

e. Disposal. Bury or scatter the destroyed parts in slit trenches, foxholes, or other holes, or throw them into streams.

f. Destroy everything.