

NAVSHIPS 91118

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INSTRUCTION BOOK

for

RF WATTMETER

ME - II / U

BIRD ELECTRONIC CORPORATION
CLEVELAND, OHIO

BUREAU OF SHIPS

NAVY DEPARTMENT

Contact: NOBsr-39113
NOBsr-42504

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19 July 1948

LIST OF EFFECTIVE PAGES

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To: All Activities Concerned with the
Installation, Operation and Main-
tenance of the Subject Equipment.

Subj: Instruction Book for RF Wattmeter
ME-11/U (NAVSHIPS 91118)

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E. W. MILLS
Chief of Bureau

FROM BUREAU OF SHIPS, NAVY DEPARTMENT, WASHINGTON 25, D. C.

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GUARANTEE

The Contractor guarantees that at the time of delivery thereof the article provided for under this contract will be free from any defects in material or workmanship and will conform to the requirements of this contract. Notice of any such defect or non-conformance shall be given by the Government to the Contractor within one year of the delivery of the defective or non-conforming article, unless a different period of guaranty is specified in the schedule. If required by the Government within a reasonable time after such notice, the Contractor shall with all possible speed correct or replace the defective or non-conforming article or part thereof. When such correction or replacement requires transportation of the article or part thereof, shipping costs, not exceeding usual charges, from the delivery point to

the Contractor's plant and return, shall be borne by the Contractor; the Government shall bear all other shipping costs. This guarantee shall then continue as to corrected or replacing articles or, if only parts of such articles are corrected or replaced, to such corrected or replacing parts, until one year after the date of re-delivery, unless a different period of guarantee is specified in the schedule. If the Government does not require correction or replacement of a defective or non-conforming article, the Contractor, if required by the Contracting Officer within a reasonable time after the notice of defect or non-conformance, shall repay such portion of the contract price of the article as is equitable in the circumstances.

INSTALLATION RECORD

Contract Nos. NOBsr-39113
NOBsr-42504

Date of Contract, 31 January 1947

Serial Number of Equipment _____

Date of Acceptance by the Navy _____

Date of Delivery to Contract Destination _____

Date of Completion of Installation _____

REPORT OF FAILURE

Report of failure of any part of this equipment, during its entire service life, shall be made to the Bureau of Ships in accordance with current regulations using form NAVSHIPS NBS 383 (revised) except for Marine Corps equipment, in which case the "Signal Equipment Failure Report" form shall be used and distributed in

accordance with instructions pertaining thereto. The report shall cover all details of the failure and give the date of installation of the equipment. For procedure in reporting failures see Chapter 67 of the Bureau of Ships Manual or superseding instructions.

ORDERING PARTS

All requests or requisitions for replacement material should include the following data:

1. Federal stock number or, when ordering from a Marine Corps or Signal Corps supply depot, the Signal Corps stock number.
2. Name and short description of part.

If the appropriate stock number is not available the

following shall be specified:

1. Equipment model or type designation, circuit symbol, and item number.
2. Name of part and complete description.
3. Manufacturer's designation.
4. Contractor's drawing and part number.
5. JAN or Navy type number.

SAFETY NOTICE

The attention of officers and operating personnel is directed to Chapter 67 of the Bureau of Ships Manual or superseding instructions on the subject of radio-safety precautions to be observed.

This equipment is generally used with equipment employing voltages which are dangerous and may be fatal if contacted by operating personnel. Extreme caution should be exercised when working with the equipment.

While every practicable safety precaution has been incorporated in this equipment, the following rules must be strictly observed:

KEEP AWAY FROM LIVE CIRCUITS:

Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside equipment with high voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors. To avoid casualties al-

ways remove power and discharge and ground circuits prior to touching them.

DON'T SERVICE OR ADJUST ALONE:

Under no circumstances should any person reach within or enter the enclosure for the purpose of servicing or adjusting the equipment without the immediate presence or assistance of another person capable of rendering aid.

DON'T TAMPER WITH INTERLOCKS:

Do not depend upon door switches or interlocks for protection but always shut down motor generators or other power equipment. Under no circumstances should any accessgate, door, or safety interlock switch be removed, short-circuited, or tampered with in any way, by other than authorized maintenance personnel, nor should reliance be placed upon the interlock switches for removing voltages from the equipment.

RESUSCITATION

AN APPROVED POSTER ILLUSTRATING THE RULES FOR RESUSCITATION BY THE PRONE PRESSURE METHOD SHALL BE PROMINENTLY DISPLAYED IN EACH RADIO, RADAR, OR SONAR ENCLOSURE. POSTERS MAY BE OBTAINED UPON REQUEST TO THE BUREAU OF MEDICINE AND SURGERY.

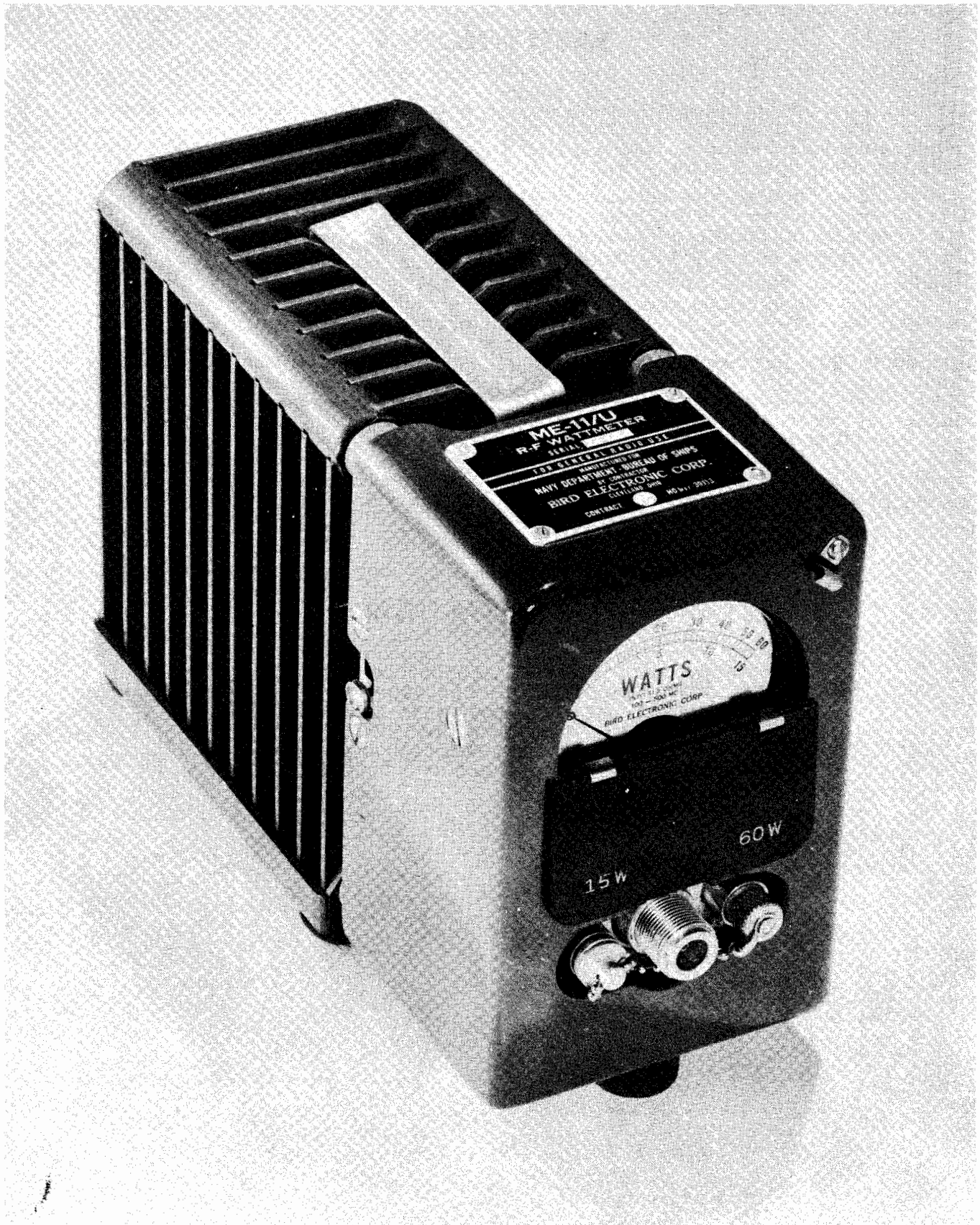


Fig. 1-1. Front View RF Wattmeter ME-11/U

SECTION 1 GENERAL DESCRIPTION

1. SCOPE OF MANUAL

This instruction book covers the description, theory, operation and maintenance of RF Wattmeter ME-11/U.

2. PURPOSE OF EQUIPMENT

a. RF Wattmeter ME-11/U is designed to measure output power and facilitate tuning of transmitters falling within the following limits:

Frequency ----- 30 to 500 megacycles/
second (Nameplate re-
ference 100-500 mc)

Power ----- 2 to 60 Watts
(Ranges are 0-15
and 0-60 Watts)

Output Circuit ----- Coaxial, 51.5 Ohms
Nominal

Type of Modulation - CW, AM, FM or Tele-
vision Type Signals.
Not designed for use
on pulsed power simi-
lar to radar.

b. It can be used to measure RF power from any source within its rating.

c. It may be used as a Dummy Load of 51.5 ohms up to 60 watts.

3. DESCRIPTION (See Fig. 1-1)

a. Power is measured under non-radiating conditions, i.e., with the transmitter disconnected from its antenna and feeding into the wattmeter only. This is an absorption wattmeter as distinguished from the other general class of "transmitted power" or "thru" wattmeters.

b. The wattmeter is built around an accurate coaxial resistor which is the transmitter load element. This resistor terminates 51.5 ohm lines so well that the voltage standing wave ratio remains below 1.1 up to above 500mc/sec. The transmitter, when loaded by the wattmeter, then operates into a known resistance of the value for which it was designed, and to a degree not often realized with antennas, particularly broad-band types.

c. Power input to the resistor is measured by means of a dual-range crystal voltmeter arrangement, the d-c meter of the voltmeter reading directly in rf watts.

d. This instrument is direct-reading in two ranges, 0-15 and 0-60 watts, range selection being made by in-

serting the crystal diode in the desired one of two sockets on the front panel. No reference to calibration charts is needed in normal use. The meter scales are expanded at lower readings, i.e., half full-scale deflection is attained at about one third full scale power.

4. SPECIFIC USES

Measurements from the RF Wattmeter ME-11/U may be useful for the following purposes, among others:

- Checking installation of transmitter.
- Routine and trouble shooting maintenance.
- Production and acceptance tests.
- Transmitting tests.
- Loss measurements on transmission lines.

f. Testing of coaxial line insertion devices, such as connectors, switches, relays, filters, tuning stubs, patch cords, etc.

g. As an accurate rf resistance, substantially independent of frequency and line length. See Section 4.

h. Modulation Monitor. Audio frequency amplitude modulation may be monitored by connecting phones, amplifiers or audio voltmeters to the d-c meter circuit.

5. MAJOR COMPONENTS (See Fig. 1-2)

a. Figure 1-2 shows all components of the RF Wattmeter ME-11/U, with the meter box detached to illustrate the arrangement for remote use of the indicating meter where the meter cannot be conveniently read when attached to the Resistor-Voltmeter unit.

b. TWO SHIELDED D-C CABLES are furnished: the short (3½ ft) cable W-101 for normal use; and the long (25 ft) cable W-102 for remote meter location.

c. The sealed meter is protectively surrounded by the meter box and is shock mounted within the box. A protective flap (Fig. 1-1) covers the meter face opening for extra precaution when being carried around. The meter is equipped with a coaxial, hermetically sealed connector, J-104.

d. The RESISTOR-VOLTMETER unit (See Fig. 1-2) includes the coaxial load resistor R-101 surrounded by a finned radiator structure on which are mounted the spare crystal diode and various hardware items. The load resistor cylinder and conical reducer are OIL

FILLED. The cylinder is terminated at the rear in a synthetic rubber expansion diaphragm which prevents pressure rise with temperature.

e. The VOLTMETER HOUSING contains the rf portions of the dual voltmeter circuits. The circuits are separately coupled to the load resistor line by capacitive probes projecting into the dielectric space of the line. The d-c output connections of the two circuits are paralleled across a bypass condenser at the d-c output jack J-103. When one power range is activated by inserting the crystal diode, the other remains dead and without effect on the active one.

f. The crystal diodes V-101 (working) and V-102

(spare) are specially selected 1N21B's, mounted in a coaxial shielding holder (See Fig. 5-1). The two crystals furnished are carefully matched and may be used interchangeably for cross checks between them at any time.

WARNING

CRYSTALS ARE NOT INTERCHANGEABLE BETWEEN WATTMETERS WITHOUT RECALIBRATION AND MIXUPS OF THIS KIND MUST BE AVOIDED BY ACTIVITIES HAVING MORE THAN ONE WATTMETER.

TABLE 1-1 EQUIPMENT SUPPLIED

Quantity per Equipment	Name of Unit	Navy Type Designation	Over-All Dimensions			Vol. (cu.ft.)	Weight (lbs.)
			High	Wide	Deep		
1	RF Wattmeter	ME-11/U	6-1/2"	3-3/4"	9-1/2"	.12	7-1/2
1	D-C Cable (long)						3/4
2	Instruction Books						
	ALL OF ABOVE BOXED FOR SHIPMENT		9-1/4"	9-3/4"	12-3/4"	.67	11

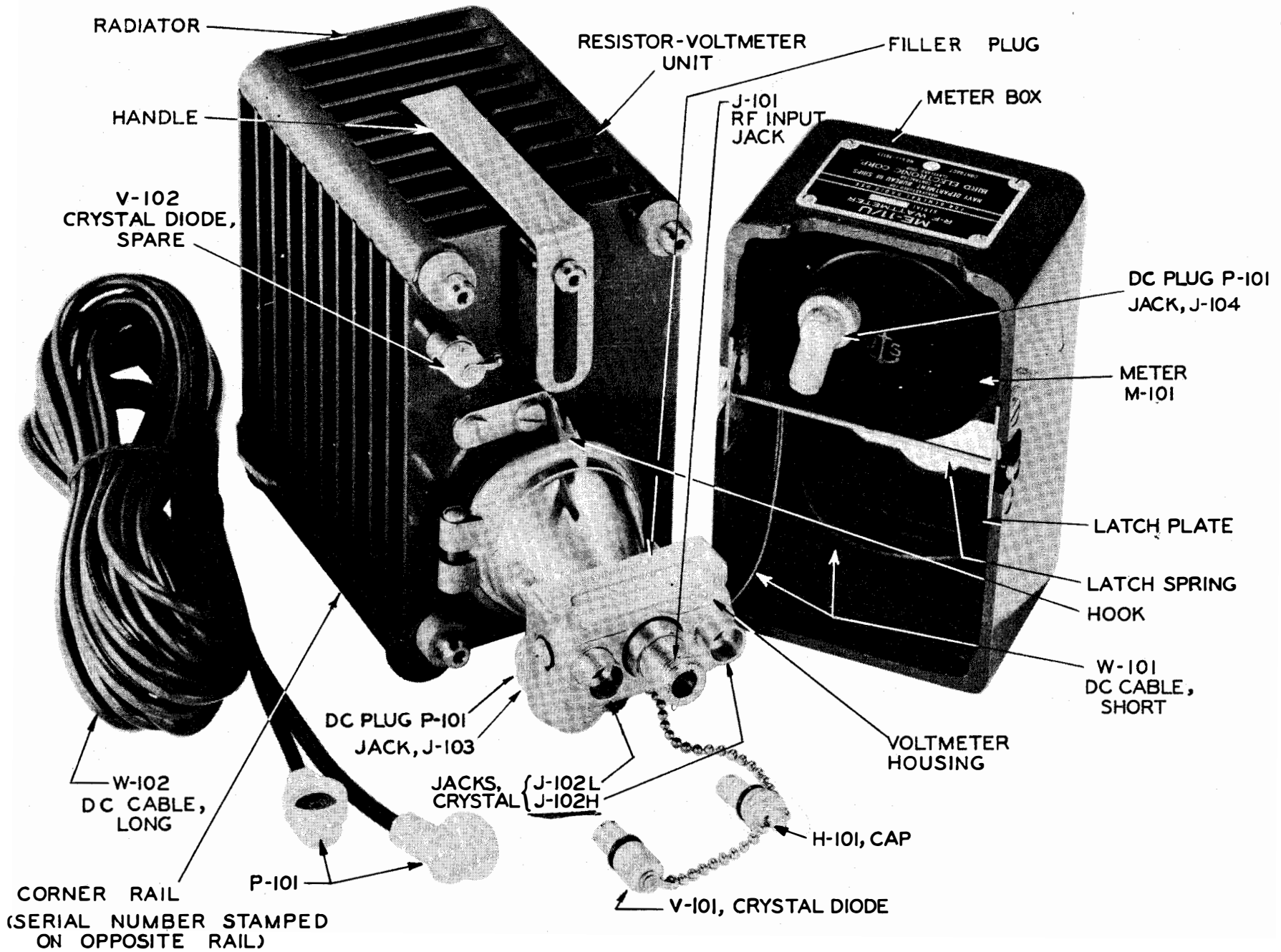


Fig. 1-2. RF Wattmeter ME-11/U, Meter Box Detached

SECTION 2 THEORY OF OPERATION

1. INTRODUCTION

There is very little lumped-constant, conventional circuitry in this instrument. Circuit elements are of the distributed constant type, machined and fabricated, as in microwave components.

2. BASIC PRINCIPLES

a. The power dissipated in a resistor is given by the relation $W = E^2/R$, where E is voltage across resistance R and is shown in Fig. 2-1. One of the oldest methods of measuring transmitter power at low radio frequencies depends upon this relation.

b. For accurate results, it is necessary that the voltmeter be connected directly across the resistor terminals, in addition to the obvious requirements that the voltmeter and resistor be accurate at, or corrected for, the operating frequency.

c. In the RF Wattmeter ME-11/U resistor and terminals are so designed as to have a constant characteristic impedance over a wide frequency range.

d. Since the coaxial lines and fittings for this frequency range generally are of 51.5 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 their usable frequency range.

e. SCALE SHAPES

(1) The voltmeter E of Fig. 2-1 may be equipped with a direct-reading scale in watts, for use with a definite load resistance R. This scale would be linear in watts if the voltmeter were of the square law type similar to thermocouple or iron vane meters.

(2) When the voltmeter is a linear type, the watt scale will be as shown in Fig. 2-2. This compares equivalent voltage and power scales for a hypothetical 50 ohm, 50 watt, 50 volt instrument. Half full-scale deflection is obtained at one-fourth full-scale power, and this scale, expanded at low readings is convenient in getting better readability at low scale readings. The voltmeter used in the RF Wattmeter ME-11/U is approximately linear and scales are of the type shown in Fig. 2-2.

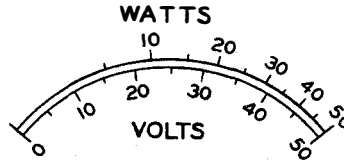


Fig. 2-2. Comparison—Illustrative Watt and Volt Scales

3. VOLTMETER CIRCUIT (See Fig. 2-3 and Fig. 2-4)

a. **CIRCUIT DESCRIPTION** - Capacitors C-101 and C-102 form an a-c voltage divider. C-101 is extremely small for minimum effect on the load resistance R-101. Crystal diode V-101 functions to charge C-102 to the peak steady state a-c voltage developed across C-102 by the divider action. Resistor R-102 and the external microammeter are a d-c voltmeter circuit used to measure the d-c voltage developed across C-102, and capacitor C-103 is an rf bypass for M-101. This circuit is a shunt-diode voltmeter circuit.

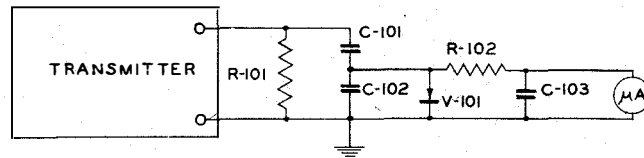


Fig. 2-3. RF Wattmeter ME-11/U Simplified Schematic

b. **DUAL VOLTMETER CIRCUIT** - With the diode V-101 removed, the circuit looking back from C-103H through R-102H is open to d-c. Therefore, another combination C-101L, C-102L and R-102L may be bridged across the load resistor, the two resistors having a common connection at C-103. The active circuit is then selected by inserting Crystal Diode V-101 across either C-102H or C-102L. The inactive circuit being open to d-c does not affect the meter reading. This circuitry is employed in RF Wattmeter ME-11/U. The two circuits are identical except for the values of capacitors C-101H and C-101L.

c. **RATIO BETWEEN RANGES** - In the wattmeter the two voltmeter circuits require a two to one (2 to 1) voltage ratio or four to one (4 to 1) power ratio, for the same deflection. Since the same crystal is used in both circuits and since the scale shape (curve of power vs. microamperes) depends on the crystal diode, both ranges read accurately on one set of divisions, when calibrated at one point on the scale.

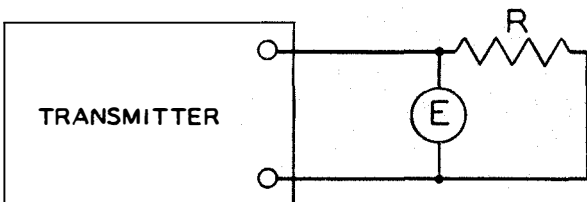


Fig. 2-1. E^2/R Method of Power Measurement

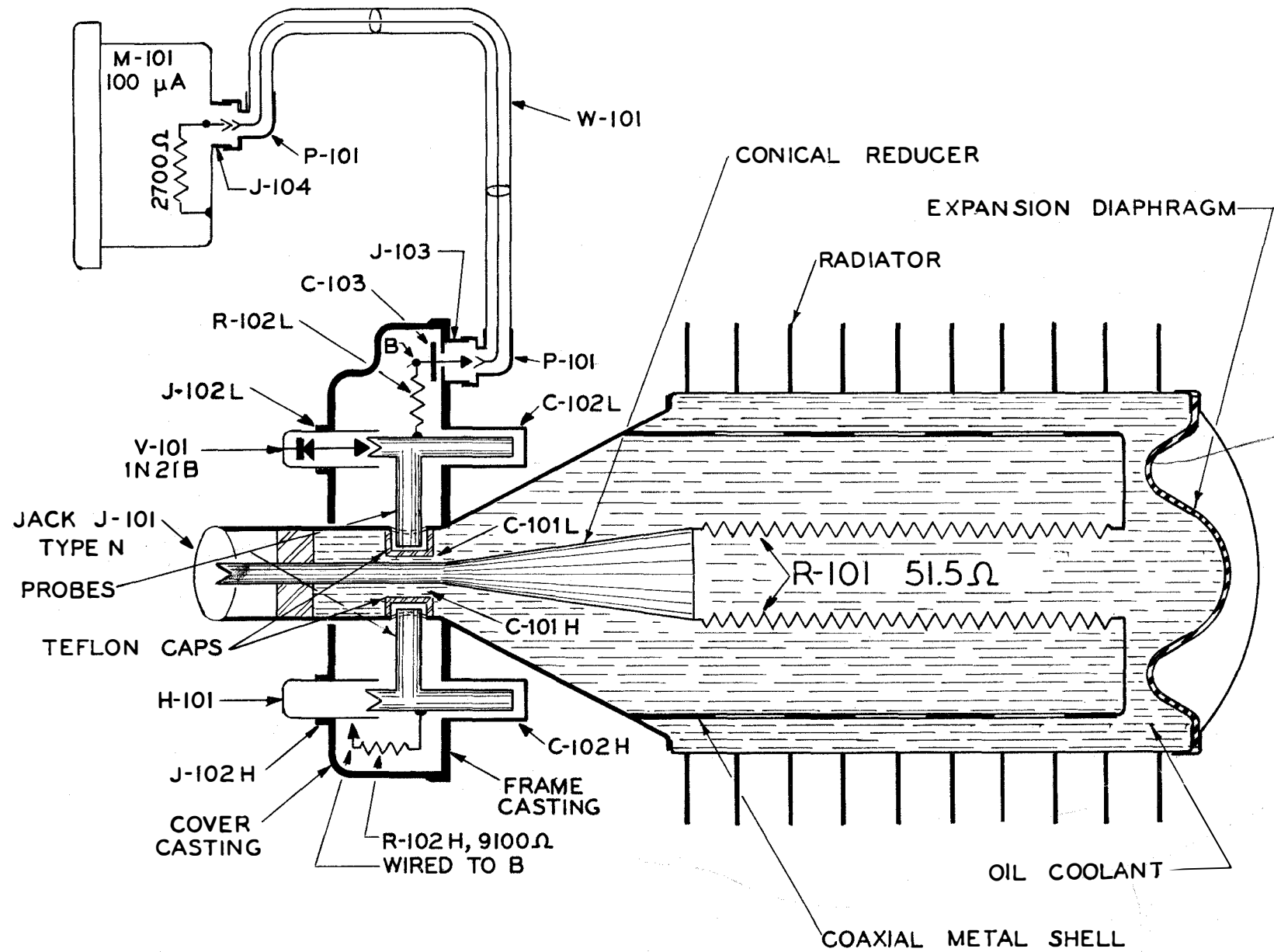


Fig. 2-4. Schematic Diagram, RF Wattmeter ME-11/U

4. LOAD RESISTOR CIRCUIT (See Fig. 2-4)

a. INPUT SECTION - The structure is coaxial, having a characteristic impedance of 51.5 ohms from the RF input Jack, J-101, to the large diameter end of the conical reducer. At the probes, a discontinuity is introduced by the lumped capacitances C-101L and C-101H between probe and center conductor, and compensation for this is obtained by proper choice of center conductor and sheath diameters. This portion of the circuit is essentially lossless.

b. RESISTOR PROPER - The load resistance proper begins at the large end of conical reducer. 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. At the far end of the film resistor, it is connected to a coaxial metal shell, which forms the return conductor. The constant resistance properties of the assembly are dependent upon the shape of this shell and the distribution of resistance along the length of the film. These factors have been worked out to give the desired results.

c. RF LOAD IMPEDANCE - Voltage Standing Wave Ratio Curves

(1) Fig. 2-5 shows the VSWR introduced by the wattmeter when connected to a 51.5 ohm coaxial line. This smooth curve is free from rapid cyclical changes of VSWR with frequency which occur with lossy-line loads.

(2) The average curve represents results of tests on many instruments. All wattmeters will have VSWR's which fall below the "allowable limit" curve. Below 500 mc, the region 350 to 400 mc tends to show highest VSWR values.

(3) Below 150 mc, the VSWR curve is flat. The input impedance at J-101 is practically a pure resistance equal to the d-c input resistance. Value of this resistance is stamped on the top of the voltmeter housing.

(4) From 500 mc to 1500 mc, the VSWR may reach 1.2 at certain frequencies. The wattmeter may be used in this frequency range at full power rating, although the direct-reading wattmeter calibration will be off.

5. VOLTMETER HOUSING DESCRIPTION

a. The schematic diagram Fig. 2-4 indicates how the parts are arranged in the voltmeter housing, consisting of the FRAME CASTING and the COVER CASTING. The circuit elements are designed into the structure to obtain the necessary rigidity. Heat resistant dielectrics are necessary in this instrument and such parts are made of either teflon or ceramic.

WARNING

NO PARTS IN THE VOLTMETER MAY BE REPLACED WITHOUT AFFECTING THE CALIBRATION.

b. DETAILED DESCRIPTION

(1) The probes, which form part of C-101L and C-101H, appear on Fig. 2-4 as heavy vertical conductors entering holes in the sheath of the rf load lines. Teflon caps surround the projecting portion of the probes and retain the coolant. These probes consist of a tubular sleeve, and a tip, adjustable by spring-locked threads. This calibrating adjustment serves to vary the capacitance of C-101 by varying the distance between the probe and center conductor.

(2) The shunt capacitors C-102L and C-102H are each coaxial, consisting of an outer brass tube electrode, a ceramic sleeve dielectric and a center beryllium copper electrode. The spring center contact for the crystal is integral with this center electrode.

(3) RESISTORS R-102L and R-102H are 1/2 watt conventional metalized resistors.

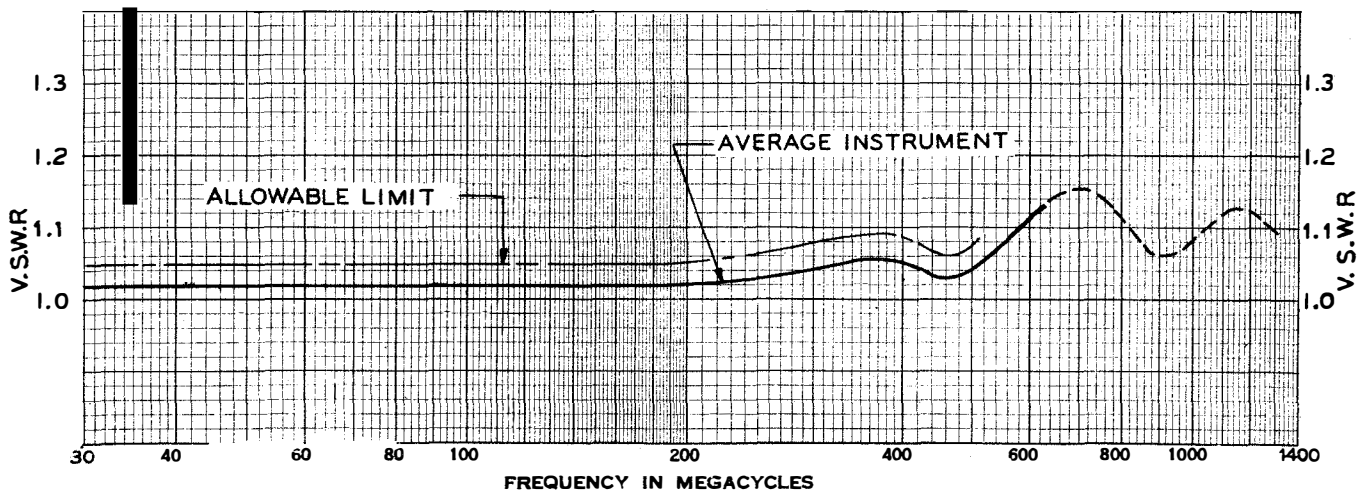


Fig. 2-5. Voltage Standing Wave Ratio vs. Frequency - RF Wattmeter ME-11/U

(4) BY-PASS CAPACITOR C-103 is a feed thru button mica type. This capacitor is built into d-c output jack J-103, to obtain the most effective by-pass action with a minimum of residual inductance. As a result of careful design of this by-pass arrangement as well as of shielded d-c cables and a shielded meter, the wattmeter is very insensitive to external rf fields which might otherwise get to the crystal along the hot d-c lead.

6. CRYSTAL DIODE HOLDERS (See Fig. 5-1)

a. SHIELDING - Since the crystal diode is detachable for range selection it is highly desirable that it be enclosed in a shielding holder. The main reason for this is to prevent high voltages from being impressed across the crystal at the moment of insertion or removal. Such voltages can appear as a result of static charges on the operator's body or from external rf fields. Since the shield makes contact with the wattmeter first, no externally caused voltages can appear across the crystal.

b. FLOATING MOUNT - It is important that the crystal be flexibly mounted in the holder to avoid radial pressure (side pressure) on the center contact pin of the crystal. Such pressure would occur in a rigid mount if any slight eccentricity existed in either crystal, holder or socket J-102. The design of the crystal holder is shown in Fig. 5-1 and is effective in preventing variation of readings as the crystal is repeatably inserted or rotated in its socket.

7. CRYSTAL VOLTAGE LEVEL

The crystals operate at 1.2 volts and 100 microamps, rectified d-c, for full scale on either range. These values are conservative with respect to overload damage. It has been determined that four times full scale power can be applied momentarily without appreciable change in crystal characteristics or calibration. Since the crystal voltmeter is connected across the load resistor, substantial power is required for voltage overload.

8. CRYSTAL STABILITY AND RELIABILITY

a. ADVANTAGES - The silicon crystal rectifiers used are comparable and in some respects superior to electron tube diodes. Some of their advantages are: Smaller size, no filament supply, and no zero shift with time or change in line voltage.

b. STABILITY - The application of crystal diodes in calibrated direct-reading voltage or power measuring instruments is relatively new. Most people are familiar with crystal diodes in different applications, such as detectors in receivers. The stability realized may prove surprising to those who have not had the opportunity to use modern crystals with good standards of rf measurement. From a long program of measurements in the laboratory and from field experience with many similar instruments in industrial use, it has been found that calibrations will hold as well as in electron tube

voltmeters. There is no indication of long time aging and calibrations may be expected to hold within 2% for variations chargeable to the crystals.

9. CRYSTAL SELECTION

Joint Army-Navy (JAN) specifications on these crystals allow considerable variation in characteristics other than stability, making special selection for wattmeter applications necessary. For this use, crystals are selected for the following properties, which are not entirely independent:

- a. Sensitivity at one point
- b. For curve shape (rf input vs. d-c output) over the range used in the wattmeter.

The two crystals calibrated with and furnished with each wattmeter are selected for identical readings on both tests above. Crystal classification tests are made at one frequency only, since there is no significant frequency difference between crystals.

Crystals furnished with different wattmeters differ considerably in sensitivity. Difference is approximately 20% in power from the average crystal sensitivity. An error of about this magnitude (20% \pm) could be expected if a randomly selected JAN-1N21B were used in an emergency.

10. VOLTMETER-FREQUENCY CHARACTERISTICS

CONTROLLING FACTORS - Three major factors were considered in design to provide flat frequency response:

- a. The voltage ratio of the capacitance divider versus frequency. Mechanical design was made to get desired result.
- b. The voltage sensitivity of the crystal versus frequency.
- c. The time constant effect, which causes the sensitivity to decrease with frequency near the low end of the range. The time constant is the product of R-102 and C-102 in Fig. 2-3. This product must be made sufficiently high to maintain a full charge on C-102 between successive positive peaks of the input radio frequency.

11. POWER CALIBRATION VS. FREQUENCY (See Fig. 2-6)

a. Fig. 2-6 shows the frequency error of the average wattmeter. The limit curves indicate the maximum deviations allowed in calibration.

b. The average and limit curves coincide in the region 300-350 mc, where the sensitivity is set to make all instruments alike. The limit curves are about 5% apart at 100 and at 500 mc, to provide for the slight differences in frequency characteristics between various wattmeters.

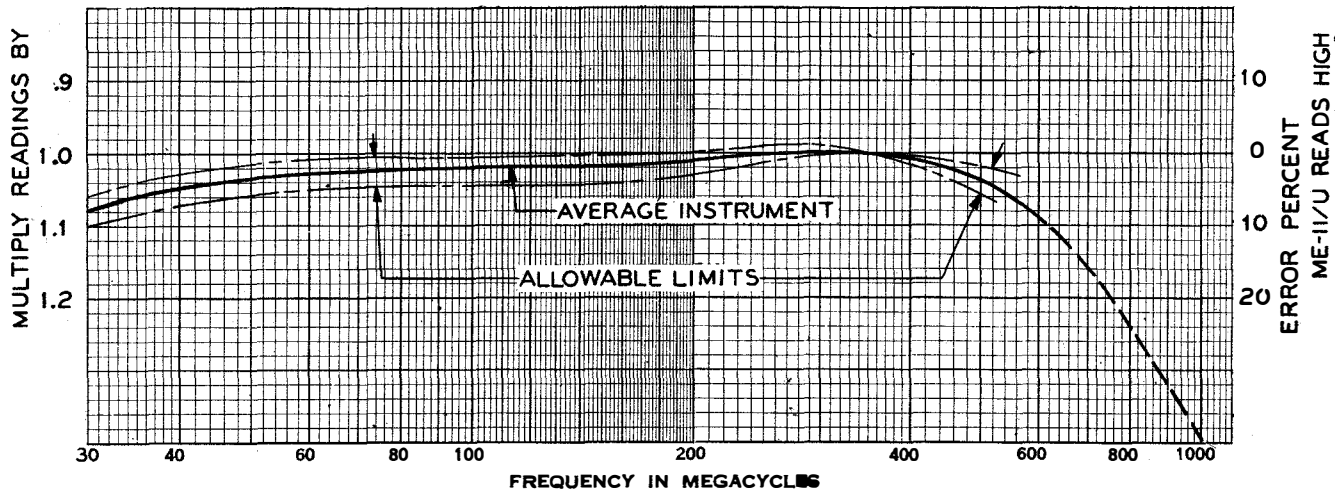


Fig. 2-6. Power Calibration vs. Frequency — RF Wattmeter ME-11/U

c. Below 50 mc, the time constant effect appears as a gradual decrease in sensitivity. To improve accuracy below 100 mc, corrections for frequency should be made according to the average curve.

d. Frequency errors between 100 and 500 mc are within the required direct reading accuracy and ordinarily there is no need to use frequency correction.

e. The falling sensitivity above 500 mc is due to the characteristic of the voltmeter. For use between 500 and 1000 mc, corrections by the dotted portion of the curve should be applied to improve accuracy. Various other factors limit wattmeter accuracy at these frequencies to about $\pm 10\%$ after correction. See also Section 4, Paragraph 9.

12. OVERALL ACCURACY

a. The combined effect of frequency and scale errors is within $\pm 5\%$ for direct readings in the 100-500 mc frequency range. Of the two, the frequency error is the greatest and more difficult to control. Certain frequency corrections can be made as outlined above.

b. Frequency error and scale error are independent. Scale error is merely the combined effect of d-c meter errors and deviations from standard crystal curve shapes.

13. CALIBRATION METHODS

a. Wattmeters are calibrated at the factory with a special "THRU" or transmitted power direct-reading wattmeter. The wattmeters are rigidly connected to this special wattmeter.

b. The wattmeter reads power at the rf input Jack J-101, so that connecting cable losses, if they matter in field use, are to be added to the wattmeter readings to get the exact power output of the transmitter.

14. COOLING SYSTEM

a. HEAT TRANSMISSION

(1) To assure full power rating, the cylindrical film resistor, R-101, is immersed in oil which carries heat by convection to the inside wall of the enclosing cylinder thru openings in the coaxial metal shell. From there heat is conducted thru the fins and carried away by air convection. The cooling system of the wattmeter is conservatively rated. It will handle rated power (60 watts) continuously without damage at an ambient temperature of 30° Centigrade (86° Fahrenheit).

(2) The coolant used is a high flash point transformer oil, conforming to Federal Specification VV-0-401.

b. ELECTRICAL SIGNIFICANCE OF COOLANT

The unit must be reasonably full of proper coolant or the rf input impedance and calibration 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 leak proof under service conditions. In order to get both high quality rf connectors and a leakproof design, teflon insulators compressed as gaskets for the rf connections and "O" rings of synthetic high temperature resistant rubber are used.

Slight leaks are not of too great significance except in the case where they appear to come from within the voltmeter housing. In this case the leak probably originates around the teflon caps sealing off the voltmeter probes. If this occurs the calibration should be checked as in Section 4, Paragraph 9. Leaks at other points, including the rf input connector J-101 will be of much less consequence and become serious only thru cumulative loss of coolant. From this standpoint, a loss of 10% of the coolant volume has a negligible effect on calibration and power rating.

15. TEMPERATURE EFFECTS

a. Particular attention has been given to design so that ambient temperature has negligible effect on power calibration and input impedance within its specified temperature range.

b. The Voltage Standing Wave Ratio changes less than .02 between "no" load and full load (60 watts). The voltmeter circuits have a small temperature coefficient, amounting to an increase in power readings of less than 0.08% per degree Centigrade for metal temperatures measured on the outside of the voltmeter housing. At this point, the full load temperature rise is about 30° Centigrade, so that the temperature error is not over 2.4% at full load.

16. INPUT RESISTANCE-D-C, SIGNIFICANCE OF

a. An accurate measurement of the d-c resistance

at rf input Jack J-101 is a very good check on the condition of the load resistor with respect to rf input impedance and calibration. The d-c resistance measured at calibration will be found stamped on the top of the voltmeter housing. A check of the d-c resistance will show up anything significant which may happen to the rf input impedance, except for the effect of radically low coolant level or substitution of wrong coolant.

b. This d-c resistance measurement should be made with an accuracy of plus or minus 1% on a bridge such as Resistance Bridge ZM-4/U. A measured value differing by more than two ohms from the value marked on the voltmeter housing is significant of calibration change. A resistor which has been subjected to considerable overload normally measures higher in resistance.

SECTION 3 INSTALLATION

1. PORTABILITY

The RF Wattmeter ME-11/U 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.

2. OPTIONAL FIXED MOUNTING

a. The wattmeter may be fastened to an operating table, test bench, etc. For this purpose, the four rubber feet may be unscrewed from the bottom of the radiator, and the four tapped holes used to mount the wattmeter.

b. If the wattmeter is to be mounted on the ship's structure or on rigid benches, etc. 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 small shock mounts may be attached to the tapped holes in the bottom of the wattmeter, and the flanges of the mounts screwed to the mounting surface or to an auxiliary metal plate.

3. LOCATION

a. Free circulation of air around the wattmeter is necessary if operated above 30 watts for more than a few minutes. Keep it reasonably in the clear, and avoid mounting it on, or alongside of, heated surfaces.

b. Where possible, operate in the normal position, feet resting on a horizontal surface, with at least 4" clearance on all sides. Space above wattmeter should be kept as clear as possible for good heat convection. Air cooling is most effective in this position and it is important above 30 watts.

c. AVOID operation in the "J-101 UP" position, i.e. resting on the expansion diaphragm cap at the rear of the radiator. In this position, any air within the coolant space will collect around the voltmeter probes (Fig. 2-4) and a change of dielectric constant in this region will affect calibration.

4. REMOTE USE OF METER BOX

a. The meter box is quickly detachable, as shown in Fig. 1-2. This box contains only the d-c indicating meter, which may be located remote from the resistor-voltmeter unit if required.

b. D-C connection, for remote meter operation, is made either with the short d-c cable W-101, normally coiled inside the meter box; with the long (25 ft) d-c cable W-102; or other shielded wiring.

c. The d-c circuit external to the resistor-voltmeter unit is not critical as to length, placement or to circuit resistance if this resistance is less than 50 ohms. If wiring other than the cables furnished are used they should be shielded, ungrounded, have good insulation and be reasonably free from audio and rf crosstalk. The d-c meter has a 100 microampere, 270 millivolt,

full scale sensitivity. If the entire d-c circuit is not visible, check it with a volt ohmmeter before connecting to the meter M-101. Be sure that the circuit will not be disturbed while in use.

5. LATCH MECHANISM

a. Referring to Fig. 1-2 and 3-1, the meter box is normally retained on the resistor voltmeter unit (as in Fig. 1-1) by bowed-spring action of the LATCH SPRING, a rod of heavy music wire.

b. The box is removable by raising the buttons, first one, then the other, to lift the spring above the notch in the hook.

c. Pull the box forward and rotate to the approximate position shown in Fig. 1-2. If cable W-101 is to be used, uncoil this cable from meter box. If W-102 is to be used disconnect D-C Plugs P-101 and P-102 from J-103 (voltmeter) and J-104 (meter). Connect W-102 to J-103 and J-104. Locate resistor-voltmeter unit and meter box as desired. The meter box should be used in the horizontal position. If it must be read in vertical position, the rubber foot may be unscrewed from bottom of meter box. To avoid loss, screw it back into the same hole but from inside the box.

d. To reassemble, disconnect at voltmeter, J-103. Coil the short cable W-101 within the meter box and around the meter, as in Fig. 1-2. With meter box in about the relative position of Fig. 1-2, tuck excess cable in by working the loops out into corners of meter box. See that both crystal diode V-101 and Cap-H-101 are plugged in. Reconnect to J-103 as shown in Fig. 1-2. Rotate the meter box to position, engaging 4 pins on corners of radiator and noting that cable W-101 is not kinked or pinched. Engage the latch spring per Fig. 3-1, first one button, then the other. The second will be found to resist with stiff spring action. Check by pulling on the meter box.

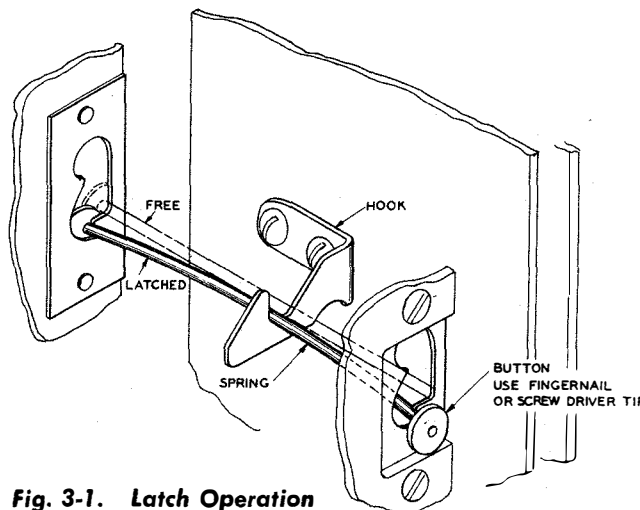


Fig. 3-1. Latch Operation

SECTION 4 OPERATION

1. TO MEASURE TRANSMITTER POWER

- a. Locate the wattmeter where a short patch cord, preferably not over 5 ft. long, will connect the transmitter to the wattmeter and where conveniently readable while adjusting the transmitter.
- b. Insert the crystal holder V-101 in either J-102L or J-102H, thus selecting the desired power range, marked above the jacks on the meter flap. If in doubt select the 60 watt range. Push the crystal holder V-101 firmly in the jack until a positive stop is felt.
- c. With the TRANSMITTER OFF, disconnect the antenna line and connect the wattmeter as shown in Fig. 4-1.
- d. Use a patch cord, consisting of a 50 ohm cable such as RG-8/U and 50 ohm Type "N" plug, such as the UG-21/U series.
- e. Turn the TRANSMITTER ON. The wattmeter will indicate the power being delivered. Read the wattmeter, using the 15 watt range if indication is below that value.
- f. If adjustment of the transmitter is necessary, follow the pertinent instruction book. OBSERVE SAFETY PRECAUTIONS about high voltages in the transmitter. The wattmeter indicates results of tuning direct in watts for the standardized termination of 51.5 ohms afforded by the wattmeter.
- g. When desired output power has been obtained, NOTE THE READINGS of the wattmeter, and of the meters provided on the transmitter, particularly of the plate current and voltage meters on the final stage and of antenna line monitor. These readings bear a direct relationship to power output, and are useful in relating transmitter output to its antenna to output in to the wattmeter.
- h. TURN TRANSMITTER OFF before opening RF connections to the wattmeter.
- i. RECONNECT THE ANTENNA LINE, TURN TRANSMITTER ON and note its meter readings. If the antenna impedance (VSWR) is correct, the transmitter meters will read as they did with wattmeter connected. Some allowances should be made for the fact that VSWR's around 2 to 1 are normal at some frequencies in the range of good broad-band antennas.
- j. In case of a significant difference between transmitter meter readings on wattmeter and antenna, RETUNE THE FINAL TANK AND ANTENNA COUPLING, using plate dip methods or antenna monitor readings as specified in instruction book for transmitter.
- k. REPEAT THE ENTIRE PROCESS FOR EACH NECESSARY FREQUENCY.

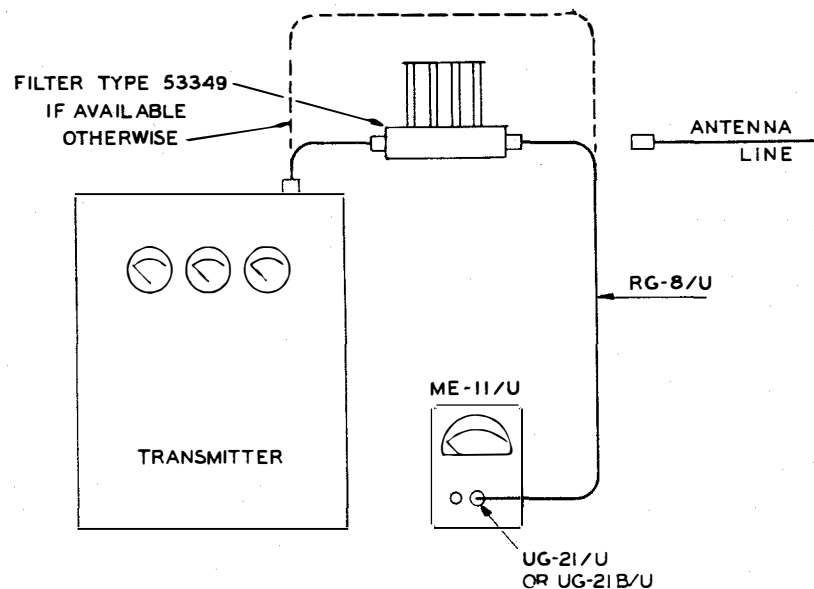


Fig. 4-1. Typical Connections to Transmitter

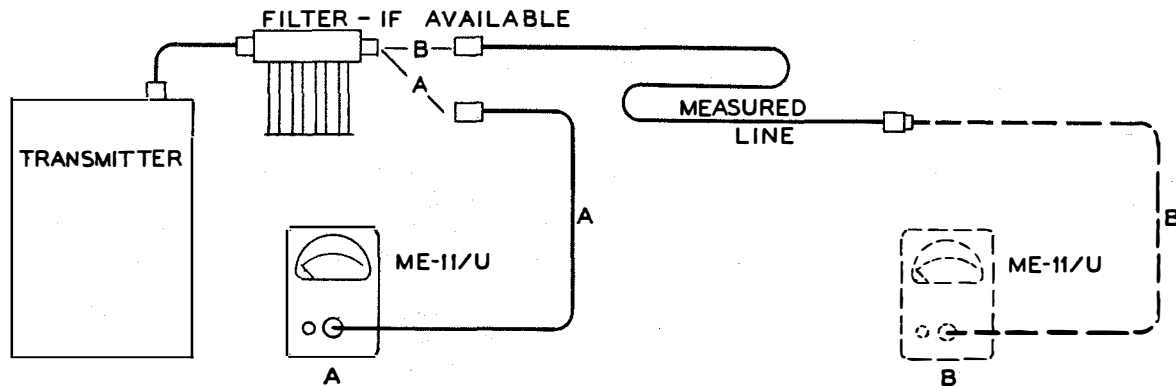


Fig. 4-2. Line Loss Measurement — Block Diagram

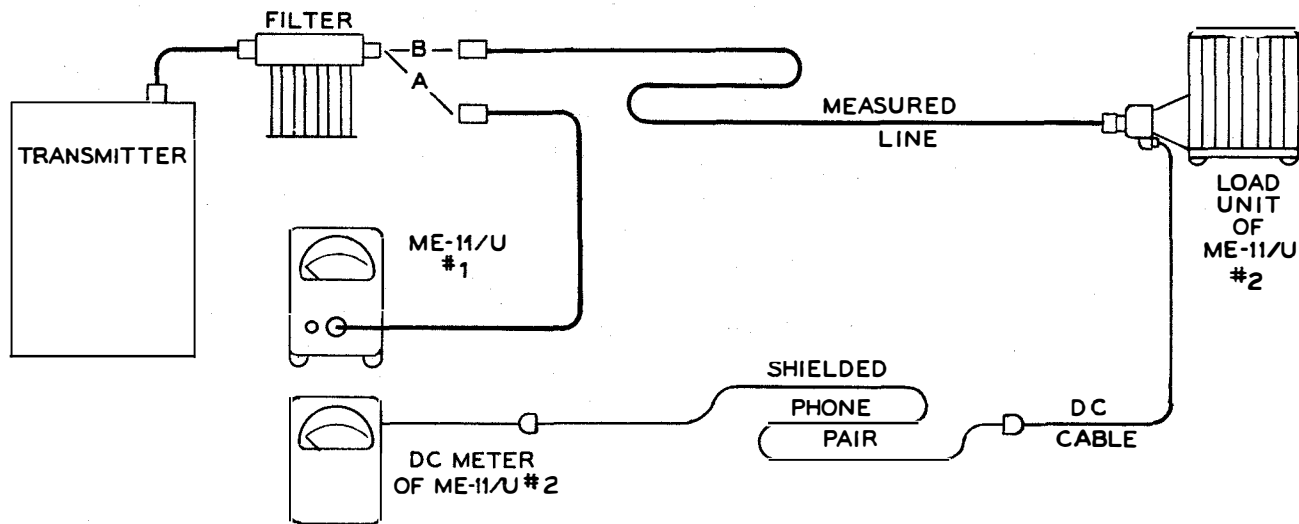


Fig. 4-3. Line Loss Measurement — Remote Use of D-C Meter — Block Diagram

2. TO MEASURE LINE LOSS

a. GENERAL - Loss measurements on 50 to 52 ohm coaxial cables may be made with the wattmeter. A transmitter whose rated output is 15 watts or more is required as a test power source. Assuming a power source of 30 watts and a minimum reading of 1 watt on the 15 watt range, the range of measured loss is 0 to 15 decibels for readable accuracy.

b. TEST PROCEDURE (See Fig. 4-2 and 4-3)

WARNING

Always turn power off when connecting or disconnecting wattmeter or antenna.

(1) Connect the wattmeter to the transmitter ("A" connection of Fig. 4-2 and 4-3). Read output power and tune final stages of transmitter for maximum power output " P_1 ".

(2) Connect line to be measured to transmitter and connect wattmeter to far end of line ("B" connection of

Fig. 4-2 and 4-3). Read power " P_2 " if the transmitter meters do not indicate a significant change in loading. Good lines terminated by the wattmeter should show little change in transmitter loading from that with wattmeter alone. Where significant changes occur, the voltage standing wave ratio of the line is high and attenuation measurements by this method should be disregarded. Cause of high VSWR should be investigated.

(3) The loss may be expressed either as a power ratio P_1/P_2 , or in decibels using the formula:

$$\text{Loss} = 10 \log_{10} \frac{P_1}{P_2} \text{ decibels}$$

(4) Example: Assume P_1 is equal to 30 watts with wattmeter connected to transmitter. Assume P_2 for the "B" connection is 11.5 watts, with the transmitter operating conditions unchanged. Substituting these figures in the above formula:

$$\text{Loss} = 10 \log_{10} \frac{30}{11.5} = 10 \times .416 = 4.16 \text{ db.}$$

c. ACCURACY

(1) The procedure and accuracy of this method is suitable for installation, operating and maintenance activities. It is a practical measurement in that the combined effects of true attenuation (power lost in heating the line) and of reflections caused by the line are given by one measurement.

(2) With reasonable care in holding the transmitter power constant, this method is accurate to within 0.5db. Under the best conditions, results within 0.2 db. are obtainable, providing the VSWR of the measured line is low.

d. ALTERNATE CONNECTIONS

(1) When both ends of measured line terminate in the transmitter room, one wattmeter measurements are convenient (See Fig. 4-2).

(2) A dual set-up with wattmeters and personnel at each end of the line may be used where the far end of the line to be measured is remote, especially when a number of frequencies or parallel lines are to be checked. With readings to be taken at both ends, a telephone connection serving as an order wire will save time.

(3) Fig. 4-3 shows one way of carrying out line measurements from the transmitter room only, when far end of line is remote.

(4) Another way, when two or more rf lines run parallel between measurement points, is to join two lines with a patch cord at the remote end, then measure the loop back to the transmitter room. For identical lines, the loss of one is half the loop loss, or the loss of one good line can be otherwise determined and subtracted from the loop loss.

3. TO CHECK COAXIAL INSERTION DEVICES

a. The term insertion devices is used to mean all forms of connectors, patch cords, switches, relays, filters, tuning stubs, etc. These devices are normally low loss units and true power loss is frequently below that measurable with accuracy. Insertion devices specifically designed for high attenuation may be checked for their loss as outlined in Paragraph 2 above.

b. Tests made in accordance with Paragraph 2 above will not show a readable power loss for a low loss insertion device in good condition. These tests may be considered "IN-OUT" tests in which the optimum performance is indicated by no readable change in wattmeter reading, whether the insertion device is in or out.

c. Tests may be either routine, simply to see that the device works, or they may attempt to discover more closely just what the insertion effect is. In the latter case time stability of the transmitter is all important since the results depend on the difference between two readings not taken simultaneously.

4. MODULATION MONITOR

On amplitude modulation, the d-c meter action of the wattmeter is typical of diode rectifiers, i.e., meter

reading generally is constant regardless of normal modulation.

a. **AUDIO AVAILABLE** - When connected to an amplitude modulated transmitter, audio signals are present across the d-c meter terminals thru the demodulating action of the voltmeter diode. This signal may be used conveniently for monitoring modulation aurally, and for certain measurements on audio characteristics of the transmitter. Specific connectors are not provided for this use.

b. CONNECTIONS

(1) High impedance phones may be bridged across the d-c meter, most conveniently by cutting into the long d-c cable W-102, or by using the d-c plugs P-101 from this cable together with other cables of RG-58/U made up for this purpose. Refer to Figs. 5-2, 5-3 for details of the plugs and of cable service, which does not require soldering.

(2) If an audio coupling capacitor, of .01 to 0.1 mfd. value, is used in series with the phones, the power calibration will be unaffected by the d-c shunting action of the phones.

(3) Higher audio signal level is available by connecting phones only to J-103 (i.e. d-c meter disconnected). However, where possible, it is preferred to bridge the phones across the meter.

(4) In all cases, connect an rf bypass capacitor, 100 to 500 mmf button mica, across the d-c cable (the wattmeter side) at the point where the center conductor emerges from the shield. Keep leads very short, or eliminate by soldering cable conductors directly to the bypass condenser terminals. While in most cases this precaution would be unnecessary, it would give additional protection to the crystal for occasional moments when stray voltage could be externally impressed across the phone terminals.

Caution

In all such use of the wattmeter, use care to avoid stray voltage being impressed across the d-c cable from the wattmeter. Remove crystal before changing connections to the external d-c circuit. A small shielded box for the phone jack is advisable. Because of body static particularly, and rf secondarily, don't touch the hot d-c lead while connected to the crystal.

5. AUDIO RESPONSE MEASUREMENTS

With suitable auxiliary equipment including an audio oscillator, audio voltmeter and amplifier, the audio response curve of a transmitter may be run. Best results are obtained by connecting a resistance, 500 to 1000 ohms, in place of the d-c meter, and the amplifier input across this resistance. Without an amplifier, and audio voltmeter, approximately 1 volt full scale, will give usable deflections connected across J-103, without any shunt resistance or d-c meter. Bypass capacitor C-103, 500 mmf., will in most cases have negligible effect on high audio frequency transmissions.

6. DISTORTION

The crystal diode V-101 is not linear enough as a voltage rectifier to make accurate checks on distortion percentages. However, serious forms of distortion in the transmitter can be detected aurally.

7. USE AS A DUMMY LOAD ONLY

By removing crystals, RF Wattmeter ME-11/U becomes an accurate termination of 51.5 ohms at all frequencies from zero (d.c.) to the top frequencies at which 51.5 ohm coaxial lines are usable.

8. USE AS A LOW FREQUENCY WATTMETER

Below the calibrated range power may be measured by utilizing the wattmeter as a dummy load as specified above and measuring the terminal voltage with an accurate electronic voltmeter suitable for the frequency being measured, such as Navy Model OBQ Vacuum Tube Volt Ohm Milliammeter. The power may then be calculated from the equation $W = E^2 / 51.5$ where E is the root mean square voltage measured by the vacuum tube voltmeter. Caution: Do not exceed the rated power dissipation of the wattmeter which is 60 watts.

9. GENERAL OPERATING NOTES

a. (1) Be careful about the condition of rf cables and connectors used in the rf circuit to the wattmeter. Proper assembly of connectors to cables is important for electrical reasons.

(2) Avoid faulty assembly of the UG-21/U Plug connecting to J-101 on the wattmeter. The center contact sleeve of J-101 is not easily replaceable if damaged.

(3) Patch cord lengths, adaptors and connectors should be kept to a minimum. Type "N" or other constant impedance, 50 ohm, connectors and adaptors should be used.

(4) Where non-constant impedance connectors must be used, as with transmitters having the output jack, Navy type 49194 (Type SO-239), keep them at the transmitter jack only, so that 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 first significant discontinuity, and this should include as much of the total circuit length as possible.

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

(6) The coaxial cable (patch cord) connecting the transmitter to the wattmeter should be made up of a 50 ohm cable with a UG-21/U series plug at one end for the wattmeter connection and a plug mating with the transmitter jack for the other connection. This procedure eliminates the need for additional adaptors. For example, if the transmitter utilizes a Navy Type 49194 Jack, the connecting cable should be made up of a UG-21/U series plug, RG-8/U cable, and a Navy type 49195 plug.

(7) Use only 50-52 ohm cables and fittings if possible. Thus, even in the case of a transmitter having nominal 75 ohm output, 50 ohm lines should be used up to the necessary point of change to something else, at the output jack of the transmitter. Equal impedance of wattmeter and cable is more important than equality between transmitter and cable.

b. OPERATORS TESTS FOR ACCURACY

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

(2) The spare crystal may be checked at any time against the installed crystal. When a steady power reading has been obtained with one crystal, remove it and insert the other. Repeat if necessary to eliminate transmitter variations with time. Results should check within 3% of full scale.

WARNING

INSERT ONLY ONE CRYSTAL AT A TIME

(3) The two power ranges may be cross checked most accurately at 10 to 15 watts input power. The 60 watt range should read within 2 watts of the reading on the 15 watt range.

(4) Comparison of two wattmeters is a practical check on both. Using precautions about time stability of the transmitter, readings should be equal within 10% of the reading (not of full scale) and normally within 5%, for readings above 1/5 of full scale. Assuming both wattmeters unchanged from time of calibration, the largest sources of error in this comparison are:

(a) The real error due to the possible differences in frequency calibration curves (Fig. 2-6).

(b) The apparent error due to normal differences between the exact input impedance values of the two wattmeters.

Minimizing (b) above depends upon whether the transmitter shows a direct relationship between final plate current and power output and whether it has an antenna coupling adjustment. Wattmeter comparisons can be more accurately made by adjusting tuning and coupling on the final tank to the same plate current and voltage values for each wattmeter.

c. WATTMETER VS. ANTENNA AS LOADS

(1) The wattmeter may load the transmitter differently from the antenna. This may be normal for broad band antennas due to voltage standing wave ratio variation at different frequencies. Since the purpose of the transmitter is to drive the antenna, a slight re-tuning of the final tank and antenna coupling may be advisable as described below.

(2) An antenna line monitor (provided in certain transmitters) indicates relative voltage or current at one point in the antenna circuit. The final adjustments should aim at peaking this meter. It will correctly indicate relative power output as long as the load impedance remains fixed. A change of antennas or frequency may cause large variations in load impedance and therefore the monitor readings are unreliable for indicating absolute power.

(3) The line monitor may show a large change of reading, roughly as much as 2 to 1 for a 2.0 VSWR, when the antenna is substituted for the wattmeter.

(4) The power values into the antenna and the wattmeter will be essentially equal if the VSWR on the antenna line is small. This condition may be recognized if after peaking employing either the line monitor or plate current dip as an indicator, the final amplifier plate current and plate voltage are the same.

d. RESPONSE TO HARMONICS AND PARASITICS

(1) The wattmeter is a broad band instrument and its action with presence of harmonics or other spurious frequencies should be considered.

(2) Wattmeter sensitivity decreases with frequency above 500 mc and below 1400 mc. Laboratory and field experience indicate that low order harmonics in this range do not appear to be serious sources of error. However, to avoid measurement error and interference troubles it is highly desirable to eliminate all frequencies except the carrier desired. Such filters as have been provided for interference control (such as Navy Type 53349 for TDZ and MAR) should be installed when employing the wattmeter as shown in Fig. 4-1, 4-2, 4-3.

(3) Above 1400 mc, two sensitivity peaks are present in the wattmeter sensitivity curve. These are approximately 1700 and 2600 mc where resonances occur in

the voltmeter circuit and cannot be eliminated without ruining the flat sensitivity obtained for normal frequencies. These peaks are of the order of 20 db above the wattmeter sensitivity at normal frequencies, so that erratically high readings occur if a spurious frequency in the transmitter output coincides with one of them. Low pass filters, such as Navy Type 53349, will eliminate such trouble should it appear.

(4) Operating symptoms of wattmeter response to these high spurious frequencies are:

- (a) Erratic high readings.
- (b) Occurs usually at certain carrier frequencies only.
- (c) Reading very sensitive to slight movement of the crystal diode V-101, in and out of the Jack, J-101, within the contacting range. Normally this makes very little difference.
- (d) Transmitter tuning adjustments much more critical than normal.

(5) To attenuate these spurious responses, insert a Low Pass Filter, such as Navy Type 53349 for tests below 400 mc, and a similar filter but of higher cutoff frequency if measurements must be made above 400 mc. Such filters have been found to eliminate the trouble completely in cases where it has occurred. Operation of the wattmeter should not continue when large spurious responses are present since the crystal may be damaged by excessive voltage overload.

FAILURE REPORTS

A FAILURE REPORT must be filled out for the failure of any part of the equipment whether caused by defective or worn parts, improper operation, or external influences. It should be made on Failure Report, form NBS-383, which has been designed to simplify this requirement. The card must be filled out and forwarded to BUSHIPS in the franked envelope which is provided. Full instructions are to be found on each card.

Use great care in filling the card out to make certain it carries adequate information. For example, under "Circuit Symbol" use the proper circuit identification taken from the schematic drawings, such as T-803, in the case of a transformer, or R-207, for a resistor. Do not substitute brevity for clarity. Use the back of the card to completely describe the cause of failure

and attach an extra piece of paper if necessary.

The purpose of this report is to inform BUSHIPS of the cause and rate of failures. The information is used by the Bureau in the design of future equipment and in the maintenance of adequate supplies to keep the present equipment going. The cards you send in, together with those from hundreds of other ships, furnish a store of information permitting the Bureau to keep in touch with the performance of the equipment of your ship and all other ships of the Navy.

This report is not a requisition. You must request the replacement of parts through your Officer-in-Charge in the usual manner.

Make certain you have a supply of Failure Report cards and envelopes on board. They may be obtained from any Electronics Officer.

FAILURE REPORT—ELECTRONIC EQUIPMENT
NAVSHIPS (NBS) 383 (REV. 8-45)
(FORMERLY NAVSHIPS (NBS) 383 AND NAVSHIPS (NBS) 304)

SHIP NUMBER AND NAME OR STATION _____

CHECK ONE: RADIO

EQUIPMENT MODEL DESIGNATION _____

TYPE NUMBER AND NAME OF MAJOR UNIT INVOLVED _____

THIS TUBE TYPE, INCLUDING PREFIX LETTERS _____

TUBE MANUFACTURER _____

FAILURE OCCURRED IN:
 STORAGE OPERATION
 HANDLING OTHER (SPECIFY) _____
 INSTALLING

NATURE OF FAILURE AND REMARKS _____

NOTICE.—Read notes on reverse side. Additional forms and envelopes may be obtained from nearest RMO.

NAME OF PERSON MAKING REPORT _____

DATE _____

ELECTRONIC EQUIPMENT FAILURE REPORT (SIG)
NAVSHIPS (NBS) 383 (REV. 11-45)

ORGANIZATION PERFORMING MAINTENANCE _____

EQUIPMENT INVOLVED:
 Navy Army USMC JAN Commercial Other _____ (Specify)
 Radio Radar Sonar Wire Test Test Power Sound Other _____ (Specify)

EQUIPMENT MODEL DESIGNATION _____ SERIAL NUMBER OF EQUIPMENT _____ NAME OF CONTRACTOR _____ CONTRACT NO. _____

TYPE NUMBER AND NAME OF MAJOR UNIT INVOLVED _____ SERIAL NUMBER OF UNIT _____ CONTRACT OR PO DATA OF UNIT _____ DATE EQUIPMENT RECEIVED _____

NOTICE.—Read notes on cover prior to preparing this form.

*REPORT No. _____

DATE _____

NAME AND RANK OF OFFICER ACCOUNTABLE FOR MAINTENANCE _____

THIS SIDE FOR TUBES		THIS SIDE FOR PARTS (NOTE 8)			
TUBE TYPE, INCLUDING PREFIX LETTERS	SERIAL NO. (NOTE 4)	NAME OF PART	CIRCUIT SYMBOL (eg R-134)	NAVY TYPE NO.	
TUBE MANUFACTURER	CONTRACT NO. (NOTE 4)	SERIAL NO.	*CONTRACT DATA	*DATE RECD.	*ARMY STOCK NO.
FAILURE OCCURRED IN	GUARANTEED HOURS (NOTE 4)	DATE OF ACCEPTANCE (NOTE 5)	*CHECK-OFF OR TAG DATA (NOTE 4)	*MANUFACTURER'S DATA (NOTE 4)	
<input type="checkbox"/> Storage <input type="checkbox"/> Operation	ACTUAL HOURS	DATE OF FAILURE	BRIEF DESCRIPTION AND CAUSE OF FAILURE, INCLUDING APPROXIMATE LIFE (CONTINUE ON BACK)		
<input type="checkbox"/> Handling <input type="checkbox"/> Other (Specify in remarks)	TYPE OF FAILURE (NOTE 7)	TUBE CIRCUIT SYMBOL V-			
NATURE OF FAILURE AND REMARKS (NOTE 4) (CONTINUE ON BACK)					

CONCLUSION:
 Normal replacement Shortage Medication Failure Transportation breakage Other _____ (Specify)

*NOT REQUIRED FOR REPORTS SUBMITTED BY NAVAL ACTIVITIES. 16-46851-1 U. S. GOVERNMENT PRINTING OFFICE

SECTION 5 MAINTENANCE

1. INTRODUCTION

The circuit simplicity and mechanical design of the wattmeter result in a minimum of maintenance since all electrical circuits are sealed and rigidly mounted.

Parts within the rf unit of the RESISTOR-VOLTMETER unit, Fig. 1-2, are not subject to field maintenance. This unit should not be opened except at the filler plug to check coolant level.

Preventive and corrective maintenance are grouped together in this section.

2. GENERAL MAINTENANCE

a. Keep jacks and plugs clean. The best method is to make sure that crystal diodes V-101 and V-102, and Cap H-101 are inserted in their jacks at all times. D-C connectors of Cable W-101 should be kept connected to exclude dirt and moisture.

b. The Plugs P-101 and P-102 should be kept tightly screwed on to their jacks. If they have been undisturbed for long periods, loosen the knurled collars slightly, and move right angle barrel to clean contact surfaces. Then retighten.

c. Dropping is the most likely source of damage, the D-C Meter M-101 being the critical item. DO NOT DROP IT. Close the METER FLAP when not in use, particularly when carrying the wattmeter around.

d. DO NOT allow the crystal diodes to be separated from the wattmeter. Keep the working crystal diode V-101 and Cap H-101 on the ball chain provided for them. Restore the spare crystal V-102 to its socket (under the meter box) after use, and secure with tape to supplement the grip of the socket.

e. If the spare crystal is to become the working crystal, attach it to the chain. This change may be readily made at the crystal end.

Note

New crystals should be requisitioned immediately upon damage to either V-101 or V-102. The serial number of the wattmeter for which intended MUST be entered on the requisition.

f. When two wattmeters are used together, do not allow the crystals to be mixed up between wattmeters. They are NOT interchangeable between wattmeters without loss of calibration.

g. The same precaution applies to interchanging meter boxes and resistor-voltmeter units, although calibration changes will be small. Matching serial numbers appear on the nameplate mounted on the meter box and stamped on one of the bottom corner rails of the RESISTOR-VOLTMETER unit. (See Fig. 1-2)

3. CRYSTAL UNIT

Fig. 5-1 shows the mounting of the crystal diode in its holder. Refer also to Section 2, Paragraph 6 and 8.

a. The SEAL "O" RING, Fig. 5-1, should be checked semi-annually and kept lubricated very lightly, with Dielectric Compound A-N Aeronautical Spec. AN-C-128, (Aviation Office Stock Catalog Number R52-C-3107-123 for an 8 lb. can; R52-C-3107-125 for a 10 lb. can.) Lubrication will prevent excessive friction when changing ranges.

b. The shield contact fingers may need occasional attention to maintain pressure against the inside wall of the Jacks, J-102L and J-102H. Make slight adjustments by bending. CAUTION. Do not allow tool to touch center contact of crystal.

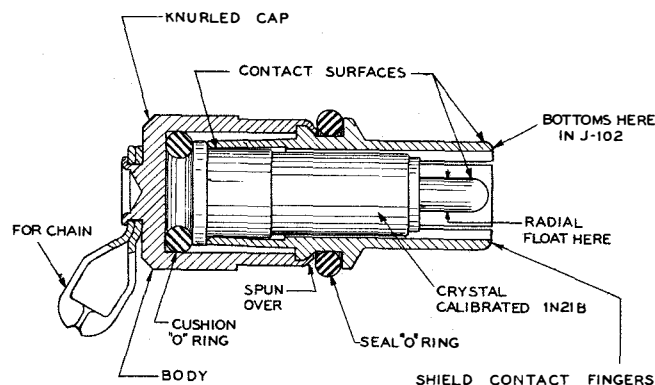


Fig. 5-1. Crystal Unit, Rectifying CAWY-40322
Crystal Diode, V-101, V-102

c. In an EMERGENCY where the wattmeter must be used and both crystals supplied with instrument have been damaged or lost, any 1N21B crystal may be used in the wattmeter with a probable error ranging up to 20%. See Section 2, Paragraph 9. To remove crystal from the holder (See Fig. 5-1) remove the seal "O" ring and file off the lip marked "Spun Over". If a drill press or lathe is available chuck the knurled cap and file while the holder rotates. The new crystal may then be used in the body of the crystal holder without the knurled cap.

WARNING

KEEP CRYSTAL RECTIFIERS IN METAL BOX OR WRAPPED IN METAL FOIL EXCEPT WHEN IN USE OR BEING TESTED. WHEN INSERTING CRYSTAL RECTIFIER IN HOLDER, HOLD CRYSTAL RECTIFIER BY BODY AND TOUCH FINGER TO GROUND TO DISCHARGE ELECTROSTATIC CHARGES BEFORE INSERTION.

4. ELECTRICAL TESTS

a. The simplest overall test of the wattmeter is the comparison test discussed in Section 4, Paragraph 9.

Caution

REMOVE CRYSTALS FROM THE VOLTMETER WHEN MAKING TEST DESCRIBED BELOW

b. D-C METER TESTS - Testing of the meter should be attempted only by one familiar with circuits and instruments for testing of sensitive d-c microammeters because of the danger of damaging it in unsuitable circuits. Test the meter as a microammeter in series with a low voltage battery, variable resistor and an external microammeter such as Navy Type 60107. Full scale current on M-101 should be 100 microamperes $\pm 2\%$. Disconnect D-C Cable W-101 at Jack, J-103 so that W-101 will be tested with the meter.

Caution

M-101 is a sensitive microammeter. Do not attempt to check with an ohmmeter.

c. D-C PLUG AND CABLE TESTS may be made with an ohmmeter and megger. Disconnect cable from both voltmeter Jack J-103 and Meter Jack J-104 for test. Check continuity and leakage.

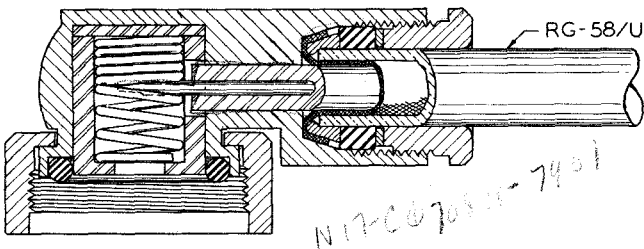


Fig. 5-2. Connector, Plug CAWY-491859 (D-C Plug P-101)

d. D-C PLUGS - CABLE SERVICE - Fig. 5-2 shows construction of the d-c plugs P-101 to P-104, Navy Type CAWY-491859. Fig. 5-3 shows proper service of RG-58/U cable for these plugs. To remove cable from this plug unscrew the bushing and pull cable out. The center conductor of the cable makes tight contact between turns of the coil spring when assembled. For easiest assembly of cable to plug, flatten the end of center conductor as shown on Fig. 5-3, and align the resulting chisel point with turns of the spring while pushing in the serviced cable.

e. SIMPLE TESTS ON VOLTMETER CIRCUITS - Remove crystal and d-c plug from the voltmeter before making any tests.

(1) The resistance to ground measured at D-C Jack J-103 indicates the insulation resistance of both voltmeter circuits. This resistance should be over 20 megohms. Low insulation resistance probably indicates moisture within the voltmeter housing. The various jacks and the joint between frame and cover castings are not hermetically sealed.

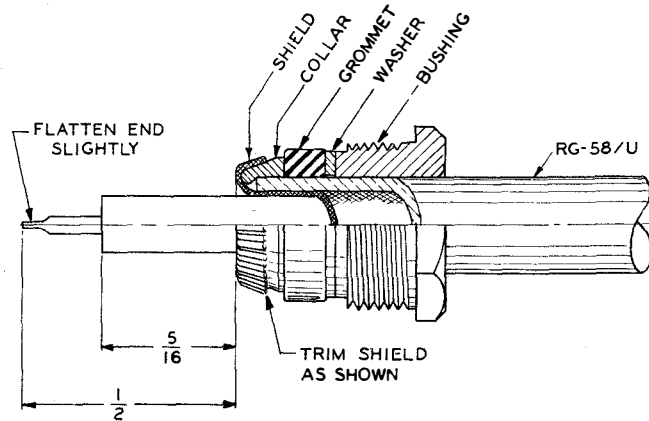


Fig. 5-3. Cable Service For Connector, Plug CAWY-491859 (D-C Plug P-101)

(2) Moisture within the voltmeter housing may be driven off by operating the wattmeter on rf power at 60 watts or by applying a maximum of 55 volts at 60 cycles to J-101.

(3) Resistors R-102L and R-102H may be measured between D-C Jack J-103 and respective center contacts of J-102L and J-102H. These resistors should measure 9100 ohms $\pm 10\%$. Differences within this tolerance are part of the calibration.

(4) Bypass capacitor C-103 may be checked with a capacitance tester, such as Navy Type 60007, connected between the center contact of J-103 and ground with W-101 disconnected. Measured values should be 500 mmf plus or minus 20%.

f. TESTING THE LOAD RESISTOR

An accurate resistance measuring instrument such as A-N Type Resistance Bridge ZM-4/U good to 1% or better at 50 ohms is required. Refer to Section 2, Paragraphs 4 and 16. Using low resistance leads (preferably a short piece of RG-8/U connected to a UG-21/U plug) measure the load resistor R-101. A change of more than 2 ohms from the original value stamped on top of the voltmeter housing is an indication that the rf resistance has changed significantly and that the wattmeter should be replaced. The coolant level should also be checked when measuring the resistor.

5. CHECKING COOLANT LEVEL

The general significance of oil seepage or leaks which may occur has been discussed in Section 2, Paragraph 14. Avoid tampering with any of the various joints at which the oil is sealed.

The filler plug is on the conical reducer, Fig. 1-2 at the lower right. It is an "O" RING SEAL plug, removable with hex key wrench, size 3/16, Federal Standard Stock Catalog #41-W-2452. Before removing plug, place the RESISTOR-VOLTMETER unit in the "filler plug up" position. The coolant level should be at or within 1/4" of the innermost thread of the fitting. If necessary to add coolant, use only transformer oil, Federal Specification VV-0-401, Federal Stock No. 14-0-3530 for a 5-gallon can.

SECTION 6
PARTS LIST

TABLE 6-1 - PARTS LIST BY SYMBOL DESIGNATION

Symbol Desig.	Name of Part and Description	Function	AWS, Jan or Navy Type DS.	Navy Stock No.	Army Stock No.	Mfr. & Mfr's Desig.	BE CO. Dwg. & Part No.	All Symbol Design. Involved
C-101H	<i>See Note 2 in Navy Stock No. Column</i> CAPACITOR, Variable, gold plated, OA dimen. @ min. cap., .800 x .312 x .252, Assy. consists of (2) Parts Sleeve and Probe NR	Voltage Divider series capacitance 60 W range		<i>See Note 2</i>		(1)	750112 750125	C-101H
C-101L	<i>Same as item 1.</i> CAPACITOR, Variable, silver plated, OA dimen. @ min. cap., .830 x .312 x .252, Assy. consists of (2) Parts Sleeve and Probe NR	Voltage Divider series capacitance 15 W range		<i>Same as Item 1</i>		(1)	750124 750115	C-101L
C-102H	<i>same as Item 1.</i> CAPACITOR, Fixed, gold plated, OA dimen. 1.305 x .157 diam. xtal contact on one end, dielectric ceramic tube ID .159, OD .249 x .625 NR	Voltage Divider shunt capacitance 60 W range		<i>same as Item 1</i>		(1)	750131 3312	C-102H
C-102L	<i>Same as Item 1.</i> CAPACITOR, Fixed, silver plated OA dimen. 1.255 x .157 diam. xtal contact on one end, dielectric ceramic tube ID .159, OD .249 x .625 NR	Voltage Divider shunt capacitance 15 W range		<i>Same as Item 1</i>		(1)	750113 3312	C-102L
C-103	<i>Same as Item 1.</i> CONDENSER, Button-Mica, 500 MMF. 10%, .450 diam. x 1/16, eyelet feed thru type NR	by-pass		<i>same as Item 1</i>		(3) 370-BH	750116	C-103
H-101	CAP, Crystal Jack, to close unused J-102L or J-102H, silver-plate, OA dimen. 1.050 x .5 diam., waterproof	Dust and Moisture Seal		<i>7N7-2201579-0846</i>		(1)	750106	H-101
J-101	<i>"See Note 2" in Navy Stock Nbr Column.</i> JACK, RF connector, female type N, part of voltmeter frame casting NR	RF input to load		<i>See Note 2.</i>		(1)	750138 750137 750139	J-101 R-101

NR = not replaceable

- E1B426
1. Low Failure Item - if required, requisition from ESO reference Navships 900, 180A.
2. For reference only
3. Shop manufacture

TABLE 6-1 - PARTS LIST BY SYMBOL DESIGNATION (Continued)

6-1

Section 6
Parts Lists

NAVSHIPS 91118
ME-11/U

PARTS LISTS

Symbol Desig.	Name of Part and Description	Function	AWS, Jan or Navy Type DS.	Navy Stock No.	Army Stock No.	Mfr. & Mfr's Desig.	BE CO. Dwg. & Part No.	All Symbol Design. Involved
J-102H	JACK, Crystal socket, part of cover casting, fits V-101 & V-102, 1/2 in. diam, extends 3/8 in. from cover casting NR	Crystal Socket high range		<i>same as above item</i>		(1)	750104	J-102H
J-102L	Same as J-102H	Crystal Socket low range				(1)	750104	J-102L
J-103	JACK, Male, part of voltmeter frame casting, silver-plate 5/8" diam. 24 thd., waterproof fits P-101 NR	Meter Connection		<i>same as above item</i>		(1)	750122	J-103
J-104	JACK, Male, part of M-101 silver-plate, 5/8" diam. 24 thd. extends 9/32 from back of meter case, waterproof, fits P-101 NR	Meter Connection		<i>same as above item</i>		(1)	75096 75098 75097	J-104 M-101
M-101	METER, DC microammeter, 100 ua, 270 millivolts, scale 0-15, 0-60 watts, 3-1/2" AWS dimens.	Meter	22722	<i>A17-7034513-2146</i>		(2) Model 46-HS	75045	M-101 J-104
P-101	CONNECTOR, Plug, female, part of W-101 & W-102, silver-plate, OA dimen. 1-1/4 x 3/4 x 5/8, waterproof	DC Cord Connections	491859	<i>A17-6070811-7901</i>		(1)	75076	P-101 W-101 W-102
P-102	Same as P-101							P-102
P-103	" " "							P-103
P-104	" " "							P-104
	NR = not replaceable							

ORIGINAL

TABLE 6-1 - PARTS LIST BY SYMBOL DESIGNATION (Continued)

Symbol Desig.	Name of Part and Description	Function	AWS, Jan or Navy Type DS.	Navy Stock No.	Army Stock No.	Mfr. & Mfr's Desig.	BE CO. Dwg. & Part No.	All Symbol Design. Involved
R-101	RESISTOR, Load, RF, 51.5 ohms± 1.5 ohms, carbon film on ceramic, assy. consists of resistor, and center contact of J-101 NR	Wattmeter Load		NA 6-70455 9570		(1)	750134	R-101 J-101
R-102H	RESISTOR, Fixed carbon, 9100 ohm 10%, 1/2 watt, 13/32 long 1/8 diam., axial leads 1-1/2 long NR	Voltmeter Load high range		See "Note 2"		(4) BTS	750117	R-102H
R-102L	Same as R-102H	Voltmeter Load low range						R-102L
V-101 *	CRYSTAL UNIT, Rectf. silicon diode, IN21B, calibrated, permanently installed in holder, OA dimen. 1-1/16 x 7/16 diam.	RF Rectifier	40322	NA 6-20099327- 1101		(1)	750147	V-101
V-102 *	CRYSTAL UNIT, Spare, same as V-101							V-102
W-101	CORD, DC, meter, length 39" RG-58/U Cable with (2) Connector Plugs P-101 & P-102	DC Connection to meter		NA 6-2011943- 9231		(1)	75072	W-101 P-101 P-102
W-102	CORD, DC, meter, length 25 ft. RG-58/U Cable with (2) Connector Plugs P-103 & P-104	DC Connection to meter		NA 6-2011948- 5631		(1)	75072 (specify length)	W-102 P-103 P-104
	* NOTE-When ordering crystals, serial no. of wattmeter must be placed on requisition.							
	NR = not replaceable							

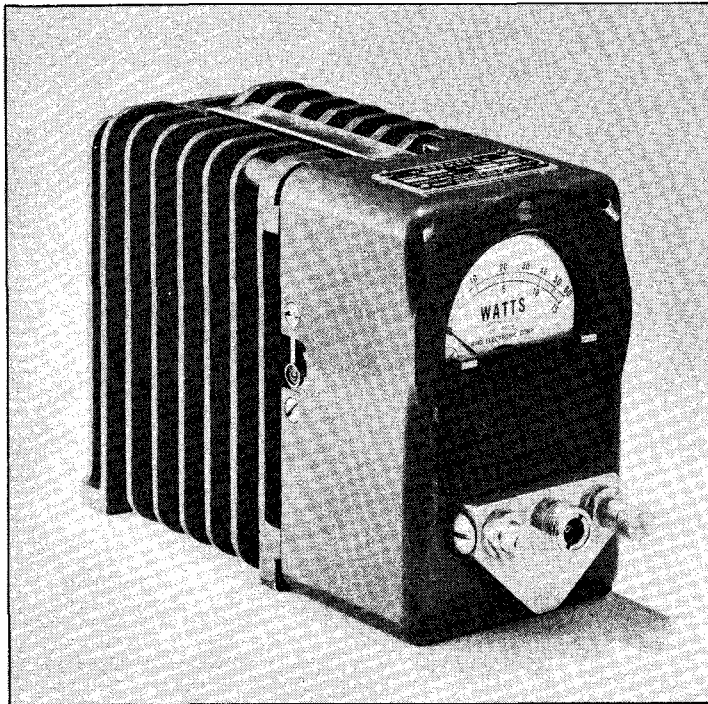
TABLE 6-2 — LIST OF MANUFACTURERS

Code #	Mfg. Prefix	Name	Address
1	CAWY	Bird Electronic Corporation	1800 East 38th St. Cleveland 14, Ohio
2	CHK	Hickok Electrical Instrument Co.	10514 DuPont Ave. Cleveland, Ohio
3	CER	Erie Resistor Co.	Erie, Pa.
4	CIR	International Resistor Co.	Philadelphia, Pa.

Model 61

Termaline

DIRECT Reading VHF-UHF Wattmeter



For the FIRST TIME . . .

Specifications

- FREQUENCY RANGE**
30 MC to 500 MC
- POWER RANGE**
Dual scale is provided with 0-20 and 0-80 watt calibration. 0-15 and 0-60 watt full scale can be provided at no extra charge.
- IMPEDANCE**
51.5 ohms --VSWR less than 1.1
- FOR USE ON**
CW, AM, FM sources. Not calibrated for pulsed power at low duty cycles.
- RANGE SELECTION**
By inserting crystal rectifier in proper socket.
- SCALE TYPE**
Expanded at low scale readings. (thus, the 2-watt point on a 20-watt scale lies at about 1/5 of full scale.)
- INPUT CONNECTOR**
Female "N". Takes UG-21/U or UG-21B/U on RG-8/U cable.
- ACCURACY**
Within 5% of full scale absolute. Repeatability 1% for readings on any one instrument. Agreement 3% between various instruments of this model and other similar models.
- PHYSICAL DIMENSIONS**
8"L x 6"H x 4" W. Weight only 7 lbs.

Here are rugged direct-reading instruments for power measurement of transmitters in the 30 to 500 MC, 1 to 500 watt ranges. Accuracy far exceeds anything available previously, while use of the Model 61 and 67 is as simple as use of an ordinary D-C voltmeter. With these instruments, you can measure transmitter power, take accurate data on how transmitter power output is affected by line voltage, transmitter temperature rise, time, etc. It gives you an accurate standard termination for 50-52 ohm coaxial lines, so that comparisons are readily made between antennas and this standard load. Transmitter line and connector losses may be readily checked to the accuracy needed in field work. Reliability of Model 61 or 67 is such that at any time you can determine exactly how present transmitter performance compares with that previously realized and know that results are accurate in absolute terms.

Design of the Model 61 and 67 and refined factory calibration standards insure accurate agreement between all instruments of this and similar new types. Such an order of accuracy has not been realized before. We firmly believe that Model 61 and 67 will settle the old question "What is a Watt?" at these frequencies for the entire transmitter field.



BIRD ELECTRONIC CORPORATION

Represented on West Coast by:
NORMAN B. NEELY ENTERPRISES
7422 MELROSE BLVD. HOLLYWOOD 46, CAL.
Whitney 1147

Instrumentation for Coaxial Transmission
1800 EAST 38TH STREET
CLEVELAND 14, OHIO
EXPRESS 3535

Technical Data--Model 61 and 67 Wattmeters

GENERAL DESCRIPTION

The TERMALINE wattmeters, Models 61 and 67 are of the absorption type, combining the functions of proper line termination, dissipation of input power and accurate direct-reading of this power. For use with low and medium power transmitters in design, production testing, installation and maintenance.

COMPONENTS

The Termaline Wattmeter consists of:

- (1) A Termaline coaxial resistor, input resistance 51.5 ohms over a frequency range d-c to 1000 mc.
- (2) Dual or triple voltmeter cartridges of a new design, using the 1N21B crystal diode. Cartridges are bridged across the input of the Termaline resistor and feed:
- (3) A d-c meter with scales direct reading in terms of r-f power input to the Termaline resistor.

DESIGN PRINCIPLES

The wattmeter therefore measures by the E^2/R method. The Termaline resistor used is very similar to the Model 81 Termaline, well known now as an excellent line termination and uniform resistance over the frequency range d-c to 4000 mc. The voltmeter cartridges are capacitively coupled by probes entering the dielectric space within the resistor. This is so done that the low VSWR of the resistor is maintained to frequencies (1000 mc or higher) beyond the calibrated range of the wattmeter. Therefore, we have a practically constant, pure resistance, the power into which can be measured by voltmeter methods.

VOLTMETER CARTRIDGES

These cartridges result from a long program aimed at good measuring elements for use with the Termaline resistor. Starting with series-thermocouple development, we soon found their possibilities inferior to the crystal diode voltmeter, which may be made flat over a far wider and higher frequency range, is more sensitive allowing lower power ranges to be made and more rugged d-c meters to be used, has less aging and temperature troubles and is quite stable. Stability is surprising in this application, and to those who have not had the opportunity to use modern crystals against good standards, we can only say that these gadgets had to be rugged to keep working at all in high power radar sets, protected only by T-R boxes.

Voltmeter cartridges as used here may be called the "shunt diode" type, the crystal being across the shunt element of a capacitive divider. Cartridges, one for each range, are identical except for coupling capacitance, thereby giving identical frequency response and scale shape for the two or three ranges. Flatness with frequency is obtained by suitable design of the "plumbing" in the cartridge. The lower frequency limit is set by time-constant effects, which are well controlled down to 30 mc. Both the Termaline, the cartridges, and the combination are actually flat to well above 500 mc., the calibration and control being limited to this frequency because of insufficient customer need to go higher.

ACCURACY

Our claims for accuracy are modest, we believe, in view of what we know can be done with these instruments. There are two main reasons for this: (a) Users face several sources of error which are not in the wattmeter, but which can be eliminated with the aid of the wattmeter as experience is gained and (b) as pioneers in this field, we know of no better standards than our own to which reference may be made. Our methods and standards have been worked on for several years, to the point where we estimate their uncontrolled errors (versus a hypothetical absolute standard of power) to be under $\pm 3\%$. Such standard errors are mainly functions of frequency, originate in the calorimetry and are such that all instruments calibrated from the standards have what error there may be in common, rather than being in disagreement from this cause. Standard errors operate as percentages of reading, not of full scale.

Calibration is done at sufficient frequencies and power levels to insure accuracy, and individual calibration data furnished with the instrument for use if desired in getting extra accuracy beyond the stated direct reading limits.

USE ON MODULATED SOURCES

Calibration is done with c-w sources and results are exact on c-w and f-m. The instrument has familiar diode voltmeter characteristics on a-m, functioning like the carrier level meter in modulation monitors. It may be used to detect carrier shift, but does not respond to the increased power going into sidebands under modulation. Aural monitoring of a-m is conveniently done with high impedance phones connected in the meter circuit. The wattmeters should not be used on pulsed transmission of radar type (low duty cycle), since the crystal voltage limit is exceeded on pulses. The instruments have possible uses on television transmission, but this has not been investigated. Correspondence is invited about modified forms of instruments, for peak power and average power measurements on TV and pulsed sources.

CALIBRATION is by methods probably unique, developed to overcome common sources of error. The instruments are directly connected to our SLOTTED LINE WATTMETER, which accurately reads power transmitted thru it, regardless of load impedance. Simultaneous readings are therefore possible on standard and calibrated instruments, without time interval or change of connections. By this general method, residual errors with frequency in the Termaline and voltmeters do not cause calibration error and it should be noted that both are free anyhow from the "long line" effects (small cyclic variations with frequency) which are so troublesome in close work with lossy line loads. Power calibrations are repeatable within $\pm \frac{1}{2}\%$ or so over considerable time intervals, and VSWR measurements to $\pm .005$.

THE SLOTTED LINE WATTMETER is the working standard. It has, in turn, been calibrated by calorimetric methods.

TEMPERATURE EFFECTS are nominal, even for continuous duty at maximum resistor rating. Both ambient and rise effects may be expressed in terms of temperatures measured on the voltmeter cartridges, and amount to readings approximately 3% high at full load, high range equilibrium, or readings 3% low at starting from OOC ambient. Expressed otherwise, readings have a positive temperature coefficient of about .08% per degree C.

TEMPERATURE RISE under load is conservative, and controlled by the aluminum radiator and sealed-in liquid coolant. An expansion diaphragm allows for coolant expansion. TERMALINE RESISTOR LIFE is in excess of 1000 hours at full rating, at which point tests were stopped.

POWER RANGES were selected to suit common transmitter ratings. The expanded low scales result from power scales applied to approximately linear voltage characteristics, and are quite useful. Single or multiple special ranges are available. Low power ranges down to around 1 watt full scale are readily made for wide frequency ranges.

MISCELLANEOUS

SHIELDING AND BY-PASSING are adequate for operation in strong r-f fields.

CRYSTALS (Model 61) are each mounted in a special shielding holder. On Model 67, they are encased in a knurled cap holder for ease in handling.

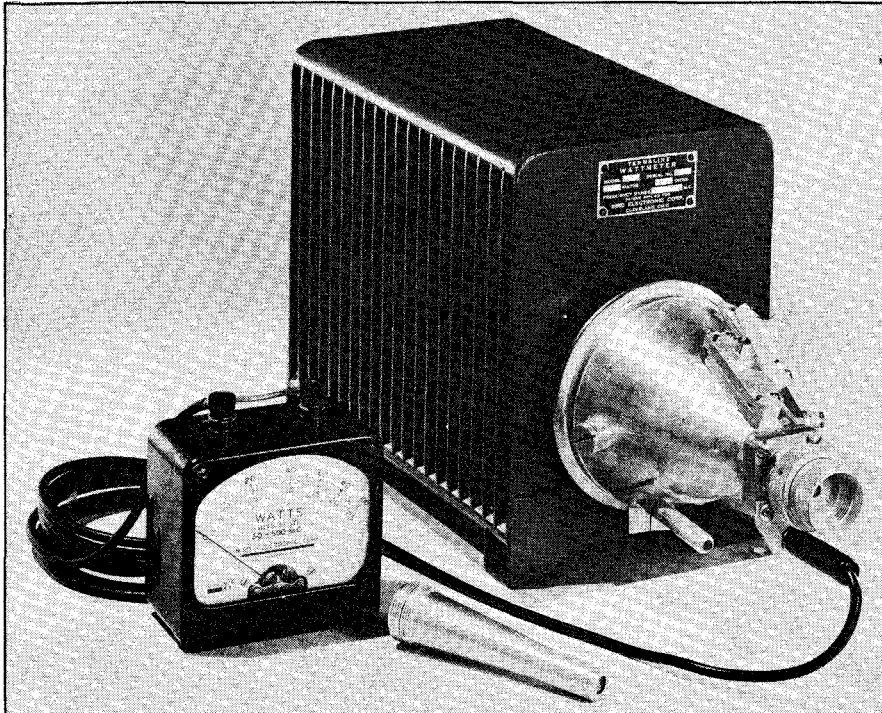
A SPARE CRYSTAL is furnished, matched to the installed crystal at all points of the scale. Available always for quick checks. Additional calibrated crystals can be furnished at any time from the factory without recalibration of the entire wattmeter. METER CASE (Model 61) is detachable, and may be used remote at the end of the 5 ft. cable included. Longer d-c extension cables may be used if desired.

THE D-C METER CIRCUIT IS INDEPENDENT OF THE COAXIAL CIRCUIT JOINING LOAD RESISTOR AND TRANSMITTER. THEREFORE, BLOCKING CONDENSERS IN THE ANTENNA CIRCUIT OF THE TRANSMITTER CAUSE NO DIFFICULTY.

Model 67

Termaline

DIRECT Reading VHF-UHF Wattmeter



TRIPLE RANGE: 25, 100, 500 WATTS FULL SCALE

FEATURES -- MODEL 67

Model 67 is a test bench instrument, wherein portability features are not so significant. It covers the power ranges of the 61 and has an additional power range of 500 watts full scale. For reasons of size economy, continuous power rating of the Termaline resistor in the 67 has been made 300 watts (ample for 250 watt rigs), while continuous operation at 500 watts calls for the aid of a small electric fan or blower (not part of the wattmeter equipment). Without fan, operation at 500 watts for short periods, up to 10 minutes, is quite alright.

The d-c meter is not built into the 67. It is a 4" rectangular portable instrument, offering longer scales and somewhat better reading accuracy than on the 61. A ten ft. shielded cord is furnished, with phone plug to fit the jack on the wattmeter proper. Especially with this larger wattmeter, it is convenient to locate the load resistor as dictated by r-f cabling, and the d-c meter for best observation.

The coaxial connector on the 67 is a large diameter Teflon dielectric Type CP19F, special to us and used for years on our slotted lines. Adapters (reducers) of low SWR design are available to suit connectors used with the RG-8, 14, 17, and 19 cables, and to suit 7/8", 1-5/8", and 3-1/8" rigid line, 51.5 ohm. The CPA 198 adapter (to suit UG-21/U or UG-21B/U and RG-8/U cable) is furnished unless otherwise specified. Among other advantages, the large CP connector makes available the full, peak power rating of the Termaline resistor.

Specifications

FREQUENCY RANGE

30 MC to 500 MC

POWER RANGE

1 watt to 500 watts

IMPEDANCE

51.5 OHMS-VSWR less than 1.1

FOR USE ON

CW, AM, FM sources. Not calibrated for pulsed power at low duty cycles.

RANGE SELECTION

By inserting crystal rectifier in proper socket

SCALE TYPE

Expanded at low scale readings (Thus, the 10-watt point on a 100-watt scale lies at about 1/5 of full scale.)

INPUT CONNECTOR

Adapter furnished which fits UG-21/U or UG-21B/U on RG-8/U cable. Other adapters available to fit any rigid or flexible coaxial line.

ACCURACY

Within 5% of full scale absolute. Repeatability 1% for readings on any one instrument. Agreement 3% between various instruments of this model and other similar models.

PHYSICAL DIMENSIONS

17" L x 8 1/2" H x 6" W. Weight 30 lbs.

THE 67 AND 61 ARE BASICALLY THE SAME EXCEPT FOR MECHANICAL FEATURES AND ARRANGEMENT OF COMPONENTS. OTHERWISE, THE DIFFERENCE IS LARGELY IN SIZE, TERMALINE RESISTOR RATING, AND IN THE POWER RANGES MEASURED.

MECHANICAL FEATURES -- MODEL 61

This model has been developed for the Navy Buships (AN designation ME-11/U) for maintenance of shipboard transmitters. Considerable mechanical refinement is incorporated. D-C meter is hermetically sealed, mounted entirely within the aluminum meter box and has the glass protected in transit with a metal flap, hinged, easily opened and closed. A special fastener design allows quick detachment of the entire meter box, but provides a secure hold when assembled. Structure is aluminum, with smooth gray enamel finish baked over anodized surfaces. Non-electrical hardware is principally stainless steel. The stainless handle recesses when not in use. Since the major components are inherently sealed and waterproof, all components have been so made. With simple precautions taken about the crystal sockets, the entire unit is immersion proof. Rough handling, too, is provided for.

SPECIAL VERSIONS

WATER COOLED models 67W and 67 C handle 2 KW easily and may be had in any reasonable range combination, not over three ranges and the highest range not over 2000 watts full scale. The 67 C is externally very much like the 67, but has copper tubing coiled in the coolant space in intimate thermal contact with the coolant, and thru it, with the heat source. Water is a thermal medium only (not used as a dielectric) and has no effect on the input impedance. The 67 C combines the air cooled features of the 67 up to 500 W with much higher power rating obtained thru the cooling effectiveness of water. In the 67 W, air cooling fins are omitted, resulting in a cylindrical outline, 4-1/4" maximum diameter. It is used only with water cooling in the range 500 to 2000 watts.

Both the 67 W and 67 C when water cooled, are to be operated with the Termaline axis vertical, input connector down. In this condition, very effective coolant convection maintains low temperature drop between heat source and water coils. Tap water is used, with connections thru light rubber hose.

OPTIONAL D-C METER

A high precision d-c meter, Weston Model 430, 5" rectangular, with 1/2% d-c accuracy, mirror and knife edge pointer, and hand drawn 100 division scale, is available with Models 67, 67 W, 67 C (or the Model 61, but not built in). For certain working standard instruments, the extra cost of this d-c meter is worthwhile.

COMPARATIVE DIMENSIONS AND WEIGHTS

Model	Length	Heighth	Width	Weight	Shipping Wgt.
61	8"	6 "	4"	7 lbs.	8 1/2 lbs.
67	17"	8 1/2"	6"	30 lbs.	50 lbs.



BIRD ELECTRONIC CORPORATION

Instrumentation for Coaxial Transmission
 Represented on West Coast by:
NORMAN B. NEELY ENTERPRISES
 7422 MELROSE BLVD. HOLLYWOOD 46, CAL. WHitney 1147
 1800 EAST 38TH STREET
 CLEVELAND 14, OHIO
 EXPRESS 3535