COLLINS

Instruction Book

302C-1 and 302C-2

DIRECTIONAL WATTMETER

Instruction Book

302C-1 and 302C-2
DIRECTIONAL WATTMETER

Cedar Rapids, Iowa

NEW YORK BURBANK DALLAS

520 5523 00
1 AUGUST 1957
Printed in the United States of America

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

COLLINS AMATEUR EQUIPMENT GUARANTEE

The Collins Amateur equipment described herein is sold under the following guarantee:

Collins agrees to repair or replace, without charge, any equipment, parts, or accessories which are defective as to design, workmanship, or materials, and which are returned to Collins at its factory, transportation prepaid, provided:

(a) Buyer has completed and returned to Collins promptly following his purchase the Registration Card included in the Instruction Book furnished with the equipment.

(b) Notice of the claimed defect is given Collins within 90 days from the date of purchase and goods are returned in accordance with Collins' instructions.

(c) Equipment, accessories, tubes, and batteries not manufactured by Collins or from Collins' designs are subject to only such adjustments as Collins may obtain from the supplier thereof.

(d) No equipment or accessory shall be deemed to be defective if, due to exposure or excessive moisture in the atmosphere or otherwise after delivery, it shall fail to operate in a normal and proper manner.

(e) Any failure due to use of equipment in excess of that contemplated in normal amateur operations shall not be deemed a defect within the meaning of these provisions.

The guarantee of these paragraphs is void if equipment is altered or repaired by others than Collins or its authorized service center.

No other warranties, expressed or implied, shall be applicable to said equipment, and the foregoing shall constitute the Buyer's sole right and remedy under the agreements contained in these paragraphs. In no event shall Collins have any liability for consequential damages, or for loss, damage or expense directly or indirectly arising from the use of the products, or any inability to use them either separately or in combination with other equipment or materials or from any other cause.

IMPORTANT! It is necessary that the business reply card included herewith be filled out and mailed to the Company promptly in order for this guarantee to be effective.

HOW TO RETURN MATERIAL OR EQUIPMENT. If, for any reason, you should wish to return material or equipment, whether under the guarantee or otherwise, you should notify us, giving full particulars including the details listed below, insofar as applicable. If the item is thought to be defective, such notice must give full information as to nature of defect and identification (including part number if possible) of part considered defective. (With respect to tubes we suggest that your adjustments can be speeded up if you give notice of defect directly to the tube manufacturer.) Upon receipt of such notice, Collins will promptly advise you respecting the return. Failure to secure our advice prior to the forwarding of the goods or failure to provide full particulars may cause unnecessary delay in handling of your returned merchandise.

ADDRESS:

Collins Radio Company
Sales Service Department
Cedar Rapids, Iowa

INFORMATION NEEDED:

(A) Type number, name, and serial number of equipment
(B) Date of delivery of equipment
(C) Date placed in service
(D) Number of hours of service
(E) Nature of trouble
(F) Cause of trouble if known
(G) Part number (9 or 10 digit number) and name of part thought to be causing trouble
(H) Item or symbol number of same obtained from parts list or schematic
(I) Collins' number (and name) of unit sub-assemblies involved in trouble
(J) Remarks

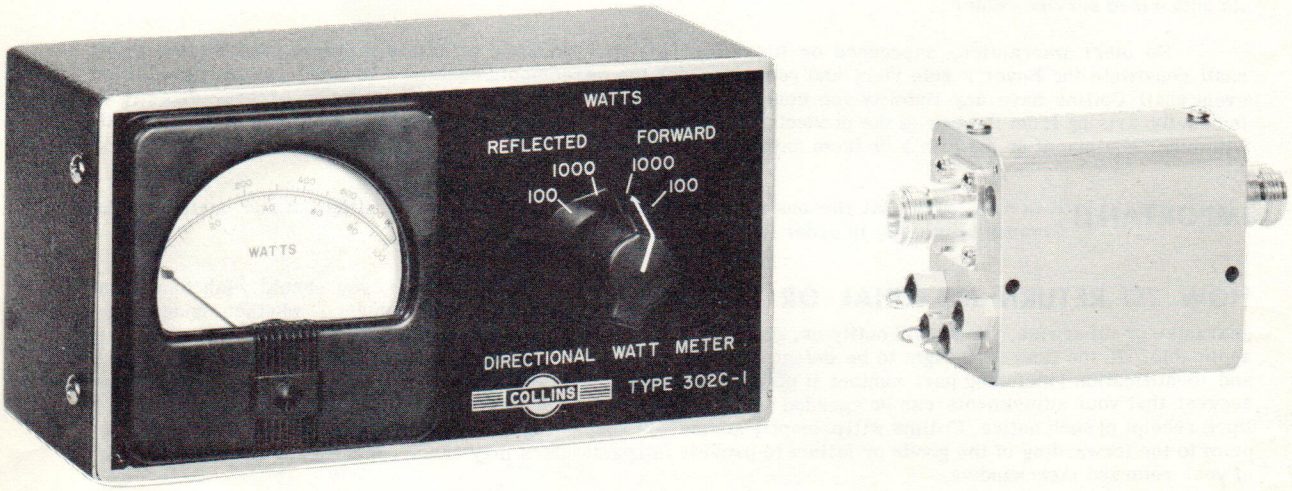
HOW TO ORDER REPLACEMENT PARTS. When ordering replacement parts, you should direct your order as indicated below and furnish the following information insofar as applicable. To enable us to give you better replacement service, please be sure to give us complete information.

ADDRESS:

Collins Radio Company
Sales Service Department
Cedar Rapids, Iowa

INFORMATION NEEDED:

(A) Quantity required
(B) Collins' part number (9 or 10 digit number) and description
(C) Item or symbol number obtained from parts list or schematic
(D) Collins' type number, name, and serial number of principal equipment



C189-06-P

Figure 1-1. 302C-1 Directional Wattmeter

NOTE

Model 302C-2 does not include indicator mounting cabinet.

SECTION I
GENERAL DESCRIPTION

1.1 GENERAL.

This instruction book contains the information necessary to install, operate, and interpret the readings for Collins Directional Wattmeters, models 302C-1 (figure 1-1) and 302C-2. Both models consist of two major subassemblies, a coupler unit and an indicator unit. The indicator unit components of model 302C-1 are housed in a small box that can be placed on the operating desk. An interunit connecting cable, prewired to the indicator unit, is supplied with this model. The indicator unit components of model 302C-2 are unmounted and are to be installed by the customer on a custom panel or in a custom housing. No interunit connecting cable is supplied with this model. Except for the differences noted, the two models are identical.

1.2 PURPOSE.

Model 302C-1 and 302C-2 Directional Wattmeters measure up to one kw of forward and one kw of reflected r-f power on 52-ohm transmission line (RG-8/U, or equivalent).

The instruments are accurate to with ±10% (±5% nominal) over the 2- to 30-mc range. Power loss and mismatch introduced by the instruments are negligible.

The forward and reflected power readings are primarily used to determine transmission line swr and transmitter power output. In addition, antenna match, antenna bandwidth (match vs frequency), attenuation in transmission lines, and other system performance characteristics can be determined from the forward and reflected power readings. During transmission, the instrument acts as a continuous monitor of transmitter performance and antenna match.

1.3 EQUIPMENT SUPPLIED.

The equipment supplied with model 302C-1 consists of a coupler unit, an indicator unit mounted in a small box, a shielded interunit connecting cable (prewired to the indicator unit) and mounting screws for the coupler unit.

Equipment supplied with model 302C-2 is identical to that supplied with model 302C-1, except that no indicator unit box is supplied, the indicator components are not mounted, and no interunit connecting cable is included. A faceplate and knob for the switch are supplied.

1.4 EQUIPMENT REQUIRED BUT NOT SUPPLIED.

Only two type N male connectors, used to connect an existing RG-8/U transmission line to the coupler unit, are required to install model 302C-1. Installation of model 302C-2 requires, in addition to the two type N male connectors, a custom panel or box for mounting the indicator components and an appropriate length of four-wire shielded cable for interconnecting the units. Two two-wire shielded cables or four single-wire shielded cables may be used instead of a four-wire shielded cable. Use AWG #22 or larger wire for cable runs up to 500 feet. (For cable runs over 500 feet, the resistance per wire may not exceed 10 ohms.)

NOTE

The custom panel or box must have a non-ferrous mounting surface, preferably aluminum.

1.5 SPECIFICATIONS.

The following specifications apply to both models.

Frequency range	2 to 30 mc
Impedance	52 ohm unbalanced
Wattmeter scales	100 watts forward
	1000 watts forward
	100 watts reflected
	1000 watts reflected
Maximum power handling capability*	2000 watts forward power
Power loss through coupler	Less than 0.1% or 1 watt with 1000 watts r-f output
SWR introduced by coupler	Less than 1.05:1
R-F connectors, coupler	Type N female
External power requirements	None

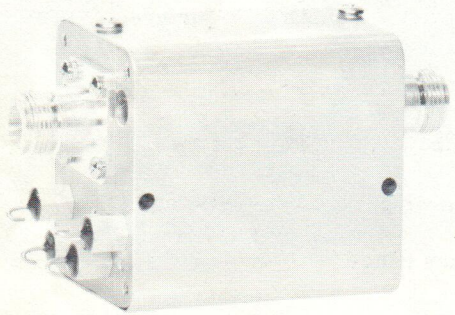
*The amount of actual transmitter output power that can be handled safely by both models depends on the swr on the line. Refer to section III for instructions.

1.6 DESCRIPTION OF UNITS.

1.6.1 COUPLER UNIT.

The coupler unit for both models (figure 1-2) is a portable, nonpressurized, dustproof unit equipped with type N female r-f connectors on each end. The connectors mate with type UG-21/U male plugs attached to RG-8/U, or similar type coaxial transmission line. The coupler unit is finished with bright, alloy plate and a bright-dipped dust cover. The coupler unit weighs 1 lb and is 2 in. wide, 2-1/2 in. high, and 2-1/2 in. long (4 in. long overall with connectors). The coupler unit has solder-lug metering terminals, which are part of feedthrough capacitors mounted on the frame.

When connected into a transmission line carrying r-f power, the coupler unit develops d-c voltages indicative of the magnitude of the forward and reflected power levels on the line.



C189-07-P

Figure 1-2. 302C-1 and 302C-2 Directional Wattmeters, Coupler Unit

1.6.2 INDICATOR UNIT.

1.6.2.1 INDICATOR UNIT OF MODEL 302C-1. The indicator unit of model 302C-1 (figure 1-3) consists of a portable nonpressurized box housing the indicator components. The box is finished in grey wrinkle paint. On the front of the box is a black anodized panel which mounts an indicating meter and a meter switch. Extending from the rear of the box is a 5-ft, 4-wire, cable terminated in tinned leads, which are to be solder-connected to the coupler unit. The indicator unit weighs 1 pound 10 ounces, and is 3 inches wide, 3-1/2 inches high, and 6-1/2 inches long.

C189-08-P

Figure 1-3. 302C-1 Directional Wattmeter, Indicator Unit

1.6.2.2 INDICATOR UNIT OF MODEL 302C-2. The indicator unit of model 302C-2 consists of an indicating meter, a switch, a knob, and a faceplate. Interunit cable and meter connections (cable not supplied) are made to solder terminals on the switch.

1.6.2.3 FUNCTION. The meter of the indicating unit reads the magnitude of the forward power and reflected power as selected by the switch.

SECTION II
INSTALLATION

2.1 UNPACKING.

The model 302C-1 and 302C-2 Directional Wattmeters are packed in a single carton containing the two major units, individually wrapped. Unwrap the units carefully, retaining the packing material. If shipping damage is evident, the units should be repacked and the shipping company or post office notified immediately.

Make a thorough visual inspection of the units to check for breakage or other damage. Reference to the photographs in section VIII will be helpful while making this check. If the instrument is not damaged, install it using the procedure given in the following paragraph.

2.2 INSTALLATION INSTRUCTIONS. (See figure 2-1.)

2.2.1 INSTALLATION AND WIRING, MODEL 302C-1.

a. Mount the coupler unit adjacent to the transmission line onto a cabinet or bracket, using the mounting screws provided. The distance between the transmitter output and the input to the coupler unit should be kept to a minimum.

b. Cut the transmission line where it passes the coupler and install two type N male connectors at the break (figure 2-3).

c. Place the indicator unit not more than five feet from the coupler. Solder the tinned cable leads to the proper terminals on the coupler.

d. Connect the transmission line from the antenna to the end of the coupler unit which has the d-c output terminals. Connect the line from the transmitter to the opposite end of the coupler unit.

e. The instrument is ready for operation.

2.2.2 INSTALLATION AND WIRING, MODEL 302C-2.

a. Mount the coupler and connect the transmission line as outlined on figure 2-1 and in paragraph 2.2.1 above.

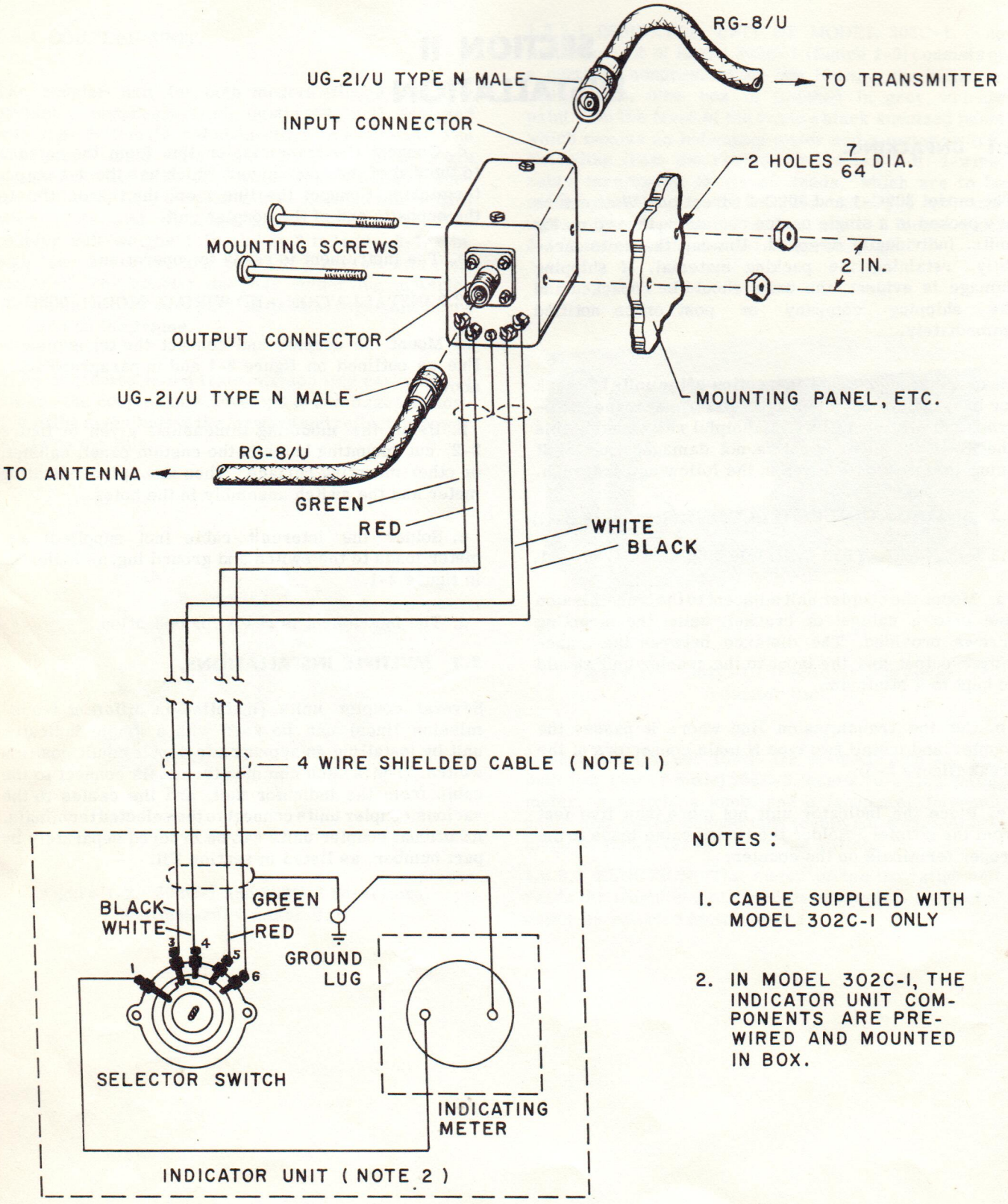
b. Using the mounting dimensions given in figure 2-2, cut mounting holes in the custom panel, cabinet, or other mounting surface. Then mount the indicating meter and the switch assembly in the holes.

c. Solder the interunit cable (not supplied) and meter leads to the switch and ground lug, as indicated in figure 2-1.

d. The instrument is ready for operation.

2.3 MULTIPLE INSTALLATIONS.

Several coupler units (installed in different transmission lines) can be used with a single indicator unit by installing an appropriate 4-pole, multiposition switch. The switch common terminals connect to the cable from the indicator unit, and the cables to the various coupler units connect to the selected terminals. Additional coupler units can be ordered separately by part number, as listed in section VII.



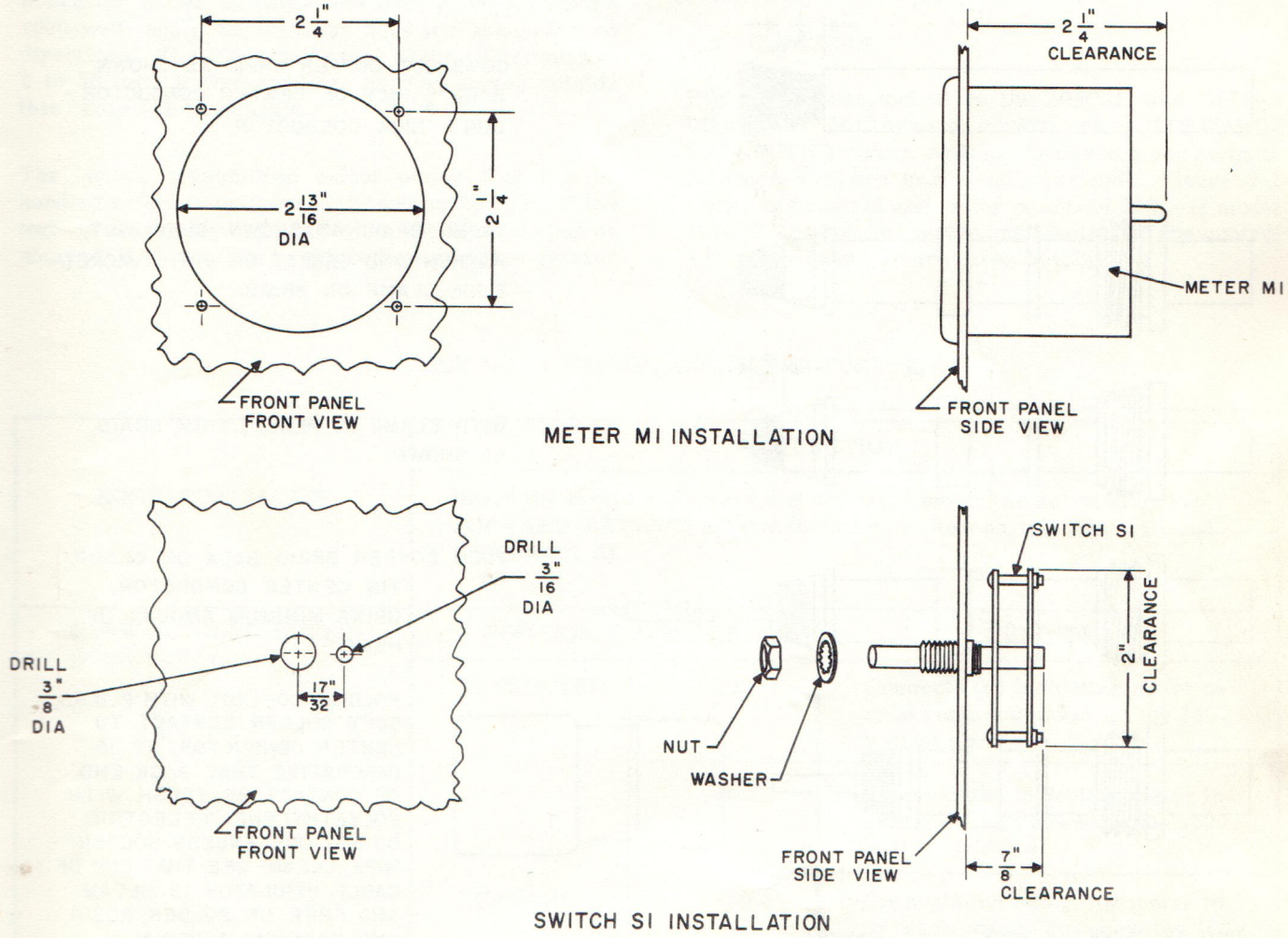
NOTES:

1. CABLE SUPPLIED WITH MODEL 302C-1 ONLY

2. IN MODEL 302C-1, THE INDICATOR UNIT COMPONENTS ARE PREWIRED AND MOUNTED IN BOX.

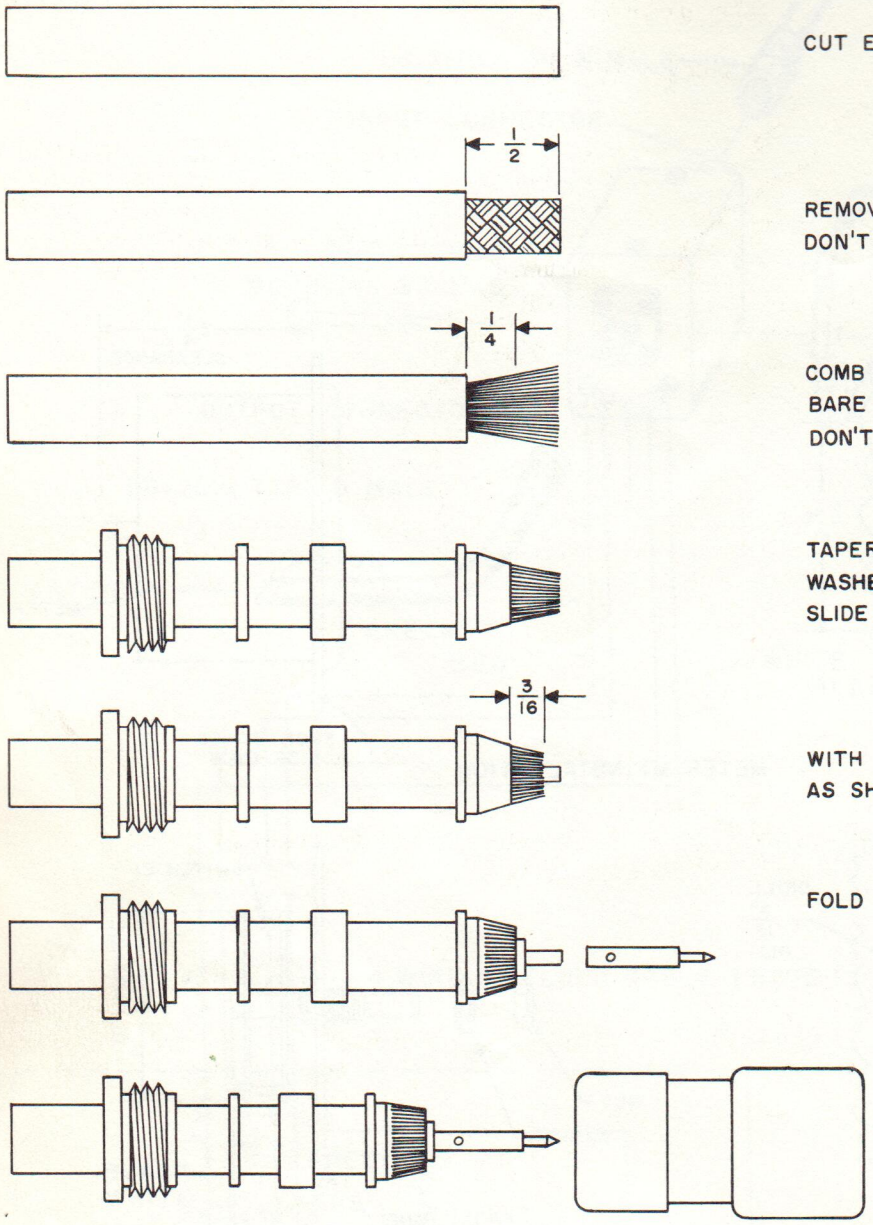
C189-04-3

Figure 2-1. 302C-1 and 302C-2 Directional Wattmeters, Installation and Wiring Diagram



C189-05-3

Figure 2-2. 302C-2 Indicator Unit, Installation Details



CUT END OF CABLE EVEN.

REMOVE VINYL JACKET $\frac{1}{2}$ INCH — DON'T NICK BRAID.

COMB OUT COPPER BRAID AS SHOWN. BARE $\frac{1}{4}$ INCH OF CENTER CONDUCTOR — DON'T NICK CONDUCTOR.

TAPER BRAID AS SHOWN. SLIDE NUT, WASHER AND GASKET ON VINYL JACKET. SLIDE CLAMP ON BRAID.

WITH CLAMP IN PLACE, TRIM BRAID AS SHOWN.

FOLD COPPER BRAID BACK ON CLAMP. TIN CENTER CONDUCTOR, USING MINIMUM AMOUNT OF HEAT.

HOLDING CONTACT WITH PLIERS, SOFT SOLDER CONTACT TO CENTER CONDUCTOR. IT IS IMPERATIVE THAT BACK END OF CONTACT BE FLUSH WITH POLYETHYLENE DIELECTRIC. DO NOT USE EXCESS SOLDER. WIPE CLEAN - SEE THAT END OF CABLE INSULATOR IS CLEAN AND FREE OF SOLDER, ROSIN AND FOREIGN MATERIAL.

SLIDE BODY INTO PLACE CAREFULLY SO THAT CENTER CONDUCTOR ENTERS HOLE IN INSULATOR. FACE OF CABLE DIELECTRIC MUST FIT FLUSH AGAINST INSULATOR. PROPERLY TIGHTEN BODY AND NUT WITH WRENCHES.

Figure 2-3. Installation of Type N Male Connectors on RG-8/U Transmission Line

C64-03-3

SECTION III
OPERATION

3.1 GENERAL.

Models 302C-1 and 302C-2 Directional Wattmeters are operated in the same manner. The coupler units are rated to handle up to 2 kw of forward power and the indicating meter is calibrated over a 100-watt and a 1000-watt scale in both the forward and reflected directions. The frequency range of the wattmeters is 2 to 30 mc. Power readings at frequencies outside this range are inaccurate.

The actual transmitter output power that can be handled safely is relative to the swr on the line. If the swr is extremely high, as when the line is open or shorted, it is possible to obtain forward power greater than 2 kw with practically no power output from the transmitter. Therefore, to avoid damaging the instrument, it is important that the operating procedure given in paragraph 3.3.1 be followed carefully when the instrument is used to measure unfamiliar levels of forward and reflected power.

3.2 CONTROLS.

The operational control on the 302C-1 and 302C-2 Directional Wattmeters consist of a FORWARD-REFLECTED power switch. The switch and an indicating meter are in the indicator unit. Figure 3-1 shows the control and meter on model 302C-1; model 302C-2 control and meter are identical. The control and meter functions are given in table 3-1.

TABLE 3-1. CONTROL AND METER FUNCTIONS

<table>
<tr><td rowspan="2">INDICATING METER</td><td colspan="3">FUNCTION</td></tr>
<tr><td colspan="3">Reads the levels of forward and reflected power, as selected by the FORWARD-REFLECTED power switch, on two scales: 100 watt and 1000 watt (1 K).</td></tr>
<tr><td rowspan="5">FORWARD-REFLECTED power switch</td><td colspan="2">POSITION AND SCALE</td><td>FUNCTION</td></tr>
<tr><td rowspan="2">REFLECTED</td><td>100</td><td>Connects the indicating meter to read reflected power on the 100-watt scale.</td></tr>
<tr><td>1000</td><td>Connects the indicating meter to read reflected power on the 1000-watt (1 K) scale.</td></tr>
<tr><td rowspan="2">FORWARD</td><td>100</td><td>Connects the indicating meter to to read forward power on the 100-watt scale.</td></tr>
<tr><td>1000</td><td>Connects the indicating meter to read forward power on the 1000-watt (1 K) scale.</td></tr>
</table>

3.3 OPERATING PROCEDURES.

The operating procedure for the directional wattmeters consists of obtaining readings for forward and reflected power. Determining swr, transmitter power output, etc., requires the calculations described in paragraph 3.4. Use of the instrument as a monitor during various types of emission is discussed in paragraph 3.5.

3.3.1 INITIAL PROCEDURE.

The initial procedure described below applies whenever the instrument is used under unknown conditions

of forward and reflected power; i.e., when the instrument is first installed, when a new antenna or transmitter is tried for the first time, etc. Perform the following steps:

a. Set the REFLECTED-FORWARD power switch to the FORWARD 1000 scale.

b. Turn on the transmitter and excite the transmission line (and the antenna or other load). Use AM. or cw emission. The indicating meter should show a forward power reading.

c. If the forward power reading is below 100 watts, either switch to the FORWARD 100 scale or increase the power output of the transmitter until a reading midscale or greater is obtained. If the forward power reading is greater than 1000 watts (off scale), reduce the power output of the transmitter until an on-scale reading is obtained. Record the reading.

d. Switch to the REFLECTED 1000 scale. Unless the antenna or load is perfectly matched (52 ohms resistive) the meter will read a reflected power reading. The reflected power reading will always be less than the forward power reading. If the reading is less than 100 watts, switch to the REFLECTED 100 watt scale. Record the reading.

NOTE

If the reflected power reading is greater than the forward power reading, the coupler unit has been improperly installed. Refer to figure 2-1 and check the installation. Either the coupler has been installed backwards (the input and output type N connectors attached to the wrong side of the line) or pairs of d-c meter leads to the indicator unit are reversed.

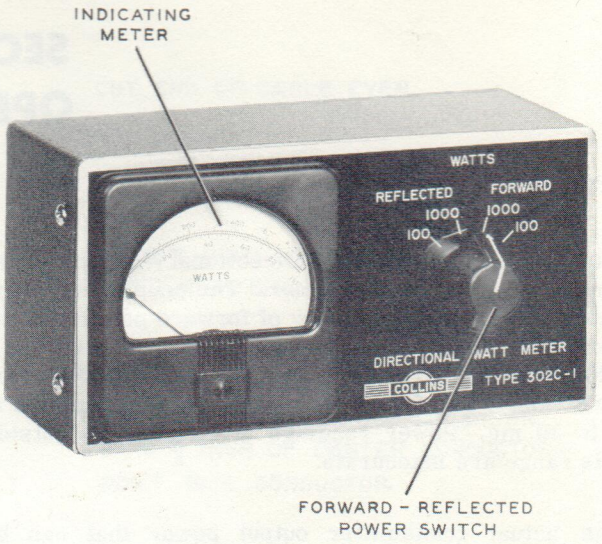
e. If the forward and reflected power readings are equal or nearly equal, the swr on the line is extremely high. This indicates a shorted, open, or poorly terminated line.

NOTE

The instrument will respond to submultiple and harmonic r-f output from the transmitter as well to r-f at the fundamental frequency. Forward and reflected r-f power on spurious frequencies will be read on the meter along with r-f power at the fundamental frequency.

3.3.2 RUNNING PROCEDURE.

When the approximate forward and reflected power readings are known, the wattmeter acts as a monitor of line conditions. Use the following procedure during operating periods:



C189-09-P

Figure 3-1. 302C-1 Directional Wattmeter, Location of Controls

a. To monitor forward power, leave the power switch set to FORWARD 1000 or FORWARD 100 scale as applicable.

b. To monitor reflected power, leave the power switch set to REFLECTED 1000 or REFLECTED 100 watt scale, as applicable.

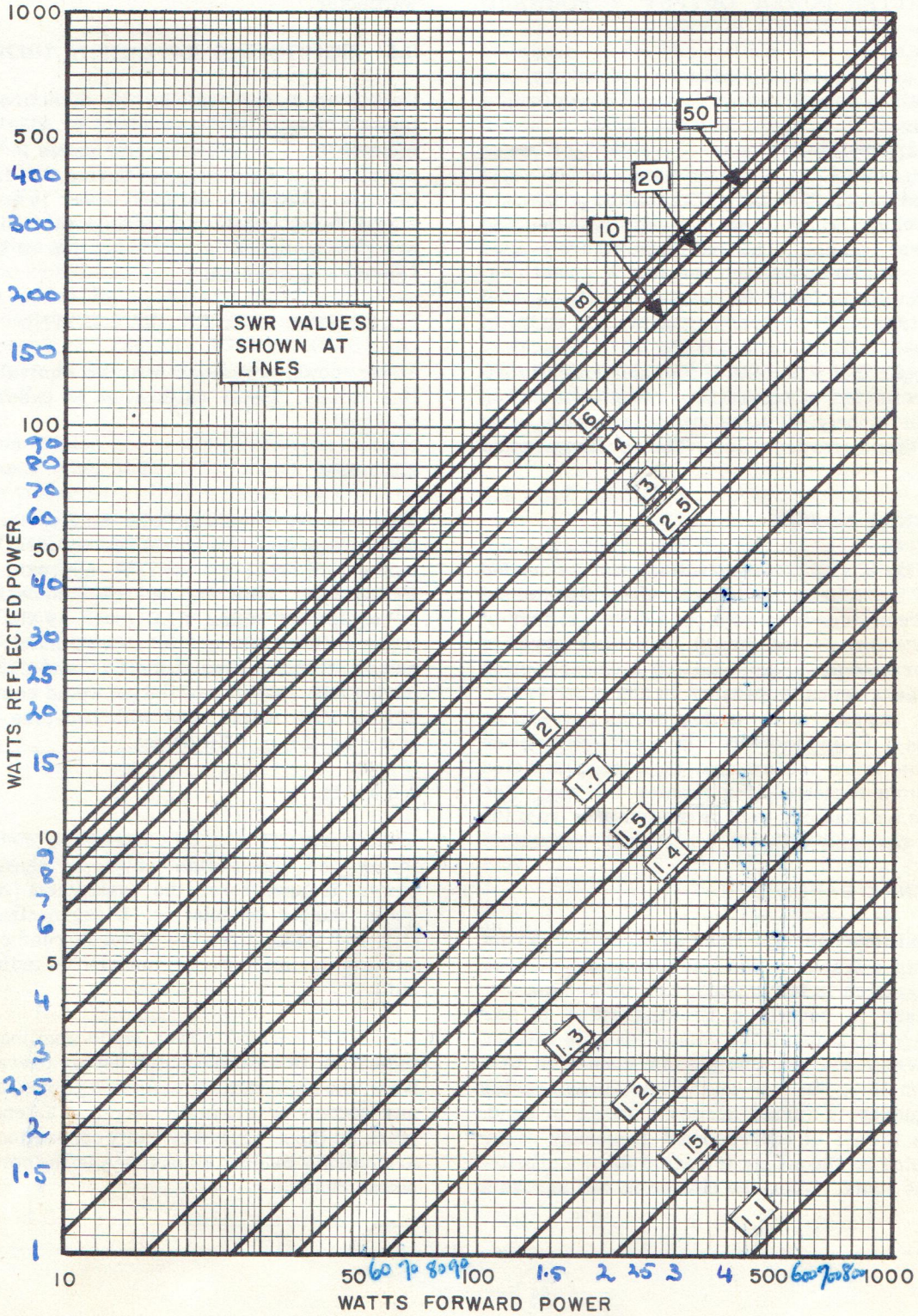
c. Paragraph 3.5 contains information that can be used as guide to interpreting monitored scale readings.

3.4 INTERPRETING RESULTS.

The recorded values of forward and reflected power can be used to determine transmission line swr and transmitter power output, as explained in paragraphs 3.4.1 and 3.4.2 below. These values in turn can be used for determining several additional conditions, examples of which are given in paragraphs 3.4.3, 3.4.4, and 3.4.5.

3.4.1 TRANSMISSION LINE SWR.

Refer to figure 3-2. Locate the point on the graph corresponding to the recorded values of forward and reflected power. If the point falls on one of the swr lines, transmission line swr is the value labeled on the line. For example, if forward power is 100 watts, and reflected power is 4 watts, the point falls on the 1.5 line so the swr is 1.5:1. If the point falls between two lines, transmission line swr is between the values labeled on the lines. Interpolate as necessary. For example, if the forward power is 500 watts and the reflected power is 6 watts, the corresponding point falls midway between the 1.2 and 1.3 lines so the swr is 1.25:1.



C189-01-1X

Figure 3-2. Graph: SWR Corresponding to Various Values of Forward and Reflected Power

3.4.2 TRANSMITTER POWER OUTPUT.

Transmitter power output (sometimes called real or net power) is determined by subtracting the reflected power reading from the forward power reading.

TRANSMITTER POWER OUTPUT = FORWARD POWER - REFLECTED POWER

Under good antenna match conditions, reflected power is quite small in comparison to forward power (with a correspondingly low swr), and the forward power reading is approximately equal to transmitter power output. For example, if forward power is 500 watts and reflected power is 4 watts, transmitter power output is 496 watts, which is only slightly less than the forward power reading. The swr (from figure 3-2) is about 1.2:1. Under poor antenna match conditions, reflected power is large in comparison to forward power, and transmitter power output is quite small in comparison to either reading. The swr is correspondingly high. For example, if forward power is 700 watts and reflected power is 650 watts, transmitter power output is only 50 watts, which is considerably less than either recorded value. The swr (from figure 3-2) is 50:1.

3.4.3 ANTENNA MATCH.

The magnitude of swr gives an indication of the degree of match of the antenna terminating the transmission line. If antenna impedance is a pure resistive load of 52 ohms, the swr is 1:1 (unity), reflected power is zero, and forward power is equal to transmitter power output. If the antenna impedance is any other resistive load, or is reactive to any degree, the swr will be greater than 1:1, and there will be a reflected power reading. The more the antenna impedance deviates from 52 ohms resistive, the greater the swr. The match of the antenna can thus be determined from the swr values obtained with the directional wattmeter.

3.4.4 ANTENNA BANDWIDTH.

Most transmitters cannot deliver a reasonable amount of power into a transmission line and antenna unless the antenna match is fairly good; i.e., unless the swr is low. There is usually a limiting value of swr beyond which the transmitter cannot load the antenna properly. When a fixed antenna is connected to a transmission line, the swr on the line always varies as the frequency is varied across a range or band. The swr is lowest at the resonant frequency of the antenna, rising as frequency is varied above and below the resonant point. When the change in swr across a given frequency range is plotted between the limiting values of swr, the resulting curve represents the match vs frequency characterisitcs of the antenna. The range between the limiting values of swr, or the bandwidth of the antenna, can be determined by plotting swr vs frequency with the aid of the directional wattmeter.

3.5 MONITORING R-F OUTPUT.

During operating periods, the directional wattmeter forward power scale readings provide a convenient monitor of transmitter performance in various types of emission. For example, during SSB transmissions the upward kick in forward power is an indication of signal level, while the rest level (which should be practically zero) is an indication of the degree of carrier suppression.

3.5.1 NBFM, FSK, CW (KEY DOWN).

Meter power readings will be equivalent to actual line values. Meter calibration is based on this type of signal.

3.5.2 SSB.

Meter power readings, with single tone modulation, will be equivalent to actual line values. With two-tone modulation, readings will be approximately 77% of PEP output. With SSB speech modulation generated by equipment using ALC (such as the KWS-1), the meter will "kick-up" to approximately 60% of PEP output. Without capacitors C11 and C12, the reading during SSB speech modulation would be approximately 20% of PEP output, and with two-tone modulation it would be 45% of PEP output.

3.5.3 AM.

Capacitors C11 and C12 cause the meter reading to follow the modulation envelope peaks. With high power transmitters, the instrument may read off scale during modulation. Disconnecting capacitors C11 and C12 causes the meter to read carrier power and any deviation during modulation indicates carrier shift.

The REFLECTED power scale readings provide an indication of antenna match during operating periods. When the approximate reflected power level is known, any sudden or gradual changes in antenna impedance (such as those caused by faulty connections, icing, etc.) are quickly evident as changes in the normal reflected power reading.

SECTION IV
PRINCIPLES OF OPERATION

4.1 R-F CIRCUIT.

Refer to figure 4-1. Transmission line current, I, flows through the line center conductor and through the center of a toroid coil. The conductor forms the primary and the coil the secondary of a toroidal transformer, T1. Induced toroid current produces a voltage that divides equally across series resistors R1 and R2. This results in two equal voltages, E_1 and E_2, across the resistors. Since the junction of the R1 and R2 is grounded, E_1 and E_2 are opposite in phase and proportional to line current, I. Line voltage, E, is applied across two capacity dividers, C1-C2 and C3-C4, resulting in two equal voltages of the same phase, E_3 and E_4.

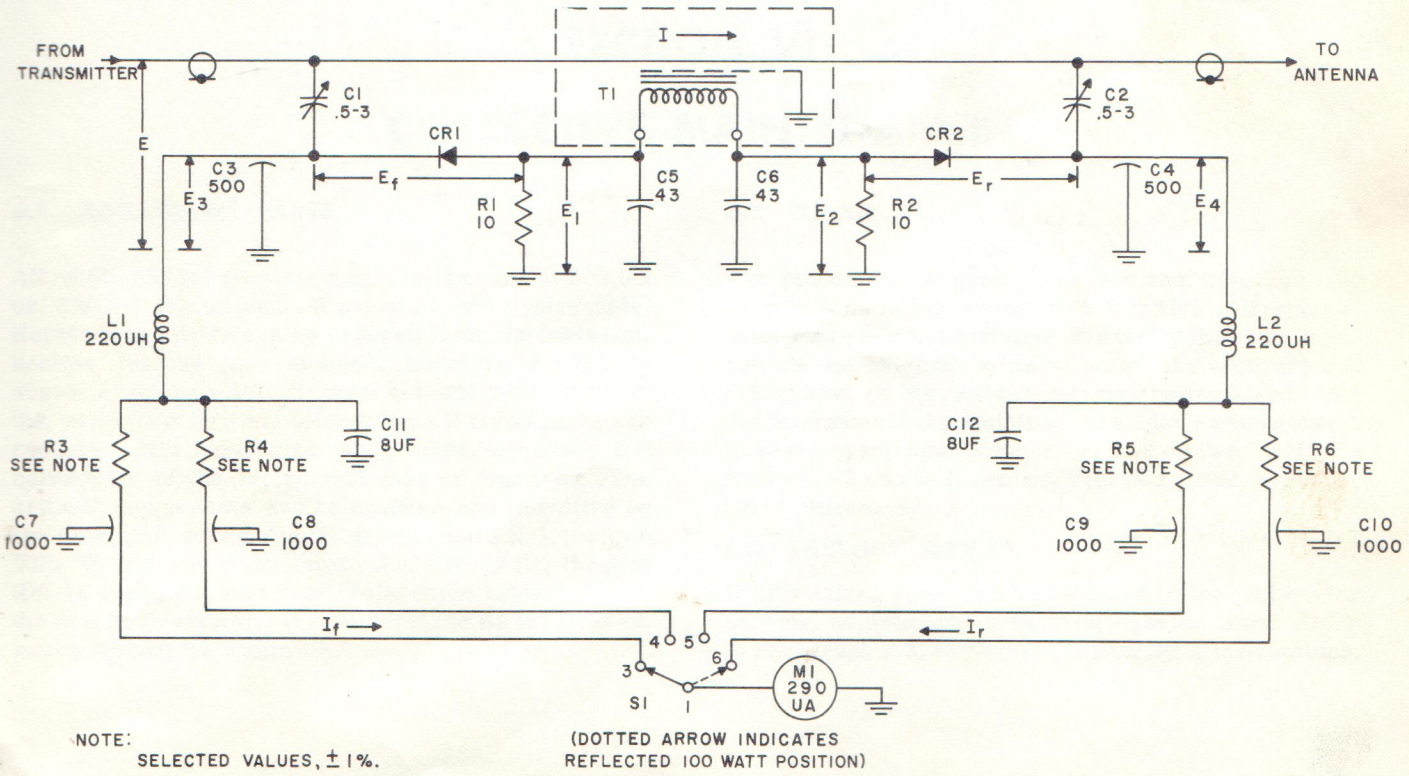
When the transmission line is mismatched (terminated in an impedance other than to 52 ohms), E_1 and E_2 represent the vector sum of two components, one proportional to the current of the forward wave, and the other proportional to the current of the reflected wave. Similarly, E_3 and E_4 represent the vector sum of forward and reflected wave voltage components. Capacitors C1 and C2 are factory adjusted so that the magnitude of the forward voltage and current components are identical; the reflected components are then equal also. The settings of C1 and C2 are correct for 52-ohm transmission line only.

The phase relationship between the various components is such that the r-f voltage across rectifier CR1 (E_f) is equal to the arithmetic sum of the two equal forward components, while the r-f voltage across rectifier CR2 (E_r) is equal to the arithmetic sum of the two equal reflected components.

When the transmission line is matched perfectly (terminated in a resistive load of 52 ohms), E_1 is equal in magnitude to E_3 and opposite in phase; E_f is the sum of E_1 and E_3, or twice the value of either. E_2 and E_4 are equal in magnitude and of the same phase, and E_r is zero volt. These relationships are used for adjusting C1 and C2 under laboratory conditions.

4.2 D-C CIRCUIT.

R-f voltages E_f and E_r are rectified and filtered by CR1, CR2, C3 and C4 to produce d-c currents, I_f and I_r, through meter M1. The meter scale is calibrated in such a way that I_f produces a scale reading proportional to forward power, while I_r produces a scale reading proportional to reflected power.



C189-02-3

Figure 4-1. 302C-1 and 302C-2 Directional Wattmeters, Simplified Schematic Diagram

Capacitors C11 and C12 cause the meter reading to approach the PEP level during SSB voice transmission.

Calibrating resistors R_3, R_4 (1000 watt scales), R_5 and R_6 (100 watt scales) are selected so that I_f and I_r give accurate indications of the two power levels.

4.3 FREQUENCY LINEARITY.

Accuracy of the r-f wattmeter is maintained over a frequency range of 2 to 30 mc in both the inductively coupled and the capacitively coupled elements. In the inductive element, the increase with frequency of the induced voltage is canceled by the voltage drop in the toroidal coil due to the increase with frequency of the inductive reactance. In the directly coupled capacitive element, the ratio of the capacitive reactances in the voltage divider remains constant even though the reactance varies with frequency. Capacitors C5 and C6 compensate for the residual series inductance of resistors R1 and R2.

4.4 REAL POWER.

Real power is the power output of the transmitter. When a line is perfectly matched, reflected power is zero and real power is equal to forward power. When the line is mismatched, the phase relationship between the forward power and reflected wave components causes the forward power to increase by an amount equal to the magnitude of the reflected power. Since the reflected power cancels a portion of the forward power at the transmitter terminals, the real power in the line is equal to the difference between forward and reflected power, or:

REAL POWER = FORWARD POWER - REFLECTED POWER

SECTION V
INSPECTION

5.1 CHECKING PERFORMANCE, GENERAL.

Unusual readings for forward and reflected power do not necessarily indicate a faulty instrument. The wattmeter may be reading the true conditions resulting from a faulty transmission line, antenna, or transmitter. If a fault in the instrument is suspected, insert the coupler in a transmission line that interconnects a known good transmitter and antenna and compare with previous results. If the instrument still seems faulty, refer to paragraph 5.2 or to section VI.

5.2 CHECKING PERFORMANCE WITH A DUMMY LOAD.

Wattmeter performance can be checked by terminating the coupler with a 52-ohm nonreactive resistor capable of dissipating the power level used, and feeding r-f power into the coupler. The forward power reading should be consistent with the power level used, and the reflected power reading should be small or zero, depending on the tolerance of the resistive load. If the load is somewhat reactive, use a frequency as low as possible within the frequency range of the instrument. If the instrument is faulty, refer to section VI.

5.3 CHECKING CALIBRATION AND ACCURACY.

Wattmeter calibration and accuracy can be checked by comparing the readings obtained in normal operation against those obtained when the coupler is reversed, i.e., when the antenna is connected to the input connector, and the transmitter is connected to the output connector. Under these conditions, the forward and reflected power readings will be reversed. If meter readings in the reversed position differ from corresponding readings in the normal position by more than 10%, calibration and/or accuracy is outside the specified limits.

SECTION VI
CORRECTIVE MAINTENANCE

6.1 REPLACEABLE PARTS.

All of the electrical parts used in either model 302C-1 or 302C-2 Directional Wattmeter are replaceable. Replacement parts can be ordered from the parts list, section VII, by part number. Location of parts is shown in section VII, figures 7-1 and 7-2. A few of the parts have critical tolerances. If these parts are replaced with unselected components, accuracy and calibration of the instrument may be impaired. The critical components and tolerances are specified on the complete schematic diagram, figure 8-1, section VIII. If any one of the selected resistors (R3 through R6) is replaced, use exactly the same value (±1%) as the original resistor. If resistor R1 or R2 is replaced, match R1 and R2 within 1%.

6.2 REPAIR.

The placement of most parts and the wire and lead lengths used in the coupler unit is critical. If replacement parts are not installed in exactly the same manner as the original in these units, the accuracy and calibration of the instrument may be impaired. Use the minimum heat possible while soldering components in place, particularly resistors and diodes. Refer to figures 7-1 and 7-2, section VII, as a guide to proper parts placement.

6.3 FACTORY SERVICE.

Faulty instruments can be returned to the factory for service, adjustment, or calibration at any time. Refer to paragraph 2.3, section II, for packaging instructions.

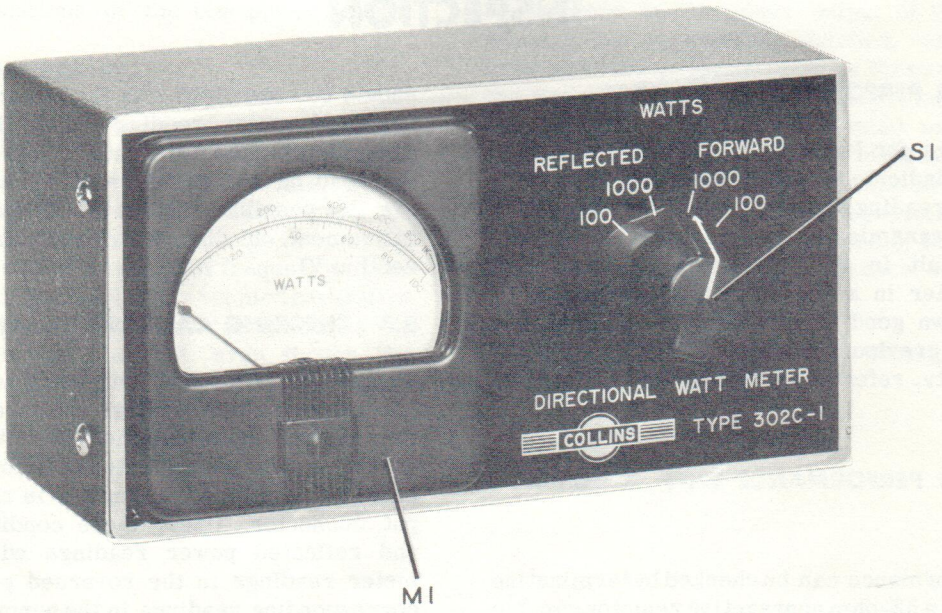
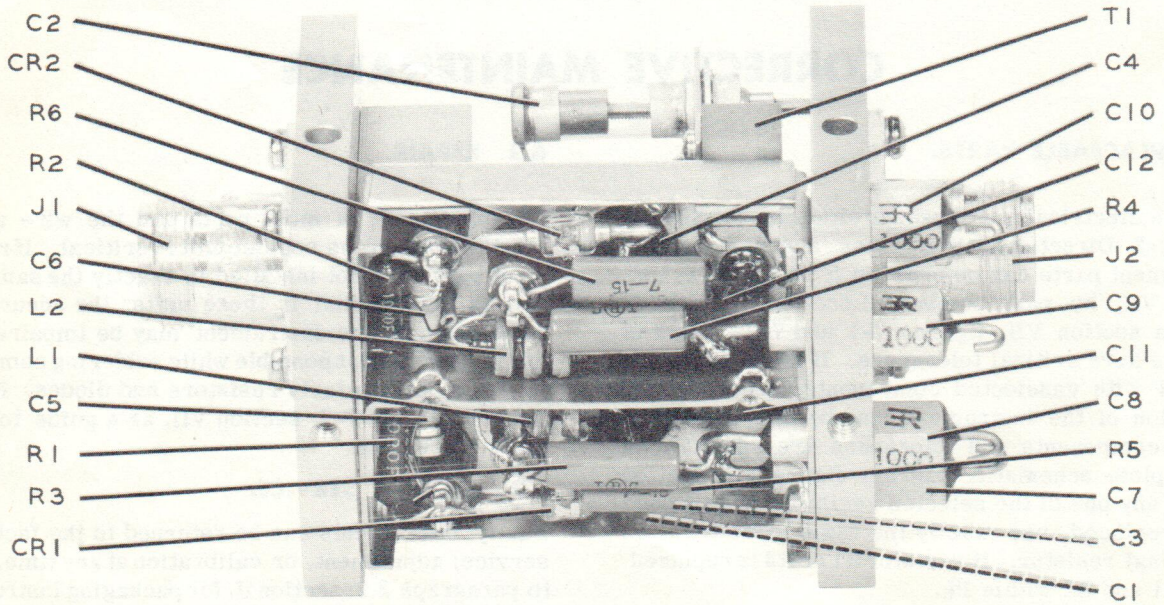


Figure 7-1. 302C-1 Directional Wattmeter, Indicator Unit

C189-10-P



C189-11-P

Figure 7-2. 302C-1 and 302C-2 Coupler Unit, Shield Removed

SECTION VII
PARTS LIST

302C-1 DIRECTIONAL WATTMETER, INDICATOR UNIT.

ITEM	CIRCUIT FUNCTION	DESCRIPTION	COLLINS PART NUMBER
M1	302C-2 indicating meter	METER: d-c micrometer scale 0-100 and 0-1000 w, black markings on white background 0-100, 0-1000 (1K) watts, ±2% full-scale deflection, 1000 ohm ±2% resistance, 3 in. by 3 in. case, four 4-36 NS-2 mtg studs; 1/4-28 NF-2, two studs	458 0388 00
S1	302C-2 indicating meter selector switch	SWITCH, ROTARY: 1 section; 4 positions; 2 moving and 10 fixed contacts, 2 poles, 3 throws, a-c, d-c, 230 v, 0.25 amp.	259 0758 00

302C-1 AND 302C-2 COUPLER UNIT.

ITEM	CIRCUIT FUNCTION	DESCRIPTION	COLLINS PART NUMBER
C1	Divider capacitor	CAPACITOR: variable; 0.5 min to 3.0 max uuf, 500 vdcw	922 0149 00
C2	Divider capacitor	CAPACITOR: same as C1	922 0149 00
C3	Divider capacitor	CAPACITOR: mica, 500 uuf, ±20%, 500 vdcw	912 0667 00
C4	Divider capacitor	CAPACITOR: same as C3	912 0667 00
C5	Phase corrector	CAPACITOR: ceramic; 43 uuf ±1%, 500 vdcw	916 4675 00
C6	Phase corrector	CAPACITOR: same as C5	916 4675 00
C7	D-c line filter	CAPACITOR: ceramic; 1000 uuf ±80%-20%, 500 vdcw	913 1292 00
C8	D-c line filter	CAPACITOR: same as C7	913 1292 00
C9	D-c line filter	CAPACITOR: same as C7	913 1292 00
C10	D-c line filter	CAPACITOR: same as C7	913 1292 00
C11	Peak reading capacitor	CAPACITOR: fixed aluminum electrolytic; 8 uf -15+100, 6 vdcw	183 1167 00
C12	Peak reading capacitor	CAPACITOR: same as C11	183 1167 00
CR1	Crystal diode IN82A	SEMICONDUCTOR, DEVICE DIODE: silica crystal diode for use as r-f mixer at freq to 100 mc; avg. rectified cur., 50 ma; peak rectified cur., 150 ma; surge cur (1 sec), 500 ma; peak inverse voltage, 5 v; conversion loss, 8 db max; noise figure 14 db max; i-f impedance 450 ohms; injection cur range, 0.5 to 4.5 ma	353 2542 00

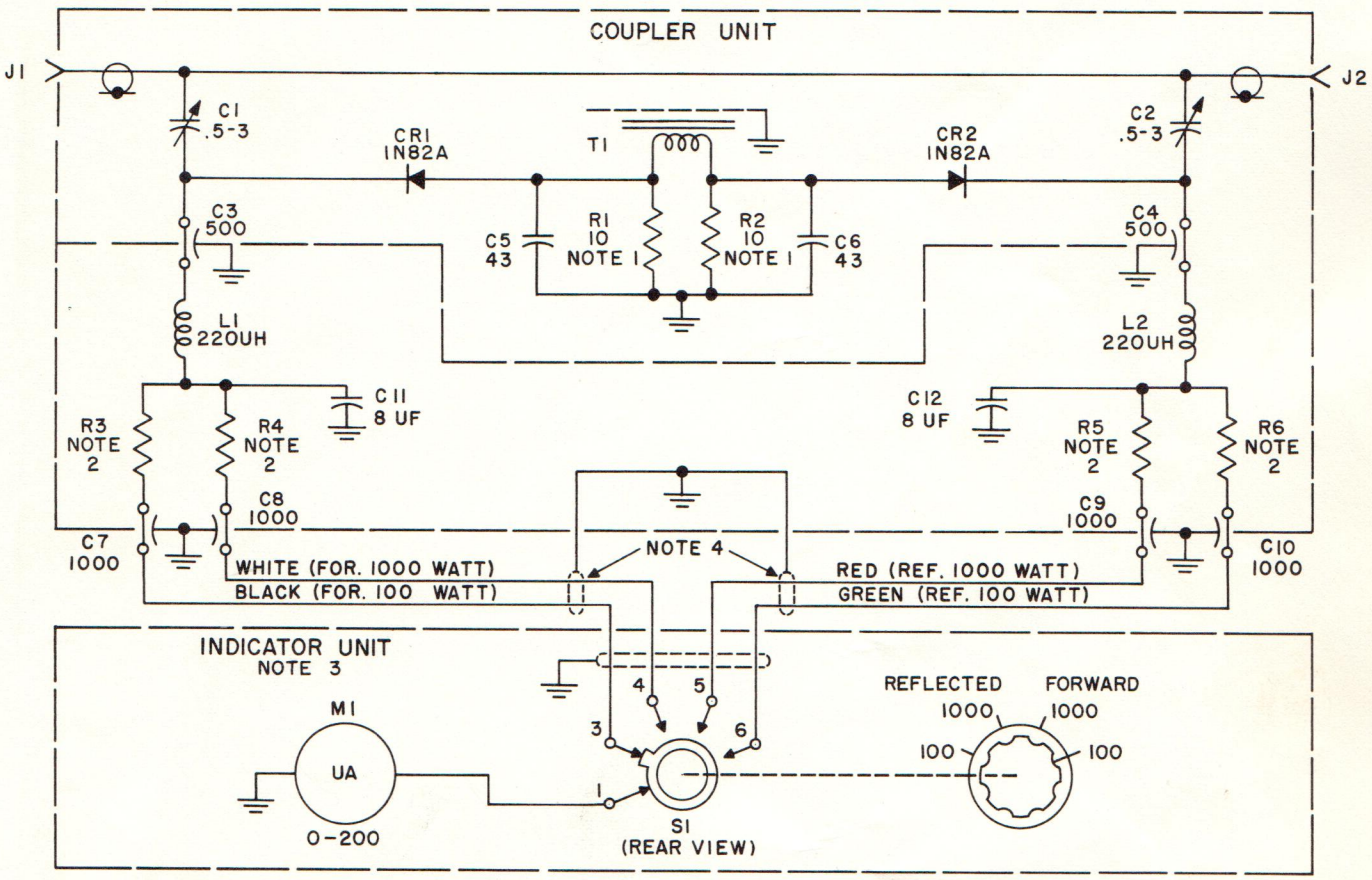
302C-1 AND 302C-2 COUPLER UNIT (Cont).

ITEM	CIRCUIT FUNCTION	DESCRIPTION	COLLINS PART NUMBER
CR2	Crystal diode IN82A	SEMICONDUCTOR, DEVICE DIODE: same as CR1	353 2542 00
J1	Trans end of 302C-2 coupler	CONNECTOR, RECEPTACLE, ELECTRICAL: 1 mating end; 1 rd female contact, 50 ohm; low loss plastic dielectric; straight shape; 0.731 in. by 1 in. by 1 in.; w/silver-plated brass enclosing shell; resistant to corrosion; 5/8-24 NEF-2 thd for locking	357 9003 00
J2	Load end of 302C-2 coupler	CONNECTOR, RECEPTACLE, ELECTRICAL: same as J1	357 9003 00
L1	R-f choke	COIL, RADIO FREQUENCY: universal wound, 3 pi; 225 total turns no. 36 AWG, enamel insulation; 220 uh inductance, 0.02 amp cur rating	240 0037 00
L2	R-f choke	COIL, RADIO FREQUENCY: same as L1	240 0037 00
R1	Toroid trans load resistor	RESISTOR: film, 10 ohm ±1%, 1/2 w	705 2356 00
R2	Toroid trans load resistor	RESISTOR: same as R1	705 2356 00
R3 and R4	Selected per operational requirement	RESISTOR: film; 4750 ohm ±1%, 1/4 w	705 7255 00
		RESISTOR: film; 4870 ohm ±1%, 1/4 w	705 7129 00
		RESISTOR: film; 4990 ohm ±1%, 1/4 w	705 7256 00
		RESISTOR: film; 5110 ohm ±1%, 1/4 w	705 7130 00
		RESISTOR: film; 5230 ohm ±1%, 1/4 w	705 7257 00
		RESISTOR: film; 5360 ohm ±1%, 1/4 w	705 7131 00
		RESISTOR: film; 5490 ohm ±1%, 1/4 w	705 7258 00
		RESISTOR: film; 5620 ohm ±1%, 1/4 w	705 7132 00
		RESISTOR: film; 5760 ohm ±1%, 1/4 w	705 7259 00
		RESISTOR: film; 5900 ohm ±1%, 1/4 w	705 7133 00
		RESISTOR: film; 6040 ohm ±1%, 1/4 w	705 7260 00
		RESISTOR: film; 6190 ohm ±1%, 1/4 w	705 7134 00
		RESISTOR: film; 6340 ohm ±1%, 1/4 w	705 7261 00
		RESISTOR: film; 6490 ohm ±1%, 1/4 w	705 7135 00
		RESISTOR: film; 6650 ohm ±1%, 1/4 w	705 7262 00
		RESISTOR: film; 6810 ohm ±1%, 1/4 w	705 7136 00
		RESISTOR: film; 6980 ohm ±1%, 1/4 w	705 7263 00

302C-1 AND 302C-2 COUPLER UNIT (Cont).

ITEM	CIRCUIT FUNCTION	DESCRIPTION	COLLINS PART NUMBER
R5 and R6	Selected per operational requirement	RESISTOR: film; 51.1 ohm ±1%, 1/4 w	705 7034 00
		RESISTOR: film; 100 ohm ±1%, 1/4 w	705 7048 00
		RESISTOR: film; 147 ohm ±1%, 1/4 w	705 7056 00
		RESISTOR: film; 196 ohm ±1%, 1/4 w	705 7062 00
		RESISTOR: film; 249 ohm ±1%, 1/4 w	705 7067 00
		RESISTOR: film; 301 ohm ±1%, 1/4 w	705 7071 00
		RESISTOR: film; 348 ohm ±1%, 1/4 w	705 7074 00
		RESISTOR: film; 402 ohm ±1%, 1/4 w	705 7077 00
		RESISTOR: film; 464 ohm ±1%, 1/4 w	705 7080 00
		RESISTOR: film; 511 ohm ±1%, 1/4 w	705 7082 00
		RESISTOR: film; 562 ohm ±1%, 1/4 w	705 7084 00
		RESISTOR: film; 619 ohm ±1%, 1/4 w	705 7086 00
		RESISTOR: film; 681 ohm ±1%, 1/4 w	705 7088 00
		RESISTOR: film; 750 ohm ±1%, 1/4 w	705 7090 00
		RESISTOR: film; 835 ohm ±1%, 1/4 w	705 7092 00
		RESISTOR: film; 909 ohm ±1%, 1/4 w	705 7094 00
		RESISTOR: film; 953 ohm ±1%, 1/4 w	705 7095 00
		RESISTOR: film; 1000 ohm ±1%, 1/4 w	705 7096 00
T1	R-f transformer toroidal SERIAL NO 119.		542 0916 002

SECTION VIII
ILLUSTRATIONS



NOTES:
1. R1 AND R2 SELECTED TO MATCH WITHIN 1%.
2. R3, R4, R5 AND R6 SELECTED VALUES ±1%. R3–R4 SELECTED FROM RANGE BETWEEN 4750–6980 OHMS. R5–R6 SELECTED FROM RANGE BETWEEN 51.1 AND 1000 OHMS.
3. INDICATOR UNIT ENCASED ON MODEL 302C-1 ONLY.
4. CABLE SUPPLIED WITH MODEL 302C-1 ONLY.

C189-03-3

Figure 8-1. 302C-1 and 302C-2 Directional Wattmeters, Schematic Diagram

Coupler Alignment / Calibration - 302C-3 & 312B4/5

by Rod Blocksome, K0DAS

The Collins instruction books for this equipment are silent on the procedures for alignment and calibration. The information in this technical note is based on the factory test procedures and should allow the amateur to repair these units.

Required test equipment

1. A 1kW dummy load of 50 ohms +/-2%
2. Independent means to measure RF power to +/-2% accuracy [Note 1]
3. DC meter, 200 micro-amp full scale +/-0.5%, internal resistance 1000 ohms +/-0.5% (needed only if the directional coupler is aligned and calibrated independently of the associated equipment meter)
4. RF power source with very low harmonic/spurious output (less than –40 dBc)

Balance adjustment

1. Connect the RF source and load in the normal direction — RF to the input and dummy load on the output. Connect the meter "+" to C10 (200 Reflected terminal) and meter "– " to ground. Temporarily short out R6 to obtain maximum sensitivity.
2. Apply RF power at 29.5 MHz and adjust trimmer C2 for minimum meter indication. As the null is approached, increase RF power to at least 500 watts and not more than 1,000 watts to do the final adjustment of C2.
3. Remove RF power and reverse the connections of the RF source and load. RF will now be flowing in the reverse direction through the directional coupler. Connect the meter to C& (200 Forward terminal). Temporarily short out R5 to obtain maximum sensitivity.
4. Apply RF power at 29.5 MHz and adjust trimmer C1 for minimum meter indication. As the null is approached, increase RF power to at least 500 watts and not more than 1,000 watts to do the final adjustment of C1.

Calibration

1. Connect the RF source and dummy load in the normal direction. Apply 100 watts +/-2% at 14.0 MHz. Test select (use a pot or resistance decade box) R5 until the meter reads 100 watts in the 200 Forward position.
2. Apply 500 watts +/-2% at 14.0 MHz. Test select (use a pot or resistance decade box) R3 until the meter reads 500 watts in the 2000 Forward position.
3. Connect the RF source and dummy load in the reverse direction. Apply 100 watts +/-2% at 14.0 MHz. Test select (use a pot or resistance decade box) R6 until the meter reads 100 watts in the 200 Reflected position.
4. Apply 500 watts +/-2% at 14.0 MHz. Test select (use a pot or resistance decade box) R4 until the meter reads 500 watts in the 2000 Reflected position.

Note 1: The common standard in many ham shacks is the Bird Model 43 wattmeter with a specified accuracy of 5% of full scale.

Frequency Response

1. Connect the RF source and dummy load in accordance with the direction given in the following table. Meter readings should fall within the ranges given in the table.

RF Direction	Frequency	Meter Position	Applied RF	Meter Reading
Normal	3.5 MHz	200W Forward	80 Watts	74 to 86 W
Normal	14.0 MHz	200W Forward	80 Watts	74 to 86 W
Normal	29.5 MHz	200W Forward	80 Watts	74 to 86 W
Normal	3.5 MHz	2000W Forward	500 Watts	465 to 535 W
Normal	14.0 MHz	2000W Forward	500 Watts	465 to 535 W
Normal	29.5 MHz	2000W Forward	500 Watts	465 to 535 W
Reverse	3.5 MHz	200W Reflected	80 Watts	74 to 86 W
Reverse	14.0 MHz	200W Reflected	80 Watts	74 to 86 W
Reverse	29.5 MHz	200W Reflected	80 Watts	74 to 86 W
Reverse	3.5 MHz	2000W Reflected	500 Watts	465 to 535 W
Reverse	14.0 MHz	2000W Reflected	500 Watts	465 to 535 W
Reverse	29.5 MHz	2000W Reflected	500 Watts	465 to 535 W

Amplitude Response

1. Connect the RF source and dummy load in accordance with the direction given in the following table. Meter readings should fall within the ranges given in the table.

RF Direction	Frequency	Meter Position	Applied RF	Meter Reading
Normal	14.0 MHz	200W Forward	100 Watts	93 to 107 W
Normal	14.0 MHz	200W Forward	100 Watts	93 to 107 W
Normal	14.0 MHz	2000W Forward	500 Watts	465 to 535 W
Normal	14.0 MHz	2000W Forward	500 Watts	465 to 535 W
Reverse	14.0 MHz	200W Reflected	100 Watts	93 to 107 W
Reverse	14.0 MHz	200W Reflected	100 Watts	93 to 107 W
Reverse	14.0 MHz	2000W Reflected	500 Watts	465 to 535 W
Reverse	14.0 MHz	2000W Reflected	500 Watts	465 to 535 W

In this issue...