knight-kit® ASSEMBLY MANUAL

P2/SWR Power Meter

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SEE FIGURE 8.

Correct placement of the P-2 SWR meter depends on your antenna feed system. Commonly used feed systems are:

TYPE 1. Coaxial cable from the transmitter straight to the antenna (no matching devices).

TYPES 2 and 3. Coaxial cable to an impedance-matching device between the transmitter and antenna.

TYPE 2. Uses coaxial cable (coax) between the matching device and the antenna.

TYPE 3. Uses balanced line or single wire feed between the matching device and the antenna.

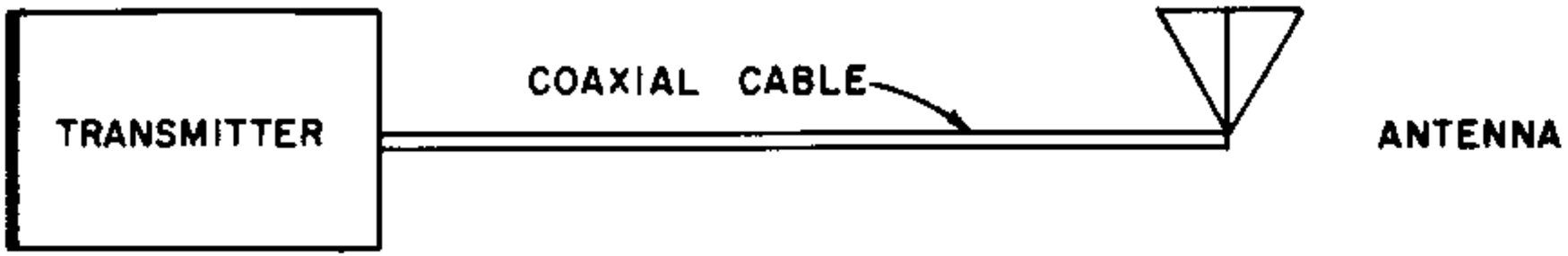
Follow the instructions that apply to your type of transmission or feed line.

IMPORTANT NOTE: To use the P-2 with Citizens Band equipment, all transmitter adjustments must be made by a properly licensed person, unless the oscillator circuit is a sealed unit. Adjusting the controls on a CB transmitter requires a First or Second Class commercial license.

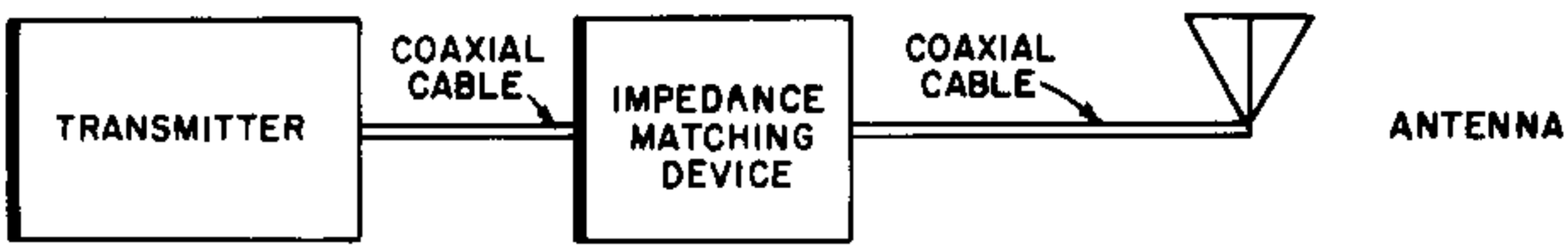
INSERTING THE P-2 IN THE TRANSMISSION LINE

TYPE 1. LINES WITH COAXIAL FEED TO THE ANTENNA (no coupling or matching devices).

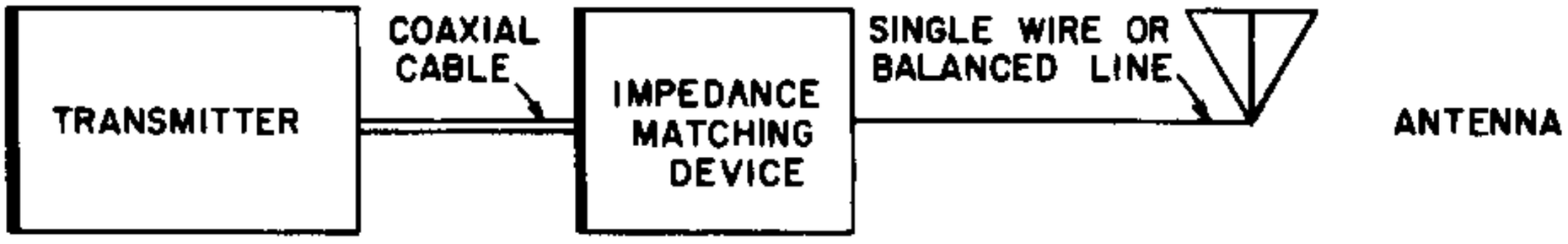
The best place to insert the pick-up unit in the antenna system is at the junction of the feed line and the antenna. There are several reasons for this. First, if an SWR greater than 1 to 1 is present, the length of the feed line will not affect the readings of the P-2. Second, if the line losses in the coax are high, it is possible that the losses will attenuate the SWR reading at the transmitter end of the coax. Although this position may be the best in terms of electrical considerations, mounting the pick-up unit at the antenna may be impractical from a mechanical or accessibility standpoint. The pick-up unit should then be placed at the output terminals of the transmitter. If a TVI filter is used, the pick-up unit should go between the transmitter and the filter.



TYPE 1. COAXIAL CABLE FROM TRANSMITTER TO ANTENNA



TYPE 2. COAXIAL CABLE FROM MATCHING DEVICE TO ANTENNA



TYPE 3. SINGLE WIRE OR BALANCED FEED FROM MATCHING DEVICE TO ANTENNA

FIGURE 8. TYPES OF FEED SYSTEMS

☐ Set the controls on the P-2 as follows: SENSITIVITY control near 10 and the POWER switch to FORWARD.

☐ Load the transmitter to the recommended input power and adjust the SENSITIVITY control for full scale deflection. Keep these tests as short as possible to prevent interference with other stations.

☐ Adjust the SENSITIVITY control on the P-2 until the meter reads CAL. on the SWR scale (the red scale).

☐ Turn the POWER switch to REFLECTED and note SWR reading.

☐ Turn the transmitter to a standby position and remove the TVI filter from the line.

☐ Turn the transmitter on and note the SWR reading on the meter. If the TVI filter affects the SWR, determine if the filter is defective or of the wrong impedance, and correct.

Proceed to the instructions under DETERMINING THE RESONANT FREQUENCY OF THE ANTENNA.

TYPES 2 AND 3. LINES WITH AN IMPEDANCE MATCHING DEVICE BETWEEN THE TRANSMITTER AND THE ANTENNA

If a TVI filter is used, the pick-up unit should be placed between the filter and the transmitter. Use the following procedure to check the filter and adjust the input circuits of an antenna coupler. If a fixed impedance matching device such as balun coils are used, there is usually no way of changing the impedance transforming properties of the device. In this case, this procedure will evaluate the correctness of the match.

☐ Set the controls on the P-2 as follows: SENSITIVITY control near 10 and the POWER switch to FORWARD.

☐ Load the transmitter to the recommended input power and adjust the SENSITIVITY control for full scale deflection. Keep these tests as short as possible to prevent interference with other stations.

☐ Adjust the SENSITIVITY control on the P-2 until the meter reads CAL. on the SWR scale (the red scale).

☐ Turn the POWER switch to REFLECTED and note the SWR reading. NOTE: The SWR indicated on the meter is the SWR between the transmitter and the antenna coupler, *NOT* the SWR of the entire antenna system.

☐ Turn the transmitter to a standby position and remove the TVI filter from the line.

☐ Turn the transmitter on and note the SWR reading on the meter. If the TVI filter affects the SWR, determine if the filter is defective or of the wrong impedance, and correct. If the filter does not affect the SWR, return the filter to the line.

If the SWR between the transmitter and antenna coupler input circuits is greater than 1 to 1 (meter indicates more than 1.0 on the SWR scale) adjust the input circuits of the coupler for minimum SWR. This may involve adjusting a variable capacitor, or a tap on the input coil, or both. The transmitter may also require adjustment after changes have been made in the coupler.

CAUTION: Turn the transmitter off when adjusting the coil taps. Do not operate the transmitter for long periods when adjusting the coupler for minimum SWR, because the output circuit of the coupler may not be efficiently coupling power to the antenna. In this case the transmitter power would be dissipated in the coupler input coil and the coil would be damaged by prolonged overheating.

When the input circuit of the coupler has been adjusted for minimum SWR, the type of transmission line you use between the coupler and the antenna will determine your next step. Follow the instructions given under your type of feed line.

TYPE 2. ANTENNA SYSTEMS USING COAX BETWEEN THE COUPLER AND ANTENNA.

Remove the P-2 from between the transmitter and the coupler, and connect it to the output of the coupler, between the coupler and the antenna.

☐ Turn the controls on the P-2 to the following settings: SENSITIVITY to 1, and the POWER switch to FORWARD.

☐ Turn the transmitter on and adjust the SENSITIVITY control on the P-2 until the meter reads 1.0 on the REL. POWER scale.

☐ Adjust the controls on both the transmitter and the output circuit of the coupler for maximum reading on the meter. The SENSITIVITY control should be turned down to keep the reading within the range of the meter. Adjust the output circuit of the coupler in the same manner as the input circuit—by changing the setting of a capacitor, or a tap on the coil, or both.

☐ When the output circuit has been adjusted, return the P-2 to the input side of the coupler (between transmitter and TVI filter). Check the matching. If necessary, repeat the adjusting of the coil taps and/or capacitor.

☐ When the transmitter and the input and output circuits of the coupler have been adjusted for maximum, insert the P-2 on the antenna side of the coupler. Set the P-2 to read CAL. on the SWR scale. Turn the POWER switch on the P-2 to REFLECTED. Note the SWR indicated on the SWR scale.

If the reading on the meter indicates an SWR greater than 1 to 1, NO AMOUNT OF ADJUSTMENT TO THE ANTENNA COUPLER WILL LOWER THE SWR. The SWR indicated on the meter is caused by a mis-match between the antenna and the feed line, and this mismatch cannot be corrected by the coupler. It must be corrected at the antenna.

When the coupler has been adjusted to indicate the maximum power output, proceed to the instructions under DETERMINING THE RESONANT FREQUENCY OF THE ANTENNA.

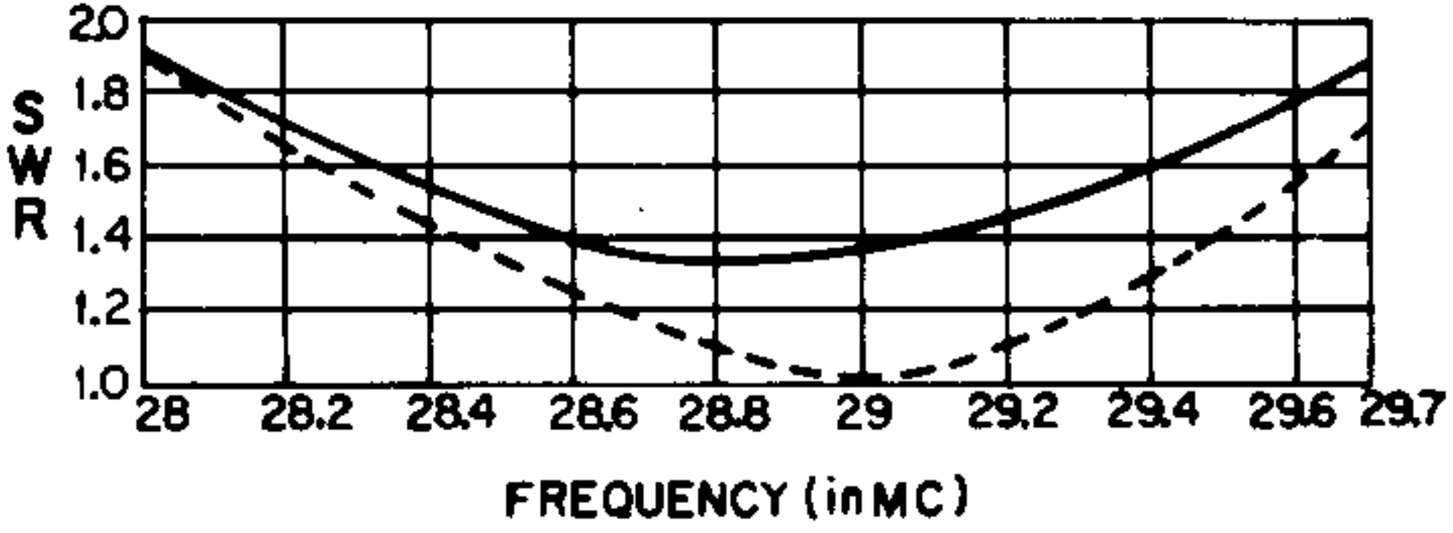


FIGURE 9.

TYPE 3. ANTENNA SYSTEMS USING BALANCED LINE OR SINGLE WIRE FEED BETWEEN THE COUPLER AND ANTENNA.

In this type of feed system the P-2 cannot be used to measure the actual SWR between the coupler and the antenna due to the fact the P-2 works only with coax lines. However, the P-2 will be quite useful in tuning the output circuit of the coupler to the antenna. Leave the P-2 between the transmitter and the coupler and adjust the controls on the P-2 as follows:

Set the SENSITIVITY to 1 and the POWER switch to FORWARD. Turn the transmitter on and adjust the SENSITIVITY control on P-2 for a reading of 1.0 on the REL. POWER scale. Adjust the output circuit of the coupler and the transmitter controls for maximum output. The reading on the P-2 indicated that more power is being delivered to the coupler by the transmitter, but it DOES NOT indicate that more power is reaching the antenna. How much power actually reaches antenna is dependent on the coupler, the resonant frequency of the antenna, the impedance of the antenna at the operating frequency and many other factors. The P-2 indicates that the load is within the range of the transmitter's output network, and that the transmitter is delivering power into that load.

DETERMINING THE RESONANT FREQUENCY OF THE ANTENNA

The resonant frequency of the antenna and the accuracy of the match between the antenna and the feed line are factors in determining the SWR of the antenna system. A simple method of determining the resonant frequency and bandwidth (the frequency range the antenna can cover with a low SWR) of the antenna is to make a graph of the indicated SWR at different frequencies in the band. Start at the low end of the band for which the antenna is cut and tune up the transmitter. Place the POWER switch on the P-2 to FORWARD and adjust the SENSITIVITY control until the meter reads CAL. on the SWR scale. Then place the POWER switch to REFLECTED and read the indicated SWR on the red scale. Repeat this procedure every 10 to 50kc (CB operators should use all the crystals they have to obtain an accurate graph over such a small frequency range) depending on the width of the band. The resulting SWR figures can be graphed against frequency as shown in Figure 9. Figure 9 represents typical responses that you might get from two antennas cut for the 10 meter band.

From the curvature of the solid line in Figure 9, one of our typical antennas is resonant at 28.8 MC, but it is not completely matched because the curve never reaches an SWR of 1 to 1—which would indicate a perfect match. The antenna represented by the dotted line is resonant at 29 MC is apparently perfectly matched. We say "apparently" because, although the SWR is 1 to 1 on the meter, we have not yet determined the effect the feed line has on the antenna.

ANTENNA MATCHING

The P-2 will also aid in decreasing the SWR as well as detecting it. In the preceding steps you have determined the resonant frequency of your antenna and also if there is an SWR greater than 1 to 1. If there is an impedance matching device at the antenna such as a gamma match, a "T" match, tuning sleeve, etc., use the following procedure with the P-2 to eliminate or lower the SWR. It should be noted at this time, that with some antennas such as beams, collinear arrays, and even dipoles a perfect match is not obtainable because of other factors such as the design of the antenna, its height above ground, nearby objects affecting the antenna, etc. In such a case, the best alternative is to lower the SWR as much as possible. To lower it, use the following procedure:

- ☐ Load the transmitter to the recommended input power and adjust the SENSITIVITY control for full scale deflection. Keep these tests as short as possible to prevent interference with other stations.
- ☐ Adjust the P-2 to indicate SWR.
- ☐ Adjust the matching system at the antenna for a minimum reading on the P-2.

For additional information on antenna matching and SWR reduction the reader is again referred to the Radio Amateur's Handbook and similar publications.

MEASURING RELATIVE POWER

The P-2 will also aid in determining the effects of modifications such as changing the bias voltage, component changes, etc. made in the transmitter. If the modifications or adjustments can be safely made while the transmitter is on the air, use the following procedure:

- ☐ Tune the transmitter to the recommended input, but do not make the modifications.
- ☐ Set the POWER switch on the P-2 to FORWARD and adjust the SENSITIVITY control for a reading of 1.0 on the REL. POWER scale.
- ☐ Make the modifications or adjustments on the transmitter, noting the effect of the change on the transmitter output directly on the P-2.

If the change results in a meter reading of 2, the output of the transmitter has been doubled. If the modifications cannot be safely made with the transmitter on the air, perform the first 2 steps of the procedure and turn the transmitter off. Make the modifications and reconnect the transmitter, but DO NOT TOUCH THE CONTROLS ON P-2. Load the transmitter to the same input and note the reading on P-2. The effect of the change will be noted in a different reading on the P-2.

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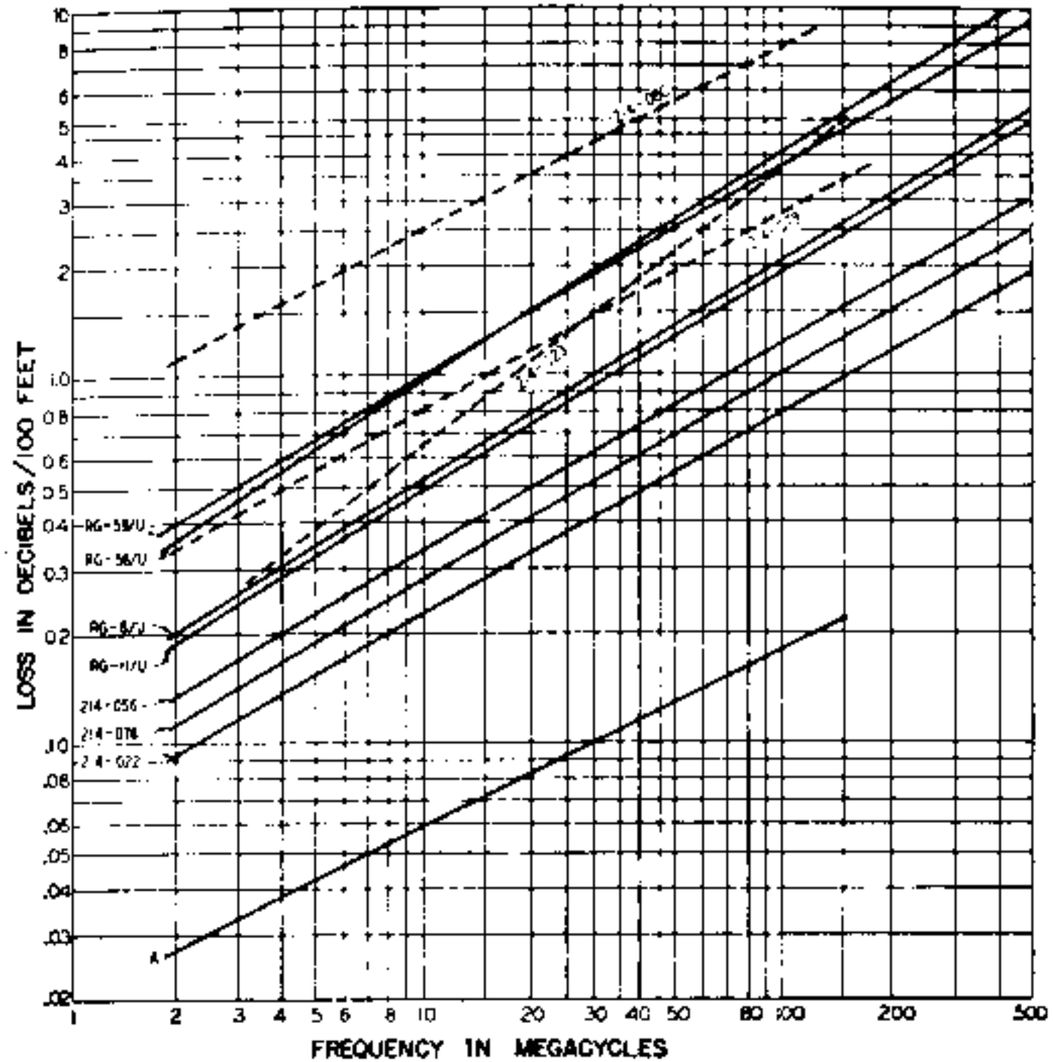
The P-2 SWR meter provides accurate readings of standing wave ratio and relative forward power . . . supplying a reliable and inexpensive indicator for adjusting antenna coupler, antenna or transmitter for maximum power transfer to the antenna.

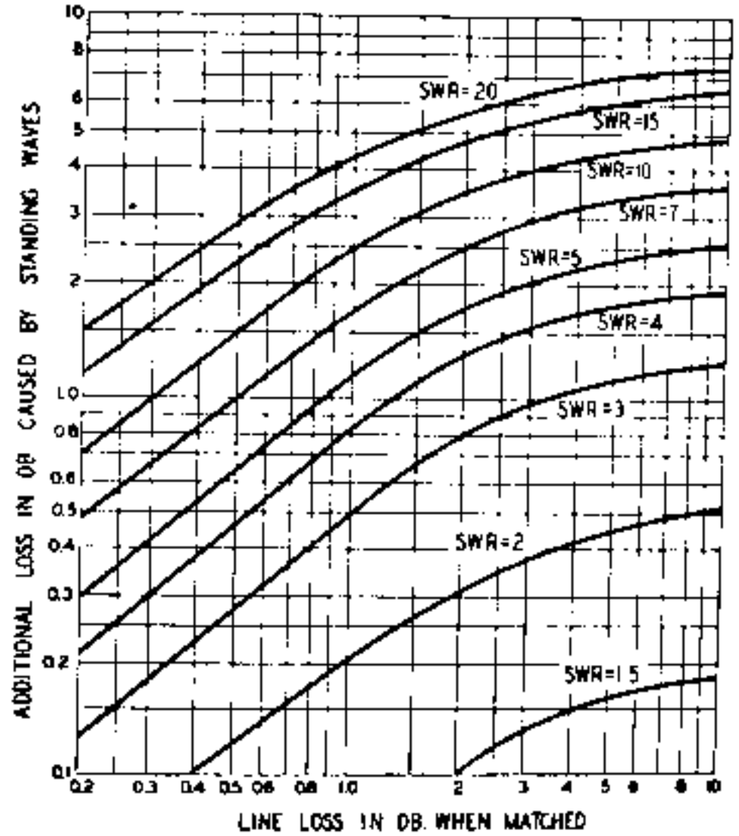
Easy to build and convenient to use, the P-2 SWR meter can be permanently installed in the transmission line for continuous monitoring . . . thanks to its high power capability (one kilowatt) and its negligible insertion loss.

SPECIFICATIONS

MINIMUM RF POWER (full scale deflection)	45 watts at 1.8 MC ½ watt at 432 MC
MAXIMUM RF POWER	1 kilowatt
INPUT AND OUTPUT IMPEDANCE	52 or 72 ohms
POWER REQUIREMENTS	None
BAND COVERAGE	1.8 to 432 MC
METER SENSITIVITY	100 microamperes, full scale
METER SCALES	Relative power, SWR, from 1:1 to 20:1



Attenuation data for common types of transmission lines. Curve A is the nominal attenuation of 600-ohm open-wire line with No. 12 conductors, not including dielectric loss in spacers nor possible radiation losses.



Effect of standing-wave ratio on line loss. The ordinates give the *additional* loss in decibels for the loss, under perfectly matched conditions, shown on horizontal scale.

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DETERMINING THE LOSSES IN THE TRANSMISSION LINE

To measure the losses in your transmission line, use the following procedure;

☐ Insert the P-2 between the transmitter and the transmission line.

☐ Connect a dummy load to the antenna end of the coax (75Ω dummy load should be used with 75Ω coax, etc.)

☐ Tune the transmitter, being careful not to exceed the capabilities of the dummy load, and adjust the P-2 for a reading of 10 on the REL. POWER scale.

☐ Turn the transmitter off and remove the P-2 from between the transmitter and the line, BUT DO NOT DISTURB THE CONTROLS ON THE P-2.

☐ Insert the P-2 between the transmission line and the dummy load. Turn the transmitter on and note the reading on the REL. POWER scale on the P-2. DO NOT TOUCH THE CONTROLS ON THE P-2.

☐ Compare the reading against the following chart to determine the losses in the line. The chart will indicate the amount of loss in decibels and percent of the input power.

REL. POWER reading at end of transmission line.	LOSS in db.	LOSS in percent of input power.
8.91	0.5	10.9
7.95	1.0	20.5
7.08	1.5	29.2
6.30	2.0	37.0
5.0	3.0	50.0
3.98	4.0	60.2
3.16	5.0	68.4
2.51	6.0	75.0

DUMMY LOADS

If 100Ω resistors were used in the P-2, the unit will work on 72Ω coaxial cable and the dummy load should be 72Ω. If 160Ω resistors were used in the P-2, 52Ω coaxial cable and dummy load should be used.

A dummy load may be made of 2 watt carbon (not wire-wound) resistors with short leads, soldered in parallel to a coaxial connector to give the proper wattage and impedance. A light bulb is *NOT* recommended for use as a dummy load.

It may be necessary to use the TUNE position on your transmitter if the wattage of the dummy load is too low. If further reduction of power output is necessary, series parallel combinations of resistors and light-bulbs may be used to dissipate the power BETWEEN THE TRANSMITTER AND THE P-2 INPUT. Reduction of power is necessary only on initial adjustment when a dummy load is used. In operation the P-2 can be left connected with no power reduction.

TROUBLE SHOOTING CHART

TROUBLE	POSSIBLE CAUSE	SERVICE PROCEDURE
No reading in either switch position	Open circuit	Check continuity between J-1 and J-2. Check soldering of metal rod to J-1 and J-2.
	Sensitivity control set too low	Check setting of control.
	Defective meter	Unsolder the black lead from S-1. Check continuity from terminal 1 of the switch to ground. The reading should vary with the setting of the sensitivity control. If not the meter is defective.
Meter reads forward in the reverse position and reverse in the forward	Switch wired incorrectly	Check switch wiring. Check cable connections to pick-up unit.
	Pick-up unit connections reversed	Check to see that J-1 is connected to the transmitter and J-2 to the antenna.

TROUBLE SHOOTING CHART

TROUBLE	POSSIBLE CAUSE	SERVICE PROCEDURE
Meter reads backward (downscale) in the forward position	CR-1 polarity reversed	Check wiring of CR-1.
Meter reads backward (downscale) in the reverse position	CR-2 polarity reversed	Check wiring of CR-2.
Meter reads Backward (downscale) in both switch positions	CR-1 and CR-2 polarities reversed	Check wiring of CR-1 and CR-2.
	Meter polarity reversed	Check meter connections.
Meter pegs	Sensitivity control set too high	Check setting of control. Check for open control.

TROUBLE	POSSIBLE CAUSE	SERVICE PROCEDURE
No meter reading in forward position	Poor connection to switch	Check connection to terminal 1 of switch.
	Defective sensitivity control	Unsolder the black lead from S-1. Check continuity from terminal 1 of the switch to ground with the sensitivity control all the way to the left. The reading should be 25K and decrease as the sensitivity control is rotated to the right. Be careful not to peg the needle of the meter.
	Defective component in the pick-up unit	With the black lead disconnected from S-1 check the resistance of R-2. If defected replace. If R-2 checks okay replace C-1 with C-2 or another .001 μf, 600 volt capacitor. If this fails to remove the trouble then the defective component is CR-1.

TROUBLE SHOOTING CHART

TROUBLE	POSSIBLE CAUSE	SERVICE PROCEDURE
No meter reading in the reverse position	Poor switch connection	Check connection to terminal 3 of the switch.
	Defective sensitivity control	Unsolder the red lead from S-1. Check continuity from terminal 3 of the switch to ground with the sensitivity control all the way to the left. The reading should be 25K and decrease as the sensitivity control is rotated to the right. Be careful not to peg the meter.
	Defective component in the pick-up unit	With the red lead disconnected from S-1. Check the resistance of R-1. If defective replace. If R-1 checks okay, replace C-2 with C-1 or another .001 μf, 600 volt capacitor. If this fails to remove the trouble then CR-2 is defective.
Can not read zero, when aligning in the forward position when using a dummy load	Improper dummy load	Check value of dummy load (52Ω with 160Ω resistors and 72Ω with 100Ω resistors). Be sure carbon resistors with short leads are used for the dummy load.
	R-2 incorrect	Be sure that R-2 is the correct value, depending on the coaxial line used, and is within 5% tolerance.
	Incorrect coax line	Check that correct impedance coax line is used.

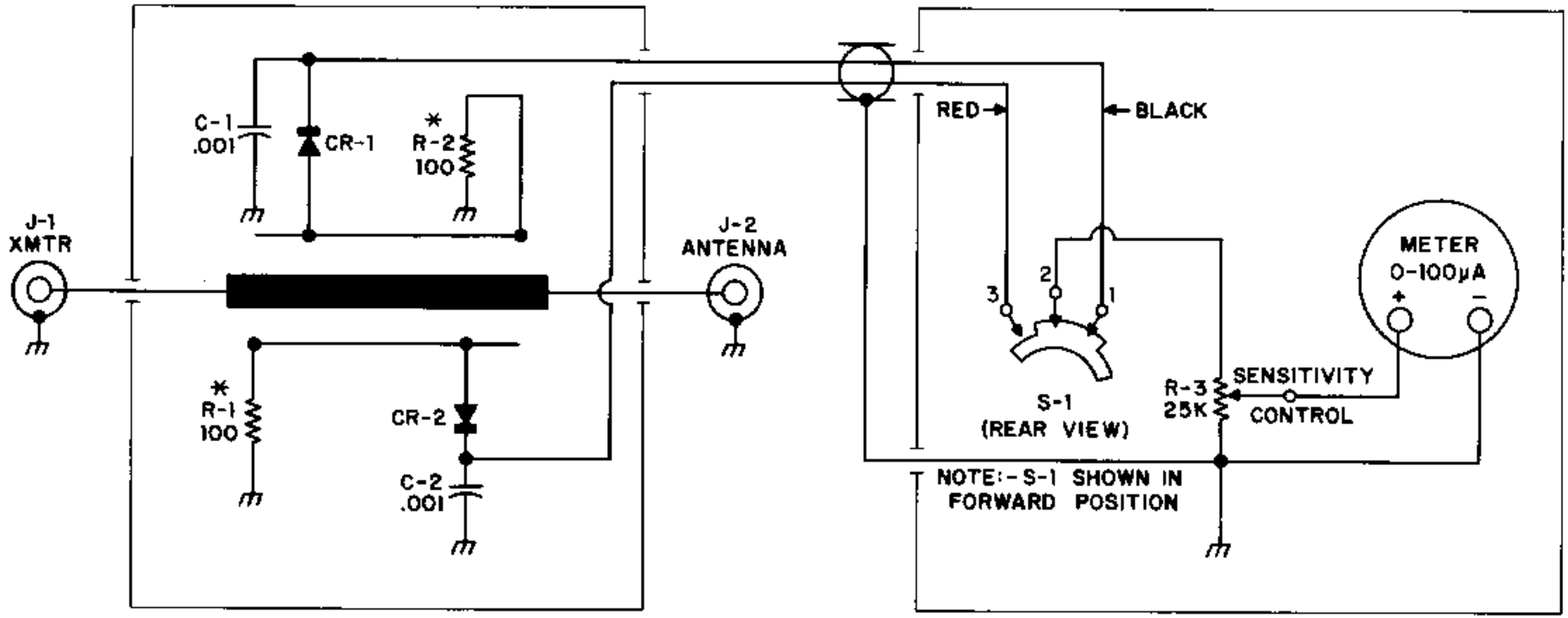
TROUBLE SHOOTING CHART

TROUBLE	POSSIBLE CAUSE	SERVICE PROCEDURE
Can not read zero when aligning in the reverse position when using a dummy load	Improper dummy load	Check value of dummy load (52Ω with 160Ω resistors 72Ω with 100Ω resistors. Be sure carbon resistors with short leads are used for the dummy load.
	Incorrect coax line	Check that correct impedance coax line is used.
	R-1 Incorrect	Be sure that R-1 is the correct value, depending on the coax line used, and is within 5% tolerance.
Can not read zero with an antenna	Unmatched antenna	Check for antenna mismatch as outlined under "Antenna Matching" in this book.
	Mismatch from a filter used for TVI reduction (if used)	Remove the filter from the line and check the meter reading. Check that the filter impedance is the same as that of the line.

CIRCUIT DESCRIPTION

The P-2 SWR/Power Meter is simply a piece of transmission line to which a linear conductor is closely coupled. In this case the section of transmission line is the hollow metal rod and the linear conductor is the piece of pick-up wire on either side of the rod. The combination of the inductive and capacitive voltage is such that the incident RF voltage on the line is balanced out, leaving only the reflected portion to be read on the meter. The circuit uses two bridge circuits (each pick-up wire comprises a separate inductor) so that either the reflected or incident component may be read.

The current flow through the meter will vary with the operating frequency of the transmitter, because of the variation in coupling impedance. A sensitivity control (R-3) is used to keep the readings in the desired section of the meter scale. Ths avoids the necessity of adjusting the transmitter level to an "on scale" reading.



NOTES

1-CAPACITORS INDICATED IN MICROFARADS.
2-RESISTORS INDICATED IN OHMS.
K=1,000 OHMS
*-VALUES SHOWN ARE FOR 72 Ω LINE.
*-WHEN USING A 52 Ω LINE, VALUES
OF R-1 AND R-2 ARE 160 Ω.

SWR/POWER METER SCHEMATIC

PARTS LIST

CAPACITORS

Symbol Number	Description	Part Number
C-1	.001 μf, 600 volts	276016
C-2	.001 μf, 600 volts	276016

DIODES

CR-1	Diode	630007
CR-2	Diode	630007

RESISTORS

For 72Ω lines:		
R-1	100Ω, 5%	302101
R-2	100Ω, 5%	302101
R-3	25K control	392163
For 52Ω lines:		
R-1	160Ω, 5%	302161
R-2	160Ω, 5%	302161
R-3	25K control	392163

SWITCH

S-1	Selector	437065

TERMINAL STRIPS

TS-1	2-terminal	440203
TS-2	3-terminal	440301

MISCELLANEOUS

Description	Quantity	Part No.
Bushing	2	880013
Bracket	1	470468
Connector, coax	2	502222
Case, meter	1	463479
Chassis, pick-up	1	463477
Cover, pick-up	1	463480
Feet	4	831002

MISCELLANEOUS (Cont'd)

Description	Quantity	Part No.
Ground lug	1	553001
Knob	2	761065
Meter	1	659253
Panel, dress	1	463481
Panel, meter sub	1	463478
Rod, metal	1	470469
Solder lug	2	553005
Supports	2	870152

HARDWARE

Flatwasher, 3/8"	2	580702
Lockwasher, #4	6	582200
Lockwasher, #6	2	582300
Nut, 4-40	8	570220
Nut, 6-32	2	570340
Nut, 3/8"	6	570840
Screw, 4-40 x 1/4"	8	560222
Screw, 6-32 x 5/16"	2	560343
Screw, self-tapping, 1/4" long	4	562292
Screw, self-tapping, 3/8" long, black	4	569345

WIRE, SOLDER AND TUBING

Bare wire, small, 4" length	1	806004
Bare wire, large, 10" length	1	806610
Cable, 2-conductor, 4' length	1	809055
Wire, 3" orange	2	801003
Wire, 4" yellow	2	801004
Solder, 2' length	1	930004