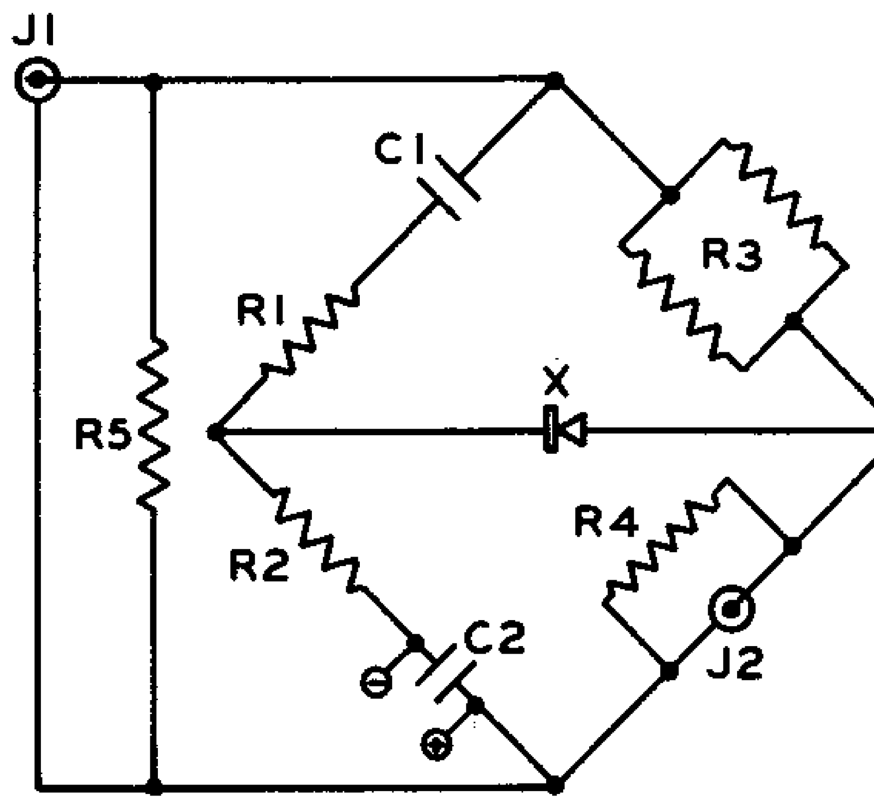
OPERATING INSTRUCTIONS
JOHNSON SWR BRIDGE

Cat. No. 250-24

GENERAL DESCRIPTION

The JOHNSON SWR Bridge is an instrument designed primarily to measure the standing wave ratio on 52 ohm coaxial transmission lines. It can, with slight modification or additional equipment, be used to measure the s. w. r. on 70 ohm coaxial lines, the s. w. r. on open wire lines, the radiation resistance of unbalanced antennas and the r. f. resistance of non-inductive resistors. The bridge is also essential for the proper adjustment of an antenna coupler unit. It is not critical with respect to frequency and will give accurate measurements up to frequencies of 150 megacycles.



PARTS LIST

Item	Part No.	Description
C1, C2	22.805	.001 MFD mica capacitor
R1, R2	22.888	100 ohm non-inductive resistor
R3	22.889	non-inductive resistor pair total 52 ohms
R4	22.802	4700 ohm non-inductive resistor
R5	22.887	18 ohm non-inductive resistor
J1, J2	22.746	83-1R receptacle
X	22.852	1N48 germanium diode

FIG. 1

CIRCUIT:

The instrument consists of a bridge circuit as shown in Fig. 1. The ratio arms of the bridge are C_1R_1, C_2R_2, R_3 and the unknown impedance paralleled by R_4. The elements R_1, R_2, C_1 and C_2 are selected and matched resistors and capacitors. The two resistors of R_3 are selected units and are used as a standard for comparison with the unknown.

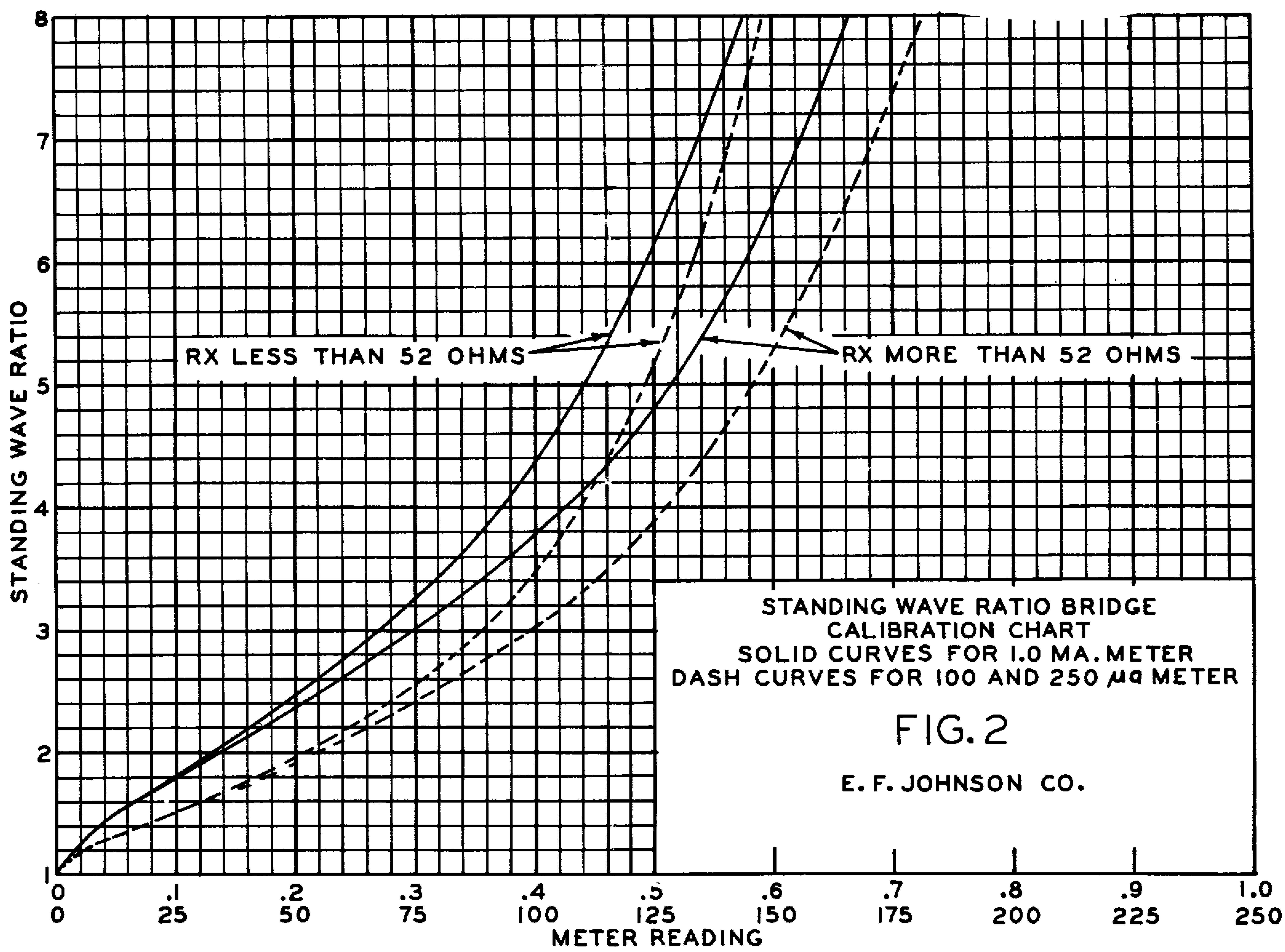
The 1N48 germanium crystal across the bridge, rectifies any r. f. voltage difference at the mid points of the two arms. This bridge unbalance current is read by connecting an external 0-1 ma. meter to the standard tip jacks provided on each side of capacitor C_2. The 4700 ohm resistor, R_4, across the output terminals provides a d. c. return when the bridge is used to measure "open circuit" impedances such as a dipole antenna. The resistor R_5 is across the input terminals (J_1) to improve the regulation of the r. f. power supplied to the bridge.

CALIBRATION CHART

The bridge calibration chart (Fig. 2) has two sets of curves for indicating the s. w. r. relative to meter readings for three types of meters. The 1.0 ma. curves are to be used with a 0-1 ma. milliammeter connected directly to the bridge. The 100 and 250 microampere curves are to be used with meters having 100 or 250 microampere full scale readings but only when used with the proper resistor in series with the positive meter lead. For approximately the same input power as required when a 0-1 ma. meter is used, the series resistor for a 100 microampere meter should be 4300 ohms and for a 250 microampere meter should be 2200 ohms.

OPERATION

A low power r. f. source, at the frequency at which the measurements are desired, is connected to the input terminals with the output terminals open. Caution must be observed in not applying more than one watt of power to avoid damaging the bridge elements and the meter. This input power should be carefully adjusted until the 0-1 milliammeter reads exactly full scale current which serves as the calibration point. Since the output is open, this current also represents the maximum unbalance between the bridge arms and therefore the maximum s. w. r. or impedance that can be measured.



STANDING WAVE RATIO BRIDGE
CALIBRATION CHART
SOLID CURVES FOR 1.0 MA. METER
DASH CURVES FOR 100 AND 250 μa METER

FIG. 2

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If difficulty is experienced in securing a low enough power level, a resistor load or lamp may be placed across the input to the bridge, preferably at the point of coupling to the transmitter. When the transmitter is a Viking I or II, the low power may be secured directly from the output coaxial fitting by tuning the final amplifier in the usual manner with both coupling controls set at minimum. Before connecting the bridge to the coaxial line from the Viking I or II, turn the drive control to zero and detune the buffer stage. When the bridge is connected, the bridge current may be adjusted by tuning the buffer stage for more or less output.

S. W. R. MEASUREMENT

The unknown impedance (transmission line or antenna) should now be connected to the output terminals of the bridge without disturbing the power input level as determined before. The 0-1 ma. meter will indicate a reduced current value which, when referred to the solid curves of the chart (Fig. 2), will indicate two values of s. w. r. directly.

When the bridge is perfectly balanced, the meter will read zero and the load (transmission line or antenna) can be assumed to be 52 ohms resistance and that the s. w. r. is 1 to 1 indicating a flat line.

If however, the load impedance is greater or less than 52 ohms or if the load contains a component of reactance, the meter will indicate a finite value of s. w. r. The design of the bridge is such that if the load resistance or impedance is greater than 52 ohms the s. w. r. must be read on the lower curve whereas a load impedance of less than 52 ohms must be read on the upper curve for greatest accuracy.

To determine whether the load resistance is greater or less than 52 ohms connect a low value non-inductive resistance (25 ohms or less) between the center terminal of the bridge output coaxial connector and the load terminal previously connected there. The indicated s. w. r. will decrease if the unknown is less than 52 ohms, will increase if the unknown is more than 52 ohms.

Referring to Fig. 2, the pair of curves drawn with solid lines are used when the indicating meter is 0-1 ma., the curves drawn with dashed lines are for 100 to 250 microampere indicating meters. At low values of s. w. r. such as 3 to 1 or less the difference between the two 0-1 ma. curves is negligible and can be ignored. This is also true of the pair of dashed curves for 100 and 250 microampere meters.

S. W. R. MEASUREMENT ON 70 OHM COAXIAL LINES:

To convert the bridge for use with 70 ohm coaxial lines, it is only necessary to replace the two resistors of R3 (Fig. 1.) with two resistors the parallel resistance of which is equal to 70 ohms such as 130 and 150 ohms. It is essential that these resistors be non-inductive and that they be installed in exactly the same manner and position as the orignal resistors so that the coupling between elements of the bridge is not disturbed.

ANTENNA COUPLER ADJUSTMENT:

The JOHNSON SWR Bridge may be used to properly adjust any antenna coupling unit including the Viking "Match-box" coupler. It should be borne in mind that the antenna coupling unit

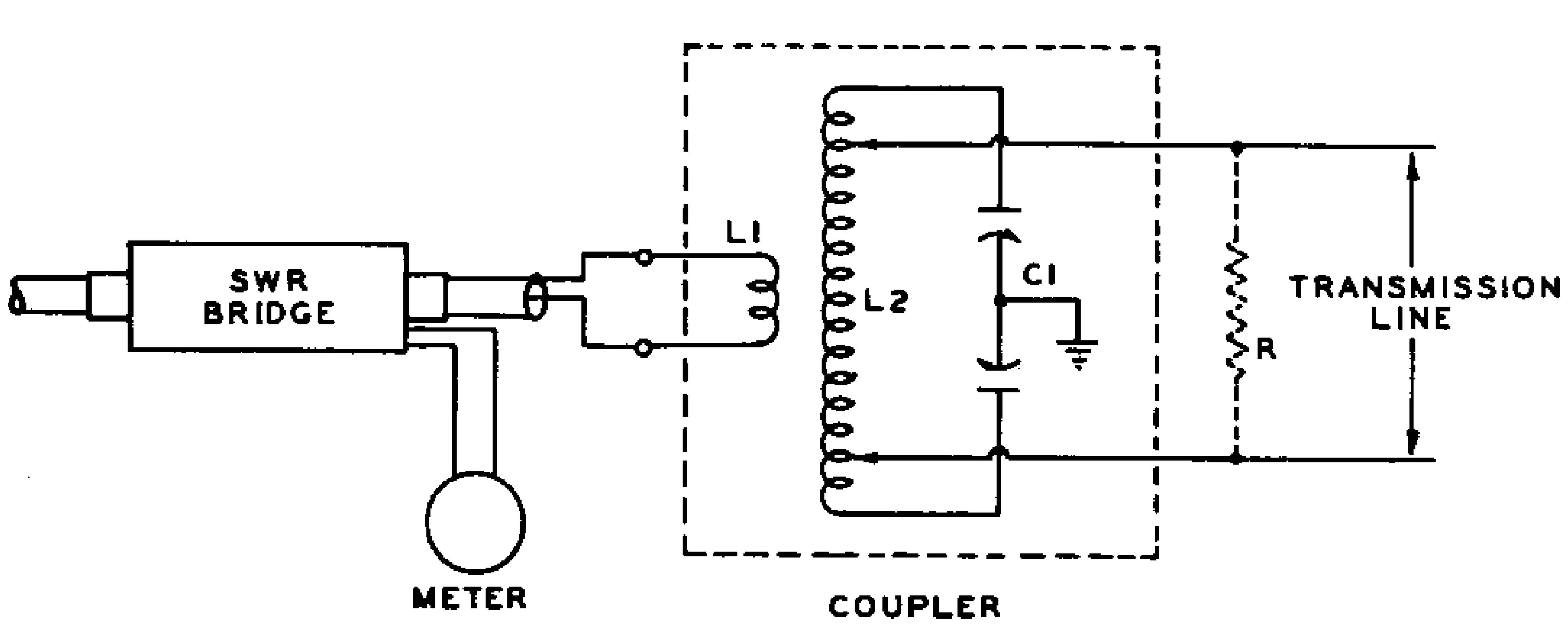

FIG.3

is a device for matching or transforming the antenna system impedance (at the feed point) to the ouptut impedance of the transmitter. The typical coupler illustrated in Fig. 3 is resonant at the operating frequency. The degree of coupling to the transmitter must be adjusted either by L_1 or some means within the transmitter such as a pi-network output circuit, variable link or other variable coupling device. The bridge should be installed between the low power r. f. source of not more than one watt and the coupler input as in Fig. 3.

With the output terminals of the bridge open, adjust for full scale deflection as previously described in these instructions. Connect the coupler to the bridge and connect the antenna transmission line to the coupler. Adjust the coupler until the bridge meter reads zero current which indicates that the antenna transmission line terminal impedance is matched into 52 ohms. If the coupler has a circuit similar to the one shown, the coupler is adjusted to resonance by the tank capacitor C_1 and the impedance matched by the taps on the coil L_2. In some cases where the antenna and transmission line system present large values of reactance to the output terminals of the coupler it will not be possible to attain a good impedance match since the s. w. r. is high. In these cases it is necessary to change the length of the antenna transmission line, or insert reactance of the sign necessary to cancel antenna reactance. The JOHNSON Matchbox coupler is adjusted by two capacitor controls and will handle a large range of antenna resistances and reactances.

S. W. R. MEASUREMENTS OF BALANCED OPEN WIRE TRANSMISSION LINES:

The bridge may be used in conjunction with an antenna coupler to measure the s. w. r. of an open wire transmission line. The coupler performs the transformation of the balanced unknown impedance into an unbalanced impedance suitable for measurement with the bridge.

The bridge is adjusted for full scale deflection with its output terminals open as before. Attach a non-inductive resistor, of the same resistance as the characteristic impedance of the antenna transmission line, across the output terminals of the coupler. (The transmission line is not connected as yet. Adjust the coupler for the lowest null reading of the bridge. This will be zero for a transformation of the load resistance to 52 ohms. (Failure to attain a zero reading indicates inability of the coupler to match the desired impedance.) The coupler must, of course, be capable of tuning to the frequency of measurement. Next, disconnect the resistor and without disturbing the bridge and coupler, attach the transmission line to the coupler output terminals. The bridge meter will indicate a current which, when referred to the chart Fig. 2, will give the s. w. r. present on the line. This does not necessarily represent a ratio of resistances since there may be reactances present on the line where it is connected to the coupler. For accurate measurements, the coupler should be adjusted for each frequency at which a measurement is taken.

MEASUREMENT OF THE RADIATION RESISTANCE OF AN UNBALANCED ANTENNA SUCH AS A VERTICAL RADIATOR:

Measurements must be made at the antenna terminals and not thru a feed line. A variable capacitor and a variable inductor are required for tuning out antenna reactance. Ground the case of the bridge with the shortest possible lead. The bridge is adjusted to full scale meter reading with the output terminal open as before. Connect the antenna to the center contact of J_2 with one of the variable reactances in series with the lead. Using first one reactance then the other, adjust the capacitor or the variable inductor until a minimum bridge reading is obtained. The reactance in the series lead will be equal but of opposite sign to the reactance of the antenna jX . If it is possible to measure the inductor or capacitor which produced minimum s. w. r. one may calculate the amount of reactance.

if the capacitor was used, $jX_a = \frac{1}{2 \pi fC}$ and jX_a is **inductive**

if the inductor was used, $jX_a = 2 \pi fL$ and jX_a is **capacitive**

Refer the minimum meter reading to the SWR/Current chart which will give the SWR. In the case of antennas where the antenna resistance is greater than 52 ohms, antenna resistance is equal to the product of the SWR and the standard resistance of 52 ohms (R_a = SWR x 52). If the antenna resistance is less than 52 ohms then antenna resistance is equal to 52 divided by the SWR

$$\left[R = \frac{52}{SWR} \right]$$

As discussed previously, the method of adding a small non-inductive resistor in series with the bridge center output terminal may be used in order to determine whether the impedance is above or below 52 ohms permitting selection of the correct SWR curve.