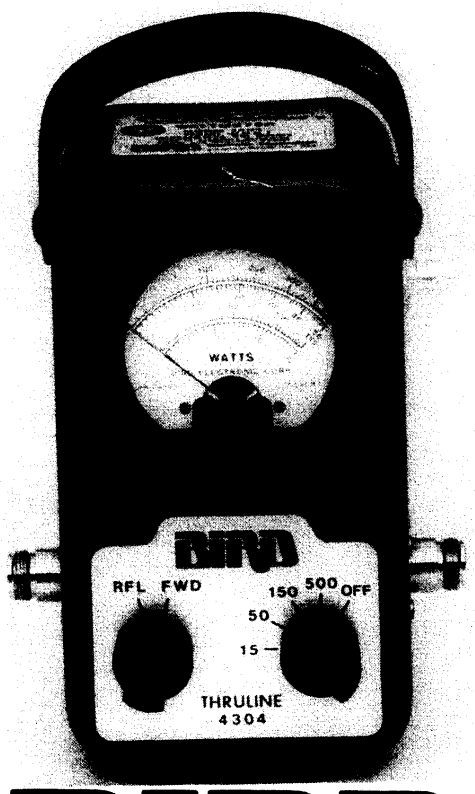
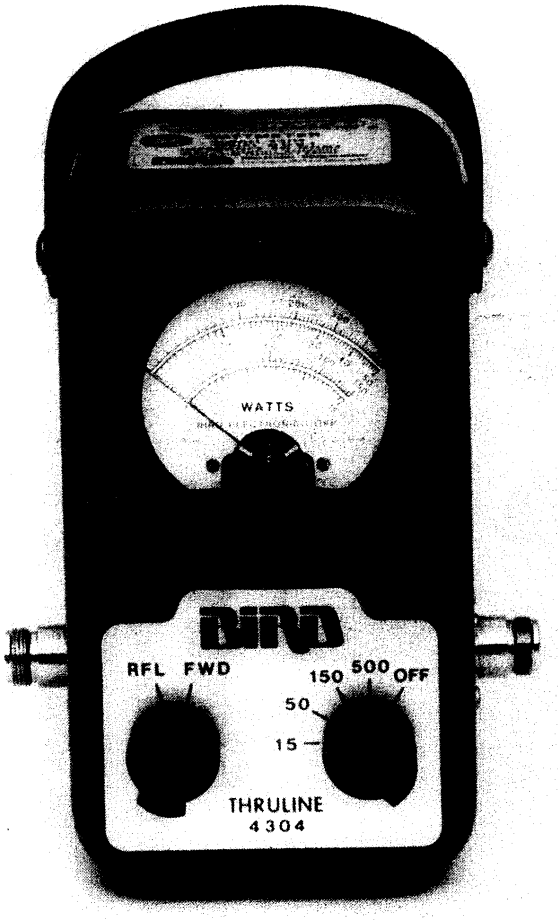
INSTRUCTION BOOK

RF Directional
multi-range dual mode Thruline® Wattmeter
Model 4304



BIRD
Electronic Corporation
30303 Aurora Road, Cleveland (Solon) Ohio 44139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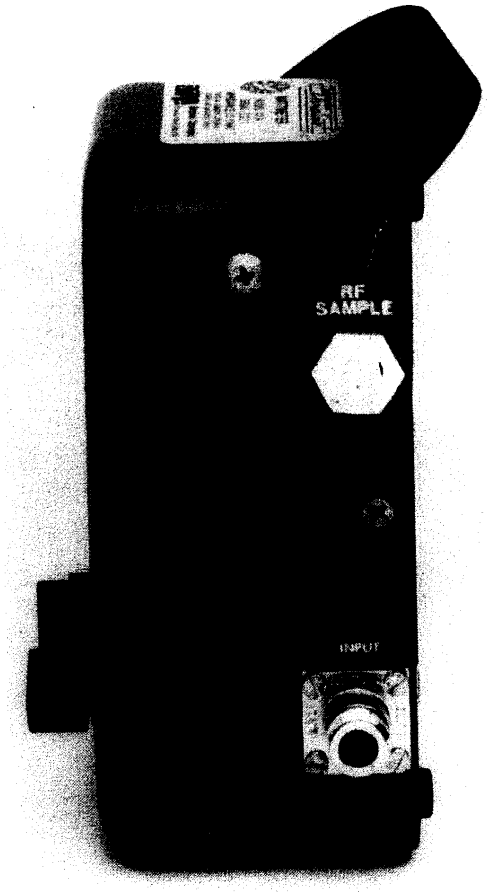
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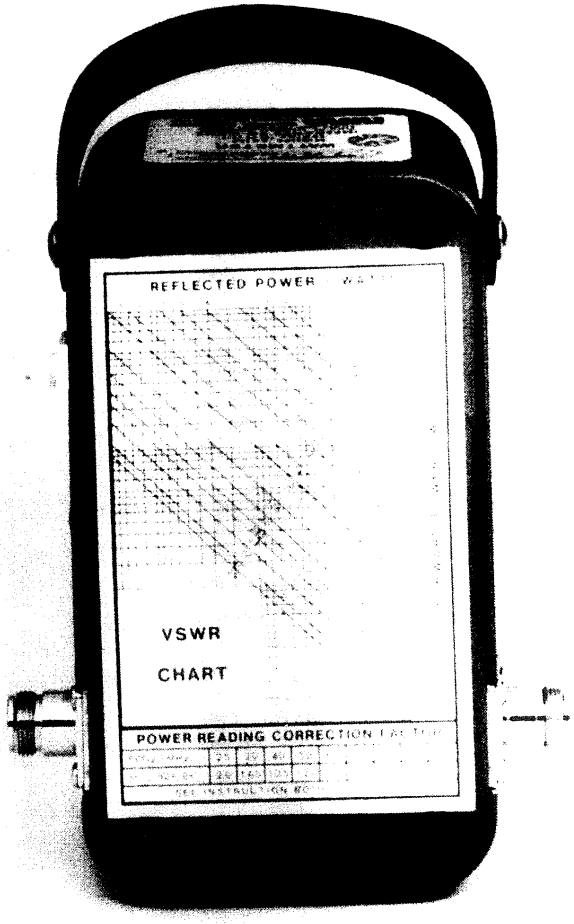
REFLECTED POWER
VSWR
CHART
POWER READING CORRECTION

Model 4304 THRULINE

Summary Specifications

Power Ranges (4)	15/50/150/500 Watts
Impedance	50 ohms nominal
Frequency Range	25 to 1000 MHz
Accuracy	
25 to 100 MHz	± 7% of full scale (with curve)
100 to 512 MHz	± 6% of full scale
512 to 1000 MHz	± 7% of full scale
RF Coupling (Sample port)	–43dB ±5dB
Insertion VSWR	1.05 max., 25 to 512 MHz 1.10 max., 512 to 850 MHz 1.15 max., 850 to 1000 MHz
Insertion Loss	0.1dB max.
Connectors	Bird Small Quick Change "SQC" type Female UHF (normally supplied)
Dimensions	Height 7" (178mm) Width (without connectors) 3-53/64" (97.2mm) Width (with F N connectors) 5-17/64" (133.7mm) Depth 3-11/16" (93.7mm)
Weight	2-1/4 lbs. (1 kg.)
Finish	Blue epoxy/polyester

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SECTION I

General Description

The Model 4304 Thruline® is a portable multi-range RF Wattmeter VSWR indicator. It is a rugged device which requires no external power source or batteries for operation. It is used to measure RF power when inserted into any 50 or 52 ohm transmission line. When operated in this manner, it is used to determine power flow and load mismatch in coaxial transmission lines. It may be used to make measurements of CW, AM, FM and TV modulation envelopes, but not for operation with pulsed transmitters.

There are four power ranges which are controlled by a selector switch on the front face of the unit. Each position of the selector switch corresponds to a power range on the read-out meter, see Summary Specifications. Another selector switch on the front panel selects forward or reflected power mode.

An additional feature of the Model 4304 is an RF sampling output for frequency analysis on a scope, spectrum analyzer or frequency counter.

The sampling signal is continuously available from a BNC type output jack located on the upper side face of the unit above the output connector. The output signal of this jack is 43dB ±5dB below the main signal level, see Summary Specifications, Page "A".

The meter, line section and related circuitry of the instrument is contained in a rugged aluminum housing. This housing is equipped with a leather carrying strap, four rubber bumper feet on the bottom and four rubber bumper feet on the back face. These bumper feet allow the unit to be used in a standing (vertical) or flat (horizontal) position.

SECTION II

Theory of Operation

Traveling wave concept - The operation of the Model 4304 Wattmeter is based on the traveling wave concept of RF transmission. As RF power is applied to a transmission line, there is a forward wave traveling from the transmitter to the load, and a reflected wave traveling from the load to the transmitter. The closer the load is attached to the line, the smaller the reflected wave will be. To determine the watts dissipated in the loading, it is necessary to determine the power of the forward wave and the power of the reflected wave. The difference between the two will indicate effective power dissipation.

Traveling wave vs Standing wave - The interference between forward and reflective waves, produces a standing wave in a coaxial system. In the standing wave concept, VSWR (voltage standing wave ratio) is a widely used implement. There is a simple relationship between forward power, reflected power and VSWR.

Example: $$VSWR = \frac{1 + \sqrt{\frac{R}{F}}}{1 - \sqrt{\frac{R}{F}}}$$

where F = forward power; and R = reflected power

Since there is a definite relationship between standing wave ratio and the forward-reflected power ratio, the forward and reflected powers may be read, as indicated by the Thruline meter, and conveniently converted to VSWR. The charts furnished in this Instruction Book or the VSWR Graph on the unit may be used for this purpose.

Coupling Circuit - When the Wattmeter is connected into the system, the RF power is directed through the metered line section, which is a short uniform section of 50 ohm air line which will not impair the impedance of the RF coaxial line into which it is inserted. There are coupling circuits in the line section, and RF waves traveling through the line section produce energy in these coupling circuits by inductance and capacitance. The inductive currents will flow according to the traveling waves producing them. The capacitive portion of these currents is independent of the traveling waves. It is therefore apparent that the current produced from the waves traveling in one direction will add in phase, while the current produced from the waves traveling in the opposite direction will subtract in phase.

The forward coupling circuit is so designed that the wave components traveling in the opposite direction will cancel each other out almost completely, making the coupling circuit highly insensitive to the reverse wave direction. Because of the highly directional characteristics of the coupling circuit, the resultant direct current which is sensed by the microammeter, indicates the power level of only the RF waves traveling in the forward direction.

Reflected Power Readings - A coupling circuit, identical to the forward power coupling circuit, is used for the reflected power reading. This circuit is positioned so that it will sense the power in the direction opposite to the forward direction. The meter will indicate this power when the mode switch is placed in the RFL position. The energy resulting from the inductively coupled component of the forward wave will bring about cancellation as described above.

Sampling Circuit - A coupling circuit similar to the forward and reflected sensors is used in the RF sampling circuit. This circuit however, delivers an unrectified, attenuated signal to the BNC type RF sample jack located on the side of the meter housing just above the output port.

SECTION III

Installation

The Model 4304 is a portable instrument, and the housing is not designed for fixed mounting. A leather strap is provided for carrying purposes. When transporting the Model 4304 Thruline, the range switch should be in the OFF position. This shunts the meter movement and protects it by dampening the pointer action during handling or shipping.

Be sure the power source is turned off and there is no RF power present in the coaxial transmission line before installation. Insert the Model 4304 Thruline in coaxial transmission lines of 50 ohms nominal impedance. Attachment is made through the connectors on either side of the wattmeter housing. A short length of 50 ohm cable fitted with the appropriate mating connectors may be useful when inserting the wattmeter in the transmission line. The input side of the unit i.e., connector labeled "Input" must be connected to the transmitter side of the coaxial transmission line and the "Output" side to the dummy load or antenna. If coaxial cables other than 50 ohm impedance are used, a mismatch will occur causing probable serious inaccuracies in readings. We urge that this condition be avoided if possible.

The Model 4304 is normally supplied with two Female UHF type connectors which are of the Bird Small Quick-Change design. Other "SQC" connectors are available, to facilitate connection to the users system. Other connectors may be obtained from Bird Electronic Corp. as required. See Section VI, Parts List.

These connectors are quickly changed by removing the four #6-32 round head machine screws from the corners of the connector flange, and pulling straight out. To install connectors, reverse the procedure making sure the center contact pin aligns properly with the socket.

CAUTION

Do not drop the Thruline or subject it to a hard blow. The microammeter is shock mounted in the wattmeter housing but its delicate mechanism could be damaged by severe impact.

SECTION IV

Operation

The apparent features of the Thruline Wattmeter have been discussed in the previous sections. As previously mentioned, no batteries or external power source is required to operate the meter. A sufficient amount of power is sensed from the transmission line into which the unit is connected.

Before applying any RF power, check to see if the meter pointer is set at zero. If adjustment is required it is necessary to zero adjust the meter under no power conditions. Using a small screwdriver, turn the zero-adjust screw on the bezel of the meter, clockwise or counterclockwise as necessary until the pointer exactly aligns with the zero of the meter scale.

The range switch should be in the OFF position or at least in the highest power setting (500 W). This is especially true when the amount of power being applied is unknown. After the RF power is applied the range switch may be switched down so that a power indication is given in the upper one-third of the scale.

The mode switch should normally be in the FWD position and switched to the RFL position after a forward reading has been taken. In the RFL position, a more accurate reflected reading can be made by turning the range switch to a lower position. However, in this condition care must be taken not to switch the mode switch back to the forward position until the range switch is returned to its original setting as over ranging the meter will result. This practice, of course, is not possible when power less than 15 watts is being measured.

If the Model 4304 was inadvertently installed backwards in the transmission line, i.e., transmitter output to wattmeter output and wattmeter input to load, the forward and reflected power readings will be reversed. Thus on the mode switch FWD will indicate reverse power and RFL will indicate forward power. Since the line couplers are similar, acceptable power indications are given, however, the stated accuracies of the instrument cannot be guaranteed and the unit should be disconnected and installed correctly. Be sure RF power is turned off before disconnecting unit.

Where appreciable power is reflected, as with an antenna, it is necessary to subtract the reflected from the forward power to get load power. Power delivered to and dissipated in a load is given by:

$$W_L = \text{Watts into load} = W_F - W_R$$

This correction is negligible (less than 1 percent) if the load is such as to have a VSWR of 1.2 or less. Good load resistors, such as Bird TERMALINE® loads, will

give this negligible or unreadable reflected power. Correction factor: at frequencies below 100 MHz, a correction factor must be applied to the indicated reading to obtain a more precise power measurement. A correction factor table will be found on the back cover plate of the unit or refer to the correction factor graph, Figure 2, on Page 15.

VSWR Calculations - After obtaining the forward and reverse power as described above, the VSWR may be found by calculations as described in Section II, (Theory of Operation). A chart is also available on the back cover and Figure 3 on Page 18, to simplify finding VSWR. Simply apply the obtained forward and reverse power readings to the chart, following the cross lines and taking the VSWR from the nearest sloping line.

RF Sampling port - As mentioned in Section I, (General Description) the Model 4304 Wattmeter is provided with an RF Sample output port. This port at 43dB delivers a sufficient amount of output for a scope, spectrum analyzer or frequency counter. Connection should be made through a 50 ohm coaxial lead, (such as RG58 A/U) equipped with an appropriate male BNC connector.

SECTION V

Maintenance

Introduction
With the simple construction and self contained nature of the Model 4304 Thruline equipment there is only a moderate amount of maintenance required. One of the major precautions is handling, use reasonable care and do not drop the unit.

Care and cleanliness is a main factor in maintenance. If any of the contacts or line connectors become dirty, they should be cleaned with dry cleaning solvent on a cotton swab stick. (Avoid excessive skin contact or inhalation of fumes when using any dry cleaning solvent). Clean all contact surfaces and especially the exposed faces of the teflon insulators.

The meter face and the housing can be cleaned with a soft damp cloth, use a mild detergent solution.

Troubleshooting
As a brief guide to the operation in isolating occasional difficulties that may occur in the use of the Model 4304, the following summary is included. The remedies for the same are referenced in the text or are self evident.

Difficulty	Suggested Cause
No meter indication	No RF power. Open or short circuit in dc circuit. Defective meter, RF sensor or switch connections.
Intermittent or inconsistent meter readings.	Faulty load. Faulty transmission line. Bad connection or faulty solder joint. Sticky or defective meter.
High VSWR or high reflected power.	Defective load or antenna. Defective or loose connectors. Shortened or open transmission line. Foreign material in RF connector bodies.

Although the Model 4304 is designed to be rugged and give years of trouble free service, occasionally repair or replacement may become necessary. Following in this section are repair or replacement procedures. Certainly no repairs should be attempted by the user for the first year while the unit is in warranty as this may be cause to void the warranty.

If a problem should occur in the line section or coupling circuits it is advised that the unit be returned to the Company for repair and recalibration. Consult with Bird Electronic Corporation Customer Service Department.

Circuit Board Repair or Replacement

1. For access to the inside of the meter housing remove the rear cover by taking loose the four screws securing it and pulling it straight off. These screws are located near the back center of the sides, bottom and top.

2. To free the circuit board for replacement of parts, unscrew the hex nuts from the meter lugs. These lugs hold the circuit board in place. Gently lift out the circuit board being careful not to disturb or tear loose the board or switch connections of the ribbon cable.

3. If the circuit board is to be removed entirely, unsolder the ribbon cable from the circuit board. Be sure to remember the location of each wire connection for reconnection. A useful hint is to make a sketch of the connections before unsoldering.

Meter Removal

With the circuit board detached as above, unscrew the three screws and nut sets retaining the meter. The meter is now free and may be lifted out of the meter housing.

Switch Removal

Before attempting to replace the range or mode switch, the line section must be removed. This is easily done by removing the two screws located on the bottom of the unit. These screws secure the line section bracket and when removed, the line section and bracket are free from the housing except for attached wiring. Gently lift the line section out of the way, exposing the rotary switches, being careful not to break the junctions of the connecting wires.

Remove the switches by the following procedure:

1. Remove knob, loosen set screw on side of knob and pull straight off.
2. Unscrew large retaining nut under knob.
3. Remove switch from inside the housing.
4. When disconnecting and replacing wires, be sure to replace them on the correct terminals.
5. To reassemble reverse the above procedures.

Calibration

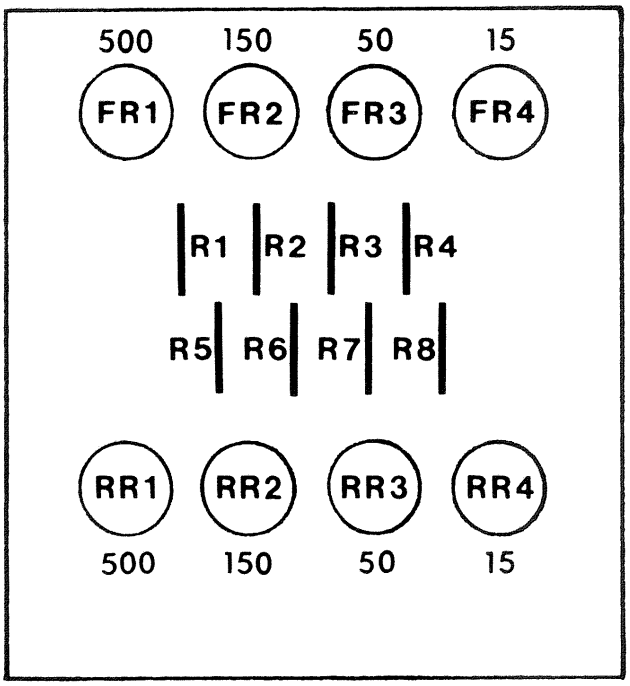
If recalibration is necessary set-up the 4304 Wattmeter in series with a standard Wattmeter with known accuracy. For example a Bird Model 43 Thruline Wattmeter could be used. A suitable low pass filter should be used between the Wattmeter and Transmitter. The set-up should be terminated in a suitable 50 ohm Load like the Bird 8201. Make all connections as short as possible to avoid mismatches and additional insertion losses.

Remove the back cover from the Model 4304 by removing the four (4) screws. This will expose the eight calibration pots. The identification of the pots and the power ranges they will adjust is shown in figure 1. Clockwise rotation of pots will increase meter reading.

Set Fwd/Rfl switch to Fwd position and set power range switch to range to be calibrated. Apply RF power of known value and frequency desired to 80% of full scale, adjust suitable calibration pot so Model 4304 agrees with standard Wattmeter. To calibrate the reflected ranges the Fwd/Rfl switch should be put in the Rfl position.

Replacement Parts List

Item	Req.	Description	Part No.
1	1	Meter	2080-051
2	3	Meter Bumpers	6254-010
3	1	Assy., P.C. Board	4304-022
4	1	RF Power Range Switch	4304-013
5	1	FWD, RFL Power Switch	4304-019
6	1	Assy., Ribbon Cable	4304-024
7	1	Assy., Coupler Plate	4304-021
8	1	Assy., Element Plate	4304-028
9	8	Bumper Feet	5-875
10	1	Carrying Strap	8580-003
11	2	Carrying Strap Spacer Screw	8240-054
12	2	10-32 x 1/2 Phillips Truss Head Screw	Std.
		("Q.C." Connectors (Type installed depends on specific order)	
13	2	Q.C. Connector - Female N	4100-014
14	2	Q.C. Connector - Female UHF	4100-017



R4, R8	2	5-1365-2	RESISTOR, 1/4W, 1.5K Ohm
R3, R7	2	5-1365-3	RESISTOR, 1/4W, 15K Ohm
R2, R6	2	5-1365-4	RESISTOR, 1/4W, 33K Ohm
R1, R5	2	5-1365-5	RESISTOR, 1/4W, 68K Ohm
RR4, FR4	2	5-1364-1	POTENTIOMETER 5K Ohm
RR3, FR3	2	5-1364-4	POTENTIOMETER, 10K Ohm
RR2, FR2	2	5-1364-2	POTENTIOMETER, 25K Ohm
RR1, FR1	2	5-1364-3	POTENTIOMETER, 50K Ohm
2	1	4391-030	HEADERS, RT. ANGLE, MOD.
1	1	4304-010	BOARD, P.C.

Figure 1

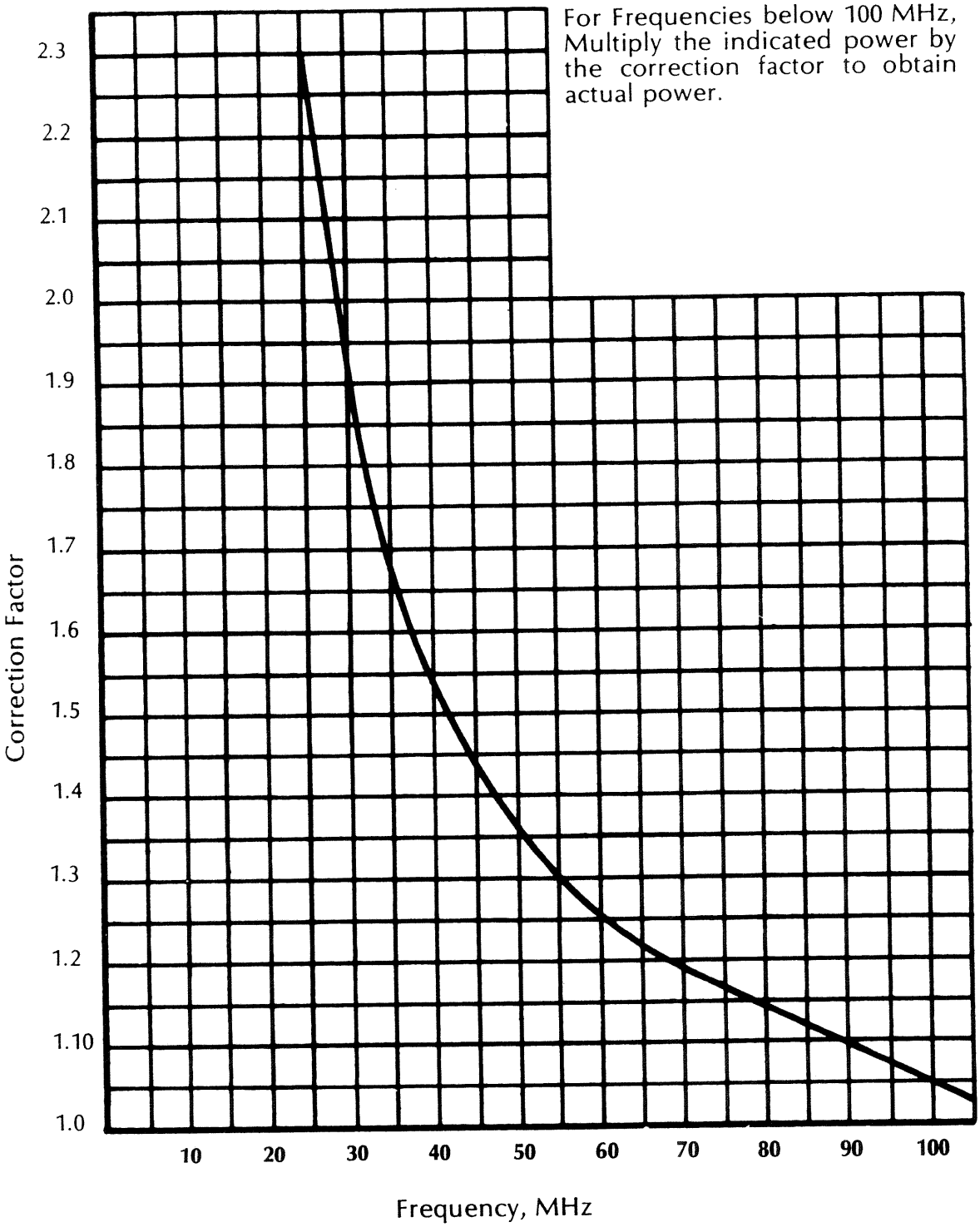


Figure 2

Model 4304
Frequency Calibration Chart

POWER VALUES vs. VSWR

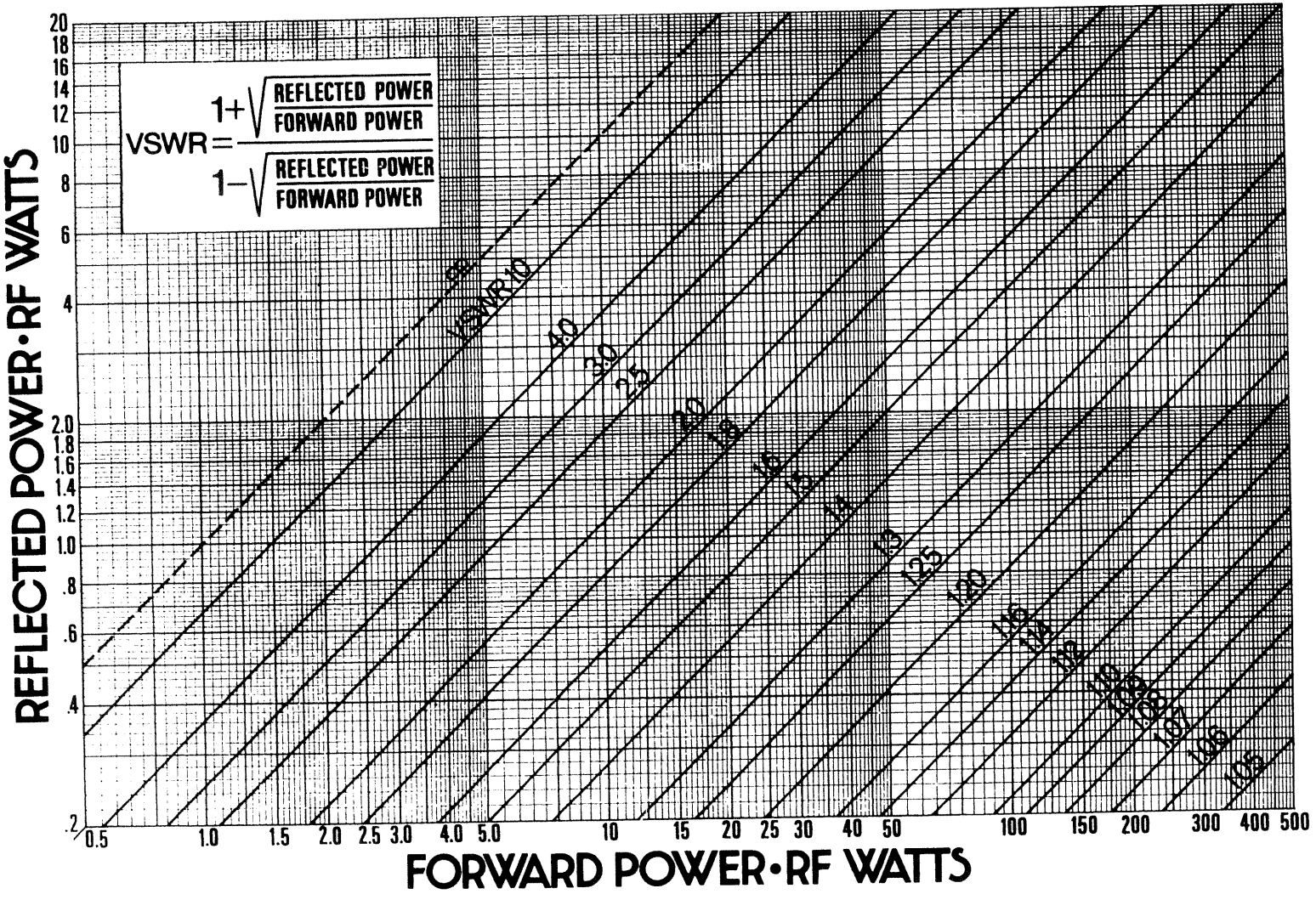


Figure 3