

PRELIMINARY



BIRD
INSTRUCTION
book

MODEL 4410

THRULINE[®] WATTMETER

LIMITED WARRANTY

We are proud of the high quality of our product and we warrant to the original purchaser that each new instrument of our manufacture will for a period of one year after original shipment be free from defects in material and workmanship under normal and proper operating conditions and that properly used during such period it will perform in accordance with our applicable specifications.

Our obligation and the purchaser's exclusive remedy for any defect or failure to meet specifications shall be limited, at our option, to repair or replacement, or if we determine said defect or failure to be so defective as to preclude remedying by repair or replacement, the purchaser's sole and exclusive remedy shall be limited to refund of the purchase price. We shall have no obligation if defects result from improper use, operation above rated capacities, repairs not made by us, or misapplication of the equipment. Our warranty does not extend to the failure of semiconductor devices and batteries, or to equipment and parts made by others except to the extent of the original manufacturer's warranty to us. No other warranty is expressed or implied. Bird Electronic Corporation is not liable for consequential damages.

Warranty returns must be first authorized by the factory office and are to be shipped prepaid.

PRELIMINARY

BIRD

INSTRUCTION MANUAL

For

THRULINE[®]

RF Directional Wattmeter

Model 4410

LIMITED WARRANTY

BIRD ELECTRONIC CORPORATION
30303 Aurora Road,
Solon, Ohio 44139

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INSTRUCTION MANUAL
THRULINE[®] RF Directional Wattmeter
Model 4410



Bird Electronic Corporation
30303 Aurora Road
Cleveland (Solon), Ohio 44139

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First printing 1983

Safety Precautions

Always remember that when working with equipment that involves the use of high electrical power, extreme caution must be taken. Observe all safety precautions and never work alone. It is always good practice to have someone near by that is proficient in modern methods of resuscitation.

Below is a list of warnings and cautions to be observed while using this equipment. They may also be found in the text of this book where applicable.

Warning

Exposure to RF power radiation and the possibility of RF shock or burns is possible with some operating conditions. Always be sure to turn off transmitter when connecting or disconnecting Wattmeter. Be sure transmission line is terminated into a load or antenna. When plug-in-element is removed from the RF line socket, the line section center conductor is exposed. DO NOT put finger or other object into this plug-in-element socket when RF power is on.

Warning

When using dry cleaning solvents or pressurized spray cleaner take necessary precautions and supply adequate ventilation. Avoid breathing fumes.

Caution

Do not drop instrument or plug-in-elements as damage could result to the meter or accuracy of the elements could be impaired.

Safety Precautions

Caution

If other than Female N type connectors are used, limit power and frequency to the capabilities of the RF coaxial cable or connectors used. Damage to connectors or errors in reading could result.

Model 4410 Thruline[®] Wattmeter

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Model 4410 Thruline® Wattmeter

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Introduction

Purpose and Application

The model 4410 THRULINE[®] Wattmeter is an insertion type RF wattmeter, designed to measure power flow and load match in 50-ohm RF coaxial transmission lines. Its use is intended for CW unmodulated or FM signals only. When used in a 50 ohm application with N type connectors it has an insertion VSWR of 1.05:1 for frequencies up to 1000MHz. The meter has two scales, a 0 to 1 scale and a 0 to 3 scale. Power is read in multiples of the values indicated by the pointer, depending on the range switch setting and by the factor on the plug-in-element. Several of these plug-in-elements may be selected to give this instrument a broad band spectrum of various power ranges (See specifications)

Description

The model 4410 is a portable unit housed in a die cast aluminum housing, with a formed sheet aluminum removable back. The unit is equipped with a leather strap for carrying, four rubber shock feet on the base and four rubber bumpers on the back, which allow the unit to stand vertical or on its back in a horizontal position when used. A slotted screw head is provided on the lower face of the meter for zeroing the pointer. Below the meter, the RF line section face protrudes slightly from the wattmeter housing with the plug-in-element socket in the center. Mounted on the line section, inside the housing, is the circuit module with an attached phosphor bronze spring contact finger which protrudes through a lateral hole and into the plug-in-element socket of the RF line section. The finger has a button on its end which mates with the contacts of the plug-in-element. The RF line section is precision

made to provide the best possible impedance match to the coaxial RF transmission line in which the model 4410 is inserted. At the ends of the line section are Bird Quick Change type RF connectors, which are readily interchangeable with many other types of Bird Quick Change "QC" connectors.

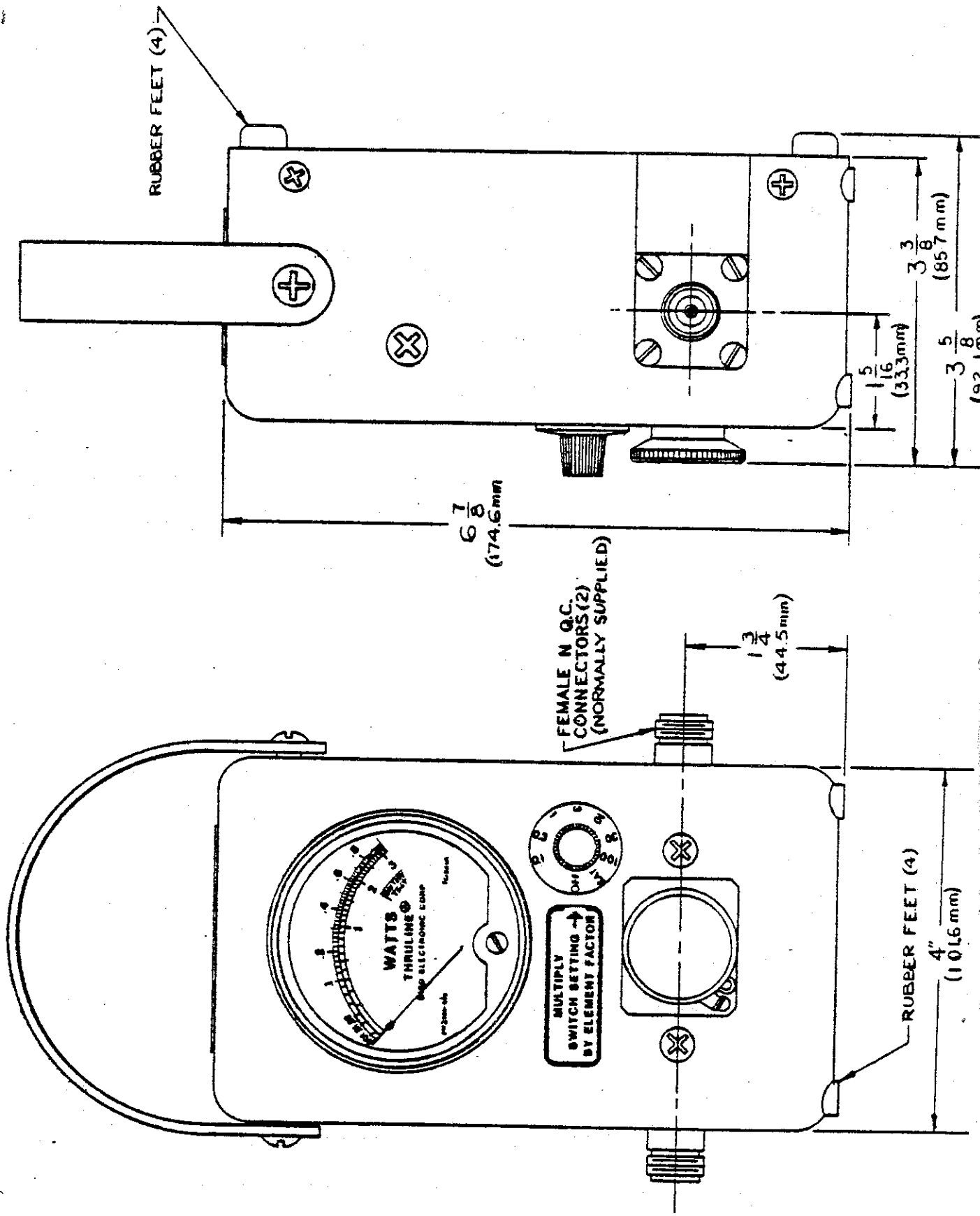
To make RF measurements, the cylindrical shaped plug-in-element is inserted into the line socket and rotated against one stop. A small catch in the lower left hand corner of the casting face, when in place, presses on the shoulder of the plug-in-element body keeping it in proper alignment assuring good contact with the DC jack and contact between the lower edge of the element body and seat of the line section body. On diametrically opposite sides of the plug-in-element body are contacts to provide DC pick-up for forward and reverse power directions. These contacts make connection with the spring finger of the line section only when the element is in the precise forward or reverse position.

Model 4410

Specifications

Impedance	50 ohms nominal
Power and Frequency Range	0-10000 watts 0.2 to 30MHz 0-1000 watts, 30 to 1000MHz (Power and frequency range is determined by 4410 type plug-in-elements used.)
Insertion VSWR	1.05 0-1GHz E/W F-N connectors (-32.3dB return loss)
Accuracy *	±5% of reading above 20% of full scale of selected power range when amplitude modulation is below 10%
Relative Humidity Range	5% to 90% non-condensing
Temperature Range (Operating) (Storage)	0 to 50°C (32 to 122°F) -25 to 65°C (-13 to 149°F)
Connectors	Bird Quick Change "QC" type Female normally supplied
Over Ranging	120% of element power rating regardless of selector switch setting. (Certain connector types limited to rating of connector)
Dimensions (approx.)	6-7/8" h x 4" w x 3-3/8" d (174.6 x 101.6 x 85.7mm)
Weight (approx.)	3 lbs. (1.4kg)
Power Requirement	9V dc alkaline battery
Battery Life	24 hours continuous use

*Exception: Element P/N 4410-1 0.200-0.535 has an accuracy of ±10% of reading.



Section II Theory of Operation

2-1 General

2-2 On any uniform RF line section there are voltages, currents and standing waves present when RF power is applied. These are the results of two traveling waves, forward and reflected. The characteristic impedance of these lines is usually a pure resistance of 50 ohms.

2-3 The main RF circuit of the Thruline is a short piece of uniform air type line section whose characteristic impedance is a very accurate 50 ohms, in which correct measurements may be made.

2-4 Coupling Circuit

2-5 The coupling circuit which samples the traveling waves in in the plug-in-element. The circuitry of the element and its relationship to the other components of the Thruline are illustrated in the diagram, Figure 2-1. Energy will be absorbed in the coupling circuit of the element by both mutual inductance and capacitance from the traveling RF waves of the line section. This signal which is to be measured, is detected and through the use of a self-balancing bridge circuit an accurate power reading is obtained. The nonlinearity and temperature instabilities of the detector diode are avoided by using a secondary balancing detector diode connected in opposition to the principal detector diode. These two diodes are selected for similar characteristics so they are nearly identical and diode variables are virtually eliminated. Also, the two diodes are mounted close to each other in the same enclosure and subjected to the same thermal environment almost eliminating thermal effects.

2-6 The inductive currents within the line section will flow according to the direction of the traveling waves producing them. The capacitative 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 arrow on the plug-in detector element indicates the additive direction of wave travel. The element is so designed that the wave components traveling in the opposite direction of the arrow will cancel each other out almost completely making the element highly insensitive to the reverse wave direction. Because of the highly directional characteristics of the element, the resultant direct current which is sensed by the microammeter indicates the power level of only the RF waves traveling in the arrow direction.

2-7 Reflected power readings. The plug-in detector element is designed so that it can be rotated 180 degrees in its socket in the line section. When it is rotated, the meter will indicate the power in a direction opposite that of the initial reading, so that if the forward direction power was read first, the reflected direction power will be read after the plug-in detector element is rotated. The energy resulting from the inductively coupled component of the forward wave will bring about cancellation as described above.

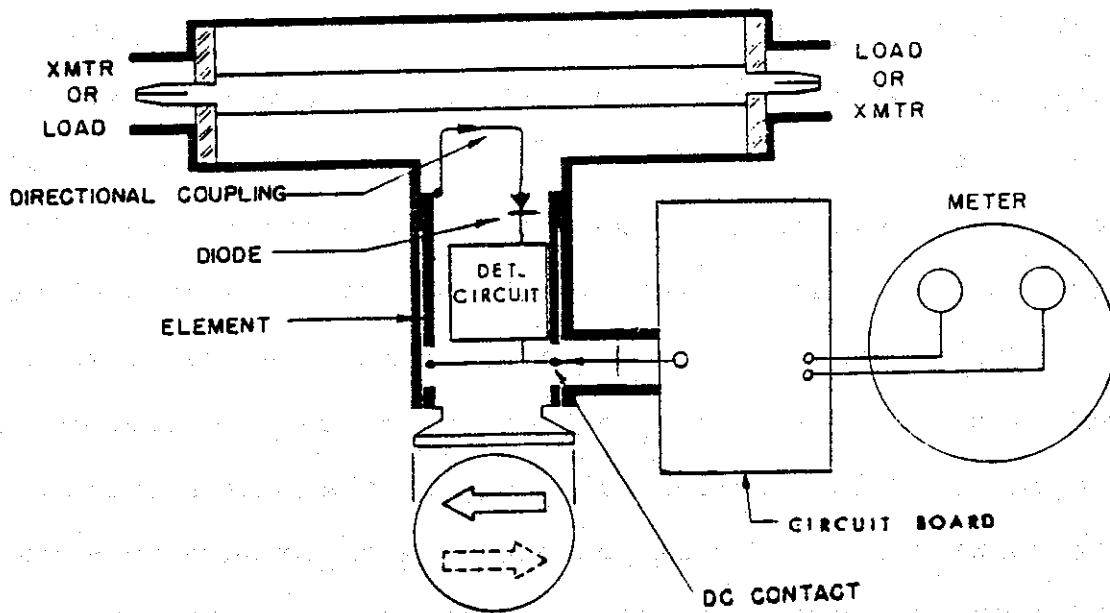


Figure 2-1 Coupling Circuit and Related Components

Section III Operating Instructions

3-1 General

3-2 Installation and appearant features of the model 4410 have been discussed in previous sections. RF power measurements are made with the insertion of the plug-in-elements previously mentioned. With the element inserted in the line section receptacle, forward power is indicated when the arrow on the element plate points in the direction of power flow, i.e. from transmitter to load. Reflected power measurements are made with the element rotated 180° with the arrow on the element plate pointing toward the transmitter. When power measurements are being made, make sure the element is rotated fully so that the index pin protruding from the elements cylindrical shaped body rests against the stop on the line section, either in the forward or reflected position. Also be sure that the small catch in the lower left hand corner of the casting face presses on the shoulder of the plug-in-element to keep it in proper alignment and assure a good contact with the dc connection and between the lower edge of the element and line section body.

* Warning *
* Exposure to RF power radiation and the possibility of RF shock *
* or burns is possible with some operating conditions. Always be *
* sure to turn off transmitter when connecting or disconnecting *
* Wattmeter. Be sure transmission line is terminated into a load or *
* antenna. When plug-in-element is removed from the RF line socket, *
* the line section center conductor is exposed. DO NOT put finger *
* or other object into this plug-in-element socket when RF power is on *

For reflected power readings the element is rotated 180° in the element socket and the same system is used, however, a much lower switch setting maybe advantageous for better resolution.

3-8 Load Power

3-9 Where appreciable power is reflected , as with an antenna, it is necessary to subtract the reflected from forward power to obtain load power. Power delivered to and dissipated in an antenna is given by; $W_L = W_F - W_R$

Where: W_L = power into load
 W_F = forward power
 W_R = reflected power

This correction is negligible, less then one percent if the load is such as to have a VSWR of 1.2 or less. A good resistor such as our Termaline^R Load Resistors will show this negligible or unreadable reflected power.

The Thruline[®] used with a Bird Termaline[®] Load Resistor of proper power rating forms a highly useful absorption wattmeter. Since the reflected power will be negligable, it will be unnecessary to rotate the element from the forward direction.

3-10 Determining VSWR

3-11 The model 4410 Thruline[®] Wattmeter is not designed to provide direct VSWR readings. It is felt that VSWR readings are no more useful than the ratio of forward to reflected power. In most cases operators find that in transmitter tune up, antenna matching and similar problems dealing with RF circuits, the forward power to reflected power ratio is a highly useful tool. However, VSWR readings can be determined very easily by the use of the provided graphs, as follows:

- a. Determine the forward and reflected power as described above

- b. Refer to the appropriate graph, Figure 3-1 or 3-2, to convert the forward and reflected power readings to VSWR. Note that the graphs convert the readings directly to VSWR without any intermediate computations.

3-12 Shutdown Procedure

3-13 When all measurements are completed be sure to turn the power range switch to the OFF position. Leaving the switch on one of the power ranges will not be detrimental to the circuit in any way other than the fact that it will shorten battery life. Note that there is a battery test position on the range selector switch. This battery test position is provided to conveniently check the condition of the battery occasionally to assure accuracy of the unit.

Always be sure the transmitter power is off before disconnecting the unit from the transmission line.

3-14 Performance Notes

3-15 The model 4410 Thruline[®] is sensitive to a modulated signal which effect the accuracy, however small amounts of AM (up to 10%) are tolerable, but for every 1% of AM the reading may increase up to 1% beyond the rated accuracy. Use above 10% AM is not recommended.

The stated accuracy does not include effect of less-than-infinite directivity of the element used. This is generally insignificant except for reflected power measurements where VSWR is low.

Although the model 4410 is equipped with quick change connector types, it must be remembered that the power rating and insertion loss may be effected if other than the "N" type connectors are used. Power limits must be governed by the type of connector or transmission line used. For other types of quick change connectors see parts list.

The accuracy of the unit may be effected by a weak battery. Check the condition of the battery occasionally by use of the battery test position on the selector switch. If the pointer on the meter indicates below the battery test zone, it must be replaced.

When the range switch of the model 4410 is set in one of the numbered positions, i.e. other than OFF or BATT, it is normal for the meter to drift or deviate off the zero setting. This condition occurs when an element is out of the line section socket or if the element is rotated 90° in the line section in a shorting position.

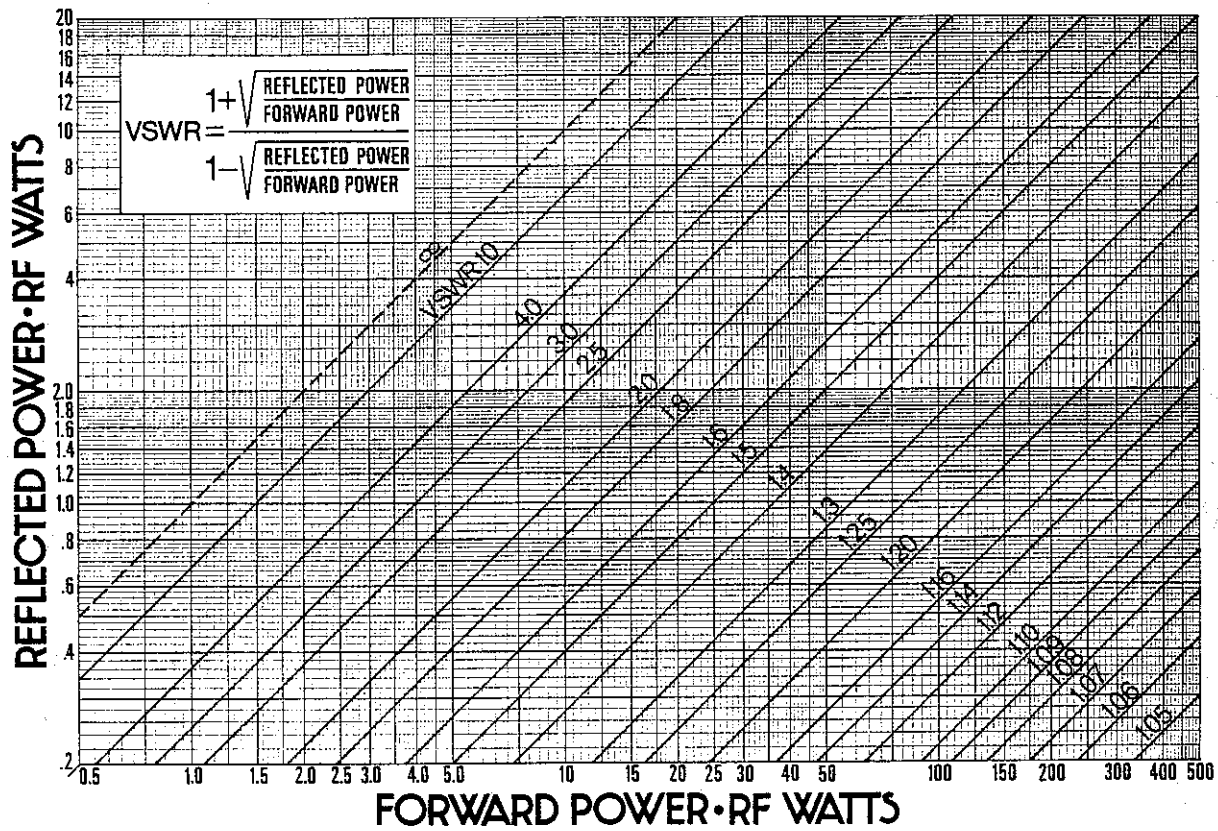


Figure 3-2. Power Values vs VSWR (Reflected Power 0.2 to 20 Watts)

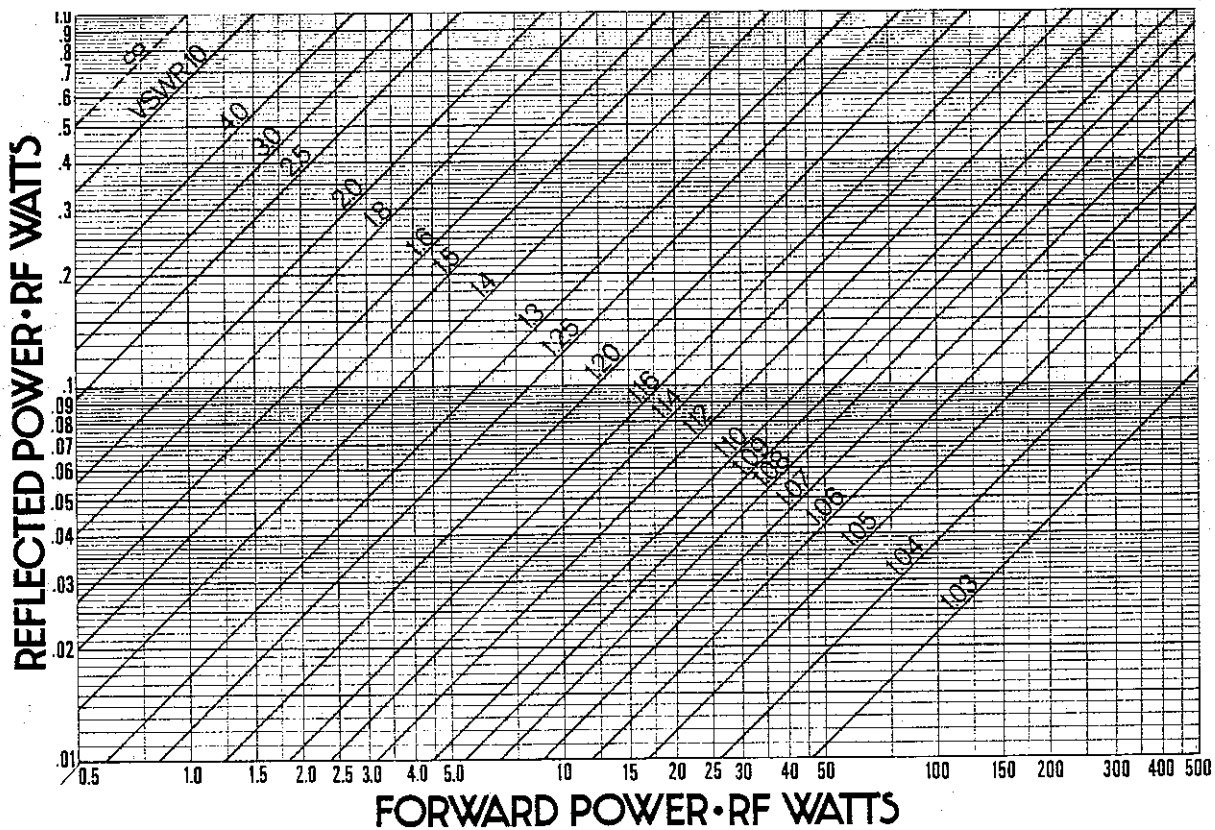


Figure 3-1. Power Values vs VSWR (Reflected Power 0.01 to 1.0 Watts)

Section IV Maintenance

4-1 General

4-2 The model 4410 Thruline[®] Wattmeter is of very rugged construction and requires very little care and maintenance except for battery replacement. Maintenance of the Wattmeter, is normally limited to cleaning. The amount of cleaning necessary can be minimized by keeping the plug-in-element in the socket of the line section as much as possible. This serves as an effective seal against the entry of dust and dirt. Cover the socket opening when the element is removed. Also, protect the RF connectors on the line section against the entry of dust and dirt by keeping them connected to the line or by covering them when the line is disconnected.

* Warning *
* When using dry cleaning solvents or pressurized spray cleaner, *
* take necessary precautions and supply adequate ventilation. Avoid *
* breathing fumes. *

4-3 Care and cleaning

4-4 All contacts must be kept clean to assure low resistance connections to and within the unit.

RF Connectors. Clean RF connectors with a cotton swab stick dampened with alcohol, freon or any acceptable dry cleaning solvent

Clean the inside of the line section socket bore and the entire circumference of the plug-in-element with a cotton swab stick dampened with dry cleaning solvent. Pay particular attention to the cleaning of the bottom rim of the element body and to the seat of the socket in the line section. When cleaning the socket bore, take care not to disturb the spring finger of the DC contact. If

necessary, the spring finger of the DC contact can be adjusted manually. The button must be positioned out far enough to make good contact with the element body, but it must not restrict the entry of the element body. Check the inside of the line section for dirt and contamination. Clean the reachable portions of the line section with a cotton swab stick. Blow out the remaining dirt with low-pressure, dry compressed air. Do not attempt to remove the RF line conductor from the line section. Any attempt to remove it will ruin the assembly.

Clean the meter and meter housing using a cloth dampened with a mild detergent. Do this only when necessary and take care not to allow water to enter any of its circuitry as damage may result.

Section V Troubleshooting & Repair

5-1 General

5-2 The model 4410 Thruline[®] Wattmeter is especially designed for independent, long term, trouble free operation. Regular mechanical maintenance, other than routine checks and cleaning care described previously, are not required. In case of malfunction of the unit or replacement of a major component the entire unit may be returned to the factory. This applies especially to any Thruline[®] still under the one year warranty. Consult with the factory. Do not tamper with calibration settings or do other unauthorized maintenance work during the first year, it could be cause to void the warranty. Test and calibration in the field may be performed as described in Section VI. Other replacements that might be needed are given in this section. A trouble chart listing some of the most common problems that might occur is provided.

Table 5-1. Trouble Chart

TROUBLE	PROBABLE CAUSE	REMEDY
NO METER INDICATION	<p>Arrow on plug-in element in wrong direction.</p> <p>No radio frequency power.</p> <p>No pickup from dc contact finger in line section.</p> <p>Open or shorted dc meter cable.</p> <p>Meter burned out or damaged.</p>	<p>Correct arrow direction.</p> <p>Check transmitter for faults.</p> <p>Adjust finger.</p> <p>Replace cable.</p> <p>Replace meter.</p>
INTERMITTENT OR INCONSISTENT METER READINGS	<p>Faulty load.</p> <p>Faulty transmission line.</p> <p>Dirty dc contacts on elements.</p> <p>Sticking or defective meter.</p>	<p>Correct fault in load.</p> <p>Correct fault in transmission line.</p> <p>Clean dc contacts.</p> <p>Replace meter.</p>
HIGH PERCENTAGE OF REFLECTED POWER	<p>Faulty load.</p> <p>Poor connectors.</p> <p>Shorted or open transmission line.</p> <p>Foreign material in line section.</p>	<p>Correct fault in load.</p> <p>Check for high resistance connections.</p> <p>Correct fault in transmission line.</p> <p>Clean line sections thoroughly.</p>

5-3 Meter Replacement

5-4 If it becomes necessary to replace the meter, the back cover must first be removed. The cover is removed by first unscrewing the four 8-32 phillips flat head screws that secure the cover. These screws are located two on each side of the meter housing near the back edge at the top and bottom of the sides. When these screws are removed the cover may be pulled straight off. Then follow the steps below.

a. On the back of the meter loosen two 8-32 nuts that secure the meter leads and remove the leads.

b. Remove the two 10-32 oval head phillips screws that secure the meter shock ring. These screws are located on each side of the meter housing just opposite the meter.

c. With the screws that secure the meter removed, the meter may be pulled out of the meter housing from the back. Now the meter retaining ring and shock mount may be removed.

d. Replace the meter by reversing the procedure above. Be sure to observe polarity when replacing the leads to the meter, black to negative etc.

5-6 Instrumentation Module

5-7 When removing the instrumentation module the back cover must be removed as above in meter removal. The instrumentation module contains the line section and circuit board chassis as an integral part and is removed as such by the steps following.

a. Using a .050" Allen wrench, loosen the set screw in the range switch knob by turning in a counterclockwise direction. Then pull the knob straight off.

b. Unsolder the leads from the connections on the top of the circuit board chassis. Take note of the color coding when

unsoldering so that they are connected to their original position when re-installing.

c. Remove the two oval head phillips screws located on the front face of the unit on either side of the line section element port. These are removed by twisting in a counterclockwise direction.

d. The instrumentation module may now be pulled straight out from the back of the unit.

e. Replace the instrumentation module by reversal of the above procedure. Be sure to reconnect the wire to their original position.

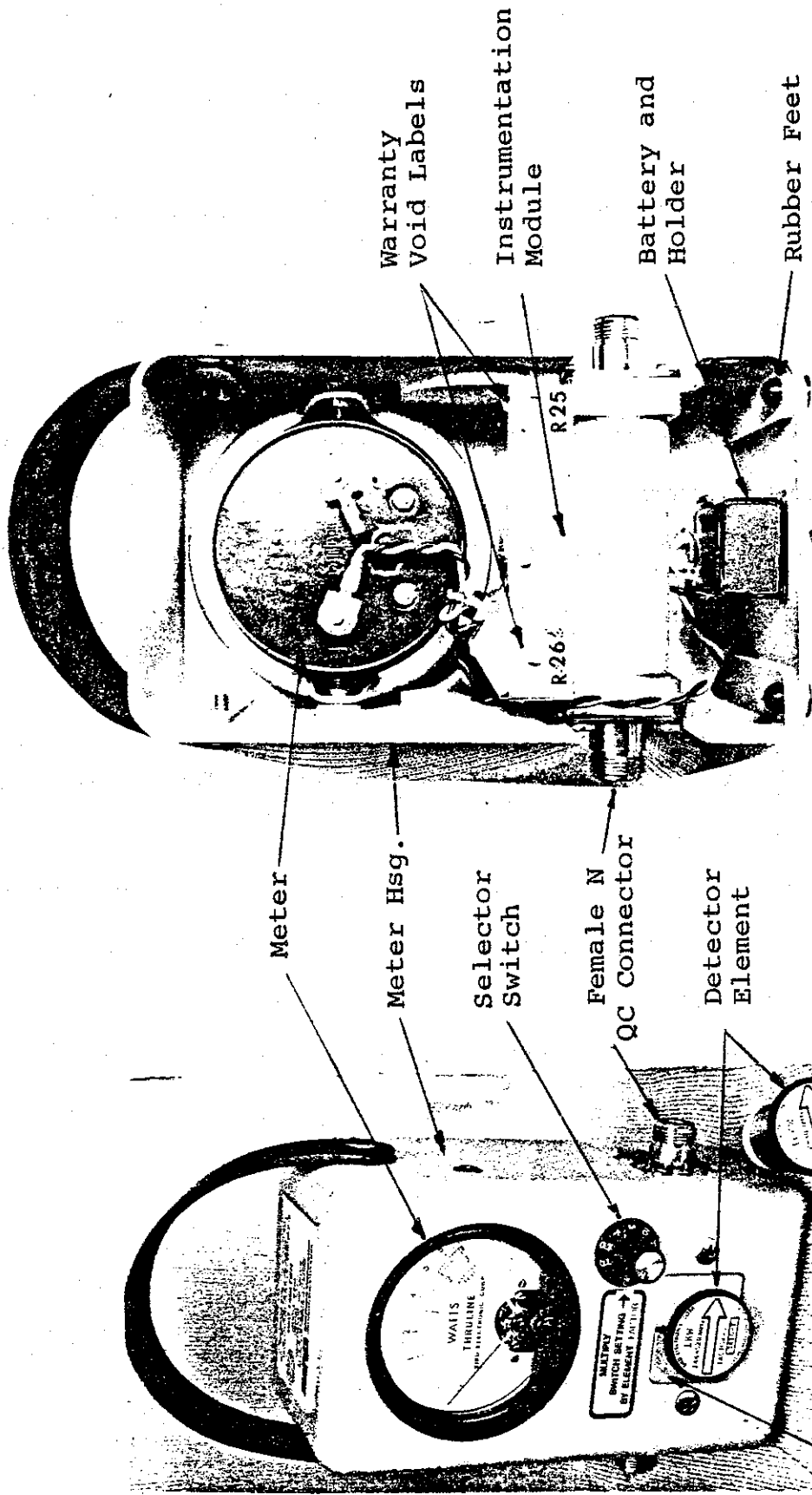
5-8 RF Connectors

5-9 To replace the RF connectors or change to another Bird "QC" type proceed as follows:

a. Remove the four 8-32 pan head screws in the corners of the connector flange by turning in a counterclockwise direction.

b. Carefully pull the connector straight off.

c. Replace the connector by reversing the procedure above. See Section VII for other available connectors.



Inside - Back Removed

Front View

RF Line Section
 Element Port

Figure 5-2 Model 4410 Thruline® Wattmeter
 General Front and Inside Views

Section VI Calibration and Test Procedures

6-1 Required Test Equipment

<u>Item</u>	<u>Qty.</u>	<u>Type Unit</u>	<u>Recommendation</u>
1	1	Sine wave generator	Hewlett Packard Model 239A
2	1	Precision Digital Multimeter	Data Precision Model 3500
3	1	Plug-in Calibration Device	Bird Electronic Model 4410-
4	1	BNC Adapter Tee	Kings Connectors (UG274 A/U)

6-2 General

6-3 This procedure provides a means for complete calibration of the model 4410 Thruline[®] meter assembly. The calibration of the 4410 type elements is covered by another document.

6-4 Equipment Notes

- a. The sine wave generator must be capable of producing 1000Hz \pm 100Hz sine wave of 1.591 volts RMS, 4.500 volts peak to peak, into a 600 ohm load. Total harmonic distortion must be less than 0.2%..
- b. The AC voltmeter must be able to measure the amplitude of the sine wave within \pm 0.1%.
- c. The Bird plug-in calibration device requires no calibration itself. However care should be taken to avoid damage to the unit due to rough handling or exposure to voltages greater than those specified.

6-5 Calibration Procedure

6-6 Connect the sine wave generator and the voltmeter to the BNC adapter "T" which is connected to the plug-in calibration device as

shown in Figure 6-1. Insert the plug-in into the model 4410 Thruline[®]. Complete the calibration by following the steps below.

a. After checking the battery condition of the unit by using the "BATT" position on the range switch, set the switch to the least sensitive range on the unit labeled "100".

b. Turn on the sine wave generator and the AC voltmeter and coarse adjust the output to 1.6 volts RMS at 1000Hz. Make sure that the sine wave generator's symmetry, offset and waveform controls are set to provide a symmetrical sine wave with zero DC offset.

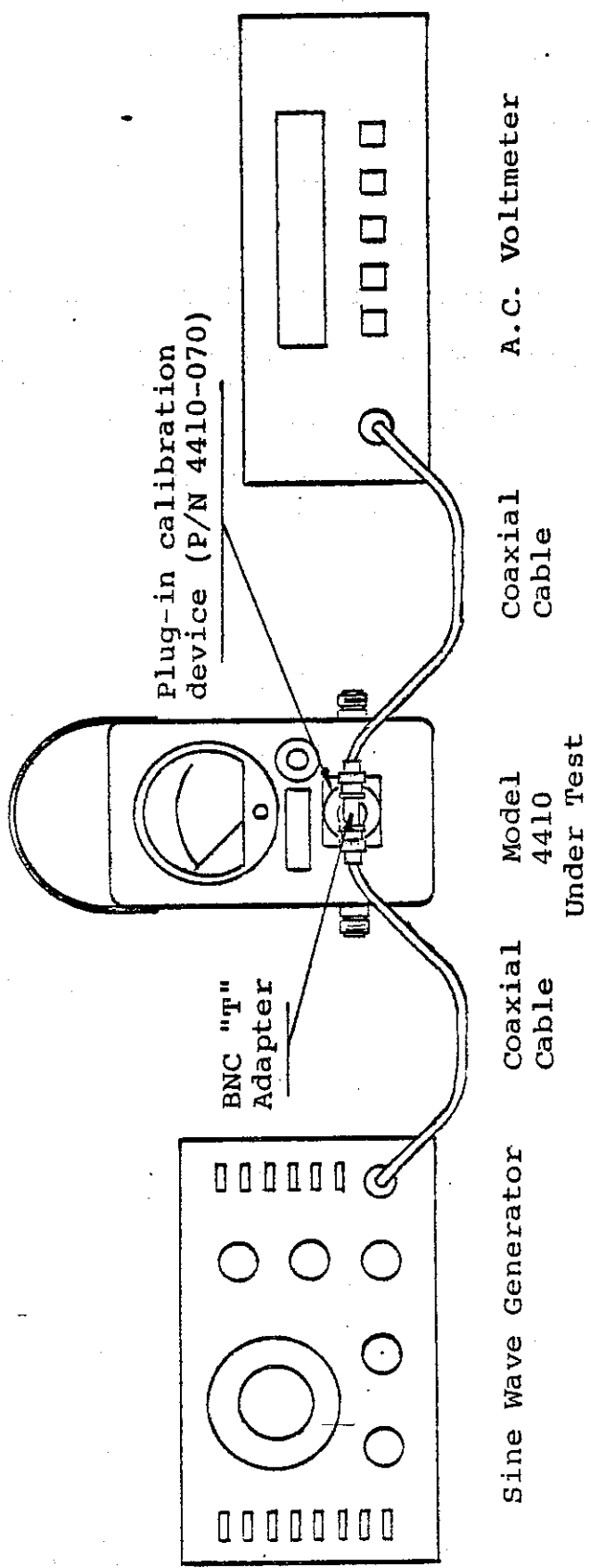
c. Leave the equipment in this condition to warm up for a period of time recommended by the manufacturers, but not less than five minutes. When more than one model 4410 is to be calibrated each one must be allowed to warm up for five minutes before zeroing.

d. After warm-up, turn the calibration device 90 degrees so as to short the contacts in the socket of the line section body, then adjust the offset potentiometer R25 until the meter pointer sweeps very slowly from right to left, i.e. full scale to zero, and comes to rest at zero on the scale. The pointer must move slowly enough that it would take approximately five seconds to sweep from full scale to zero. It may be necessary to rotate the plug-in back to the stop several times to perform this adjustment.

e. The location of R25 is shown in Figure 5-1. Two holes are provided in the shield box for access to this potentiometer. The adjustment tool is inserted through the hole in the back of the box while the hole in the top of the box allows visual alignment of the tool with the potentiometer.

f. Now rotate the plug-in calibration device back against the stop and carefully adjust the sine wave generator until the voltmeter reads exactly 1.591 volts RMS. The 4410 pointer should be at or near full scale. Adjust the trimmer potentiometer R26 until the meter reads exactly 1.0 on the top scale. The location of R26 is shown in Figure 5-1.

g. At this time disconnect the BNC adapter from the plug-in calibration device and verify that the meter pointer returns to zero. Then re-test the battery as a precaution to make certain it has not failed during the procedure



Plug-in calibration device (P/N 4410-070)

BNC "T" Adapter

A.C. Voltmeter

Coaxial Cable

Model 4410 Under Test

Sine Wave Generator

Figure 6-1 Model 4410 Thruline[®] Wattmeter Calibration Set-Up

Section VII

Parts List

Item	Qty. Req'd.	Description	Part Number
1	1	DC Meter	2080-052
2	1	Instrumentation Module (Includes line section and Instrumentation)	4410-021
3	1	Housing Assembly, Meter	4410-003
4	1	Cover, Meter Housing	4210-005-1
5	1	Knob, Selector Switch	4410-015
6	1	Strap, Carry (Included in 4410-003)	8580-003
7	1	Battery (Std. 9V Alkaline, Duracell or equivalent)	5-1375
8	1	Plug-in calibration device (Optional item)	4410-070
9	2	"QC" Connectors (F-N normally supplied)	See Below

Available QC Type Connectors

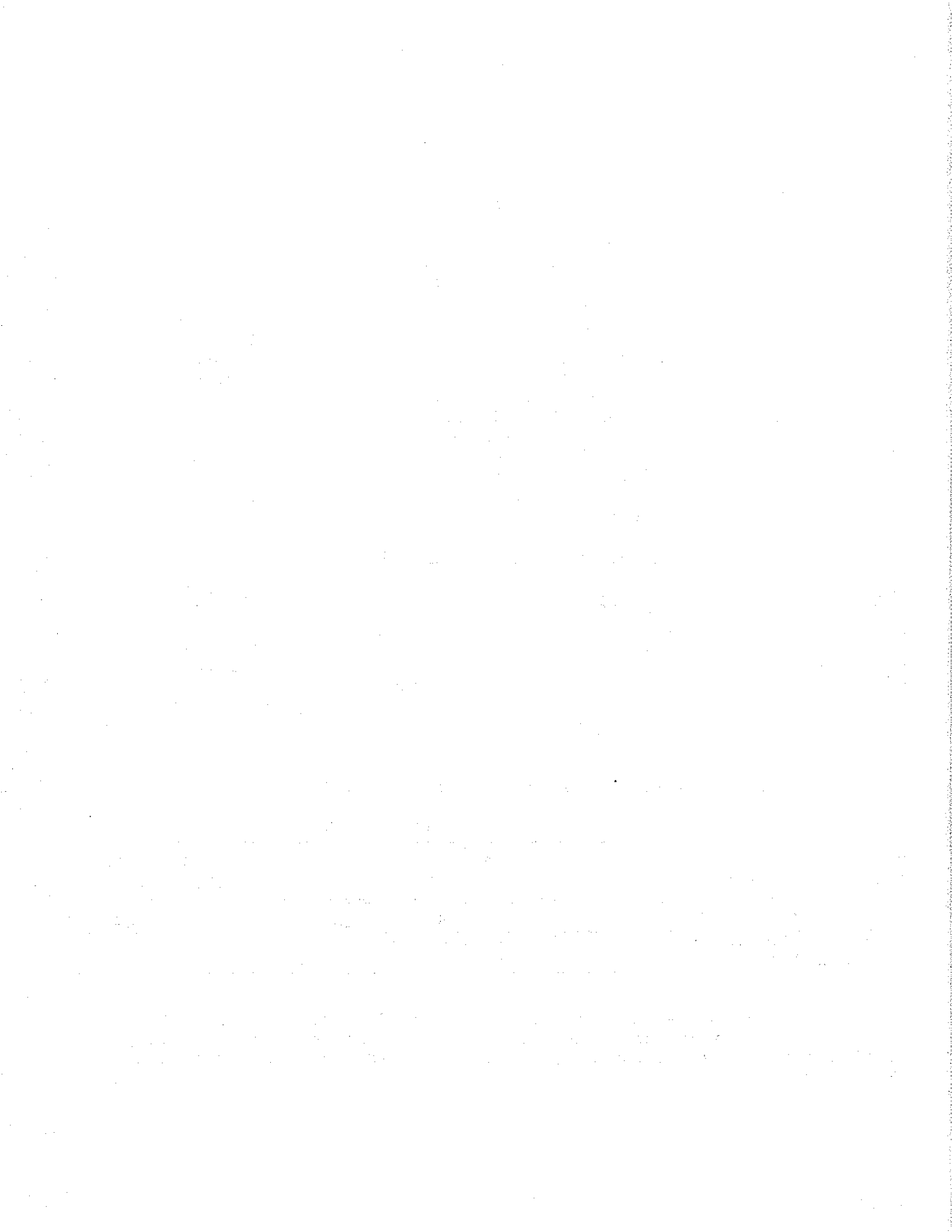
N-Female	4240-062	LT-Female	4240-018
N-Male	4240-063	LT-Male	4240-012
HN-Female	4240-268	C-Female	4240-100
HN-Male	4240-278	C-Male	4240-110
LC-Female	4240-031	UHF-Female	4240-050
LC-Male	4240-025	(SO-239)	
		UHF-Male (PL-259)	4240-179
		7/8" EIA Air Line	4240-002

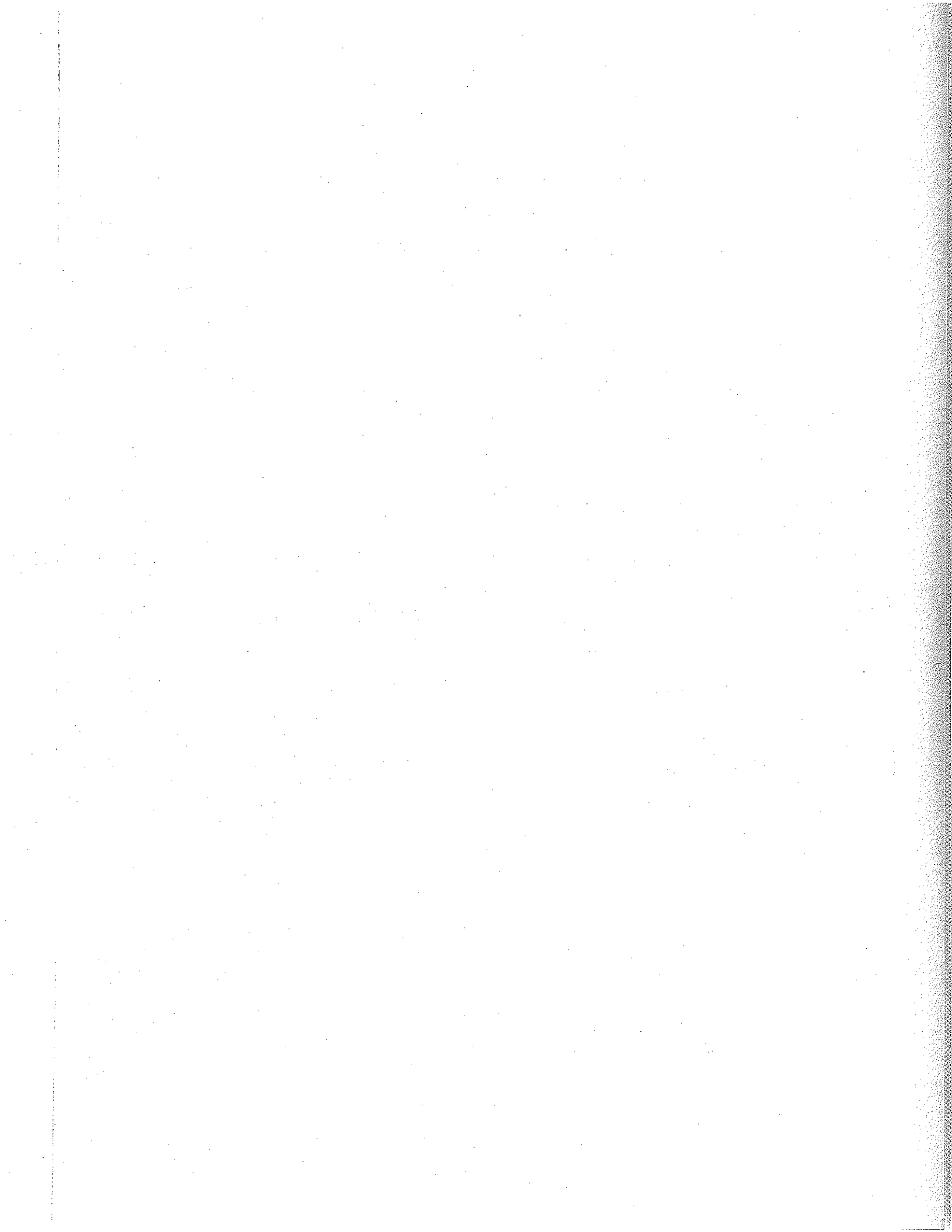
Bird 4410 Series plug-in elements (catalog numbers)

Frequency Ranges

Full-Scale Power Ranges (watts)	0.200-0.535	0.45-2.5	2-30	25-80	50-200	144-520	200-1000
1/3/10/30/100/300/1000			4410-3	4410-5	4410-6	4410-7	4410-8
10/30/100/300/1000/3000/10000	4410-1	4410-2	4410-4				

A high-quality leather carrying case, designed to protect your 4410 and up to seven elements during travel, is available as an accessory. It also stores a spare battery, and is supplied with a handy laminated VSWR chart.





**QUALITY INSTRUMENTS
FOR RF POWER MEASUREMENT**

**From 2 to 2300 MHz and from 25 milliwatts
to 250 kilowatts in 50-ohm coaxial line systems.**

TERMALINE

**ABSORPTION
WATTMETERS**

LOAD RESISTORS

CALORIMETERS

THRULINE

**DIRECTIONAL
MONITORING
WATTMETERS**

TENULINE

ATTENUATORS

COAXWITCH

**SELECTOR
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