INSTRUCTION BOOK

OPERATING INSTRUCTIONS

RF DIRECTIONAL THRULINE WATTMETER MODEL 4314B

Electronic Corporation
Cleveland (Solon) Ohio USA

Instruction Book Part Number 920-4314B Rev. C

Safety Precautions

The following are general safety precautions that are not necessarily related to any specific part or procedure and do not necessarily appear elsewhere in this publication.

Keep Away From Live Circuits

Operating personnel must at all times observe normal safety precautions. Do not replace components inside equipment with the high voltage supply turned on. To avoid casualties, always remove power.

Do Not Service Or Adjust Alone

Under no circumstances should any person reach into an enclosure for the purpose of service or adjustment of equipment except in the presence of someone who is capable of rendering aid.

Safety Earth Ground

An uninterruptible earth safety ground must be supplied from the main power source to test instruments. Grounding one conductor of a two conductor power cable is not sufficient protection. Serious injury or death can occur if this grounding is not properly supplied.

Shock Hazard

Do not attempt to remove a RF transmission line while power is present. Radiated RF power is a potential health hazard.

Resuscitation

Personnel working with or near high voltages should be familiar with modern methods of resuscitation.

Safety Symbols

WARNING
Warning notes call attention to a procedure, which if not correctly performed could result in personal injury.

CAUTION
Caution notes call attention to a procedure, which if not correctly performed could result in damage to the instrument.

This symbol appears on the equipment indicating there is important information in the instruction manual regarding that particular area.

☞ Note: Calls attention to supplemental information.

4314B Warning Statements

The following warnings appear in the text where there is danger to operating and maintenance personnel, and are repeated here for emphasis.

WARNING
Exposure to RF power radiation and the possibility of RF shock or burns exists with some operating conditions. Always be sure to turn off the transmitter when connecting or disconnecting a wattmeter. Be sure the transmission line is terminated into a load or antenna. When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

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

4314B Caution Statements

The following cautions appear in the text whenever a procedure, if not properly followed, could put the equipment in danger of damage and are repeated here for emphasis.

CAUTION
Do not drop the Thruline Wattmeter or its elements or subject them to hard blows. The microammeter is shock mounted in the wattmeter housing, but its delicate mechanism may be damaged by severe impact.

CAUTION
Severe damage to the Plug-In Element or wattmeter can result from exposure to excessive RF power. Make sure the Plug-In Element installed in the wattmeter has a sufficiently high wattage rating to handle the line load when it is first applied to the RF line.

CAUTION
Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage may result.

CAUTION
Do not apply RF power to the wattmeter in excess of the full scale range of the element.

CAUTION
When making low reflection readings using a more sensitive element, take care to insert the element so that it senses reflected power only. Do not rotate the element in the socket so that it is subjected to forward power. This can result in damage to the Plug-In Element, the microammeter, or both.

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 4314B Safety Statements

USAGE

ANY USE OF THIS INSTRUMENT IN A MANNER NOT SPECIFIED BY THE MANUFACTURER MAY IMPAIR THE INSTRUMENT'S SAFETY PROTECTION.

USO

EL USO DE ESTE INSTRUMENTO DE MANERA NO ESPECIFICADA POR EL FABRICANTE, PUEDE ANULAR LA PROTECCIÓN DE SEGURIDAD DEL INSTRUMENTO.

BENUTZUNG

WIRD DAS GERÄT AUF ANDERE WEISE VERWENDET ALS VOM HERSTELLER BESCHRIEBEN, KANN DIE GERÄTESICHERHEIT BEEINTRÄCHTIGT WERDEN.

UTILISATION

TOUTE UTILISATION DE CET INSTRUMENT QUI N'EST PAS EXPLICITEMENT PRÉVUE PAR LE FABRICANT PEUT ENDOMMAGER LE DISPOSITIF DE PROTECTION DE L'INSTRUMENT.

IMPRIEGO

QUALORA QUESTO STRUMENTO VENISSE UTILIZZATO IN MODO DIVERSO DA COME SPECIFICATO DAL PRODUTTORE LA PROZIONE DI SICUREZZA POTREBBE VENIRNE COMPROMESSA.

SERVICE

SERVICING INSTRUCTIONS ARE FOR USE BY SERVICE -TRAINED PERSONNEL ONLY. TO AVOID DANGEROUS ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS QUALIFIED TO DO SO.

SERVICIO

LAS INSTRUCCIONES DE SERVICIO SON PARA USO EXCLUSIVO DEL PERSONAL DE SERVICIO CAPACITADO. PARA EVITAR EL PELIGRO DE DESCARGAS ELÉCTRICAS, NO REALICE NINGÉN SERVICIO A MENOS QUE ESTÉ CAPACITADO PARA HACERIO.

WARTUNG

ANWEISUNGEN FÜR DIE WARTUNG DES GERÄTES GELTEN NUR FÜR GESCHULTES FACHPERSONAL.

ZUR VERMEIDUNG GEFÄHRLICHE, ELEKTRISCHE SCHOCKS, SID WARTUNGSARBEITEN AUSSCHLIEßLICH VON QUALIFIZIERTEM SERVICEPERSONAL DURCHZUFÜHREN.

ENTRENTIEN

L'EMPLOI DES INSTRUCTIONS D'ENTRETIEN DOIT ÊTRE RÉSERVÉ AU PERSONNEL FORMÉ AUX OPÉRATIONS D'ENTRETIEN. POUR PRÉVENIR UN CHOC ÉLECTRIQUE DANGEREUX, NE PAS EFFECTUER D'ENTRETIEN SI L'ON N'A PAS ÉTÉ QUALIFIÉ POUR CE FAIRE.

ASSISTENZA TECNICA

LE ISTRUZIONI RELATIVE ALL'ASSISTENZA SONO PREVISTE ESCLUSIVAMENTE PER IL PERSONALE OPPORTUNAMENTE ADDESTRATO. PER EVITARE PERICOLOSE SCOSSE ELETTRICHE NON EFFETTUARRE ALCUNA RIPARAZIONE A MENO CHE QUALIFICATI A FARLA.

RF VOLTAGE MAY BE PRESENT IN RF ELEMENT SOCKET - KEEP ELEMENT IN SOCKET DURING OPERATION.

DE LA TENSION H.F. PEAT ÊTRE PRÉSENTE DANS LA PRISE DE L'ÉLÉMENT H.F. -CONSERVER L'ÉLÉMENT DANS LA PRISE LORS DE L'EMPLOI.

HF-SPANNUNG KANN IN DER HF-ELEMENT-BUCHSE ANSTEHEN -ELEMENT WÄHREND DES BETRIEBS EINGESTÖPSELT LASSEN.

PUEDE HABER VOLTAJE RF EN EL ENCHUFE DEL ELEMENTO RF -MANTENGA EL ELEMENTO EN EL ENCHUFE DURANTE LA OPERACION.

IL PORTAELEMENTO RF PUÒ PRESENTARE VOLTAGGIO RF - TENERE L'ELEMENTO NELLA PRESA DURANTE IL FUNZIONAMENTO.

About This Manual

This instruction book guides the user through the operation and maintenance of the Bird Model 4314B RF Directional Thruline Wattmeter.

This instruction book is arranged so that the essential information about safety is in the front of the book. Reading the Safety Precautions section before operating the equipment is strongly advised.

The remainder of this manual is divided into chapters and sections. At the beginning of each chapter, a general overview describes the contents of that chapter.

Operation

First time users should read Chapter 1 - Introduction, Chapter 2 - Installation, and Chapter 3 - Theory of Operation, to get an overview of equipment capabilities. An experienced operator can refer to Chapter 4 - Operating Instructions. All instructions necessary to operate the equipment are in this chapter.

Maintenance

All personnel should be familiar with preventive maintenance found in Chapter 5 - Maintenance. If a failure should occur, the troubleshooting section will aid in isolating and repairing the failure.

Parts

For the location of major assemblies or parts, refer to the parts list in Chapter 5 - Maintenance.

Changes To This Manual

We have made every effort to ensure this manual is accurate. If you should discover any errors, or if you have suggestions for improving this manual, please send your comments to our factory. This manual may be periodically updated. When inquiring about updates to this manual refer to the part number and revision level on the title page.

Table of Contents

Chapter 1

Introduction

Purpose and Function

The Model 4314B Thruline Wattmeter is an insertion-type RF wattmeter designed to measure power flow and load match in 50 ohm coaxial transmission lines. It is intended for use on CW, AM, FM, SSB, TV, and pulse signals only.

Description

The Model 4314B Thruline Wattmeter is a portable unit contained in a die cast aluminum housing. The unit is equipped with a plastic 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 lie flat in a horizontal position when used. For additional protection, the microammeter is specially shock mounted. A slotted screw is provided on the lower front face of the meter for zeroing the pointer. The RF line section face below the meter protrudes slightly from the wattmeter housing with the Plug-In Element socket in the center. The circuit module is mounted on the line section inside the housing. It has an attached phosphor bronze spring contact finger, which protrudes through a lateral hole and into the Plug-In Element socket on the RF line section. The finger has a button on its end which makes connection with the contacts of the Plug-in Element. The silver-plated brass RF line section is precision made to provide the best possible impedance match to the coaxial RF transmission line in which the wattmeter is inserted. At each end of the line section are Bird Quick-Change type RF connectors, which may be quickly interchanged with any other Bird "QC" connectors.

Performance Characteristics and Capabilities

To make measurements, insert a Plug-In Element into the line section socket and rotate it to either stop. Point the element arow in the source to load direction of power flow and the meter will display a reading of forward power. Rotate the element so that the arrow is pointed in the opposite direction to obtain a reflected power reading. With known values of forward and reflected power the load match can now be determined by calculating the VSWR or by using the graphs supplied in this manual (pages 20-21).

Setting the front panel toggle switch to peak mode gives the wattmeter the capability of indicating peak pulse or envelope power.

Power Requirements

The Model 4314B can operate from two different power sources. The wattmeter comes supplied with two 9 V alkaline batteries which typically provide 20 hours of operation. AC adapters are also available for use with either a 115 or 230 Vac line.

Additional Equipment

The only additional equipment required by the Model 4314B is a Plug-In Element (see table below). Most of them are designed to read both average and peak power. Some are designed exclusively for peak reading application.

Standard Plug-In Elements

Use	Frequency (MHz)	Power Ranges (Watts)
Average of Peak	0.45-2.5	1000, 2.5 kW, 10 kW
	2-30	50, 100, 250, 500, 1000, 2500, 5000
	25-60, 50-125, 100-250, 200-500, 400-1000	5, 10, 25, 50, 100, 250, 500, 1000
	60-80, 80-95 95-125, 110-160, 150-250, 200-300, 275-450, 425-850, 800-950	1 Watt
	60-80, 80-95, 95-150, 150-250, 200-300, 250-450, 400-850, 800-950	2.5 Watts
	950-1260, 1100-1800, 1700-200, 2200-2300	1, 2.5, 5, 10, 25
Peak Only	25-60, 50-125, 100-250, 200-500, 400-1000	2.5 kW, 5 kW, 10 kW
	950-1260	50, 100, 250, 500, 2.5 kW, 5 kW

Specifications

Impedance	50 ohms nominal
Insertion VSWR With "N" Connectors	1.05 Max. to 1000 MHz, 1.1 Max. to 2300 MHz
Connectors	Bird Quick Change "QC" Female N normally supplied
RF Power Ranges Average (CW) Mode	100 mW to 10 kilowatts (± 5% of full scale)
Peak-pulse or envelope-power mode	100 mW to 10 kilowatts (± 8% of full scale)
Frequency Range	0.45 to 2300 MHz (either mode)
Pulse Parameters	
Minimum duty factor	1.0×10^{-4}
Minimum repetition rate	30 pps
Minimum pulse width	0.4 microseconds at 100-2300 MHz 1.5 microseconds at 26-99 MHz 15 microseconds at 2-25 MHz
Weight	3 lb. (1.4 kg)
Dimensions	3-5/8"L x 4"W x 7"H (92.1 x 102 x 178 mm)
AC Power requirements (using adapter)[1]	115 Vac. ± 10%, 60 Hz 220 Vac, ± 10%, 50Hz
Batteries	Two 9 V alkaline
Battery Life	20 hours of operation, typically

1 Use only adapter supplied by Bird Electronic Corporation

Chapter 2

Installation

Portability

The Model 4314B is a portable instrument; the housing is not designed for fixed mounting. A strap is provided for carrying purposes.

> CAUTION
> Do not drop the Thruline Wattmeter or its elements or subject them to hard blows. The microammeter is shock mounted in the wattmeter housing, but its delicate mechanism may be damaged by severe impact.

When transporting the Thruline Wattmeter, it is best to insert the original dust plug, or a Plug-In Element with the arrow pointed down, in the measuring socket, and secure it with the catch. This will shunt the meter circuit and serve to protect it by dampening the pointer action during handling or shipping. Also, set the wattmeter controls to ON and CW modes. In this position, any unnecessary battery drain will be avoided. Handle the Plug-In Elements with care at all times as their calibration could be disturbed if they are dropped.

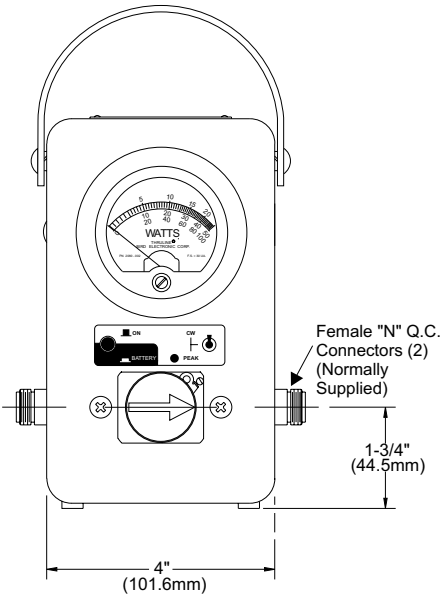
> WARNING
> Exposure to RF power radiation and the possibility of RF shock or burns exists with some operating conditions. Always be sure to turn off the transmitter when connecting or disconnecting a wattmeter. Be sure the transmission line is terminated into a load or antenna. When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

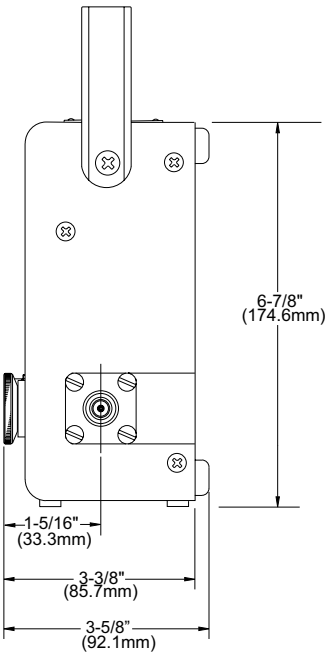
Connections

The Model 4314B Wattmeter is normally supplied with two Female N type connectors which are of the Bird Quick-Change "QC" design. Other "QC" connectors are available as listed in the Replacement Parts list at the back of this manual.

Quick-Change connectors can be replaced by removing the four 8-32 screws from each corner of the square flange of

Figure 1
Model 4314B
Outline
Drawing





the connector and then pulling it straight outward. Install the new connector by reversing this procedure.

Insert the Model 4314B Thruline Wattmeter in coaxial transmission lines of 50 ohms nominal impedance. The signal source and load connections can be made to either side of the wattmeter with no difference in effect. Use a coaxial transmission line fitted with suitable matching RF connectors. If cables of other than 50 ohms impedance are used, a mismatch will occur which could cause serious inaccuracies in the readings.

CAUTION

Severe damage to the Plug-In Element or wattmeter can result from exposure to excessive RF power. Make sure the Plug-In Element installed in the wattmeter has a sufficiently high wattage rating to handle the line load when it is first applied to the RF line.

Chapter 3

Theory of Operation

Traveling Wave Viewpoint

The operation of this wattmeter is based on the travelling wave concept of RF transmission. As RF power is applied to a transmission line, there is a forward wave travelling from the transmitter to the load, and a reflected wave travelling from the load to the transmitter. The closer the load is matched to the transmission line, the smaller the reflected wave will be. To determine the amount of power dissipated in a load resistor, it is necessary to determine the wattage of the forward wave and the wattage of the reflected wave. The difference between the two indicates load power.

VSWR (Voltage Standing Wave Ratio) has become a widely used tool in the travelling wave concept. The standing waves which are produced by transmission line mismatch cannot be read directly. However, the VSWR can be easily determined by the use of the VSWR Conversion Nemographs (figures 5-6, pages 20-21), without requiring the use of unwieldy and expensive slotted line equipment. Many users find that the ratio of $\frac{\textit{watts reflected}}{\textit{watts forward}}$ is more useful than VSWR.

Coupling Circuit

When the wattmeter is connected into the system, the RF power is directed through the unit's line section. The air line is a short, uniform section which does not impair the impedance of the RF coaxial line into which it is inserted. When the Plug-In Element is installed in the socket of the line section, the RF waves travelling through the line produce energy in the coupling circuit of the Plug-In Element by both inductance and capacitance (figure 2). The inductive currents will flow according to the direction of the travelling waves producing them. Therefore, assuming that the Plug-In Element remains stationary, the coupling currents produced from the waves of one direction add in phase, while those produced from the waves of the opposite direction subtract in phase. The additive or "arrow" direction is assigned to the forward wave. The element is designed so that the wave components travelling in the opposite direction of the arrow will nearly cancel each other out, making the element highly insensitive to the reverse wave direction. Because of the highly directional characteristics of the element, the resultant direct current

sensed by the microammeter indicates the power level of only the RF waves travelling in the arrow direction.

The Plug-In Element is designed so that it can be rotated 180 degrees in its socket in the line section. When it is rotated, the meter indicates the power in a direction opposite that of the initial reading. If the forward direction power is read first, the reflected direction power will be read after the Plug-In Element is rotated. The energy resulting from the inductively coupled component of the forward wave will bring about cancellation as described above.

Peak Power Operation

The Model 4314B is designed to measure peak power in addition to average power. When the toggle switch is placed in peak mode, battery power energizes the amplifier system. If the ac adapter is being used, it energizes relay (K1) and disengages the batteries (figure 3).

The battery test circuit is energized when the pushbutton of switch S2 is depressed. If the voltages of the two 9 V batteries are within the limits necessary to properly operate the amplifier circuit, the pointer of the meter deflects beyond the battery test mark on the meter scale. If the pointer fails to reach the mark, the batteries need replaced. Replacement of both batteries simultaneously will assure that sufficient battery power will be available for extended periods of time (see Chapter 5, Maintenance).

The amplifier circuit is designed to provide current to the meter which indicates at a steady state the peak of the power applied to resistor R5. Resistor R5 exactly matches the resistance of meter M so that the existing circuit in the Plug-In Element is loaded exactly the same as during the average reading mode (figure 2).

When switch S1 is pressed, the dc input which is normally applied to the meter is interrupted and is applied instead to resistor R5 and differential amplifier Q1. This results in a current gain ratio of approximately 100:1. This output is applied to a resistance bridge consisting of resistors R6, R7, R8, R9, and R10. Variable resistor R8 of this bridge permits zero calibration of the amplifier circuit. Bridge output is applied to differential amplifier U1 which provides a voltage gain of about 1000:1. This ratio represents the surge of voltage from the amplifier which charges capacitor C3 and indicates the minimum pulse duration. Capacitor C3 applies a potential to differential amplifiers Q2 and Q3 as long as the capacitor remains

charged. These amplifiers provide a massive current gain ratio, but unity or slightly less voltage gain. This is applied to meter M to indicate the peak power in the line. A portion of the dc output of amplifiers Q2 and Q3 is fed back to resistor R4 and to amplifier Q1. Resistor R4 is matched to resistor R5 to provide unity gain to the amplifier. This feedback circuit maintains the output from Q1 and U1 to keep capacitor C3 charged to that value which yields unity closed loop gain.

The capacitor continues to energize Q2 and Q3, to maintain the reading of the meter even though the peak of the pulse is no longer applied to the amplifier assembly input. Only the peak power is indicated even though there is a wide fluctuation of input power.

Because of capacitor leakage, diode back resistance, and transistor input current, there will be a decay in the circuit that limits the time the amplifier system will retain its output level. As the circuit decays, the meter will return to zero if no additional pulses are received at resistor R5.

Figure 2 Schematic Diagram - Element

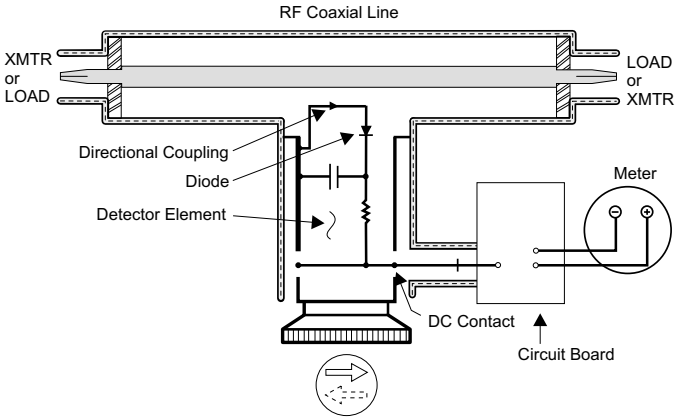
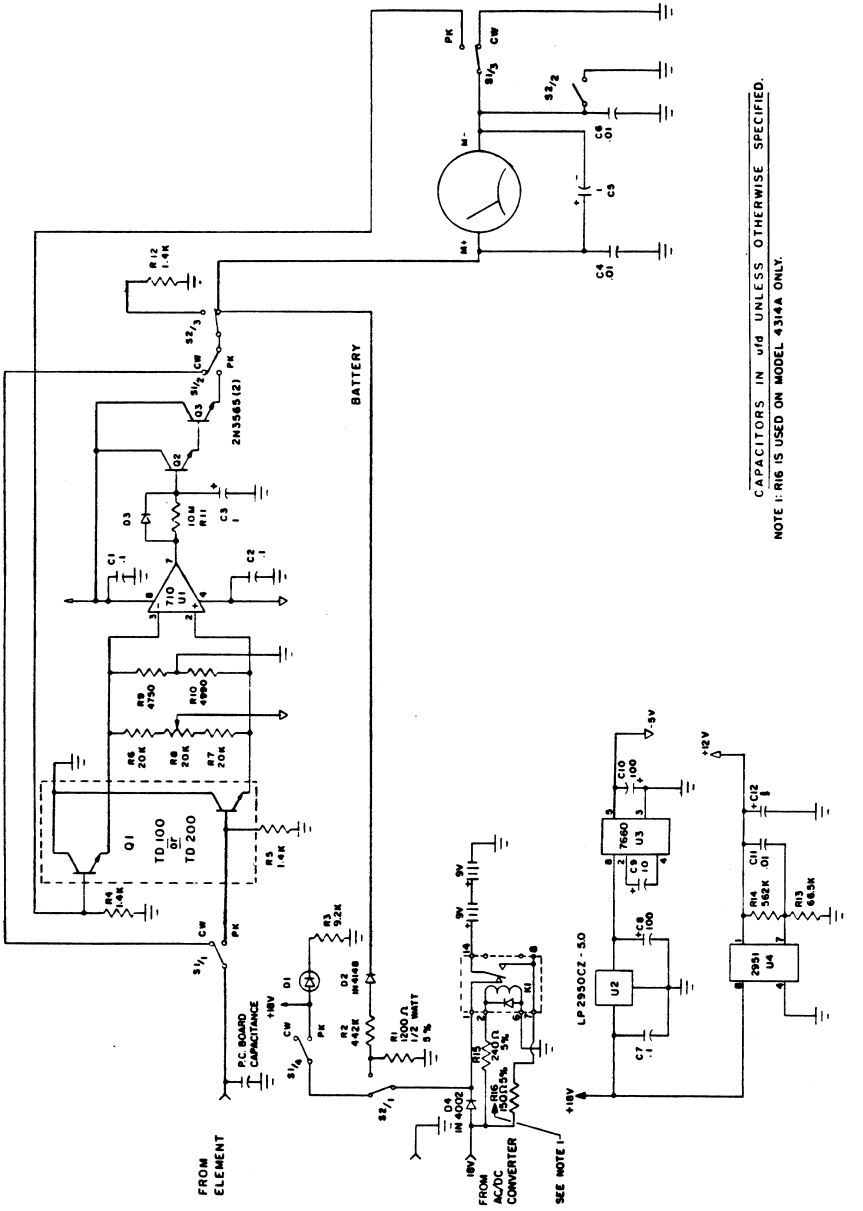


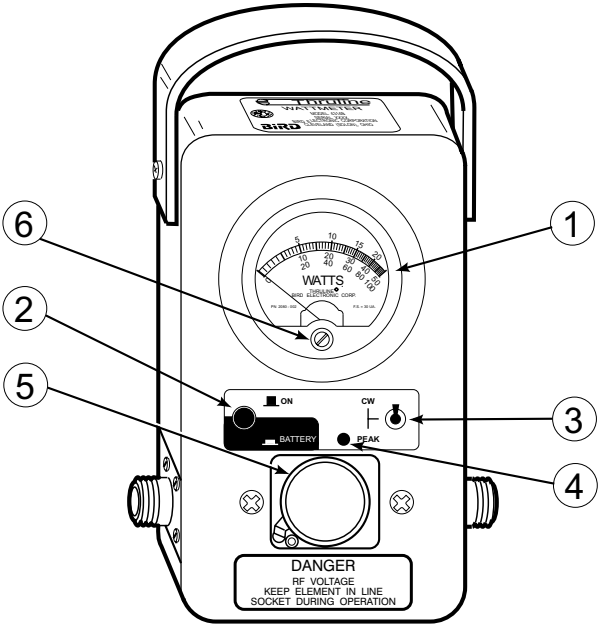
Figure 3
Model 4314B Schematic Diagram

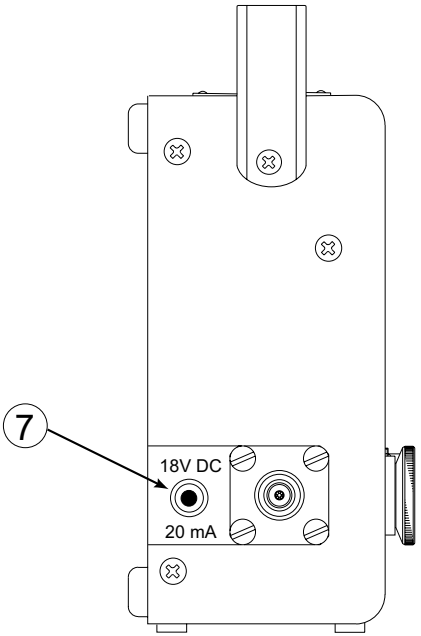


Component Description

Item	Feature	Description
1	Meter	Indicates in watts the transmission line power flow sensed by a Plug-In Element. Contains three scales which correspond to the full scale ratings of various Plug-In Elements.
2	ON/BATTERY Switch	When the switch is in the ON mode, CW or peak power will be indicated on the meter. With switch in BATTERY mode, the current state of the battery will be indicated on the meter.
3	CW/PEAK Switch	When switch is in the CW mode, average power will be indicated on the meter. With switch in the PEAK mode, peak pulse or peak envelope power is indicated on meter.
4	Peak LED	Indicates wattmeter is in PEAK mode and power is supplied to the peak sensing circuitry.
5	Plug-In Element	Determines whether forward or reflected power is being sensed. When arrow points to load, the instrument senses forward power. When arrow points to transmitter, the instrument senses reflected power.
6	Meter Zero Adjust	Provides a zero adjustment for the meter.
7	DC Jack	Input connector for supplying power to peak sensing circuit when the wattmeter is used in conjunction with ac adapter.

Figure 4
Component
Diagram





Chapter 4

Operating Instructions

Zero Adjust Meter

Before taking any readings with the wattmeter, it is necessary to zero the meter under no-power conditions.

Rotate Plug-In Element so that the arrow points down.

Set wattmeter's controls to ON and CW modes.

Using a small screwdriver, turn the meter's zero adjust screw clockwise or counterclockwise so that the meter pointer aligns with the zero mark on the meter scale.

> WARNING
> Exposure to RF power radiation and the possibility of RF shock or burns exists with some operating conditions. Always be sure to turn off the transmitter when connecting or disconnecting a wattmeter. Be sure the transmission line is terminated into a load or antenna. When a Plug-In Element is removed from the RF line socket, the line section center conductor is exposed. Do not put fingers or other objects into the Plug-In Element socket while RF power is applied.

> CAUTION
> Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage may result.

> CAUTION
> Do not apply RF power to the wattmeter in excess of the full scale range of the element.

Plug-In Element Selection and Insertion

The elements determine the power range to be read on the meter scale. The major markings (50 W, 100 W, etc.) are the full scale power value for that element. Elements are also marked for frequency range. The transmitter frequency must be within the band of the element used.

RF power measurements are made with the insertion of a Plug-In Element. Insert the element into the line section's receptacle. Forward power is indicated when the arrow on the element points in the direction of power flow; from

transmitter to load. Reflected power measurements are made with the element rotated 180° and the arrow pointing towards the transmitter. The element must be rotated fully when power measurements are being made. The index pin protruding from the element's body should rest against the stop on the line section in both the forward and reflected position. The small catch in the lower left hand corner of the casting face should press down on the shoulder of the Plug-In Element. This will keep the Plug-In Element in proper alignment and insure good contact with the dc pickup, the lower edge of the element and the line section body.

CW Power Measurements

Set the wattmeter controls to the ON and CW modes, and read the appropriate meter scale corresponding to the element full-scale value.

Peak Power Measurements

Set the ON/BATTERY switch to the BATTERY mode. If the pointer of the meter indicates below the battery test zone, the batteries must be replaced. (see chapter 5, Maintenance) Return ON/BATTERY switch to the ON position. Set CW/PEAK switch to PEAK mode, and read the appropriate meter scale corresponding to the element full-scale value.

Load power

Where an appreciable amount of power is reflected, as with an antenna, it is necessary to subtract the reflected from the forward power to obtain the effective load power. Power delivered to and radiated by an antenna is given by:

$$W_l = W_f - W_r$$

Where: W_l = load power

W_f = forward power

W_r = reflected power

A load closely matched to 50 ohms resulting in a VSWR of 1.2 or less, will require less than a one percent correction. A good RF load resistor, such as a Bird Termaline Load Resistor, will produce this sort of negligible or unreadable reflected power.

The Model 4314B Thruline Wattmeter used with a Bird Termaline Load Resistor of proper power rating forms a highly useful absorption wattmeter. Since the reflected power will be negligible, it will be unnecessary to rotate the element from the forward direction.

Determining VSWR

The Model 4314B Thruline Wattmeter is not designed to provide direct VSWR readings. In most cases, operators find that the ratio of forward to reflected power is of equal use. However, VSWR readings can be determined very easily by the use of the provided graphs as follows:

Determine the forward and reflected power as described above.

Using the appropriate VSWR Conversion Nomograph (pages 20-21), determine the intersection of the forward and reflected power values. The slanted line passing closest to this point indicates the VSWR.

Figure 5
VSWR Conversion Nomograph

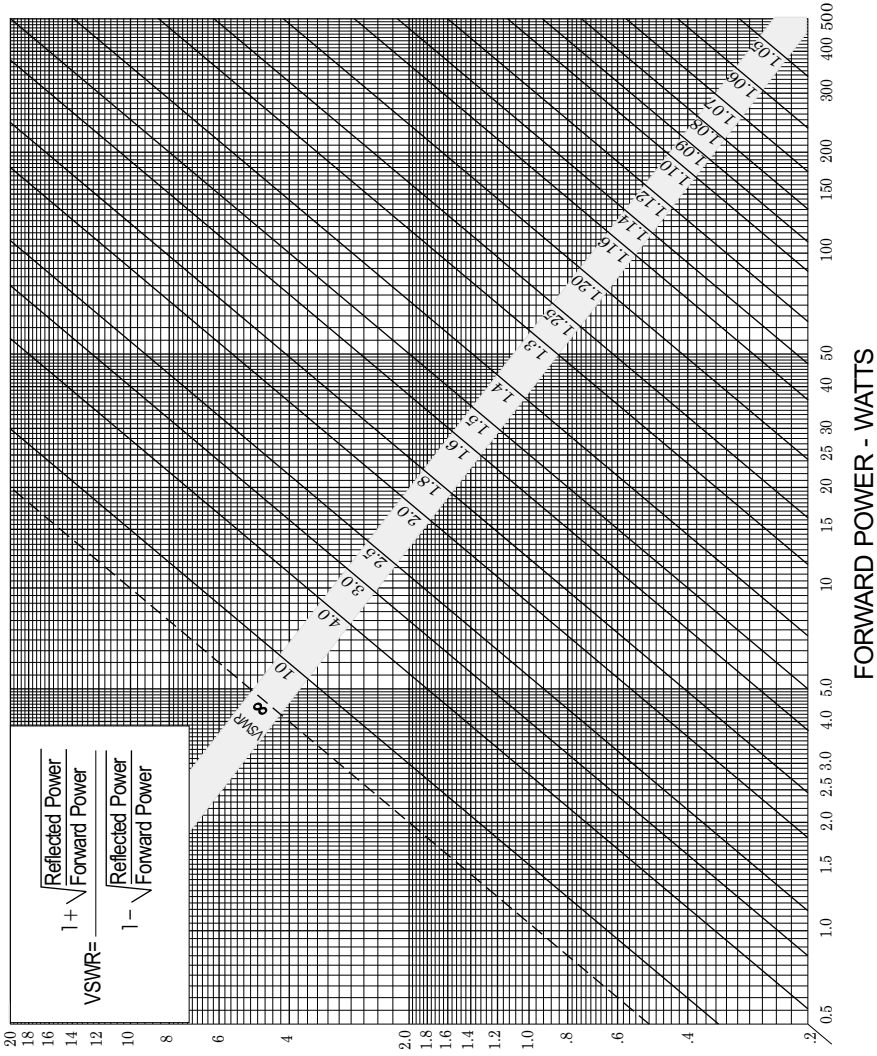
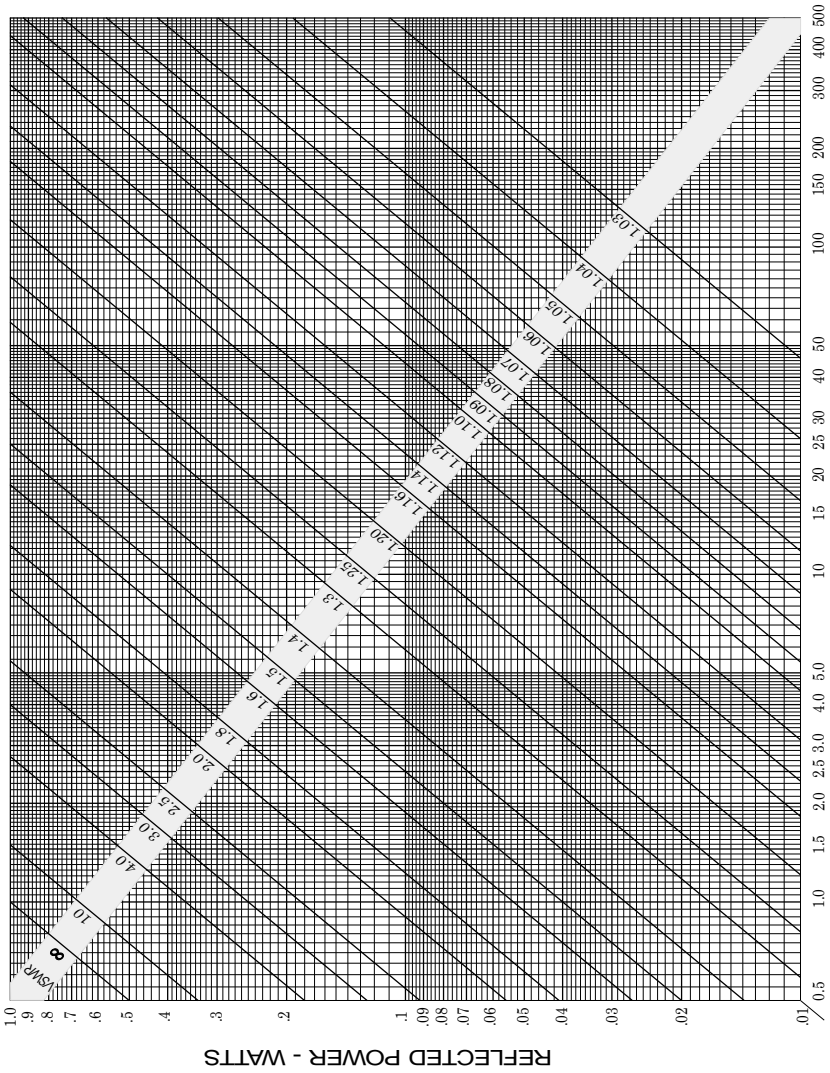


Figure 6
VSWR Conversion Nemograph



Making Low Reflection Readings

It is sometimes desirable to make more accurate low reflection readings. This can be done using a more sensitive element, provided that care is taken to prevent application of high forward power to the low-power element. This procedure is limited to use with higher power transmitters only.

Measure watts forward, using the proper Plug-In Element. Reverse the arrow direction of the element to determine the general level of reflected power.

Remove the Plug-In Element and insert a lower power element which has a maximum rating of more than the reflected power indicated in the first measurement. Carefully insert the element so that it reads reflected power only.

> CAUTION
> When making low reflection readings using a more sensitive element, take care to insert the element so that it senses reflected power only. Do not rotate the element in the socket so that it is subjected to forward power. This can result in damage to the Plug-In Element, the microammeter, or both.

Read the reflected power on the meter in the usual manner.

When using the two-element method of reading low reflected power, we do not recommend using a pair of elements which has a full scale power differential of greater than 10 to 1.

Testing Lines, Connectors, Filters and Related Components

Lines, connectors, filters, and related components can be tested using the Thruline Wattmeter. The method of testing depends upon the circumstances involved for any particular test. Some of these tests are listed below:

The standing wave ratio or the reflected-power to forward-power ratio of a line can be determined by terminating the line with a good load resistor, such as a Bird Termaline Load Resistor. Proceed as described under determining VSWR. Low reflected power may be measured as described above.

Line attenuation (power lost as heat in the line) can be determined by inserting the line of unknown value between two Thruline Wattmeters. The end of the line must

be terminated by a load resistor. The attenuation of the line can be determined by comparing readings made at the two ends. Allowances must be made for normal instrument error where very small values of attenuation are involved. Some correction may be made by direct rigid connection of the Thruline Wattmeters.

Attenuation By Open Or Short Circuit

Attenuation can also be determined by the open circuit method. The test set exhibits good equality between forward and reflected readings when the load connector is open or short circuited. When this is checked on an open circuit and an open-circuited length of line of unknown attenuation is connected to the load connector, the ratio shown is the attenuation in two passes along the line (down and back). To convert the reading to decibels, divide it in half or double the line length because twice the line length is being measured (down and back). This measurement must be supplemented with a reflected power to forward power ratio check or with a dc continuity check or leakage check, since open circuits or shorts may exist part of the way along the line.

Attenuation can also be determined as described above by using a short circuit rather than an open circuit. The open circuit method is preferred because the initial equality (forward power to reflected power) is more easily achieved in an open circuit.

Measuring Percentage Of Positive Modulation

To measure the percentage of positive modulation in an amplitude modulation system, employ the average and peak reading characteristics of the unit since:

$$\text{Percentage pos. mod.} = \frac{E_{MAX} - E_{CARRIER}}{E_{CARRIER}} \times 100$$

By substitution we get:

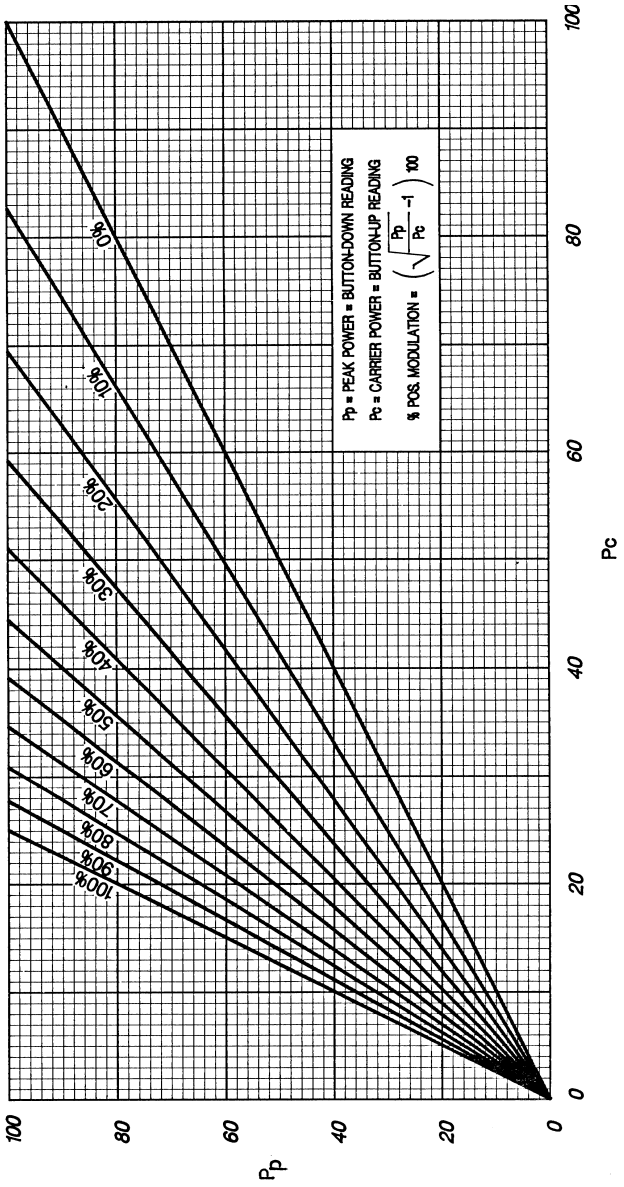
$$\text{Percentage pos. mod.} = \left(\frac{\sqrt{P_P} - \sqrt{P_C}}{\sqrt{P_C}} \right) \times 100$$

Where: P_P = peak power as read with CW/PEAK switch in PEAK mode.
P_C = carrier power as read with CW/PEAK switch in CW mode

Or:

$$\text{Percentage pos. mod.} = \left(\frac{\sqrt{P_P}}{\sqrt{P_C}} - \frac{\sqrt{P_C}}{\sqrt{P_C}} \right) \times 100$$

Figure 7
Graph Converting Carrier Power and Peak Power to Percent



And by cancellation:

$$\text{Percentage pos. mod.} = \left(\frac{\sqrt{P_P}}{\sqrt{P_C}} - 1\right) \times 100$$

After determining average and peak readings, find the intersection of the carrier and peak powers on figure 7 to determine the percentage of positive modulation.

Performance Notes

Although the Model 4314B Thruline Wattmeter is equipped with Quick-Change connectors, it must be remembered that the power rating and insertion loss may be affected if other than "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 Chapter 5 for the replacement parts list.

When a Model 4314B is used to match a load to a transmitter and a good match is obtained, removing the instrument will not cause any change in the conditions. A well matched 50 ohm load can be placed at the end of a 50 ohm transmission line of any length without altering conditions at the transmitter.

When the load is not well matched, like an antenna with a VSWR of 1.5 or 2.0, line length becomes critical since the length of line between a mismatched load and the source transforms the impedance of the load as seen at the source. If the adjustments for maximum power transfer were made with the Model 4314B in place, removing it shortens the line by four inches plus two connectors. This still is no cause for concern at low frequencies where four to five inches is a small fraction of a wavelength. At higher frequencies; e.g., above 100 MHz, the power output and frequency of the source may be affected.

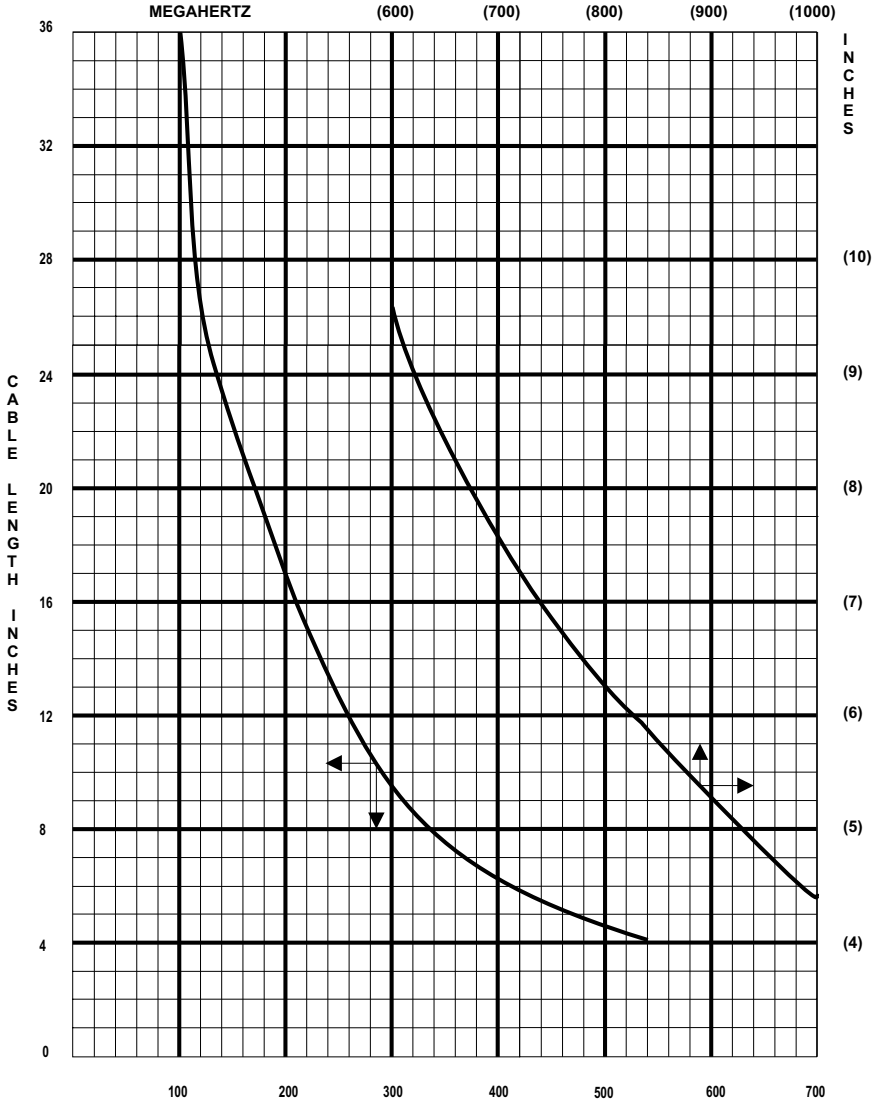
To insure that the impedance is identical on either side of ½ wavelength in your transmission line with the Model 4314B either in or out of the line, it is only necessary to insert or remove a ½ wavelength.

Make up a length of cable which, when added to the Thruline Wattmeter, equals ½ wavelength at the frequency of measurement. If more than one frequency is involved, then a separate cable is needed for each frequency. Use figure 8 to determine the cable length required.

☞ Note: When using UHF Plug PL-259, the cable length is measured from tip to tip of center pin of plugs.

☞ When using other connectors, the cable length is measured from the ends of the outer conductor of the connectors.

Figure 8
Cable Wavelength Matching Graph



Shutdown

When all measurements are completed, be sure to set the CW/Peak switch to CW mode and the ON/BATTERY switch to the ON position. Leaving the unit in other switch positions will shorten battery life.

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

Chapter 5

Maintenance

Cleaning

If any of the contacts or line connectors become dirty, they should be cleaned with a good contact cleaner or dry cleaning solvent on a cotton swab stick.

It is important to keep the following surfaces clean:

- Socket bore
- Element body circumference
- Bottom rim of the socket in the line section
- DC contacts on the element

Take care not to disturb the spring finger of the DC contact when cleaning the socket bore. The spring finger can be manually adjusted. The button must be pushed out far enough to make good contact with the element body but it must not restrict the entry of the element.

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

> CAUTION
> Use reasonable care in handling. Do not drop or subject the wattmeter or elements to hard blows as accuracy may be impaired or other damage could result.

Preventative Maintenance

Care and maintenance required for the 4314B Thruline Wattmeter is primarily limited to cleaning. Keeping the Plug-In Element in the socket of the line section as much as possible serves as an effective seal against the entry of dust and dirt and to prevent damage to the meter. An aluminum dust plug may be used to cover the socket opening when the element is removed.

Line Section Care

The RF connectors on the line section should also be protected against the entry of dust and dirt by keeping them

covered when the wattmeter is disconnected from the RF line.

If there is evidence of contamination inside the line section, the reachable portions should be cleaned and the interior carefully blown out. Do not attempt to remove the RF center conductor under any circumstances. Any attempt to do so will damage the assembly

Inspection

Periodic inspections should be performed at six-month intervals.

Inspect the meter for a cracked meter glass.

Inspect wattmeter line section for a damaged or missing latch and pivot pin assembly.

Inspect all "QC" connectors for bent, broken, or missing pins.

Trouble-shooting

Due to its complexity, field repair of the Model 4314B Thruline Wattmeter is recommended only for certain malfunctions. Only those functions within the scope of normal maintenance are listed.

The following guide contains troubleshooting information for problems which can occur during normal operation. Locate the problem, review the possible cause and perform the corrective action listed.

If a malfunction is not listed or not corrected by the listed corrective actions, notify a qualified service center for further instructions.

Troubleshooting Guide

Problem	Possible Cause	Remedy
No meter indication (CW or PEAK)	No radio frequency	Turn on transmitter.
		Check transmitter operational conditions, refer to operating instruction manual of equipment used.
		Check connections, interconnecting cables, and auxiliary in-line equipment.
	Arrow on element pointing in wrong direction	Rotate element so that arrow points in direction of RF power flow.
	Meter burned out or damaged	Replace meter. (page 34)
	No pick-up from dc contact	Clean line section and element. (page 25)
	Defective Plug-In Element	Check element. Replace element if defective.
No meter indication (PEAK only)	Faulty instrumentation module	Check module. If faulty, replace instrumentation. (page 36)
	Dead or low battery	Depress ON/BATTERY selector switch to the BATTERY position. If the battery test indicates weak batteries, replace them with new ones. (page 33)
		If pointer does not move from zero during the battery test, remove the batteries and measure their voltage. If less than 6.25 volts, replace the batteries. (page 33)

Erroneous or inaccurate	Low battery	Depress ON/BATTERY selector switch to the BATTERY position. If the battery test indicates weak batteries, replace them with new ones. (page 33)
	Shorted or opened cable	Check connections, in-line equipment, interconnecting cables, and auxiliary in-line equipment.
	Wattmeter out of calibration	Check calibration. (page 36)
Intermittent or inconsistent	Faulty transmission line, line connections, antenna, or load conditions	Inspect and correct meter operation or load.
	Dirty line section, dc contact, and/or element	Clean line section and element. (page 27)
	Sticky meter	Replace meter. (page 34)
High VSWR or high percentage reflected power	Bad load or poor load, antenna, or connectors	Replace connectors. (page 36)
	Shorted or open transmission line	Replace transmission line.
	Foreign material in line section or in RF connector bodies	Check for foreign material and clean as required. (page 27)

Battery Test

The Model 4314B Thruline Wattmeter uses two 9 V alkaline batteries to supply power for the peak circuitry. To test these batteries, set the ON/BATTERY switch to the BATTERY position. The meter pointer should travel to the right of the "BAT.TEST" mark. If the pointer stops below the mark, replace the batteries.

Battery Replacement

Remove the back cover by unscrewing the four 8-32 Phillips flat head screws located two on each side of the meter housing near the back edge at the top and bottom of the sides. Pull the cover straight off.

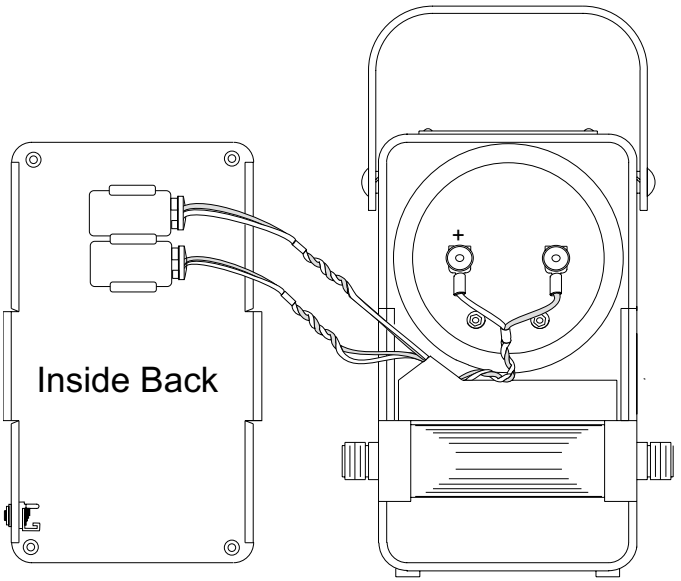
Rotate the battery in its clip, then pull upward freeing the battery.

Remove the snap-on battery connector.

Insert the battery into the clip and replace.

Repeat above procedure for the other battery.

Figure 9 Battery Replacement



Meter Replacement

Remove the back cover by first unscrewing the four 8-32 Phillips flat head screws located two on each side of the meter housing near the back edge at the top and bottom of the sides. Pull the cover straight off.

Loosen the two 8-32 nuts on the back of the meter that secure the meter leads and remove the leads.

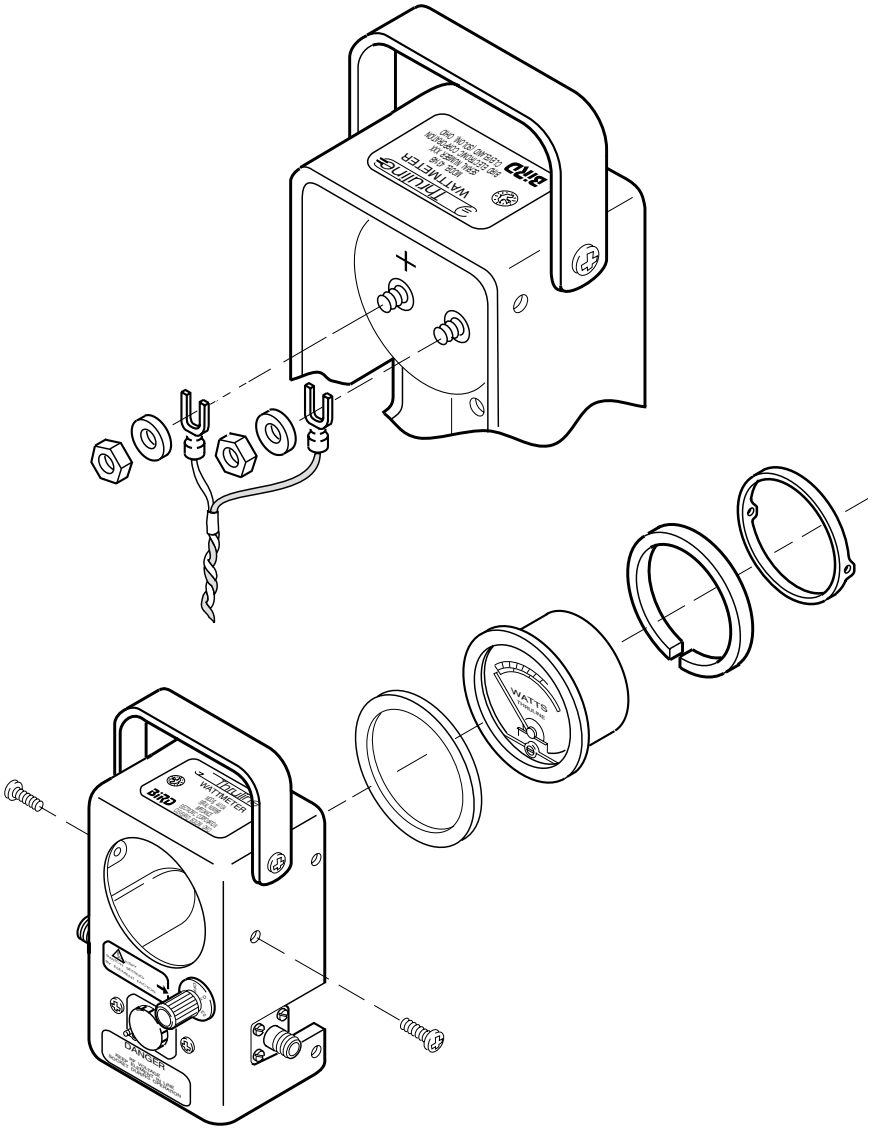
Remove the two 10-32 oval head Phillips screws that secure the meter shock ring located on each side of the meter housing just opposite the meter.

Pull the meter and shock ring assembly out of the housing from the back. If the three rubber shock mount buttons, P/N 4420-098, that the meter rests on are to be reused, be careful not to lose them. However, if the replacement shock ring, P/N 4410A261, is to be used instead, the buttons may be discarded. Remove the meter retaining ring and shock mount from the meter.

Replace the meter. If the replacement shock ring is used, peel off the white strip covering the adhesive backing. Carefully adhere the shock ring to the front bezel flange. Be sure to observe the polarity when replacing the leads to the meter, black to negative, red to positive.

Zero adjust the meter.

Figure 10
Meter Replacement



Instrumentation Module Replacement

Remove the back as above in meter replacement. The instrumentation module contains the line section and circuit board chassis as an integral part.

Using a 7/16 wrench, loosen the dress nut on the CW/PEAK switch. Care should be taken not to scratch the label.

Remove the wire assemblies from the batteries, meter, and dc jack. Remove the battery wires (item 4) first at the printed circuit board by pulling up on the slip-on connector. Next remove the dc jack wires (item 5). Remove the meter wires (item 3) also at the printed circuit board. Care should be taken not to break the wires. Note the wire location for ease of reassembly.

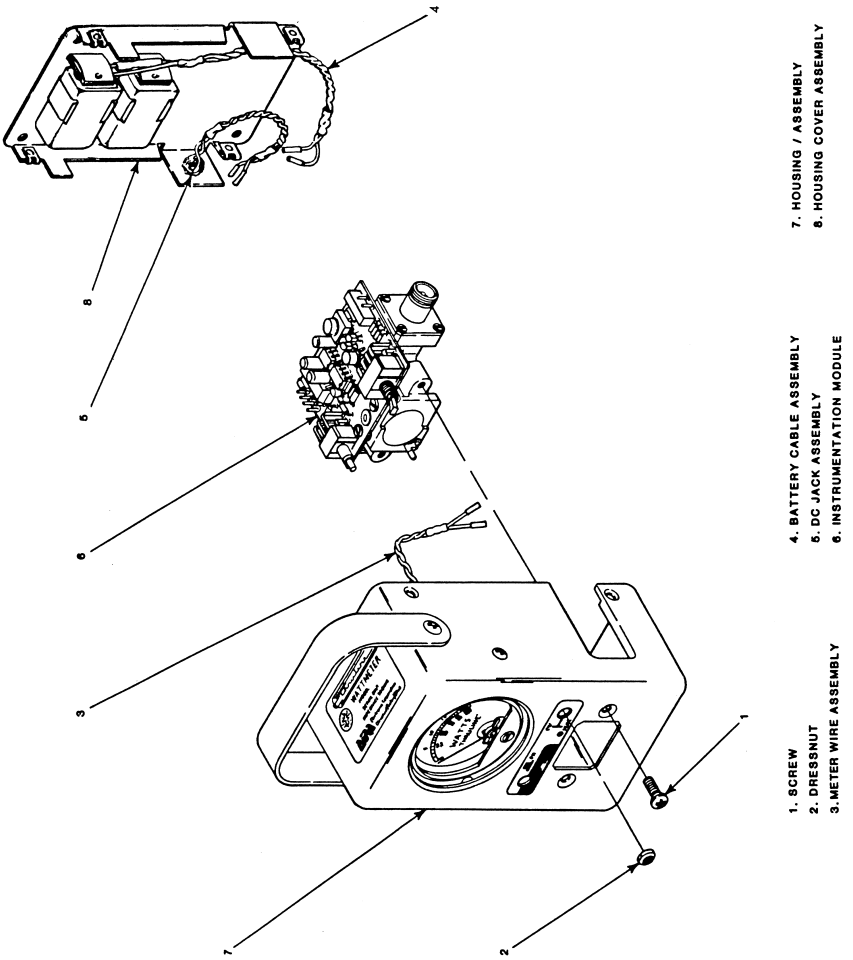
Remove the two oval head Phillips screws located on the front face of the unit on either side of the line section element port.

Pull the instrumentation module straight out from the back of the unit.

Replace the connector.

Zero adjust the meter.

Figure 11
Instrumentation Module Replacement



> 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.

RF Connector Replacement

Remove the four 8-32 pan head screws from the corners of the connector flange.

Carefully pull the connector straight off.

Replace the connector.

Calibration

Zero adjustment of the meter is the only calibration required for the 4314B. This should be done any time the meter pointer is not exactly aligned with the zero mark on the meter scale when no power is being applied. Zero adjustment must also be performed after the meter or instrumentation module has been replaced.

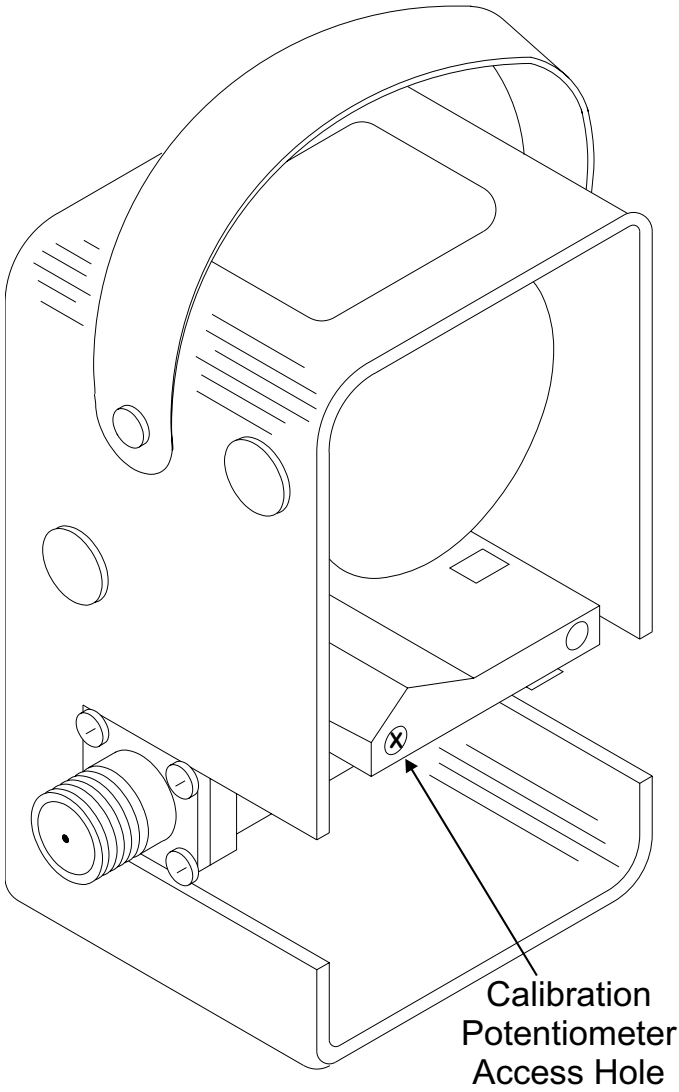
To assure that the meter reads correctly for both average and peak operation, apply direct current from a battery source to the input of the amplifier circuit (figures 5 and 6, pages 20-21). The steady direct-current peak level should be the same as the average current level because no peaks exist in this current. Apply a direct current and adjust as necessary so that the same reading is attained in both average and peak modes.

Install a voltage-dropping variable voltage dividing potentiometer and a battery in series with the input of the amplifier. Make sure the resistor is set for zero output. Connect the positive (+) side of the circuit to input and the negative (-) side to ground. Install a voltmeter across the circuit. Slowly operate the potentiometer to adjust output to apply approximately 21 millivolts. Use a suitable resistive network.

Check the reading of the meter. The pointer should deviate or travel about half of full scale. Set the CW/PEAK switch to PEAK mode while watching the meter pointer. There should be no deviation of the pointer from average to peak reading.

If the pointer reads a different value for peak reading than for average reading, adjust potentiometer R8 until the two readings coincide.

Figure 12 Calibration Potentiometer



Customer Service

Bird Electronic Corporation maintains a complete repair and calibration department at our corporate headquarters. This department is set up to provide our customers with the best possible service of Bird equipment.

All instruments returned for service must be shipped prepaid and to the attention of the Customer Service Group.

Bird Electronic Corporation
30303 Aurora Rd
Cleveland (Solon), OH 44139-2794
Phone: (440) 248-1200
Fax: (440) 248-5426

Replacement Parts

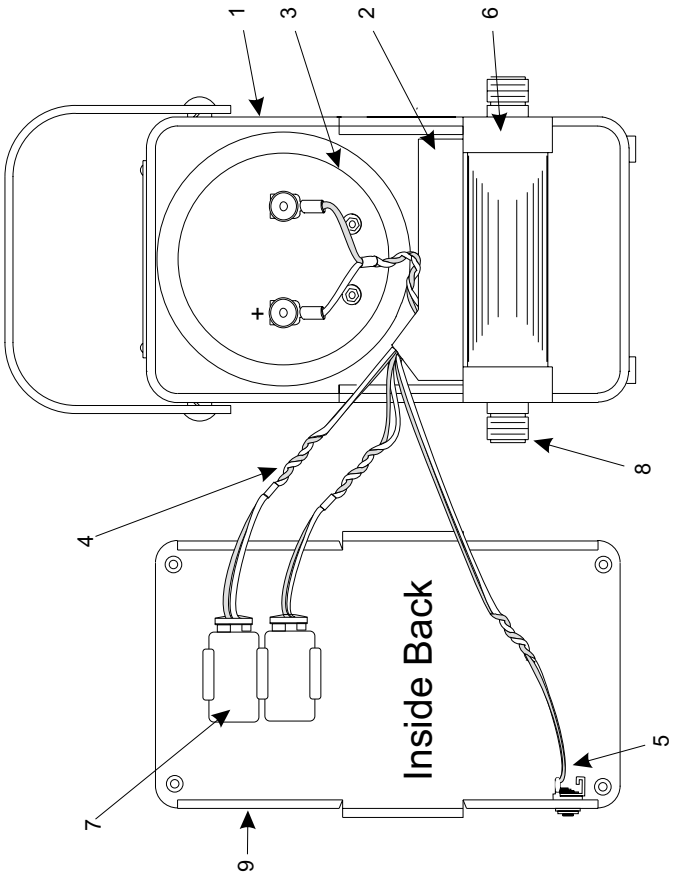
Item	Quantity	Description	Part Number
1	1	Housing assembly	4314-103
2	1	Instrumentation module	4314-202
3	1	Meter	2080-044
4	1	Battery cable assembly	4314-116
5	1	DC jack wire assembly	4314-117
6	1	Meter wire assembly	4314-119
7	2	9 V battery	5-1375
8	2	"QC" connectors	(Female N normally supplied)*
9	1	Housing cover assembly	4314-114
10	1	Dress nut	5-1670
11	1	AC to dc converter 115 Vac 230 Vac	 5-1864 5-1940

*Available QC Type Connectors

N-Female	4240-062	BNC-Male	4240-132
N-Male	4240-063	LT-Female	4240-018
HN-Female	4240-268	LT-Male	4240-012
HN-Male	4240-278	C-Female	4240-100
LC-Female	4240-031	C-Male	4240-110
LC-Male	4240-025	UHF-Female (SO-239)	4240-050
BNC-Female	4240-125	UHF-Male (PL-259)	4240-179
7/8" EIA Air Line	4240-002		

Items 10 and 11 not shown in figure 13.

Figure 13
Replacement Parts



Limited Warranty

All products manufactured by Seller are warranted to be free from defects in material and workmanship for a period of one (1) year, unless otherwise specified, from date of shipment and to conform to applicable specifications, drawings, blueprints and/or samples. Seller's sole obligation under these warranties shall be to issue credit, repair or replace any item or part thereof which is proved to be other than as warranted; no allowance shall be made for any labor charges of Buyer for replacement of parts, adjustment or repairs, or any other work, unless such charges are authorized in advance by Seller.

If Seller's products are claimed to be defective in material or workmanship or not to conform to specifications, drawings, blueprints and/or samples, Seller shall, upon prompt notice thereof, either examine the products where they are located or issue shipping instructions for return to Seller (transportation-charges prepaid by Buyer). In the event any of our products are proved to be other than as warranted, transportation costs (cheapest way) to and from Seller's plant, will be borne by Seller and reimbursement or credit will be made for amounts so expended by Buyer. Every such claim for breach of these warranties shall be deemed to be waived by Buyer unless made in writing within ten (10) days from the date of discovery of the defect.

The above warranties shall not extend to any products or parts thereof which have been subjected to any misuse or neglect, damaged by accident, rendered defective by reason of improper installation or by the performance of repairs or alterations outside of our plant, and shall not apply to any goods or parts thereof furnished by Buyer or acquired from others at Buyer's request and/or to Buyer's specifications. In addition, Seller's warranties do not extend to the failure of tubes, transistors, fuses and batteries, or to other equipment and parts manufactured by others except to the extent of the original manufacturer's warranty to Seller.

The obligations under the foregoing warranties are limited to the precise terms thereof. These warranties provide exclusive remedies, expressly in lieu of all other remedies including claims for special or consequential damages. SELLER NEITHER MAKES NOR ASSUMES ANY OTHER WARRANTY WHATSOEVER, WHETHER EXPRESS, STATUTORY, OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS, AND NO PERSON IS AUTHORIZED TO ASSUME FOR SELLER ANY OBLIGATION OR LIABILITY NOT STRICTLY IN ACCORDANCE WITH THE FOREGOING.

DECLARATION OF CONFORMITY

Manufacturer: Bird Electronic Corporation
30303 Aurora Road
Cleveland, Ohio 44139-2794

Product: Thruline Wattmeter
Models: 4314B

The undersigned hereby declares, on behalf of Bird Electronic Corporation of Cleveland, Ohio, that the above-referenced product, to which this declaration relates, is in conformity with the provisions of the following standards;

- EN 55011:1991 - Emissions: (Class B)
- IEC 801-2:1984, Part 3 - EMF Immunity
- IEC 801-4:1988, Part 4 - Fast Transient/Burst Immunity

These standards are in accordance with EMC Directive (89/336/EEC).

- European Standard EN 61010-1:1993 - Part 1:General Requirements

This standard is in accordance with Low Voltage Directive (73/23/EEC), 1973

The technical documentation file required by this directive is maintained at the corporate headquarters of Bird Electronic Corporation, 30303 Aurora Road, Cleveland, Ohio 44139

Bob Gardiner
Director of Quality
Bird Electronic Corporation