Thruline™ Wattmeter
Model 4700A series

Operation Manual

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Instruction Book Part Number 920-4700AS Rev. B

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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. These precautions must be thoroughly understood and apply to all phases of operation and maintenance.

WARNING
Keep Away From Live Circuits
Operating Personnel must at all times observe general safety precautions. Do not replace components or make adjustments to the inside of the test equipment with the high voltage supply turned on. To avoid casualties, always remove power.

WARNING
Shock Hazard
Do not attempt to remove the RF transmission line while RF power is present.

WARNING
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.

WARNING
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.

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

WARNING
Remove Power
Observe general safety precautions. Do not open the instrument with the power on.

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.

Note: *Calls attention to supplemental information.*

Warning Statements

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

WARNING
Never attempt to disconnect the transmission line while RF power is being applied. Leaking RF energy is a potential health hazard.

See page 12.

Caution Statements

The following equipment cautions appear in the text and are repeated here for emphasis.

CAUTION
The Thruline wattmeter, elements, and line section have been calibrated together. Replacing any component without recalibrating all the components as a unit may affect accuracy.

See pages 5 and 11.

CAUTION
Do not attempt to remove the RF center conductor. It is tightly frozen in place and any attempt to remove it will ruin the assembly.

See page 15.

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.

IMPIEGO

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 NINGÚN 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, SIND 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 manual covers the operating and maintenance instructions for the following models:

4712A	4715-200A	4715-300A
4720A	4712-037A	4723-200A

Changes to this Manual

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

Literature Contents

Introduction — Describes the features of the Wattmeter, lists equipment supplied, and optional equipment.

Theory of Operation — Describes how the Wattmeter functions.

Installation — Describes how set up the Wattmeter.

Operating Instructions — Describes procedures required for operating the Wattmeter.

Maintenance — Lists routine maintenance tasks as well as troubleshooting for common problems. Specifications and parts information are also included.

Table of Contents

Chapter 1 Introduction

This publication refers to the Thruline Wattmeter Series 4700A. The differences between models are listed in the specifications. All models will generally be referred to as a Wattmeter throughout this manual.

The information in this instruction book pertains to all models except noted differences referred to in the text.

Purpose and Function

The Bird Thruline Wattmeters are directional RF wattmeters designed to detect and measure power flow in either direction in 1-5/8 inch, 50 ohm, coaxial transmission lines. Therefore, they are useful for load matching in standard coaxial lines. Power levels are indicated on a direct reading meter in accordance with the elements selected by the user.

Performance Characteristics and Capabilities

Elements are available for measuring power levels up to 25 kW (6 kW for Models 4712-037A and 4715-300A) full scale in stated frequency bands from 2 to 1000 MHz (50 to 250 MHz for Models 4712-037A and 4715-300A). Other wattmeter systems of 8 kW for frequencies from 100 to 250 MHz can be formulated on special order. The maximum measurement error is ± 5 percent of the power rating of the element. The insertion VSWR (voltage standing wave ratio) will not exceed 1.05 to 1 over the stated frequency band.

Dimensions and Weight

The flanged sections of Models 4712A, 4715-200A, 4712-037A, and 4715-300A are 6-3/4 inch (171.5 mm) from flange face to flange face. The barrel of the line section is 1-5/8 inch (41.3 mm), and the flange fittings are 3-1/2 inch (89 mm). The weight of the single socket line section is 3 lb (1.4 kg), and the double socket is 3-1/4 lb (1.5 kg). The unflanged line sections are 6-3/8 inch (162 mm) end to end, and the barrel is 1-5/8 inch (41.3 mm). The single socket line section weighs 1-1/4 lb (0.6 kg) and the double socket weighs 1-1/2 lb (0.7 kg). The meter and housings are 3-11/64 inch L x 5-9/16 inch W x 6-1/2 inch H (80.6 x 141 x 165 mm) and weigh approximately 3 lb (1.36 kg). Add 2 lb (0.9 kg) for the overall shipping weight.

Power And Utility Requirements

Because Thruline Wattmeters are passive and self-contained devices, they do not require any utility service or outside power, other than the RF input power, for operation.

Environmental Requirements

Thruline Wattmeters should be used in a dust and vibration-free environment. Measurements should be made at 25°C ± 5°C (77°F ± 9°F) for maximum measurement accuracy.

Items Supplied

Series 4700A Thruline Wattmeters consist of:

- Line Section
- Detector Element
- Meter in a Housing
- Connecting Cables

The line section is a short length of matching 1-5/8 inch coaxial transmission line. For Models 4712-000A, 4712-037A, and 4715-300A the line section has flanges that are fixed on one end and swivel type on the other. Models 4720A and 4723-200A are unflanged line sections.

The meter is scaled in 5, 10, and 25 kW ranges for Models 4712A, 4715-200A, 4720A, and 4723-200A. Models 4712-037A and 4715-300A are scaled in 15, 30, and 60 kW ranges. Other wattmeter combinations include scales of 8 and 80 kW ranges.

A standard ten foot (approx. three meter) cable is supplied with each wattmeter and is equipped with a DC connector plug on one end and lugs on the other. Alternate lengths are available on request. This instruction book is the only other item supplied. Wattmeters with two separate element sockets (one for Forward and one for Reflected power measurement) are equipped with a dual DC input meter case and two shielded cables. The switch mounted on the meter face selects the desired reading.

Items Required But Not Supplied

The coaxial transmission line must be equipped with 1-5/8 inch flanged or unflanged connectors to match the line section. Additional elements must be ordered for the desired frequency bands and power levels, contact the factory for more information.

Tools And Test Equipment Required

End wrenches or an adjustable wrench for the flange bolts are the only tools required for the Series 4700A Wattmeters.

Figure 1 Outline Drawings of Line Sections

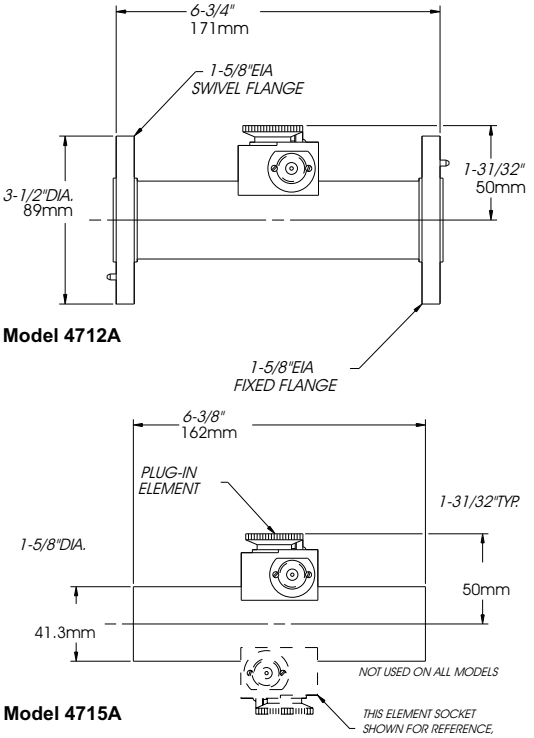
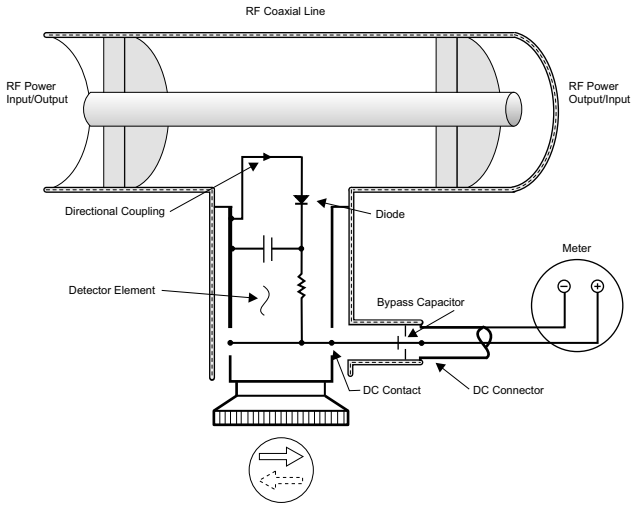


Figure 2 Schematic Diagram - Element



Element

The function of the element is to detect (sense) the forward or reflected RF power in the line section at any given time. The direction in which the “arrow” on the element cap is oriented indicates the direction in which it is sensing the RF power flow in the system.

Traveling Wave Viewpoint

The best way to visualize the Thruline Wattmeter idea is from the Traveling Wave viewpoint on transmission lines. This viewpoint illustrates that the voltages, currents, standing waves, etc., on any uniform line section are the resultants of two traveling waves, forward and reflected.

Coupling Circuit

The coupling circuit which samples the traveling waves is in the Plug-In Element (Figure 2 on page 3). Energy will be produced in the coupling circuit of the element by both mutual inductance and capacitance from the traveling RF waves of the line section. Of course, the inductive currents will flow according to the direction of the traveling waves producing them.

The capacitive portion of these currents is naturally independent of the direction of the traveling waves. Therefore, it is apparent that the inductive portion of the current produced from the waves of one direction will add in phase to the capacitive portion of the current, and those of the opposite direction will subtract in phase. The additive direction is the forward or “arrow” direction of the element.

The forward wave travels and its power flows from the source to the load. It has an RF voltage E_f and current I_f in phase, with $E_f / I_f = Z_o$.

The reflected wave originates by reflection at the load, travels and its power flows from the load back to the source. It has an RF voltage E_r and current I_r in phase, with $E_r / I_r = Z_o$.

Each component wave is mathematically simple and is completely described by a single figure for power, for instance:

$$W_f = WattsForward = E_f^2 / Z_o = I_f^2 Z_o = E_f I_f$$

$$W_r = WattsReflected = E_r^2 / Z_o = I_r^2 Z_o = E_r I_r$$

Z_o is the characteristic impedance of the uniform line, and simplifies matters by being a pure resistance, usually 50 ohms for useful lines. The main RF line circuit of the Thruline Wattmeter is a short piece of uniform air line section, whose Z_o is 50 ohms, in which accurate measurements may be made.

The electrical values of the element circuits are carefully balanced and so designed that the inductive current produced from the reverse direction wave will cancel its portion of the capacitive current almost completely. The result is a directivity always higher than 25 dB, which means that the element is highly insensitive (nulled) to the reverse direction wave. By being highly directional, the Thruline Wattmeter is sensitive at either one of its settings, but to only one of the two traveling waves which produce standing waves by interference. Thruline Wattmeter measurements are also independent of their position along the standing waves. The circuitry of the element and its relationship to the other components of the wattmeter are illustrated in Figure 2 on page 3.

Element Socket

An accurately positioned socket for inserting a radio frequency coupling device, called a Thruline Plug-In Element, is mounted on the outer conductor. The line sections for 4715-200A, 4723-200A, and 4715-300A have two such sockets. The socket is precision bored to hold the rotatable element in its calibrated position, with a spring-loaded clasp to keep the element firmly seated. The machined step on the top face of the socket engages a stop-pin on the element. Rotary movement of the element is thereby restricted to 180 degrees and is stopped on the axial center line.

The measuring socket has a hole bored through the wall through which an insulated phosphor bronze contact finger projects. The Plug-In Element has terminals on diametrically opposite sides of its body, so that pickup can be made from either side. A small silvered button tip can contact the element only in the precise forward and reflected measuring positions, against the end stops. A specially designed jack mounted on the side of the socket mates with the plug on the DC cable furnished with the read-out meter. The DC jack assembly has a built-in filter capacitor shunted across the meter circuit. This more fully protects meter readings against the adverse effects of any stray RF energy generated in the Plug-In Element. The line section is bright silver plated over practically all of its metal parts.

Matching

CAUTION

The Thruline wattmeter, elements, and line section have been calibrated together. Replacing any component without recalibrating all the components as a unit may affect accuracy.

The scale on the read-out meter reads full scale for the power rating stamped on the cap of the Plug-In Element. The Thruline Wattmeter, the Plug-In Element, and the Thruline Section are all stamped with matching serial numbers. The equipment is supplied as a matched and calibrated set and the parts, particularly the elements, should not be interchanged with any other like equipment. Such an interchange of the measuring elements could produce readings with an error greater than the stated 5 percent of full scale accuracy.

Load Power

Power delivered to and dissipated in a load is given by:

$$W_L = LoadInWatts = W_f - W_r$$

Where appreciable power is reflected, as with an antenna, it is necessary to subtract the reflected power from the forward power to get the effective power. This correction is negligible, less than 1 percent, if the loading device has a VSWR of 1.2 to 1 or less.

VSWR scales, and their attendant controls for setting the reference point, have been intentionally omitted from the Thruline Wattmeter for two reasons.

1. Why make something similar to a hypothetical DC volt ohmmeter with control potentiometers for the voltmeter multipliers? Even more complications arise when diodes at RF are involved.
2. Experience using the Thruline Wattmeter on operating problems, such as transmitter tune-up, antenna matching etc., shows that the power ratio of ϕ is no mean competitor, in practical usefulness, to the standing wave ratio ρ = VSWR.

A trial is suggested for a few days - forget VSWR and try thinking in terms of $\phi = W_r / W_f$ when the Thruline Wattmeter is used. It will be noted that even without bothering to calculate the ratio exactly the two meter readings, W_r and W_f, give an automatic mental impression which pictures the situation. Thus, in an antenna matching problem the main objective usually is to minimize W_r, and anything done experimentally to this end is noted directly when the Thruline Element is turned to the reflected position. Furthermore, the ratio of readings, even if only mentally evaluated, is a reliable guide to the significance of the remaining reflected power.

ρ vs. ϕ and its Significance

Since there are definite simple relationships between standing wave ratio ρ and the reflected/forward power ratio ϕ indicated by the Thruline Wattmeter, the latter may be conveniently used to measure VSWR.

$$\rho = \frac{1 + \sqrt{\phi}}{1 - \sqrt{\phi}}$$

and

$$\phi = \left[\frac{\rho - 1}{\rho + 1}\right]^2$$

where

$$\rho = VSWR$$

and

$$\varphi = \frac{W_r}{W_f}$$

Note that around ϕ = 10 percent, below which W_r will appear insignificant and may be hard to read, you are close to the commonly accepted lower limit ρ = 2. Trying to adjust to an even lower value of ϕ, in order to improve antenna match still further, becomes less and less worthwhile in many systems. Experimentally by using the Thruline Wattmeter it can be readily shown that reducing ϕ below 10 percent produces little in the way of increased W_L. TV transmitter antenna lines and VHF omni-range transmitters are among those systems that require much lower levels of reflected power but for reasons other than simple power transmission. A very small level of reflected power, e.g., ϕ = .06 percent, corresponds to ρ = 1.05. With just a single element suitable for measuring W_f, detection of reflected power is possible down to about ϕ = 1 percent (ρ = 1.2), providing W_f approaches full scale. However, measurement is possible only down to about ϕ = 5 percent (ρ = 1.5).

Measuring & Monitoring Transmitter Power

Little more need be said about this in view of the preceding load power discussion. The Thruline Wattmeter is useful for the continuous monitoring of transmitter output and is also helpful for the continuous monitoring of reflected power, for instance in checking intermittent antenna or line faults. Like diode devices in general, the Thruline meter indicates the carrier component on amplitude modulation, with very little response to side band components added by modulation.

Items Required

- Thruline Wattmeter
- Elements

  Note: *Ordered separately, P/N depends on Wattmeter model, power level, and frequency ranges.*

- Coupling Kit

  Note: *Ordered separately, P/N depends on transmission line type.*

- DC Cable

General

Install the line section in a 1-5/8 inch 50 ohm coaxial transmission line where the measurement is desired and the insertion coupling is feasible. Be sure that all exposed electrical surfaces, both on the metal contacts and insulators, are thoroughly clean and free of moisture before making the installation.

Coupling Kits

The line section is a short length of matching 1-5/8 inch coaxial transmission line. For Models 4712A, 4712-200A, 4712-037A, and 4715-300A the line section has bolted flanges that are fixed on one end and swivel type on the other. It is inserted into the existing transmission line with the aid of a coupling kit, P/N 4712-020.

For Models 4720A and 4723-200A, the line section is unflanged. It is inserted into the existing transmission line with the aid of an unpressurized straight coupling kit. While installing the coupling kit, refer to Figure 3 on page 10.

Models With Flanged Line Sections

For the models with flanged line sections (Models 4712A, 4715-200A, 4712-037A, and 4715-300A Wattmeters) the center conductor anchor bullets, P/N 4712-021, mate with the center conductor of the 1-5/8 inch 50 ohm coaxial transmission line. This line should be fitted with 1-5/8 inch EIA flanges. It is permissible for the mating flanges of the stationary line to both be of the rigid type because the line section has a rigid type flange on one end and a swivel type flange on the other.

1. Locate the line section so that the element sockets are oriented for easy access.

2. Ensure the center conductor anchor bullets have been positioned with insulators properly seated in the counter bores.
3. Attach the line section to the transmission line using eight suitable bolt assemblies (5/16-18 x 1-1/2 nut and bolt assemblies are recommended).

   Note: *It is usually better to attach the fixed flange of the line section first.*

4. Tighten evenly all around to get a firm and uniform contact.

   Note: *The coaxial line should be continuous with no bends or offsets in its axial line.*

Models With Unflanged Line Sections

For the models with unflanged line sections (Models 4720A and 4723-200A Wattmeters) the connector bullets mate with the center conductor of the 1-5/8 inch 50 ohm coaxial transmission line.

1. Locate the line section so that the element sockets are oriented for easy access.
2. Insert the bullets firmly in the center conductor of the line section and push them in until they bottom in the conductor.

   Note: *The insulator discs will approximately touch the inside face of the outer conductor.*

3. Slide the clamp bands over the transmission line first.
4. Insert the line section into the transmission line.

   Note: *Both bullets should be firmly seated in the center conductor with the ends of the line section butted snugly against the ends of the transmission line.*

5. Slide the clamp bands over the junctures of the line section and the transmission line.
6. Position the clamp bands approximately 3/4" from the ends of the sleeve.
7. Tighten the clamping screws to complete the installation.

   Note: *The coaxial line should be continuous with no bends or offsets in its axial line.*

Elements

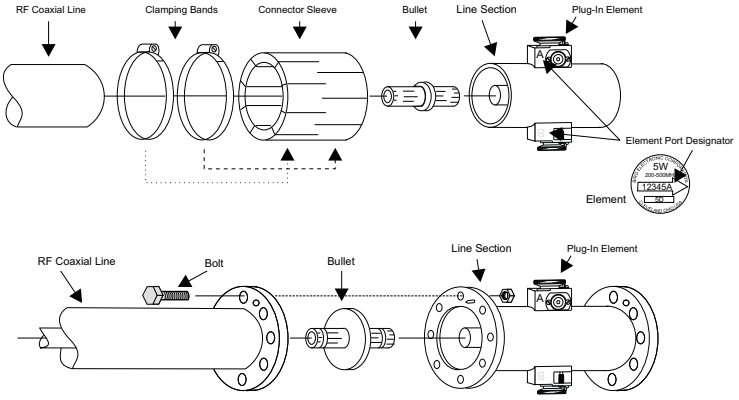
The element port designator is stamped on the line section ports and after the serial numbers on the elements. Be sure to match these designators to achieve stated accuracy.

Meter

The meter may be placed anywhere within the reach of the DC cable, but avoid locations that are dusty or subject to temperature extremes.

1. Connect the DC cable plug to the jack on the measuring element socket.
2. Ensure the connection is tight and clean to insure accurate readings.

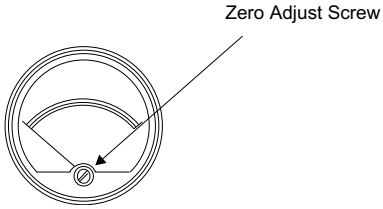
Figure 3 Coupling Kits



Zero Adjust

The meter should be checked for zero set under no power conditions. With no power applied, the meter pointer should set exactly on zero. If adjustment is required, turn the adjustment screw until the pointer is set at zero (Figure 4).

Figure 4 Zero Adjustment of Meter



Use and Function Of Controls

CAUTION
The Thruline wattmeter, elements, and line section have been calibrated together, Replacing any component without recalibrating all the components as a unit may affect accuracy.

Measurements are made by the insertion and operation of the Plug-In Elements previously mentioned. The elements have a power range that matches one of the scales on the meter face and the major markings are the power values for that element. Elements are also marked for frequency range. The transmitter power and frequency must be within the range of the element used.

The “arrow” on the element indicates the sensitive direction, i.e., the direction of power flow which the meter will read. Forward and reverse are directional terms used in reference to the Thruline element and mean respectively the sensitive and null directions of the element. Rotate the element 180 degrees to reverse the sensitive direction. Forward and reflected are directional terms used in reference to the source load circuit. Note that the transmitter output line may be attached to either connector of the RF line section. It makes no difference which external RF connection is selected, since the elements are reversible and the RF circuit is symmetrical end for end. For Models 4715-200A, 4723-200A, and 4715-300A a FWD (Forward) and RFL (Reflected) selector switch is provided. Used in conjunction with the double socket line section included with these models, it makes measuring the desired power flow much more convenient.

Initial Control Setting

Direct power readings are made from the wattmeter dial. For double socketed line section models set the selector switch for the desired direction of power measurement.

Start-up

After the line section is properly installed in the transmission line, and the DC connector cables from the element socket to the meter have been attached (see "Installation" on page 8), nothing more is required.

Normal Operation

Insert the appropriate element in the socket of the line section and rotate the element so that the “arrow” on its nameplate is pointed away from the RF source for forward power and towards the source for reflected power. Turn on the RF source and read the power level indicated on the appropriate meter scale.

Operation Under Abnormal Conditions

The elements for Thruline Wattmeters can withstand at least a 20 percent overload. If the power to be measured is greater, by a reasonable amount, than the maximum value of the element available, the Thruline Wattmeter and element may be used to give an indication of power flow even though the pointer is over-ranged and it is not possible to ascertain the true maximum power.

Shutdown

Because these Thruline Wattmeters are passive devices and require no external source of power, they cannot be shut off. The RF source must be shut off instead.

Emergency Shutdown

> WARNING
> Never attempt to disconnect the transmission line while RF power is being applied. Leaking RF energy is a potential health hazard.

In case of an overload, it is possible to rotate the element to the midpoint between the forward and reflected positions and thereby electrically decouple the element from the meter. Do not remove the element while RF power is still flowing through the line section.

Chapter 5 Maintenance

Any maintenance or service procedure beyond the scope or those provided in this section, should be referred to a qualified service center.

Troubleshooting

Only those functions within the scope of normal maintenance are listed in the table on the next page. This manual cannot list all malfunctions that may occur, or all corrective actions. If a malfunction is not listed or corrected by the listed corrective actions, notify a qualified service center.

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

Problem	Possible Cause	Corrective Action
No meter indication	No RF power.	Check RF source.
	"Arrow" on Plug-In Element pointing in wrong direction.	Change position of element. See "Element" on page 4.
	No pickup from DC contact finger.	Adjust per contact adjustment paragraph. See "Contact Adjustment" on page 15.
	Open or Short circuit.	Replace defective cable on DC meter cable (RG-58/U). See "DC Cables" on page 16.
	Meter burned out or damaged.	Return wattmeter, line section, and elements to the factory for meter replacement and recalibration. See "Customer Service" on page 17.
Intermittent or inconsistent meter readings.	Faulty transmission line.	Inspect line. See "Line Section" on page 16.
	Sticky or defective meter.	Return wattmeter, line section, and elements to the factory for meter replacement and recalibration. See "Customer Service" on page 17.
	Dirty DC contact on elements.	Clean contacts. See "Cleaning" on page 14.

Problem	Possible Cause	Corrective Action
High VSWR or reflected power	Bad load or poor connectors.	Replace load or connectors.
	Shorted or open transmission line.	Have line serviced.
	Foreign material in the line section or in the RF connector bodies.	Refer to the line section care paragraph. See "Line Section" on page 16.

Cleaning

If any of the contacts or line connectors become dirty, they should be wiped off with a clean cloth and a dry cleaning solvent. Use an aerosol contact cleaner that is self-drying, but forms no residue, on the inaccessible internal parts. Clean all contact areas and especially the exposed faces of the Teflon insulators.

It is important to keep the following surfaces clean:

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

The outside surface of the meter housing can be cleaned with a soft cloth dampened with a mild detergent solution. Do not wipe the meter glass with a dry cloth. A static charge could develop, causing an erroneous indication on the meter.

Inspection

Inspect the Thruline unit from time to time for cleanliness and proper adjustment. Make sure all connections are clean and tight. Check the meter with RF power off and adjust the zero setting if necessary.

Preventive Maintenance

The element socket should be kept plugged as much as possible to prevent the intrusion of dust. If a Plug-In Element is to be used for this purpose, use the highest power element available. The element should be positioned so that the “arrow” is pointing midway between the FWD and RFL measuring positions. This will not only protect the meter by shunting the movement, but will also avoid exposing the element’s diode to dangerous potentials if the RF line section should be energized.

Line Section Care

> CAUTION
> Do not attempt to remove the RF center conductor. It is tightly frozen in place and any attempt to remove it will ruin the assembly.

If there is any evidence of contamination inside the RF line section, the reachable portions should be cleaned and the interior carefully blown out. Keep all connections tight, and keep the nut of the meter cord plug turned tight on the line section DC jack. This connection may often be serviced by simply loosening the nut of the DC plug, rotating the body several times through a fraction of a turn and re-tightening the knurled nut securely.

Disassembly

There is no disassembly possible of the Thruline unit other than the disconnection of the line section and the DC cable (See "Installation" on page 8).

Repairs

There are no replacement parts furnished with this equipment. As previously mentioned, components of these matched units cannot be interchanged or individually replaced. The only replaceable portions of the line section are standard parts of coaxial line fastenings.

Contact Adjustment

In cleaning the socket bore, be careful not to disturb the spring finger of the DC contact. It is important that the operating position of this part be properly maintained. If the spring finger of the DC contact requires adjustment, it may be done manually if carried out with care. The tip must be positioned far enough out to maintain good contact with the element but not so far as to interfere with easy entry of the element body. Follow the instructions below for adjustment instructions.

1. Detach the DC jack, with attached spring finger, for service by removing the two 4-40 fillister head machine screws which fasten it to the side of the RF line section.
2. Lift off the jack assembly, carefully to avoid losing the small Teflon insulating bead, that straddles the base of the phosphor bronze spring and nests in a counter bore on the side of the RF body.

When replacing the assembly, reverse the above directions and be sure that the bead is again properly inserted.

Preparation For Shipment

Elements

The elements can be left in the sockets of the line section with their “arrows” turned midway between the measuring positions. Two additional elements can be placed in the storage sockets in the sides of the meter housing, if so equipped. Any additional elements should be well padded and wrapped before being put in the shipping container.

Line Section

Wrap the connectors on the flanged models with padding and tape them securely in place. Cover both ends of the line section and the socket to keep out dust and foreign material. Place the line section in a sturdy shipping container.

DC Cables

Pad and wrap the DC connector plugs and then coil the cables tightly. For convenience place them in the open back of the meter housing.

Meter

Cover the meter face with padding to protect the glass window, then wrap the housing and place it in the same box as the line section.

Storage

No special preparations for storage are necessary other than to cover the equipment to keep out dust and dirt. Store these units in a dry and dust-free environment where the ambient temperature will remain within the -40°C to +45° C (-40°F to +113°F) working range of the loads. For an extra precaution, leave an element in the socket with the “arrow” turned midway between the measuring positions.

Customer Service

Any maintenance or service procedure beyond the scope of those in this chapter should be referred to a qualified service center.

If the unit needs to be returned for any reason, request an Return Material Authorization (RMA) through the Bird Technologies website. All instruments returned must be shipped prepaid and to the attention of the RMA number.

Bird Service Center
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Fax: (440) 248-5426
E-mail: *bsc@bird-technologies.com*

For the location of the Sales Office nearest you, visit our website at:

http://www.birdrf.com

Specifications

Impedance, Nominal	50 ohms
Insertion VSWR	1.05:1.00 maximum
Accuracy	5% of full scale
Dimensions, Nominal Flanged Line Section Unflanged Line Section Meter	 6-3/4"L (171 mm) 6-3/8"L (162 mm) 3-11/64"L x 5-9/16"W x 6-1/2"H (80.6 x 141 x 165 mm)
Weight, Approx. Flanged Line Section Unflanged Line Section Meter	 3 lb (1.36 kg) 1.25 lb (0.57 kg) 3 lb (1.36 kg)
Ambient Temperature	25°C 5°C (77°F 9°F)
Finish Meter Housing Line Section	 Grey Powder Coat Bright silver plate

Model Number	Freq. Range[1] (MHz)	Power Range[1] (kW)	Scale	Connector Type	Sockets
4712A	2-1000	0.25-25	5/10/25	1-5/8" Flg	Single
4715-200A	2-1000	0.25-25	5/10/25	1-5/8" Flg	Double
4720A	2-1000	0.25-25	5/10/25	1-5/8" Unflg	Single
4723-200A	2-1000	0.25-25	5/10/25	1-5/8" Unflg	Double
4712-037A	50-250	0.3-6	15/30/60	1-5/8" Flg	Single
4715-300A	50-250	0.3-6	15/30/60	1-5/8" Flg	Double

1. Actual Frequency and Power Ranges are determined by element used.

Note: *Models 4712A and 4720A utilize meter in housing assembly, P/N 6810-309-7, and replacement meter, P/N 2150-230.*

Note: *Models 4715-200A and 4723-200A utilize meter in housing assembly, P/N 6810-220, and replacement meter, P/N 2150-230.*

Note: *Model 4712-037A utilizes meter in housing assembly, P/N 6810-307,and replacement meter, P/N 2150-259.*

Note: *Model 4715-300A utilizes meter in housing assembly, P/N 6810-230, and replacement meter, P/N 2150-259.*

Replacement Parts

As mentioned previously, there are no field replaceable parts except the following:

Item	Qty	Description	Part Number
1	1 or 2	DC connector plug	7500-076
2	1 or 2	Cable assembly	6810-214-1
3	1 or 2	DC connector assembly	4230-010

The following listings are for reference only.

Item	Qty	Description	Part Number
4	1	**Meter Models:** 4712A, 4715A, 4715-200A, 4720A, 4723-200A 4712-037A, 4715-300A For 8 kW use	 2150-230 2150-259 2150-268
5	1	Meter and Housing Assembly Models: 4712A, 4720A 4715-200A, 4723-200A 4712-037A 4715-300A With 8 kW wattmeter combinations	 6810-309-7 6810-220 6810-307 6810-230 6810-265

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. Routine (regularly required) calibration is not covered under this limited warranty. 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.