INSTRUCTION BOOK

OPERATING INSTRUCTIONS

RF POWER CALORIMETER
MODEL 6091 & 6091P

Electronic Corporation
Cleveland (Solon) Ohio USA

Instruction Book Part Number 920-6091-1 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. These precautions must be thoroughly understood and applied to all phases of operation and maintenance.

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.

Shock Hazard

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

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.

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.

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 connect or disconnect RF cables while RF power is on. Radiated RF is a potential health hazard.

WARNING
HIGH VOLTAGE
Electrical shock hazard. Be careful when working near high voltage cables. Always have someone near capable of rendering aid.

WARNING
Do not place compressed air near or directly against skin. Do not use compressed air in excess of 30 psi (207 kPa) when cleaning or drying parts. Improper use of compressed air can cause serious injury or death.

WARNING
Coolant containing ethylene glycol is a potential health hazard. Avoid ingestion, inhaling of vapors and eye and skin contact.

WARNING
Do not attempt to handle or move this unit alone. More than one person is needed to move this unit to avoid possible injury.

Caution Statements

The following equipment cautions appear in the text whenever the equipment is in danger of damage, and are repeated here for emphasis.

CAUTION
The Calorimeter can overheat if operated without sufficient coolant. Failure to keep coolant reservoir adequately filled can result in serious damage to the equipment.

CAUTION
Use only premixed coolant Bird part number 6091-120. Use of other solutions will damage the instrument and void all warranties.

CAUTION
Do not tighten the jack screws with a screwdriver. The screwdriver slots in the screw are provided for removal purposes only.

CAUTION
During remote operation, periodically monitor the bus service request line. Failure to detect the service request can result in major equipment damage.

CAUTION
The rack enclosure must provide at least 100 ft^3/min of unrestricted air flow. Avoid mounting the Calorimeter above instruments that give off heat. If necessary, isolate the Calorimeter from heat-generating devices with foam or fiberglass.

CAUTION
The total length of all cables used must be less than the number of devices connected times 2 meters (6.6 feet). Never exceed 20 meters of total length.

CAUTION
Only finger-tighten the GPIB connector screws. The screwdriver slots are provided for loosening and removal of screws only. Connector screw threads may be stripped if tightened with a screwdriver.

CAUTION
Never turn off the Calorimeter's main power switch while RF source power is applied to Calorimeter input. Failure to turn off RF power source can result in major equipment damage.

CAUTION
Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

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.

BE SURE THE 115/230V AC VOLTAGE SELECTOR IS SET TO THE PROPER LINE VOLTAGE, AND THE CORRECT AC LINE FUSE IS INSTALLED BEFORE AC POWER IS APPLIED.

S'ASSURER QUE LE SÉLECTEUR DE TENSION 115/230V C.A. EST BIEN RÉGLÉ POUR LA TENSION DU RÉSEAU ET QUE LE FUSIBLE DE LIGNE C.A. CORRECT EST EN PLACE AVANT DE METTRE SOUS TENSION C.A.

CERCIORESE QUE EL SELECTOR DE VOLTAJE DE 115/230V CA ESTE COLOCADO A LA LINEA DE VOLTAJE APROPIADA Y QUE EL FUSIBLE ESTE INSTALADO A LA LINEA CA ANTES DE APLICAR LA CORRIENTE ALTERNA.

VOR EINSCHALTEN DER WECHSELSTROMZUFUHR SICHERSTELLEN, DASS DER 115/230V WECHSELSPANNUNGS-SELEKTOR AUF DIE VORSCHRIFTSMÄ

SSIGE LEITUNGSSPANNUNG EINGESTELLT UND DIE RICHTIGE WECHSELSTROM-HAUPTSICHERUNG EINGESETZT IST. PRIMA DI EROGARE CORRENTE, ASSICURARSI CHE IL SELETTORE DI VOLTAGGIO 115/230 V.C.A. SIA REGOLATO CORRETTAMENTE E CHE IL FUSIBLE ADATTO ALLA LINEA DI ALIMENTAZIONE C.A. SIA INSTALLATO.

About This Manual

This instruction manual covers the Models 6091 and 6091P RF Power Calorimeters.

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

The remainder of this instruction book is divided into chapters and sections.

Operation

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

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 location of major assemblies or parts refer to the parts lists and associated drawings in Chapter 5.

Changes To The 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 manuals 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

This instruction book is intended for use by operators of the Model 6091 and Model 6091P Calorimeter.

This chapter contains introductory information including product specifications; items supplied; and accessory items available.

Purpose and Function

The Bird Electronic Model 6091/6091P Calorimeter is a laboratory-grade power meter that accurately measures the average RF power dissipated through an internal load resistor. The 6091/6091P Calorimeter requires no additional measuring devices or correction tables.

Model Differences

The Calorimeter is available in two different configurations. The Model 6091 is housed in an instrument case, ready for bench-top use. The Model 6091P is the same instrument without the component case, ready for installation into a standard 19-inch rack. Refer to figures 1 and 2 for identification of the two models. Except where noted, operating and maintenance procedures for both models are the same.

Figure 1
Model 6091

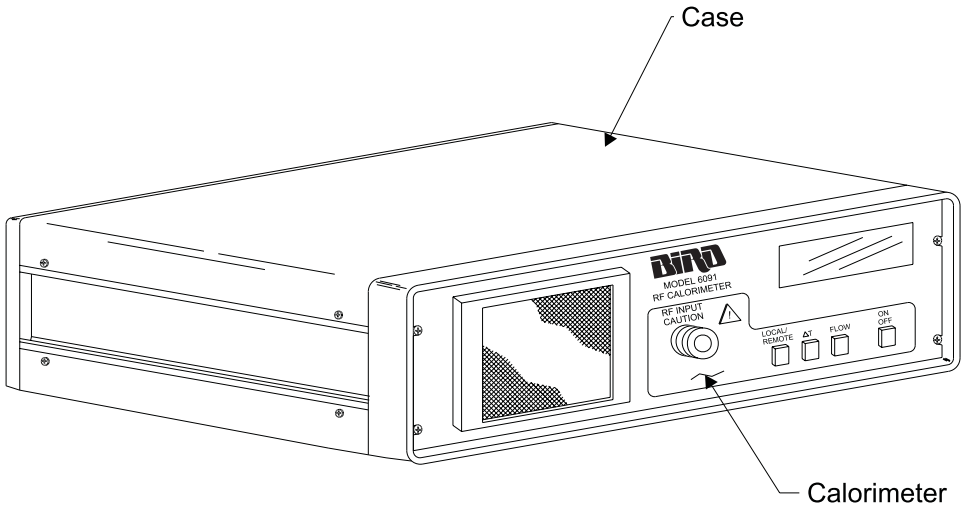
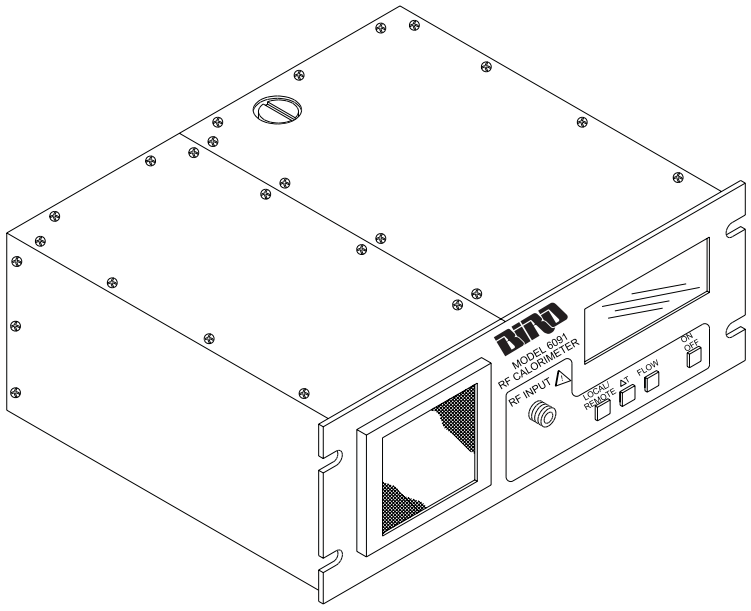


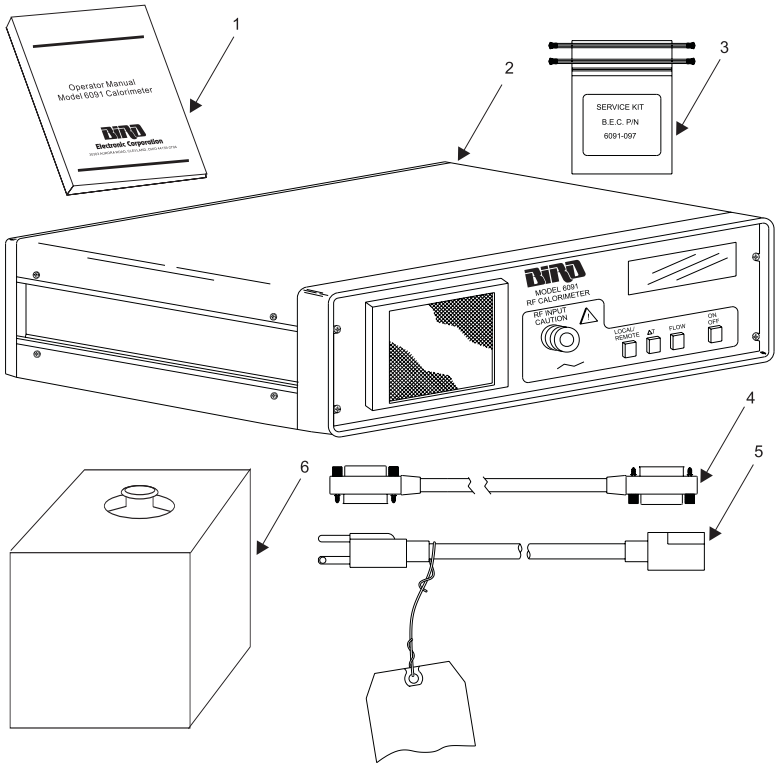
Figure 2
Model 6091P



Items Supplied

The items supplied with the Calorimeter are shown in figure 3, and described below.

Figure 3 Items Supplied



1. Instruction manual.

2. Model 6091 Calorimeter.

3. Service kit P/N 6091-097 (contents):

Item	Part Number
Spigot	5-2056-9
Coolant Filter	5-2054
Drawstring Bag	5-1883

4. General Purpose Interface Bus (GPIB) cable.

5. AC Power Cord.

6. One gallon of premixed coolant, Bird P/N 6091-120.

7. A plotted graph card of load VSWR (not shown)

Functional Description

Coolant - One gallon of premixed coolant, Bird P/N 6091-120.

Load VSWR Graph Card - A plotted graph card of load VSWR is used in conjunction with equipment test procedures to evaluate Calorimeter performance.

AC Line Cord - An ac power cord with three-pronged, U.S. Standard, male connector plugs into a standard 110/120 Vac wall receptacle. An IEC 320 style female connector at the opposite end plugs into the back of the Calorimeter unit.

GPIB Bus Compatible Interface - The general purpose interface bus (GPIB) is a standard bus for parallel control of electronic equipment. The two meter (6.6 foot) cable supplied connects the Calorimeter unit to a user-supplied GPIB controller. The GPIB cable meets the requirements of IEEE Standard 488-1978.

Accessory Items

A two meter (6.6 ft) GPIB cable is supplied with the Calorimeter. Other GPIB cables are available as follows:

Bird Part Number	Cable Length
5-1317-1	1 meter (3.3 ft)
5-1317-3	4 meter (13.1 ft)

Recommended Test Equipment

Table 1 list equipment recommended for performance testing and maintenance of the Calorimeter. The critical equipment parameters listed are the minimum specifications applicable to test and measurement devices other than those listed. Valid Calorimeter tests and measurements are critical and depend largely on the accuracy of the test and measurement devices used. Refer to Chapter 5 - Maintenance for more information on testing and calibration.

Table 1

Recommended Test Equipment

Equipment Type	Recommended Model	Critical Equipment Parameters
AC Power Source	Elgar 501SL with PIP 9012	Output - 10 to 200 watts @ 50 ohms Stability - greater than 0.1% THD - less than 0.25% Frequency - adjustable to 60, ±1 Hz
AC Power Meter	YEW 2533	Range - 10 to 200 watts Accuracy - 0.1%
Automatic Network Analyzer	HP 8753 with 85046A	±0.2 dB accuracy for return loss measurements
Cable Assembly		Test connections as shown in figure 12 in Chapter 5 - Maintenance

Electromagnetic Interference

The Calorimeter has been tested and was found to meet Class A limits as specified in Part 15J of the FCC requirement for electromagnetic emissions.

Specifications

Power Range	10 to 200 watts (average power, independent of wave shape)
Frequency Range	DC to 2500 MHz
Accuracy of Reading[1]:	
@ 10 to 25 watts	±3%
@ 25 to 200 watts	±1.25%
Input Connector	Female, Type N
Input Impedance	50 ohms
Input VSWR:	
DC to 1000 MHz	1.10 maximum (26.4 dB minimum return loss)
1000 to 2500 MHz	1.25 maximum (19.1 dB minimum return loss)
Response Time[1] (10 to 200 watt step response)	1 minute maximum to reach 97% of final reading
GPIB Function Supported (IEEE 488, 1975)	SH1, AH1, T6, L4, SR1, RL1, PP0, DC1, CO, E1, TEO, and LE0
Maximum Bus Reading Rate	3 readings per second
Power Requirements (Single phase)	104 to 132 Vac or 195 to 264 Vac @ 47 to 63 Hz
Power Consumption	45 to 70 watts
Coolant Type	Ethylene Glycol mixture (Bird part number 6091-120)
Coolant Capacity	525 ml (10 fluid oz)
Operating Position	Horizontal
Storage Temperature	10°C to 50°C (50°F to 122°F)
Operating Temperature[1]	15°C to 35°C (59°F to 95°F)
Weight:	
Model 6091	18.1 kg (40 lb)
Model 6091P	11.3 kg (25 lg)
Dimensions:	
Model 6091	15-3/4”L x 20-15/32”W x 8-17/64”H (400 mm x 520 mm x 210 mm)
Model 6091P	14-7/8”L x 19”W x 6-31/32”H (378mm x 483 mm x 177 mm)

[1] To achieve the accuracy and response time specified, the Calorimeter must be operated in a stable ±5°C (±9 F°) ambient temperature environment. Accuracy specification does not include losses due to mismatch.

Theory Of Operation

Measuring AC power at frequencies above 100 kHz can be difficult. Primary voltage and current measurements become more difficult near the VHF band frequencies. One method of accurately measuring broad band power is calorimetry. This section describes how the Model 6091 and 6091P Calorimeters measure RF power.

Basic Calorimetry

The term calorimetry refers to the measurement of quantities of heat. Heat is energy that can be transferred by a thermal process. The rate of heat exchange can be expressed in calories per second (cal/sec); a change in energy per unit time. A calorie is the quantity of heat needed to raise the temperature of one gram of water one degree Celsius.

The first law of Thermodynamics states that energy can be neither created nor destroyed only changed from one form to another. An RF watt is electrical energy spent per unit time. By changing incoming RF power to heat and measuring the resulting temperature difference at a known flow rate, we can determine an accurate measure of the RF power being generated from a source in watts.

Calorimeter Overview

The Calorimeter measures the amount of heat created when RF power is dissipated into a load resistor. The following paragraphs describe how the 6091/6091P Calorimeter performs an RF power measurement. Refer to the block diagram in figure 4 during the following discussion.

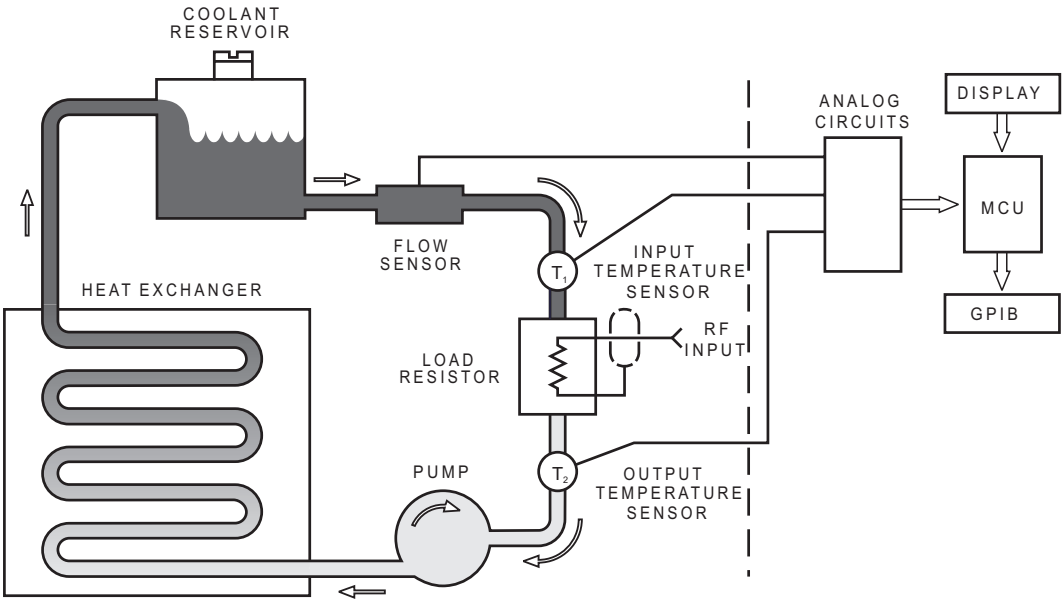
Calorimeter Functions

An RF power source is attached to the RF input connector on the front panel of the Calorimeter. RF power is applied, through the front panel connector, to a precision internal 50-ohm load resistor. The internal load resistor converts the RF power to heat and transfers the heat into the surrounding coolant.

The center of the load resistor is hollow to allow liquid to flow through the resistor. The resistor core is connected in line with a closed loop pumping system. Coolant is continually pumped from the coolant reservoir, through the load resistor, to the pump. From the pump, the coolant is forced through an air-cooled heat exchanger and back into the coolant reservoir.

Figure 4

System Block Diagram



The heat exchanger removes excess heat from the coolant. The coolant reservoir holds most of the coolant volume in the system. The reservoir allows the coolant temperatures to stabilize and helps keep the average coolant temperature down.

An input temperature sensor (T_1) measures the average coolant temperature just before it enters the load resistor. As coolant flows through the load resistor, it absorbs the heat energy. The load resistor is very efficient, allowing nearly all of the RF power to be converted to heat which is transferred by conduction into the coolant. An output temperature sensor (T_2) measures the average coolant temperature as it exits the load resistor.

To ensure high accuracy of temperature measurements, solid-state thermistor assemblies are used. The thermistors are semiconductor devices that respond to small temperature variations by large changes in electrical resistance. The resistance of each thermistor is measured by the analog circuitry and processed by the micro-computer (MCU) for use in determining the temperature difference (T_2-T_1).

A volume flow sensor measures the flow rate of the coolant through the system. The flow sensor produces an electrical square wave signal based on the coolant flow rate. The signal frequency increases as the coolant flow rate increased. The flow rate signal is sent to the analog circuits. The analog circuits process the square wave, producing a flow rate signal for use in the MCU. The MCU calculates the RF power dissipated in the load resistor. The calculation is based on the coolant flow rate and the rise in coolant temperature as it flows through the load resistor.

The flow rate and temperature difference measurements are continually corrected to account for changes in the specific heat and density of the coolant as the overall coolant temperature rises. All temperature, volume, and flow measurements along with resulting temperature change and power calculations are monitored by the MCU. This allows the user to display, watts, flow, or temperature difference via the front panel keyboard or request measurement data over the General Purpose Interface Bus (GPIB).

Chapter 3

Installation

This chapter contains information on site and shelter requirements, unpacking and inspection, and preparing the Calorimeter for use.

Site and Shelter Requirements

The Model 6091/6091P Calorimeter is designed for use in a laboratory environment. The unit is not intended for outdoor use, or use in areas of condensing humidity. It must be located near an ac power source.

> WARNING
> Do not attempt to handle or move this unit alone. More than one person is needed to move this unit to avoid possible injury.

Unpacking and Inspecting

1. Carefully inspect the Calorimeter shipping container for signs of damage. If damage is noticed, do not unpack the unit. Immediately notify the shipping carrier and Bird Electronics of the damage.
2. If the container is not damaged, unpack the unit. Save the shipping materials for repackaging.
3. Check contents against the equipment list in Chapter 1. Inspect all components for visual signs of damage. Immediately notify the shipping carrier and Bird Electronic Corporation of equipment damage or missing parts.

Setting the Voltage Selector Switch

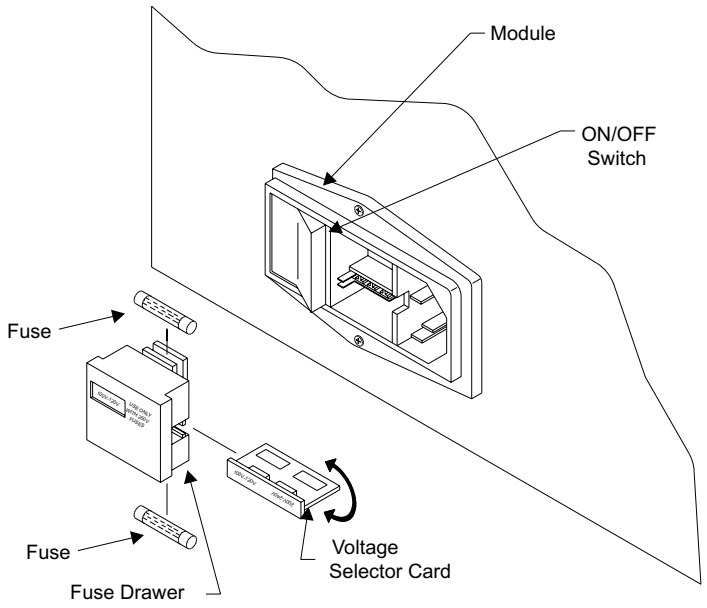
The Calorimeter can be operated at 104 to 132 volts RMS or 195 to 264 volts RMS.

The sensor unit is preset at the factory for 115 Vac operation. Verify voltage selection and fuse rating; follow the steps below if a change is required.

1. Locate the power entry module, refer to figure 5, on the back of the Calorimeter unit.

Figure 5

Power Entry Module



2. Use a small flathead screwdriver to gently pry the fuse drawer out of the power entry module.

3. Slide the voltage selector card out of the fuse drawer. Reinsert the card so that the correct line voltage appears in the window.

4. Check the current rating of the fuses with requirements in table 2. Install the correctly rated fuses in the fuse drawer.

5. Re-install the fuse drawer in the power entry module.

Table 2

Fuse Ratings and Part Numbers

Voltage Setting	Voltage Range (volts RMS)	*Fuse Rating	Bird Part No.
100-120V	104 to 132	2.0A, 250V Fast Acting	5-1976-19
220-240V	195 to 264	1.0A, 250V Fast Acting	5-1976-16
* Replace with only IEC 5 x 20 mm type fuses.			

AC Power Connection

An ac power cord is supplied with the Calorimeter unit. The female end of the power cord plugs into the power entry module, refer to figure 5.

The male end of the power cord is equipped with a U.S. standard NEMA 5-15, three-pronged connector for mating with a grounded 120-volt wall receptacle. You must purchase the appropriate cord for connection to any other receptacle.

Make ac power connections as follows:

1. Locate the power ON/OFF switch on the rear panel of the unit. Place the switch in the OFF position.

2. Check the input voltage rating indicated on the power entry module. Verify that the voltage indicated matches the supply voltage for your installation. If not, change the voltage selector switch per the Setting the Voltage Selector Switch section.

3. Plug the female end of the power cord into the power entry module.

4. Plug the male end of the power cord into a mating three-pronged receptacle.

Filling the Coolant Reservoir

The Calorimeter requires 525 ml (10 fl oz) of coolant (Bird P/N 6091-120). The coolant reservoir is emptied prior to shipment or extended storage. Refer to figure 6 and fill the coolant reservoir as follows:

WARNING
Coolant containing ethylene glycol is a potential health hazard. Avoid ingestion, inhaling of vapors and eye and skin contact.

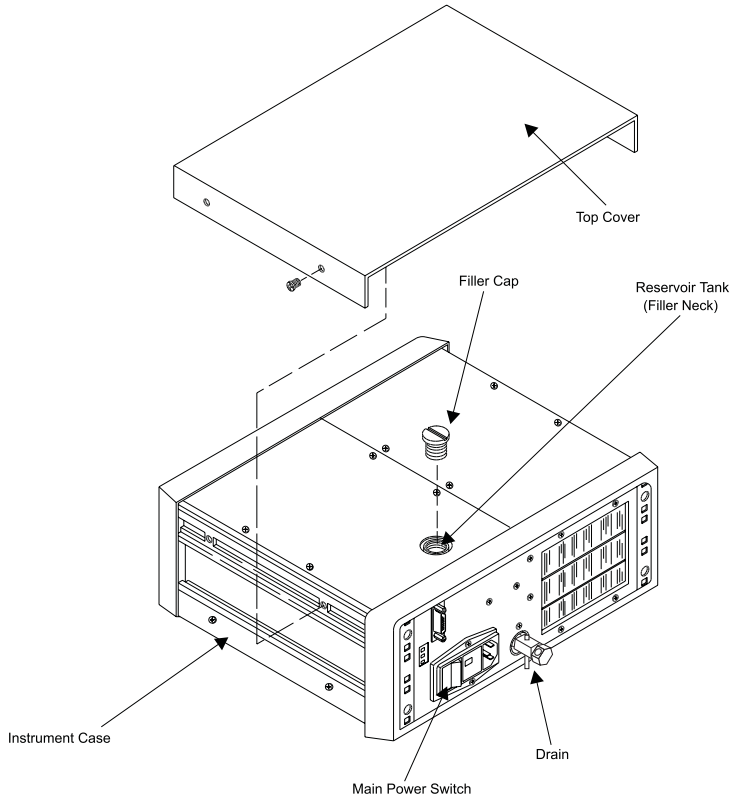
CAUTION
Use only premixed coolant Bird part number 6091-120. Use of other solutions will damage the instrument and void all warranties.

CAUTION
The Calorimeter can overheat if operated without sufficient coolant. Failure to keep coolant reservoir adequately filled can result in serious damage to the equipment.

CAUTION
Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

Figure 6

Filling Coolant Reservoir



1. Remove the power cord from the instrument if it is attached.
2. Remove the top cover from the instrument case (if supplied).
3. Unscrew and remove the filler cap from the reservoir tank.
4. Make sure the drain, located on the rear panel, is closed.

☞ Note: The unit is shipped drained of coolant. The drain must be closed when filling the unit with coolant for the first time.

5. Remove the spigot from the service kit and thread it onto the coolant container.
6. Add coolant until the level reaches the base of the filler neck. Use a funnel to prevent coolant from spilling onto the instrument. If spilling occurs, wipe the coolant up and allow the equipment to dry before proceeding to step 7.
7. Connect the Calorimeter to ac main power.
8. Turn the power ON/OFF switch to on to start up the fan and coolant pump. An alarm may sound until the coolant starts to circulate and sufficient flow rate is achieved.
9. Run the pump for a few minutes. Refill the coolant reservoir if the coolant level dropped.
10. Install the filler cap and wipe away any spilled coolant.
11. Reinstall the top cover onto the instrument case, if used.

Rack Mounting

The model 6091P Calorimeter is ready for installation into a 19-inch, type 4U electronics equipment rack. The model 6091 can also be rack mounted. To rack mount the 6091, unscrew the four front panel screws and remove the unit from the instrument case (Store the case for future use).

The ON/OFF switch and power cord connector on the rear panel may not be accessible once the unit is installed in the rack. Connect the power cord (at the back of the unit only) and place the ON/OFF switch in the ON position before installing the Calorimeter in the rack.

CAUTION
The rack enclosure must provide at least 100 ft^3/min of unrestricted air flow. Avoid mounting the Calorimeter above instruments that give off heat. If necessary, isolate the Calorimeter from heat-generating devices with foam or fiberglass.

Install the Calorimeter in the equipment rack as follows:

1. Carefully slide the Calorimeter into the rack opening.
2. Fasten the front panel in place with four 1/4-20 pan head screws.
3. If possible, attach vertical support brackets to the rear panel of the Calorimeter.

Connecting GPIB Cables

The Calorimeter and up to 14 other measurement devices can be connected to one GPIB controller.

CAUTION
The total length of all cables used must be less than the number of devices connected times 2 meters (6.6 feet). Never exceed 20 meters of total length.

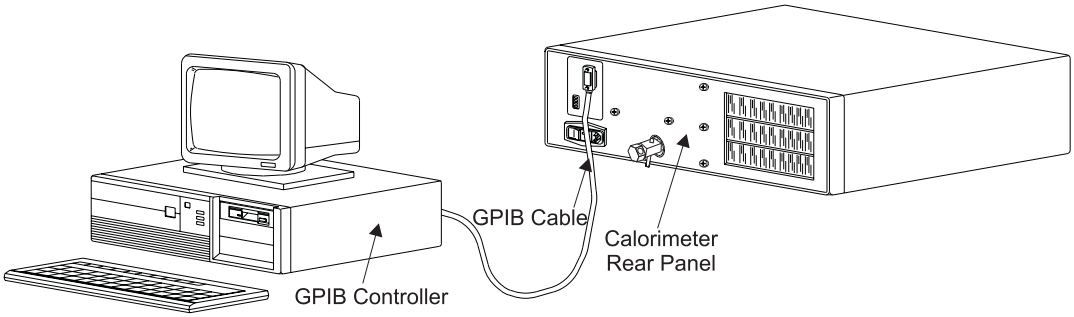
CAUTION
Only finger-tighten the GPIB connector screws. The screwdriver slots are provided for loosening and removal of screws only. Connector screw threads may be stripped if tightened with a screwdriver.

☞ Note: GPIB cables mount one on top of the other. This allows the connection of several instruments in a “daisy chain”.

Use the GPIB cable supplied to connect the Calorimeter and GPIB controller as shown in figure 6. Press the mating connectors together firmly. Secure the connectors with the screws provided.

Figure 6

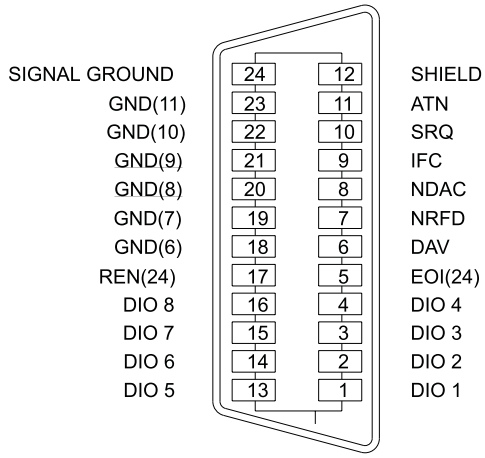
GPIB Cable Connections



The contact assignment of the 24-pin GPIB cable connector is shown in figure 7.

Figure 7

GPIB Connector



GND, (N) refers to the signal ground return of the reference contact, EOI and REN return on Contact 24

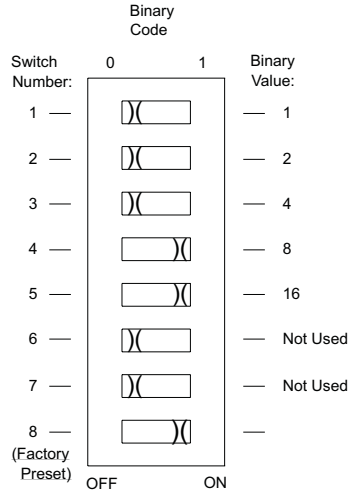
Setting the GPIB Bus Address

Each instrument connected to the GPIB is identified by a unique address. The instrument address value is a whole decimal number between 00 and 30.

Set the address using the address switch, refer to figure 8, located on the rear panel. The switch is binary coded and comes factory set to address 24 (1-1000). To change the address, slide the switches with a small tool or pencil. Switch positions six and seven are not currently used and should be left at zero. Switch eight is preset at the factory and should not be changed.

Figure 8

Address Select Switch



Preliminary Equipment Check

Check for proper equipment operation using the performance test procedures in Chapter 5 -Maintenance. If the unit does not pass the performance test, notify Bird Electronic Corporation.

Chapter 4

Operating Instructions

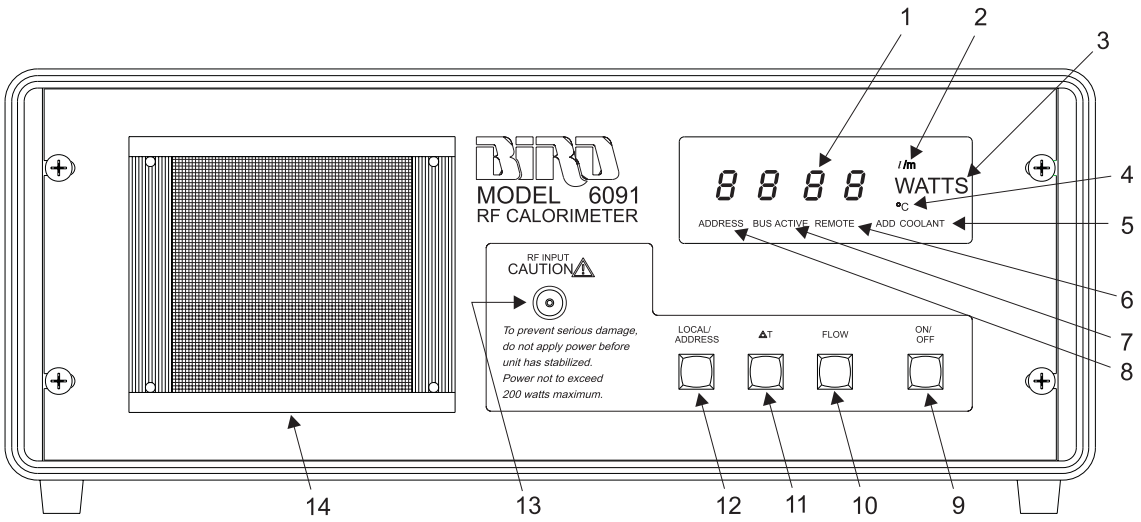
A description of all operator controls and indicators is provided in this chapter. Instructions for normal operation and for remote operation using the GPIB controller are also included in this chapter. Read and become familiar with the instructions before operating the RF Power Calorimeter.

Features, Controls, and Indicators

Front panel controls and indicators are shown in figure 9. Rear panel controls and indicators are covered in figure 10.

Figure 9

Front Panel Controls and Indicators

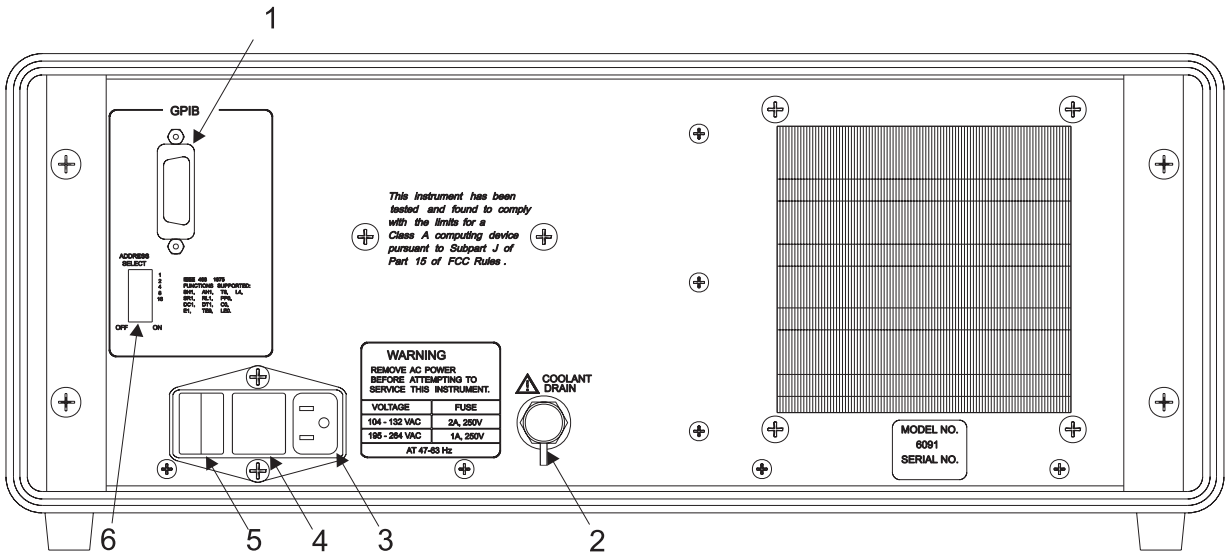


Key	Control or Indicator	Function
1	Display Window	The display window provides a four-digit readout of the selected measurement parameter. The description or unit of measurement for the displayed parameter is automatically backlit beside or below the display window. (Figure 9 shows all segments of the display illuminated).
2	l/m Annunciator	The liters per minute (l/m) annunciator lights up to indicate the units of the current readout on the display window (1). The indicator will remain lighted while the FLOW pushbutton (10) is pressed.
3	WATTS Annunciator	A stable power measurement in watts is indicated when the WATTS annunciator is lighted. The indicator remains dark until the power measurement is within 3% of its final value.

4	°C Annunciator	The °C annunciator lights up to indicate units (degrees Celsius) of the current readout in the display window (1). The annunciator will remain lighted while ΔT pushbutton is pressed.
5	ADD COOLANT Annunciator	The words ADD COOLANT light up when the coolant level in the reservoir reaches a low limit. Add coolant whenever this message is displayed.
6	REMOTE Annunciator	The REMOTE annunciator lights up whenever the Calorimeter is in the remote (GPIB) operating mode. It remains lighted until local mode operation is resumed.
7	BUS ACTIVE Annunciator	The words BUS ACTIVE flash on and off in the display window (1) when the Calorimeter is servicing a GPIB processor request.
8	ADDRESS Annunciator	The ADDRESS annunciator lights up when a GPIB address is displayed in the display window (1).
9	ON/OFF Pushbutton	Pressing the ON/OFF pushbutton puts the calorimeter into an idle state. The display will be turned off. Pressing the ON/OFF pushbutton again returns the calorimeter to normal operation.
10	FLOW Pushbutton	The FLOW pushbutton selects the flow rate parameter for display. The coolant flow rate is displayed while the pushbutton is pressed. The “l/m” annunciator lights up to indicate that display is in liters per minute. The display will revert to WATTS when the pushbutton is released.
11	ΔT Pushbutton	Pressing the ΔT pushbutton causes the temperature differential value to be displayed. The value indicates the temperature gradient of coolant passing through the load resistor. The °C annunciator lights up to indicate that degrees Celsius is displayed. The display will revert to WATTS when the pushbutton is released.
12	LOCAL / ADDRESS Pushbutton	When the Calorimeter is in the remote operating mode (GPIB operation), pressing the LOCAL/ADDRESS pushbutton returns unit control to the front panel. The REMOTE annunciator goes out to indicate when the unit is in local operating mode. When in the local operating mode, pressing the LOCAL/ADDRESS pushbutton causes the unit to display current address setting.
13	RF Input Connector	The RF input connector mates with a coaxial RF power cable. The RF power cable (not provided) connects the Calorimeter with the RF power source for measurement. The RF input connector is a precision 50 ohm, female, type N connector.
14	Air Filter	The air filter prevents dirt and dust from entering the Calorimeter housing. The filter is easily removed for periodic cleaning.

Figure 10

Rear Panel Controls and Indicators



Key	Control or Indicator	Function
1	GPIB Connector	A GPIB controller can remotely control the Calorimeter by transferring signals through this connector. The connector meets the requirements found in IEEE-488 of 1978.
2	Coolant Drain	The coolant is removed through this drain. Refer to chapter 5 - Maintenance for complete instructions on draining the coolant.
3	AC Power Receptacle	The ac power for operating the Calorimeter is connected through this receptacle. It will accept a standard IEC 320 style female connector, such as the one on the power cord supplied. The receptacle is filtered to reduce the possibility of EMI.
4	Fuse Drawer	The ac power line is fused to protect against short circuit fire and shock hazards. The fuses are housed within the fuse drawer. Refer to chapter 5 - Maintenance for complete instructions for replacing these fuses.
5	Main Power ON/OFF Switch	The main power on/off switch turns ac power on and off to the Calorimeter unit.
6	Address Dip Switch	The address dip switch sets the address code for the Calorimeter unit when the unit is connected to a GPIB processor. The dip switch is set to “10011000” (binary 24) when shipped from the factory.

Equipment Startup

Perform the following steps to start up the Calorimeter:

1. Depress the rear panel main power ON/OFF switch to the on position. The front panel display will light for about four seconds and the pump and fan will run. After initialization the display will indicate 0.0 watts; showing that the calorimeter is in power measurement mode.

☞ Note: A false power level may be displayed if coolant has just been added or the ambient room temperature has recently changed. If either happens, allow up to 30 minutes for the system temperature to stabilize.

2. Check the front panel display. If the ADD COOLANT annunciator is lit, immediately shut off the power ON/OFF switch and add coolant per instructions in chapter 5 - Maintenance.

3. Press and hold the FLOW pushbutton. Coolant flow rate will be displayed. Flow rate must fall between 0.284 and 0.473 liters per minute. Refer to chapter 5 - Maintenance if the flow rate is outside of these limits.

WARNING
Never attempt to connect or disconnect RF cables while RF power is on. Radiated RF is a potential health hazard.

CAUTION
Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

4. *With the Calorimeter unit running*, connect the RF power source to the RF input connector. The connecting cable should be as short as possible. Use a high quality, 50 ohm coaxial cable such as RG 11/U.

Normal Operating Procedures

In normal operating mode all controls and indicators are used when operating the calorimeter. RF power readings will be displayed on the front panel display window, refer to figure 9 for identification. Coolant flow rates and temperature differential measurements can also be displayed to assist with maintenance checks. Before operating the Calorimeter read and become familiar with the shutdown procedures in this chapter.

CAUTION
Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

Measuring RF Power

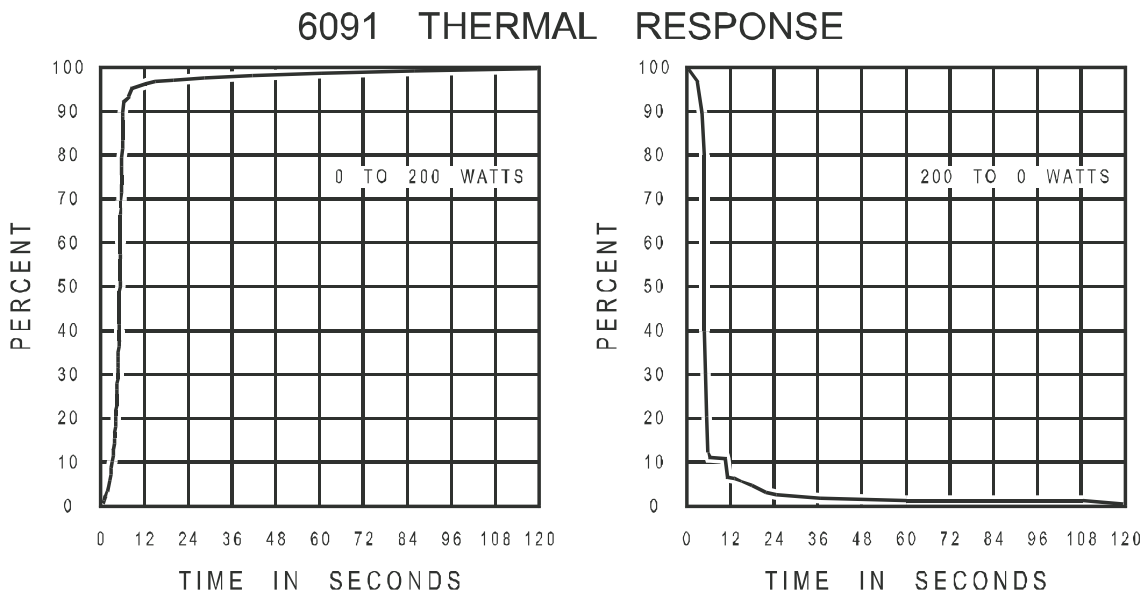
1. Make sure the RF power source is connected and the startup procedures have been followed.

2. Turn on the RF power source. The Calorimeter will display an RF power reading. The corresponding Watts unit of measure annunciator lights when the power measurement is within 3% of its final value. For large changes in power, this can take up to three minutes.

☞ Note: The Calorimeter is a broad band power meter that will measure the resultant power of all signal components up to 2500 MHz. Make sure to filter all unwanted signal components out before they reach the input connector.

Figure 11

Typical Response Times



Typical response times for the Calorimeter are shown in figure 11. The first curve shows the response time with power stepped up from 0 to 200 watts. The second curve indicates the response when the input is stepped down from 200 to 0 watts. The step-down response time is considerably longer than the step-up response time. This is due to residual heat stored in the system.

Measuring Coolant Flow Rate

The flow rate is displayed in liters per minute. The flow rate should be between 0.284 to 0.473 liters per minute. An alarm will sound if the flow rate drifts outside of this range.

1. Press and hold the FLOW pushbutton to check the coolant flow rate.
2. Release the FLOW pushbutton to return the display to the power display mode.

Measuring Temperature Differential (ΔT)

The temperature differential is displayed in degrees Celsius. The ΔT is normally between 0.380° to 7.610°C and increases linearly with the RF power input level. An alarm will sound if the ΔT exceeds 8.500°C. If the alarm sounds, shut down according to the emergency shutdown procedures in this chapter.

1. Press the ΔT pushbutton to check the rise in temperature as the coolant passes through the load resistor.
2. Release the ΔT pushbutton to return the display to the power display mode.

GPIB Operation

The Calorimeter is capable of remote operation via the General Purpose Interface Bus (GPIB). Detailed information relating to bus capabilities together with programming examples are detailed in Appendix A - Remote Operating Procedures.

Normal Shutdown Procedure

When power measurements are completed, shutdown the Calorimeter as follows:

> CAUTION
> Never turn off the Calorimeter's main power switch while RF source power is applied to Calorimeter input. Failure to turn off RF power source can result in major equipment damage.

1. Turn off RF power source device.

2. Disconnect RF power cable.
3. Allow unit to run until ΔT is less than 0.040°C.
4. Press front panel ON/OFF button.

☞ Note: If the alarm sounds, check ΔT. The alarm will stop when the conditions of step 3 above are met.

5. Turn off the rear panel main power ON/OFF switch.

Emergency Shutdown

The Calorimeter has a built in alarm that will sound during equipment emergencies. If an emergency occurs, shut down the Calorimeter as follows:

> CAUTION
> Never turn off the Calorimeter's main power switch while RF source power is applied to Calorimeter input. Failure to turn off RF power source can result in major equipment damage.

1. Turn off RF power source device.
2. Disconnect RF power cable.
3. If coolant flow is less than 0.284, turn off the rear panel power switch.
4. If coolant flow is above 0.284, leave the unit running until ΔT is less than 0.040°C.

Chapter 5

Maintenance

With basic care, the Calorimeter should provide many years of trouble free operation. This chapter contains operator maintenance, performance testing, preventive maintenance, and cleaning instructions.

Performance Testing

Check for proper equipment operation using the performance test procedures in this section. Acceptable performance is determined by comparing the test results with the equipment specifications listed in Chapter 1 - Introduction. If the unit does not pass the performance test, notify Bird Electronic Corporation.

Equipment Required

Refer to table 3 for a listing of the test equipment required for performance testing. The equipment parameters listed are the minimum specifications applicable to the test equipment models other than those listed. Valid Calorimeter tests and measurements are critical and depend largely on the accuracy of the test equipment used.

Table 3

Test Equipment Specifications

Equipment Type	Suggested Model	Critical Equipment Specifications
AC Power Source	Elgar 501SL with PIP 9012	**Output** - 10 to 200 watts @ 50 ohms **Stability** - greater than 0.1% **THD** - less than 0.25% **Frequency** - adjustable to 60, ±1 Hz
AC Power Meter	YEW 2533	**Range** - 10 to 200 watts **Accuracy** - 0.1%
Automatic Network Analyzer	HP 8753 with 85046A	±0.2 dB accuracy for return loss measurements
Cable Assembly	Bird P/N 6091-099	Test connections as shown in figure 12

Test Data Sheet

A test data sheet is provided on page 21. Photocopy the data sheet. Record performance test data in the spaces provided. Maintain completed test data sheets for records of equipment performance and testing.

Performance Test Setup

Set up the Calorimeter and test equipment by following the instructions below. Refer to figure 12.

1. Connect the cable assembly from the Calorimeter to the ac power meter.

2. Connect the power meter to the ac power source.

Calorimeter Performance Test

Perform the calorimeter performance testing as follows:

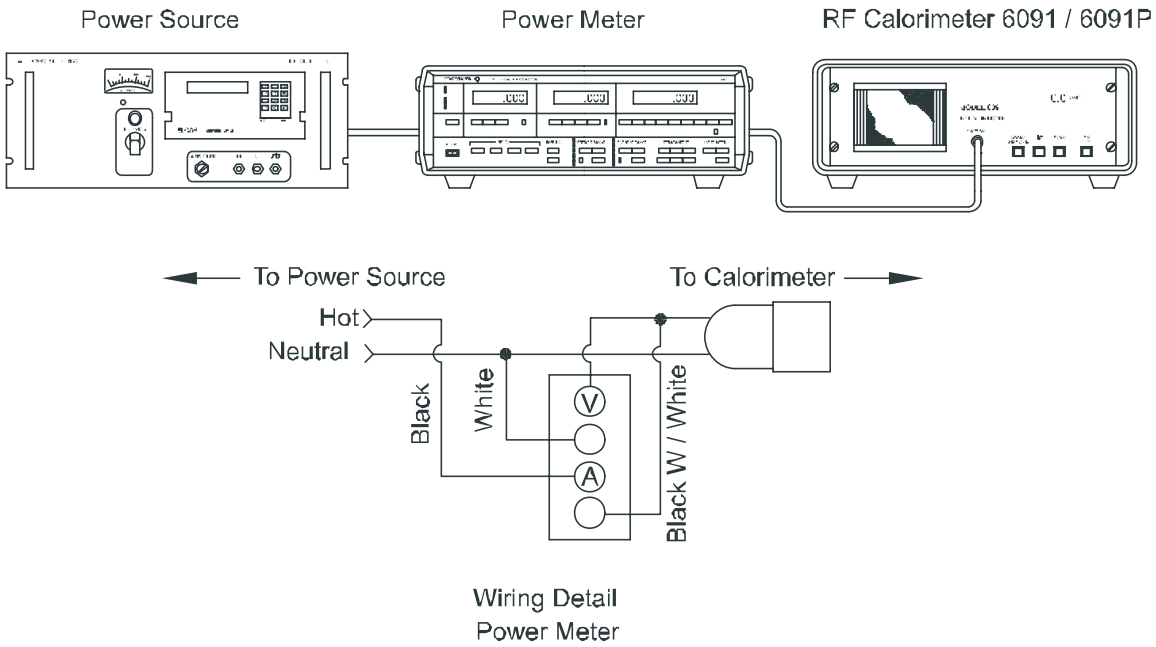
CAUTION

Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

1. Turn power on to Calorimeter and test equipment. Allow a 30 minute warm-up period for all electronic equipment. While the equipment is

Figure 12

Performance Test Setup



Wiring Detail
Power Meter

warming up, connect the Automatic Network Analyzer (ANA) to the RF input connector.

2. Adjust the ANA frequency for a VSWR measurement between 300 kHz and 1000 MHz. Find and record the maximum VSWR reading in this range.

3. Find and record the maximum VSWR reading while adjusting the ANA frequency between 1000 and 2500 MHz.

4. Set up the ANA to measure reflection coefficient from 300 kHz to 2500 MHz frequency range. Plot the results for use during error analysis.

5. Turn off the network analyzer and disconnect it from the RF input connector.

WARNING
HIGH VOLTAGE
Electrical shock hazard. Be careful when working near high voltage cables. Always have someone near capable of rendering aid.

6. Hook up the AC Power Source output cable the RF input connector.

7. Adjust the AC Power Source to each of the voltages listed below. For each voltage setting, wait for the Calorimeter to reach a stable RF power (Watts) reading. For each voltage setting, read and record the power indications on the Calorimeter and the AC Power Standard.

   22.4, ±0.5 volts RMS, 60 Hz
   35.4, ±0.7 volts RMS, 60 Hz
   70.7, ±1.4 volts RMS, 60 Hz
   100.0, ±2.0 volts RMS, 60 Hz

8. Adjust the AC Power Source for 0.0 volts RMS. Allow the Calorimeter to run until the ΔT is less than 0.040°C.

9. Turn off the power to the equipment.

MODEL 6091/6091P CALORIMETER PERFORMANCE TEST RECORD

Calorimeter Unit Serial Number:

MAXIMUM VSWR

	Frequency Range	Maximum VSWR		Acceptable Limit (max)	
	300 kHz to 1000 MHz			1.10	
	1000 MHZ to 2500 MHZ			1.25	

POWER MEASUREMENT ACCURACY

Volts RMS	Nominal Power	Power Meter Reading	Minimum Acceptance Limit[1]	Calorimeter RF Power Reading	Maximum Acceptance Limit[2]	Allowable Error
22.4	10 watts					±3.0%
35.4	25 watts					±1.25%
70.7	100 watts					±1.25%
100.0	200 watts					±1.25%

[1]Subtract allowable error from power meter reading to find minimum acceptance limit.

[2]Add allowable error to power meter reading to find maximum acceptance limit.

COMMENTS:

Tested by:_____ Date:_____

Preventive Maintenance

The preventive maintenance procedures listed and referenced in table 4 are designed to prevent equipment failures and downtime. Perform these procedures at the recommended intervals.

Table 4

Preventive Maintenance Procedures

Frequency	Task	Procedures
Before use	Check load resistor.	Visually inspect center conductor pin of RF input connector for signs of wear or spreading.
		Measure resistance between inner and outer conductors of RF input connector. Resistance should be 50, ±2 ohms.
	Check ac power cord.	Inspect for worn or broken insulation. Replace power cord, if worn or damaged.
	Check coolant level.	With the Calorimeter running, check that the ADD COOLANT annunciator stays off. If annunciator is on or flashing, fill coolant reservoir per the instructions in the coolant para.
	Check GPIB address.	With the Calorimeter running, press the LOCAL/ADDRESS key. The current GPIB address will be displayed on the front panel. If the address is incorrect, reset ADDRESS dip switches per the instructions.
Weekly	Clean exterior of the calorimeter unit.	Clean the exterior connector and surfaces of the unit per the Cleaning paragraph.
Monthly	Clean the air filter element.	Remove and clean the air filter element per the instructions.
	Replace the coolant.	Drain coolant per the instructions. Fill the coolant reservoir with clean coolant.
Trimonthly	Test Calorimeter performance.	Perform equipment performance testing per the instructions.
Semi-annually	Replace coolant filter.	Remove and replace the coolant filter per the instructions.
	Return unit for calibration.	Package calorimeter unit per the instructions in the Preparation for Storage and Shipment section. Return the unit to the nearest authorized service center for recalibration.

Filling the Coolant Reservoir

Fill the coolant reservoir according to the following instructions.

> WARNING
> Never attempt to connect or disconnect RF cables while RF power is on. Radiated RF is a potential health hazard.

> WARNING
> Coolant containing ethylene glycol is a potential health hazard. Avoid ingestion, inhaling of vapors and eye and skin contact.

> CAUTION
> The Calorimeter can overheat if operated without sufficient coolant. Failure to keep coolant reservoir adequately filled can result in serious damage to the equipment.

> CAUTION
> Use only premixed coolant Bird part number 6091-120. Use of other solutions will damage the instrument and void all warranties.

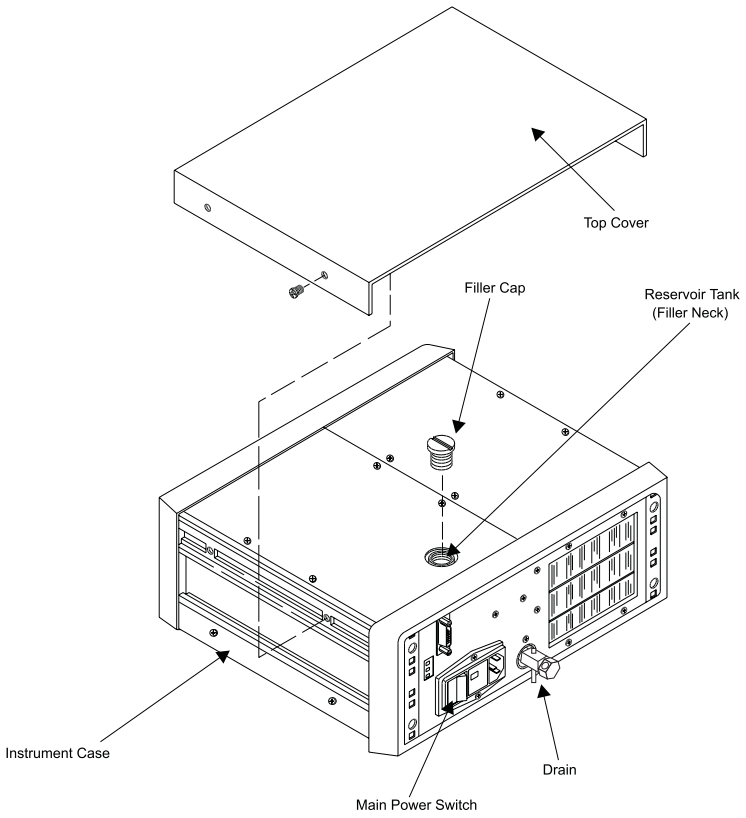
> CAUTION
> Do not apply RF power to the load without proper coolant flow. Failure to keep coolant at proper flow rate can result in serious damage to the equipment.

The Calorimeter requires 525 ml (10 fluid ounces) of coolant. Fill the coolant reservoir as follows. Refer to figure 13.

1. Remove the power cord from the Calorimeter.
2. Remove the top cover from the Calorimeter case (if supplied).

Figure 13

Filling Coolant Reservoir



3. Unscrew the filler cap from the reservoir and install funnel. (Drain valve must be closed).

4. Remove spigot from the service kit and thread onto the coolant container.

5. Add coolant until the coolant level reaches the base of the filler neck. Remove the funnel and wipe up any spilled coolant.

6. Connect the Calorimeter to the ac main power. Turn on the main power switch to start up the fan and the coolant pump.

☞ Note: An alarm may sound until the coolant reaches a sufficient flow rate.

7. The coolant level may drop after the pump has run for a few minutes. Check and refill the coolant reservoir as needed

8. Replace the filler cap and reinstall the top cover on the instrument case, if used.

Equipment Cleaning

Clean the Calorimeter case, RF input connector, front and rear panels, and display window according to the following instructions.

> WARNING
> Do not place compressed air near or directly against skin. Do not use compressed air in excess of 30 psi (207 kPa) when cleaning or drying parts. Improper use of compressed air can cause serious injury or death.

RF Input Connector Use clean, dry, compressed air at 30 psig (207 kPa) maximum pressure to remove loose dirt or metallic particles from the connector. Use a soft cotton swab dipped in a dry cleaning agent to remove grease, oily films, or other stubborn deposits.

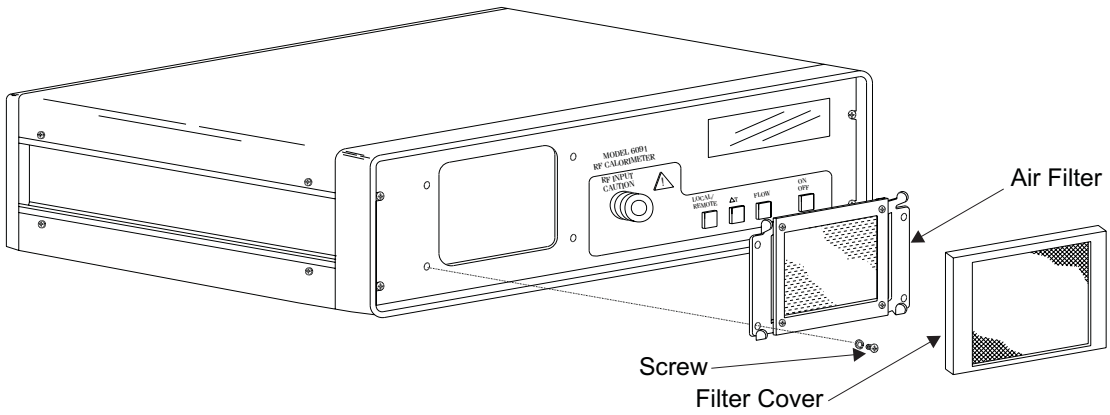
Instrument Case Gently remove loose dirt and grime using a soft clean cloth and warm soapy water. Do not use paint thinner or other solvents that may damage the finish on the surface of the instrument case.

Front and Rear Panels Use a clean, lint-free cleaning cloth and warm soapy water to clean all areas of the panels except for the display window.

Display Window Clean the display window area with a nonabrasive cleaner and a soft, lint-free cleaning cloth.

Figure 14

Air Filter Cleaning



Air Filter Cleaning

Remove and clean the air filter element according to the following instructions. Refer to figure 14.

1. Use the flat blade of a small screwdriver to gently pry off the air filter cover.
2. Remove the four screws and lock washers that secure the air filter to the front panel.
3. Scrub the air filter with hot soapy water until clean. Rinse the filter in a stream of hot water to remove all traces of soap.
4. Reinstall the filter on the front panel using screws and lockwashers removed in step 2.
5. Snap the air filter cover back in place on the front panel.

Drain the Coolant and Replace Coolant Filter

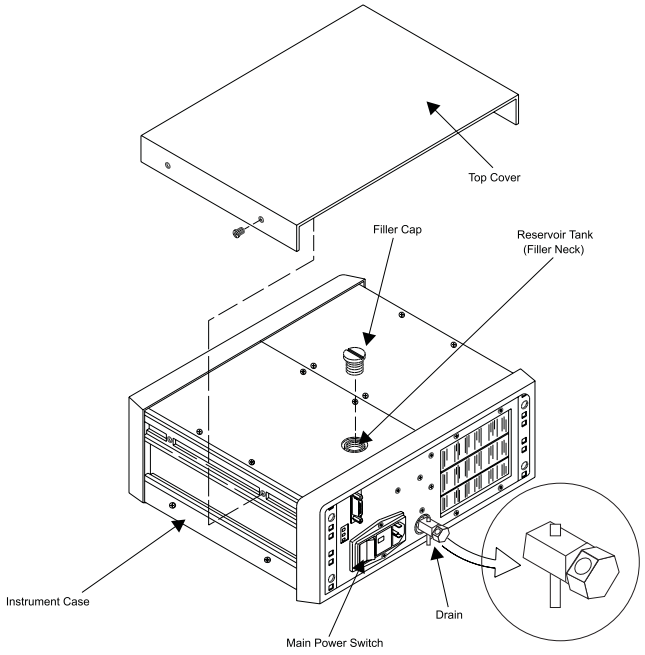
Remove and replace the coolant filter according to the following instructions. Refer to figures 15 and 16.

> WARNING
> Coolant containing ethylene glycol is a potential health hazard. Avoid ingestion, inhaling of vapors and eye and skin contact.

1. Shut down calorimeter unit according to the shutdown procedure.
2. Remove the four screws securing the top cover to the instrument case, if used. Place the Calorimeter unit on a flat surface with the rear panel extending out over the edge.
3. Place a suitable container below the drain tube. With the container in place, remove the reservoir filler cap.
4. Open the drain valve by turning the hex counter-clockwise. Allow all of the coolant to drain from the Calorimeter.

Figure 15

Draining the Coolant



5. Turn the main power switch on to pump the coolant from the instrument. Turn the main power switch off when the coolant stops draining. Close the drain valve and replace the filler cap in reservoir tank.

6. Unplug the ac power cord from the wall outlet or turn the power off at the main disconnect. Then, unplug the ac power cord from the back of the Calorimeter.

7. Remove the front panel mounting screws and slide the Calorimeter unit out of the instrument case or equipment rack.

8. Remove the 11 screws and lockwashers securing the top, right-hand panel. Remove the panel.

9. The coolant filter is attached to the coolant reservoir inside the Calorimeter housing. Unscrew and remove the filter bowl, while being careful not to spill the coolant.

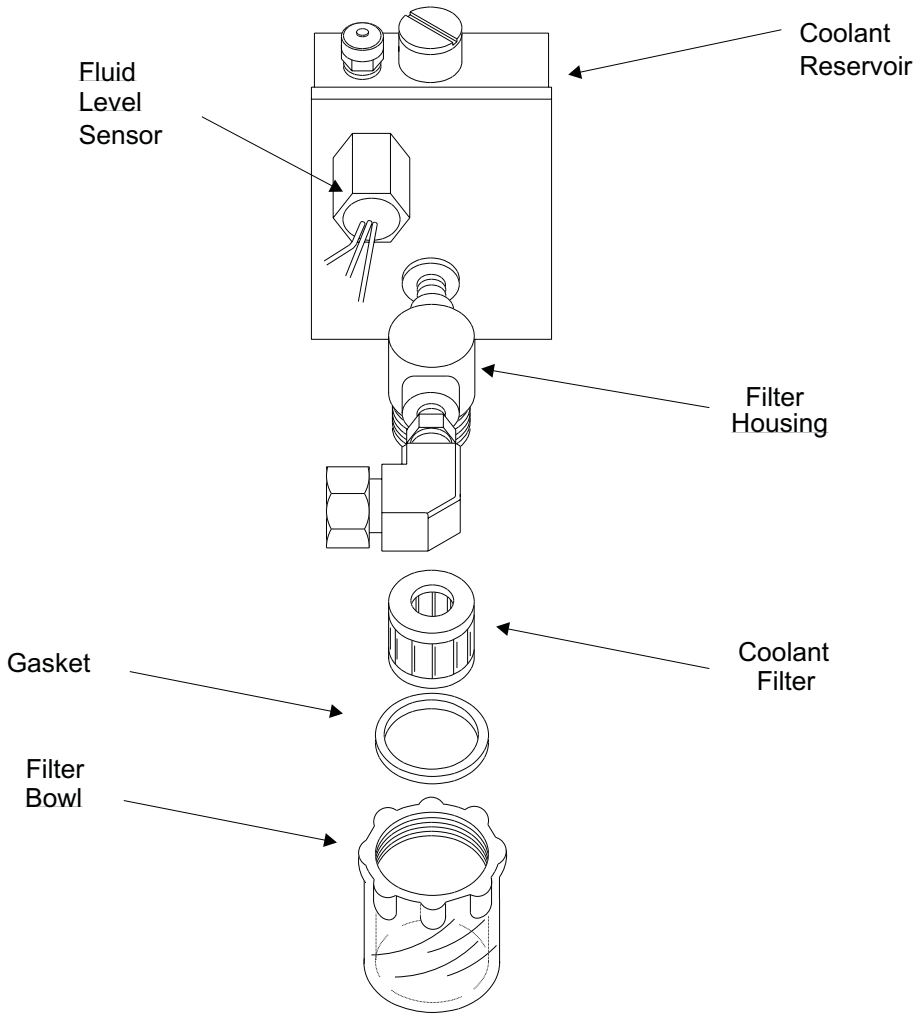
10. Grasp the coolant filter by the black ring and pull it out of the filter bowl. Discard the filter.

11. Throughly rinse the filter bowl and gasket with distilled water. Remove the replacement filter from the service kit.

12. Install the filter and reseat the gasket in the bowl. Screw the filter bowl (finger tight) onto the filter body. Do not over tighten. Wipe up any spilled coolant.

Figure 16

Replacing the Coolant Filter



13. Install the top, right-hand panel with screws and lockwashers previously removed.

CAUTION
Use only premixed coolant Bird part number 6091-120. Use of other solutions will damage the instrument and void all warranties.

14. Refill the coolant tank with fresh coolant per the instructions.

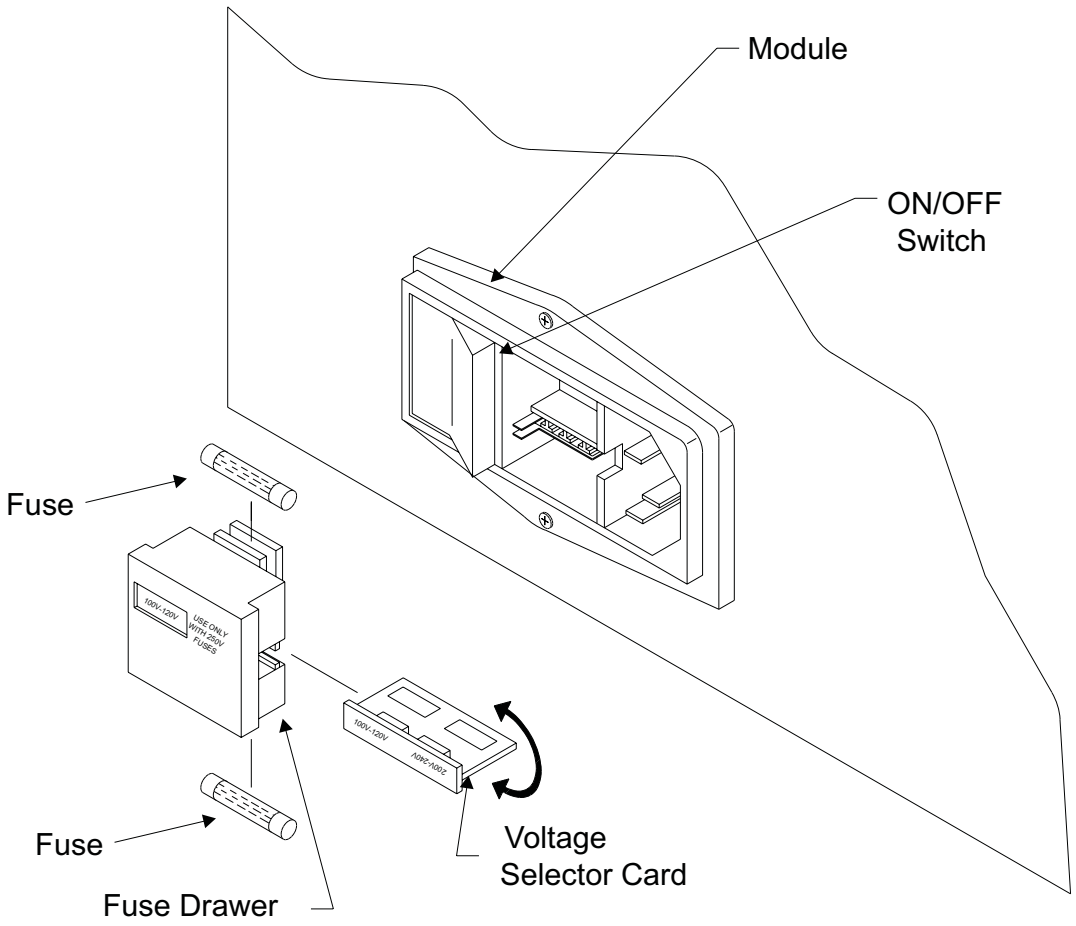
15. Slide the calorimeter unit into the component case or equipment rack and secure with panel mounting screws removed earlier.

Checking Voltage Selector and Power Line Fuses

Follow the steps below and refer to figure 17.

Figure 17

Power Entry Module



1. Unplug the ac power cord from the power entry module.

2. Use a small flat blade screwdriver to gently pry the fuse drawer out of the power entry module.

3. Slide the voltage selector card out of the fuse drawer. Reinsert the card so that the correct line voltage appears in the window.

4. Check the current rating of the fuses with the requirements in table 2 on page 8. Install the correctly rated fuses in the fuse drawer.

5. Reinstall the fuse drawer in the power entry module.

Troubleshooting

Table 5 contains troubleshooting information for problems which can occur during normal operation. Locate the problem, review the possible cause, and perform the corrective action listed.

Table 5

Troubleshooting

Symptom	Probable Causes	Corrective Action
Fan and pump will not operate.	Blown power line fuses.	Check power line fuse and replace if blown.
	Voltage selector set to wrong voltage.	Reset voltage selector.
	Faulty ac power cable.	Repair or replace the cable.
Inaccurate RF power measurements.	Faulty RF power source.	Check power source with another power meter.
	Faulty RF power cable. Dirty RF input or RF power cable connector.	Repair or replace faulty RF cable. Clean the RF input and RF power cable connector.
	Bent or Broken center pin in the RF load resistor.	Return unit to nearest authorized service center.
	Low coolant level.	Check level. If low, add coolant.
	Coolant temperature not stable.	Run Calorimeter 30 minutes without RF power input.
	Unstable room temperature.	Stabilize room temperature to within ±5°C.
ΔT greater than 8.500°C	Excessive RF input power.	Reduce RF power.
	Air intake obstructed.	Clean air filter element.
	Coolant flow rate less than 0.284 liter/min.	Replace the coolant filter.
Coolant flow rate too low.	Low coolant level.	Fill coolant reservoir.
	Blocked coolant filter.	Replace coolant filter.
	Pump or analog controller PC board faulty.	Return unit to the nearest authorized service center.
High load resistor VSWR.	Dirty input connector.	Clean input connector.
	Bent or broken center pin in the RF load resistor.	Return unit to the nearest authorized service center.
	Damaged load resistor.	Check load resistor. If damaged, return unit to the nearest authorized service center.
No response to GPIB controller.	Loose GPIB cable connection.	Connect the GPIB cable.
	Calorimeter set to wrong address.	Check current address of calorimeter unit. If address is incorrect, change the address.
	Incompatible terminator settings.	Default terminator code is a carriage return [CR] followed by a line feed [LF]. If necessary, change the terminator settings.

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

Preparation for Shipment or Storage

The following section provides the special instruction needed to prepare the instrument for shipment or storage.

Storage Requirements

The Calorimeter should be stored in a cool, dry area. Ambient temperature of the storage area must be within °10 to 50°C (50° to 122°F). If storage period is expected to exceed 30 days, drain coolant per the following paragraph. Package the unit per the Packaging section to keep it free of dust and dirt, and to protect it against rough handling.

Draining the Coolant

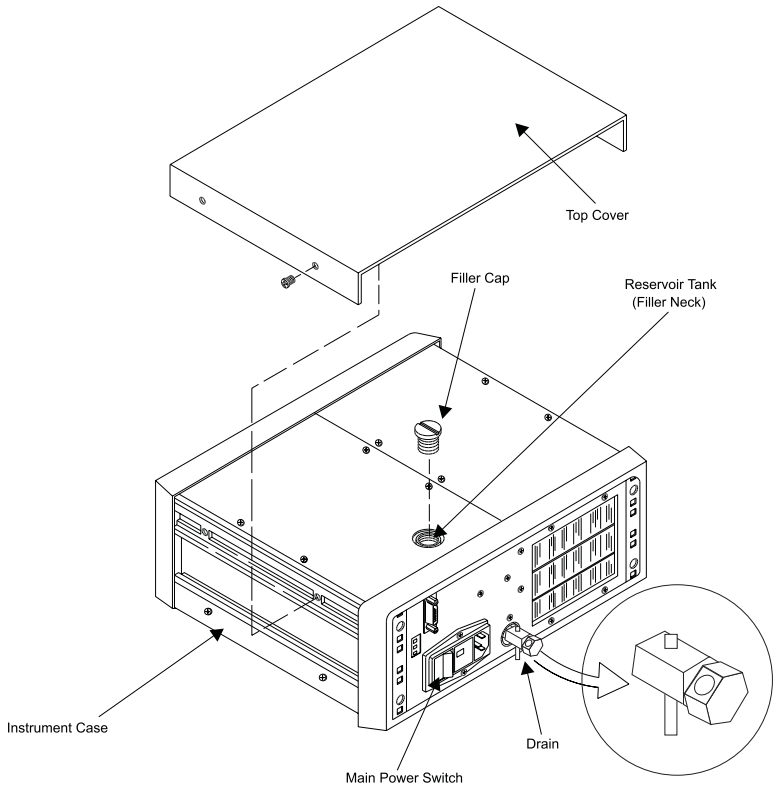
Prior to storing or shipping the Calorimeter, drain the coolant according to the following procedure:

WARNING
Coolant containing ethylene glycol is a potential health hazard. Avoid ingestion, inhaling of vapors and eye and skin contact.

1. Remove four screws securing the top cover to the instrument case, if used. Refer to figure 18.
2. Place the Calorimeter unit on a flat surface with the rear panel extending out over the edge.
3. Place a suitable container below the drain tube. With the container in place, remove the reservoir filler cap and turn the hex on the drain valve counterclockwise to open the drain. Allow all of the coolant to drain from the Calorimeter.

Figure 18

Coolant Draining



4. Turn on the main power switch to pump coolant from the instrument. Turn the power switch off when coolant stops draining.

5. After draining, turn the hex on the drain valve clockwise to close the drain.

Packaging

Package the Calorimeter using the original shipping container. If the original shipping container is not available, use a heavy-duty, corrugated box. Place shock absorbing material around all sides of the instrument to prevent movement during handling or shipment.

Customer Service

Calibration of the Model 6091/6091P RF Power Calorimeter is beyond the scope of these maintenance instructions. For maximum performance and accuracy, the Calorimeter should be calibrated once every six months. Return the unit to the nearest authorized service center for recalibration.

Any maintenance or service procedure beyond the scope of those provided in this section should be referred to a qualified service center. Bird Electronic Corporation maintains complete repair and calibration facilities at the following address.

Sales / Repair Facility

U.S.A. Sales and Manufacturing

Service Group
Bird Electronic Corporation
30303 Aurora Road
Cleveland (Solon), Ohio 44139-2794
Phone: (440) 248-1200
Fax: (440) 248-5426

Sales Offices

For the location of the nearest sales office, give us a call or visit our Web site at:

http://www.bird-electronic.com

Parts List

Qty.	Description	Part Number
1	Calorimeter, RF power, Model 6091 - Complete	6091-001
1	*Calorimeter Subassy, RF power	6091-002-1
1	*Case, Instrument	6091-080
1	Hardware, mounting	6091-081
1	Cord Assembly, power	4421-055
1	Cable, GPIB, 2-meter	5-1317-2
1	Instruction Book	920-6091-1
1	Kit, Service	6091-097
1	Coolant	6091-120
1	Filter Cartridge	5-2054

*RF Power Calorimeter, Model 6091P does not include these items.

Appendix A

Remote Operating Procedures

The following instructions explain how to use the GPIB feature to remotely control the calorimeter. All front panel key functions, except the display ON/OFF, can be controlled via the GPIB. Before proceeding with the remote operating procedures make sure you are throughly familiar with the normal operating procedures of this equipment.

Sample GPIB program statements are included for two of the more common GPIB controllers; National GPIB-PCII and Hewlett Packard Model 9000, Series 200/300. The National GPIB-PC is a controller card that installs into an expansion slot of an IBM PC/XT/AT or compatible computer. The HP 9000, Series 200/300 is a stand alone scientific computer. In each sample statement, it is assumed that the device address code is set to 24.

All sample statements are presented in the BASIC/BASICA programming language. For National GPIB-PC programs, UD% is the Calorimeter unit descriptor and BRD% is the controller card descriptor. Consult National GPIB-PCII documentation for more information about the UD% and BRD% descriptors.

GPIB Overview

The general purpose interface bus (GPIB) is a standard cable for parallel control of electronic equipment. Up to 15 pieces of equipment can be controlled and monitored for automated testing or data retrieval. A GPIB controller, usually a computer, is used to take over instrument controls and retrieve measurement data.

GPIB Capabilities

The Calorimeter's GPIB capabilities comply with the requirements of IEEE-488 1978, Standard Digital Interface For Programmable Instrumentation. Table 6 lists the GPIB capabilities supported by the calorimeter.

Table 6
GPIB Capabilities

Function	Level Supported	Description
Source Handshake	SH1	Complete capability
Acceptor Handshake	AH1	Complete capability
Talker	T6	Basic talker, serial poll and unaddressed if MLA
Listener	L4	Basic listener and unaddressed if MTA
Service Request	SR1	Complete capability
Remote Local	RL1	Complete capability
Parallel Poll	PP0	No capability
Device Clear	DC1	Complete capability
Device Trigger	DT1	Complete capability
Controller	C0	No capability
Extended Talker	TE0	No capability
Extended Listener	LE0	No capability

GPIB Commands

The activity on the bus is managed under the control of messages or commands. The instruments operation is divided into two sets of function; general interface functions and device dependent functions. General interface functions insure the instrument responds correctly with respect to the GPIB signal lines. Device dependent functions are used for specific instrument control, such as taking a power measurement.

General Interface Commands

Table 7 below lists general GPIB interface commands applicable to the calorimeter. The syntax for executing general commands varies among controllers; check the documentation supplied with your controller for the proper command structure.

Table 7

General Interface Commands

Command	Syntax	Function
Remote ENable	REN	Enables remote operation.
Go To Local	GTL	Enables local operation.
Local LockOut	LLO	Disables local operation.
InterFace Clear	IFC	Ends bus activity, returns control to GPIB controller.
Device CLear	DCL	Resets device command status.
Selective Device Clear	SDC	Clears command status of selected devices.
Group Execute Trigger	GET	Starts measurement cycle for devices set to trigger on GET.
Serial Poll Enable	SPE	Send device status bytes to controller.
Serial Poll Disable	SPD	Clears controller status bytes and turns off serial poll.

Remote **EN**able (REN)

Function

Enables remote operation.

Remarks

Unit must be addressed to listen after setting REN true.

Remote annunciator lights when device is remoted.

Flow, ΔT, ON/OFF buttons are disabled.

Press LOCAL/ADDRESS button to return to local mode.

Statements

National GPIB-PCII

```
V%=1
CMD$=CHR$(56)
CALL IBSRE (BRD%,V%)
CALL IBWRT (BRD%,CMD$)
```

HP 200/300

```
REMOTE 724
```

Go **T**o **L**ocal (GTL)

Function Returns device to local operation.

Remarks Press LOCAL/ADDRESS key to manually enable local operation.

Issuing a GTL command while the device is in Local Lockout mode does not clear the lockout condition.

Statements

National GPIB-PCII	**HP 200/300**
Call ILLOC (UD%)	LOCAL 724

Local **LO**ckout (LLO)

Function Disables local operation of all devices on the bus.

Remarks LOCAL/ADDRESS key will not function in the local lockout mode.

LLO is cleared by setting REN false.

Statements

National GPIB-PCII	**HP 200/300**
MDE$=CHR$(17) CALL IBCMD (BRDO.MDE$)	LOCAL LOCKOUT 7

InterFace Clear (IFC)

Function Terminates all bus activity and passes control to system controller.

Remarks All devices set to talker and listener idle states.

The National card sends IFC with the first device command.

Statements

National GPIB-PCII	HP 200/300
CALL IBSIC (UD%)	ABORT 7

Device Clear (DCL)

Function Resets the status of all devices to an initialized state.

Remarks Calorimeter returns to the default condition as listed below:

WA	RF POWER MODE
YT	TWO TERMINATORS (CR) (LF)
PY	SEND PREFIXES
T1	TRIGGER ONE SHOT ON TALK
KY	EOI ENABLED
M00	SRQ MASK OFF

Statements

National GPIB-PCII	HP 200/300
MDE$=CHR$(14) CALL IBCMD (BRDO%,MDE$)	CLEAR 7

Selective **D**evice **C**lear (SDC)

Function Clears the status of a selected device to an initialized state.

Remarks Only the device addressed will be cleared.

Calorimeter returns to the default condition.

Statements

National GPIB-PCII	**HP 200/300**
IBCLR (UD%)	CLEAR 724

Group **E**xecute Trigger (GET)

Function Initiates a measurement cycle for all devices previously set to trigger on GET.

Remarks Calorimeter must be set to trigger on GET.

Used to synchronize measurements of multiple instruments.

Statements

National GPIB-PCII	**HP 200/300**
CALL IBTRG (BRD%)	TRIGGER 7

Serial **P**olling **E**nable/**D**isable (SPE/SPD)

Function

Issued by controller to enable or disable the serial poll sequence.

> CAUTION
> During remote operation, periodically monitor the bus service request line. Failure to detect the service request can result in major equipment damage.

Remarks

SPE command puts all devices in serial poll mode waiting to be addressed.

When addressed device issues status byte to controller.

State of bit 6 of status byte determines service requirements. (Refer to the status byte section in this appendix.)

bit 6 = 1 service required

bit 6 = 0 no service required

Service request line not asserted for Command Error (bit 0) or Command Complete (bit 3) conditions until after device is triggered.

SPD command clears status byte and ends serial poll sequence.

Statements

National GPIB-PCII	**HP 200/300**
IBRSP (UD%,SPR%)	P=SPOLL(724)
Note: Decimal value of status byte is returned in variable SPR%.	Note: Decimal value of Status byte is returned in variable P.

Device Dependent Commands

GPIB commands specific to a piece of equipment are known as device dependent commands. The device dependent commands supported by the 6091/6091P Calorimeter are listed in Table 8.

Procedures for sending the device dependent commands are provided in the Sending Device Dependent Commands section of this Appendix.

Table 8

Device Dependent Commands

Category	Command	Function
Measurement	WA*	Watts
	FL	Flow rate
	IN	Input coolant temperature
	OU	Output coolant temperature
	DT	Delta coolant temperature
Terminator	YT*	Two terminators; [CR] [LF]
	YO	One terminator; [CR]
	YN	No terminators
EOI on/off	KY*	Turn on EOI signal
	KN	Turn off EOI signal
Prefix	PY*	Turn on data prefix
	PN	Turn off data prefix
Trigger	T0	Continuous on Talk
	T1*	One shot on Talk
	T2	Continuous on GET
	T3	One shot on GET
	T4	Continuous on measurement command
	T5	One shot on measurement command
SRQ Mask	Mxx*	Mask xx (0 to 63) - default is 38
Self-Test	J0	Starts self-test
Status	U0	Return Machine Status word
	U1	Return Error Status word
	U2	Return Revision History word
Writeable Store	WSxxxxxx	Store 6 bytes of ASCII data in RAM

*denotes power-up default setting

WAtts (WA)

Function

Selects RF power measurement mode.

Remarks

Measurement results are returned in Watts.

Statements

National GPIB-PCII

```
LET CMD$="WA"
CALL IBWRT (UD%,CMD$)
```

HP 200/300

```
OUTPUT 724; "WA"7
```

FLow rate (FL)

Function Selects coolant flow rate measurement mode.

Remarks Measurement results are returned in liters per minute.

Statements

National GPIB-PCII	**HP 200/300**
Let CMD$="FL" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "FL"

INput temperature (IN)
OUtput temperature (OU)
Delta **T**emperature (DT)

Function Selects input, output or delta temperature measurement modes.

Remarks Measurement results are returned in degrees Celsius.

Input temperature is the temperature of the coolant entering the load resistor.

Output temperature is the temperature is the temperature of the coolant leaving the load resistor.

Delta temperature is the output temperature minus the input temperature. (DT = OU - IN)

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="DT" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "DT"

Terminators (Yx)

Function

Selects the terminating characters that follow the end of data string.

Set x to:

"T" for Two terminators; a C_R (carriage return) followed by a L_F (line feed).

"O" for One terminator; a C_R (carriage return).

"N" for No terminators. Message can be terminated by EOI.

Remarks

Many controllers use the terminator sequence to recognize the end of an input sequence. Use of an improper terminator sequence can cause the bus to hang up.

On power up or following DCL/SDC, the default setting is for two terminators (YT).

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="YT" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "KY"

End **O**r **I**dentify (EOI) mode (Kx)

Function

Enables or disables End or Identify signal.

Set x to:
"Y" for enable

"N" for disable

Remarks

Calorimeter assert EOI line only to indicate the end of a multiple byte data string.

On power up or following DCL/SDC, EOI is enabled.

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="KY" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "KY"

Prefixes (Px)

Function

Turns the prefix mode on or off.

Set x to:
"Y" for enabling prefix messages.
"N" for suppressing prefix messages.

Remarks

Prefixes indicate status of current measurement.
"N" (Normal) prefix when reading is within ±3% of final value.
"Y" (Transient prefix when reading is not stable.

On power up or after DCL/SDC, default is prefix mode on "PY".

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$ = "PY" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "PY"

Triggers (Tx)

Function

Selects the type of stimulus on which the instrument will trigger to initiate a measurement.

Set x to:
"0" for continuous on Talk.
"1" for one shot on Talk.
"2" for continuous on GET.
"3" for one shot on GET.
"4" for continuous on measurement command. (WA, FL, IN, OU or DT)
"5" for one shot on continuous measurement command. (WA, FL, IN, OU or DT)

Remarks

Failure to trigger device before requesting a reading will lock up the bus.

T0 or T1 trigger. The measurement is triggered when the Calorimeter is addressed to talk.

T1 trigger. Halts bus until reading is available.

T4 and T5 trigger. Reading is triggered only after receiving a measurement command.

On power up or following DCL/SDC, the default trigger mode is one shot measurement on Talk (T1).

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="TO" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "T0"

SRQ Mask (Mxx)

Function

Selectively masks status bits to prevent unwanted service requests.

		32	16	8	4	2	1	Binary Value
0	0	1/0	1/0	1/0	1/0	1/0	1/0	

Bit:	Message:
0	Command Error
1	Flow Error
2	ΔT above 8.500°C
3	Command complete
4	Low coolant level
5	Coolant temp. above 41.6°C
6	Can't mask
7	Not used

Remarks

Valid range of xx is 0 to 63. Bit 6 (value 64) will not mask.

If status bit is masked (bit = 0), then SRQ will not be asserted.

On power up or after DCL/SDC, default is M38.

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="M04" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "M04"

Self Test (J0)

Function

Initiates a bus hardware and software test.

Remarks

The results of self test are contained in bytes 15 and 16 of the Error Status word.

"J0" must be issued before reading the result.

On power up or after DCL/SDC, default status of self test result is FL (fail).

Statements

National GPIB-PCII	**HP 200/300**
LET CMD$="J0" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "J0"

Status Words (Ux)

Function

Read one status word and return information in character string.

Set x to:
"0" for Machine Status
"1" for Error Status
"2" for Revision History

Machine Status Word (U0) - Contents include current operating parameters. To ensure correct status is issued, this status word should be requested as soon as possible after command is sent. Operator may choose to record this data for re-configuration of device to previous parameters.

Machine Status Word:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
-	6	0	9	1	-	W	A	P	Y	Y	T	T	1	M	0	0	K	Y	CR	LF	
																					Terminators per bits 12 & 13 EIO (KY, KN) SRQ Mask (M00 to M63) Trigger (T1 through T5) Terminator (YT, YO, YN) Prefix (PY, PN) Measurement Command (WA, FL, IN, OU, DT) Header

Status Words (Ux) (Continued)

Function

Error Status Word (U1) - Contents indicate validity of command or command options. Used in conjunction with bit 0 of the status byte to determine what command condition asserted a command error. ASCII characters used to indicate command condition are described as follows:

VCM - Valid device dependent command has been received by device.

ICM - Invalid device dependent command has been received, such as V2 (V is illegal).

VCO - Valid device dependent command option has been received by device.

ICO - Invalid device dependent command option has been received, such as T6 (6 is illegal).

Error Status Word:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
-	6	0	9	1	-	V	C	M	Sp	V	C	O	Sp	P	S	Sp	CR	LF	
																			Terminators Space Self Test Results (PS - Pass, FL - Fail) Space Command Option Status (VCO - Valid, ICO - Invalid) Space Command Status (VCM - Valid, ICM - Invalid) Header

Status Words (Ux) (Continued)

Function

Revision History Word (U2) - Contents include current six bytes contained in writeable store, hardware and software revision levels and the revision level of the IEEE-488 standard being implemented by the Calorimeter for GPIB programming.

If Calorimeter requires repair, supply hardware and software revision level to service center.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
-	6	0	9	1	-	X	X	X	X	X	X	Y	Y	Z	Z	7	8	A	A	CR	LF	
																						Terminators Address IEEE-488 1978 Hardware Revision Software Revision Writeable Store Header

Remarks

Status word returned only once for each Ux.

Machine Status - A 19 character string containing the current command settings.

Error Status - A 17 character string that indicates valid/invalid commands and command options as well as results from the self-test (J0).

Revision History - A 20 character string containing hardware and software revision levels, writeable store data and the current instrument address.

Statements

National GPIB-PCII

```
Let CMD$="U1"
CALL IBWRT (UD%,CMD$)
```

HP 200/300

```
OUTPUT 724; "U1"
```

Writeable Store (WSxxxxxx)

Function Temporary storage for six bytes of ASCII data.

Remarks All six bytes need to be sent each time.

Data stored is lost when the Calorimeter is turned off.

On power up and after DCL or SDC, storage is filled with ASCII null characters (00 hex).

Statements

National GPIB-PCII	**HP 200/300**
Let CMD$="FL" CALL IBWRT (UD%,CMD$)	OUTPUT 724; "FL"

Status Byte Format A typical status byte (binary, 8-bit string) for the Calorimeter is shown in figure 19 with a list of the associated status bit messages. When a status bit is set to one (1=true), the condition indicated by the message is valid. When the status bit is aero (0=false), the condition is not valid.

> CAUTION
> During remote operation, periodically monitor the bus service request line. Failure to detect the service request can result in major equipment damage.

Figure 19 Status Byte

0 1 0 1 0 0 0 0 Shows service required due to low coolant level

Bit:	Message:
0	Command error
1	Flow error
2	ΔT above 8.500°C
3	Command Complete
4	**Low coolant level**
5	Coolant temperature above 41.6°C
6	**Require Service**
7	Not Used

Sending Device Dependent Commands

The controller sends commands over the bus to control the Calorimeter. More than one command can be grouped together and sent at the same time. the following examples demonstrate how to send device dependent commands. The first set of examples sends the Watts command to the Calorimeter. The second example sends the Watts command and also turns off prefixes and sets the trigger to continuous on Talk.

National GPIB-PCII	**HP 200/300**
LET CMD$="WA"	OUTPUT 724;"WA"
CALL IBWRT (UD%,CMD$)	
or	
LET CMD$="WAPNT0"	OUTPUT 724;
CALL IBWRT (UD%,CMD$)	"WAPNT0"

Receiving Data

Measurement results are returned to the controller in a 16-bit ASCII character string. The following demonstrate how to enter the measurement data and shows the content and format of the character string. Measurement data is entered into string variables, RD$.

National GPIB-PCII	**HP 200/300**
140 RD$=SPACE$(16)	90 ENTER 724;RD$
150 CALL IBRD (UD%,RD$)	

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
N	W	A	Sp	Sp	1	0	2	.	5	5	W	Sp	Sp	CR	LF	
																Terminators (CR or CR, LF) Units (W,C, l/m) Numeric Data Space or "-" Sign Space Measurement Command (WA, FL, IN, OU, DT) Stable Read Indicator (N - Normal, T- Transient)

Sample Test Programs

The following sample programs illustrate GPIB command Structure and data format for operation of the Calorimeter in the remote mode.

National GPIB-PCII:

```
10  REM INCLUDE LINES 20 THROUGH 40 (SUPPLIED WITH THE NATIONAL CONTROLLER)
20  CLEAR ,60000! : IBNIT1=60000! : IBINT2=IBINT1+3 : BLOAD "bib.m", IBINT1
30  CALL    IBINIT1(IBFIND, IBTRG, IBCLR, IBPCT, IBSIC, IBLOC, IBPPC, IBBNA, IBONL, INRSC,
    IBSRE, IBRSV, IBPAD, IBSAD, IBIST, IBDMA, IBEOS, IBTMO, IBEOT, IBRDF, IBWRTF, IBTRAP,
    IBDEV, IBLN)
40  CALL    IBINT2(IBGTS, IBCAC, IBWAIT, IBPOKE, IBWRT, IBWRTA, IBCMD, IBCMDA, IBRD, IBRDA,
    IBSTOP, IBRPP, IBRSP, IBDIAG, IBXTRC, IBRDI, IBWRTI, IBRDIA, IBWRTIA, IBSTA%, IBERR%,
    IBCNT%)
50  REM CLEAR SCREEN
60  CLS
70  PRINT "TYPE END TO QUIT PROGRAM"
80  REM DEFINE DEVICE AND BOARD PARAMETERS
90  BI%=0:PAD%=24;SAD%=0:TMO%=13:EOT%=1:EOS%=&H40a:BRD%=0
100 CALL IBDEV(BI%,PAD%,SAD%,TMO%,EOT%,EOS%,BRD%)
110 REM SEND INTERFACE CLEAR
120 CALL IBCLR (BRD0%)
130 REM SEND COMMAND TO DISABLE TERMINATORS
140 CMD$="YN":CALL IBWRT(BRD%,CMD$)
150 REM ENTER COMMAND STRING
160 INPUT "COMMAND STRING";CMD$
170 CMD$="END" THEN 260
180 REM WRITE COMMAND STRING TO DEVICE
190 CALL IBWRT(BRD%,CMD$)
200 REM DEFINE READ STRING AND READ DATA
210 RD$=SPACE$(36)
220 CALL IBRD(BRD%,RD$)
230 REM PRINT DATA AND LOOP TO COMMAND STRING INPUT
240 PRINT RD$
250 GOTO 160
260 END
```

HP 200/300:

```
10    ! REMOTE THE DEVICE
20    REMOTE 724
30    ! SEND COMMAND TO DISABLE TERMINATORS
40    OUTPUT 724;"YN"
50    ! ENTER COMMAND STRING
60    PRINT "TYPE END TO QUIT PROGRAM"
70    INPUT "COMMAND=",C$
80    IF C="END" THEN 150
90    OUTPUT 724;C$
100   ! READ DATA
110   ENTER 724;V$
120   ! PRINT DATA AND LOOP TO COMMAND STRING INPUT
130   PRINT V$
140   GOTO 70
150   END
```

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.

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