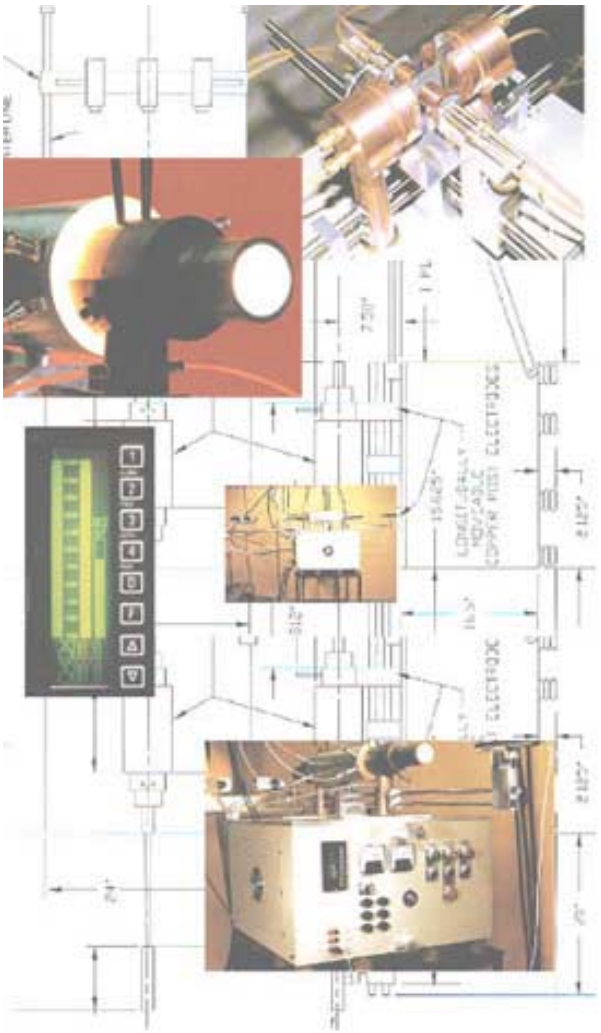
Thermo Gauge Instruments Inc.



PRECISION BLACKBODIES

CATALOG 38

Table of Contents

1 Introduction 3
1.1 Company Profile 3
1.2 The Rapid Heating Concept 3
1.3 Furnace Overview 3
2 System Description 4
2.1 Power Supply 4
2.1.1 Electrical: 5
2.1.2 Cooling: 5
2.1.3 Gas purge: 5
2.1.4 Interlocks: 5
2.1.5 Mechanical Dimensions: 6
2.2 Modular Blackbody Assemblies: 7
2.3 Flat Plate Assembly: 8
2.4 Temperature Controller: 9
2.5 Options And Accessories: 10
2.5.1 Optical rail bench: 10
2.5.2 Aperture wheel: 10
2.5.3 Emittance measurement apparatus: 10
2.5.4 Remote mounted Blackbody: 11
2.6 System Upgrades: 11
2.6.1 HT-7000A and Exactus:™ 11
2.6.2 Field replaceable graphite parts: 11
3 Specifications: 12
4 How To Order: 13
5 Replacement Parts: 15
5.1 5/8" Blackbody 15
5.2 1" Blackbody 16
5.3 1.5" Blackbody 17
5.4 2" Blackbody 18

Thermo Gauge Instruments, Inc.
P.O. Box 1457
Fort Ashby, WV 26719
Phone: (304) 298-3769
Fax: (304)-298- 4509
Web: www.thermogauge.com

Copyright 2003 Thermo Gauge Instruments, Inc.

1 Introduction

Our precision Blackbodies are used worldwide by those who know thermal radiation sensors and their calibration needs.

Laboratory Blackbodies approximate Max Planck's ideal. We strive to provide the closest approximation for precise sources of Blackbody thermal radiation that a reasonable budget can provide.

1.1 Company Profile

Thermo Gauge Instruments, Inc. is a manufacturing corporation exclusively oriented to the science of thermal technology. The company goal is to provide customers' with the tools necessary to make fast and accurate temperature measurements at the best dollar value.

Thermo Gauge Blackbody furnaces were pioneered by furnace designer and inventor Chuck Brookley. Some of the original models, nearly 30 years old, are still in use today. Since then Thermo Gauge has constantly made improvements to help set the standard for Blackbody calibration.

1.2 The Rapid Heating Concept

The classical furnace concept is to use a highly insulated heater element and a small power supply which will slowly pump up the heater element to the desired temperature. This design results in the most economical furnace cost. The slowest of these designs take hours to heat up and/or change temperature. The fastest of these designs are not much better. Ideally, in the calibration of thermal instrumentation, a series of temperature steps are needed which can be changed in rapid succession. The Thermo Gauge furnaces are designed to fulfill this requirement and can achieve temperature step changes which are measured in seconds.

The Thermo Gauge calibration furnace concept is based on the principle of direct resistance heating of a graphite heater element using large AC currents and low voltages to put large amounts of power into a poorly insulated heater element. The graphite heater element is poorly insulated so that it can cool down almost as fast as it heats up. The Thermo Gauge concept significantly reduces the man-hours required to obtain the necessary measurements.

1.3 Furnace Overview

All Thermo Gauge furnaces have moveable copper electrode posts which can be expanded or contracted to accommodate modular hater element assemblies of different lengths. Normally, the two copper electrode posts project up through slots in the top plate of the power supply. However, for those applications where the heater element assembly must be used in a variety of positions, the electrodes can be mounted on a separate plate that is connected to the power supply by flexible power cables. The modular heater element assembly concept increases the versatility of the furnaces since the furnaces can accept a variety of heater element assemblies of different geometries.

Basically, there are just two heater element designs which are used in the Thermo Gauge calibration furnace. They are tubular designs and flat plate designs. All of the heater elements are designed for quick and simple attachment to the end caps by the user in the field. This eliminates the requirement of return to the factory for replacement of heater elements or any other graphite part.

Since graphite is easily oxidized, inert gas is fed into each end cap of a tubular assembly, part of which eventually exits as a purging shield at the mouth of each end cap. Purge gas is also routed

into the graphite felt and graphite tape insulation which surrounds the outside of the tubular heater element. This insulation is encased in a transparent quartz tube that engages both end caps.

2 System Description

All Thermo Gauge calibration systems are made up of a power supply and heater element assembly. The heater element assembly is either a tubular, dual cavity blackbody or tube, or a flat plate. The Dual Blackbody heater element is used for optical thermometer calibration and some heat flux calibration. The flat plate assembly is used only for heat flux calibration. The power supply makes up most of the system and all power supplies can be set up with all heater element assemblies.

Blackbody calibration systems also require a closed loop control system. The temperature sensor is optical and the controller is all digital with a temperature and set point display. The control system has a very large influence on the system stability, accuracy, and overall performance. For this reason Thermo Gauge custom builds a temperature controller, HT-7000A, to address the specific requirements of the system.

2.1 Power Supply

HT-5500 or HT-9500
Blackbody Power Supply
With Enclosed Blackbody

2.1.1 Electrical:

All Thermo Gauge power supplies operate on single phase 50/60 Hz AC. The voltage of operation is chosen by the customer and can be anywhere from 208V to 480V. This is a standard service that is offered at no additional cost. The highest voltage that can be provided by the customer facility should be used. The electrical connection is made by hard wiring the furnace to the electric service by the customers plant personnel or a qualified electrical contractor.

The electrical power is controlled from the front panel and by the temperature controller. The front panel has three buttons; emergency off (which is used as normal off), standby, and run. The standby mode applies control power inside the cabinet but does not turn on the high power. This allows the interlock indicators to function so the operator can check the interlock status before continuing.

If all the interlocks are clear and the run button is pressed the high power will be turned on. The selector switch selects external or manual power control. In external the furnace is controlled by the temperature controller. In manual the furnace is controlled by the rotary knob on the front panel. In most cases the system will only be used in the external mode, but for special application the manual mode used.

2.1.2 Cooling:

The systems also require cooling water. The cooling water does two primary functions. The first of which is to cool the copper end caps, transformer, and electrode posts. The second is to cool the reflector jacket that surrounds the blackbody. The water cooling of the reflector jacket has the great advantage of removing unwanted heat from the calibration room and reducing the temperature inside the furnace cabinet. All cooling water plumbing is inside the cabinet and hard copper pipe is used whenever possible to reduce system maintenance. The cooling water connection is on the back of the furnace and has one inlet and one outlet.

A re-circulation cooling system is recommended to minimize contaminates to the system and conserve cooling water. The re-circulation system is very simple and consists of a large volume storage tank and water pump. The advantage is after installation the operation cost is only the cost of running the pump.

If plant chilled water or tap water is used it should be filtered to prevent contamination.

2.1.3 Gas purge:

Purge gas is also required. Again all purge gas plumbing is inside the cabinet and the connection is on the back of the furnace.

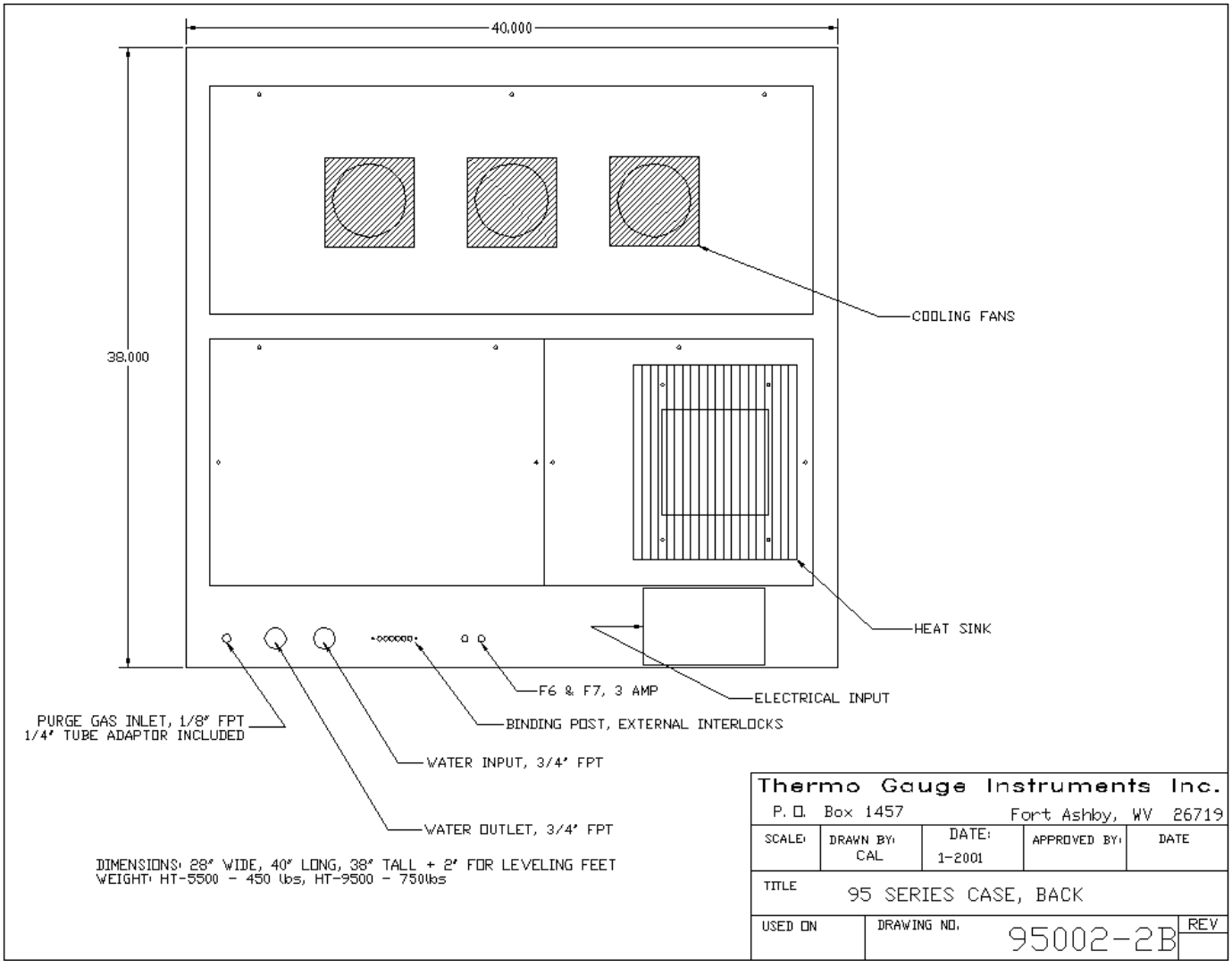
2.1.4 Interlocks:

To protect the furnace from operating without proper cooling or purge gas it is equipped with an interlock system. The interlock system has indicators on the front panel and prevents furnace operation if the cooling water flow is low, or the cooling water temperature is high, or the purge gas flow is low, or an external interlock is open. If any on the interlocks become active while the furnace is operating the system will shut down (return to standby mode) and require an operator to restart.

The external interlock binding post is located on the back of the furnace and can be used by the customer to add as many interlocks as needed. The binding post also has a SPDT relay contact that operates with the interlock. This can be used to sound an alarm or other application.

2.1.5 Mechanical Dimensions:

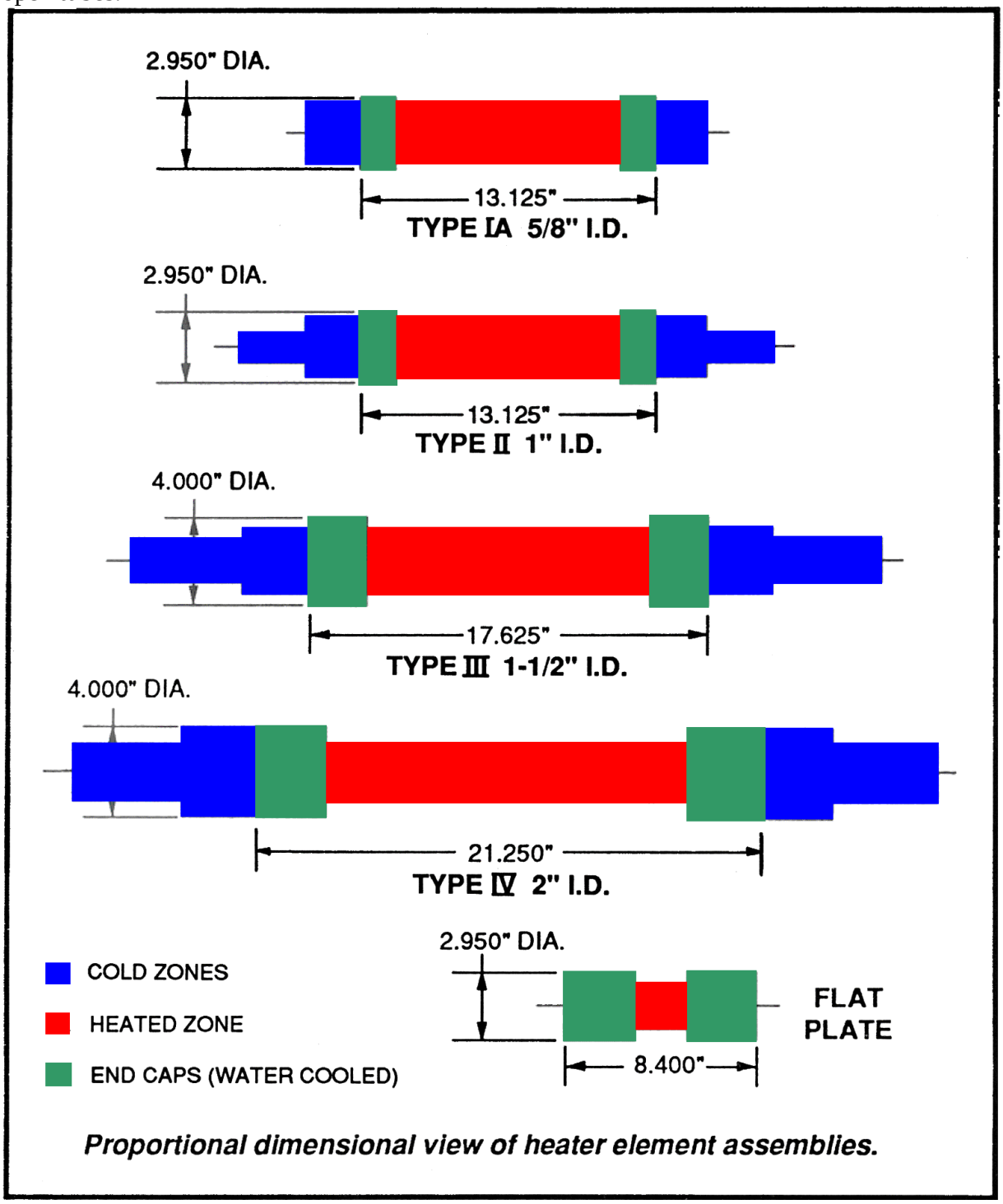
HT-5500 and HT-9500 mechanical dimensions.



2.2 Modular Blackbody Assemblies:

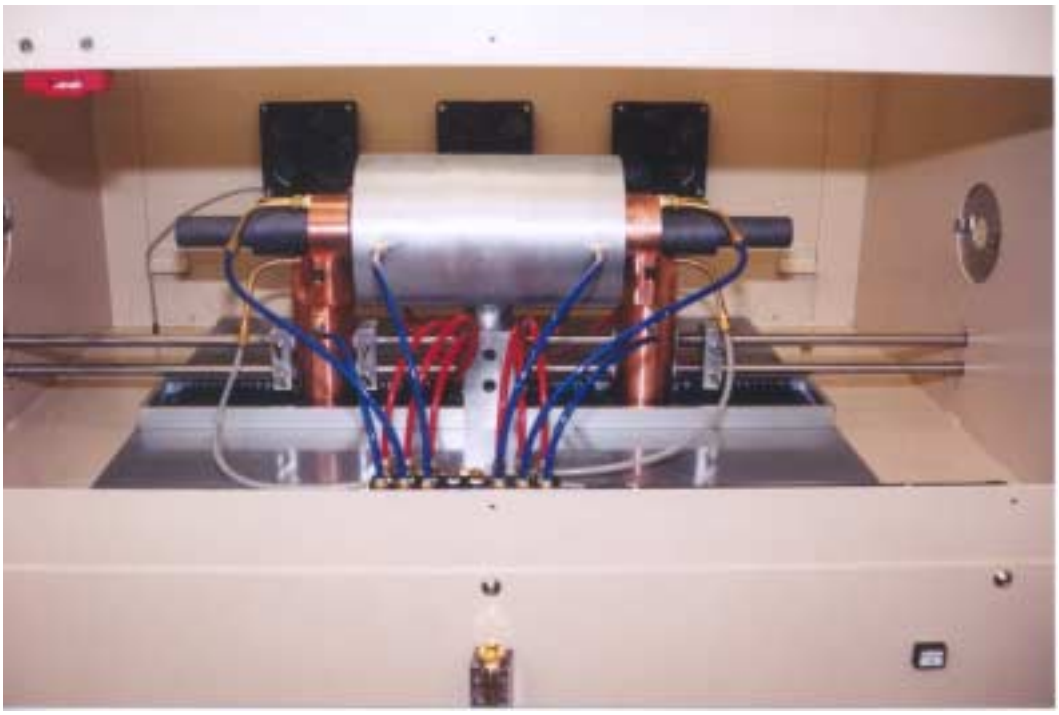
Each modular heater element assembly utilizes two water-cooled copper end caps between which the heater element is mounted. These water-cooled copper end caps are cylindrical in shape and are bolted directly to copper cradles attached to the top of each electrode post. Water cooling of the end caps in necessary to maintain physical integrity.

The modular heater element assembly concept increases the versatility of the furnaces since the furnaces can accept all of the different assemblies made by Thermo Gauge. Below is a sketch of all the heater element assemblies. All of the tubular designs can be either dual Blackbody cavities or open tubes.



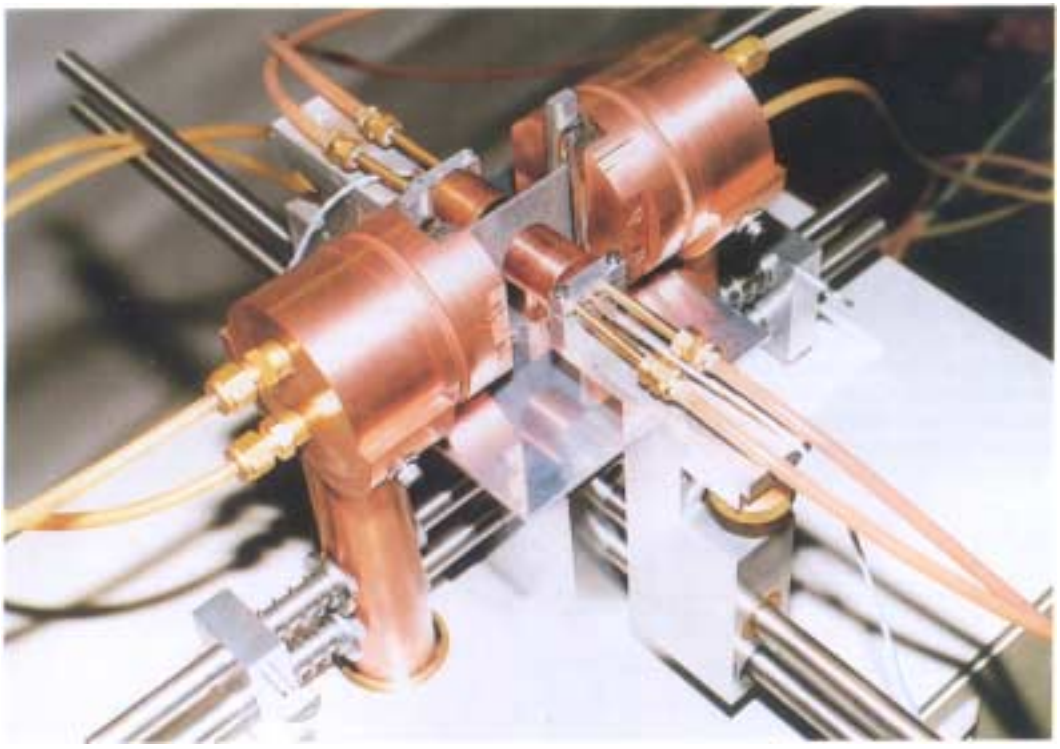
Proportional dimensional view of heater element assemblies.

This is a pictured of an assembled 1” type II dual cavity Blackbody. The assembly is mounted on a HT-9500 and the front cover panel is removed. Notice how easy it is to access the water cooling tubing (color coded red and blue) and the available space for maintenance.



2.3 Flat Plate Assembly:

The flat plate assembly, shown below, is used to calibrate heat flux gages. Two gages are mounted on opposite sides of the graphite plate, equal distances from the plate, and coated with a common high absorptivity paint. Power is gradually applied to the plate and the output signal from both gages are recorded.



2.4 Temperature Controller:

The model HT-7000A is a high precision PID furnace controller specifically designed to be used with the Thermo Gauge Instruments, Inc. Blackbody furnaces and the Exactus™ optical pyrometer. The combination of the HT-7000A controller and the Exactus™ pyrometer make a repeatable, stable system that is used for precision high temperature work.

The controller operates stand alone and is dedicated to maintaining the temperature of the Blackbody. A RS-232 port is provided to allow the user to monitor the Blackbody temperature and change the set point with an external computer. In this way the Blackbody is independent of other data recording computers but the lab can be automated.

Features:

- Blackbody temperatures in °C, °F or K with 0.1° resolution.
- Set point temperature in °C, °F or K with 0.1° resolution.
- User selectable set point increments of 1, 10, and 100°C.
- One button increment or decrement. Increase or decrease set point with one key press.
- Numeric keypad to enter set point and other data.
- Standard RS-232 port for monitoring blackbody temperature and changing the set point by remote computer.
- True all digital controller. The controller has no analog calibration and no analog error.
- 4 line by 20 character LCD display that simultaneously shows
    - Blackbody temperature
    - Set point temperature
    - Increment step size

Exactus™ optical pyrometer:

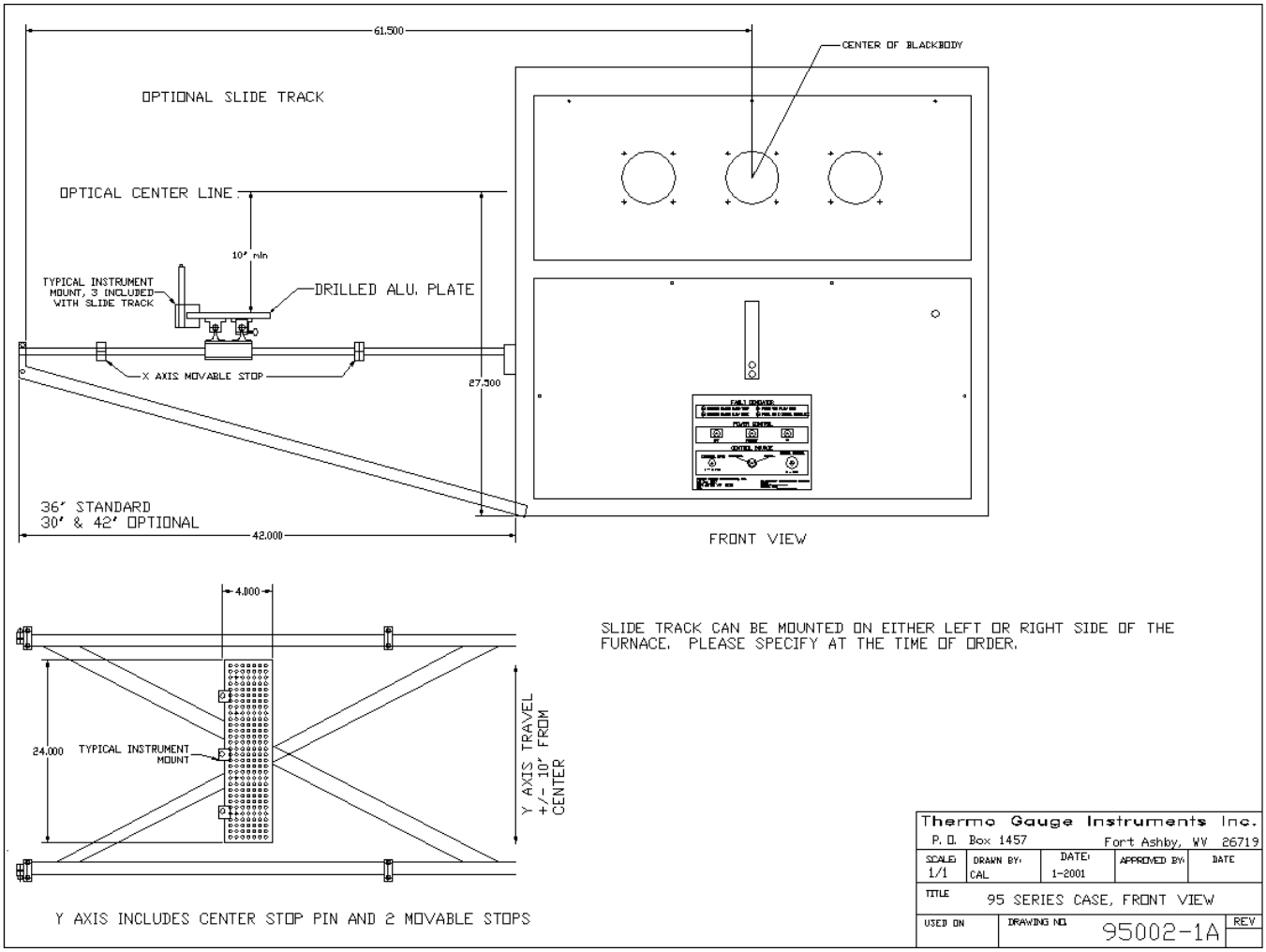
- Wavelength 900nm or 1600nm
- Accuracy ±0.2%
- Repeatability ±0.5°C, long term
- Resolution better than 0.1°C
- Ambient Range 10°C to 60°C
- True digital output. Once calibrated it can be used with any HT-7000A controller.

The 4-line LCD display simplifies the operation of the furnace and assists the operator by providing logical menus for set up options.

2.5 Options And Accessories:

2.5.1 Optical rail bench:

The optical rail bench is a X-Y sliding optical bench. The travel in the X direction is 39” and travel in the Y direction is 22”. This is an excellent option and a great time saver for calibrating multiple instruments or instruments without view through optics.



2.5.2 Aperture wheel:

A cool aperture wheel that can be mounted on the stainless steel instrument mount rods is available. The standard aperture wheel has 5 holes of sizes; 1", .5", .375", .3125", and .1875". The wheel is very useful for determining field of view of the instrument. Custom hole sizes are available.

2.5.3 Emittance measurement apparatus:

The emittance measurement apparatus consists of an air cylinder mounted on a rigid aluminum support assembly that attaches to the furnace case. A water-cooled copper cylindrical rod extension from the air cylinder connects to a high strength graphite rod extending into the graphite tube furnace. Attached to the end of the graphite rod is a graphite sample cub containing a piece of the

material to be tested. This cup is initially positioned in the center of the tube furnace. Because of reflections from the cylindrical section the resulting cavity will radiate as a blackbody, regardless of the emittance of the sample material. When activated the air cylinder rapidly moves the disk (test specimen) to the end of the heater tube. The test specimen is then standing in a cool zone and the only radiation seen by the detector is from the test specimen. The ratio of the free standing radiation to the blackbody radiation is the emissivity. A fast response radiometer with a wide band, flat absorption detector is focused on the disk to record both the blackbody radiance and the free standing radiance

2.5.4 Remote mounted Blackbody:

For special applications the Blackbody can be remotely mounted and connected to the power supply by large power cables. This allows the Blackbody to be used in any position or to be mounted on a track or arm. We are willing to customize for special applications.

2.6 System Upgrades:

Every improvement or upgrade is made to apply to as many blackbodies as possible. In this way the user can keep up with changing technology without the expense of purchasing a new unit. The philosophy at Thermo Gauge Instruments Inc. is to make the unit as modular as possible to allow easy repairs and simple upgrades.

2.6.1 HT-7000A and Exactus:™

The most exciting upgrade at this time is the HT-7000A controller and the Exacuts™ pyrometer. This upgrade improves the useful range and the usability of the system and it will work with every blackbody made by Thermo Gauge.

2.6.2 Field replaceable graphite parts:

Now all circular copper end caps can be fitted with field replaceable graphite parts. This is automatically done at no additional cost if the end caps are returned for repair. The customer can also purchase the parts and install them in the field.

3 Specifications:

Specifications for HT-9500 and HT-5500

1.	Range	500°C - 3000°C standard, 300°C - 2000°C optional
2.	Wavelengths	900nm or 1600nm (Control Pyrometer)
3.	Accuracy	± 0.2%
4.	Repeatability	± 0.5°C
5.	Resolution	0.05°C (Decreasing near low end of temperature range)
6.	Cavity	Graphite dual cavity blackbody, one cavity for control and one cavity for measurements.
7.	Source diameter	The HT-5500 and HT-9500 accept the 5/8", 1", $1^{1/2}$", and 2" aperture Blackbody cavities.
8.	Emissivity	0.995+
9.	Cooling	Water cooled, recommended re-circulation system, flow rate varies with Blackbody aperture (see chart). All units include water cooled reflector around the Blackbody and water cooled power transformer to reduce the heat load to the room.
10.	Purge gas	Argon, flow varies with Blackbody aperture (see chart).
11.	Interlocks	Cooling water over temperature, low purge gas flow, low cooling water flow rate, or open external interlock. The user can add as many other interlocks as needed and connect to the external interlock.
12.	Sensor	Exactus
13.	Controller	Thermo Gauge Instruments Inc. HT-7000A. All digital PID controller with 16 key keypad for easy set point changes. Four line LCD display for set point, Blackbody temperature and other information.
14.	Remote control	Set point control and temperature monitoring by RS-232.
15.	Warm up time	Varies with Blackbody cavity (see chart).
16.	Ambient temp	10°C to 55°C
17.	Power	HT-5500 - 15KW, single phase AC 50/60 Hz. Standard voltage is 240 VAC. Custom voltage at no extra charge. HT-9500 - 48KW, single phase AC 50/60 Hz. Standard voltage is 400/480 VAC. Custom voltage at no extra charge.
18.	Dimensions	28" wide, 40" long, 39" tall. Weight about 450 lbs. Custom stands available to align the optical center line with the customers application. Powder coated case provides durable easy to clean surface.

4 How To Order:

The primary consideration when choosing a power supply is the aperture size and the maximum temperature. Naturally, the larger the aperture the more power required. Also, the higher the temperature the larger the power supply. Therefore, determine the aperture size and maximum temperature then look up the power supply and assembly in the table.

All combinations of power supplies and Blackbody assemblies are possible. As a general rule choose the smallest aperture for the specific application.

HT-9500 FURNACE SPECIFICATIONS

Dual Blackbody Type	Aperture	Part number	Useful Temperature Ranges in Degrees C a) -with 900nm Exactus™ b) -with 1600nm Exactus™	Time to Max Temperature	Gas Purge Flow Rate (Cuft/hr)	Water Cooling (gal/min)
IA	5/8"	76611010	a) 500 - 3000 b) 300 - 2000	200 Seconds	3	5
II	1"	76511010	a) 500 - 3000 b) 300 - 2000	300 Seconds	10	5
III	1.5"	77611010	a) 500 - 3000 b) 300 - 2000	500 Seconds	20	10
IV	2"	77411010	a) 500 - 2500 b) 300 - 2000	800 Seconds	30	10

HT-5500 FURNACE SPECIFICATIONS

Dual Blackbody Type	Aperture	Part number	Useful Temperature Ranges in Degrees C a) -with 900nm Exactus™ b) -with 1600nm Exactus™	Time to Max Temperature	Gas Purge Flow Rate (Cuft/hr)	Water Cooling (gal/min)
IA	5/8"	76611010	a) 500 - 3000 b) 300 - 2000	300 Seconds	3	5
II	1"	76511010	a) 500 - 3000 b) 300 - 2000	400 Seconds	10	5
III	1.5"	77611010	a) 500 - 3000 b) 300 - 2000	500 Seconds	20	7
IV	2"	77411010	a) 500 - 2500 b) 300 - 2000	800 Seconds	30	7

Power supplies including HT-7000A temperature controller and Exactus™ optical pyrometer with standard part numbers are listed below. Custom voltages are available at no extra cost but must be specified when the order is placed.

POWER SUPPLY SELECTION CHART

Power supply	Operating Voltage	Operating Current	Part number	Cost
HT-9500, 48KW, 50/60Hz	380/480	127/100	701483801	Call for Quote
HT-9500, 48KW, 50/60Hz	400/480	120/100	701484001	Call for Quote
HT-5500, 15KW, 50/60Hz	208/240	73/63	701152401	Call for Quote
HT-5500, 15KW, 50/60Hz	380/480	40/32	701153801	Call for Quote
HT-5500, 15KW, 50/60Hz	400/480	38/32	701154801	Call for Quote

BLACKBODY/OPEN TUBE AND FLAT PLATE ASSEMBLIES

Description	Part number	Cost
Type IA, 5/8" aperture Blackbody assembly	76611010	Call for Quote
Type II, 1" aperture Blackbody assembly	76511010	Call for Quote
Type III, 1.5" aperture Blackbody assembly	77611010	Call for Quote
Type IV, 2" aperture Blackbody assembly	77411010	Call for Quote
Flat plate assembly	75411010	Call for Quote

OPTIONAL EQUIPMENT

Description	Part number	Cost
Slide track instrument mount. Specify left or right	48411010	Call for Quote
Instrument mount for standard stainless steel rods (specify height)		Call for Quote
Aperture wheel (call for custom sizes)	685120100	Call for Quote
Emittance measurement apparatus		Call for Quote
Remote mounted Blackbody		Call for Quote

Select one power supply (including control system) and one Blackbody assembly, add any options or spare parts, then add $550.00 for packaging for shipment.

We are always happy to help determine the correct furnace and options for you application. Please contact us for additional information or a quote.

The point of contact at Thermo Gauge Instruments Inc. is:

Chris Liller
P.O. Box 1457
Fort Ashby, WV 26719

Phone: 304-298-3769, Fax: 304-298-4509, e-mail: cliller@thermogauge.com

Parts can be ordered by phone, fax, e-mail or hard copy.

All new system orders require a hard copy of the Purchase Order. All new systems are subject to the following terms; 50% payment at the time the order is placed, 25% payment before shipment, and 25% net 30 days. Similar terms can be negotiated.

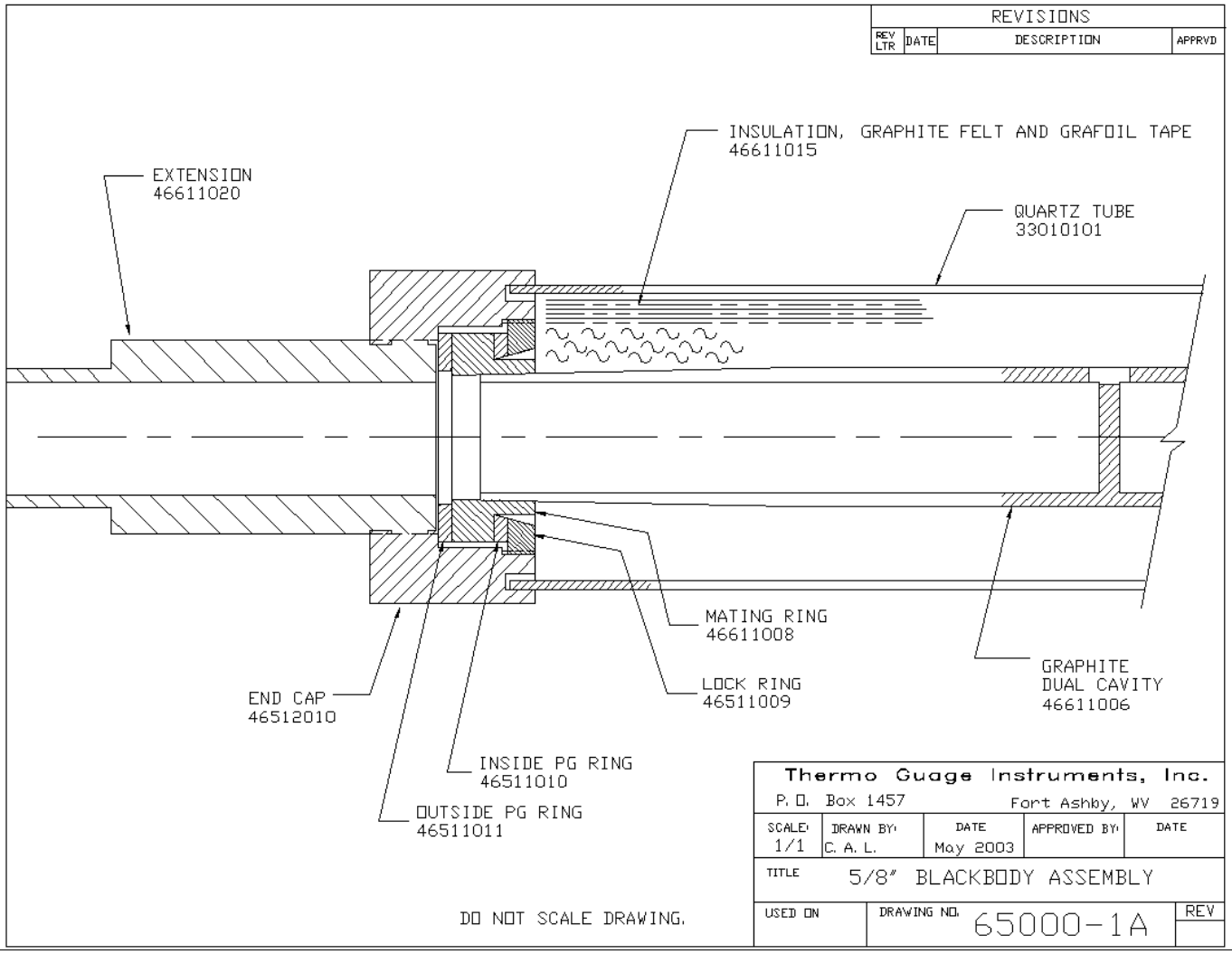
5 Replacement Parts:

Select spare or replacement parts form the tables below. All parts are designed to be replaceable in the field but if you choose to send back the end caps for repair at the factory there is no additional charge. The cost will be the cost of the parts and shipping. Normally only the parts that are worn out will be replaced. Please contact the factory before any parts are returned for repair. This repair offer only applies to replacing the graphite parts. If the copper is damaged by dropping or in any other way there will be a fee for repair.

5.1 5/8" Blackbody

Parts for 5/8" Blackbody, see drawing number 65000-1A

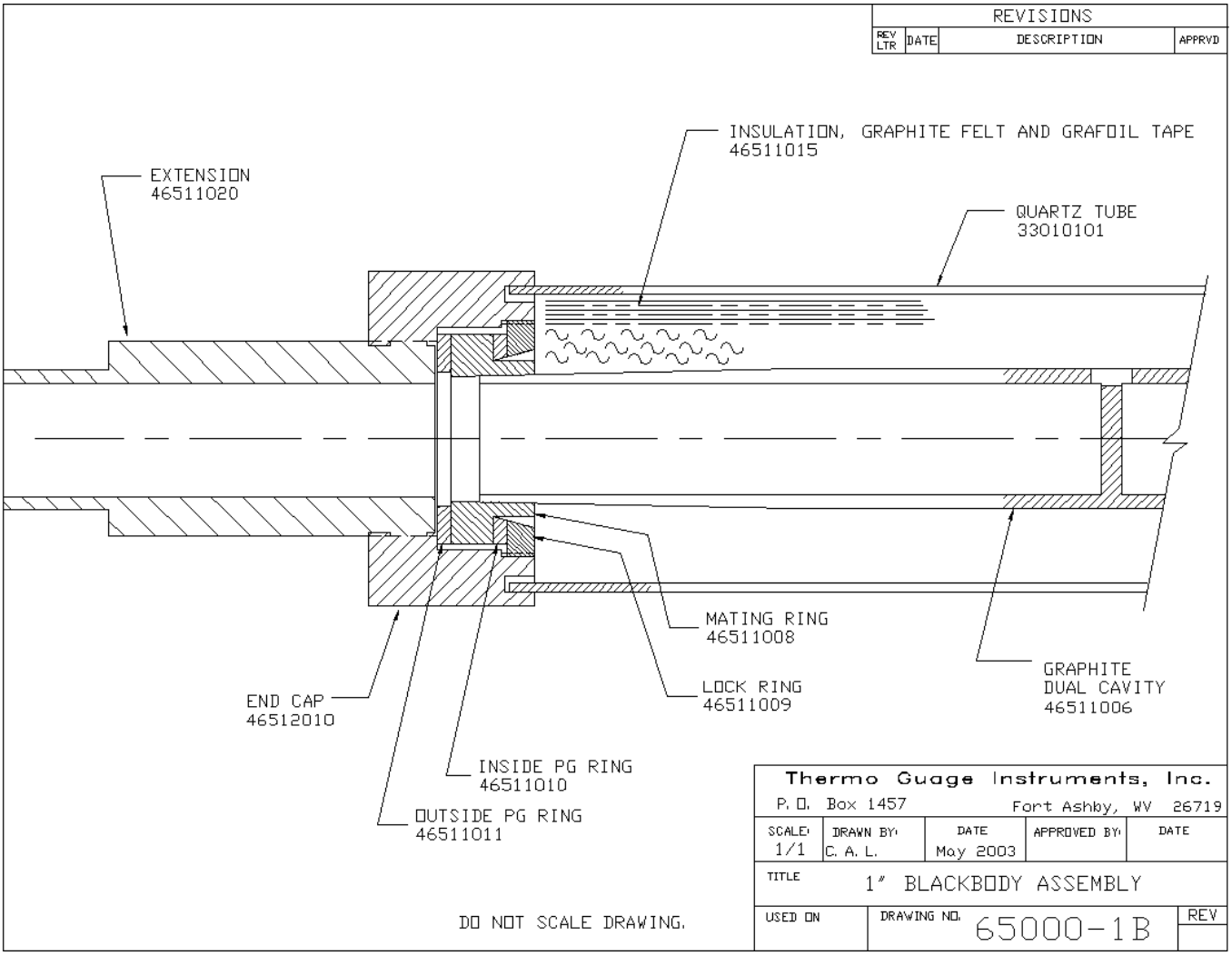
Part Number	Description	Price $
33010101	Quartz tube for 5/8" and 1" Blackbody	Call for Quote
46511009	Lock ring for 5/8" and 1" Blackbody	Call for Quote
46511010	Inside PG ring for 5/8" and 1" Blackbody	Call for Quote
46511011	Outside PG ring for 5/8" and 1" Blackbody	Call for Quote
46611006	Heater element for 5/8" Blackbody	Call for Quote
46611008	Mating ring for 5/8" Blackbody	Call for Quote
46611015	Felt and tape for 5/8" Blackbody	Call for Quote
46611020	Extension tube for 5/8" Blackbody	Call for Quote
76611010	5/8" Blackbody Assembly (order only with new furnace)	Call for Quote



5.2 1" Blackbody

Parts for 1" Blackbody, see drawing number 65000-1B

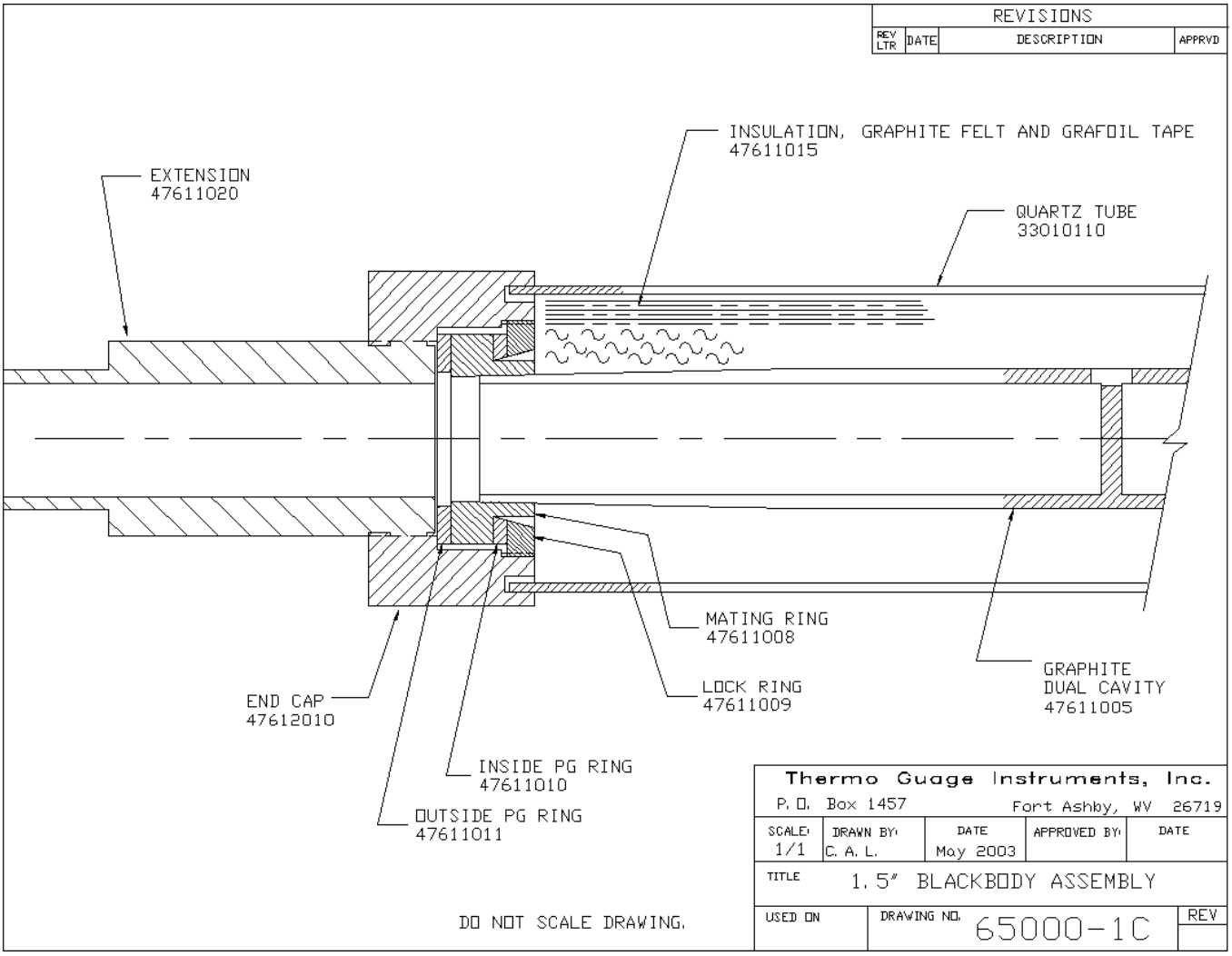
Part Number	Description	Price $
33010101	Quartz tube for 5/8" and 1" Blackbody	Call for Quote
46511009	Lock ring for 5/8" and 1" Blackbody	Call for Quote
46511010	Inside PG ring for 5/8" and 1" Blackbody	Call for Quote
46511011	Outside PG ring for 5/8" and 1" Blackbody	Call for Quote
46511006	Heater element for 1" Blackbody	Call for Quote
46511008	Mating ring for 1" Blackbody	Call for Quote
46511015	Felt and tape for 1" Blackbody	Call for Quote
46511020	Extension tube for 1" Blackbody	Call for Quote
76511010	1" Blackbody Assembly (order only with new furnace)	Call for Quote



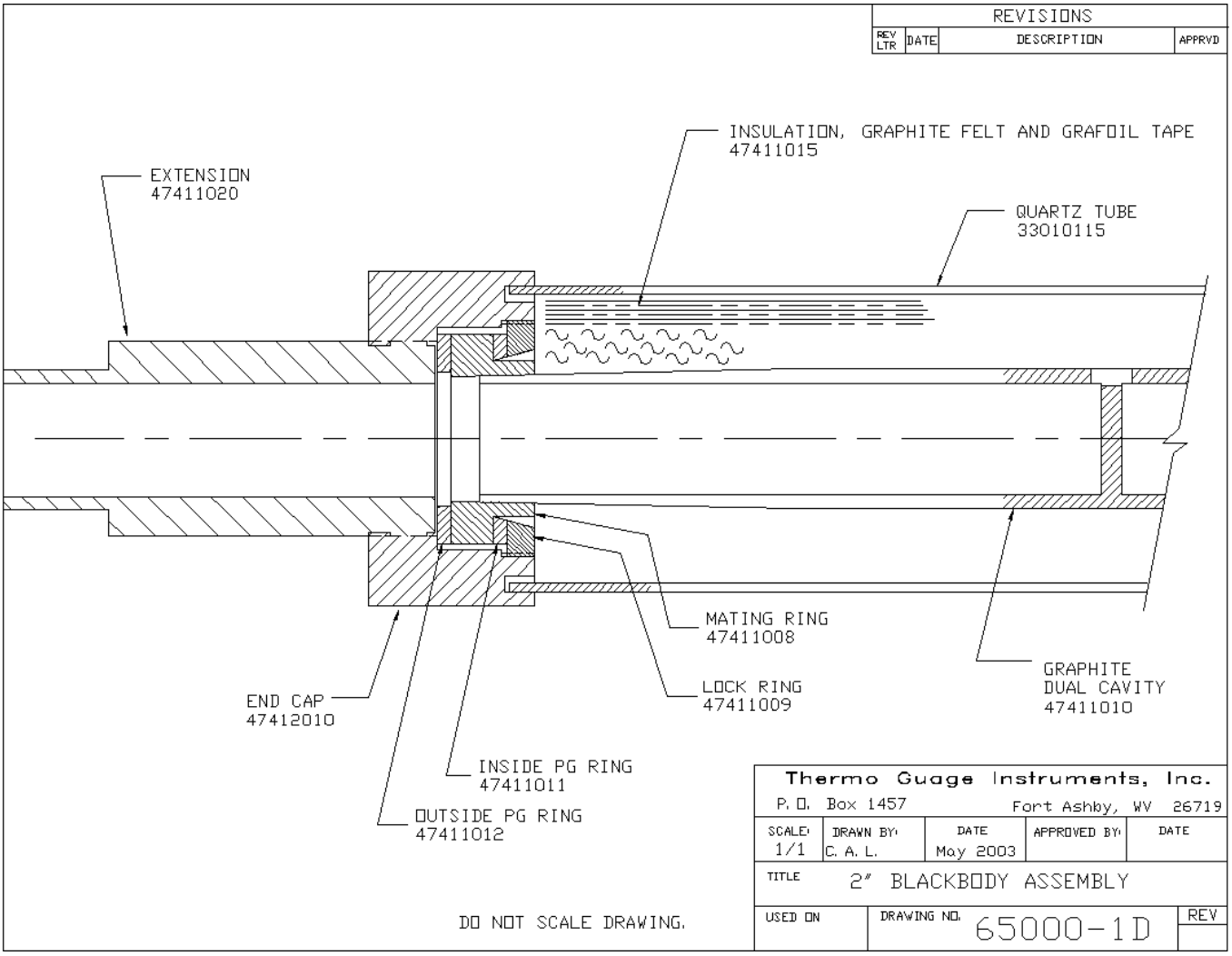
5.3 1.5" Blackbody

Parts for 1.5" Blackbody, see drawing number 65000-1C

Part Number	Description	Price $
33010110	Quartz tube for 1.5" Blackbody	Call for Quote
47611009	Lock ring for 1.5" Blackbody	Call for Quote
47611010	Inside PG ring for 1.5" Blackbody	Call for Quote
47611011	Outside PG ring for 1.5" Blackbody	Call for Quote
47611005	Heater element for 1.5" Blackbody	Call for Quote
47611008	Mating ring for 1.5" Blackbody	Call for Quote
47611015	Felt and tape for 1.5" Blackbody	Call for Quote
47611020	Extension tube for 1.5" Blackbody	Call for Quote
77611010	1.5" Blackbody Assembly (order only with new furnace)	Call for Quote



5.4 2" Blackbody

Parts for 2" Blackbody, see drawing number 65000-1D

Part Number	Description	Price $
33010115	Quartz tube for 2" Blackbody	Call for Quote
47411009	Lock ring for 2" Blackbody	Call for Quote
47411011	Inside PG ring for 2" Blackbody	Call for Quote
47411012	Outside PG ring for 2" Blackbody	Call for Quote
47411007	Heater element for 2" Blackbody	Call for Quote
47411008	Mating ring for 2" Blackbody	Call for Quote
47411015	Felt and tape for 2" Blackbody	Call for Quote
47411020	Extension tube for 2" Blackbody	Call for Quote
77411010	2" Blackbody Assembly (order only with new furnace)	Call for Quote