Water Bath Black Body Operating Instructions

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NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

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Table of Contents

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Introduction

The Water Bath Blackbody is an instrument designed and built for use in the 5 to 60 degree Celsius temperature range with an aperture of approximately 10.8 cm. Measurements have indicated that the temperature is uniform to better than +/- 15 mK. Details on the conceptual design and testing the the water bath blackbody are described in a companion report written by Jon Geist and Joel Fowler. [1]

This manual contains instructions for setting up the water bath blackbody and associated hardware and instructions for operating the instrument.

I. Hardware

<Refer to page 8 for a listing of the hardware provided>

A. Constant Current Source

First, a note regarding the constant current source: In order for the current source to completely stabilize, it must be turned on and allowed to stabilize for a period of approximately 24 hours. After it has warmed up it **SHOULD NOT BE** turned off again. All operating connections can be made with the power on.

B. Equipment Connections

1. Connect the computer to any 120 VAC outlet. (The monitor can be connected to the outlet at the back of the computer.)

2. Connect the DVM to any 120 VAC outlet and connect the IEEE cable from it to the output of the GPIB Card on the back of the computer. (The cable is provided)

3. Connect the printer cable (provided) from the printer to the parallel port on the back of the computer.

C. Water Bath Setup

-Refer to Figure 1, page 9-

1. Make sure the Baffle (Fig. 1) is in place and the tubing is connected to the nozzle.

2. Place the N-4 Module on the bath and attach with the two mounting screws on the stainless steel plate.

3. Place the **Control Head** on top of the **N-4 Module**.

- Refer to Figure 2, page 10-

4. Make the following cable connections:

a. The **Remote Temperature Control Cable** has a 5-pin Male Connector at one end and a Triax connector at the other. Connect the 5-pin connector to Socket 1 on the back of the **Control Head** and the Triax connector to the Triax socket on the back of the computer.

b. Connect the Flat Cable from the **N-4 Module** to the 25-pin socket (4) on the **Control Head**

c. Connect the Power Cable of the **N-4 Module** to the Socket on the rear of the **Bath.**

d. Connect the 6-pin Control Cable to the socket of the **N-4 Module** and its mate on the **Bath.**

e. Connect the Main Power cable to 220 VAC.

-SWITCH THE CONTROL HEAD POWER SWITCH TO OFF-

f. Switch the on/off switch on the back of the Bath to the '1' position. (On)

II. Filling the Bath Cavity

A. Pour the contents of one 12 oz. bottle of Anti-Rust and Water Pump Lubricant in the cavity chamber.

B. Fill the chamber with tap water until the level indicator of the N-4 module shows a reading of about 9. This should be somewhere very near the indentation of the cavity chamber. Overfilling will cause the bath to overflow when operated and underfilling will set off the alarm.

NOTE: If you are operating the bath at the higher temperature ranges over a period of days, check the level of the water on a regular basis as the water will tend to evaporate.

C. Turn on the bath and allow the solution to mix for a minute or so. Turn off and continue connection procedure.

D. Place the styrofoam cover on the cavity and insert the thermistor to the proper height. (where the teflon seats into the styrofoam.)

E. Connect the Thermistor wires as follows:

-Note: the labels are stamped on the connector lugs-

One each of the two lugs marked #1 are connected to the Red(+) jack of the constant current source and the DVM Hi (top) Input on the DVM. One each of the two lugs marked #2 are connected to the Black (-) jack of the constant current source and the DVM Lo (middle) Input on the DVM.

The fifth wire of the four wire thermistor is the shield and is stamped G on the lug. Connect this to the bottom connector on the DVM, which is marked 'I' and is to the right of the fuse.

III. Turn On Procedure

-Refer to the Control Panel Diagram, Fig. 3, page 11-

A. Turn on the water bath with the switch located at the upper left hand corner of the control panel. The green indicator light should come on.

B. If the bath is on 'EXT', indicated by the amber indicator, it should be switched via that button to 'Internal.'

<The 'EXT' switch is located directly beneath the on/off switch >

NOTE: The internal temperature has been preset to 22-25 deg. C. The control head stores this information for up to 12 months even when the power is off. The over-temperature, alarm condition parameter has been preset to 70 deg. C. and also is stored by the control head.

IV. Computer and Program Operations

A. Booting Up

1. Switch the computer on
   (The power on switch for the computer is located on the back of the unit in the upper right corner)

2. The programs necessary to operate the Water Bath Black Body are resident on the hard disk.

3. The monitor will initially ask the user:
   TEST MEM (Y/N)

-The system will default to 'N' after a short delay. You can hasten the system bootstrap slightly by typing an 'N'.-

-After booting up, you will be asked to set the date and the time.

After these are set, the computer will display the prompt: "C:\wb>" on the screen.

-This indicates that you are in the correct directory for the water bath temperature control program.

B. Accessing the Control Program

There are two ways to get into the temperature control program:

1. Following the prompt, type "Tbasic"

```
C:\wb>Tbasic
```

-Once the program is loaded, the prompt will appear as ->
When this prompt appears, respond as follows:

```
->old"ctemp.sav"
->run
```

(NOTE: "old" is Tbasic command for "Load" and "ctemp.sav is the temperature control program.)

2. To simplify loading, you may just type:

```
C:\wb>tbasic ctemp.sav
```

C. Using the Program

Follow the instructions on the monitor as in the following example:

```
INPUT FILENAME<data filename...something
      other than ctemp.sav; i.e: Test1.001>
```

-at this point, you may select one of four options pertaining to the data you wish printed to your file-

```
What data do you want in your file?
     (1) stable data only     = S
     (2) unstable data only   = U
     (3) both                 = B
     (4) none                 = N
  ?
```

-type in the letter corresponding to your selection. After a brief delay, the program will respond with the current temperature of the bath-

```
Current Temp. is <current temperature>
Please input maximum dt (eg..01 = 10mK)
     <Input the maximum desired Delta T, i.e.:0.015
     for 15mK>

INPUT SETPOINT <input the temperature value
     at which you wish the bath to operate.
     DO NOT follow the value
```

with "deg. C", just the number. ie:
60.00 for 60 deg. C>

Switch water bath to "EXT", then hit any key
<"EXT" is located just below the power switch on the water bath control panel (the temperature display on the bath head should blank out and the 'EXT." light should come on) then hit any key on the computer keyboard>

?
Changing Temperature

-The computer is now monitoring the temperature of the water bath and will display the temperature and the difference from the setpoint. When the bath gets near the setpoint, the computer will display this and keep you apprised of the stability of the bath as well.

- Once the temperature becomes stable (see Note 1 below), proceed with your measurements.

D. **Stopping the Program**

1. The program is in a loop that is necessary for it to control the water bath to your setpoint. If you wish to change your setpoint or shut down the system, proceed as follows:

2. Ctrl C will give you an error stop and then the computer will beep. <'Ctrl' and 'C' must be typed simultaneously.>

3. The monitor will display the prompt, '->'

4. To restart the program (the program will not default to your previous parameters, all values must be reset whether you are changing them or not) type RUN

5. To terminate the program and Tbasic, set the water bath to internal and type QUIT

E. **Data File Access**

1. If you wish a hardcopy of the information being displayed on the monitor during the time the water bath is in operation, simply enter a CTRL P as you initiate the run. You can stop the print out at any time by entering another CTRL P

2. To examine the data files you have created, you must be out of TBasic. That is, you have exited the temperature control program with a CTRL C, typed 'Quit' in response to the prompt ->, and are seeing the prompt

C:\wb on the screen.

a. Typing dir following the prompt will list the files in the wb directory. The names, dates, and times your input files were created will be displayed.

b. To look at a data file, enter type <filename> after the prompt. Again, for a hardcopy of the information, enter a CTRL P before using the CR after the filename

F. **Shutting Down the System**

1. Stop the program and 'quit' Tbasic.

2. Turn off the power to the computer and the water bath (using the switch located on the Control Head) in any order.

REMEMBER: DO NOT TURN OFF THE CURRENT SOURCE !

NOTES

Note 1. - The stability of the water bath black body is dependent upon two factors. First, the ambient temperature will have an effect on the stability. If the operating temperature (setpoint) is close to the room temperature, it will be more difficult to maintain. Secondly, the heating system is more powerful than the cooling system. As a result, while the bath may take a relatively long time to reach stable condition at higher setpoint levels (30 - 60 deg. C), the duration of the stable condition will be longer than the duration of the stable condition at the lower setpoints (0 - ~25 deg. C). However, the bath wil remain stable at the lower temperatures for a sufficient time for completing any measurements easily.

Note 2. -Alarm conditions-

An audible and visual alarm will begin and the pump will shut down if the water temperature reaches the preset parameter or if the water level becomes too low. The alarm can be shut off by means of the **'Alarm Release Switch'** which is visible only during alarm conditions.

Reference

[1] "Water bath black body", J. Geist and J. Fowler (to be published)

EQUIPMENT LIST

* Olympia NP Printer
* Columbia Personal Computer & Keyboard
* Amdek Video-300 Monitor
* Hewlett-Packard 3457A Digital Voltmeter
* Constant Current Source
* Thermometrics Thermistor
* Haake N-4R incl.:
  - control head
  - N-4 module
  - Bath
* Hook-up cables for all units
* Equipment Manuals
* Columbia Software

This equipment list is not an endorsement, either expressed or implied, of any of the commercially available equipment noted herein.

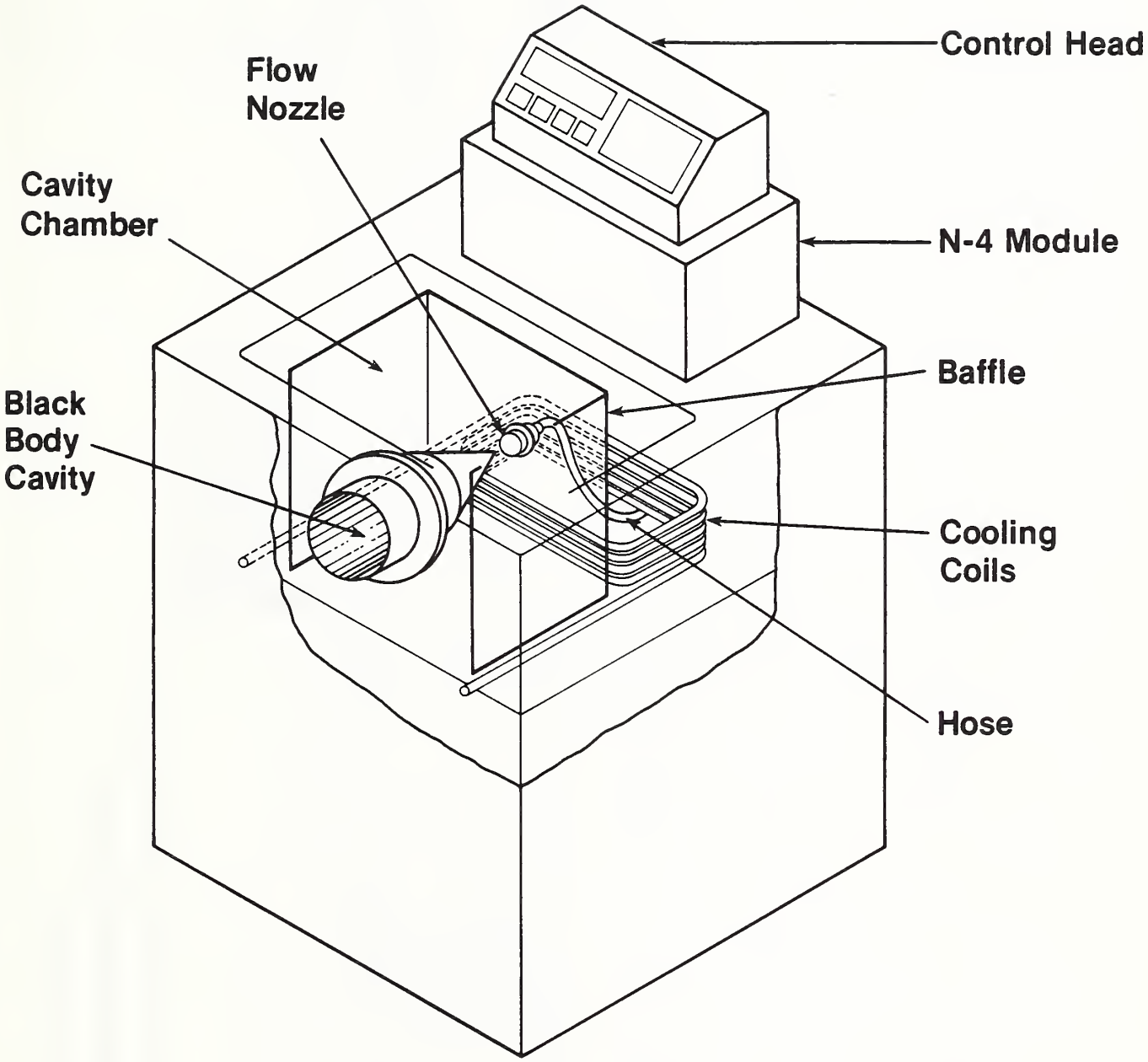
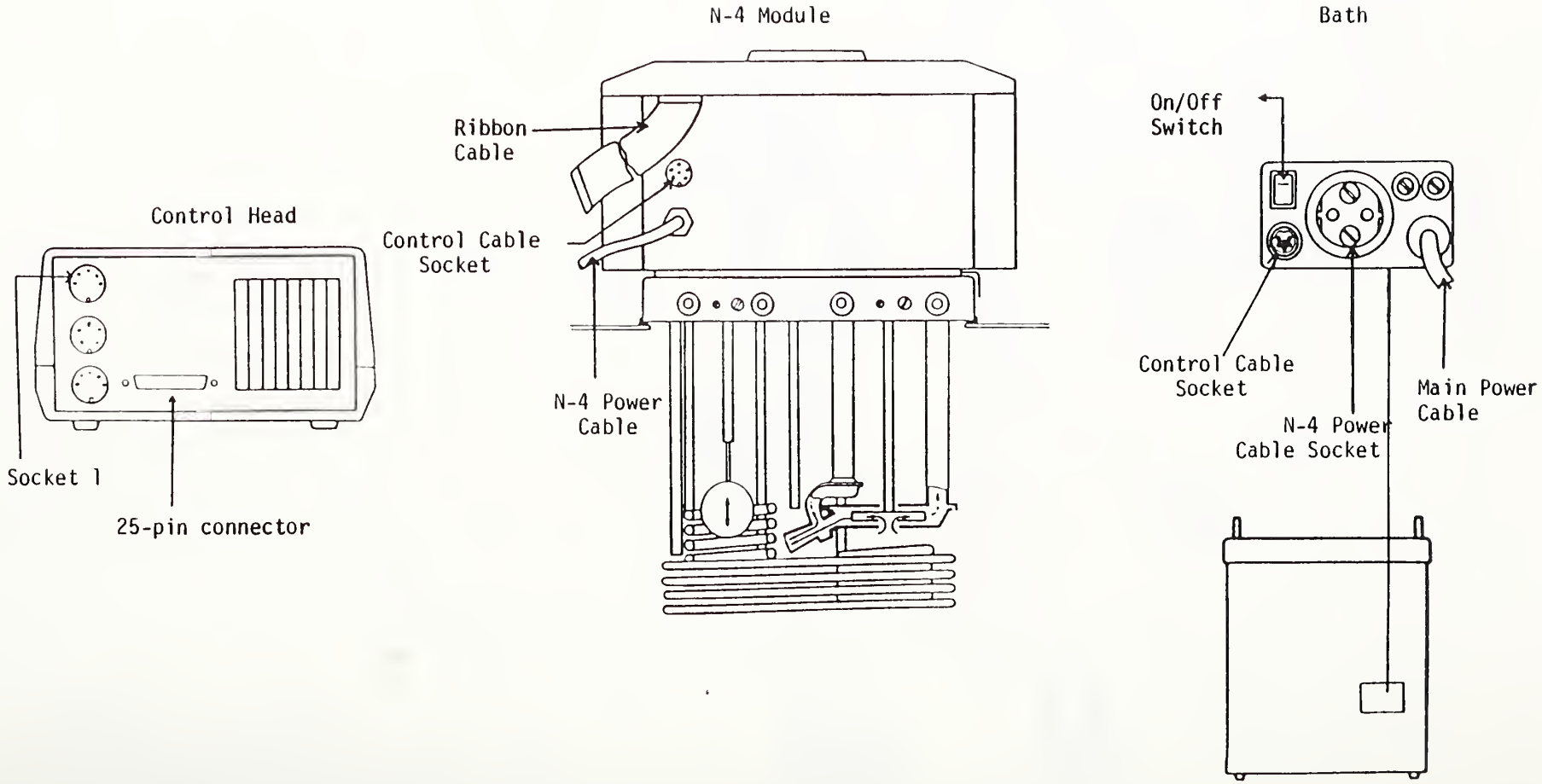

Control Head
Flow
Nozzle
Cavity
Chamber
N-4 Module
Baffle
Black
Body
Cavity
Cooling
Coils
Hose

FIGURE 1

FIGURE 2

CABLE CONNECTION DIAGRAMS



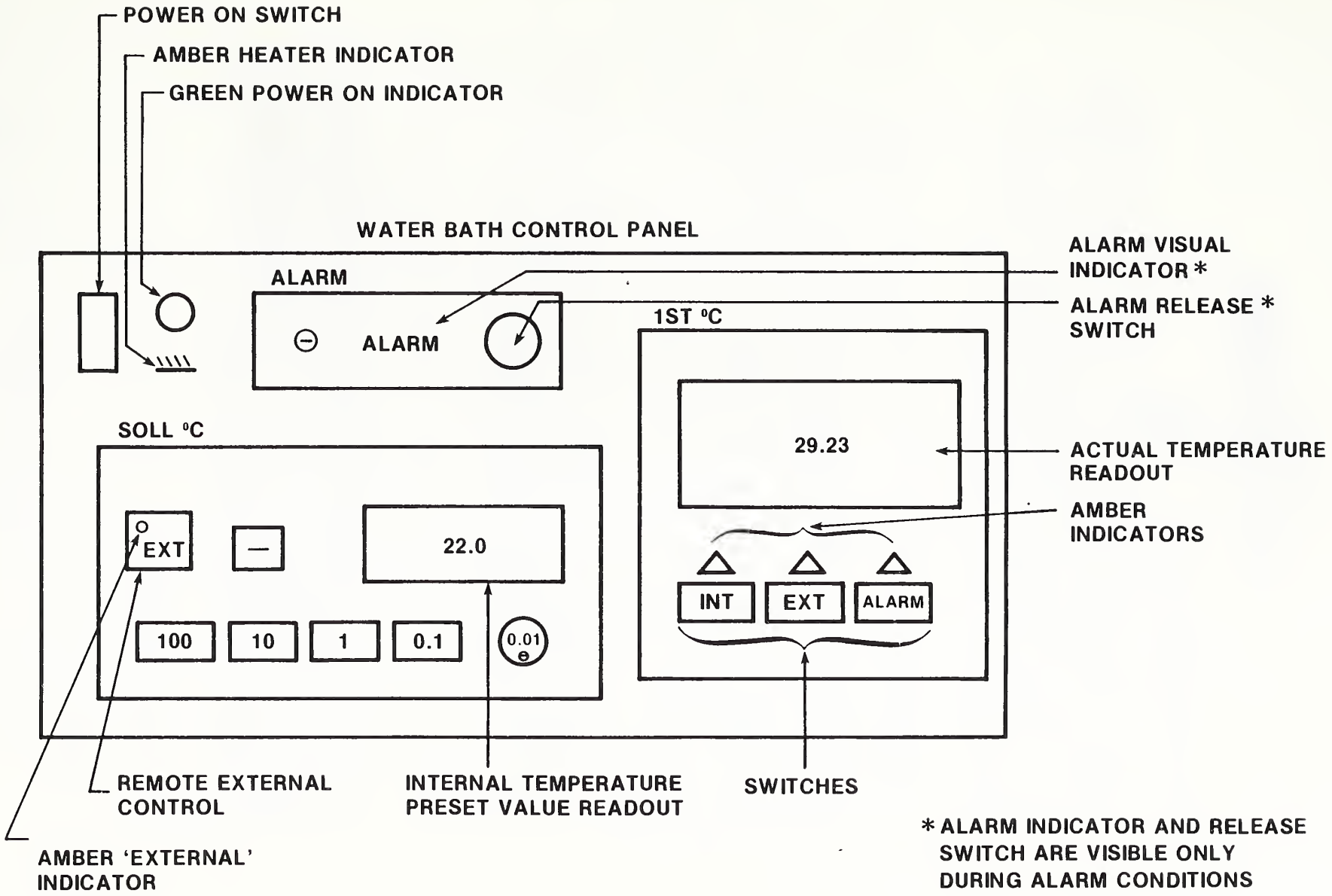

POWER ON SWITCH
AMBER HEATER INDICATOR
GREEN POWER ON INDICATOR
WATER BATH CONTROL PANEL
ALARM VISUAL INDICATOR *
ALARM RELEASE * SWITCH
ALARM
ALARM
1ST °C
SOLL °C
29.23
ACTUAL TEMPERATURE READOUT
AMBER INDICATORS
EXT
22.0
INT
EXT
ALARM
100
10
1
0.1
0.01
REMOTE EXTERNAL CONTROL
INTERNAL TEMPERATURE PRESET VALUE READOUT
SWITCHES
AMBER 'EXTERNAL' INDICATOR
* ALARM INDICATOR AND RELEASE SWITCH ARE VISIBLE ONLY DURING ALARM CONDITIONS

FIGURE 3

APPENDIX 1

1a.) Constant Current Source

The constant current source (built at N.B.S.) is a fixed 10 micro amp source designed especially for the thermistor used in the bath. Although the source is very well thermally stabilized, it is advisable to leave it on at all times if possible. The circuit is short circuit limited, so it is permissible to make connections to it without turning off the power. A minimum of one hour should be allowed before use, although 24 hours is preferable.

1b.) Thermistor

The four wire thermistor is a high precision laboratory grade unit with a nominal room temperature (25 deg. C) resistance of 4000 ohms. The stability of this unit is 0.005 degrees C per year, the temperature accuracy is better than 0.0015 degrees C over the range of 0 deg. C to 60 deg. C. Using the current source described above we simulate the conditions used to calibrate the thermistor.

1c.) DVM

The Hewlett-Packard 3457A DVM used in the system is accurate to 0.0025% +/- 39 counts over 90 days on the 300 mV scale used by the program. The short term accuracy is much better. When all the calculations are made, the unit falls well within the specifications necessary for this application.

1d.) DAC

The DAC is a 16 bit unit on a carrier card within the computer chassis. It has been modified to operate over the range of +0 to 1.0 V instead of +/- 10.0V by placing a resistor in parallel with the feedback resistor at the output operational amplifier. The change of the ourput voltage swing was necessary for the correct operation of the bath with the additional benefit of a smaller delta V per step for the DAC.

THERMOMETRICS INC

REPORT OF CALIBRATION
FOR
S-10 FOUR-WIRE THERMISTOR STANDARD
SERIAL NO. 374

The above designated thermistor standard was calibrated in Aug.-1985, using the test currents shown below.

The following calibration values were obtained and are traceable to the National Bureau of Standards.

Temperature[1]	°C	.01	25	30	32	37	60
Resistance[2]	Ω	11224.36	3995.87	3307.43	3071.15	2560.92	1181.24
Test Current	μa	5	10	10	10	10	10

1. All temperature observations were made by comparison with a standard platinum resistance thermometer L & N Model 8163, Serial No 439808. Calibration of the platinum standard at the triple point of water was performed prior to and after calibration of the S-10 Standard. The drift in the platinum standard was found to be less than .0002 °C. The uncertainty in the temperature measurement was less than 0.0015°C.

2. All resistance observations were made using a bridge whose readings were corrected against a ratio bridge, using comparison techniques. The ratio bridge used has an accuracy of 0.0002%. Ratio measurements were made against temperature controlled standard resistors having an accuracy of 0.001%. The total corrected resistance uncertainty was less than 0.0025%.

Stephen Weber 8/14/85

Approved by [signature] 8/14/85

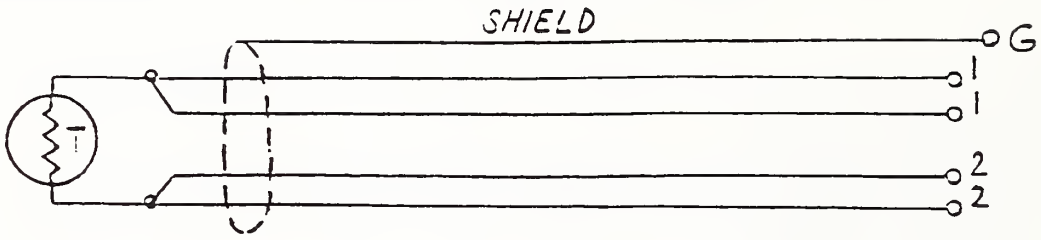
808 U.S. HIGHWAY 1 EDISON, NEW JERSEY 08817 201-287-2870

THERMOMETRICS INC

TM

S-10-4 WIRE STANDARD

WIRING DIAGRAM:



USE OF S-10-4 WIRE STANDARD:

The standard for which the attached calibration values and table apply was calibrated for use as a four-terminal device. As such, the lead resistance does not enter into the measurement.

Should it become necessary or desirable to use this S-10 as a two-terminal device, the following procedure should be used:

a) Resistance between a single pair of terminals, 1-2:
Add .177 ohms per lead or a total of .354 ohms to each calibration or table value.

b) Resistance between terminals 1-1 connected in parallel and terminals 2-2 connected in parallel:
Add .177 ohms to each calibration or table value.

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Appendix 2: The Control Computer

DESKTOP, DUAL DISK DRIVE
IBM PC COMPATIBLE

SPECIFICATIONS:

MICROPROCESSOR	8088 CPU (16 bit) 4.77 MHz Socket for 8087 co-processor
MEMORY	16K bytes ROM 128K bytes RAM
STORAGE	Two 5 1/4 inch full-size Disk Drives x 360K bytes each (Operate double sided, double density)
KEYBOARD	IBM PC compatible layout Soft Touch operation Lock indicator lights
VIDEO CONTROLLER	Color graphics or high resolution monochrome
PERIPHERAL INTERFACES	2 Serial Ports (RS 232) Parallel Port (IBM compatible) DMA Controller (4 channel) Interrupt Controller (8 level priority)
EXPANSION INTERFACES	8 Slots (full size); 7 available; IBM PC compatible
POWER	100 Watt, 110/120 AC, 50/60 Hz System Reset Button UI listed FCC CLass B/CSA appr.
CONSTRUCTION	Steel and Plastic cabinet
SIZE	CPU 22.5 (w) x 15 (d) x 5 (h) inches
WEIGHT	25 pounds
SERVICE	Nationwide through Bell G. Howell Service Co.

NBS-114A (REV. 2-8C)

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5. AUTHOR(S) Joel B. Fowler and Barbara J. Belzer

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WASHINGTON, D.C. 20234

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9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)

SAME

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This is an operating instruction manual for the water bath black body built in the Radiometric Physics Division, National Bureau of Standards.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Constant current source; computer; DAC; GPIB board; temperature control; thermistor; water bath blackbody

13. AVAILABILITY

☒ Unlimited

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