CANNON
INSTRUMENT COMPANY®

CT-2000
Extended Range Constant Temperature Bath

Operation

Manual

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Introduction/Installation

This manual is intended to provide information on the installation, characteristics, and operation of the CANNON CT-2000 Constant Temperature Bath.

The CANNON CT-2000 Constant Temperature Bath is designed to maintain precise temperatures at a wide range of settings for accurate viscosity measurements. Because of its temperature stability and ease of use, it is also suitable for any other application where temperatures must be maintained within hundredths of one degree Celsius.

The CANNON CT-2000 is designed to maintain temperatures from 10 °C to 150 °C.

Figure 1: CANNON CT-2000 Extended Range Constant Temperature Bath

Temperature Selection and Selection

The CT-2000 offers convenient keypad entry of temperature settings up to three decimal places over the entire temperature range of the instrument. The bath temperature will remain stable within one 1/100ths of one degree of the temperature setting.

The CANNON CT-2000 can maintain temperatures of 10 °C to 100 °C within 0.01 °C and temperatures of 101 °C to 150 °C within 0.03 °C. (Temperature stability at or below ambient may vary depending on the quality of the external cooling unit.)

Bath Description

The bath chamber is a cylindrical clear vessel 300 mm (12 inches) in diameter and 300 mm (12 inches) high. A stainless steel baffle coated with white PTFE is located in the center of the bath and provides a convenient backdrop for viewing viscometers placed within the bath. The top cover contains seven round holes, 51 mm (two inches) in diameter, for insertion of viscometer holders. Two smaller holes are provided for thermometers, as shown in Figure 2. Twin fluorescent lamps provide glare-free illumination of the bath.
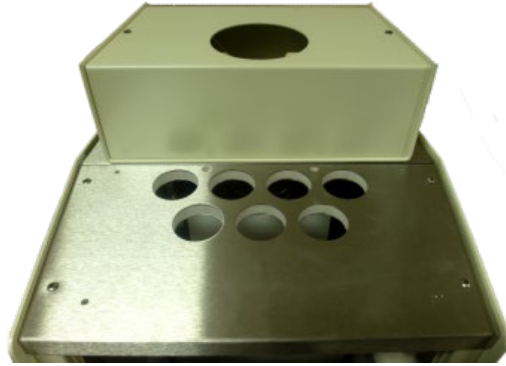
Figure 2: CT-2000 Top View of Viscometer Holders

Microprocessor circuitry, functioning in tandem with a pair of heaters and a stainless steel encased RTD provides stable and accurate temperature control. A motor-driven stirrer ensures that a uniform temperature is maintained throughout the bath.

The bath housing is fabricated from heavy aluminum and coated with a corrosion-resistant epoxy. The top cover consists of three layers: a stainless steel top surface, an insulating layer, and a bottom stainless steel heat reflector as shown in Figure 3.

Figure 3: CT-2000 Housing

ASTM D445 Specifications

The CT-2000 temperature control provides the accuracy required by ASTM D445 for kinematic viscosity measurements.

Cooling Coil

A built-in cooling coil, when connected to tap water or a cooling system, permits operation to 10 °C.

Notes/Cautions/Warnings

Please keep this manual easily accessible for necessary information while operating or preparing for operation.

Notes, caution, and warnings are used in the manual to call an operator's attention to important details prior to performing a procedure or step. Read and follow these important instructions. Failure to observe these instructions may void warranties, compromise operator safety, and/or result in damage to the instrument.

Notes *provide more information about the content that follows.*

Cautions *alert the operator to conditions that may damage equipment.*

Warnings *alert the operator to conditions that may cause injury.*

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If you should find any part in this manual not clear to understand or missing article, contact your local CANNON dealer or sales representative.

Manufacturer is not liable for any loss or damage directly or indirectly caused by use of the instrument or its consequences.

This manual pertains directly to the CT-2000 constant temperature bath. For details relating to other accessories or equipment please refer to the appropriate manufacturer supplied documentation.

Safety Precautions

Always observe cautionary messages, signs and warnings in order to protect yourself as well as prevent others from physical injury or property damage.

Overheat Thermistor

A thermistor in the bath senses any over-temperature fault condition. If such a condition occurs, all power is removed from the bath until the operator resets the over-temperature limit circuit.

RTD Cutoff Detection

If the control RTD is disconnected, all power to the bath heaters is cut off.

Liquid-Level Sensor

Bath operation is only possible when it is filled with liquid to a safe operating level. A liquid-level sensor prevents the control circuit from heating the bath until the safe operating level is attained. The bath heaters automatically turn off if the bath liquid drops below the minimum safe level.

- Only qualified personnel should operate the CT-2000.

- Place the CT-2000 on a stable surface such as a laboratory table or bench. Do not place instrument on a cart or stand.

- If any liquids are spilled into the electronic components of the CT- 2000, contact Cannon Instrument Company immediately.

- Position power cords so they will not be walked on or pinched by items placed on or against them. Keep all connections as neat as possible.

- Unplug the power cord from the wall outlet if the CT-2000 will not be used for an extended period of time. Disconnect the power cord by pulling it out by the plug, never pull by the cord.

- Read and understand all operating instructions and safety precautions listed in this manual before installing or operating the instrument. Any questions regarding instrument operation or documentation should be referred to Cannon Instrument Company.

- Do not deviate from the installation, operation, or maintenance procedures described in this manual. Improper use of the CT-2000 may result in a hazardous situation and may void the manufacturer's warranty.

- Handle and transport the unit with care. Sudden jolts or impacts may cause damage to components.

- Never operate the instrument without proper levels of approved bath fluid in bath.

- Observe all warning labels. Never remove warning labels.

- Never operate damaged or leaking equipment.

- Unless procedures specify otherwise, always turn off the unit and disconnect the MAINS cable from the power source before performing service or maintenance procedures, or before moving the unit.

- Refer all service and repairs to qualified personnel.

Warning: *The bath fluid used with the CT-2000 may be hazardous. Use proper safety precautions when handling the bath fluid and refer to the (Material) Safety Data Sheets included with the bath fluid for more detail.*

Caution: *Do not attempt to service the CT-2000 system by removing panels and trying to effect repairs. Contact CANNON regarding service and repair needs.*

~MAINS	*The **~MAINS** symbol indicates the connections for the AC power supply. The AC power input must match the electrical specifications of the instrument.* *Never operate the equipment with a damaged MAINS AC power cable.* *Use only the manufacturer-supplied MAINS AC power cable. This cable must be inserted into a receptacle with a protective earth ground.*
(O)	*The **(O)** symbol indicates the OFF position for the electrical switches for your unit.*

Specifications

Table 1: CT-2000 Specifications

Specifications	Details
Model	CT-2000 Extended Range Constant Temperature Bath
Methodology	ASTM D445, ASTM D446, ISO 3104/3105
Applications	Formulated oil analysis, hydraulic oil analysis, additive analysis, marine fuel testing, base stock analysis, light and heavy fuel testing, waxes/paraffin, crude oil testing, glycols
Dimensions (W × D × H)	43.8 cm × 46.4 cm × 58.4 cm (17.25 in × 18.25 in × 23 in)
Weight	51.4 kg (113 lb)
Sample Capacity	7
Temperature Range & Accuracy	10 °C to 100 °C ± 0.01 °C* 100 °C to 150 °C ± 0.03 °C *Test temperatures <40 °C and high ambient temperature test environments require an optional bath cooler*
Bath Height	12 inches
Bath Volume	17 L (4.5 gal)
Operating Conditions	15 °C to 30 °C, 10% to 75% relative humidity (non-condensing), Installation Category II, Pollution Degree 2
Electrical Specifications	120 VAC, 50/60 Hz; 240 VAC, 50/60 Hz 1400 watt power consumption
Compliance	CE Mark: EMC Directive (2004/108/EC); Low Voltage Directive (2006/95/EC); HI-POT (1900 V_{DC}, 60 sec.); ROHS
Data Output	RS-232 and RS-485

Unpack & Assemble

This section of the manual provides assistance in unpacking and assembling the CT-2000 Constant Temperature Bath.

Unpack the CT-2000

The CANNON CT-2000 Constant Temperature Bath is shipped in several boxes containing the following components:

- Bath housing, including the electronics drawer

- Motor and stirrer, including the impeller and mounting plate

- Glass bath jar

- Allen wrench

- Front glass panel pieces (2)

- Seven hole covers

- Jar gasket top and bottom

- Rubber thermometer holder

- Instruction manual

The bath unit housing is shipped completely assembled. However, the glass jar, the glass panels, and the motor and stirrer must be installed. To install these components, some disassembly of the bath unit housing is required. The tools required are a utility knife, Phillips screwdriver, and a 1/8" Allen wrench which is included with the bath. The utility knife and Philips screwdriver must be supplied by the user.

1. Remove all components from the shipping container(s).

2. Remove any and all packing materials (Styrofoam, etc.) from the components.

3. Verify reception of shipped materials by comparing equipment items with packing/parts list(s). Report missing items to Cannon Instrument Company immediately.

4. Inspect each component for signs of damage. Report any damages to the shipper and to Cannon Instrument Company immediately.

Figure 4: Primary Bath Components

Damaged Items

Retain all packing materials until the instrument is connected and functioning properly. If any component(s) must be returned to CANNON, the damaged item(s) should be packaged in the original shipping container. Refer to the *Warranty* section of this manual for instructions on returning defective equipment. Customers outside the United States should contact their local CANNON agent for procedures on returning products to Cannon Instrument Company.

Assembly Procedure

1. Unpack the bath unit housing and move it to its permanent location on a stable laboratory bench or table.

2. Remove the eight screws from the stainless steel top covers. Refer to Figure 5 and Figure 6.

Remove all screws

Figure 5: Detaching Top Cover   **Figure 6: Remove Screws from Top Covers**
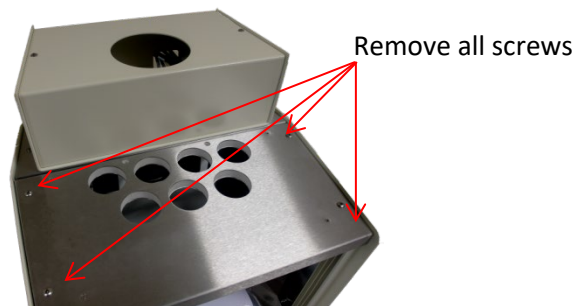
3. Disconnect all external cabling including probes, heaters, and float switch from the upper rear panel.

4. Remove the front top cover and rear top cover. Carefully remove the rear top cover as the temperature control probes and heating elements are attached to it, as shown in Figure 7.
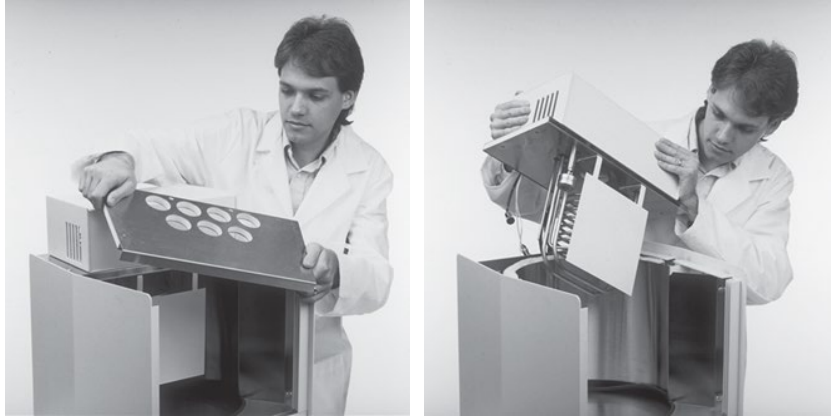
Figure 7: Remove Top and Rear Top Covers

5. Remove the glass jar from its box and packing, using caution as it is heavy.

⚠️ **Caution:** *The glass jar is heavy. Use caution when lifting/removing jar.*

6. Ensure the rubber support ring is properly seated around the bottom of the jar opening in the bath unit, as shown in Figure 8.

Figure 8: Checking Support Ring is Seated Properly

7. Place the rubber gasket around the top rim of the jar. The rubber may have to be trimmed slightly to allow the ends of the rubber gasket to meet, with **no** gap, when placed around the rim. Refer to Figure 9.

Figure 9: Placing Rubber Gasket around Rim of Jar

8. Remove the large piece of foam packing from the inside of the cabinet. Also remove the small piece of foam from the float level, located on the upper left corner of the inside of the cabinet.

9. Lower the glass jar into the cabinet so it seats squarely on the rubber support ring. Refer to Figure 10.

Figure 10: Installing Bath Jar

10. Remove the wrapping from around the two glass panels. Place the thinner of the two pieces of glass in the slot closest to the jar. Refer to Figure 11.

Inner Wall

Figure 11: Placing Inner Glass Plate

11. Place the wider (tempered) piece of glass in the front slot furthest away from the jar. The middle slot is left empty to create a vapor barrier.

12. Replace the rear top cover. Align the four holes, then insert and tighten the previously removed screws.

13. Replace the front top cover. Line up the four holes, then insert and tighten the previously removed screws.

14. Ensure that the gasket forms a tight seal with the top covers of the bath:

    a. Loosen the IEC lock screw securing the AC power cord to the rear panel of the electronics drawer.

    b. Unplug all three cables (AC power, rectangular Cinch connector and round Amp connector) from the rear of the electronics drawer.

    c. Pull out the electronics drawer using the handles installed on the front of the unit. Press down or pull up on the plastic release bars on either side of the drawer track to release the drawer, then pull the drawer completely free of the unit and set it aside.

    d. When the drawer is removed, locate the four ¼-20 set screws visible at the top of the drawer opening underneath the bath.

    e. Turn the set screws clockwise with the included Allen wrench until the top of the jar forms a tight seal with the covers. Tighten the set screws uniformly so the jar remains level.

    f. Run the AC cord through the rear panel opening.

    g. Replace the drawer in the slide tracks and push the drawer back into its opening. Insert the two power plugs into the rear of the drawer assembly.

15. Remove the motor-stirrer from its box. Remove the two screws on the top heater housing and lift off the housing. Refer to Figure 12.

Removing two screws

Figure 12: Remove Heater Housing

16. Check the motor-stirrer impeller blades to make sure that the flat sections all lie along the same plane (see *Appendix I: Correcting Shaft & Impeller Misalignment*), then insert the motor-stirrer into the opening provided, as shown in Figure 13.

Insert motor-stirrer into opening
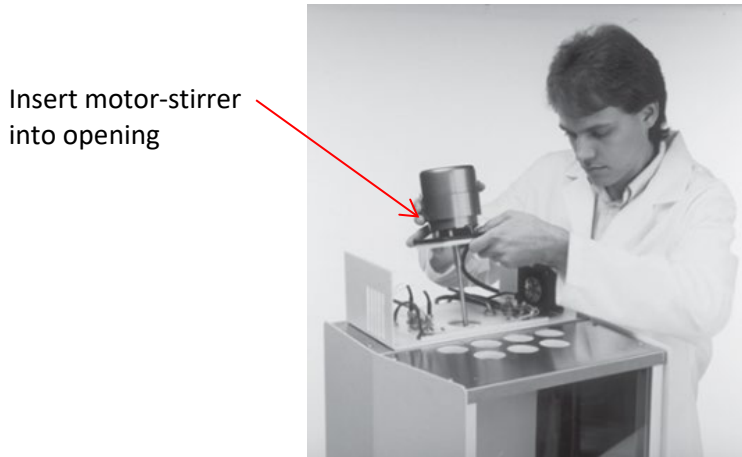
Figure 13: Install Motor-Stirrer

⚠️ **Caution:** *Avoid accidental bending of the motor shaft by NOT holding the motor assembly by the shaft. Use care when inerting the motor shaft and impeller to prevent damage to delicate components.*

✳️ **Note:** *Two screws located on either side of the opening serve as the locating pins for the motor support pad. Do not remove these screws as the holes in the pad fit loosely over their heads. The motor line cord should point towards the rear of the bath (offset slightly to the right or left). The motor-stirrer should now lie flat on the top of the bath.*

17. Connect all plugs and probes to the correspondingly labeled sockets at the rear of the CT-2000 bath unit as shown in Figure 14 and in the following list.

Control Heater
PreHeat Cable
Control Probe
Over-Temp
Level Float Cable
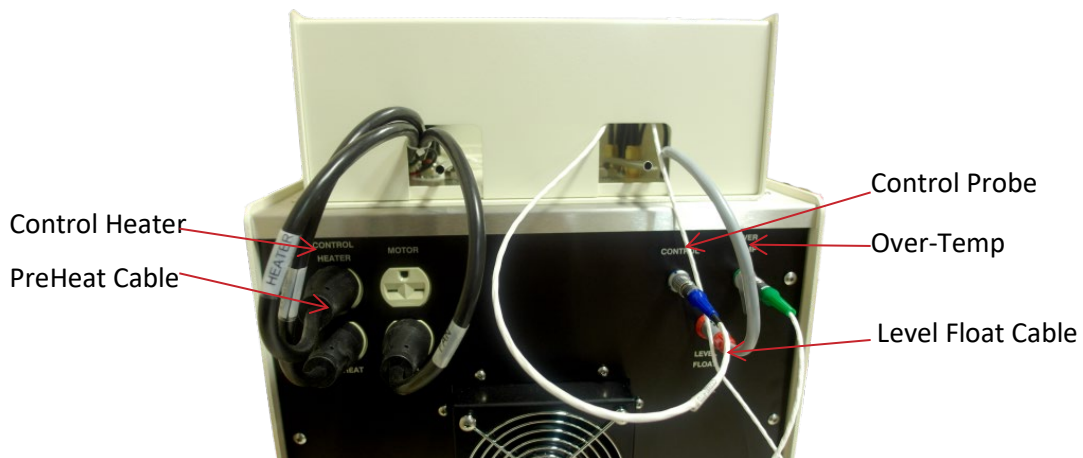
Figure 14: CT-2000 Electrical Connections

- **PREHEAT** cable to PREHEAT socket

- **CONTROL HEATER** cable to CONTROL HEATER socket

- **FAN** cable to FAN socket

- **MOTOR STIRRER** cable to MOTOR socket

- **CONTROL PROBE** cable to CONTROL PROBE socket

- **OVER TEMP** cable to OVER TEMP socket

- **LEVEL FLOAT CABLE** to LEVEL FLOAT socket

18. Reattach the top heater housing, ensuring that the heater, motor, and fan cords pass through the left side opening (as viewed from the rear) and that the control probe, over-temperature probe, and level switch cords exit from the right side opening (also viewed from the rear). The back lip on the rear top cover fits into the slot on the top heater housing. Line up the holes, insert screws, and tighten.

19. Adjust the four leveling feet on the bottom of the bath housing to level the bath jar. This adjustment must be done prior to filling the bath with fluid.

20. Plug the CT-2000 main power cord at the back of the electronics drawer into an outlet with electrical specifications matching the label on the rear of the instrument.

Insert Viscometer Tubes/Thermometers

The top cover of the CT-2000 contains seven apertures, 51 mm (2") in diameter, for the insertion of viscometer tube holders. Two additional holes are provided for insertion of thermometers. Refer to Figure 15.

Figure 15: CT-2000 Top View shown without Hole Covers

If necessary, remove the viscometer tube cover(s) from the top of the bath and carefully place the viscometer tube(s), with the proper holder attached, into the bath through the aperture(s) in the top

cover. The viscometer tube should be inserted to a depth which ensures that the liquid under test and/ or any timing marks are a minimum of 6 mm (¼") below the top level of the liquid.

Thermometer Immersion

Proper thermometer immersion is critical for viscosity measurements. Even a calibrated thermometer will read incorrectly if it is not properly immersed in the bath. Total immersion kinematic viscosity thermometers should be used with the bulb and only the mercury column (if applicable) beneath the surface of the liquid, but with the emergent stem above the surface at ambient temperatures.

Note: *Different thermometers have different immersion requirements. Refer to the information included with your particular thermometer for specific requirements.*

Filling the Bath

After CT-2000 unit assembly is complete, fill the bath.

Caution: *The bath must be placed in its intended final position before adding bath fluid. Never move the CT-2000 when filled with bath fluid.*

Warning: *Never use flammable bath liquids.*

1. Make sure that the instrument power is OFF and select a bath liquid appropriate to your operating temperature range. Refer to *Appendix II: Choosing a Temperature Bath Liquid.*

2. Fill the jar with bath liquid at ambient temperature to a level sufficient to engage the float switch. This float permits bath operation when the minimum amount of fluid has been added to the bath jar. Refer to Figure 16.

Figure 16: Filling the Bath

3. Continue to add fluid until the bath liquid level has risen to within approximately 40 mm (1.5") of the top of the jar.

4. Turn the instrument power ON and incrementally heat the bath to desired control temperature while monitoring the bath liquid level carefully. The bath level must be 15 mm to 20 mm (approximately ½" to ¾") from the top of the jar at the control temperature. If it becomes apparent that this liquid level will not be achieved, return the bath to within 10 °C of ambient, turn the instrument power OFF, and add or remove liquid as necessary.

5. Repeat step four until you have attained the proper bath liquid level at the desired control temperature.

Caution: *Different bath fluids expand at different rates. Be careful not to overfill the bath.*

Warning: *Monitor the bath liquid level closely when operating the CT-2000 at higher temperatures (100 °C to 150 °C). The bath liquid expands as the temperature increases. The CT-2000 bath jar is not designed to contain liquid under pressure. If the bath is overfilled the liquid may overflow and damage equipment.*

Drain the Bath

If it becomes necessary to drain the liquid from the bath, follow the steps outlined in this section.

1. Obtain a suitable container to hold all of the liquid drained from the bath (approximately 20 to 22 liters or 4.5 to 5 gallons), ensuring that the bath liquid is within 10 °C of ambient temperature.

2. Insert a tube into the bath chamber from the top opening and siphon the liquid from the bath into a container positioned lower than the bath.

Warning: *Always use a rubber bulb or similar device to apply suction to a tube containing bath liquids.*

Bath Operation

Caution: *Do not power on the CT-2000 without completing the installation requirements. Make sure the* MAINS *voltage specified on the rear identification label matches your MAINS voltage.*

Note: *The CT-2000 stores the "last-used" temperature setting in memory. Upon power-up, the bath will attempt to adjust to the last known/entered temperature.*

Cold Start

The Cold Start is the normal start-up mode for the CT-2000. During the Cold Start process, the CT-2000 performs several diagnostics (see *Self-Test Sequence*). At the conclusion of a successful test procedure, the results are briefly displayed on the LCD screen. The bath heaters are activated and the Bath Unit begins controlling the temperature according to the most recent temperature entry. The current bath temperature and the target bath temperature are visible on the liquid crystal display (LCD) as shown in Figure 17.

```
          TEMPERATURE
      Actual    Target
     20.003 C  100.000 C
            HEATING
```
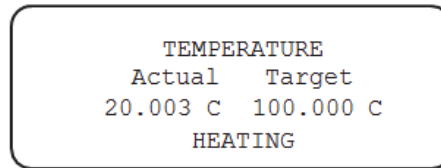
Figure 17: LCD Temperature Setting

To Cold Start the CT-2000, toggle the power BATH switch up. The POWER lamp should light when bath power has been activated. The five LED's in the lower row of keys will blink on and then off, and the instrument will emit a short "beep" tone.

Bath Lighting

To activate the Bath Unit fluorescent lights, toggle the LIGHTS switch up. The switch lamp indicator lights up when power is supplied to the fluorescent lights.

Warm Start

The Warm Start is the abnormal start-up mode for the bath and it occurs only if the power was previously off for a period of less than about two seconds, or if a fault was detected in the microprocessor during the *Self-Test Sequence*. If the CT-2000 Process Function Monitor senses a momentary or ongoing failure in the system hardware and/or software, the heating elements are shut down and the system is reactivated in Warm Start mode. The keypad lights flash in a repeating pattern and the heater power is disabled (heating LED will not light).

The display will appear as shown in Figure 18.

```
            POWER UP
           Warm Start


       Consult User's Guide
```
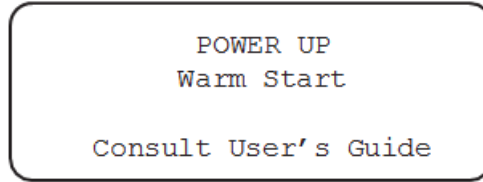
Figure 18: Warm Start Display

If this condition occurs:

1. Turn the BATH power switch off.

2. After waiting at least five seconds, turn the BATH power switch to the ON position and wait for the display to indicate either a warm or cold start again.

3. If the bath comes up in a Cold Start condition and starts its normal self-test sequence, it is likely that a momentary power interruption caused the Warm Start condition and no further action is required.

4. If the bath continues to enter the Warm Start condition, consult CANNON for further assistance.

Self-Test Sequence

The CT-2000 start-up includes a self-test procedure encompassing key components of the system. These tests, which are displayed on the LCD during start-up, are described in Table 2.

Table 2: CT-2000 Self-Test

Test	Test Purpose
Display	Verifies function of the liquid crystal display (LCD) screen. User may visually check for bad segments on the display.
32K Ram	Verifies normal operation of CT-2000 system memory.
Pulse Width Modulator	Verifies function of the PWM.
A/D	Calibrates analog-digital converter and verifies function and consistency.
Voltage Levels	Verifies power supply voltage levels (positive and negative).

Figure 19 illustrates the LCD sequence for a normal self-test:

```
Testing Display
■■■■■■■■■■■■■■■■■
■■■■■■■■■■■■■■■■■
■■■■■■■■■■■■■■■■■
```

```
Testing 32k RAM ...

■■■■■■■■■■■■■■■■■
■■■■ Test Passed ■■■■
```

```
Testing Pulse Width
Modulator.....
■■■■■■■■■■■■■■■■■
■■■■ Test Passed ■■■■
```

```
Testing A/D ......
Calibrating ....OK
Consistency ....OK
```

```
Testing Voltage Levels
......
Positive Supply...OK
Negative Supply...OK
```

```
Diagnostic Report
All tests PASSED
Entering Normal
Operation
```

Figure 19: Normal Test Sequence Display

If the self-test sequence is accomplished successfully, the CT-2000 commences normal operations.

If any component of the self-test fails, a FAILED message will appear on the LCD, accompanied by an audible warning tone as shown in Figure 20.

```
Diagnostics Report
Some Tests FAILED
See Owner's Manual
Press ENTER to go on
```

Figure 20: Self-Test Fail Warning Screen

The **ENTER** key will flash in a repeating pattern and the heating LED will not light (see section *Warm Start*). In the event of a FAILED test, turn off the CT-2000 power for at least five seconds and then restart the unit.

It may be possible to resume normal operation of the CT-2000 following a failed self-test by pressing the **ENTER** key. If **ENTER** is pressed, the "**Attempting Normal Operation**" LCD message appears as shown in Figure 21.

```
┌─────────────────────────────┐
│    Attempting Normal        │
│        Operation            │
│                             │
│   Proceed with CAUTION      │
└─────────────────────────────┘
```
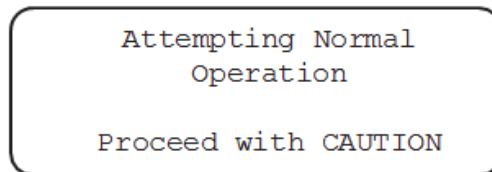
Figure 21: Press Enter to Attempt Normal Operation

> ⚠️ **Caution:** *A failed self-test may result in flawed operation and damage to the CT-2000. If the CT-2000 repeatedly fails the self-test sequene, call* CANNON *to arrange for a service call for the unit.*

Following the self-test, the CT-2000 proceeds with its normal display condition provided that the RTD temperature sensor is connected properly. If the RTD sensor is unplugged at any time, the LCD displays a warning that it is necessary to reconnect the RTD before proceeding with normal bath operations. Refer to Figure 22.

```
┌─────────────────────────────┐
│   The RTD sensor has        │
│   been disconnected.        │
│   Please reconnect it       │
│   to reset the Bath.        │
└─────────────────────────────┘
```
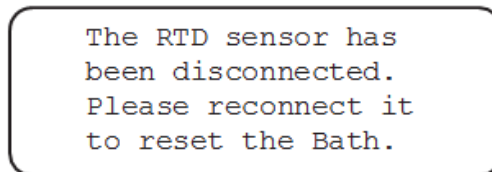
Figure 22: RTD Sensor Warning

Front Panel Operations

Following a successful Cold Start (refer to *Bath Operation* if needed), the CT-2000 is ready for instructions from the user.

> **Note:** *Check bath fluid levels before commencing with use of the CT-2000.*

The front panel of the CT-2000 provides a Liquid Crystal Display (LCD) screen and a simple keypad interface as shown in Figure 23.

Figure 23: CT-2000 Front Panel

The keypad on the front panel of the CT-2000 consists of fifteen keys:

- White buttons - numbers 0 through 9

- A white button - decimal point (.) key

- A yellow button - **SET TEMP** (set temperature) key

- A yellow button - **CAL TEMP** (calibrate temperature) key

- A yellow button - **MENU** key

- An orange button - **ENTER** key

The keys on the bottom row (non-numerical yellow and orange keys) illuminate to assist the operator in selecting key entry options.

Press the appropriate keypad choice(s) firmly to make your selections. The CT-2000 signals reception of each keypad command with a short, high-pitched beep sound. A longer beep indicates a data entry error (unacceptable input), such as a temperature value outside the range of the unit.

ENTER

The **ENTER** button is the most-used feature on the CT-2000 keypad. Each menu choice and numeric input must be confirmed by pressing the **ENTER** button.

Selecting Options/Cancelling Options

Press the appropriate keypad button once to access that option (**SET TEMP**, **CAL TEMP** or **MENU**). If you make a data entry error and wish to cancel your input sequence, simply press the original keypad option button again to clear data.

Note: *If the keypad does not receive user input for five minutes after a primary option is selected, the instrument returns to the LCD temperature display screen without saving any changes.*

These three buttons are the only options available when the Cold Start routine is begun—**SET TEMP**, **CAL TEMP** and **MENU**:

- **SET TEMP** allows user to enter the desired bath temperature setting. See details below.

- **CAL TEMP** allows user to recalibrate the temperature sensing mechanism. See section *Calibrating the CT-2000.*

- **MENU** allows user to change temperature scale (°F or °C), reset calibration offsets and change other system settings (See section *MENU Options*).

Setting Bath Temperature

SET TEMP Procedure

1. To set the bath temperature, choose **SET TEMP** from the keypad after a successful Cold Start.

2. The LCD displays a message requesting input of the new target temperature. Use the numerical keys to enter the new temperature. Enter positive numbers from 10 °C to 150 °C (50 °F to   302 °F) with up to three decimal places.

3. Press the **ENTER** key to save your data. The bath now attempts to equilibrate at the new temperature.

The temperature may be reset at any time.

Data Entry Errors

If data is entered incorrectly while setting the temperature, press the **SET TEMP** key again to exit the data entry screen. Then repeat the **SET TEMP** procedure.

Lower Temperatures

If the desired temperature setting is slightly above or below ambient, coolant must be circulated through the cooling coil. Input/output connections for the coil are located on the upper portion of the rear panel.

Coolant temperature must be lower than the desired CT-2000 control temperature.

Caution: *Extreme temperatures or variability in the temperature of the coolant liquid may adversely affect the CT-2000 temperature control.*

Note: *If a temperature is entered that is outside the operational temperature range of the CT-2000, a* **RANGE ERROR** *message appears on the LCD screen. To correct this error, press* **ENTER** *and follow the prompts to enter correct data.*

When the CT-2000 is controlling temperature within 1/10th of a degree, the LCD displays a temperature graph in 5/100th degree increments at the bottom of the LCD screen. A small "tick" mark above the graph provides a visual cue to the exact temperature of the bath relative to the requested temperature. Refer to Figure 24.
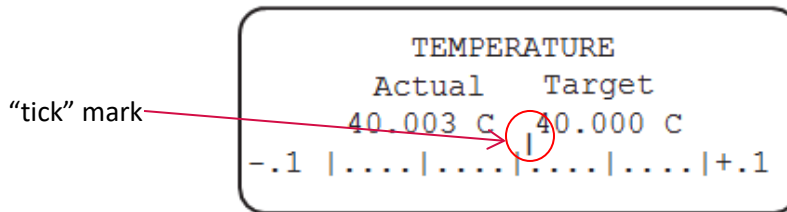
```
              TEMPERATURE
           Actual    Target
"tick" mark 40.003 C  40.000 C
                        |
           -.1 |....|....|....|....|+.1
```

Figure 24: Temperature Graph

Calibrating the CT-2000

The CT-2000 has the ability to be calibrated to a temperature reference standard for any desired temperature, Celsius or Fahrenheit. The controls for entering the target (desired) temperature and the calibration at this temperature are convenient and largely intuitive. The instrument stores calibration corrections for every temperature integer.

Procedure

Use the **CAL TEMP** keypad option to calibrate the CT-2000 to your ASTM thermometer for a given temperature.

> **Note:** *Before calibrating the CT-2000, make sure the bath has stabilized at the desired temperature.*

1. Set the CT-2000 to the desired test temperature.

2. When the CT-2000 indicates that the instrument is controlling at the desired temperature, place the thermometer in the bath and wait for the temperature reading to stabilize (at least 10 minutes).

3. Press the **CAL TEMP** key and enter the thermometer reading up to three decimal places, subject to the following parameters:

   a. A decimal point may be included as an entry.

   b. The entered temperature must be within the operational temperature range of the bath. If not, a **CALIBRATION ERROR** is displayed on the LCD screen.

   c. The entered actual temperature must not cause a correction in temperature greater than ± 2.5 °C.

> **Note:** *If an error is made when entering the temperature, press the **CAL TEMP** button again to cancel the operation, exit the calibration screen and reurn to normal CT-2000 operation.*

4. When data entry is complete, press **ENTER** to store the calibration data.

5. A new calibration constant has been stored for that test temperature.

6. You may now recalibrate for any test temperature at any time.

Calibration Theory

The CT-2000 stores user calibration information in a "bin" corresponding to every temperature integer. This calibration adjustment value for the bin is effective at all temperature ranges within 0.5 degrees of the temperature integer.

The CT-2000 combines user calibration input with readings obtained by the temperature probe and data from the general bath offset, a protected menu option, which is preset at the factory by Cannon Instrument Company (see the *MENU Options* section for more information).

MENU Options

The MENU selection from the CT-2000 keypad permits the user to access three functions:

- **Change to (C/F):** Changes screen display to alternate temperature scale

- **Bath Temperature Offsets**: Globally adjusts calibration data

- **COM Setup:** Sets computer communication options

Change to (C/F)

The **Change to** (Celsius or Fahrenheit) option is essentially a toggle between two temperature scales. If the instrument is currently displaying numeric data in degrees Celsius, selecting this option changes the scale to Fahrenheit, and vice versa.

To switch from one unit of measure to another, press the **MENU** key, press **1** and press **ENTER.**

Keypad Sequence:

MENU > **1** > **ENTER**

Bath Temperature Offsets

To select a **Bath Temperature Offset** function, first press the **MENU** key, then press **2**, and press **ENTER**.

Keypad Sequence:

MENU > **2** > **ENTER**

The **Bath Temperature Offset** option, when selected, displays two sub-menus:

- **Clear Bins**: Clears all user-input calibration data for individual bins

- **Set General Bath Offset**: Allows global calibration adjustment by CANNON.

Clear Bins

In rare instances, it may be desirable to clear all temperature calibrations and recalibrate each offset. To accomplish this function, select **Clear Bins**, then press **1**. The LCD will display a warning message as shown in Figure 25.

```
ABOUT TO CLEAR ALL
CALIB. CONSTANTS!
ARE YOU SURE?
ENTER-Yes MENU-No
```
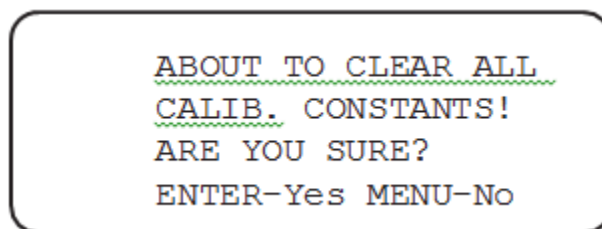
Figure 25: Clear Bins Warning Message

To erase user calibration data for all integer bins, press the **ENTER** key. To exit the **Clear Bins** screen without altering user calibration data, press the **MENU** key.

> ⚠️ **Caution:** *Once the offset values are cleared they cannot be restored. The instrument may require recalibration for all offsets to produce reliable data.*

General Bath Offset

The **General Bath Offset** is a protected function of the CT-2000. This option is a global adjustment which is made at the factory by CANNON. In rare instances when this setting may need to be altered, the adjustment should be made in consultation with an authorized CANNON representative.

Communication Options

Several communication options between the CT-2000 and your computer may be configured from the **MENU** keypad option.

Change Port Speed

The **Change Port Speed** option provides a speed setting for data transfer between the CT-2000 and a computer via the RS-232C connection. Select the baud rate (the default for most software is 9600) in bps (bits per second) from one of the following options:

1. 1200
2. 2400
3. 8600
4. 19.2k
5. 38.4k

Keypad Sequence

MENU > **3** > **ENTER** > **1** > **ENTER** > Input speed choice **(1 – 5)** > **ENTER**

MODE

The **MODE** keypad option permits RS-232C or RS-485 communication options.

The CT-2000 is equipped with a full-duplex RS-232C point-to-point interface as well as a half-duplex RS-485 network interface. Commands and Queries may be sent to the CT-2000 via either interface. Responses and Reports may be received by the master controlling computer.

This interface is configured as 8 data bits with no parity and one stop bit.

The mode of operation, polled (multi-drop) or point-to-point, can only be configured via the front panel menu.

Procedure

To select the **MODE** option, press **2** from the **COM Setup** menu.

Keypad Sequence

MENU > **3** > **ENTER** > **2** > **ENTER**

If the CT-2000 was previously configured to operate in a polled (RS-485) environment, the Communication Mode message appears on the LCD as shown in Figure 26.
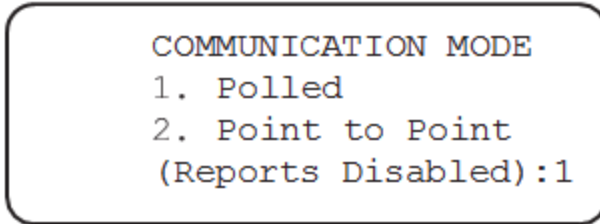
```
COMMUNICATION MODE
1. Polled
2. Point to Point
(Reports Disabled):1
```

Figure 26: Communication Mode Display

The last line on the LCD indicates that timed reports are disabled and the present mode is polled.

In this example, the keypad sequence to press in order to operate in a point-to-point (RS-232) environment with or without timed interval reports is: **2** > **ENTER**

If the CT-2000 is configured to operate in a point-to-point (RS-232) environment, the Communication Mode message appears on the LCD when the RS-232 option is enabled, as shown in Figure 27.

```
COMMUNICATION MODE
1. Polled
2. Point to Point
3. Config Reports :2
```
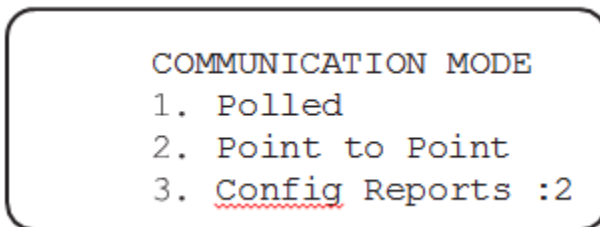
Figure 27: Communication Mode Display

The last line on the LCD (3. Config Reports) indicates that timed reports may be utilized and the present mode is point-to-point (2). In this example, the keypad sequence to reset the bath to a polled environment is: **1** > **ENTER**

Reports

The Reports option is accessed from the **MODE** sub-menu and is only enabled when the Point-to-Point mode is selected.

Keypad Sequence

(from initial LCD temperature display):

MENU > **3** > **ENTER** > **2** > **ENTER** > **3** > **ENTER**

The report is a serial dump of information on the operation of the CT- 2000 and includes:

- Instrument address

- Unit of temperature measurement (C/F)

- A time reference

- Target bath temperature

- Actual bath temperature (as measured by the bath RTD)

The frequency of temperature sampling (in seconds) for the report can then be selected from the options on the LCD screen. The report parameters range from a report each second (keypad selection **2** > **ENTER**) to a report every two minutes (keypad selection **8** > **ENTER**).

> **Note:** *This option can be turned off (selection 1) if there is no computer connected via the serial line.*

The serial connection can only provide time interval reports of the actual and desired bath temperatures if the CT-2000 is configured in the point- to-point mode of operation. Otherwise, the **REPORTS DISABLED** message appears on the LCD and report configuration options cannot be accessed until the point-to-point mode is resumed.

Full Duplex (point-to-point) Connections

The RS-232 interface is furnished for a direct connection between the CT-2000 and one computer. A DB-25 connector on the rear panel of the CT-2000 is configured as Data Communication Equipment (DCE). This configuration permits a direct connection (straight through cable--pins 1- 8, 20).

An existing computer's DB-9 connector may be used with a DB-25 adaptor cable (DB-25 male connector to DB-9 female connector).

Half Duplex and Polled (Multi-Drop) Operations

The RS-485 interface is provided to permit network connections from one computer to a multiple number of instruments. A three-wire (with feed-through) screw terminal connector is located on the CT-2000 rear panel. A three-conductor cable (two wire-shielded preferred) can be connected to the instrument via this terminal. The computer must have an RS-232 to RS-485 adaptor plugged into the computer serial port. With the 3-wire connection in place, the network is capable of supporting up to 16 instruments at cable distances up to a combined total of 4000 feet.

With three or more occupants or long distances, termination resistors may be added to enhance the performance of network operations. Contact CANNON service for further assistance on more extensive network configurations.

Commands, Queries & Responses

The protocol for the serial interface includes commands and queries sent by the master controlling computer, and replies/responses sent by the CT-2000. The CT-2000 may also issue timed interval reports automatically if configured to do so in the point-to-point mode (see *Reports*). In the polled (multi-drop) mode, specific reports are only issued in response to a specific query.

All Commands or Queries must be preceded by the forward slash (/) and the selected address (0-9 or A-F). Commands are identified with the letter C and Queries are identified with the letter Q; these identifiers follow the address and precede the command or query information. All Commands or Queries must end with a carriage return (ENTER).

For examples of CT-2000 command and query language, consult Table 3 on the following pages.

Table 3: CT-2000 Commands and Queries

Command Type ($$)	Possible Argument (&..&)	Action Description
AD	None	Calibrate the 16 bit A to D converter. When complete, the response is **AD_NO** if the calibration failed or **AD_YES** if calibration is successful. If the command is not recognizable, **ERROR** is displayed. For example, if this command is sent to a CT-2000 with an address of 5: **/5CAD**; then the response may be: **-5CADYES**
RT	None	Run a complete self-test like the one run at power up. A response immediately indicating receipt of command **RT_YES**, or the command is unrecognizable and **ERROR** is displayed. For example, if this command is sent to a CT-2000 with an address of 6: **/6CRT**; then the response may be: **-6CRTYES**
DC	None	Display all temperatures in °C on LCD and in all reports. This command places the bath in Celsius mode for all temperature references. An immediate response of command **DCYES** is returned, or if command is unrecognizable then **ERROR** is displayed. For example, if this command is sent to a CT-2000 with an address of 1: **/1CDC**; the response may be: **-1CDCYES**
DF	None	Display all temperatures in °F on LCD and in all reports. This command places the bath in Fahrenheit mode for all temperature references. An immediate response of command **DCYES** is returned, or if command is unrecognizable then **ERROR** is displayed. For example, if this command is sent to a CT-2000 with an address of 2: **/2CDF;** then the response may be: **-2CDFYES**
SR	&&&	Set the reporting interval to the value of half-seconds as defined by the three character argument &&& in hexadecimal. Only arguments from 000 to FFF are accepted where 000 turns all reports off and any other numbers permit reports to be issued on any half-second interval from 0.5 seconds up to 2,047.5 seconds, but only if the CT-2000 is in point-to-point mode of operation. If the command is accepted, instrument returns an **SRYES** response and the new report interval takes effect. If an invalid hex is given, a response of **SR_NO** is displayed and anything else results in an **ERROR**. For example, if this command requesting reports every one second interval is sent to a CT-2000 with an address of 3: **/3CSR002**; the response may be: **-3CSRYES**
ST	+&&&.&&&	Set the desired target temperature of the bath as defined by the argument +&&&.&&&, in °C or °F as previously established. Only fixed point numbers are accepted and must be within the bath's

Command Type ($$)	Possible Argument (&..&)	Action Description
		operating range.) If the command is accepted, **STYES** message displays, or **ERR** if not accepted. For example, if this command is sent to the CT-2000 with an address of 4: **/4CST+080.000**; the response may be: **-4CSTYES**
CB	C | F	Clear all calibration offset Bins as defined by the argument in °C or °F. This command performs immediately and there is no response. This is usually used prior to sending **SB** type commands. In all cases, it should end with an **EE** type command. For example, if this command is sent to the CT-2000 with an address of 9: **/9CCBC**; the response may be **-9CCBCYES**
SB	C@@@±&.&&& F@@@±&.&&&	Set the calibration offset Bin for the specified whole degree temperature @@@ as defined for °C or °F with the offset as defined in degrees &. &&&. The °C or °F Bin must be defined along with a plus or minus symbol, and can be defined to the thousandths of a degree with &.&&&. If the command is accepted, **SBYES** is the response. If not, **ERR** displays. After a series of these commands are issued, the EE type command should follow. For example, if this command is sent to a CT-2000 with an address of 3: **/3CSBC040-0.123**; the response may be **-3CSBYES**
EE	none	Copy the contents of the volatile RAM to non-volatile EEPROM memory. This command should be used to end any sequence of CB and SB type commands which update the contents of the Bin. After the memory transfer is successfully complete, **EEYES** message displays. If the transfer fails, **EE_NO** displays. Or **ERR**. For example, if this command is sent to a CT-2000 with an address of 8: **/8CEE**; the response may be **-8CEEYES**
TB	CF	Transmit all the whole degree temperature Bins for either °C or °F or **ERR** is displayed. This response has the Bin number in the first five columns followed by two spaces, and then the sign (if any, a space is none) and the offset. For example, if the following query is sent to a CT-2000 at an address of 9: **/9QTBC** this queries the °C Bin. The following report is received: **10C 0.000; 11C +0.123** (continues in order with….) **149C -0.456** **150C -0.789** **-9QTBYES** (end of report identifier)

Command Type ($$)	Possible Argument (&..&)	Action Description
TR	none	Transmit a report of key bath parameters. This is a single line report with a network address in the first column followed by the time elapsed since the last affected temperature: One space and then a C or F to designate the temperature scale, followed by at least one space and then one or two digits to indicate hours followed by a colon, two digits for the minutes, a decimal and two digits for the seconds. This is followed by at least one space and then the desired temperature (to the thousandths of a degree). For example, if the following query is sent to a CT-2000 in °C with a target temperature of 40 °C and at address 3: **/3QTR**. This queries the temperature report. The following report is the response: **3 C 12:34.56 40.000 40.002 -3QTRYES** [end of report identifier]
MT	none	Query the machine type and firmware version. A single line report is issued indicating the model, number designation and the firmware revision level for the instrument at this address. For example, if the following query is sent to a CT-2000 at network address 7: **/7QMT**; this queries the machine type. The following report is received: **-7QMTMTCT2000 FV01.01**

Downloading Firmware

The CT-2000 is capable of receiving new operational instructions via either the RS-232 or RS-485 interface. If the CT-2000 firmware is updated and a new release is issued by Cannon Instrument Company, a disk or link will be sent to the user along with instructions on how to perform this upgrade.

A download push button is located on the rear panel of the CT-2000. Pressing and holding this button for several seconds places the CT-2000 instrument in the download mode.

Note: *If the download button is pushed inadvertantly it may be necessary to restart the CT-2000.*

When the CT-2000 is in the download mode, the front LCD panel displays the version number for the resident download hardware code and the operational firmware.

Troubleshooting

A successful CT-2000 self-test is an indication that there are no detectable errors and checked components are functional. There are certain conditions, however, that cannot be verified by the automatic tests. These include:

1. Viscosity of the bath liquid

2. Temperature probe installation

3. Motor-stirrer functionality

4. Temperature probe functionality

5. Heater operation

Problems with the first three items listed above (bath liquid viscosity, temperature probe installation and motor-stirrer functionality) may cause incorrect temperature stability. If items 4 or 5 fail (temperature probe functionality and/or heater operation), the bath may be non-operational.

Consult Table 4 for assistance in troubleshooting your CT-2000. If the following table fails to resolve the difficulties, call your local CANNON representative for assistance.

Table 4: Troubleshooting Causes and Solutions

Problem	Possible Cause/Solution
Bath does not appear to have power	- Power cable is not connected to outlet or connected to rear electrical drawer. - Power cord is unplugged. Attach cord to appropriate outlet. - Power is out on MAINS. Restore power.
Bath illumination not functioning	- Separate switch for LIGHT must be on. - Florescent lamps may be defective. Replace lamps. - Lamps may be out of socket. Tighten lamps. - Lamp ballast may be defective. Replace lamp ballast. - Ballast power supply may not be working properly. Replace ballast power supply.
Bath liquid not agitated	Stirring motor not functioning. Check connection of stirring motor on rear panel. Visually check for working motor by connecting it to an outlet with the proper voltage.
Bath does not heat	- Sensors are not operational. Check sensor connections on rear panel. - Temperature is set lower than current bath temperature. Check temperature setting. It must be above the existing bath temperature for heat to turn on.

Problem	Possible Cause/Solution
	• Bath fluid level is too low. Add fluid per manual instructions. Refer to *Filling the Bath* if needed.
Bath control is outside specific limits	• Bath fluid viscosity is too high. If the fluid is too viscous at the desired temperature, the stirring will be inadequate resulting in poor control. • Stirring motor or impellor is not operating properly. Check stirring motor and impeller. • Faulty RTD probe. Remove control RTD probe plug and check resistance with an ohmmeter (apx. 100W at room temperature).
Bath top surface temperature is too high	• Defective fan. Check cooling fan on rear panel and in top assembly.
Air bubbles in the bath fluid	• Fluid level is too low. Add fluid per manual instructions. Refer to *Filling the Bath* if needed. • Stirring impeller is on the shaft on the wrong orientation. See *Appendix I: Correcting Shaft & Impeller Misalignment.* • Bath fluid is too viscous for operation at this temperature. Replace with appropriate fluid. Refer to *Appendix II: Choosing a Temperature Bath Liquid* if needed.

Spare Parts List

Table 5 provides a list of parts for the CT-2000 available from CANNON upon request.

Table 5: CT-2000 Spare Parts List

Part Number	Description
20.1	Borosilicate Jar 12 x 12
20.22	Thermometer holder, rubber
22.26	Jar top gasket
22.39	Hole covers & thermometer holder set
27.1175	Jar support gasket
27.1260	Socket lamp
27.1300	Fluorescent lamp
27.1310	Laminated safety glass
27.1320	Plate glass
25.3190	Over-temp probe
27.2280	Ballast Solid State
27.5110	Front bath cover with round holes
27.5250	PTFE coated baffle, white
27.5260	Cooling coil (SS)
27.5270	Heater 700W 115V
27.5271	Heater 700W 230V
27.5290	Heater 400W 115V
27.5291	Heater 400W 230V
27.8037	Control Probe RTD 100
27.5410.1	Level Switch
27.6100	Motor Stirrer, 120V
27.6101	Motor Stirrer, 240V
27.4120	Vent shroud (optional)
51.1432	Lighted switch rocker 115V
51.1433	Lighted switch rocker 230V
62.1338	Solid state relay 25A

Warranty

Products Limited Warranty

In addition to other manufacturers' warranties, Cannon Instrument Company ("the Company") warrants all products (other than reagents and chemicals) delivered to and retained by their original purchasers to be free from defect in material and workmanship for one year from the date of the Company's invoice to the purchaser. For a period of one year from the date of such invoice, the Company will correct, either by repair or replacement at the Company's sole discretion, any defect in material or workmanship (not including defects due to misuse, abuse, abnormal conditions or operation, accident or acts of God, or to service or modification of the product without prior authorization of the Company) without charge for parts and labor. The determination of whether any product has been subject to misuse or abuse will be made solely by the Company.

The Company shall not be liable for any special, incidental, or consequential damages, or any damage to plant, personnel, equipment or products, directly or indirectly resulting from the use or misuse of any product. Representations and warranties made by any person, including dealers and representatives of the Company, which are inconsistent, in conflict with, or in excess of the terms of this warranty shall not be binding upon the Company unless placed in writing and approved by an officer of the Company.

Reagent and Chemical Warranty

Cannon Instrument Company ("the Company") warrants all reagents and chemicals sold by the Company and delivered to and retained by their original purchasers to conform to the weight, specifications and standards stated on the package. The Company will, at its sole discretion, either replace or refund the price (net of freight, handling charges and taxes), of any reagent or chemical sold by CANNON which does not conform to such weight, specifications and standards upon the prompt return of the unused portion. Except for replacement or refund of the net price, the Company shall not be liable for any damages occurring as a consequence of the failure of any reagent or chemical sold by the Company to conform to the weight, specifications and standards stated on the package.

Returning a Product to CANNON

Before returning a CANNON product for repair or service, make every attempt to identify the problem. If, after careful checking, the problem remains unidentified or unsolved, telephone Cannon Instrument Company (or the local service agent) to consult with a product specialist. If the specialist cannot recommend a simple solution or repair, CANNON will authorize the return of the product through the issuance of a Return Authorization number (RA).

CANNON Telephone Number: 814-353-8000

CANNON Fax Number: 814-353-8007

Products returned to CANNON must be carefully packed (often in their original packaging). Ship prepaid to the following address:

CANNON Instrument Company

ATTN: Return Authorization # _____

2139 High Tech Road

State College, PA 16803 USA

Required Information

The following must be included:

- The Return Authorization number (RA).

- The name and telephone number of the person at your company to contact regarding the product.

- Shipping and billing instructions for the return of the product to your location.

- A detailed explanation of the reason for the return. If the product is not covered by warranty, the customer will be provided with an estimate of the repair costs and asked for approval before any repairs are made. The customer will be required to issue a purchase order for the cost of the repairs.

Hazardous Materials

Please contact CANNON before returning a product that could possibly contain hazardous material.

Shipping Notification

Products returned without CANNON's prior authorization will not be accepted. The customer may be billed a testing fee if a product is returned to CANNON and found to be working properly.

Appendix I: Correcting Shaft & Impeller Misalignment

Motor-stirrer units supplied by Cannon Instrument Company are checked after assembly to ensure minimum run-out (deviation from concentric rotation) at the impeller end of the shaft. The following instructions are intended to assist those who may be experiencing excessive vibration in the motor-stirrer because of shaft run-out or misalignment of the impeller blades.

Set Screw Alignment

The motor shaft contains a flat area. The coupling should be oriented in such a way that the set screw is aligned with the flat. The stirrer shaft and motor shaft should be inserted to approximately the same length in the coupling.

You can test for shaft run-out and impeller blade alignment by placing the motor on a soft surface with impeller facing up.

Connect the motor to the appropriate AC power source and observe the impeller and shaft. If run-out is severe, the motor will vibrate and the shaft will flutter noticeably. The impeller will appear blurred if the impeller blades are not in the same plane.

If necessary, adjust the impeller blades by bending the large horizontal sections of each of the four segments so that they lie in the same plane. Since these segments are easily bent, check alignment whenever the impeller is bumped, or if there is any suspicion that the blade segments may have become misaligned.

Shaft Run-Out Correction Procedure

Use the following procedure to correct shaft run-out:

1. Remove the motor-stirrer from the CT-2000 bath.

2. Grasp the motor firmly with the left hand.

3. Touch the tip of a soft crayon (such as a glass marking pencil) momentarily to the side of the shaft near the impeller end while the motor is running. The mark produced by the crayon will be evident as a line part way around the shaft.

4. Unplug the motor, hold the motor tightly against the body, and grasp the shaft in the right hand.

5. Bend the shaft away from the line segment on the shaft.

6. Repeat the test procedure, marking the shaft at a location slightly removed from the first crayon mark.

7. If the mark appears at the same side of a shaft as the first mark and is about the same length, the bending was not great enough to alter the condition and should be repeated with more force

applied. If the mark has shifted to the opposite side, the force was too great and the shaft must be bent back with less force to correct the situation.

This is a trial-and-error process which usually must be repeated several times. When the crayon makes a line at least two-thirds of the way around the shaft, the run-out is diminished to an acceptable level. A uniform line completely around the shaft would indicate no run-out detectable by this procedure.

Appendix II: Choosing a Temperature Bath Liquid

The ideal bath liquid would possess low viscosity, high heat capacity, and low vapor pressure over a wide range of temperatures. In addition, the liquid should have a very high flash point and be relatively low in cost. If the fluid is for use in a kinematic viscosity bath where it is necessary to view the instruments through the bath liquid, then it is important for the liquid to be clear and provide high visibility. Unfortunately, no single fluid meets all these requirements. When selecting a fluid, keep the following guidelines in mind as shown in Table 6.

Table 6: Ideal Bath Liquid

Viscosity	Should be low so moderate stirring can effectively eliminate temperature gradients in the bath.
Heat Capacity	Temperature gradients in the bath are less rapid with a high heat capacity. With the exception of water, most choices for bath fluids will have about the same heat capacity.
Volatility	A liquid with a low vapor pressure will require more frequent replenishment. Further, rapid evaporation at the bath surface produces a cooling effect, making temperature control more difficult.

Because no single fluid can be used at all possible bath temperatures, the choice of a suitable fluid must begin by establishing the temperature range over which the bath will be operated. Refer to Table 7 for a list of operating temperature ranges and suitable bath liquids for use in these ranges.

Table 7: CT-2000 Bath Fluid Options (10 °C to 150 °C)

Temperature Range (°C)	Suitable Bath Liquids
10 °C to 20 °C	Isopropyl alcohol, low-viscosity silicones
10 °C to 60 °C	Water, low-viscosity oils, silicones (Dow 200 fluid, 1 cSt)
60 °C to 135 °C	White oils with oxidation inhibitor, IBF oil, Silicones (DOW 200 fluid, 20 cSt)
135 °C to 150 °C	Silicones (Dow 200 fluid, 20 cSt)

IBF Bath Oil

IBF Bath Oil contains an oxidation inhibitor which reduces tendency to darken at higher temperatures. Viscosity is 36 cSt at 40 °C and 5.6 cSt at 100 °C. This oil is available from CANNON as part number 9726-L20.

Silicone Fluids

Silicone fluids are available in a wide range of viscosities and can be used over an extensive range of temperatures. However, silicones are also relatively expensive liquids and a bath containing silicones

requires extra care when used for capillary viscometry. If silicones are introduced into a viscometer capillary, its calibration factor is significantly altered.

Water

Water is the near ideal fluid for the temperature range in which it can be used. Due to the possibility of algae formation in some circumstances, an inclusion of water treatment is necessary. Water can be used at temperatures close to the boiling point, but water replenishment to offset evaporation becomes a nuisance and exposure to the hot vapor can make working above or near the bath uncomfortable. Also, it may be difficult to establish optimum control at elevated temperatures because of the rapid cooling resulting from surface evaporation.

Refined White Oils

Refined white oils (paraffin oils) of relatively low viscosity can be used at temperatures above the level at which water becomes unsatisfactory. Because these oils will turn faintly yellow and continue to darken with prolonged exposure to heat, CANNON recommends adding an oxidation inhibitor to retard discoloration. The addition of an inhibitor will prolong the useful life of the oil, but it will eventually become as dark as untreated oil and need replaced.

The search for more suitable bath oils is continuous. Some success has been found with hydrogenated vegetable oils, coconut oil, synthetic oils, and certain chemical compounds at various temperatures.

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