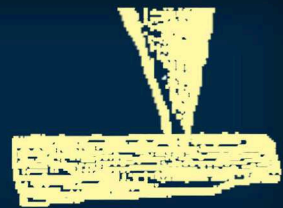




# *Cell MicroControls*

*Equipment for cellular &  
electrophysiology research*



[www.cellmc.com](http://www.cellmc.com) . 757-622-0261 . Norfolk, VA 23509, USA

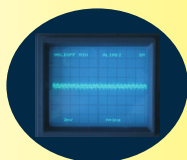
Since 1989 Cell Microcontrols has been designing and manufacturing temperature control and perfusion instruments for electrophysiology and microscopy research.

With a customer base spanning over 250 universities and companies worldwide, customer support and satisfaction is our main objective. By carefully researching our designs, we are able to make novel, dependable equipment available at a reasonable cost.

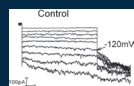
## Temperature Control



- Flexible 2/3 channel controller for heating/cooling
- Low noise for patch, whole cell recording
- External temp control input and outputs



Output noise  
<1mV at 5V,  
0.72A

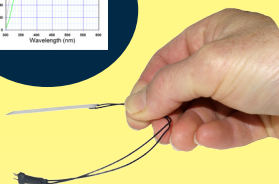
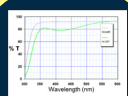


Patch recording from rat  
ventricular myocytes @  
37C using TC2BIP. H-G  
Yu, WVU, WV

## Transparent heaters

- Thin (<200μm) heaters for inverted microscopes-short working distance lens
- Thick (0.6-1.1mm) for long working distance lens & conventional microscopes.
- Rapid heating, uniform temperatures

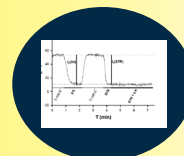
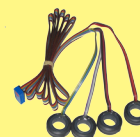
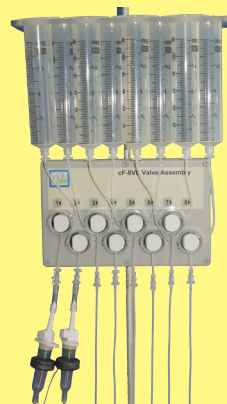
Transmission  
spectrum thin  
heater



## Perfusion System



- 8 channel perfusion control
- Rapid pinch valve switching (typ. 50ms)
- Simultaneous flow control and solution switching
- Digital, analog and RS232 for computer control
- Upgradeable firmware

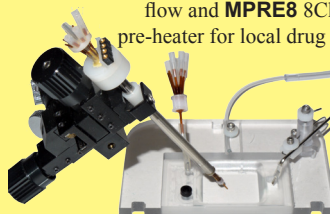


Na/K pump current with solutions switched with cFlow. J. Gao SUNY @ Stony Brook, NY

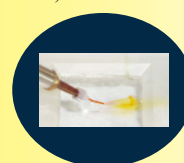
## Accessories

Below are a few of over 100 of our accessories.

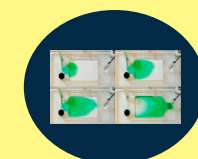
Setup with 8 to 1 manifold for bulk flow and MPRE8 8Ch miniature pre-heater for local drug application



Temperature controlled solutions are switched at the mixing tip (1μL dead vol.) of the MPRE8



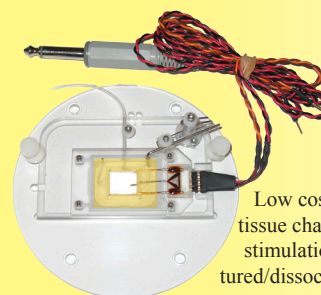
Flow test for  
BT-1-18BV tissue  
chamber



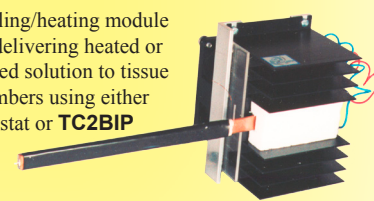
3 loop high efficiency  
inline heaters, 0-3ml/  
min and 0-6ml/min



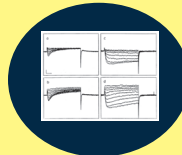
Low cost reusable  
tissue chamber with  
stimulation for cultured/dissociated cells



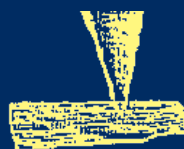
Cooling/heating module for delivering heated or cooled solution to tissue chambers using either rheostat or TC2BIP



Ca currents in Purkinje myocytes recorded at 14.5°C. N. Dattner SUNY @ Stony Brook, NY



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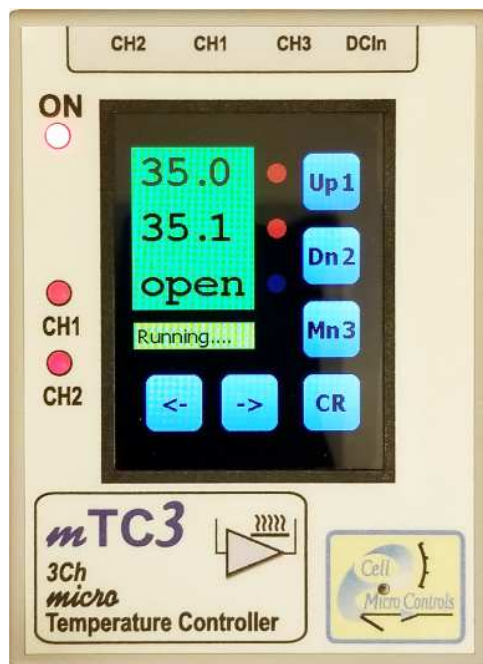


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*Equipment for cellular & electrophysiology research*

# mTC3 *micro*-Temperature Controller & Heaters



- **Miniature temperature** controller for heating small tissue baths, microscope stages, small animal heaters
- **3 independent channels** with feedback
- **Compatible** with many low voltage **heater elements**
- **USB-RS232** port for control and temperature logging
- **2 heating modes**, **PWM** (more power) or **analog** (low noise).
- Maintains **setpoint** and **parameters** in **EEPROM**
- **Bluetooth** control for remote operation
- **Firmware reprogrammable** - for upgrades, customization

## DESCRIPTION

The **mTC3 micro-Temperature Controller** is a multi-purpose microcomputer based temperature controller powerful enough to heat small tissue baths, microscope stages, small animal heaters or containers used in a laboratory. It is simple to set up a mini-incubator to hold cells, or alternatively, heat tubes on a shaker. The **mTC3** uses a state-of-the-art microcontroller to provide a flexible instrument rather than a on/off PID module where there is no control over the user interface and instrument function. Updated or customized firmware can easily be downloaded via the USB-RS232 port to add new features and update existing firmware. For example our firmware checks the heater resistance in case there is a shorted or damaged lead. Firmware also detects the temperature of the internal heatsinks used for the power amps and controls the internal fan speed. In an onboard library parameter sets are saved for many different heaters and devices and can be updated or new ones created. Via the USB-RS232 port you can easily change the setpoints, change parameters and receive reports of the probe temperatures

for data logging and analysis. Parameters for control, set-points etc. are stored in non-volatile EEPROM. Our control software for the **mTC3** to create temperature protocols, chart and log temperature data (eg. to condition with a temperature protocol, test for thresholds etc.). The **mTC3** can also be controlled using Labview, MATLAB, C# and other programs using VCP.

On Ch1 & Ch2 the **mTC3** outputs **high output powers** (approx 15W), and up to 1.5Amps/ Lower power is available on Ch3.

## Application notes

The **mTC3** can drive virtually all our accessories including the **HPRE2** and **MPRE8** pre-heaters, all our ITO heaters and foil type heaters with a resistance of 5-15 $\Omega$  as well as custom devices designed by customers. Our **HS-3x3p** silicon coated heater and our **TH-10Kmr** Tygon sleeved rectal probe can be used as a small animal heater. Without heaters the additional channels can monitor temperatures. In analog mode the **mTC3** can drive low power devices and achieve some low level electrical measurements where digital mode switching noise would be an issue.

## Controls & Display

**Up/down:** Increments or decrements set-point, also used for menu selection.

**Menu:** Displays parameters. Can set control parameters for each channel, set TFT display mode, etc.

**Display:** Shows current temperatures, digital/analog mode, status

**LEDs:** ON-indicates that unit is receiving DCIn

CH1-indicates output to heater and error (flashing)

CH2-indicates output to heater and error (flashing)

**Input/Output:**

CH1 - channel 1 heater thermistor

CH2 - channel 2 heater thermistor

CH3 - channel 3 heater thermistor

## Control software(avail Q2 2023)

**Compatibility:** Windows 7/8/10/11.

**Protocol:** can set temp protocol for each channel. Also can set to repeat protocol.

**Control:** can set separate set points or have common setpoint.

**Charting:** 2 minute scrolling plot. Main plot can continue for months. Can zoom, set axis range, select plots to view.

**Logging:** Log data for unlimited time to .csv file. Includes time stamp for each point.

## Specifications

**Temp Ref Range:** 5°C (in cool env) to 50°C (also version to 95°C).

Accuracy:  $\pm 0.2^\circ\text{C}$  (reduced for 95°C version)

**Heater Output:** 0 to 12V at up to 1.5Amps.

PWM (pulse width modulated) output (15W Max)

Analog output (2W Max)

**Suitable Heaters:** 5 to 15 $\Omega$  resistance.

**Supply Voltage/DCIn:** 15V at up to 4.0Amps.

**Included power supply:** 15V, 4.0Amp switching power supply.

**Temperature sensor:** Compatible with 10k $\Omega$  interchangeable thermistors.

**Fan:** internal fan under microprocessor control

**Control:** USB/RS232 port for temperature logging and control

**Dimensions:** 4.5 x 3.25 x 1.5 inches (LxWxH)



## Accessories

Below are some of the accessories compatible with the **mTC3** 3Ch micro-Temperature controller. Most accessories used with the **TC2BIP** will also work with the **mTC3**. For example you can use the **HI-xx** heaters plus **TH-10Kmp** probe, **HPRE2**, **MPRE8** etc. Also different heaters on each channel. The **mTC3** uses the **CAB-HXTH/DIN** or **CAB-HP2/DIN** cables for heater/thermistor probe setups or pre-heaters.

### TH-10Kmp Thermistor probe

**Application:** general purpose miniature thermistor probe



- TH-10Kmp thermistor 0.45mm diam.
- max oper. temp: 100°C; 15cm lead.

### TH-10Kmrp Thermistor probe

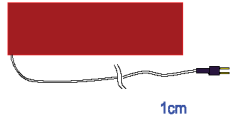
**Application:** mouse rectal probe



- TH-10Kmrp Tygon sleeve 1.7mm diam
- max oper. temp: 100°C; 15cm lead; 6mm plug

### HLS-1p/HLS-8x0.8p Heater - objective, silicon

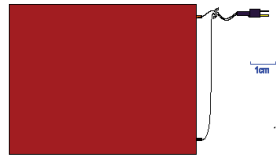
**Application:** objective heater (typically used with **TH-10Kmp** Thermistor probe)



- heater size:  
HLS-1p 20x70x≈0.35mm thick  
HLS-8x0.8p 8x80x≈0.35mm thick
- max. operating temp. 150°C

### HS-3x3p Heater - 7.5x7.5cm, silicon

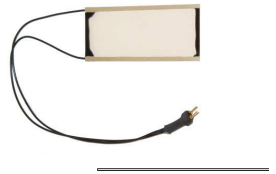
**Application:** small animal heater, culture dish heater



- size 7.5cm x 7.5cm.
- resistance nominally 4.9Ω
- constructed of a thin foil coated silicon. Total thickness 0.5mm.
- max. operating temperature 150°C

### HI-24p/24Tp Heater-ITO transparent

**Application:** heating **BT-1-xx** Tissue chamber or similar small tissue chambers. Use with **inverted** or **conventional** microscope. **HI-24Tp** is thinner for fluorescence or work with immersion lenses.



- **transparent** indium tin oxide coated heater
- sizes:  
HI-24p: 40x22x≈0.25mm thick.  
HI-24Tp: 40x22x≈0.14mm thick.  
Heated area≈35x18mm
- resistance nominally 6-13Ω
- max. operating temp. 70°C

### HPRE2/HPRE2HF Pre-heaters

**Application:** pre-heating solution (3 loop high efficiency capillary heater)



- **HPRE2[HF]** dims. 45[70] x14x7mm (LxWxH); heater resistance ≈11Ω
- Thermistor sensor: 10kΩ NTC

### MPRE8 Multitube Pre-heater

**Application:** superfusion of cells or small tissue pieces



- Dims. 10 x 0.4cm (LxDiam); heater resistance ≈11Ω
- Thermistor sensor: 10kΩ NTC

### HI-22Dp/25Dp/55Dp/57Dp/711Dp/812Dp Heater-ITO transparent

**Application:** heating 30mm culture dishes, Nunc Lab-Tek chambers. Heater forms a platform for dishes/chambers.



- **transparent** indium tin oxide coated heater
- sizes: HI-22/25/55/57Dp 0.6mm thick; HI-711/812Dp 1.1mm thick.
- resistance 6-12Ω
- max. operating temp. 70°C

### HWPT-96NIK/OLY Well plate heater/ITO transp. microscope stage

**Application:** heating well plates, culture dishes, Nunc Lab-Tek chambers



- **transparent** ITO microscope stage heater
- size: 70x110mm x1.1mm
- resistance nominally 9Ω
- versions for Olympus/Nikon round inserts
- max. operating temp. 70°C

### HWPT-384S Well plate heater & HWPT-LID Heated lid

**Application:** heating well plates, culture dishes, Nunc Lab-Tek chambers



- **transparent** ITO micro. stage **HWPT-384S**
- **transparent** lid **HWPT-LID**
- fits within well plate base
- fits optical instruments/auto stages
- resistance nominally 9Ω
- max. operating temp. 70°C

### BT-I55D ITO transparent microscope stage

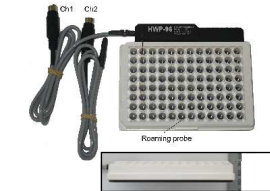
**Application:** heating culture dishes, Nunc Lab-Tek chambers



- **transparent** ITO microscope stage heater
- size: 50x50mm x0.6mm.
- fits into any MSA-xxx stage adapter
- resistance nominally 9Ω
- max. operating temp. 70°C

### HWP-96 Well plate heater

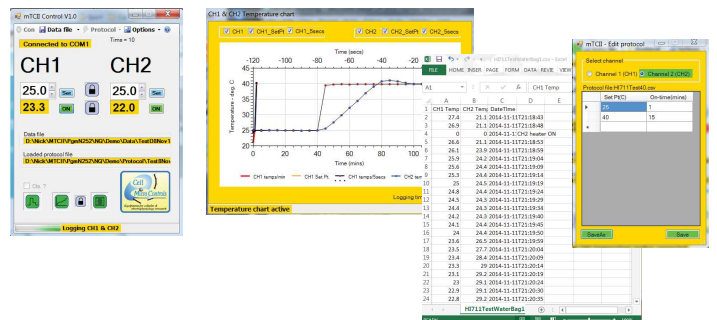
**Application:** heating 96/384 well plates. Low profile fast warmup heater with integrated thermistor sensor.

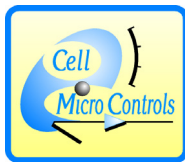


- **Low thermal mass, fast heatup**
- Fits within well plate base
- connects directly to **mTC3**
- Supports temp. sensing from well using second thermistor probe

### mTC3 Control software (avail Q2 2023)

**Application:** Allows control of temperatures, protocols, data plotting and logging. Also allows channel setpoints to be locked. Runs on Windows 7/8/10/11.





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*Equipment for cellular & electrophysiology research*

# Temperature Control Systems



## ■ 3 Temperature Control System versions:

**TC2PKG** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx) for **no/low flow** situations

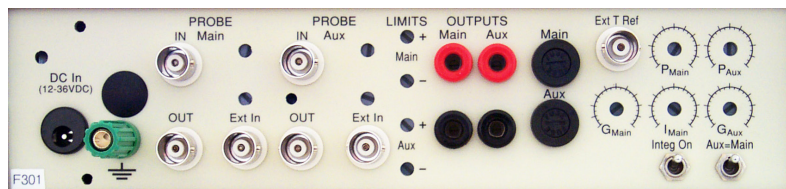
**TC2PKG-P** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx, HPRE2, FL-1) for **flowing** solutions.

**TC2PKG3P** - (incl. TC2BIP, BT-xx, TH-10Km, HI-xx, MSA-xx, HPRE2, FL-1, HLS-xx, TC2-CH3) for **flow** with 3rd channel for **objective** heater or **superfusion** (MPRE8)

- **Bipolar, 2 channel** [3rd heat opt] controller for **heating/cooling** low volume tissue baths
- **Thin transparent** (ITO) heaters
- **DC/Battery** powered to **eliminate** interference
- **Flexible** controller, **many** control options
- **Accurate** temperatures for **wide range** of flow rates
- For **conventional** and **inverted** microscopes
- **Uniform** temperatures ( $<\pm 1^{\circ}\text{C}$ ) obtained over **>35x18mm** area (**HI-24p**)
- **Rapid** temperature changes (eg. with **BT-1-xx** chamber & **HI-24p** Heater  $>0.5^{\circ}\text{C/sec}$ )
- **External** input for **programmed** temperature changes

## DESCRIPTION

The **Temperature Control Systems**<sup>†</sup> (see below) consist of the sophisticated **TC2BIP** 2 channel controller together with accessories to form a complete setup for patch clamping/microscopy or for experiments with brain slices or other small pieces of tissue (eg. DRG). The system provides excellent optics and reliable and accurate temperature control in small experimental chambers. The **BT-1-xx** tissue chambers are suitable for the study of acutely isolated or cultured cells or small tissue preparations. For temperature control the Main channel of the **TC2BIP** compares the bath temperature (the Aux channel typically compares the **HPRE2** pre-heater temperature) with a reference temperature set either by the TEMP1 or TEMP2 controls or by an external programming voltage. The bath temperature is maintained at the reference temperature during changes in flow rate, inflow solution temperature or ambient temperature. The Main channel uses both proportional and integral control, while the Aux channel uses proportional control. The



integrator eliminates the steady state error which exists when small proportional gains are used. The **TC2BIP** was designed to be battery operated to eliminate electrical interference but can also be operated from DC power supplies.

In rapid heating systems the temperature often overshoots before settling to the reference temperature. The **TC2BIP** works to minimize this overshoot, thereby protecting the cells from damage due to transient high temperatures. With proper adjustment of the **TC2BIP** control parameters the temperature across a 15x8mm area in the **BT-1** or larger areas in bigger chambers can be regulated within  $<\pm 1^{\circ}\text{C}$  for flow rates of zero to  $>2\text{ml/min}$  (higher flow rates can be used with larger chambers). Typically, heating rates of  $>0.5^{\circ}\text{C/sec}$  can be expected with chamber volumes less than 0.25ml. The cooling rate ( $\tau_{\text{cooling}}$ ) depends on the experimental chamber design as well as the solution flow rate. For the **BT-1** bath,  $\tau_{\text{cooling}}$  ranges from 30 secs (2ml/min) to 112 secs (0.2ml/min) (see Dwyer, Gintant and Cohen (1985)<sup>§</sup> for performance of a similar system).

The **HI-24p** heater is a transparent indium tin oxide coated (ITO) heater with a #1 1/2 cover slide thickness. This heater provides a 45x18mm transparent, uniformly heated area 0.18mm thick, suitable for both conventional and inverted microscopes. The **HI-24Tp** heater is thinner (#0 cover slide thickness; 0.12mm) for microscopy studies or use with fluorescence.

<sup>§</sup>Ref: Dwyer, Gintant & Cohen (1985). "Versatile temperature controlled tissue bath for studies of isolated cells using an inverted microscope." *Pflügers Archiv*, **403**, 318-323.

<sup>†</sup>You need to purchase a power supply for the TCS. We recommend different power supplies depending on the application. Typically a 12V (or 13.8V, max. 4.5Amp) regulated supply for whole cell, intracellular or microscopy studies. For single channel or smaller whole cell currents we suggest a 12V ( $>15\text{AH}$ ) gel battery and charger. For use with Peltier elements an additional 12V ( $>15\text{AH}$ ) battery is recommended to boost the supply to 24V. For high resistance heaters (eg. 50 $\Omega$ ) a 36V supply is recommended. Please call or see website for more details.  
 ...over



## Controls

### Front controls

**TEMP1,2:** 2 setpoints allow switching between two preset temperatures or independent setpoints.

**POWER:** Controls overall output power to limit rate of temp increase and put controller in standby mode.

**Aux/Main:** Display temperature of main probe or auxiliary probe. Output at rear can be used to monitor Aux temperature continuously with a DVM.

**Cool/Heat or Heat:** Cool/Heat is used for Peltier devices. Heat is used for resistance type heaters.

**OUTPUTS:** LEDs display output current and direction of current.

**Aux On/Off:** Shuts down Aux output.

**Low Pwr:** Indicates when power input is too low for proper function.

### Rear controls

**PROBE Main:** Accepts **TH-10Km**, YSI-400 and YSI-500 series or compatible probes. Two adjustments allow customization for miniature non-interchangeable probes (eg. **TH-1**).

**OUT:** Temperature output for DVM, computer or chart recorder.

**Ext In:** Allows input from other probes (eg. Sensortek).

Automatically switches to external input.

**PROBE Aux:** As for Main.

**T Aux Offset:** Offsets Aux reference  $\pm 6^{\circ}\text{C}$ .

**LIMITS:** Sets max output voltage for particular heater type. Min is max output voltage for Peltier for cooling.

**OUTPUTS:** Output to Main heater (or Peltier) and Aux heater (pre-heater or Peltier). (3rd channel uses MiniDIN connector for heater/thermistor.)

**Fuses:** Protects controller power amplifier from overload. Internal fuse and microcontroller based overload/short protection. Internal heatsink overheating sensing and shutdown.

**Ext T Ref:** External temperature programming (eg. for computer setting of temperature).

**P<sub>Main</sub>:** Proportional gain for main output.

**I<sub>Main</sub>:** Integral gain for main output.

**Integ On:** Integrator on/off control.

**P<sub>Aux</sub>:** Proportional gain for auxiliary output.

**G<sub>Main</sub>:** Overall gain of output amplifier for main output.

**G<sub>Aux</sub>:** Overall gain of output amplifier for auxiliary output.

**Aux=Main:** Aux output =  $G_{\text{Aux}}/G_{\text{Main}} \times \text{Main output}$  (pre-heater as slave).

## Specifications

**Temp Ref Range:**  $0^{\circ}\text{C}$  to  $50^{\circ}\text{C}$  (can be extended to  $>60^{\circ}\text{C}$ )

**Output (Main & Aux)**

DC In:12V max: -8V to +8V; 5-15 $\Omega$  load; 2Amp max

DC In:24V max: -12V to +8V; 5 $\Omega$  load; 2Amp max  
max: -18V to +18V; 15 $\Omega$  load; 2Amp max

DC In:36V max: -28V to +28V; 50 $\Omega$  load; 0.7Amp max

3rd channel : max: 8V 1.5Amp.

**Suitable heaters:** 3.5 - 50 $\Omega$  resistance. eg. **HI-24xp**, **HI-5xDp**, **HC-1p**

For 50 $\Omega$  heaters need >24V supply.

**Suitable Peltier:** 12V, 2A device.

**Supply Voltage: Resistive heater**

12V at 4.0Amp max. Typ. 1.5 Amp. for **HI-24** & **HPRE2**

36V at 1.4Amp max.

**12V Peltier element**

18V at 4.0Amp max.

**Dimensions:** 8.0 x 10.0 x 3.0 inches (LxWxH)

## Application notes

### Power supply options

The **TC2BIP** has very flexible power options and heater resistance options. For resistive heaters 15-50 $\Omega$  a 12V supply will provide from 4-13Watts of power respectively. For 12V Peltier devices a 18-24V supply (eg. two 12V gel batteries in series) is ideal although a 13.8V DC supply is often adequate. If you are using resistive heaters with high resistances (eg. 50 $\Omega$ ) you can use a higher power supply (up to 36V). The  $G_{\text{Main}}$  and  $G_{\text{Aux}}$  controls allow expansion of the output voltage range at these higher supply voltages.

### Chambers

The **BT-1** Bath performance is described in Datyner, Gintant & Cohen (1985). It provides for rapid solution changes (eg. 6 times/min at 1.5ml/min flow rate), reliable temperature control and uniform temperatures (with the **HI-24p/25p** heaters). Baths with a central chamber (preferably rectangular) with similar dimensions to the **BT-1-xx** will provide predictable rates of heating/cooling and good temperature uniformity. The **HI-24p/25p** heaters

will also suit baths with larger working areas (up to 45mm x 18mm). If you want advice on adapting baths that you currently use please call us.

Figures of better than  $\pm 0.2^{\circ}\text{C}$  are often quoted in describing temperature controller regulation. Since the exact conditions (flow rate, probe location, ambient temp. etc.) affect this figure and cells are often not located adjacent to the probe, actual temperatures in different locations in the experimental chamber must be measured under actual conditions of use (see Datyner, Gintant and Cohen (1985)). Use of the **HI-24p/25p** heaters and **HPRE2** Pre-heater optimizes the temperature uniformity.

Our **BT-I55D** or **HWPT-96OL/NK** transparent microscope heater stages are intended for heating 30mm culture dishes or any other transparent dishes.

### Temperature probes

The **TC2BIP** accepts **TH-10Km** (standard), **TH-2Km**, YSI-400 and YSI-500 probes. The Ext In for each PROBE accepts sensor outputs with 10mV/ $^{\circ}\text{C}$  (eg. Sensortek thermocouple transducers).

### Special optics (eg. fluorescence)

The **HI-24Tp** can be used for fluorescence microscopy or where there is limited working distance (transmission data is available on a separate **ITO heater flyer**).

### Pre-heating

The **HPRE2** is a miniature pre-heater with a thermistor for sensing the pre-heater temperature. The pre-heater supports a wide range of flow rates. The cable plugs into the Probe Aux and Aux Output.



### Superfusing

The **MPRE8** is a miniature 8 channel pre-heater with a tiny dead volume (1-2 $\mu\text{l}$ ) and internal thermistor that can be used for superfusing cells, small pieces of tissue for perfusing small chambers at low flow rates (<1ml/min). It plugs into the Main, Aux or TC2-Ch3 channel of the **TC2BIP**.



### Subambient temperatures

The **TC2BIP** can drive 12V Peltier devices. When switched to Cool/Heat the outputs can swing both positive (for heating) and negative (for cooling). Our **CH** Cooling/Heating module can be directly driven by the **TC2BIP**. Another option is to use the **CH** to pre-cool and then reheat and control the inflow temperature with the **HPRE2**. This allows rapid increases and decreases in temperature.

### Other applications

The **TC2BIP** is versatile enough to be adapted to many different temperature control tasks. For example with a special heater it has been used to control the temperature of fluid entering kidney tubules. Other labs have used it with larger tissue chambers for a variety of tissues including whole lenses. Please call if you want advice on any special application.

### Opt. 3rd channel superfusion/objective heating

An optional 3rd heat only channel (**TC2-Ch3**) is available for the **TC2BIP**. It can be used for microscope objective heating (with **HLS-1p**) for immersion lenses or for superfusing solutions via our **MPRE8**. The upgrade can be installed later (or pre-installed eg. **TC2PKG3P**).

## Accessories (partial list)

**Probes:** **TH-10Km**, **TH-2Km**

**ITO Heaters:** **HI-24p**, **HI-24Tp**, **HI-22Dp**, **HI-25Dp**, **HI-55Dp**, **HI-57Dp**, **HI-711Dp**

**Foil heaters:** **HLS-1p**, **HLS-8x.8p**

**Extra channel:** **TC2-Ch3**

**Pre-heaters:** **HPRE2**, **HPRE2HF**, **MPRE8**

**Positioning:** **FL-1**



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# cFlow V2.x 8-Channel Switch/Flow Control System



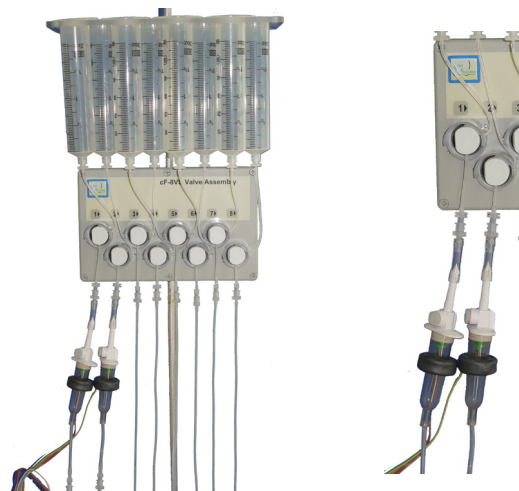
- **cFlow 8 Ch Flow/Switch System versions:**  
**CFPKGH** - for **switching (8Ch)**  
**CF4PKGH**- for **flow (up to 4Ch)** and **switch (8Ch)**  
**CF8PKGH**- for **flow (up to 8Ch)** and **switch (8Ch)**
- **8 Channel perfusion control**
- **Rapid pinch valve switching (typ. 50ms)**
- **Simultaneous flow control (0.1-10ml/min)**
- **Detects if solution stops flowing**
- **RS232, Digital (eg. CLAMPEX) & Analog input for computer control**
- **Upgrade microcontroller firmware via RS232 for addition of new features**

## DESCRIPTION

In addition to switching solutions the **cFlow** 8 Channel Flow controller can regulate the flow rate on user selected channels using an optical drop sensor that fits around standard dripsets. For example you could have 2 channels for background solutions with flow sensors and the other 6 channels switched via a superfusion device (eg. **MPRE8**) where you only want to switch solutions. One instrument functions as two separate devices. In other modes the flow can be regulated (at different rates) on all 8 channels (eg. to feed multiple chambers).

Channels are selected with either Push buttons or commands via the RS232 interface or using digital or analog input.

There is a single Flow rate control so that flow rates can be stored (using the Read Rate switch) and consistently set to the same value. The backlit LCD display shows the channel, flow rate and other useful information depending on the mode of operation.



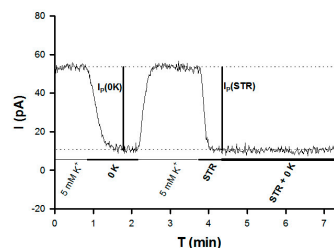
**cF8Vs Set up for switching 6ch & flow 2ch**

**Drop sensors on Ch1, Ch2**

## Application notes

### ■ Flow control vs switching

The **cFlow** 8 Ch Flow controller has the capability to monitor and control the flow rate in each channel but in many applications only a single or several drop sensors are required. eg. for perfusing a 0.25-1ml chamber you might have flow control of one or several background perfusates but switch the other solutions rapidly via the **MPRE8** pre-heater or other miniature manifold. For these channels the drop sensors are not used. For small volume (eg. <0.1ml) chambers an 8 to 1 manifold (**MAN81**) can be used before the inflow and simple switching used (see figure below).



**Na/K pump current with solutions switched with cFlow.**  
 Courtesy J. Gao SUNY  
 @ Stony Brook, NY

### ■ Use with MPRE8 8 Ch Miniature pre-heater

The **MPRE8** is a miniature 8 channel pre-heater with a tiny mixing volume at the tip (1-2µl). The **MPRE8** plugs into the **TC2BIP** or **mTCII** Temperature Controllers and has an integrated thermistor to control and sense the **MPRE8** outflow temperature. With the **cFlow** relatively rapid switches (typ. 100msec) can be made using the **MPRE8** to pre-heat solutions. Without the mixing tip the **MPRE8** can also be used for perfusing small chambers.

### ■ Two or more simultaneous flows

The **cFlow** can control two or more flows simultaneously for applications where there are multiple test chambers or a test chamber and holding chamber. For 2 flows one comes from group 1-4 [or 1-6] and a second from group 5-8 [or 7-8]. The solutions can come from common reservoirs but must have separate dripsets. Alternatively, up to **8 channels** can flow **simultaneously**.



## ■ Computer control

There are several automated methods for controlling the **cFlow**. Serial (RS232) allows channel switching to be controlled from any device supporting RS232 communications. An analog input allows a voltage input to switch the channel at precise times (eg. in CLAMPEX). The Digital output from a data acquisition system (eg. Digidata with CLAMPEX) can also be used for control (using cable **CAB10R/BNC**). Alternatively the 5 line Digital IO port can also supply status information to a host to log user control.

## ■ Upgrading

The **cFlow** is a microcontroller based instrument with built in firmware. It isn't a simple valve driver. Updated firmware can be simply download via the RS232 port to upgrade or customize the performance of the **cFlow** for a particular application.

## ■ Other valves

The **cFlow** is supplied with pinch valves but other low power 12V valves are also suitable. In the design of the **cFlow** we have allowed for mixing two different types of valves for channels 1-4 and 5-8. Please call if you need advice.

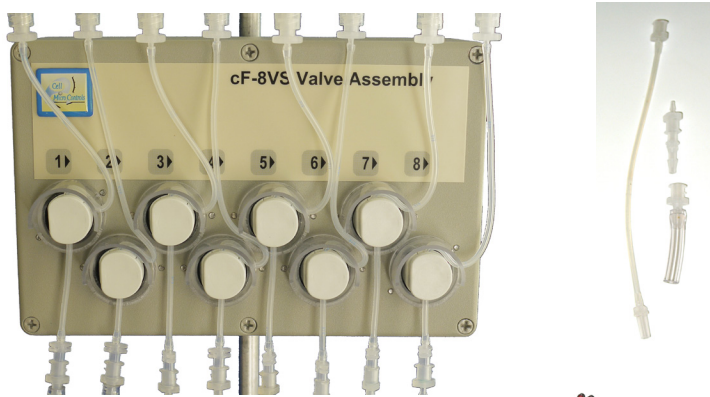
## ■ Effect of valve on/off on flow

You might think that since the flow control uses an on/off valve then the flow would be pulsatile. In fact the dripset bulb and tubing compliance "buffers" the flow so that when the flow enters the chamber even at a modest flow rate ( $>0.1$  ml/min) the flow is smooth. Smaller drippers and also be used for very slow flow rates since the drop sensor (**cf-4SEN**) can detect very small drops. Conversely for higher flow rates (3-10ml/min) a larger dripper is used (eg. 10 or 15dpm dripsets).

## System components/Accessories

### cF-8VS 8 ch shielded valve assembly

Shielded for use in electrophysiology setups where low noise levels are important. 8 valves are contained in a metal housing. Attaches to 3/8" diameter retort rod. Includes plumbing kit for flow and switch (8 sets).



### cF-4SEN drop sensor assembly

The drop sensor fits around the dripset and is used to sense a drop as it passes in an IR beam. The **cF-4SEN** are designed to fit the **IV60D8** IV sets but can be used with other dripsets with an O.D. less than 0.6". Attaches to 3/8" diameter retort rod.



### SYRHLD8 Syringe holder

The **SYRHLD8** holds 8 60cc syringe barrels. The holders can be adapted to smaller syringe barrels with collars. Attaches to 3/8" diameter retort rod.



### IV60D8 IV infusion sets

These infusion sets (8 pieces) have drippers designed for 60 drops/ml. They can be used with the **cFlow** for flow rates up to 3ml/min.

### SYR608 60cc syringes

60cc (8 pieces) are provided with the Flow/switch control systems.

## cFlow Specifications and Controls

**Flow rate range:** 60/15 drop/ml dripset => 0 - 3/0-10 ml/min  
60 drop/ml dripset will give smoother flow at low flow rates.

**Drop sensor:** infra-red source/detector

**Valve control modes:** a) 1 of 8 valves b) 1 of 1-4, 1 of 5-8 c) 1 of 1-6 1 of 7-8 d) n of 8

**Control modes:** Analog control (0-5V), RS232 input and Digital input (4 wire)

**Reporting:** RS232 output, digital output gives state of channel

**Push-button functions:** Purge valves, close Bank0, close Bank1, drain valves.

**Read rate:** Reads rate from potentiometer.

**Flow thru:** Used to halt flow when fluid runs out to prevent bubble entry.

**LCD display:** Displays channel/rate depending on mode.

**Supply Voltage:** 24V at 1.1A max. Typ. 100mA per valve open.

**Dimensions** (controller): 6.5 x 5.0 x 2.7 inches (LxWxH)

## Optional accessories

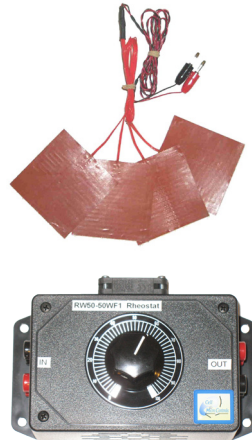
### CAB-I10R/BNC Interface cable

The **CAB-IOR/BNC** cable connects to the I/O port on the rear of the **cFlow**. For CLAMPEX you can use digital input mode and set a bit pattern using 4 lines (see examples on website). For Analog control you can use I/O line and just connect a single BNC cable.



## Syringe barrel heater kit (SYRHT8K)

For situations where solutions need to be pre-heated either to dissolved gasses to prevent bubbles forming in tubing, you should use the Syringe barrel heater kit. This contains 8 silicon heaters (2 of **SYRHT4**) that wrap around a 60cc syringe barrel (leaving a gap to observe the solution level). The heater is sleeved with a clear heatshrink or velcro so that it makes good thermal contact. A rheostat (**RH50-50WF**) is used to control the current to the heaters. Thermostating is not necessary since the heat losses are largely independent of the heated volume. The heaters run from an inexpensive DC power supply (**PS12V3**).



## MAN81 8 to 1 manifold

For merging solutions before entering a chamber (flow  $<5$  ml/min). Easy to clean with polyimide inlet and outlet suiting 1/32" ID silicon tubing. Dead volume approx 5µl.



## MPRE8 Multi-tube Pre-heater

For supertusion of cells or small tissue pieces. The **MPRE8** has 8 fine glass tubes which are heated and converge in a very small mixing volume. The temperature is sensed near the solution outflow by a miniature thermistor sensor. Normally the **MPRE8** connects with the **TC2BIP** Bipolar Temperature Controller or **mTCII** 2Ch micro-Temperature controller.  
**Dims.** 10 x 0.4cm (LxDiam); heater resistance  $\approx 11\Omega$   
**Thermistor sensor:** 10k $\Omega$  NTC  
**Dead space:** Tubes-approx 5µl; Tip-approx. 1-2µl.  
**Outflow tube:** 360µm inside diameter  
**Inflow tubes:** Tube outside diam. 0.7mm. Connects to 0.06" OD, 0.02" ID Tygon tubing.







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# Brain slice chambers

## BT-1xxxSY/LN/Sci Brain slice chambers

The **BT-1xxxSY** brain slice chambers fit into the **Siskiyou Inc. 8090C** stage as well as our **MSAS-xxx** Stage adapters. Some are also available for the **Luigs & Neumann (LN)** stage and **Scientifica (Sci)** stages. These slice chambers all have inflow and outflow via a slit to promote laminar flow for flow rates up to 2ml/min (4ml/min for larger chambers). They come either with a smooth top or with a machined recess allowing electrode access at low angles.

Typically a transparent ITO heater (eg. **HI-25Dp**) will be used to directly heat the chamber from below. Perfusing solution is heated with the **HPRE2** Pre-heater connected to the inlet tube. Chambers have a thermistor groove to allow permanent placement of the thermistor sensor for measurement/control of the chamber temperature. Ground wires can either be placed in the outflow area or in the main working area to the side of the slice.

### Superior flow pattern

Turbulence in solution flowing through chambers can create regions with non-uniform drug concentrations. Our chamber designs demonstrate a predictable laminar flow pattern as in the example below.

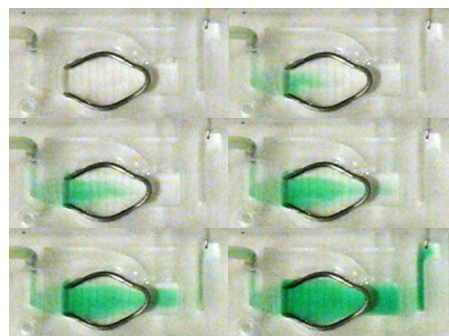


Fig 1. shows dye containing solution flowing into **BT-112B-45SY** fitted with a Warner Instruments, Inc 12mm harp (eg. SHD26H/10). Typical laminar flow pattern for solution front.

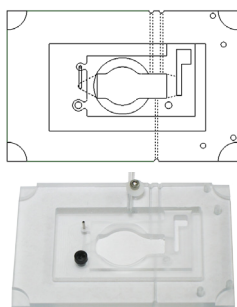
### Customization

Please call with any questions about modifying the chambers. We can for example vary the angle of the bevelled area to suit your lens or for example adapt a chamber for use with another microscope stage (see Fig. 2). With our advanced CAD/CAM software we have designed many chambers and can usually modify current chambers at no extra cost.



Fig 2. **BT-1-TB** chamber adapted to Luigs & Neumann stage.

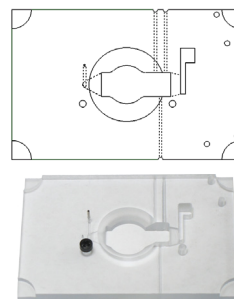
## BT112B45/SY/Sci/LN



**Application:** brain slices-low electrode angles

- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 12.7mm dia; 1mm lower level; 3.2mm height; 42° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**
- compatible with **12mm** harp (Warner Instruments, Inc SHD-26/xx)

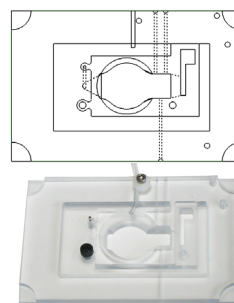
## BT112B37HSY



**Application:** brain slices

- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 12.7mm dia; 1mm lower level; 5mm height; 37° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**
- compatible with **12mm** harp (Warner Instruments, Inc SHD-26/xx)

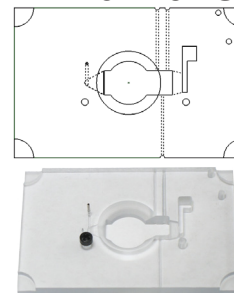
## BT113B45/SY/Sci/LN



**Application:** brain slices-low electrode angles, 12mm cover slides

- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 14.3mm diam; 1mm bottom height; 3.2mm height; 45° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**

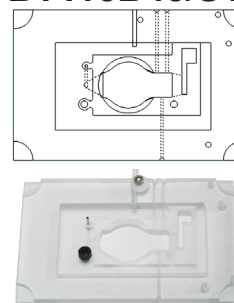
## BT113B45HSY



**Application:** brain slices-12mm cover slides

- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 14.3mm diam; 5mm height; 45° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**

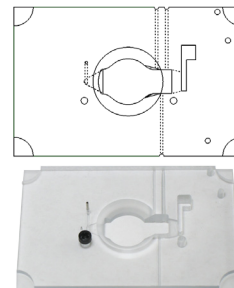
## BT115B45/SY/Sci/LN



**Application:** brain slices-low electrode angles,

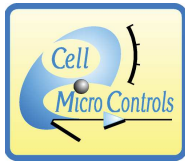
- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 15.2mm diam; 3.2mm height; 45° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**
- compatible with **15mm** harp (Warner Instruments, Inc SHD-26G/xx)

## BT115B45HSY



**Application:** brain slices

- size platform 7.4 x 4.9 x 0.5cm
- size central chamber: 15.2mm diam; 5mm height; 45° bevel
- outflow chamber, ground & thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp**
- compatible with **15mm** harp (Warner Instruments, Inc SHD-26G/xx)



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# MPRE8 Multi-tube Preheater

## DESCRIPTION

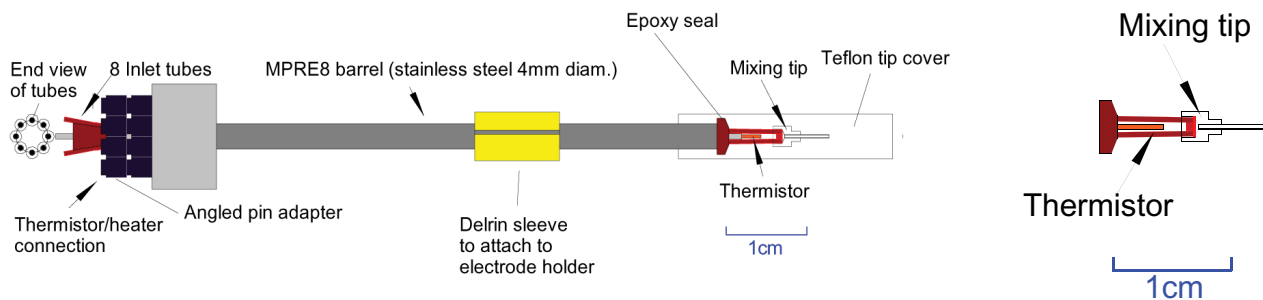
The **MPRE8** Multi-tube pre-heater is an 8 tube pre-heater for either superfusion or for the inflow of a tissue chamber. It has a very small mixing volume at the tip (1-2 $\mu$ L) which allows rapid switching between solutions (<<1sec). Switching can be achieved



using valves or using our **cFlow** 8Channel Flow Controller to operate pinch valves.

The unique construction of the **MPRE8** permits the use of a single thermistor sensor so that it is compatible with the **TC2BIP** and other controllers using a 10k $\Omega$  thermistor sensor. Solution can also flow in multiple tubes for mixing applications. Flow rates up to 1ml/min (higher flow rates with pressurised systems) can be used. The **MPRE8** tip is has a unbreakable polyimide outlet tube with a 360 $\mu$ m inside diameter. The outlet tube length can be varied for different applications. The mixing tip can be easily removed and replaced (**MPRE8-TD5** box of 5 tips). Custom tips can be used.

Where valuable compounds are used the small dead volume in the tubes of the **MPRE8** minimises the amount of drug wasted in the tubing. Also the **MPRE8** can be used to heat and perfuse a region of a chamber where it impractical to heat the whole chamber.



## MPRE8 Specifications

**Dims.** 10 x 0.4cm (LxDiam); heater resistance  $\approx$ 11 $\Omega$

**Thermistor sensor:** 10k $\Omega$  NTC

Plugs into **TC2BIP** or **mTCII**. Check with us for compatibility with other temperature controllers.

**Dead space:** Tubes-approx 5 $\mu$ L; Tip-approx. 1-2 $\mu$ L.

**Outflow tube:** 360 $\mu$ m inside diameter

**Inflow tubes:** Tube outside diam. 0.7mm. Connects to 0.06" OD, 0.02" ID Tygon tubing.

**Rate of heating:** At 0.5ml/min temp increases >1 $^{\circ}$ C/sec.

**Outflow temp vs flow rate:** [preliminary] Temperature changes <1 $^{\circ}$ C for flow rates from 0.85ml/min to 0.2ml/min.

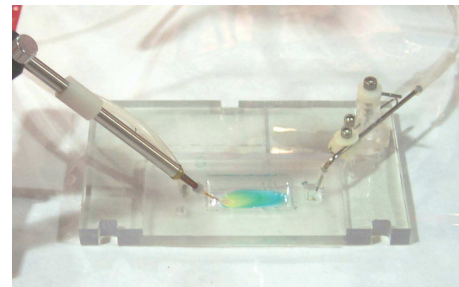
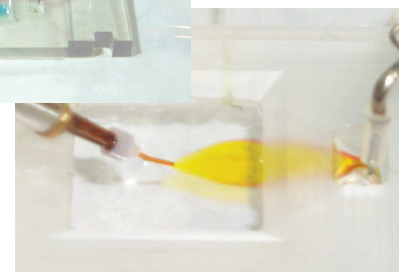


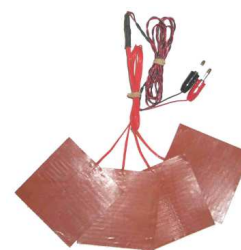
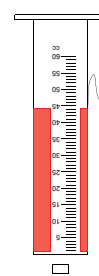
Fig.1. shows **MPRE8** 8Ch Pre-heater superfusing region of **BT-1** chamber demonstrating laminar flow pattern.



**Fig 2.** **MPRE8** superfusing solution in **BT-1-TB** tissue chamber

## Syringe barrel heater kit (SYRHT8K)

For situations where solutions need to be pre-heated either to remove dissolved gasses or where solutions are bubbled (eg. solutins using bicarb buffers) you should use the Syringe barrel heater kit. This contains 8 silicon heaters (2 of **SYRHT4**) that wrap around a 60cc syringe barrel (leaving a gap to observe the solution level. The heater is sleeved with a clear heatshrink so that it makes good thermal contact. A rheostat (**RH50-50WF**) is used to control the current to the heaters. Thermostating is not normally necessary since the heat losses are largely independent of the heated volume. The heaters run from an inexpensive DC power supply (**PS12V3**).



**SYRHT4** Syringe barrel heaters



**RH50-50WF** Rheostat





## BT-1xxx [-SY] Tissue chambers

The **BT-1xxx [-SY]** tissue chambers all have inflow and outflow via a thin slit to promote laminar flow for flow rates up to 2ml/min (4ml/min for larger chambers (eg. **BT-1-PS**). In applications using an inverted microscope with air type objective or upright microscope you can use a transparent ITO heaters (eg. **HI-24p**, **HI-25Dp**) to heat the chamber directly from below. If perfusing, the inflow is heated with the **HPRE2** Pre-heater which connects to the inlet tube. Chambers have a thermistor groove to allow permanent placement of the thermistor sensor for measurement/control of the chamber temperature.

For inverted microscopes using immersion lenses there is typically insufficient working distance to use an ITO heater so you use a thin cover slide for the bottom of the chamber a **HPRE2** Pre-heater and possibly an objective heater (eg. **HLS-1p**). At flow rates >1ml/min most heating is done by the pre-heater. For cell culture applications consider our Reusable culture chamber system (**CSTRGPKG** or **CSTPKG**).

All the **BT-1xxx** series chamber fit into our microscope stage adapters. If we don't have a suitable stage adapter we will machine one for you at no extra cost. The **BT-1xxx-SY** fit the **Siskiyou, Inc. 8090c** platform.

Please call with any questions about chambers. With our advanced CAD/CAM software we have designed many chambers and can often modify current chambers at no extra cost.

### Customization

Please call with any questions about modifying the chambers. For example we can vary the angle of the bevel or remove it, add slots or screw holes etc.. Also modify perimeter for some stages. With our advanced CAD/CAM software we have designed many chambers and can usually modify current chambers at no extra cost.

## Superior flow pattern

Turbulence in solution flowing through chambers can create regions with non-uniform drug concentrations. Our chambers designs demonstrate a predictable laminar flow pattern examples of which are given below.

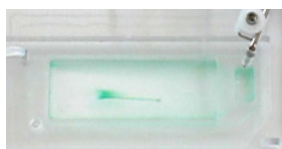


Fig.2. **BT-1-PS** after drop of dye was injected in chamber. Shows linear path taken by dye.

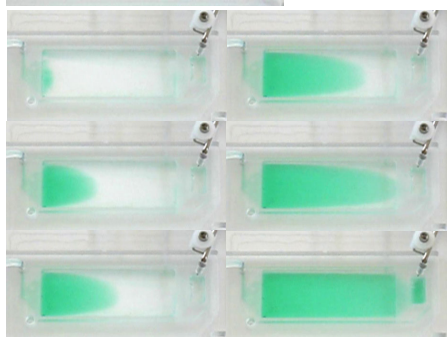
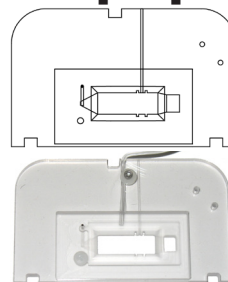


Fig 3. shows dye containing solution flowing into **BT-1-PS**. Typical laminar flow pattern for solution front.

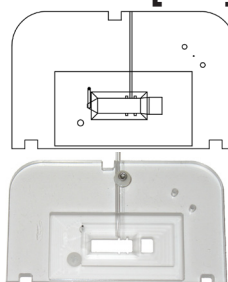
### BT-1 [-SY]



**Application:** cardiac/isolated cells, cells cultured on cover slides

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 22.4x8x1.3mm≈0.25ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p**, **HI-25Dp**, **HI-24Tp**

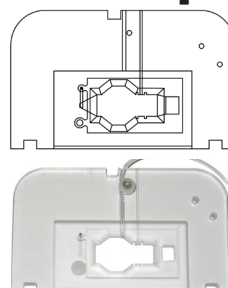
### BT-1AR [-SY]



**Application:** cardiac/isolated cells, cells cultured on cover slides

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 15.7x5.6x1.3mm≈0.12ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p**, **HI-25Dp**, **HI-24Tp**

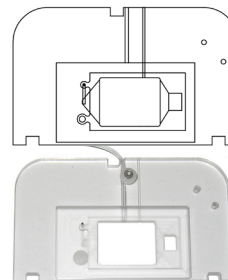
### BT-1-13B [-SY]



**Application:** upright microscopy, brain slice, 12mm cover slides

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 22.4x13x3.5mm≈0.5ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p**, **HI-25Dp**, **HI-24p**

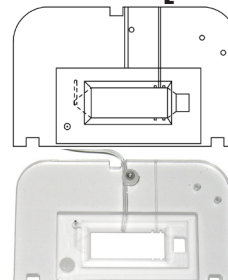
### BT-1-18/BT-1-18BV [-SY]



**Application:** upright/inverted microscopy, DRG larger preps

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 22.4x18x3.5mm≈1.4ml vol **BT-1-18**  
22.4x18x3.5mm≈1.4ml vol **BT-1-18BV** has bevelled sides
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p**, **HI-25Dp**, **HI-24Tp**

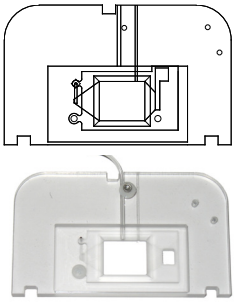
### BT-1-RR [-SY]



**Application:** cardiac/isolated cells, cells cultured on 9x22mm cover slides

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 28x10.9x1.3mm≈0.4ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p**, **HI-25Dp**, **HI-24Tp**

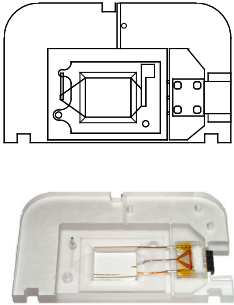
## BT-1-TB [-SY]



**Application:** cardiac/isolated cells, cells cultured on 12mm cover slides.

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 16x14.5x1.3mm≈0.5ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp, HI-24Tp**

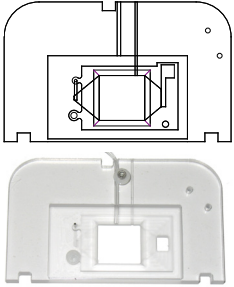
## BT-1-TBS/BT-1-TBSN/BT-1-TBSG [-SY]



**Application:** cardiac/isolated cells, cells cultured on 12mm cover slides where field stimulation (using **STIM-TB**) is needed. **BT-1-TBSG** can be sealed.

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 16x14.5x1.3mm≈0.5ml vol (**BT-1-TBS**)  
16x14.5x4.0mm≈0.9ml vol (**BT-1-TBSG**)  
16x11.0x1.3mm≈0.4ml vol (**BT-1-TBSN**)
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp, HI-24Tp**

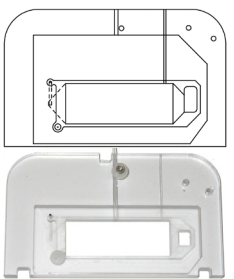
## BT-1-TB16 [-SY]



**Application:** cardiac/isolated cells, cells cultured on 12mm cover slides.

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 16x16x1.3mm≈0.6ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-25Dp, HI-24Tp**

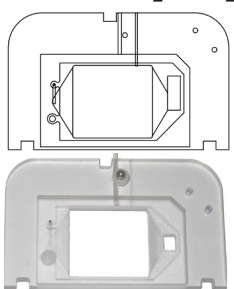
## BT-1-PS [-SY]



**Application:** sciatic nerve and other nerve or long preps.

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 40x15x3.5mm≈1.5ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-25Dp**

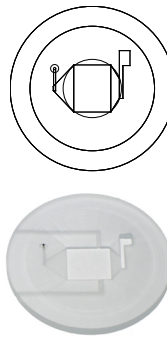
## BT-1-27 [-SY]



**Application:** for 25mm cover slides.

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 30x27x3.5mm≈2ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-55Dp**

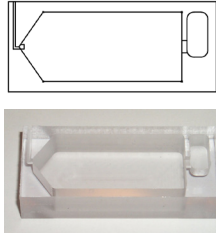
## BT-1-TB-LN



**Application:** cardiac/isolated cells, cells cultured on 12mm cover slides.

- size for Luigs & Neumann stage (62mm diam.). Low electrode angles.
- size central chamber: 16x14.5x1.3mm≈0.5ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p, HI-24Tp**

## BD-42



**Application:** dissection/holding chamber with inflow and outflow

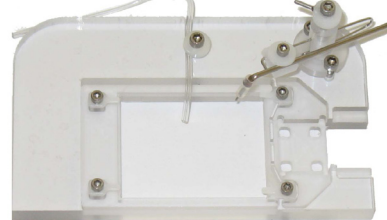
- size platform 6 x 2.6 x 1.25cm
- size central chamber: 40x20x10.4mm
- inflow/outflow chamber,
- constructed of polycarbonate

## Culture chamber system

**Application:** culturing cells for microscopy/electrophysiology

- size platform 8.3 x 5.1 x 0.55cm
- size central chamber: 13x12x1.3mm; 0.3ml volume
- inflow/outflow chamber
- stimulation assembly with thermistor
- constructed of polycarbonate

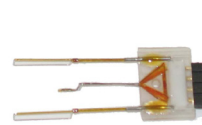
### Chamber Holder (HLDRG)



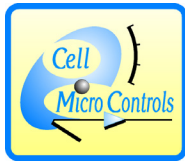
### Chamber (BTRG)



### Stim/therm assy (STIM-AT)





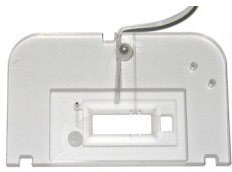


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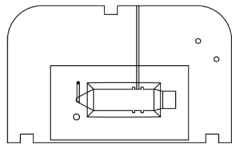
# Temperature Controller Accessories (partial listing)

## BT-1-xx Tissue chamber-(see BT-xx flyer)

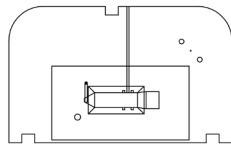
**Application:** tissue chambers-for isolated cells, tissue or brain slices.



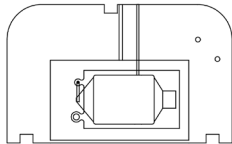
- size platform 8.3 x 5.1 x 0.55cm
- size central chamber:  
**BT-1:** 22.4x8x1.3mm $\approx$ 0.25ml vol  
**BT-1AR:** 15.7x5.6x3.5mm $\approx$ 0.12ml vol  
**BT-1-13B:** 22.4x13x3.5mm $\approx$ 0.5ml vol  
**BT-1-18:** 22.4x18x3.5mm $\approx$ 1.4ml vol
- inflow/outflow chamber, thermistor groove
- constructed of polycarbonate
- compatible with **HI-24p/24Tp/25p/25Dp**



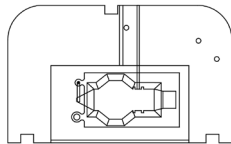
**BT-1**



**BT-1AR**



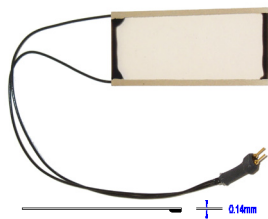
**BT-1-18**



**BT-1-13B**

## HI-24p/24Tp Heater-ITO transparent-(see HI-xx flyer)

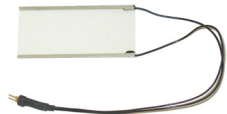
**Application:** heating **BT-1-xx** Tissue chamber or similar small tissue chambers. Use with **inverted** or **conventional** microscope. **HI-2xTp** are thinner for fluorescence or work with immersion lenses.



- **transparent** indium tin oxide coated heater
- sizes:  
**HI-24p[25p]:** 40[50]x22x $\approx$ 0.18mm thick.  
**HI-24Tp:** 40x22x $\approx$ 0.12mm thick.  
Heated area $\approx$ 35x18mm
- resistance nominally 6-13 $\Omega$
- max. operating temp. 70°C
- plugs into **TC2BIP** or **mTCII** using **CAB-HX**

## HI-22Dp/25Dp/55Dp/57Dp/711Dp Heater-ITO transparent-(see HI-xx flyer)

**Application:** heating 30mm culture dishes, Nunc Lab-Tek chambers. Heater forms a platform for dishes/chambers.



- **transparent** indium tin oxide coated heater
- sizes: HI-22/25/55/57 $\approx$ 0.6mm thick.
- size: HI-711 $\approx$ 1.1mm thick.
- resistance nominally 9 $\Omega$
- max. operating temp. 70°C
- plugs **TC2BIP** or **mTCII** using **CAB-HX**

## HLS-1p/7x1.3p/8x.8p Heater-lens,silicon

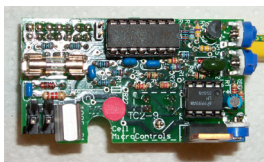
**Application:** objective heater (typicall used with **TH-10Kmp** thermistor probe).



- heater size HLS-1p 7x2cm
- all heaters 0.35mm thick away from contacts
- connects to **TC2BIP** or **mTCII** using **CAB-HX**

## TC2-Ch3 3rd Heat only channel

**Application:** optional 3rd channel for **TC2BIP**



- independent controller
- power from **TC2BIP**
- max. 8V, 1.5Amp output
- fits inside **TC2BIP**

## HPRE2/HPRE2HF Pre-heaters

**Application:** 3 loop capillary heater for pre-heating solution



- **HPRE2[HF]** dims. 45[70] x14x7mm (LxWxH); heater resistance  $\approx$ 11 $\Omega$
- Thermistor sensor: 10k $\Omega$  NTC
- Plugs into Heater Aux of **TC2BIP**

## BT-I55D Transparent ITO stage

**Application:** Heating culture dishes etc for EP or microscopy

- Uses **HI-55Dp** heater and **TH-10Kmp** probe
- Plugs into Probe and Heater Aux of **TC2BIP** or **mTCII**



## MPRE8 Multitube Pre-heater

**Application:** superfusion of cells or small tissue pieces



- Dims. 10 x 0.4cm (LxDiam); heater resistance  $\approx$ 11 $\Omega$
- Thermistor sensor: 10k $\Omega$  NTC
- Plugs into Heater Aux or TC2-Ch3 of **TC2BIP** or **mTCII**

## TH-10Km/TH-10Kmp Therm. probe

**Application:** miniature thermistor probe ( $\approx$ 0.45mm diam.)



- general purpose mini probe, submersible
- $R_{th}$  @ 25°C: 10k $\Omega$
- $\tau$  < 100ms, plunge water
- max oper. temp: 100°C; 1.2m lead; 6mm plug
- compatible with Probe input of **TC2BIP** & **mTCII**

## FL-1 Miniature positioner

**Application:** adjust bath solution levels, position ref. electrodes.



- size: base 13mm dia., height 24mm
- adjuster height range  $\approx$ 3mm; $\approx$ 0.5mm/turn
- miniature block for clamping tube, electrode

## MSA-xxx Microscope stage adapters -(see MSA-xx flyer)

**Application:** to adapt **BT-1-xx** tissue chambers and **HLD-CS** to different microscope stages



**MSA-NIKD**  
**MSA-OL11**



**MSA-TS100**



**MSA-LEI/DM**



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# Transparent ITO heaters

**HI-25p**



**CAB-HX**



**<200 $\mu$ m thick**



- **Transparent glass heaters** for microscopy and/or patch clamping
- Suitable for **fluorescence** measurements (see fig)
- **Thin (HI-24p 180 $\mu$ m typ.; HI-24Tp 120 $\mu$ m typ. thick)** for short working distance objectives
- **Thicker (HI-22Dp, HI-25Dp, HI55Dp, HI57Dp 0.6mm typ.; HI-711p 1.1mm typ. thick)** for long working distance objectives
- **Uniform temperatures** inside 2mm edge
- Not damaged by **high** temperatures
- **Low resistance** (typ. 10 $\Omega$ )

## DESCRIPTION

The **HI-24p/HI-24Tp** and **HI-xxDp** Transparent Indium Tin Oxide (ITO) heaters are intended for microscopy and/or patch clamping applications. ITO is a transparent surface coating that is highly electrically conductive. The coating is on the non-tissue side of the glass. The heaters can be used for studies of acutely isolated cells or for cultured cells where slides can be placed in a chamber where the heater forms the bottom. The **HI-24p/HI-24Tp** heaters are very thin but with an epoxy "frame" edge cracking is much reduced and strength is significantly increased.

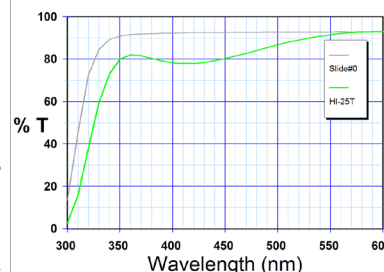
## Application notes

In a typical application an ITO heater is used to form the bottom of a tissue chamber (eg. **BT-1-xx**). Where flowing solutions are used the **HPRE2** Pre-heater can be used to pre-warm solutions entering the chamber.

Although there is no reason deeper solutions can't be used over the ITO heaters, shallow solutions levels (<2mm) are typically employed. For these low fluid levels a miniature temperature probe (eg. **TH-10Km**) must be used to accurately measure the temperature in the tissue chamber.

## Fluorescence microscopy

The **HI-24Tp** is suitable for fluorescence applications and where a short working distance lens is employed. The plot below shows that for wavelengths greater than 350nm transmission is greater than  $\approx 80\%$  compared to 92% with an uncoated #0 cover slide. Transmission for the **HI-25p/HI-24p** is a little less than the **HI-24Tp** because of the extra glass thickness.



%Transmission HI-25T vs #0 slide

## Specifications-thin heaters

**Construction:** transparent indium tin oxide coated heater

**Size: HI-25p:** 50x22x $\approx 0.18$  Heated area  $\approx 45 \times 18$ mm

**Size: HI-24p / HI-24Tp:** 40x22x $\approx 0.18$  / 0.12mm thick. Heated area  $\approx 35 \times 18$ mm

**Size: HI-22p:** 25x22x $\approx 0.25$  Heated area  $\approx 20 \times 18$ mm

**Resistance: HI-25p** nom. 10 $\Omega$ ; **HI-24p** nom. 12.5 $\Omega$

**Max. operating temp.:** 70°C

**Compatibility:** Use with **TC2BIP** and **mTCII** with **CAB-HX**. Can be used with other controllers accepting 7-18 $\Omega$  heaters.

## Thick ITO heaters

**Application:** heating 30mm culture dishes, Nunc Lab-Tek chambers. Heater forms a platform for dishes/chambers.



**HI-25Dp**



**HI-711Dp**

## Application notes

These are much thicker heaters (and stronger) than the heaters above which allows them to be used as a platform for culture dishes like the Nunc Lab Tek chamber and BD Supercell chambers. To allow for the lip on culture dishes a round 25mm #2 cover slide can be placed beneath the dish to improve heat transfer. Because of the larger volume of glass, solutions in the culture dishes (especially ones with plastic bottoms) will get to their operating temperature more slowly (over minutes). Glass bottomed chambers (eg. Nunc, BD) will be much faster (<30sec).

## Specifications--thick heaters

**Construction:** transparent indium tin oxide coated heater

**Size: HI-22Dp:** 25x22x $\approx 0.6$ mm thick

**Size: HI-25Dp:** 50x25x $\approx 0.6$ mm thick

**Size: HI-55Dp:** 50x50x $\approx 0.6$ mm thick

**Size: HI-57Dp:** 50x70x $\approx 0.6$ mm thick

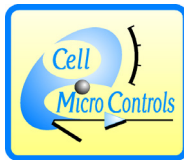
**Size: HI-711Dp:** 70x110x $\approx 1.1$ mm thick

**Resistance:** nom. 7-15 $\Omega$

**Max. operating temp.:** 70°C

**Compatibility:** Use with **TC2BIP** and **mTCII** with **CAB-HX**. Can be used with other controllers accepting 7-18 $\Omega$  heaters.

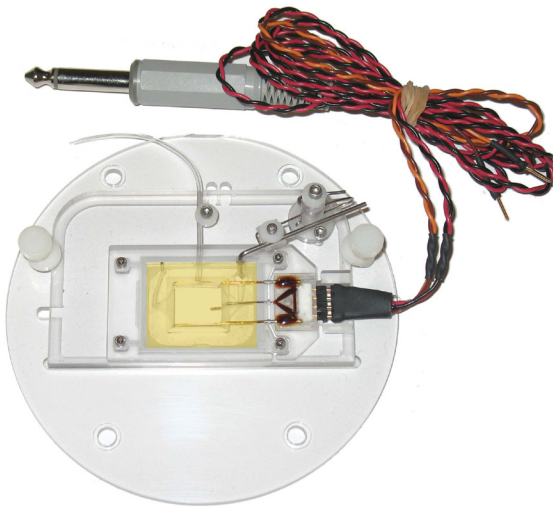




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# Culture chamber system

## Replaceable glass



- **Reusable culture/stim chamber/gasket (BTRG-CH/GB), and bottom clip (BTRG-BC)**  
 -small volume, laminar flow (to 2ml/min), inflow/outflow port, accommodates #1 or #1 1/2 glass or plastic cover slide bottoms
- **Stimulation assay (STIM-AT) presses into place- no tools**

### DESCRIPTION

The **Culture Chamber system-RG** uses a **low cost** but complete cell perfusion chamber (**BTRG-CH/GB/BC**) for either culturing cells in or using cells grown on a 24x30mm #1 or #1 1/2 glass or plastic cover side. The chamber is then transferred to a microscopy or electrophysiology setup. The **BTRG** has an inflow tube and separate port for aspirating solution and supports laminar flow over a range of flow rates (up to 2ml/min). The **Stimulation/thermistor assay (STIM-AT)** presses into the **Chamber holder (HLDRG-CS)**. The unique design of the stimulation electrodes is such that they clip into a small recess cut along the front and rear lower edges of the chamber. They can be rebent to their original shape if they are accidentally damaged. The aspirator is positioned with the **FL-1 Miniature postioner** which is attached to the **HLDRG**.

In a typical setup with temperature control the **HPRE2 Pre-heater** is used for heating the chamber. perfusate The **MPRE8 8 channel pre-heater** can be used to superfuse a region of the chamber. These can both be controlled by the **TC2BIP Temperature Controller** for electrophysiology or **mTCII micro-Temperature Controller** for microscopy. If the **TC2BIP** is equipped with the third channel (**TC2-Ch3**) the temperature in the chamber can be monitored with the thermistor built into the **Stimulation/thermistor assay**.

The **Chamber holder** fits into the **Microscope stage adapter**. These are available for most microscopes but if we don't already have one we will make one for you at the same cost as a standard one.

### Specifications

**BTRG-CH:** Central chamber-volume 0.3ml

- 13x12mm
- aspiration port matches male Luer for priming
- polycarbonate (autoclavable)

**BTRG-GB:** Silicon gasket (self adhesive) attached to **BTRG-CH**

**BTRG-BC:** Polycarbonate bottom clip (autoclavable)

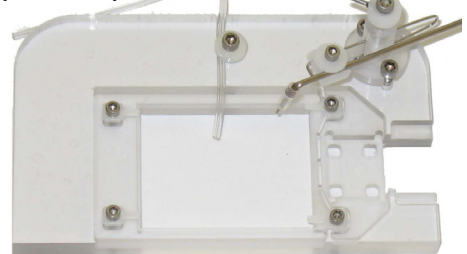
**STIM-AT:** Platinum Iridium stimulation wires, snaps into **HLDRG**

**HLDRG:HLDRG2** Holds **BTRG-CH/GA/BC**, **STIM-AT** and **FL-1**. Fits into **MSA-XXX** stage adapters.

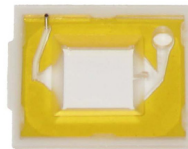
**HLDRG2** has extra connection for a Ag/AgCl ground wire or pellet.

**Cover slides:** #1 plastic or glass

**Chamber Holder (HLDRG)**

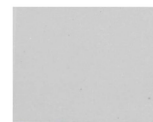
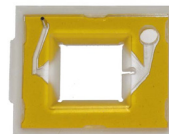


**Chamber (BTRG) Stim/therm assy (STIM-AT)**

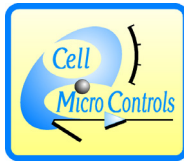


**Chamber & gasket**

**Bottom clip**

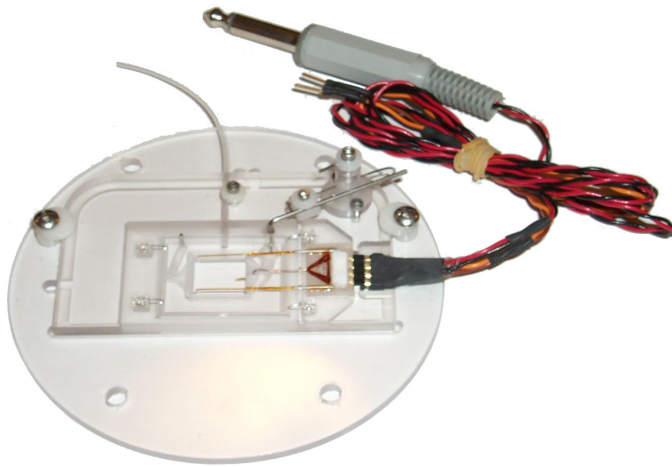


**Cover slide**

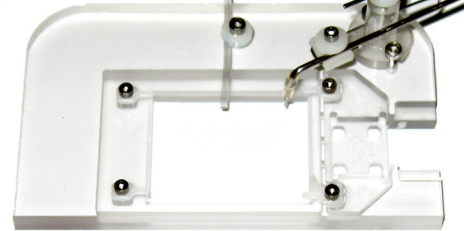


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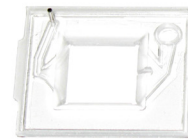
# Culture chamber system



**Chamber Holder  
(HLD-CS)**



**Chamber (BT-CS) Stim/therm assy  
(STIM-AT)**



- **Low cost reusable culture/stim chamber (BT-CS)**  
 -small volume, laminar flow, inflow/outflow port, #1 glass bottom
- **Stimulation/thermistor assy (STIM-AT)** presses into place-**no tools required**
- **Holder (HLD-CS)** for chamber, aspirator
- **Microscope stage adapters (MSA-NIK, MSA-TS100, MSA-OL11, MSA-LEI/DM, MSA-MZ etc.)** for all popular microscopes
- **BT-CS fits Ionoptix Corp C-Dish** for stimulation during culture

## DESCRIPTION

The **Culture Chamber system** uses a **low cost** but complete cell perfusion chamber (**BT-CS**) for holding cells or small pieces of tissue and then transferring them to a microscopy or electrophysiology setup. The **BT-CS** has an inflow tube and area for aspirating solution and has laminar flow over a range of flow rates. The **Stimulation/thermistor assy (STIM-AT)** presses into the **Chamber holder (HLD-CS)**. The unique design of the stimulation electrodes is such that they clip into a small recess cut along the front and rear lower edges of the chamber. They can be rebent to their original shape if they are accidentally damaged. The aspirator is positioned with the **FL-1 Miniature positioner** attached to the **HLD-CS**.

In a typical setup with temperature control the **HPRE2 Pre-heater** is used for heating the chamber. perfusate. The **MPRE8 8 channel pre-heater** can be used to superfuse a region of the chamber. These can both be controlled by the **TC2BIP Temperature Controller** for electrophysiology or **mTCII micro-Temperature Controller** for microscopy. If the **TC2BIP** is equipped with the third channel (**TC2-Ch3**) the temperature in the chamber can be monitored with the thermistor built into the **Stimulation/thermistor assy**.

The **Chamber holder** fits into the **Microscope stage adapter**. These are available for most popular microscopes (see our website for further information).

## Specifications

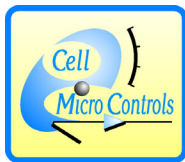
**BT-CS:** Central chamber-volume 0.3ml

- 13x12mm
- aspiration port matches male Luer for priming
- supplied with #1 cover slide attached
- polycarbonate (autoclavable)

**STIM-AT:** Platinum Iridium stimulation wires, snaps into **HLD-CS**

**HLD-CS:** Holds **BT-CS**, **STIM-AT** and **FL-1**. Fits into MSA-XXX stage adapters





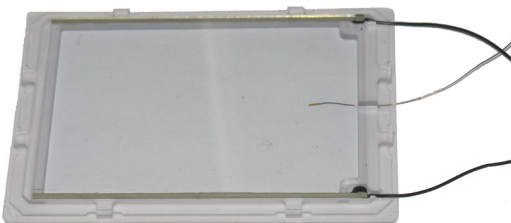
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# HWPT-96OL/NK/384/LID Transparent ITO stages, heaters & lid

## Transparent stage heater/well plate heater/lid



**HWPT-96OL**



**HWPT-384[S]**

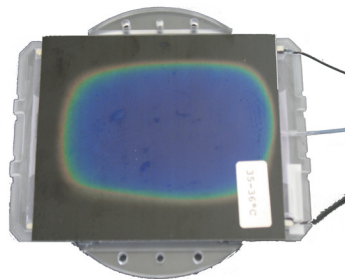


**HWPT-384 + HWPT-LID**

The **HWPT-96OL** (for Olympus), **HWPT-96NK** (for Nikon) **Transparent stage/96 Well plate heater** is made up of the **HI-711Dp ITO Transparent heater** in the **MSA-OLH711** or **MSA-NKH711 Microscope stage adapters**, along with the **TH-10Kmp Thermistor probe** and **CAB-TH** and **CAB-HX** cables. This provides a low profile heater for 96 well plates and provides **uniform heating** ( $\pm 2.5^\circ\text{C}$  @  $36^\circ\text{C}$ ) for the **inner 60 wells**. The outer wells can be used but the temperature in these wells will be lower. The ITO glass is 0.7mm thick while the glass plus stage adapter is 6.5mm thick.

Well plates are held in position by tabs on the edge of the heater plate so that well plate will not slide when the heated stage is attached to a moveable stage. The stage is compatible with Costar, Falcon, Greiner and Nunc 96 well plates (call for other brands).

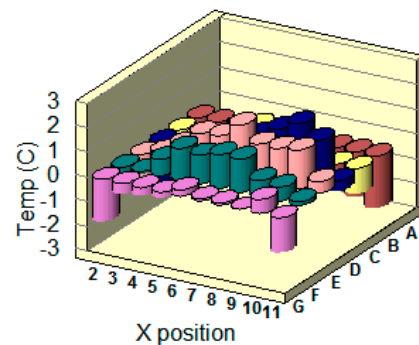
Other structures or chambers sitting on top of the heater can also be heater. In this case the temperature is uniform



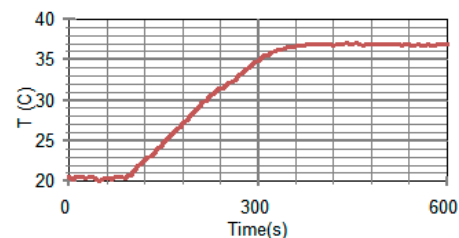
**Liquid crystal sheet 35-36C (brown to blue)**

( $\pm 1^\circ\text{C}$  @  $35.5^\circ\text{C}$ ) in a central area of  $5 \times 7 \text{ cm}$ .

The stage is designed to be connected to the **mTCII 2Ch micro-Temperature controller**. One channel is used to regulate the temperature of the heated stage while the second channel can be used either for a roaming probe to monitor individual well temperatures or to control the well temperatures to allow more rapid heating of the wells.

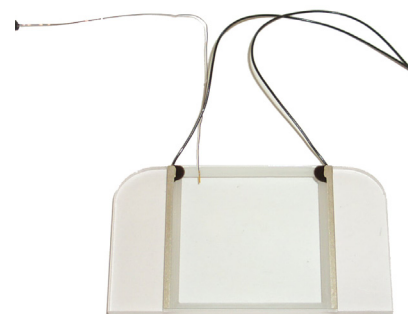


**Well temp vs position- inner 60 wells**

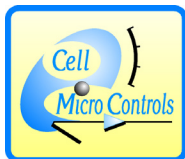


**Well temp vs time**

## BT-I55D Transparent ITO stage



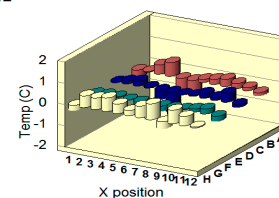
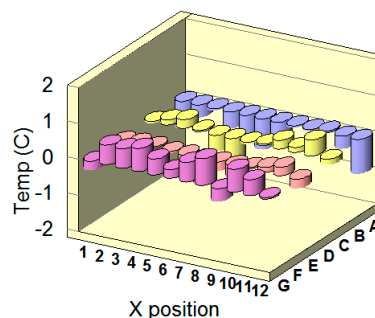
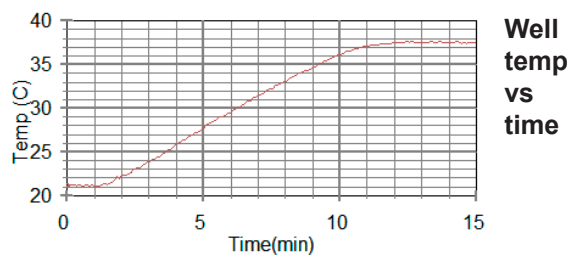
The **BT-I55D Transparent ITO stage** provides a uniformly heated area (approx.  $47 \times 47 \text{ mm}$ ; heater 0.7mm thick) for microscopy, electrophysiology applications. It can be fitted in any of our microscope stage adapters. Applications include observation of culture dishes or other tissue chambers. You can also build a tissue chamber directly on the ITO heater. The heater and thermistor probe can be connected to the **TC2BIP 2Ch Temperature controller** for electrophysiology applications or the lower cost **mTCII 2Ch micro-Temperature controller** for microscopy applications.



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# HWP-96 Well plate heater

## HWP-96 Well plate heater



The **HWP-96 Well plate heater** is a low profile heater for 96 well (and some 384 well) plates. The unique design compensates for the greater heat losses from the edges of the well plate to give superior temperature uniformity in well temperatures throughout the well plate. The thermistor probe for temperature control is integrated into heater stage. A second connector allows a roaming probe to be used to monitor an individual well temperature.

The low thermal mass of the heater speeds up heating and reduces the amount of temperature overshoot. The heater plate is less than 4.5mm thick and adds only 1.5mm to the thickness of the well plate. This means that it can be used with readers which have limited clearance above the wells.

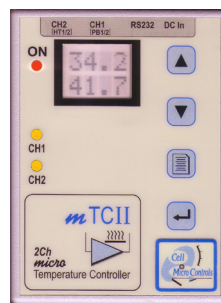
Well plates are held in position by tabs on the edge of the heater plate so that well plate will not slide when the heated stage is attached to a moveable stage. The stage is compatible with Costar, Falcon, Greiner and Nunc 96 well plates (call for other brands) and Greiner deep well type 384 well plates (call about others).

The stage is designed to be connected to the **mTCII 2Ch micro-Temperature controller**. One channel is used to regulate the temperature of the heated stage while the second channel can be used either for the roaming probe to monitor individual well temperatures or to control the well temperatures to allow more rapid heating of the wells.

## Performance

The unique design of the heater plate allows rapid and stable heating of the well plate. The top graph shows the well temperature versus time using a 96 well plate with all wells filled with water. The lower 3D graphs show the deviation from 37°C versus well position for a Costar 96 well plate.

## mTCII 2Ch micro-Temp controller



- **Miniature low power** controller for heating small tissue baths, microscope stages, small animal heaters
- **2 independent channels**
- **Compatible** with many low voltage **heater elements**
- **RS232** port for control, logging
- **2 heating modes**, PWM or analog

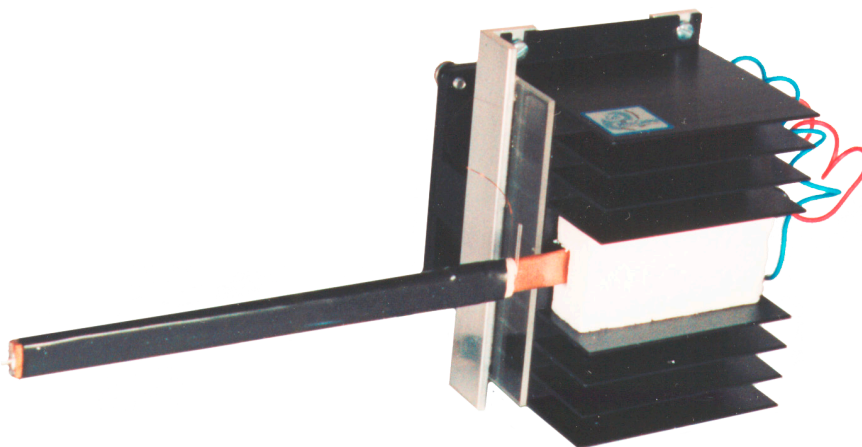
- Maintains **setpoint** and **parameters** in **EEPROM**
- **Firmware reprogrammable** - for upgrades, customization

The **mTCII micro-Temperature Controller** is a multipurpose microcomputer based 2 channel temperature controller powerful enough to heat small tissue baths, microscope stages, small animal heaters or containers used in a laboratory. The **mTCII** uses state-of-the-art microcontrollers to provide a flexible instrument rather than a modular PID design where there is no control over the user interface and instrument function. The **mTCII** has two ways of driving heaters, with a **PWM** (pulse width modulated 2.5-20kHz) or an **analog** output for lower noise. In the **PWM** mode it can control currents up to 1.5Amps provided by a battery or 15V block type power supply.



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# Cooling/Heating module



- **Simple** device for **cooling/heating** flowing solutions.
- **Access** to confined **microscope** stage provided by **heatpipe**
- **Air cooled** heatsink-no fluid required
- **Inexpensive**

## Description

The **CH Module** is a self-contained Peltier cooling (heating) device typically used to cool the perfusate for small experimental preparations. Unlike conventional cooling/heating systems, our **CH Module** uses air cooling rather than a water jacket. The fan can be mounted separately from the heatsink to eliminate any problems caused by vibration. To maximize working space on the microscope stage the entire **CH Module** is placed at a distance; a slender heatpipe (see **Operation of heatpipe** for description) transports heat between the microscope stage and the **CH Module**. The surface of the heatpipe is used to pre-cool (or heat) inflowing solutions passing through a glass capillary.

Ref: Datyner & Cohen (1991). "Cooling/heating module for tissue chambers and solutions: theoretical considerations and practical design." J. Neuroscience Methods. 40 (No.1), 49-62.

## Specifications at 25°C

**Input voltage:** 0-13V DC

**Current:** 0-3A

**Weight:** 375gm without fan

500gm with fan

**Dimensions:** Heatsink 6.7 x 6.4 x 12cm

Heatpipe 1 x 18 x 0.25cm

(width x length x thickness)

Estimated heat removed from entire surface of heatpipe for different input voltages

Input (V[A])	7.3[1.6]	10.5[2.3]	13.2[2.9]
Heat removed (W)	2.6	3.0	2.9

\*Note: max heat removed is achieved for voltages >10.5V.

## Application notes

### ■ Operation of heatpipe

The heatpipe is a sealed hollow structure, filled with a refrigerant and covered with a thin copper skin. At the cool end refrigerant condenses, flows along a wicking material to the hot end where it evaporates and returns along the hollow core thereby completing a heat transport cycle. The heatpipe conducts heat like a large diameter copper bar but is light in weight and has a very low thermal mass.

### ■ Cooling solutions

Solutions may be cooled by the cooler module by passing them through a glass capillary held against the heatpipe by a grooved copper plate (**CP-1** Capillary Plate). Typically outflow temperatures down to about 5°C can be achieved for typical flow rates (1-3mls/min). At high flow rates (eg. 6ml/min) cooling will be limited to about 15°C.

The heatpipe can be brought very close to the inlet to a tissue chamber to minimize heat losses.

### ■ Heating solutions and chambers

As with all Peltier devices the **CH Module** is more efficient for heating than cooling with a typical efficiency of 150% because the input power both generates and transports heat. For heating solutions and tissue chambers the power required will be a small fraction of that used for cooling (typically 20%) and temperatures of at least 50°C can be achieved.

### ■ Cooling/heating tissue chambers

If the **CP-1 Capillary plate** is removed the heatpipe can be used to cool or heat an aluminium or copper substage which is attached to the end of the heatpipe.

### ■ Temperature control

When flow rates are relatively constant the **RH50-50WF Rheostat** and a power supply can be used to control the **CH Module** temperature. Where feedback temperature control is required our **TC2BIP** Bipolar Temperature Controller can be used. The temperature of outflowing solution can either be directly controlled by regulating the **CH** heatpipe temperature or by pre-cooling solution with the **CH** and then at the outflow point, reheating with a **HPRE2 Pre-heater**. temperature of inflowing solution. In the latter case rapid drops in temperature can be achieved because only the thermal mass of the **HPRE2** (which is very low) has to be cooled to reduce the temperature of the solution exiting the **HPRE2**.



Since 1989 we have been designing and manufacturing temperature control and perfusion instruments for electrophysiology and microscopy research, where precision and low noise are critical. Our wide range of accessories include tissue chambers, thin transparent ITO heaters, miniature thermistor probes, reusable culture chambers, miniature perfusion devices, etc. Our customers are in over 250 universities and companies in North America, Europe and Asia.

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Email: [sales@neuro-s.co.jp](mailto:sales@neuro-s.co.jp)

**Warranty information**

**TC2BIP, mTCII/mTC3, cFlow, CH** are warranted against defects in material or workmanship for 2 years. **TC2BIP, mTCII/mTC3 & cFlow** accessories warranted against defects in material or workmanship for 6 months.



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