

Programmable Micropipette Puller
PMP - 102
USER'S GUIDE



MicroData Instrument, Inc.

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The Puller's Features

The PMP-102 is a very sophisticated single micropipette double-pulling puller. It can produce varied micropipettes, including patch clamp electrodes, intracellular electrodes, injection micropipette and micro-needles. Not only one, but two identical pulled pipettes will be produced at a time. To achieve this versatility and the higher degree of reproducibility, many advanced technologies are applied on the PMP-102 :

Exclusive Optical-Digital Taper Measurement

Instead of mechanical tip length setting from other pipette puller, there is an exclusive optical-digital ruler in the PMP-102 to perform precise taper length setting, real-time measurement and controlling. With this feature, a user can handle taper pulling very precisely and easily. Equipped with a powerful computerize tip sensing function, the PMP-102 can automatically finish the tip pulling. It gives the user a quick reference to pull an ideal tip.

Computerize Real-Time Feedback Heater Control

In the PMP-102, there is an advanced microcontroller to perform real-time heater power monitoring and controlling. If a heating level is selected and preset, the microcontroller will measure the actual heating power during heating power on. The measurement will be real-time displayed and feedback to the control unit to match the set point dynamically. As a result, the PMP-102 always provides precise heating power, despite of many times of pipette pulling or thermal/electrical characteristic changing. If the heating level is set to AUTO, the heater will automatically search the melting point for different glass pipettes. Under a microcomputer controlling, the heater is smart and reliable.

Programmable and Savable Sequences for Creation and Reproduction

There are 99 user programmable and savable pulling sequences with 18 steps in each sequence. Users can easily program different pipette tip size, tip length and tip shape in different sequence for different application. Time number, heat level, heat control and action parameters can be individually set in each step. After a special sequence setting up, double identical micropipette will be automatically produced by just pressing the Start button. A straight taper with a fine tip of only 0.1um diameter is usually pulled by more than 3 short taper pulls then a rapid final pull after precise preheating. Without programmable steps and variable parameter setting, an ideal pipette is hardly pulled.

Manufacture Preset Programs for Major Different pipette pulls

Every PMP-102 is tested and installed major different pipette pulling programs. A new user will easily select the right program or just change a few step parameters to fit their special need. SQ1-22 are preset sequences and SQ51-72 are backup preset sequences. The preset programs are convenient and important, not only because they can pull different pipette samples but also they can be copied as templets to make other programs with only minor parameter change.

Pneumatic Pulling Force and Very Compact Size

Comparing with other pipette puller using gravity or magnetic field as pulling force, the PMP-102 applies precise controlled pneumatic pressure as the pulling force, which gives more controllable, even and consistent dragging characteristics. The PMP-102 can pull an ideal injection tip or microelectrode tip easily, which can hardly be produced by other pullers. Within a very compact size, the PMP-102 can precisely perform single pulling to multiparameter multi-pulling without manual interrupt. A precision micro-linear ball bearing rail and advanced pneumatic components are used to provide no fault pulling movement. A simple 4x4 keypad and full

information display LCD let users control easily and read all pulling parameters directly, which include sequences, steps, time, timing, heater level, heater control, tip length and actions. With versatility of the intelligent PMP-102, users not only can reproduce but create different types of micropipette which they exactly need, but can't be produced by other puller.

Specifications

<table> <tr> <td>Pulling force</td> <td>Pneumatic</td> </tr> <tr> <td>Heater</td> <td>Nichrome coil</td> </tr> <tr> <td>Heater control</td> <td>Microcontrollor</td> </tr> <tr> <td>Heating</td> <td>74 general heat levels (24-99), 64 automatic heat levels (45-98).</td> </tr> <tr> <td>Number of sequences</td> <td>99</td> </tr> <tr> <td>Steps of each sequence</td> <td>18</td> </tr> <tr> <td>Taper length setting</td> <td>0.5 - 20 mm</td> </tr> </table>	Pulling force	Pneumatic	Heater	Nichrome coil	Heater control	Microcontrollor	Heating	74 general heat levels (24-99), 64 automatic heat levels (45-98).	Number of sequences	99	Steps of each sequence	18	Taper length setting	0.5 - 20 mm	<table> <tr> <td>Pressure 1 regulator</td> <td>0.1 - 10 psi</td> </tr> <tr> <td>Pressure 2 regulator</td> <td>0.1 - 60 psi</td> </tr> <tr> <td>Cool Air regulator</td> <td>0.5-30 psi</td> </tr> <tr> <td>Pressure gas input</td> <td>30 - 60 psi</td> </tr> <tr> <td>Actions</td> <td>Pull 1, Pull 2, Pull 2/ Cool, and Cool Air.</td> </tr> <tr> <td>Display</td> <td>20x4 LCD</td> </tr> <tr> <td>Power input</td> <td>110 / 240 VAC</td> </tr> <tr> <td>Power consumption</td> <td>Maximum 150 watts</td> </tr> <tr> <td>Dimension</td> <td>14" x 11" x 7"</td> </tr> <tr> <td>Weight</td> <td>13 lbs.</td> </tr> </table>	Pressure 1 regulator	0.1 - 10 psi	Pressure 2 regulator	0.1 - 60 psi	Cool Air regulator	0.5-30 psi	Pressure gas input	30 - 60 psi	Actions	Pull 1, Pull 2, Pull 2/ Cool, and Cool Air.	Display	20x4 LCD	Power input	110 / 240 VAC	Power consumption	Maximum 150 watts	Dimension	14" x 11" x 7"	Weight	13 lbs.
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<p>PMP-102M:</p> <p>All of above and:</p> <ol style="list-style-type: none"> 1. Microforge power supply connector and switch on back panel. 2. Air output connector, air output control foot switch connector and STOP heater foot switch on the front panel. 																																			

Setting Up the Puller

1. Unpacking and connections

Unpack the puller from the shipping package and check that the following items are included with the puller: Power cord, Pressure gas input tubing with connectors, User's Guide.

Connect the power cord to the puller and then plug into a grounding power supply with the same voltage as specified on the puller's back panel. Connect the gas input tubing to the gas input port of the puller and then connect the tubing to a pressure air source which 30 - 60 psi is sufficient. If the pressure air source is a compressor, there should be an on/off valve, a tank and a coarse regulator for a 30-60 psi output pressure. **An input pressure higher than 90 psi will damage the puller.** Turn on the power first and then turn on the pressure.

2. Safety Requirements:

Read this manual before installation of the instrument. This instrument is intended for using in laboratory environment. This instrument needs correct power supply and correct gas source supply.

- [1] **The power supply should be the same voltage level as the specification on the back panel and must has ground connection.**
- [2] **Any very active, flammable or corrosive gas can not be used as the input gas source. 30-60 psi compression air pressure with no less than 2 gallon air tank is sufficient. The gas source supply should not be higher than 60 psi. If using gas (nitrogen for example) other than compression air, fresh air ventilation is required.**
- [3] **Do not use the puller to pull flammable material.**
- [4] **If not using the instrument or the user left the instrument, the power supply and pressure gas supply should be turned off.**
- [5] **Do not disassemble the instrument box cover or service inside components.**

VIEW OF REAR PANEL



3. For First Time Using

The first time user can follow the following steps to quickly use the PMP-102. Please refer to other chapters for details instructions such as the Key Pad Functions and Display, Programming the Pulling Sequences, Installing a capillary glass, Troubleshooting etc.

Twenty two sequences (SQ1-22) of pulling program are already installed in the PMP-102. These sequences give user all different samples: from injection needle, electrode to hold cell pipette, from intracellular fine tip to bigger clamp tip and different size of pipette, all in the key you pressing. Most of users will find the sample sequences are useful and can fit their need. Also, these example sequences give users directions of how to pull different type of micropipette in this puller. They are all changeable and can be upgraded. A new user can test these programs, and then modify some steps to set their own program to suit their specific conditions or requirements.

A. Using a Stored Program:

1) Ensure input gas pressure is less than 60 psi (4200 millibar), **higher than 90 psi will damage the puller**. 30-50 psi is the requirement.

2) Switch on power, READY status will be displayed.

3) To select required stored program (see Preset Sequences Reference of closest tip shape and size):
Press PROG key PROGRAM status achieved and displayed flashes on the program sequence number.

Press ^ or v key To select stored program (SQ01-SQ22).

Press READY key READY status achieved

4) **Adjust** the COOL PRESSURE and PRESSURE 2 and 1 (displayed as Cxx.x, Pxx.x and pxx.x) for cool pressure, first and second pulling force to match the required values in the stored program memory (display as Mxx, mxx.x and Mxx.x), that means $C_{xx} = M_{xx}$, $P_{xx.x} = m_{xx.x}$ and $p_{xx.x} = M_{xx.x}$. Check the Cool Air pressure usually set on about 18-25 psi for all sequences, change to match the memory number.

5) Move (press RETURN key or manual push) the pipette holder clamps to start position.

6) Load a glass capillary (**See Installing a Micropipette page**).

7) Pull down the cover, then press the START key. The programmed pulling sequence now takes place automatically.

B. Setting a New Program Sequence: (Up to 99 programs can be stored in the memory)

1) Ensure input gas pressure is the less than 60 psi (4200 millibar), 30-50 psi is the requirement.

2) Switch on power, READY status will be displayed.

3) To select number of program (up to 20 programs are preset) to modify.

Press PROG key for 2 seconds: COPY status achieved and displayed flashes cursor on program sequence number.

Press < or > key: To select a source sequence or destination sequence.

Press ^ or v key: To select a sequence number being copied or copy to .

Press START key: To enter a copy function or press EXIT to cancel.

Press < or > key: To select a step to modify. There are maximum 18 steps in each sequence.

Each step displayed as a function line , beginning with T1, T2, T3, etc.

Modify some factors of an existing sequence will give many changes on the pulling pipette shape and length or for different pipette size. Refer the printed sequence in this manual to recover missing original sequence.

4) If a complete new sequence is needed, read Programming Pulling Sequence pages to understand pulling factors. For programming the first step:

Press STEP or > key Move the cursor to the first step T1 position.
Press STOP key Always reset all values before programming the step.
Press PULL1 key To set first pull and replace timer control with pulling length control: displayed as <-L and PU1: XX.
Press ^ and v keys Select PULL1 length digit values (Every number represent 0.5mm, maximum setting=40x0.5mm=20mm). More than 40 setting will turn the length control to time control, and then the time number must be set.
Press > or < key Move the cursor to next setting position: time digits--heat level digits--actions.
Press ^ and v keys Select time and heat level digital values or automatic heat start setting point.

5) To turn off the heater or set cool down pause between first and second pull:

Press > key or STEP then v key Move the cursor to next step T2 position.
Press STOP key Always reset all values before programming the step.
Press > or < key Move the cursor to next setting position: time digits--heat level digits--actions.
Press ^ and v keys Select time digit values. No heat or action setting.

6) To set the preheat for final pulling step:

Press > key or STEP then v Move the cursor to the next step T3 position.
Press STOP key Always reset all values before programming the step.
Press > or TIMER key Move the cursor to timer digit position
Press ^ and v keys Select time digit values. The time setting is very important for the last pulling step. Preheating too long will cause the 'hair tip' in the last pulling. Preheat too short will cause the broken tip in the last pulling. Refer to the timer setting in sample sequences.
Press > or HEAT key Move the cursor to heat level digit position
Press ^ and v keys Select the heating digit. The preheat level is also very critical for the last pulling step. Too high will cause 'hair tip', too low will break the tip or be insufficient to final pull. Only preheat but no other action in this step.

7) To set the final pulling step:

Press > key or STEP then v key Move the cursor to the next step position.
Press STOP key Always reset all values before programming the step.
Press PULL2 key Set last pull and replace timer control with pulling length control: display as <-L for time and PU2:xx for action. When the pulling reaches the length set point the heater will stop if heat level higher than 0 or the air will inject to the heater if 'c' is combined with 'PU2'.
Press ^ and v keys If the final pull no need for air cool, just press the length digit higher than 40 setting, then COOL key and then set enough time for the final pull (5-10 sec). If air cool is needed, select PU2:xx length digit values, for example :03 (Every number represent 0.5mm,

maximum setting=40x0.5mm=20mm), and then press COOL key which is displayed as ' PU2:03c '. That means the air will be injected to the heat coil after pulling 1.5mm long and the pipette is continually pulled to beak. No heat setting on this step.

8) To set recover cooling step:

Press > key or STEP then v key Move the cursor to next step position.

Press STOP key Always reset all values before programming the step.

Press > key Move the cursor to time digit positions.

Press ^ and v keys Select timer digit values. No heating setting.

Press COOL key Set cool air injection to thoroughly cool down the heater to recover the original heater condition.

9) To set last step for completion of program:

Press > key Move the cursor to last step position.

Press STOP key Clear all values for the termination.

IMPORTANT: If the total of steps in the programmed sequence is less than 18, it is essential to program STOP on the last step to enable the program to finish. If all 18 steps have been set, the sequence will automatically stop after 18 steps.

It is now necessary to set the gas pressure values for the force of Pull 1 and Pull 2:

10) Within the READY or PROG status, pressure 1, 2 (p and P as displayed) can be adjusted to match the requirement. But only in PROG status, the pressure readings can be saved to the memory:

Press P MEMO SAVE? key Move the cursor to Pressure Memory position.

Press P SAVE? key again Display real Pressure 1, 2 measurements.

(Press P SAVE? key third time) (Cursor will back to Pressure Memory position, no memory change.)

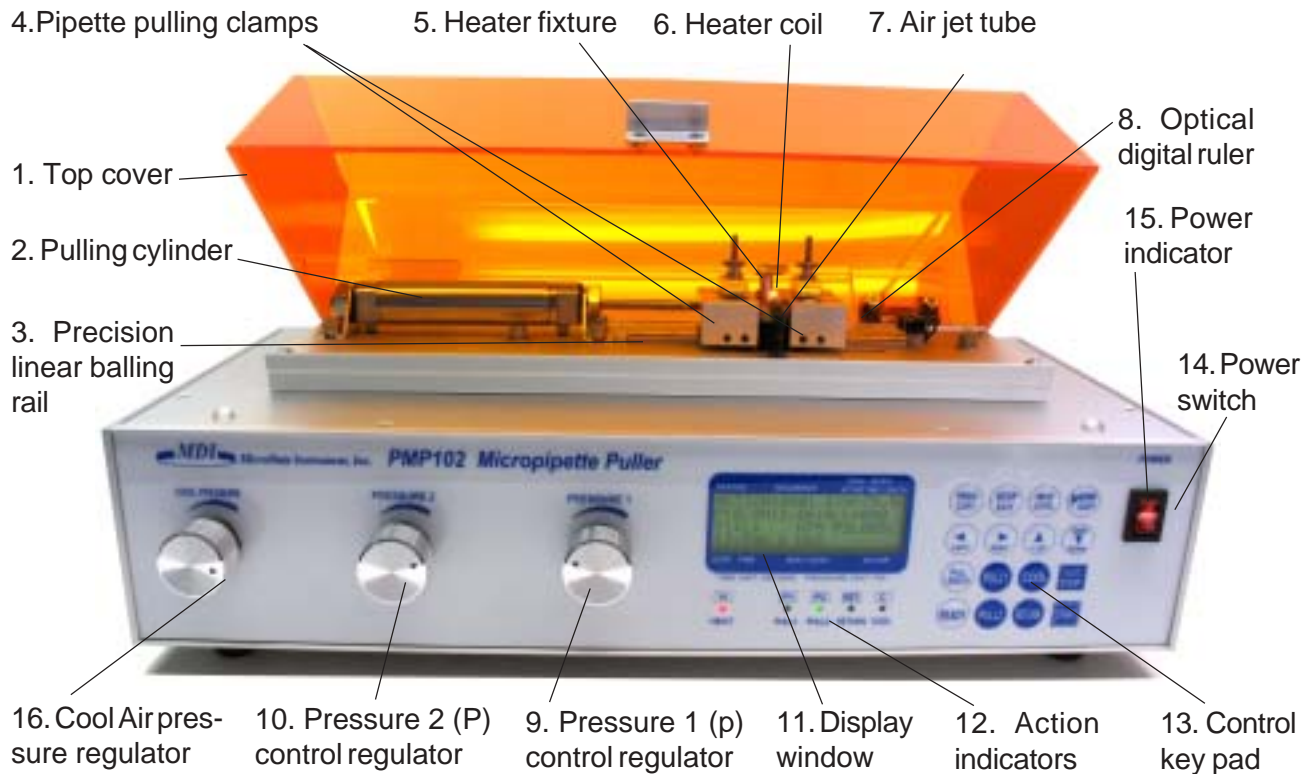
Adjust knobs of Pressure 1, 2 To get required pressures.

Press SAVE DOWN (v) key To save the pressure measurements and up date the pressure memory and back to Pressure Memory position,

Press READY key Back to READY status. The instrument is now ready to operate the programmed sequence.

Understanding the Puller's Control and Functions

1. Parts and Functions on the Front Panel



1. Top Cover. Open up for installing and picking the micropipette. Cover down for pulling actions.

2. Pulling Cylinder. Pneumatic pulling actuator.

3. Precision Linear Balling Rail for precision linear pulling movement.

4. Pipette Pulling Clamps clamp both sides of a capillary glass for pulling.

5. Heater Fixture. Turning two screws to replace the heating coil.

6. Heater Coil. There are different turns of heating coils for different pipette pulling.

7. Air Jet Tube can inject air to cool down the heater coil from Pressure 2 (P).

8. Optical/Digital Ruler for measuring Pull 1 and Pull 2 length. The resolution is 0.5mm.

9. Pressure 1 (p) Control Regulator supplies regulated pressure 0.1-10 psi for Pull 1 action.

10. Pressure 2 (P) Control Regulator supplies regulated pressure 0.1-50 psi for Pull 2 action and Air Pressure Out (optional).

11. LCD Display Window displays all pulling parameters and programs.

12. Action Indicators will light for corresponding actions.

13. Control Key Pad is used for programming and action controlling.

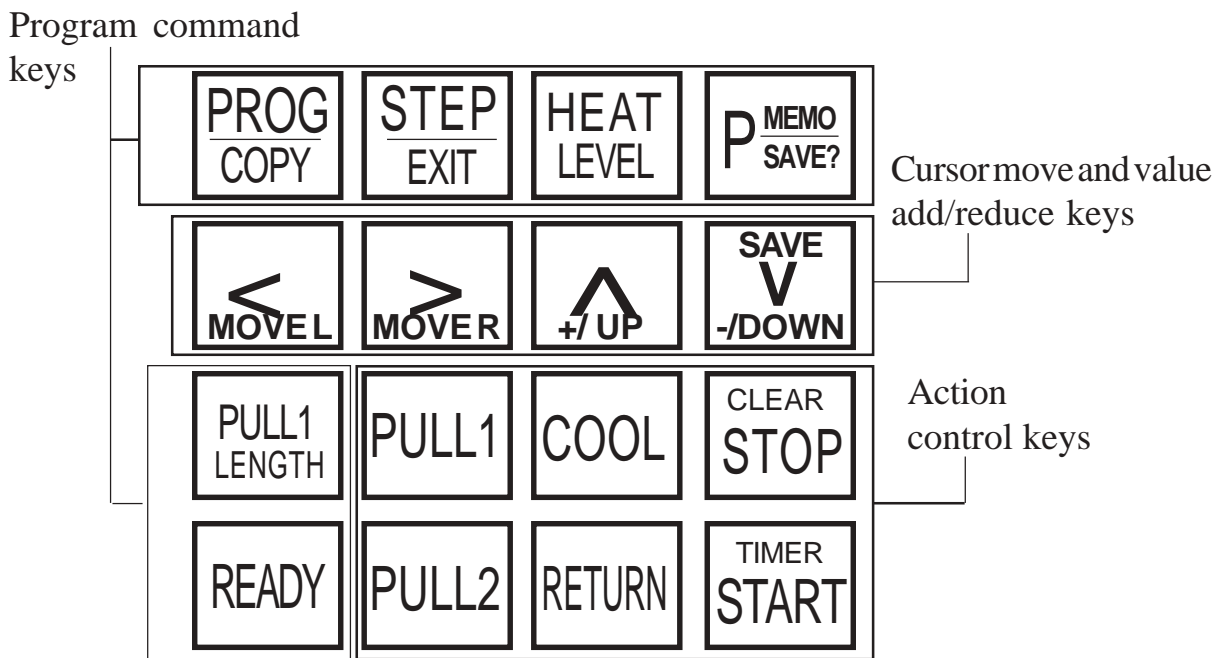
14. Power Switch On/off power supply.

15. Power Indicator lights when power is on.

16. Cool Air Pressure Regulator supplies regulated pressure 0.1-30 psi for air jet under the heater.

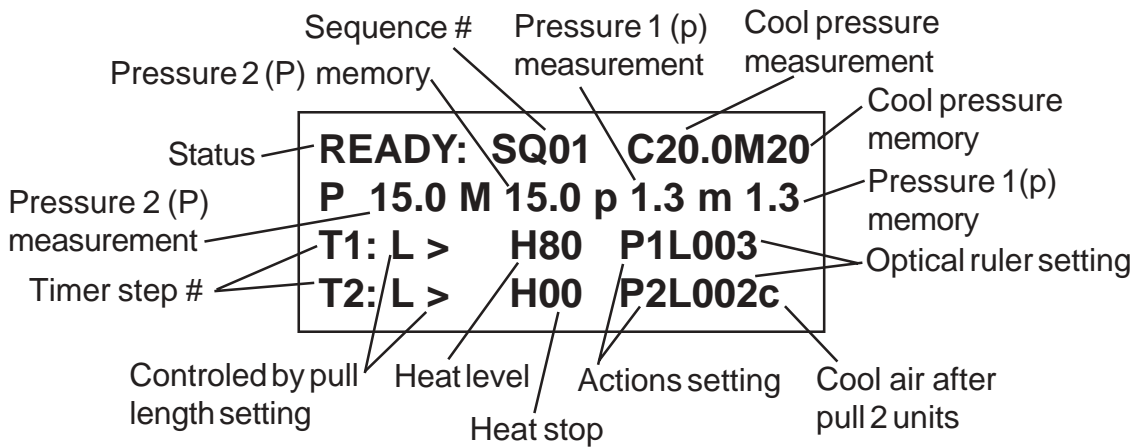
2. Key Pad Functions and Display

The PMP-102 Key Pad

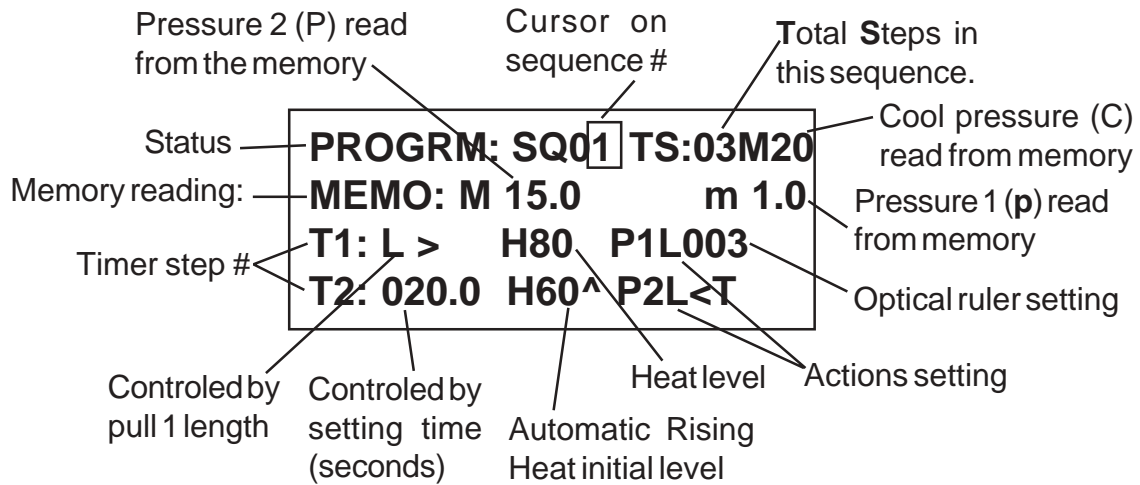


The PMP-102 Display Window

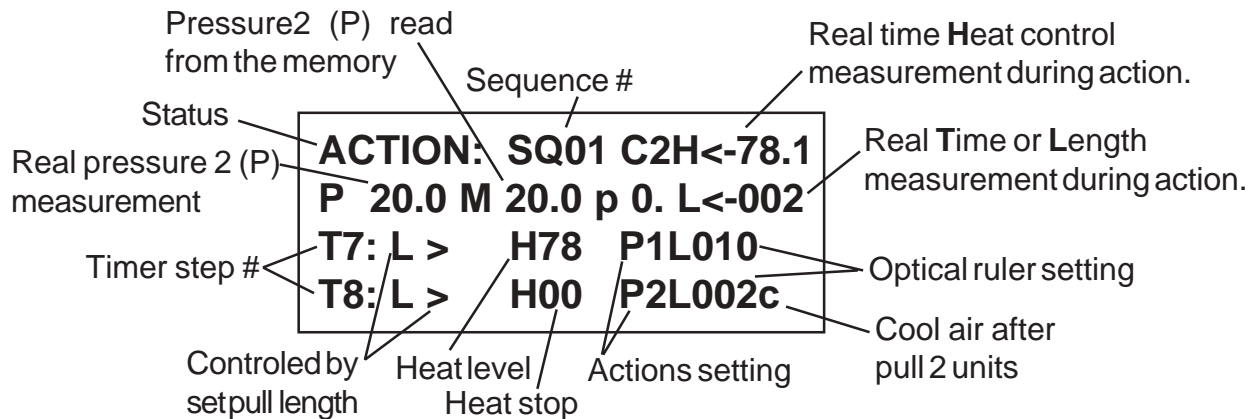
Status READY :



Status PROGRAM :



Status ACTION :



READY, PROGRAM and ACTION are three status modes in the PMP-102. The **READY** status is ready for manual action and automatic action according to the displayed action sequence. The **PROGRAM** status is for selecting programs (sequences) stored in the memory and programming a new sequence. The **ACTION** status indicates an action is taking place. By pressing one of five Program Command Keys (**PROG, STEP, HEAT, P-SAVE?, PULL1 LENGTH**), the PMP-102 will go to **PROGRAM** status from **READY** status. By pressing **READY** key, the PMP-102 will back to **READY** status from **PROGRAM** status.

Within the READY status: Pressing one of four action keys (**PULL1, PULL2, COOL, RETURN**), the action will take place as long as the finger press on the key. Pressing the **START** key will trigger the action according the displayed sequence. Pressing the **STOP** key will interrupt the sequencing and terminate the action. Before pressing the **START** key, check and adjust the actual pressure 1(p) and pressure 2 (P) to match the required values in the program memory (i.e. $p=m$ and $P=M$). See page 15 for how to install a micropipette. The Cool Air pressure (Cxx.x) usually is set to about 20 psi, or according M number.

Within the PROGRAM status: The cursor blinks to indicate the program parameter that can be changed. Press the '<' and '>' keys to move cursor to different parameters or digits. (Sequence #-> Timer step #-> Time setting digits --> Heat level setting digits--> Action setting or length of Pull), press **STEP** to step position, press **HEAT** to heat level position, press **PULL LENGTH** to pull length setting position or press **TIMER (START)** to timer position. Then press the '^' or 'v' key to select value.

There are a total of 99 sequences that can be programmed and saved, with maximum 18 steps in each sequence. For each timer step, a user can set time (from 0.0 to 999.9 second), heat level (from 26-99) or **AUTO HEAT** levels (from 50^ -98^) and action (Pull 1, Pull 2, Pull2+Cool or Cool Air). To select a program (sequence), press the **PROG** key then press '^' or 'v' key.

If a new program is setting , press the < or > key or **STEP** then v or ^ to select a step. Before setting any new parameter in a step, press the **STOP** key to clear and reset the step first. Or, press **PROG/COPY** key for one minute to enter **COPY** mode, then following the display to copy a sequence which you want to modify to an empty sequence number, then modify the new sequence.

Pressing the **TIMER** key, the cursor will blink on the 'Txxx.x' position. Pressing the **HEAT** key, the cursor will blink on 'Hxx' position. Press **HEAT** key second time will change the heat setting to 'H50^' automatic heat rising initial number. Press < or > to select a digit and press ^ or v key to select value (the optical ruler setting value = digit # x 0.5mm). Pressing the same action key second time will cancel that action setting.

The pressure 1 and 2 real-time measurements are displayed as 'pxx.x' and 'Pxx.x'. The previous pressure values which were saved in the memory are displayed as 'mxx.x' and 'Mxx.x'. In the **READY** status, both real-time measurements and memory are displayed and the pressure 1 and 2 can be adjusted. Pressing the 'P-MEMO/SAVE?' key second time , the two real-time pressure measurements are displayed only and a 'SAVE?' is asked and the regulated pressure values can also be changed by turning the regulator knobs. By pressing the 'SAVE DOWN(V)' key and the new pressures will be saved and updated in the memory. If the update is not required, pressing the 'P-MEMO/SAVE?' again will back to previous **PROGRAM** status.

Please refer following pages for detail function of each key.

Display Window:

```

PROGRM: SQ01 TS:11M20
MEMO:M 20.0 m03.0
T3: L > H78 P1L003
T4: 010.0 H00
    
```

```

COPY SEQ01 TO SEQ01 ?
START = YES
EXIT = NO
    
```

```

PROGRM: SQ01 TS:11M20
MEMO:M 20.0 m03.0
T3: L > H50^ P1L003
T4: 010.0 H00
    
```

```

PROGRM: SQ01 TS:11M20
MEMO:M 20.0 m03.0
T3: L > H50^ P1L003
T4: 010.0 H00
    
```

AUTO HEAT function: Heat can rise from H50^ automatically to until pipette be pulled to length setting.

```

PROGRAM: SEQ01 TS 11
MEMO:M 20.0 m03.0
T3: L > H50^ P1L003
T4: 010.0 H00
    
```

Dynamic memory: H75

setting and the heat grade will be recorded on the pulling length set point. Back to Programming statu and press HEAT key second time, the initial '50^' will be replaced by the recorded heat grade, H75 for example. Pressing HEAT key one more time the initial '50^' can be back to the setting. There is a '^' which indicates that the heater will automatically rise heat level from set 45-97 to what ever until the pipette can be pulled to the length of P1Lxxx or P2Lxxx setting and the melting heat grade is recorded. If pulling are controlled by timer instead by length, the heater will automatically rise heat level until time due. No heat grade will be recorded but for manual check and test only. To get initial heat level closer to actual pulled heat point, the ^ key and v key can be used to select the 'Hxx^' digit setting up and down. The 'Hxx^' can be set from 'H45^' to 'H97^'. An excess of this range will back to fixed heat setting of 'Hxx', which can be set from 'H26' to 'H99'. After actual execution of a sequence with a 'Hxx^' setting, the heat level had risen to a point which was capable of pulling the pipette. That point already had been stored. Pressing the AUTOHEAT key again, the stored heat point digit (yy) will replace the beginning setting of 'Hxx^' to 'Hyy'. But if press the AUTOHEAT key again, the 'Hyy' will go back to initial 'Hxx^' setting again.

Pressing Keys:

PROG COPY

The status will change to PROGRAM and the cursor will be turned on by pressing one of these keys. When pressing the 'PROG' key, the cursor will blink on sequence # position.

STEP EXIT

Pressing the 'STEP' key, the cursor will blink on time step position. Pressing the 'P-MEMO/SAVE?' key the cursor will blink on pressure memory position.

P MEMO SAVE?

Pressing the TIMER (START) key, the cursor will blink on the timer position.

TIMER START

Press and hold PROG/COPY key about 2 seconds the LCD will display COPY mode. During COPY mode use '<', '>' keys to switch source or destination sequence. Press '^', 'v' to select a sequence number. Press START key to enter copy function or press STEP/EXIT key to cancel.

< MOVE L

Pressing the < key will move cursor to one setting position left and pressing the > key will move cursor to one setting position right.

> MOVE R

When the cursor is on timer step number position, pressing ^ key or v key will move timer step up or down.

^ +/UP

When the cursor is on sequence digits, timer digits or heat level digits positions, press ^ or v key will add or reduce the digit number.

SAVE v /DOWN

When an underline cursor is on 'Pressure SAVE?' position, adjust the pressure regulator and see the change on real pressure display. Press the v key will save the real pressure measurements to the memory (update the pressure memory).

Pressing the 'P-MEMO/SAVE?' key only, the display will back to pressure MEMO without update the pressure memory.

HEAT

Pressing the 'HEAT' key, the cursor will blink on the heat level position. If AUTOHEAT function is performed, the puller has a dynamic memory for recording pipette melting heat grade. To perform the AUTOHEAT function, set higher than H99 then becomes H50^ - H90^ . For example, if H50^ is set, the heater will be rising heat grade automatically from H50. Until the pipette be pulled and reached to the P1Lxxx or P2Lxxx length

Display Window:

Pressing Keys:

```

PROGRAM: SQ01 TS:03M20
MEMO:M 20.0 m03.0
T2: 008.0 H00
T3: L > H80 [P1]L001
    
```

PULL1

Pressing the 'PULL1' key within PROGRAM status will set 'P1L:xx' on the cursor flashing step action position. Set the pull 1 length 'xx' for optical ruler measuring. The maximum setting is 40 (40x0.5mm=20mm). Setting more than 40 will change the pull1 control from optical ruler to a timer. Pressing the 'pull1' again will erase that PULL1 setting. During READY status, pressing the 'PULL1' key will trigger Pull 1 action which will pull distance as the setting of 'P1Lxxx', if the finger pressing the key long enough.

```

PROGRAM: SQ01 TS:03M20
MEMO:M 20.0 m03.0
T9: 010.0 H90
T10: L > H00 [P2]L003c
    
```

PULL2

Pressing the 'PULL2' key within PROGRAM status will set 'P2Lxxx' on the cursor flashing step action position. Set the pull 2 length 'xx' for optical ruler measuring. The PULL2 optical ruler control is different with the PULL1 optical control. When the pulling reaches the length set point, the PULL1 optical

control will stop the heater and pulling, but the PULL2 optical control only stop the heater, pulling is continue. The maximum length setting is also 40 (40x0.5mm=20mm). Setting more than 40 will change the pull1 control from optical ruler to a timer. Pressing the 'PULL2' again will erase that PULL2 setting. During READY status, pressing the 'PULL2' key will trigger Pull 2 action which will pull as long as the finger pressing the key. If pressing COOL key after setting PULL 2 in the same step, the setting becomes powerful function of PULL then AIRJET (P2Lxxx c). With the 'P2Lxxx c' setting, an air jet will cool the heater immediately as the tip being pulled for setting xx length. The heater is stop but the pulling is continue until a fine and very sharp tip is pulled to finish. There is an exclusive **Tip Sensing Function** for the PULL2 action. With the Tip Sensing Function, if the heater is too cool to finish a tip, the heater will be turned on again to repeat the pulling. However, repeating 'P2Lxxx c' pulling may not be the best way to pull a tip. If this is the case, change 'Hxx' setting or preheat time to find out correct heat setting level digit or change the PULL2 pressure or add one more PULL1 step before the final tip pulling. The following table will illustrate the heating, pulling and tip sensing functions for PULL1 and PULL2 different setting:

SETTING	HEATER	PULLING	HEATGRADE RECORDED	TIP SENSING FUNCTION
xxx.x Hxx P1L<T	Heat as long as set time.	Pull as long as set time.	No	No.
<L Hxx P1Lxxx	Heat as long as set length.	Pull as long as set length.	No	No.
<L Hxx^ P1Lxxx	Heat auto-rising from set point, stop on set length.	Pull as long as set length.	Yes	No.
xxx.x Hxx P2L<T	Heat as long as set time.	Pull as long as set time.	No	No.
<L Hxx P2Lxxx	Heat as long as set length.	Pull to the end.	No	No.
<L Hxx^ P2Lxxx	Heat auto-rising from set point, stop on set length.	Pull to the end.	Yes	Yes.
<L Hxx P2Lxxx c	Heat as long as set length, then air cool.	Pull to the end.	No	Yes.
<L Hxx^ P2Lxxx c	Heat auto-rising from set point, stop on set length, then air cool.	Pull to the end.	Yes	Yes.

Display Window:

Pressing Keys:

```
PROGRM: SQ01 TS:03M20
MEMO:M 20.0 m03.0
T1: L > H80 P1L001
T2: 006.0 H00
```

PULL1
LENGTH

Pressing the PULL1-LENGTH key will turn the READY status to PROGRAM status, and move the cursor to pulling length setting position.

```
PROGRM: SQ01 TS:11M20
MEMO:M 20.0 m03.0
T11: 003.0 H00 COOL
T12: 000.0 H00
```

COOL

In the PROGRAM status, pressing the COOL key will set air ejection on the step. The air jet can be used for cool down the heater before next pulling sequence. Press the same key again will erase the setting. However, if the status is READY, pressing the COOL key will trigger air ejecting as long as the finger is pressing on the key.

```
PROGRM: SQ01 TS:11M20
MEMO:M 20.0 m03.0
T11: 003.0 H00 COOL
T12: 000.0 H00
```

STOP

In the PROGRAM status, when all steps of setting are finished, but total number of steps is less than 18, don't forget to press 'STOP' key for next step to terminate the sequence. If the total number of steps is 18, the sequence will automatically stop after step 18. Pressing the 'STOP' key will set timer, heater and action to zero. Always press this key in the beginning of a new step setting. During ACTION status, pressing the 'STOP' key will halt the action and stop executing the sequence.

```
READY: SQ01 C20.1M20
P20.1 M 20.0 p 03.0 m03.0
T1: L > H80 P1L002
T2: 006.0 H00
```

READY

Press the 'READY' key when finishing the programming of a sequence. Pressing the 'READY' key will turn status to READY from PROGRAM. The READY status is ready for manual control or automatic sequential actions.

RETURN

Press to return the clamp blocks.

PULL1

PULL2

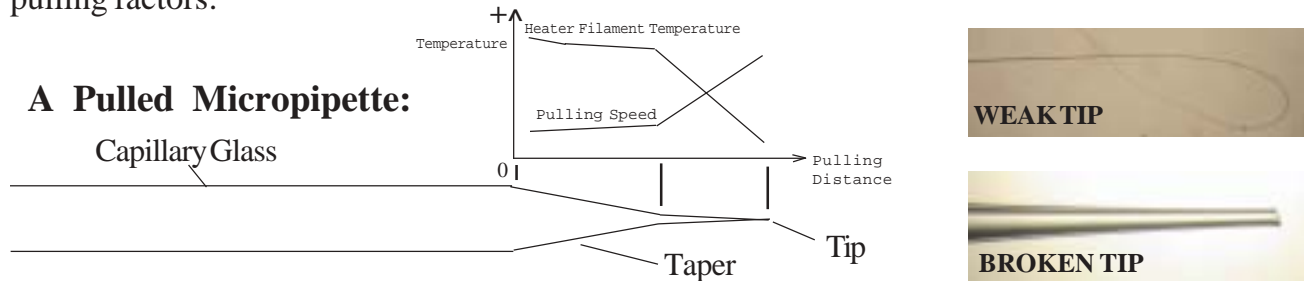
See page of Installing a Micropipette for how to install a capillary in the puller clamps. Make sure 'pxx.x' and 'Pxx.x' pressures are adjusted to the same value as the memory setting pressures, that means $pxx.x = mxx.x$ and $pxx.x = Mxx.x$. Then press PULL1 key to test the security of clamping of the glass for PREHEAT PULL or REST HEAT PULL (see next page). Press PULL2 to test the security of clamping for HEAT AND PULL only. If the clamping is secure, the START key can now be pressed to start an automatic pulling sequence.

START

Programming The Pulling Sequences

1. Pulling Factors

The temperature level, pulling force and timing are three major parameters to pull a micropipette. A micropipette with desired tip shape and size is produced by a special combination of these three factors. The following graphic will illustrate the relationship between a pulled pipette and the pulling factors:



The general principles for making a micropipette :



- [1] Pulling the micropipette taper with melting temperature and pulling the tip with higher speed and dropping down temperature.
- [2] The taper length controlled by the setting of optical ruler.
- [3] The higher heat and faster pulling speed, the longer and sharper tip length will be.
- [4] Too high heat with high pulling force will tend to make a tip thready and weak.
- [5] Sufficient pulling force with insufficient heat will tend to make a tip opening bigger or broken without tip.
- [6] More pulling steps with less length setting in each step will make shorter taper.
- [7] Longer pulling setting or more pulling steps are needed for bigger size pipette.
- [8] Faster final pulling needs higher cooling pressure, higher cooling pressure tend to shorter tip. But too high cooling pressure will bend the tip.

Making a desirable taper: In the PMP-102, the PULL1 is used to pull different taper. A gradual reducing diameter and long taper can be produced by one time pulling with 5-20 units length setting, median heat (70-85) and light pulling force (0.4-3 psi). A rapid reducing diameter and shorter taper needs more than two pulls with short length setting (1-2 unit) in each pulling and 0.5-1psi lighter pulling force. More pulling steps (PULL1) with short length setting (1-2) in every step will pull shorter and stronger taper. One or two pulling steps with longer length setting (4-6) will pull thin and longer taper. Carefully combining with desirable taper setting and tip setting, an ideal pipette can be pulled. (see detail sample sequences).

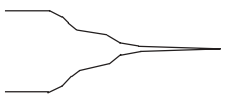


Making a desirable tip: How to heat a micropipette for a final pulling is the critical point to make a desirable tip. **There are three major methods to pull a tip:**

- [1] **Heat & Pull:** The puller performs a last step tip pulling with heater turning on, then turns off the heater and air cooling on certain pulling distance to end the pulling. The pulling force and heater is beginning simultaneously. The advantage for this method is that the tip opening size and taper are adjustable from the finest to larger by adjusting the pulling force, pulling distance and heating level. However, the pulling is very sensitive to the pulling force and heat setting and the repeatability is difficult to control. If performing multistep pulling, the transfer from taper to tip is some abrupt.

[2] Preheat Pull: Before last step pulling, the pipette is preheat to certain temperature without pulling. Then the pipette is pulled with heater turned off and heating temperature rapid dropping down. The advantage for this method is the tip will be pulled to a fine tip and transfer between taper and tip is smooth. The repeatability is high. But the preheat level and preheat time setting are very critical for the final pulling.

[3] Rest Heat Pull: The heat for pulling the taper is also used for the last step tip pulling. After the taper pulling, the heater turns off and the temperature begins to drop. The final pulling is triggered during heater temperature dropping down. This method will pull a tip from the taper with smoothest transfer. **This is specially good to make different sizes of tip opening by selecting a right timing to trigger the final pull. The longer trigger timing and the bigger tip opening will be (See SQ21-22).** 1 um tip:  10 um tip: 

This micropipette puller can perform all these three methods to pull a tip. The following pages of pulling examples will discuss the details of setting and programming different method sequences.

METHOD	HEATER ACTION	FEATURES	TAPER TO TIP
Heat & Pull	The heater is turned on with the beginning of last pull.	Tip opening size can be controlled by last step heat and pressure 2 (0.1-3um). The tip size is very sensitive to the P2 pressure. The transfer from taper to tip has some abrupt for multistep pull.	
Preheat Pull	There is preheat step before last pull, heater off during last pull.	Finest tip(0.3-5um) can be pulled and sensitive to the preheat step. The transfer from taper to tip is smooth. Repeatability is higher.	
Rest Heat Pull	Preheated by previous pulling only, the last pull works depending on the rest heat.	Fine tip (<1um to 10um) can be pulled and sensitive to previous pulling heat and wait time. The smoothest transfer from taper to tip can be achieved. Repeatability is high.	

How to Modify Existing Sequence or Setting a New Sequence:

There are 22 different pulling sequences which have been pre-programmed inside the PMP102. These 22 preset sequences (from SQ1-SQ22) cover Heat & Pull (7 sequences), Preheat Pull (7 sequences) and Rest Heat Pull samples (8 sequences). The SQ51-SQ72 are back up preset sequence copies. A new user can see the provided pulled samples or image references (next page) to select a preset sequence which fits or is closer your desired pipette shape and size. Then try to pull one. If the pulled sample is closer what you need but need some change, there are two ways to modify the sequence. One is pressing the PROG key to PROGRAM mode to directly modify the sequence, but you will change the original setting. Another is pressing the PROG key for more than 2 seconds and go to COPY mode. Copy the sequence which you need to modify to one of sequence SQ23 -SQ50 or SQ73 -SQ99 (SQ51-SQ72 are back up preset sequences). Now you can easily modify the closer sequence and without worry about loss of the original one. When you modify a sequence, always change one unit of only one factor in one time. If a broken tip is happen, add more heat or pull faster on the last pulling step. If a tip is not pulled to the end after the last step (although the puller will automatically sensing the fail and add one more pulling step until pull to the end), the last step P2L:xxc must be too short to cool down the heater, add more units to the xxc or increase the last heat step level. If a tip is thready and weak, the last heat step level must be too high, reduce the heat level or shorten the cool distance of P2L xxc.

2. Preset Sequences

Reference Picture for Preset Sequences:

X40	X100		X40	X100	
		Taper length: >2.5 mm for 10-40 um OD Tip opening: 0.1-0.8 um			Taper length: 350-500um for 2-50 um OD Tip opening: 0.8-3 um
		Taper length: >3.5 mm for 25-50 um OD Tip opening: 0.5-2 um			Taper length: 0.5-0.6mm for 3-50um OD Tip opening: 1-6 um
		Taper length: >2 mm for 10-50 um OD Tip opening: 0.1-0.8 um			Taper length: 0,75mm for 2-100 um OD Tip opening: 1-6 um
		Taper length: 2.2 mm for 5-50 um OD Tip opening: 0.1-0.8 um			Taper length: 1.5 mm for 2-50 um OD Tip opening: <1-1 um
		Taper length: 0.7-1mm for 4-30um OD Tip opening: 0.1-0.8 um			Taper length: 2.5 mm for 5-25 um OD Tip opening: 1-5 um
		Taper length: 5 mm for 12-20 um OD Tip opening: 1-12 um			Taper length: 0.75mm for 2-50 um OD Tip opening: 0.8-2 um
		Taper length: 0.3-0.5mm for 5-50um OD Tip opening: 1-5 um			Taper length: 3 mm for 7-20 um OD Tip opening: <1-3 um
		Taper length: 2.5 mm for 10-25 um OD Tip opening: 0.5-3 um			Taper length: 0.4mm for 2-50 um OD Tip opening: <1-2 um
		Taper length: 0.5-0.7mm for 5-100um OD Tip opening: 1-5 um			Taper length: 0.3 mm for 2-20 um OD Tip opening: <1-2 um
		Taper length: 0.1-0.2 mm for 2-50 um OD Tip opening: 1 um			Taper length: 0.75-1 mm for 2-50 um OD Tip opening: <1-2 um
		Taper length: 1.2-1.6mm for 30-100um OD Tip opening: 2-30 um			Taper length: 5 mm for whole taper Tip opening: <0.5-2 um

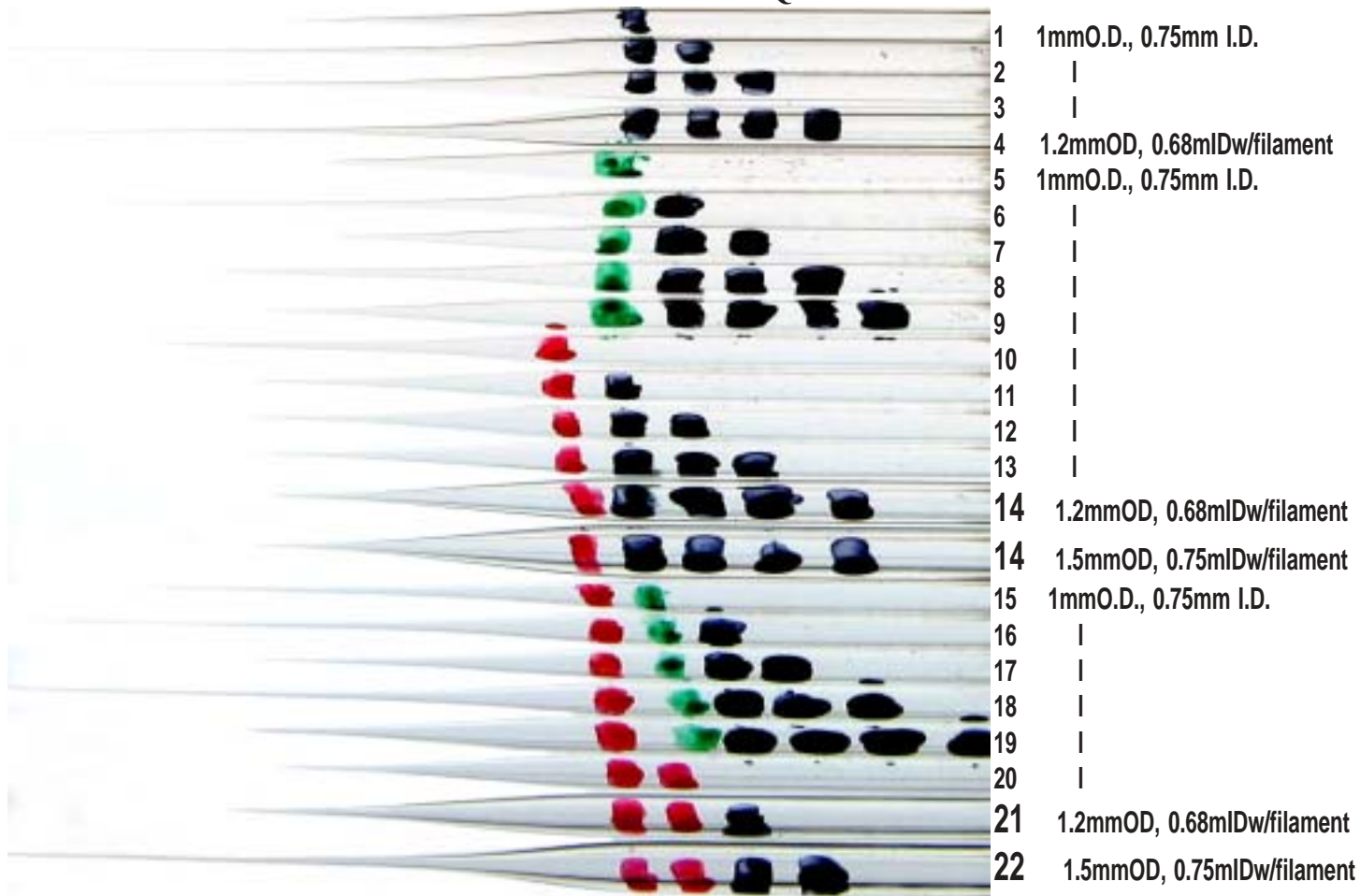
Heat & Pull sequences (Sequence # 1-7) Preheat Pull sequences (Sequence # 8-14) Rest Heat Pull sequences (Sequence # 15-20)

All micropipette: 1 mm OD/0.58 ID with filament, except *: 1.08 mm OD/0.79 ID without filament, **: 1.2 mm OD/0.58 ID with filament, ***: 1.5 mm OD/0.84 ID without filament

Pulled pipette samples Picture for Preset Sequences:

SEQUENCE NUMBER (BLACK=+1, GREEN=+5, RED=+10) :

SEQUENCES 1- 22:



EXTRA SEQUENCES 23 - 30:



Using HC-2 1/8" ID, 5 turns Heater coil and Cool air pressure 18-25 psi range for all sequences.

Heat & Pull Sequences (#1-7): (For intracellular injection, electrode or holding pipette).

Sequence #1: Pressure cool(C)= 25 psi, Pressure 1 (p) = 1.5 psi, Pressure 2 (P) = 10-20 psi, Borosilicate capillary: 1mm OD/0.58mmI.D. with inner filament, or 1mm OD/0.75mm ID thin wall.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H78(65-85)	P2L004c	Pull about 2 mm with heating level 72-90, then let heat off and eject air to rapid cool the heater for continue pulling a vary sharp tip (<0.02 um, about 20Mohm resistance). Change P2 can change tip opening size: 4 um(P2=16), 5 um(P2=12), 7 um(P2=10). Don't forget to clear and reset the last step to stop the sequence.
T2	0.0	H00		

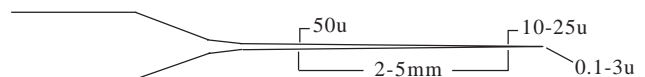
Sequence #2 : Pressure C (cool)= 20 psi, Pressure 1 (p) = 1.5 psi, Pressure 2 (P) = 5-8 psi, Micropipette: 1mm OD/0.58mmI.D. with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H65(60-78)	P1L004(3-6)	Pull 2-3 mm taper with heating level 60-88 and P1, Then let heat off and pull with lower P2. When P2 pulling 2 mm, eject air to deeper cool the heater for continue pulling a medial tip (1-2 um). Don't forget to clear and reset the last step to stop the sequence.
T2	L >	H00	P2L004c(2-4)	
T3	0.0	H00		

Sequence #3 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 1.5 psi, Pressure 2 (P) = 3.5-5.5 psi, Micropipette: 1mm OD/0.58mmI.D. with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H70(65-80)	P2L007c	Pull 3.5 mm longest taper with heating level 65-80 and more lower P2, then let heat off and eject air to rapid cool the heater for continue pulling a larger tip (0.5-3 um). Don't forget to clear and reset the last step to stop the sequence.
T2	0.0	H00		

Comment: Very sharp tip and smooth taper, but sensitive to P2 and heating level. Pulling taper with temperature rising to soften the glass pipette. Then rapid drop down heater temperature by turning heat off and air cool the heater to pull tip. Lower the Pressure 2 (P) or heat level or both will make the tip shorter or tip opening larger. But too low pressure or heat level will not pull the tip to the end or pipette broken in the middle. Higher heat and higher P2 together will make tip sharper and opening smaller. Lower heat with slow pull (lower P2 pressure) will make tip opening bigger.



A micropipette pulled by sequence 1:



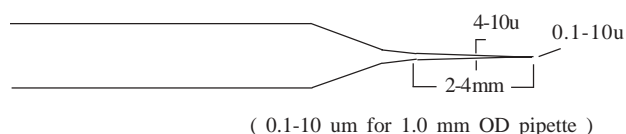
A micropipette pulled by sequence 2:



Sequence #4 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 2 psi, Pressure 2 (P) = 5-10 psi, Micropipette: **1.2 mm OD/0.68mm ID** with inner filament.

STEP	ACTION TIME (sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H70(65-85)	P2L008c	For pulling bigger OD pipette in single step sequence, the pulling length should be increased. But the heating level can be remained the same or be increased little for more bigger OD pipette.
T2	0.0	H00		

Comment: Pulling a bigger pipette with the same shape of a smaller pipette usually leads to result of longer taper and tip, because more glass is pulled from bigger pipette. Very sharp tip and smooth taper, but sensitive to P2 and heating level. Pulling taper with temperature rising to soften the glass pipette. Then rapid drop down heater temperature by turning heat off and air cool the heater to pull tip. Lower the Pressure 2 (P) or heat level or both will make the tip shorter or sharper. But too low pressure or heat level will not pull the tip to the end or pipette broken in the middle.



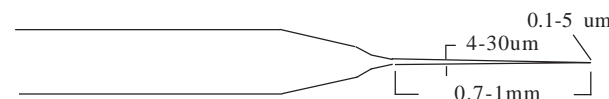
A micropipette pulled by sequence 4:



Sequence #5 : Pressure C (cool)= 25 psi, Pressure 1 (p) =0.5- 2 psi, Pressure 2 (P) = 7-12 psi, Micropipette: 1mm OD/0.58mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H75	P1L002(03)	First pull 1 mm or 1.5 mm taper distance. Stop heat and let the pipette cool 5 second.
T2	05.0	H00		
T3	L >	H70(60-72)	P2L003c(1-4)	Pull 1-2 mm with heating level 60- 72, then let heat off and eject air to rapid cool the heater for continue pulling a tip. Don't forget to clear and reset the last step to stop the sequence.
T4	0.0	H00		

Comment: Shorter taper and longer tip / longer taper and shorter tip. Before pulling a tip, pull taper 1-1.5 mm to reduce the pipette diameter little more. Then pull the tip as Sequence 1, but increasing PU2 force. Higher Pull2 force or higher Pull2 heat will make tip longer, vice versa.

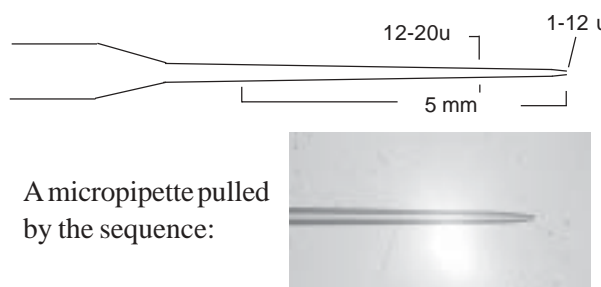


A micropipette pulled by sequence 5:

Sequence #6 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.5-2 psi, Pressure 2 (P) = 2-10 psi, Micropipette: **1.0mm OD/0.75mm thin wall borosilicate without inner filament.**

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H70-80	P1L008(6-18)	First pull 3-9 mm taper distance.
T2	0.2-5	H00		Stop heat and let the pipette cool 0.2-5 seconds.
T3	L >	H70-85	P2L003c(3-6c)	Final pull 1.5 to 3.0 mm with heating to level 70-85, then heater off and eject air to rapid cool the heater for continue pull to the end.
T4	03.0	H00	COOL	Eject air cool the heater for next operation.
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Longest taper with big tip opening. Pulling taper with long P1L setting is the feature of this sequence. Longer setting needs lower force to pull. The higher the Pressure 2 (P) is, the smaller tip opening will be. Longer P2L006c setting will make longer taper. It fits to pull a holding pipette or a sperm pick up needle using thin wall pipette without filament.

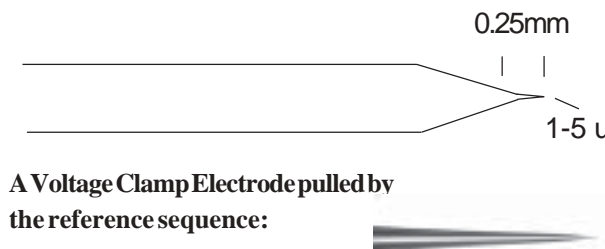


Sequence # 7 : (for voltage clamp electrode 2-6 MOhm)

Total 10 steps. Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.8-1.5 psi, Pressure 2 (P) = 0.5-3 psi, Micropipette: **1.0mm OD/0.75mm thin wall borosilicate without inner filament.**

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H85	P1L002	First pull 1mm taper distance.
T2	04.0	H00		Stop heat and let pipette cool 4 seconds.
T3	L >	H80	P1L001	Pull more 0.5mm taper distance.
T4	04.0	H00		Stop heat and let pipette cool 4 seconds.
T5	L >	H75	P1L001	Pull more 0.5mm taper distance.
T6	04.0	H00		Stop heat and let pipette cool 4 seconds.
T7	L >	H75	P1L001	Pull more 0.5mm taper distance.
T8	04.0	H00		Stop heat and let pipette cool 4 seconds.
T9	L >	H65-90	P2L003c(01c-05c)	Pull tip with level 65-90 heat on. The Heat Level and Pressure 2 setting are very critical for the final tip pulling. The higher heat level the longer and thinner tip will be. Adjust heat level one by one. The higher Pressure 2 setting, the smaller tip opening will be (higher resistance). Adjust the Pressure 2 even by 0.1psi, you will see the difference.
T10	003	H00	COOL	
T11	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Perform many short taper pulls before the final pull. The taper is short and OD reduced gradually, that is the feature of this sequence. Pulling tip with heat turns on. Carefully adjust the Pressure 2 will achieve different resistance tips, since the tip opening is very sensitive and varying to both P1 and P2 settings.



Preheat Pull Sequences (#8-14) :

Sequence # 8 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 1-2 psi, Pressure 2 (P) = 6-10 psi, Micropipette: 1 mm OD/ 0.58 mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H82	P1L006	First pull 3 mm taper distance.
T2	06.0	H00		Stop heat and let the pipette cool 4-6 seconds.
T3	3.5-7	H65-80		Setting preheat 3.5-7 seconds for final pull. The heater and time setting are very critical for the final tip pulling. Even small amount of time adjustment will change the final tip length.
T4	L >	H00	P2L004c	Final pull with heater turning off.
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 9 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 1- 2 psi, Pressure 2 (P) = 10 psi, (for voltage clamp or patch clamp electrode). Micropipette: 1 mm OD/ 0.58 mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

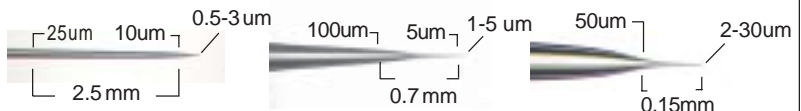
T1	L >	H70-75	P1L002	First pull 1 mm taper distance.
T2	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T3	L >	H68	P1L001	Pull 0.5 mm taper distance with lower heat level.
T4	7	H00		Stop heat and let the pipette cool 7 seconds.
T5	L >	H67	P1L001	Repeat above two steps 3 times in following ...
T6	7	H00		
T7	L >	H67	P1L001	
T8	7	H00		
T9	L >	H65	P1L001	Tip is expected to break in this step.
T10	5	H00		But still need final steps to finish unexpected no break tip.
T11	4(4-8)	H70-78		Preheat certain time for final pull. Time and heat level setting is critical.
T12	L >	H00	P2L001c	This sequence can produce smooth and short taper with small tip opening, good for patch or voltage clamp applications.
T13	03.0	H00	COOL	
T14	0.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 10 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 1- 2 psi, Pressure 2 (P) = 10 psi, Micropipette: 1 mm OD/ 0.58 mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H75	P1L006	First pull 3 mm taper distance.
T2	05.0	H00		Stop heat and let the pipette cool 4-6 seconds.
T3	L >	H75	P1L002	One more taper pulling step is added.
T4	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T5	4-6.0	H70-72		Setting preheat 4-6.0 seconds for final pull. The heater and time setting are very critical for the final tip pulling. Even small amount of time adjustment will change the final tip length.
T6	<-L	H00	P2L004c	Final pull with heater turning off and air blew after 2 mm pull.
T7	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Long and smooth taper to tip. Preheat before final pull. Pulling tip with temperature rapid low down. Adjust the first pull distance to make different taper length.

A micropipette pulled by the sequence 8: by the sequence 9: by the sequence 10:



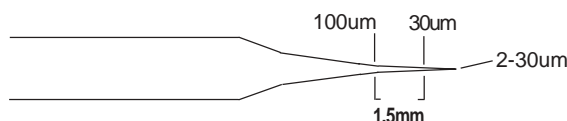
Sequence # 11 : (for extracellular electrode, or injection pipette) Pressure C (cool)= 25 psi, Pressure 1 (p) =1- 2 psi, Pressure 2 (P) = 10 psi, Micropipette: 1mm OD/0.58mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H85	P1L001	First pull 0.5 mm taper distance.
T2	09.0	H00		Stop heat and let the pipette cool 9 seconds.
T3	L >	H80-85	P1L002	Pull 1 mm taper distance with lower heat level.
T4	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T5	L >	H75-80	P1L002	Pull 1 mm taper distance with lower heat level.
T6	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T7	L >	H70-75	P1L001	Repeat above six steps with lower heat level in following ...
T8	08.0	H00		
T9	L >	H65-70	P1L002	Tip may be made in this step for short tap application.
T10	07.0	H00		
T11	4-6	H65(65-80)		Preheat for final pull. Time and heat level setting is critical.
T12	L >	H00	P2L002c (1c- 4c)	Final pull with heater turning off and ejecting air after pull 0.5-2 mm then to end.
T13	3.0	H00	COOL	Cool the heater by ejecting air for next operation.
T14	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 12 : Pressure C (cool)= 25 psi, Pressure 1 (p) =0.8- 2 psi, Pressure 2 (P) = 10 psi, Micropipette: 1mm OD/0.58mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H85	P1L001	First pull 0.5 mm taper distance.
T2	09.0	H00		Stop heat and let the pipette cool 9 seconds.
T3	L >	H80	P1L0:02	Pull 1 mm taper distance.
T4	04.0	H00		Stop heat and let the pipette cool 4 seconds.
T5	L >	H75	P1L002	Pull 1 mm taper distance.
T6	05.0	H00		Stop heat and let the pipette cool 5-8 seconds.
T7	L >	H75	P1L001	One more taper pulling step is added.
T8	08.0	H00		
T9	2-6.0	H70-85		Level 78 heater setting preheat 2-6 seconds for final pull. The heater and time setting are very critical for the final tip pulling. Even small amount of time adjustment will change the final tip length.
T10	L >	H00	P2L003c	Pull 1.5 mm with heater turning off. Then air cool heater and pull to the end.
T11	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Preheat before final pull. Pulling tip with temperature rapid low down . The transfer from taper to tip is smooth. Adjust the preheat time to achieve a desired tip. Longer preheat time will make longer tip. There are many pulling steps. If tip is broken before the last step, reduce P1 pressure or reduce PU1 length units.



A micropipette pulled by sequence 11:

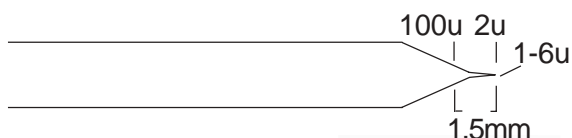
Sequence # 13 : (for voltage clamp electrode) Pressure C (cool)= 25 psi, Pressure 1 (p) =0.5- 1.6 psi, Pressure 2 (P) = 10-15 psi, Micropipette: 1.0mm OD, 0.58mm ID, with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	ACTION TIME (sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H88	P1L002	First pull 1mm taper distance.
T2	07.0	H00		Stop heat and let pipette cool 7 seconds.
T3	L >	H78	P1L001	Pull more 0.5mm taper distance.
T4	07.0	H00		Stop heat and let pipette cool 7 seconds.
T5	L >	H75	P1L001	Pull more 0.5mm taper distance.
T6	07.0	H00		Stop heat and let pipette cool 7 seconds.
T7	L >	H72	P1L001	Pull more 0.5mm taper distance.
T8	07.0	H00		Stop heat and let pipette cool 7 seconds.
T9	L >	H70	P1L001	Pull more 0.5mm taper distance.
T10	07.0	H00		Stop heat and let pipette cool 7 seconds.
T11	3-7.0	H70-83		Level 78-83 heater setting preheat 3.0-7.0 seconds for final pull. The heater and time setting are very critical for the final tip pulling. Even small amount of time adjustment will change the final tip length.
T12	L >	H00	P2L002c	Final pull with heater turning off and rapid cool down heater by ejecting air after pull 0.5mm, then pull to the end.
T13	03.0	H00	COOL	Cool the heater by ejecting air for next operation.
T14	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 14 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.5-2 psi, Pressure 2 (P) = 10.0 psi, Micropipette: **1.0-1.5mm OD, 0.68-0.75mm ID**, with or without inner filament.

T1	L >	H88	P1L002	First pull 1mm taper distance.
T2	07.0	H00		Stop heat and let pipette cool 7 seconds.
T3	L >	H78	P1L001	Pull more 0.5mm taper distance.
T4	07.0	H00		Stop heat and let pipette cool 7 seconds.
T5	L >	H75	P1L001	Pull more 0.5mm taper distance.
T6	07.0	H00		Stop heat and let pipette cool 7 seconds.
T7	L >	H72	P1L001	Pull more 0.5mm taper distance.
T8	07.0	H00		Stop heat and let pipette cool 7 seconds.
T9	L >	H70	P1L001	Pull more 0.5mm taper distance.
T10	07.0	H00		Stop heat and let pipette cool 7 seconds.
T11	L >	H70	P1L001	Pull more 0.5 mm taper distance. The only difference compare to SEQ13 is one pulling step added for bigger size pipette.
T12	07.0	H00		Stop heat and let pipette cool 7 seconds.
T13	4-5.0	H70-83		Level 73-83 heater setting preheat 4-5 seconds for final pull. The heater and time setting are very critical for the final tip pulling. Even small amount of time adjustment will change the final tip length.
T14	L >	H00	P2L003c	Final pull with heater turning off and rapid cool down heater by ejecting air after pull 0.5-1.5mm, then pull to the end.
T15	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: To pull a tip with short and rapid reducing taper size, many short pulls must be made before the final pull. If pulling a bigger OD pipette, add more pulling steps. Preheat before final pull. Pulling tip with temperature rapid low down. Adjust the preheat time to achieve a desired tip. There are many pulling steps. If tip is broken before the last step, reduce P1 pressure or reduce PU1 length units.



A micropipette pulled by this sequence:



Rest Heat Pull Sequences (#15-22):

Sequence # 15 : (for intracellular injection pipette)

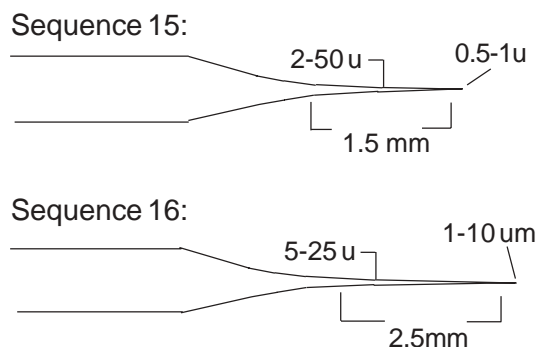
Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.3-1.0psi, Pressure 2 (P) = 16.0psi, Micropipette: 1mm OD/0.58mm ID with inner filament, or 1 mm OD/0.75 mm ID thin wall borosilicate capillary.

STEP	OPERATING TIME(sec)	HEAT LEVEL	ACTION	EXPLAINATION
T1	L >	H80-89	P1L005	First pull 2.5 mm taper distance.
T2	1.6-3	H00		Stop heat and let cool only 1.2-2 second. The time setting is very critical for the final tip pulling.
T3	L >	H00	P2L001c	Pull 1 unit then pull to end with air jet cooling down the heater.
T4	3.0	H00	COOL	Eject air cool the heater for next operation.
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 16 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.3-1.5psi, Pressure 2 (P) = 10-16 psi, Micropipette: 1mm OD/ 0.58mm ID with inner filament, or 1 mm OD/0.75 mm ID thin wall borosilicate capillary.

T1	L >	H65-85	P1L010	First pull 5 mm taper distance.
T2	0.5-4	H00		Stop heat and let cool only 0.5-4 second. The time setting is very critical for the final tip pulling.
T3	L >	H00	P2L000c	Immediately pull to end with air jet cooling down the heater.
T4	3.0	H00	COOL	Eject air cool the heater for next operation.
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Long, smooth and sharp tip. Pull only one longer taper. Preheated by previous pulling and continue pull a tip with temperature rapid low down. Adjust the time between taper pull and last pull to achieve a sharp tip with very smooth transferring from taper. But higher T1 heat with longer waiting time T2 may cause tip pulling without straight line. For longer taper pulling, if tip is broken before the last step, reduce PU1 length units. If the pulled taper is not straight, reduce the P1 pressure. Adjust P2 will change the tip opening. The higher P2, sharper and smaller tip opening will be. Too high P1 or P2 may cause curve or thready tip.



A micropipette pulled by sequence 16:



Sequence # 17 : (for voltage clamp electrode or injection pipette)

Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.5-2.0psi, Pressure 2 (P) = 9.0psi, Micropipette: 1mm OD/ 0.58mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	OPERATING TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H85	P1L002	First pull 1mm taper distance.
T2	06.0	H00		Stop heat and let cool 6 seconds.
T3	L >	H75	P1L003	Second pull 1.5mm taper distance.
T4	1.1-2.1	H00		Stop heat and let cool only 1-2.5 second. The time setting is very critical for the final tip pulling.
T5	L >	H00	P2L000-4c	Pull with heater off, then air ejects after pull some distance to end.
T6	03.0	H00	COOL	Eject air cool the heater for next operation.
T7	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

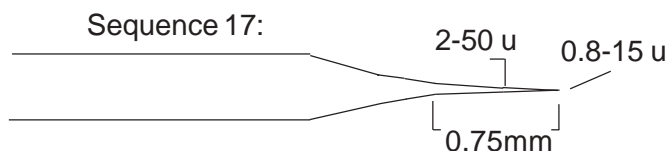
Sequence # 18 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1.5 psi, Pressure 2 (P) = 9.0psi, Micropipette: 1mm OD/ 0.58mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H70-75	P1L002	Continue serial pull 1mm three times with heat level continue reduced .
T2	L >	H65-70	P1L002	
T3	L >	H62-67	P1L002	
T4	L >	H59-64	P1L003	
T5	L >	H60-70	P1L002-5	Continue 5th pull 1-2.5 mm taper with heat level reduced.
T6	0.5-3.0	H00		Stop heat and let the pipette cool 0.5-3 seconds.
T7	L >	H00	P2L000-3c	Go to final pull to the end with heat stop, then air eject cooling on setting pulling distance.
T8	03.0 00.0	H00 H00	COOL	Continue eject air cool 3 second for next operation. Don't forget to clear and reset the last step to stop the sequence. This continue pulls can make tip long and smooth.

Comment: Shorter or longer and smooth

tip. Preheated by previous pulling and continue pull a tip with temperature rapid low down. Adjust the time between heat pull and last pull to achieve a tip with very smooth transferring from taper. If tip is broken before the last step, reduce P1 pressure or reduce PU1 length units.

The Sequence 18 with 5 non-stop continue pulls can make a long, even and smooth tip with about 10-20um OD. It is good to be a needle for injection or holding .



A micropipette pulled by sequence 17:



A micropipette pulled by sequence 18:



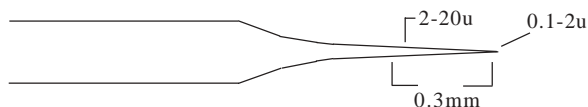
Sequence # 19 : (for patch clamp or voltage clamp electrode) Pressure C (cool)= 25 psi, Pressure 1 (p) =0.5-1.5 psi, Pressure 2 (P)= 15 psi, Micropipette: 1mm OD/0.58 mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

STEP	ACTION TIME (sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H85	P1L001	First pull 0.5 mm taper distance.
T2	09.0	H00		Stop heat and let the pipette cool 9 seconds.
T3	L >	H80	P1L002	Pull 1 mm taper distance.
T4	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T5	L >	H75	P1L002	Pull 1 mm taper distance.
T6	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T7	L >	H70	P1L001	Pull 0.5 mm taper distance.
T8	0.5-1.5	H00		Stop heat and let cool only 0.5-1.5 second. The time setting is very critical for the final tip pulling.
T9	L >	H00	P2L002c	Air cool when 1mm pulled then continue pull to the end.
T10	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 20 : (for patch clamp or voltage clamp electrode) Pressure C (cool)= 25 psi, Pressure 1 (p)=0.3- 1.5 psi, Pressure 2 (P)= 15-20 psi, Micropipette: 1mm OD/0.58 mm ID with inner filament, or 1 mm OD/ 0.75 mm ID thin wall borosilicate capillary.

T1	L >	H85	P1L001	First pull 0.5 mm taper distance.
T2	09.0	H00		Stop heat and let the pipette cool 9 seconds.
T3	L >	H80	P1L001	Pull 0.5-1 mm taper distance.
T4	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T5	L >	H75	P1L001	Pull 0.5- 1 mm taper distance.
T6	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T7	L >	H75	P1L001	Pull 0.5 mm taper distance.
T8	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T9	L >	H75	P1L001	One more pulling step.
T10	05.0	H00		
T11	L >	H75	P1L001	One more pulling step.
T12	0.5-1.5	H00		Stop heat and let cool only 0.5-1.5 second. The time setting is very critical for the final tip pulling.
T13	L >	H00	P2L000c	Immediately air cool heater and pull to the end.
T14	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Preheat by previous Pulling and continue pull a tip with temperature rapid low down . Adjust the time before last pull to achieve a tip with very smooth transferring from the taper. There are many pulling steps in above sequences. If tip is broken before the last step, reduce P1 pressure or reduce PU1 length units.



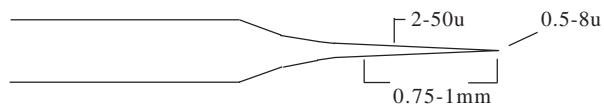
A micropipette pulled by this sequence:



Sequence # 21 : (for patch clamp or voltage clamp electrode) Pressure C (cool)= 25 psi, Pressure 1 (p)=0.3- 1.5 psi, Pressure 2 (P)= 8-20 psi, Micropipette: **1.2 mm OD/0.68 mm ID** with inner filament.

STEP	ACTION TIME (sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H85	P1L002	First pull 1 mm taper distance.
T2	09.0	H00		Stop heat and let the pipette cool 9 seconds.
T3	L >	H80	P1L002	Pull 0.5-1 mm taper distance. More pulling units compare SEQ#20.
T4	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T5	L >	H75	P1L001	Pull 0.5- 1 mm taper distance.
T6	08.0	H00		Stop heat and let the pipette cool 8 seconds.
T7	L >	H80	P1L001	Pull 0.5 mm taper distance.
T8	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T9	L >	H75	P1L001	Pull 0.5 mm taper distance.
T10	05.0	H00		Stop heat and let the pipette cool 5 seconds.
T11	L >	H75	P1L002	More pulling units compare SEQ#20 for larger (1.2-1.5 mm) O.D.
T12	0.5(0.5-3)	H00		Stop heat and let cool only 1-3 second. The longer time setting and bigger tip opening will be: 1 um tip/1 sec, 3 um tip/2 sec, 8 um tip/3 sec.
T13	L >	H00	P2L001c	Air cool heater after pull setting units then pull to the end.
T14	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Pulling more length units for bigger size pipette. Preheat by previous Pulling and continue pull a tip with temperature rapid low down . Adjust the time before last pull to achieve different tip opening. There are many pulling steps in above sequences. If tip is broken before the last step, reduce P1 pressure or reduce PU1 length units.



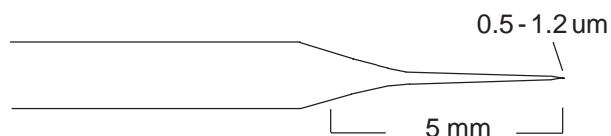
A micropipette pulled by this sequence:

Time before last pull (second): 1 2 3
Tip opening (um): 1 3 8

Sequence # 22: Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) =10-16psi, Micropipette: **1.5 mm OD/ 0.84mm ID with filament or thin wall 1.12mm ID.**

T1	20.0	H80-93		Preheat certain time with high heat. Time setting is critical for different diameter pipette
T2	1-3	H00	P1L<T	Then slow pull 1-3 seconds until heater cool down completely.
T3	7.0	H00		Wait cool 7 seconds.
T4	L>	H65-78	P1L08-12	Heat and pull 10 units (4-6mm).
T5	0.5-3.0	H00		Then stop heat for short time (0.5-3 seconds), time setting is critical for final pulling.
T6	L>	H00	P2L00(1-3)c	Fast pull some distance then eject air cool and pull to the end.
T7	03.0	H00	COOL	Continue eject air 3 second to complete cool down the heater.
T8	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Smooth tip for bigger size pipette. Preheat first, then slow pull taper with heater off until the heater completely cool down. Pull tip with heater turned on again, then rapid pull to the end with air cool. Adjust preheat time or P1 pressure is critical to guaranty taper pull ing not too long or too short before heat completely cool down.



A micropipette pulled by sequence 22:

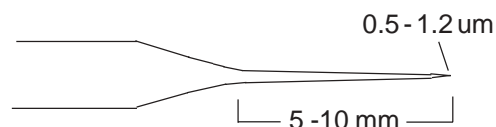
EXTRA SEQUENCES:

Pull different tip opening and longer taper for direct using or further microgrinding and microforging.

Sequence # 23: Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.5-1.5 psi, Pressure 2 (P) =9-18 psi, Micropipette: **1 - 1.5 mm OD** thin-wall or with filament pipette.

STEP	ACTION TIME (sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L>	H61-70	P1L012	Slow pull 6 mm with low heat.
T2	02.0	H00		Wait heat stop cool down for 0.5-3second.
T3	L>	H00	P2L002c	Fast pull some distance with heat stop then ejecting air cool and pull to the end.
T4	00.0	H00	COOL	Cool down the heater completely
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Slow pull taper certain distance with low heat. Then apply rest heat rapid pull to the end with air cool. Adjusting P1Lxxx distance or heat level will change taper length or tip shape.



A micropipette pulled by sequence 23:



Sequence # 24: Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) =9-18 psi, Micropipette: **1-1.5 mm OD** thin-wall or with filament pipette.

T1	L>	H61-70	P1L012-18	Slow pull 6-9 mm with low heat.
T2	L>	H00	P1L004-8	Pull 2-4 mm with heat shut off
T3	0.5-5	H00		Wait heat stop cool down for 0.5-5second.
T4	L>	H00	P2L000c	Fast pull with heat stop, ejecting air cool and pull to the end.
T5	00.0	H00	COOL	Cool down the heater completely.
T6	00.0			Don't forget to clear and reset the last step to stop the sequence.

Comment: Slow pull longer distance taper with low heater and low force. Then apply less rest heat rapid pull to the end with air cool. Adjusting P1Lxxx distance or wait cool time will change taper length or tip opening size.



A micropipette pulled by sequence 24:



Sequence # 25 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette:1-1.5 mm OD/ 0.58 mm ID with filament or thin wall borosilicate capillary.

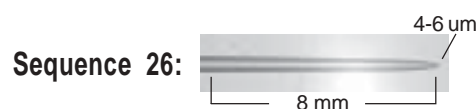
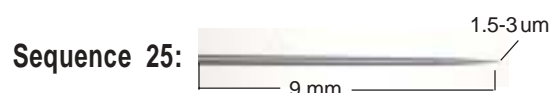
STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H70	P1L003	Pull 1-4 mm with heat grade 65-75.
T2	07.0	H00		Stop heat and let the pipette cool 7 seconds.
T3	L >	H65	P1L005	Pull 2.5 mm taper with heat 65.
T4	L >	H00	P1L010	Continue pull 5 mm with heat off.
T5	2-6	H00		Stop heat and let the pipette cool 2-6 seconds.
T6	L >	H00	P2L000c	Final pull with heater turning off (Tip is cut off).
T7	3.0	H00	COOL	continue cool 3 second to complete cool down heater.
T8	0.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 26 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette:1-1.5 mm OD/ 0.58 mm ID with filament or thin wall borosilicate capillary.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLANATION
T1	L >	H70	P1L003	Pull 1-4 mm with heat grade 65-75.
T2	07.0	H00		Stop heat and let the pipette cool 7 seconds.
T3	L >	H65	P1L005	Pull 2.5 mm taper with heat 65.
T4	L >	H00	P1L008	Continue pull 4 mm with heat off.
T5	2-6	H00		Stop heat and let the pipette cool 2-6 seconds.
T6	L >	H00	P2L000c	Final pull with heater turning off (Tip is cut off).
T7	3.0	H00	COOL	continue cool 3 second to complete cool down heater.
T8	0.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Pull different tip opening. These two sequences can pull tip from 1u- 5u tip opening with one short prepull first. Then continue pull with rest heat from the first pull. Adjust the continue pull distance to make different diameter. Wait enough time to final put to break off the tip. Tip opening size can be changed by setting different pulling length (T4) and cool time (T5). Longer pulling length or shorter cool time can make tip opening smaller, Shorter pulling length or longer cool time can make tip opening larger.

A micropipette sample pulled by



Sequence # 27 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette:1 mm OD/0.58 mm ID with filament or thin wall borosilicate capillary.

T1	15.0	H88		Preheat 13-18 second.
T2	L >	H00	P1L030	Pull 15 mm taper distance.
T3	0.1-6.0	H00		Stop heat and let the pipette cool 0.1-6 seconds.
T4	L >	H00	P2L000c	Final pull with heater turning off (Tip is cut off).
T5	03.0	H00	COOL	continue cool 3 second to complete cool down heater.
T6	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 28 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette: 1-1.5mm OD/ 0.58 mm ID with filament or thin wall borosilicate capillary.

STEP	ACTION TIME(sec)	HEAT LEVEL	ACTION	EXPLAINATION
T1	18.0	H88		Preheat 18-20 second.
T2	L >	H00	P1L030	Pull 15 mm longer taper distance.
T3	0.1-6.0	H00		Stop heat and let the pipette cool 0.1-6 seconds.
T4	L >	H00	P2L000c	Final pull with heater turning off (Tip is cut off).
T5	03.0	H00	COOL	continue cool 3 second to complete cool down heater.
T6	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 29 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette: 1-1.5mm OD/ 0.58 mm ID with filament or thin wall borosilicate capillary.

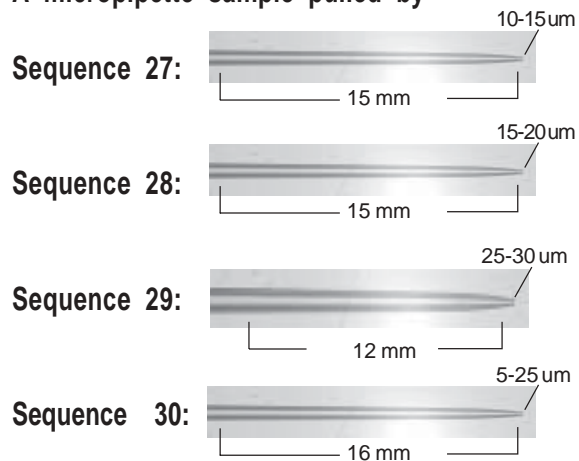
T1	18.0	H88		Preheat 18-20 second.
T2	L >	H00	P1L027	Pull 13 mm long taper distance.
T3	0.1-6.0	H00		Stop heat and let the pipette cool 4-6 seconds.
T4	L >	H00	P2L000c	Final pull with heater turning off (Tip is cut off).
T5	03.0	H00	COOL	continue cool 3 second to complete cool down heater.
T6	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Sequence # 30 : Pressure C (cool)= 25 psi, Pressure 1 (p) = 0.1-1 psi, Pressure 2 (P) = 10-12 psi, Micropipette: 1-1.5mm OD/0.58 mm ID with filament or thin wall borosilicate capillary.

T1	18.0	H88		Preheat 18-20 second.
T2	L >	H00	P1L023	Pull 11 mm not too long taper distance with heater turning off.
T3	L >	H00	P2L001-9c	Final pull with some distance then eject cool air.
T4	03.0	H00	COOL	continue cool 3 second to complete cool down heater.
T5	00.0	H00		Don't forget to clear and reset the last step to stop the sequence.

Comment: Pull different larger tip opening with Long taper. SEQ27-30 sequences apply preheat before pull. Then pull tip with heat stop and temperature rapid low down. Adjust the first pull distance to make different diameter and taper length. Wait longer time then final put to cut off the tip at the right distance and right opening size. Tip opening size can be changed by pulling length (T2) and cool time for final tip breaking (T3) adjustment. Longer pulling length or shorter cool time can make tip opening smaller, Shorter pulling length or longer cool time can make tip opening larger.

A micropipette sample pulled by



Operating the Puller

1. Installing a Micropipette

To install a glass capillary in the puller, follow steps and illustration below:

(1) Make sure the puller is in READY status and the real pressure measurements ('p' and 'P') are what you need (They should be the same as the 'm' and 'M' numbers). Press RETURN key to move two clamps back to the center position.

(2) Loosen two clamp screws.

(3) Insert the capillary through the filament coil and lay it down on the clamp slots. Make sure both clamp blocks are at the center. Then tighten the clamp screws gently to just hold the pipette securely. **The clamp is high friction design. Don't turn the screw too tight, otherwise the glass pipette will be broken and the friction pack inside the clamp will be damaged.**

(4) If pulling sequence is Preheat Pull or Rest Heat Pull, press the PULL1 key to pull the pipette manually (without heating) to test pipette tightening security. If pulling sequence is Heat & Pull, press the PULL2 key to test. If the pipette is tighten securely, then go to next step, Otherwise, tighten the clamps again.

(5) Let the puller cover down to cover the pulling machinery and make sure no powerful light source on the top of the puller (bright light on the top will effect the optical ruler). Then , just press the START key to pull the pipette automatically following the displayed sequence.



2. Monitoring A Pulling Sequence Execution

The following information is important for users to create and test a new pulling sequence.

Besides sequence setting parameters, there are two real time measurement(<-) displayed on the display window during a pulling sequence execution. One is the dynamic heat control and Heat power measurement(H<-xx.x) displayed on the upper right corner of display window. Another Timer real-time counting(T<-xx.x) or pulling Length movement(L<-xx.x) is counting in the second row of display window. You will find the measurements match the setting exactly.

	Heating power indicator	Dynamic heat control counting	
	ACTION: SEQ01 H<-89.9 P20.1 M 20.0 p:3. L<-002		Action Time(T) count up or optical ruler(L) movement
Action step	T1: 030.0	H90 P1L002	The Display Window
	T2: 003.0	H00	

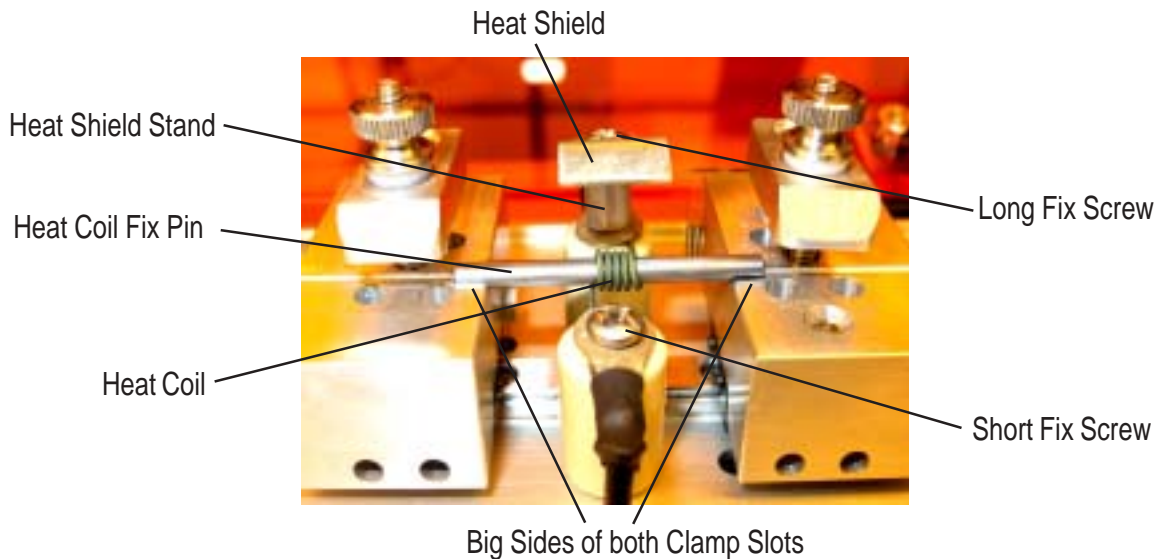
The window always displays the acting step on the third row during action. The Action Time (T->) counts up till reach the acting step time set point , and then goes to next step counting. If the acting step is PULL1 controlled by optical ruler, the pulling Length count (L->)will show the optical ruler movement count till reach the P1LXXX set point.

If the heater is acting in the current step , the 'H->' will be displayed on the third row of window followed by dynamic heat control power measurement counting. The less significant numbers of heat control changing and jumping indicate the computer heat control is working intensely.

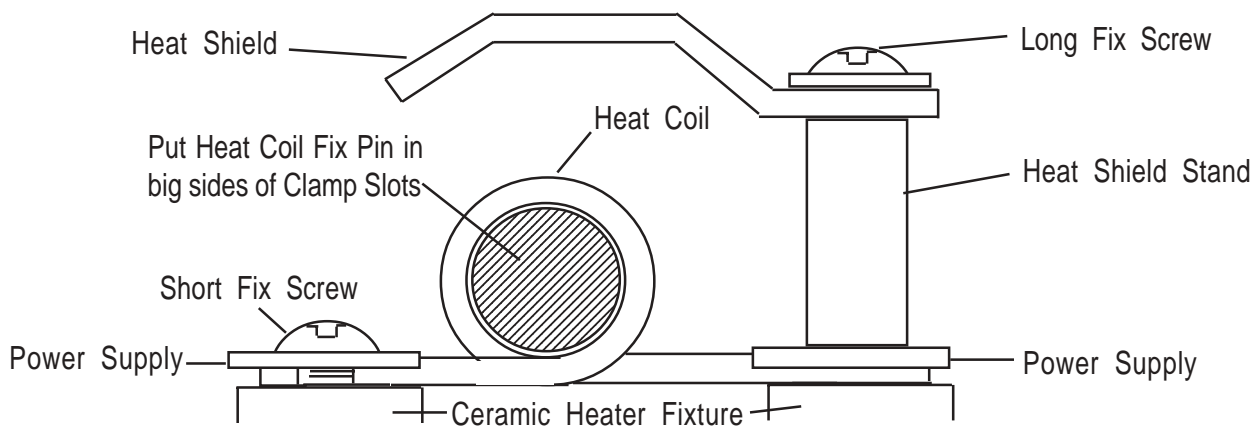
3. Replacing Heating Filament

If a heat coil replacement is needed, loosen two (short and long) fix screws in the heater fixture . Take out the old or broken heat coil and replace a new one. Before tightening the fix screws, insert a straight metal "Heat Coil Fix Pin" into the heat filament coil without tightening the fix screws. Then move clamp blocks to place both sides of Heat Coil Fix Pin on the bigger side of clamp slots, so that the heat coil is in the correct position. Adjust the heat filament coil to place the wire ends of the coil under the washers of long/short fix screws, then tighten the two fix screws (See following pictures). **Be careful do not force the screws too tight or bend the heat shield stand, otherwise , the ceramic heater fixture will be broken.** Take out the heat coil fix pin after tighten the heat coil. After finishing all above, one more time coil adjustment is necessary by using a pair of tweezers.

A heat coil with more turns will pull longer taper of pipette tip, but the maximum heat level setting value may not be reached. There are different current limits for different diameter and different turns of filament coil. Therefore, the highest heat setting (H99) may not be reached for some kinds of filament. Checking the dynamic heat control counting on the display window, if the most significant counting number is less than the most significant heat setting number, it means the heating current reach the limit . Changing up the heat setting number will not increase the heater power in such condition.



THE HEAT COIL SHOULD BE FIXED TO CENTER THE CLAMPED PIPETTE :



Troubleshooting

Sympton	Cause	Solution
The pipette is broken when it is clamped.	The clamp is too tight. The pipette is not clamped on the slot. There is broken glass on the slot.	Do not turn the clamp screws too tight. Place the pipette on the slot position. Clean the slot before clamp.
The pipette is pulled out from clamp during PULL 2 action.	The clamps was not tighten enough, or heater setting is too low.	Tighten the clamp again. Check the heating level.
When executing a pulling sequence, the pipette is broken without tip.	The Pressure 2 (final pulling force) is too high. The preheat is not enough.	Set longer or higher preheat time before final pull. Low down the pressure 2.
The pipette tip is not pulled to break even the pulling sequence is finished.	Pressure 2 is not high enough or preheat is too long or heat level too high for the last pull.	Adjust regulator 2 for higher pressure 2, or set 'PU2xxc' for rapid cool when PULL 2, or reduce the preheat time.
The PULL 1 is not controlled by the ruler setting.	The optical ruler is interfered by other light source.	Turn off or shield off the top light source.
There are no pull nor heat stop on PULL1 step.	The heating level of PULL1 step is too low.	Press the stop to interrupt the sequence. Then reprogram the PULL 1 heat level.
The pull 1 stop distance is longer than PU1:xx setting.	The pull 1 pressure is too high.	Reduce the PU1 pressure 'p'. Higher than 3.5 psi is not recommended.
Same sequence, but pull different shape pipette.	The real pulling pressures are not adjusted as the memory required ones.	Adjust the real pressures to match the memory. If pressures are updated, change the memory also.

Warranty

The following warranty is in place of all other warranties, expressed or implied, and all other warranties, including warranties as to merchantability or fitness, are expressly excluded.

1. SYSTEM, PARTS AND LABOR. MDI (MicroData Instrument, Inc.) warrants purchased equipment to be free of defects in material and workmanship under normal use and maintenance from the date of shipment for a period of one year (90 days in the case of (a) fuses, light emitting diodes, and (b) separately purchased replacement parts). Consumable supplies and cables are warranted to be free of defects in material and workmanship at the time of shipment. Labor invoiced in connection with repairs performed at MDI's facility is warranted for a period of 90 days from the day of shipment of the repaired equipment.

2. LIMITATION OF REMEDY. MDI shall have no liability for any direct, incidental or consequential damages resulting from breach of warranty, from the breach of nonperformance of any term. This limited warranty does not include service to repair damage from improper installation, improper connections with peripherals, external electrical fault, accident, disaster, misuse, abuse or modifications to the equipment not approved in writing by MDI.

3. GEOGRAPHICAL LIMITATION, NONTRANSFERABILITY AND INCONSISTENT LANGUAGE. In the case of equipment located outside of the 50 states, the District of Columbia and the Commonwealth of Puerto Rico which is returned (in whole or in part) to MDI for warranty service, the transportation costs incurred in such return shall be at buyer's expense. This warranty is not transferrable and may not be supplemented or amended except in writing referring specifically hereto and signed by buyer and MDI. Without limiting the generality of the foregoing, any inconsistent language contained in requests for quotation, buyer's purchase orders, shipping instructions or similar documents is specifically rejected by MDI.



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