INSTRUCTION MANUAL

PUL-1000

Microprocessor-Controlled Micropipette Puller
(Up to 4-Step Control*)

**The first three steps run only once, and the fourth step can run unlimited loops until the glass breaks.*

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QUICK START

1. Push the carriages together toward the center.
2. Install the appropriate glass clamp pad that matches the diameter (OD) of the glass.
3. Mount the glass capillary onto the carriage, and secure it with the glass clamps.
4 On the LCD display, choose the correct sequence. If you do not have a sequence yet, choose one from the program storage.

NOTE: Program sequence 00 is designed for OD 1.0 mm borosilicate capillary glass (WPI# **1B100-4**), and sequence 00 is designed for OD 1.14 mm borosilicate capillary glass (WPI# **504949**). Refer to the *PUL-1000 Cookbook* containing the installed program sequence.

5. Close the cover.
6. Press **START**, and the puller will do the rest. Each pull results in two identical micropipettes.

ABOUT THIS MANUAL

The following symbols are used in this guide:

This symbol indicates a CAUTION. Cautions warn against actions that can cause damage to equipment. Please read these carefully.

This symbol indicates a WARNING. Warnings alert you to actions that can cause personal injury or pose a physical threat. Please read these carefully.

NOTES and TIPS contain helpful information.

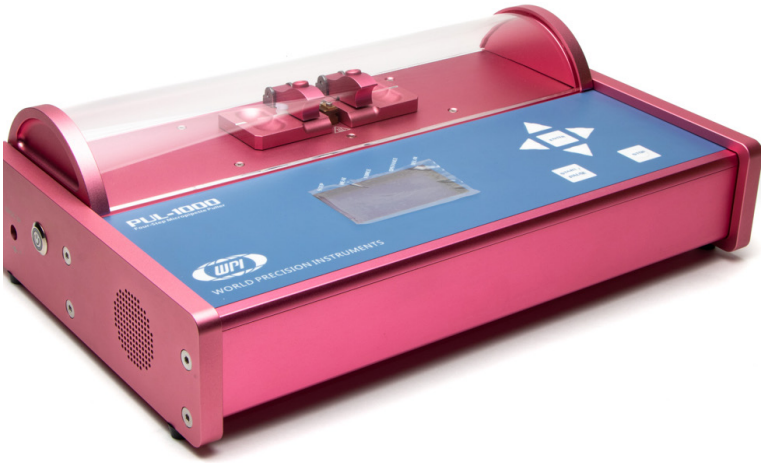

Fig. 1—The PUL-1000 is programmable.

INTRODUCTION

PUL-1000 is a microprocessor controlled, up to four-stage, horizontal puller for making glass micropipettes or microelectrodes used in intracellular recording, patch clamp, microperfusion and microinjection. The puller was designed with tight mechanical specifications and precision electronics for complete control of the pulling process and accurate reproducibility. It offers programmable sequences of up to four steps with heating, force, movement and cooling time. This allows graduated cycles for a variety of applications.

NOTE: This is a puller for educational and research purposes, not a production puller. If the puller stops in the middle of a pull as a result of overheating, allow time for it to cool down.

When pulling glass tips finer than 1 um, you should first wash the glass capillaries in

filtered acetone (or filtered distilled water and filtered 95% alcohol) then allow the fluids to evaporate in a clean dust free environment. This assures that submicron tips are not immediately clogged with glass particles from the manufacturing of the capillaries.

A glass capillary is heated by a platinum/iridium filament and pulled by a controlled force. The **PUL-1000** is capable of producing a vast array of pipette shapes, such as a long graduated taper, a short graduated taperand a short taper (bee stinger).

Pipettes–PUL-1000 can produce pipettes with a broad range of tip diameters. The process of pulling tips less than 4 µm is easily repeatable. When you require consistent tip diameters greater than 5 µm, we recommend using a second operation like bevelling. Microprocessor settings control the pulling automatically.

Pulling pipettes is a science and an art, and reliable results depend on factors like the operating environment, the type of glass used and your technique. Understanding how the puller works is critical to manufacturing the pipettes you want. Glass capillaries can even be slightly different for every lot. Each time you open a new vial of glass capillaries, recalibrate the puller heat parameters for the new glass.

Programming–The settings for a 4-stage pull may be stored in memory. Up to 95 user-selectable programs can be permanently stored in memory for later recall. The instrument contains 15 factory installed and tested programs. Choose from the factory installed programs for a quick start or create your own for precise, custom results.

Construction–The cover of the pulling chamber is made with tempered glass to minimize the effects of humidity and air currents on the reproducibility of pulled pipettes.

Power Supply–PUL-1000 has a switching power supply for use anywhere in the world without worry about the line voltage differences. Pulling reproducibility is unaffected by line voltage fluctuation. Heating voltage can be controlled to within 0.1% accuracy even when line voltage fluctuates from 100–240 VAC.

Key Features

- Microprocessor controlled
- Program sequences up to four pulling steps
- Produce micropipettes with a broad range of tip diameters
- Store up to 95 programs in memory
- 15 factory programs installed
- Tempered glass cover reduces the effects of humidity and air currents on puller reproducibility
- Switchable power supply for any line voltage 100–240 VAC ensures that line voltage fluctuations don't affect reproducibility

Parts List

After unpacking, verify that there is no visible damage to the instrument. Verify that all items are included:

(1) **PUL-1000** Puller
(2) Glass clamp pads for 1.0~1.2 mm OD glass (translucent, pre-installed as default)
(2) Glass clamp pads for 1.0~1.2 mm OD glass (translucent, spares)
(2) Glass clamp pads for 1.5 mm OD glass (black)
(2) Glass clamp pads for 2.0 mm OD glass (red)
(1) Power supply

Unpacking

Upon receipt of this instrument, make a thorough inspection of the contents and check for possible damage. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed damage should be reported at once to the carrier and an inspection requested. Please read the section entitled "Claims and Returns" on page 19 of this manual. Please contact WPI Customer Service if any parts are missing at (941) 371-1003 or customerservice@wpiinc.com.

Returns: Do not return any goods to WPI without obtaining prior approval (RMA # required) and instructions from WPI's Returns Department. Goods returned (unauthorized) by collect freight may be refused. If a return shipment is necessary, use the original container, if possible. If the original container is not available, use a suitable substitute that is rigid and of adequate size. Wrap the instrument in paper or plastic surrounded with at least 100 mm (four inches) of shock absorbing material. For further details, please read the section entitled "Claims and Returns" on page 19 of this manual.

INSTRUMENT DESCRIPTION

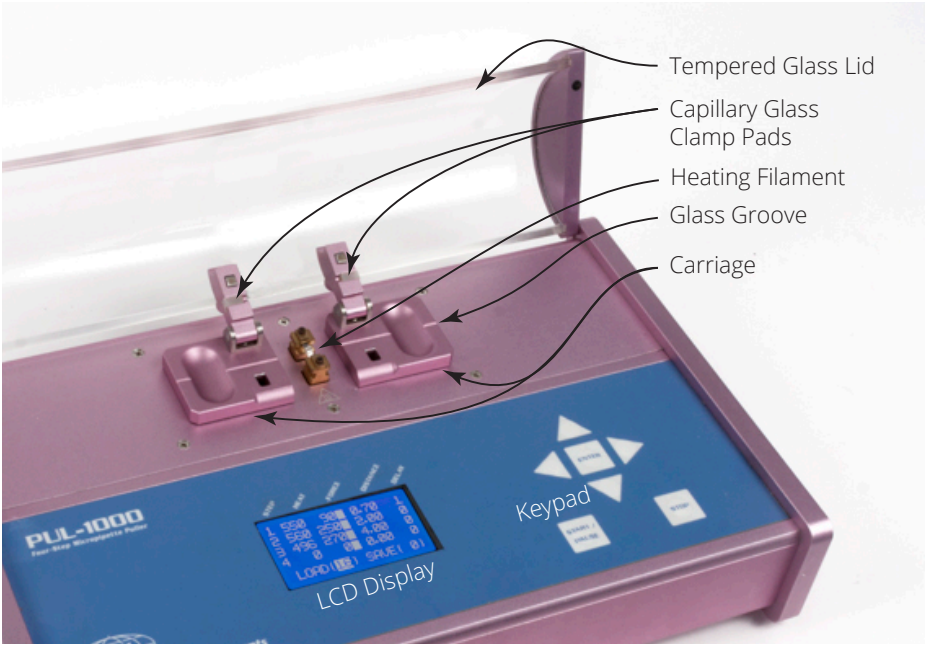

Fig. 2—The parts of the puller are identified.

Tempered Glass Lid–For safety, the lid should be closed whenever you are pulling glass or moving the unit.

Capillary Glass Clamp Pads–These two silicone clamp pads securely hold the glass when you are pulling pipettes. Check the glass OD and install appropriate pads accordingly.

Heating Filament–The **PUL-1000** comes with a circular 2.5 mm platinum/iridium filament (WPI #**13834**), which may be easily replaced, as needed. (See "Accessories" on page 14.)

Glass Groove–Slide a single piece of capillary glass into the groove from one side or the other. The groove helps line up the glass to slide easily through the filament and hold it in the proper position during pulling.

Carriage–The carriage should move freely when the clamps are unlocked. It slides apart as the glass is pulled. Then, you can manually slide the two ends of the carrier together before the next pull.

LCD Display–This display shows the programming sequence and the defined parameters. If you press the STOP key on the keypad, you can toggle to the Glass Capillary Softening Test display.

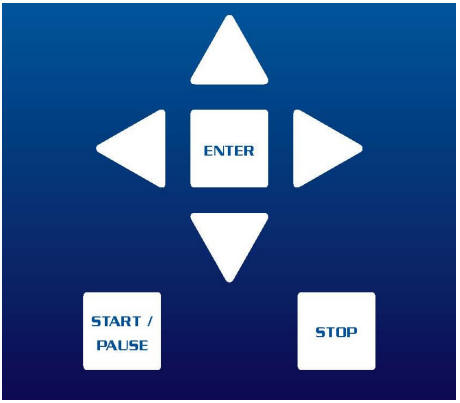

Fig. 3—The front panel has an intuitive keypad.

Keypad–The keypad has the following keys:

- **Arrows**–Press the arrow keys to move the cursor in Edit mode. The Up or Down arrow keys increment or decrement the last digit by 1. Press the Left and Right arrow keys to increment or decrement the last number by 10. For example, when you are in Edit mode, you could press the Right arrow to increase the distance from 0.50 to 0.60 or to increase the force from 200 to 210.
- **ENTER**– Press to enter or exit the Edit mode.
- **START/PAUSE**–Press to begin running a pulling program. Press it again to pause the program.
- **STOP**–Press to switch between windows or to terminate the pulling program and return to the main window while the puller is running.

Program Sequence

A saved program can be loaded into the **PUL-1000** microprocessor. When the LCD cursor is flashing next to the entry "LOAD" on the display, use the arrows on the keypad to select a program. Refer to the PUL-1000 Cookbook for the details of the factory set programs and to pull the WPI pre-pulled tip types. You can start from these settings to get your own ideal program setting.

For other type of glass capillaries, the first step is to do a Glass Capillary Softening Test. (See "Glass Capillary Softening Test" on page 12.) This helps you find the required heating power setting for that glass in the specific ambient environment defined. Then, you can choose a sequence to match. Finding the right sequence to get the desired glass pipette requires experimentation.

The table below is provided to show some basic guidelines when setting up a sequence.

Parameter	Increase (↑)	Decrease (↓)
Heat	Longer Taper	Shorter Taper
Force	Smaller Tips, Longer Taper	Larger Tips, Shorter Taper
Distance	Smaller Tips	Larger Tips
Delay	Shorter Taper	Longer Taper

Table 1–Effect different parameters on pre-pulled pipette shapes and dimensions.

OPERATING INSTRUCTIONS

When heat is applied, and the glass becomes soft, the carriages pull outward, drawing the glass into a micropipette. A position sensor in the carriage assembly monitors the movement. When the movement exceeds the programmed distance, the heating stops.

Quick Start Setup

1. The **PUL-1000** glass capillary package includes the **PUL-1000**, 100-240 VAC power supply with a cord that is suitable for use in the country where the unit is shipped. Plug the power cord into the wall outlet. An LED light on the power supply illuminated when the unit is connected to power (Fig. 4).

Fig. 4—PUL-1000 power supply cord

2. Plug the power cord into the rear panel of the **PUL-1000**. Then, the switch illuminates (Fig. 5).

Fig. 5—The power is on, and the PUL-1000 switch is illuminated.

3. Press the Power button on the rear panel to turn on the display (Fig. 6).

Fig. 6—PUL-1000 display

4. To open the clamps, place your thumb under the clamp and depress the release button with your index finger. Press the clamp release button to unlock the glass capillary clamps. This allows the carriages to move freely.

5. Lift the clamps and slide in the glass capillary clamp pads matching the outer diameter (OD) of the glass capillary.

6. Lock a glass in the glass groove with the glass capillary clamps. Then recall a program. Refer to the PUL-1000 cookbook for details about the factory installed programs.

Glass	Use Glass Clamp Pads	Programs to Recall
1B100-4	Translucent for 1.0~1.2 mm OD glass	00, 01 or 02
504949	Translucent for 1.0~1.2 mm OD glass	10, 11 or 12
1B120-4	Translucent for 1.0~1.2 mm OD glass	20, 21 or 22
1B150-4	Black for 1.5 mm OD glass	30, 31 or 32
1B200-4	Red for 2.0 mm OD glass	40, 41 or 42

Program	Glass OD (mm)	Long Graduated Taper	Short Graduated Taper	Short Taper (Bee Stinger)	Glass SKU
00	1.0	X			**1B100-4**
01	1.0		X		**1B100-4**
02	1.0			X	**1B100-4**
10	1.14	X			**504949**
11	1.14		X		**504949**
12	1.14			X	**504949**
20	1.2	X			**1B120-4**
21	1.2		X		**1B120-4**
22	1.2			X	**1B120-4**
30	1.5	X			**1B150-4**
31	1.5		X		**1B150-4**
32	1.5			X	**1B150-4**
40	2.0	X			**1B200-4**
41	2.0		X		**1B200-4**
42	2.0			X	**1B200-4**

Load the Glass in the Carriages

The glass capillary is held by clamps mounted on two movable carriages. Both carriages synchronously slide as a program is executed. Manually slide them back together when you are loading the glass.

1. To open the clamps, place your thumb under the clamp and depress the release button with your index finger.

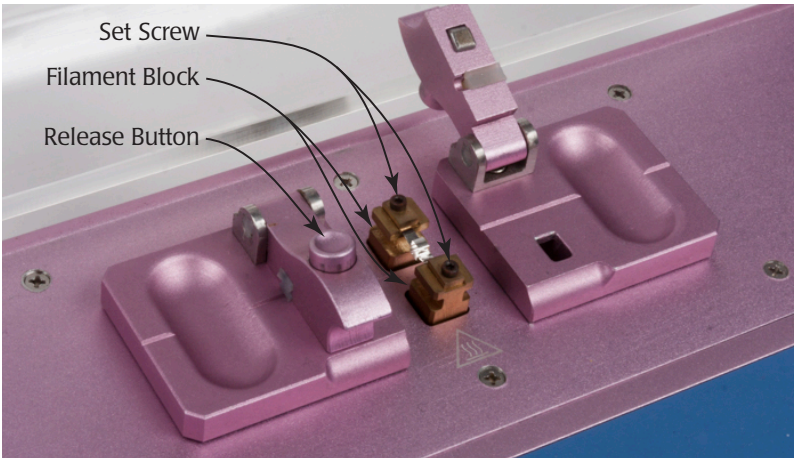

Fig. 7—Press the Release Button to open the clamp.

2. Slide the glass capillary into the Groove from one side. Slide it through the center of heating filament onto the other side. If you want two equivalent length micropipettes, be sure to center the glass in the filament.

3. Secure the glass capillary with the clamps.

CAUTION: The carriage has a narrow clearance above the body of the puller. If foreign material such as broken glass becomes wedged underneath the carriages, it can cause a bind between the carriage and the body. Remove foreign material from this area using **vacuum** only. Use of compressed air may drive particles deeper, making them more difficult to remove.

Running a Puller Program

The top and bottom arrows on the keypad navigate numbers in increments of 1.

The left and right arrows on the keypad navigate numbers in increments of 10.

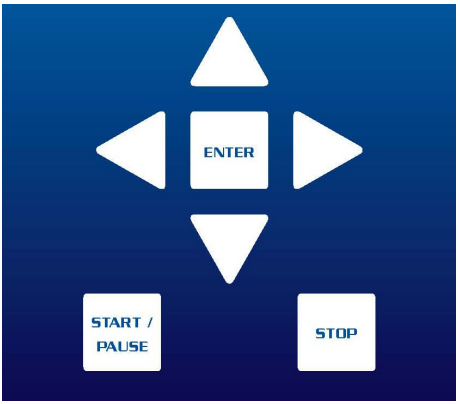

Fig. 8—Display setting options.

Loading a Program

1. Use the arrows to navigate to LOAD (00).
2. Press ENTER. The number will start blinking.
3. Use the arrows to navigate to the program number you would like load. Use the increments stated above for quick access.
4. Once you reach the desired program, press ENTER.

Setting & Saving a New Program

1. Use the arrows to navigate to STEP 1 - HEAT.
2. Press ENTER. The number will start blinking.
3. Use the arrows to set the desired value for the heat.
4. Press ENTER.
5. Navigate to STEP 1 – FORCE.
6. Press ENTER. The number will start blinking.
7. Use the arrows to set the desired value of force.
8. Press ENTER
9. Navigate to STEP 1 – DISTANCE.
10. PRESS ENTER. The number will start blinking.

11. Use the arrows to set the desired value for the pulling distance.
12. Press ENTER.
13. If you are only using 1 Step, you do not need a delay. If you need more than one step, set your delay and repeat the above for STEP 2.
14. Once you have successfully set all numbers of your desired settings, navigate to the SAVE (00).
15. Press ENTER. The number will start blinking.
16. Use the arrows to navigate to the program number where you want to save your new program. Once you reach the desired display press ENTER.

Modifying an Existing Protocol

1. Use the arrows to navigate to and load the program you wish to overwrite or modify.
2. Then navigate to SAVE (00).
3. Press ENTER. The number will start blinking.
4. Use the arrows to navigate through parameters you would like to modify. Once you set the modified parameters to desired values, press ENTER.
5. The unit will prompt you for confirmation before you overwrite the existing program (YES or NO). Use the arrows to highlight YES and press ENTER.

Programs

The temperature, tensile force, distance of movement and delay time between steps are all programmable parameters. Each of these parameters is user-defined for each step in a four-step sequence. A total of 95 sequences may be stored for recall by program number. When the unit is powered on, the LCD screen displays the last used sequence in the window. **PUL-1000** is designed to form the pipette in up to four steps. A basic program step (called a line) consists of four entries:

1. The first stage is to pull a thin section on the capillary. The heating power, pulling force and pulling length determine the taper shape and length.
2. The thin section is pulled again in the second stage to reach a preset length. When the glass capillary is pulled thinner and longer, the waist of pulled section is proportional to pulled length. The capillary outside diameter is dependent on the properties of the glass, heating power and pulling force.
3. The third stage is used to control the glass temperature.
4. If necessary, the program repeats until the glass capillary is ready to break. In the fourth stage, the capillary breaks at a lower temperature to form the tip. The puller can produce pipettes with tip diameters from less than 0.1 µm up to 10 µm and higher.

Program Parameters

Fig. 9—The main display shows the parameters which may be controlled.

For each step of a four-step sequence, the four primary parameters may be set. A description of each follows:

HEAT–The HEAT parameter determines the amount of heat produced by the filament. The units represent the amount of current to be passed through the filament. Values range from 0 to 999. The useful range of values depends upon the filament and glass type. Usually the value used is close to the value determined in the Glass Capillary Softening Test (below). During execution of a program line, the puller gradually establishes a moderate pulling force, and then the filament current is turned on.

CAUTION: Do not increase the heat values in the programs supplied with the puller until you have read and understood the sections of the manual describing the selection of heat values. The use of too much current can melt the filament, although it will not damage the puller. The melting point of any type of glass may be determined using a special procedure called the Glass Capillary Softening Test.

FORCE–The FORCE parameter determines the amount of force delivered to the carriage by the solenoid. The units are arbitrary (ranging from 50–400g) with the maximum value set to prevent overheating of the solenoid. The value of the FORCE determines the solenoid force at the maximum for the pulling stage. The force ramps from zero to the setting.

NOTE: The force applied may be set as a constant force or a gradient force. The constant force applies the same amount of force throughout the entire program. A gradient force allows the force to slowly taper off as the program runs. When the force gradually diminishes in the fourth stage, the tip breaks more smoothly. To toggle between constant and gradient force, move the cursor to the number under force and press STOP.

DISTANCE–DISTANCE in millimeters (ranging from 0-9.99mm) is the change in distance between the center of two carriages to the point where the glass starts to deform.

DELAY–DELAY values may range from 0 to 999 and are in units of 0.1 seconds. After one stage is done, the glass is allowed to cool for the DELAY time before the next stage begins.

Glass Capillary Softening Test

Run the Softening Test when:

- You change the filament
- Lot numbers or capillary types change
- You create or modify a program
- The ambient environment changes

1. Press the STOP key to quit any running program. The following window displays (Fig. 10).

NOTE: A force of 150 g is the factory set value for testing borosilicate glass capillaries using a 2.5 mm square box filament (WPI #**13834**).

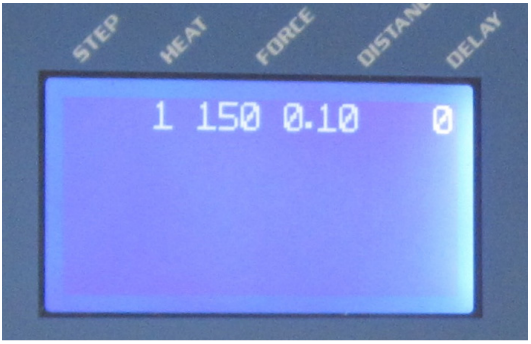

Fig. 10—The window displays when you press the STOP key.

2. Mount a glass capillary on the carriage. See "Load the Glass in the Carriages" on page 8.
3. Press the START key to run the Glass Capillary Softening Test. The heating power increases gradually. The heating stops when the glass begins to move.
4. Record the heating power. This is the baseline heating value for the glass type tested. It is a good starting point for the first stage of your program.

MAINTENANCE

Replacing a Filament

The filament support blocks are located between the two carriages in the middle of the mechanical unit. The filament clamps are attached to the support blocks. The filament clamps are held to their supports by set screws (Fig. 11). You may adjust the filament position by loosening the set screw, repositioning the filament and tightening the set screw.

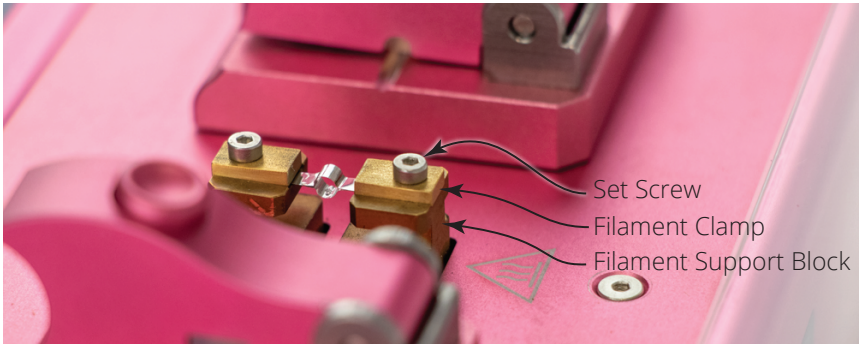

Fig. 11—The set screw secures the Filament Clamp to the Filament Support Block.

If the filament wears out or is damaged, it must be replaced. To replace the filament:

1. Loosen the set screws that secures the Filament Clamp on the Filament Support Block.
2. Remove the old filament or its remaining pieces. Be careful not to drop any material into the mechanical unit.
3. Then, position the new filament and tighten down the set screws. It is best to approximate the position of the previous filament with the new one. The box filament should be positioned so that when the glass is clamped it place, it runs through the center of the box filament. If the filament is not square, or if it is off center, the glass will not heat evenly.

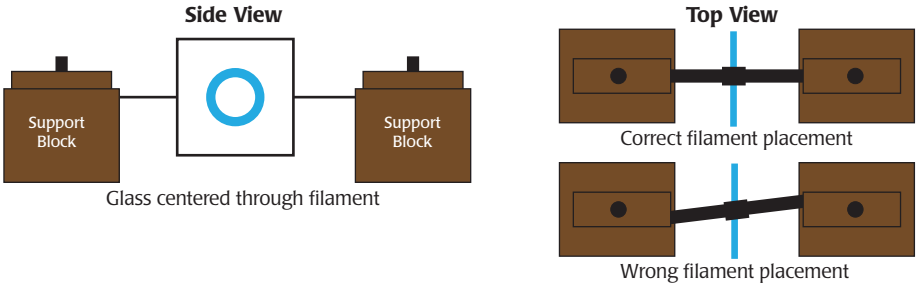

Fig. 12—Position the filament so the capillary glass runs through the center of the filament.

If you are using a filament with a different shape or are pulling a different diameter of glass, be sure to test the placement of the glass capillary to verify that it remains in the center of the filament. When you are pulling larger diameter glass, you will need a larger filament. Typically, a larger filament has a greater offset from the Filament Support Block to compensate for the change of the glass position when you are using glass with a larger diameter.

Choosing a Filament

Appropriate filament selection depends on your research application, but generally **Box Filaments** are recommended. This configuration is particularly suitable for slice preparations where long, parallel walls will aid penetration. If you are using a box filament, the size of the square box should be approximately 1.0mm to 1.5mm larger than the outside diameter of the glass to be pulled.

ACCESSORIES

Part Number	Description
13834	Replacement box filament, 2.5 mm square, platinum iridium, 2.5 mm wide
14074	Replacement box filament, 3 mm square, platinum iridium, 2 mm wide

SPECIFICATIONS

This unit conforms to the following specifications:

Heater Element	Platinum/Iridium Filament
Pulling Force	(50–400) Solenoid, adjustable
Taper Length	1–10 mm
Capillary OD Range	1.0–2.0 mm
Maximum Capillary Length	170 mm
Minimum Capillary Length	55 mm
Permanent Memory Set	95 (including 15 factory-installed programs)
Auto Shut-off Time	90 s
Power Input	100-240 VAC 1.5 A 50-60 Hz
Power Output	19 VDC at 4.74 A (5.5 x 2.5 barrel connector with positive tip)
Dimensions	37 x 24 x 15 cm
Shipping Weight	16 lb.

NOTE: This puller is designed for single barrel borosilicate glasses or patch glass, not quartz or aluminosilicate.

TROUBLESHOOTING

Issue	Possible Cause	Solution
Puller stops in the middle of a pull. Unit beeps.	The unit is over heating	Allow the unit time to cool down before attempting to pull more glass
	If program fails in the middle of a pull, you may have exceeded the parameters of the unit. For example, when you add up the distance of travel for all the stages, you may have exceeded the maximum range of travel.	Check your program. You may need to alter the heating or travel parameters to conform with the unit's maximums.
New glass doesn't pull well	Parameter are not set properly for the properties of the new glass	Run the Glass Softening Test to establish a new baseline heating parameter. See "Glass Capillary Softening Test" on page 12.
	The filament is wearing out or has broken.	Install a new filament. See "Replacing a Filament" on page 12.
Cannot select a program	Puller may be in Edit mode. It will not execute a program until you exit the Edit mode.	Press the Exit key to exit the program editing mode without saving the program. Press Start to run your program.
Unit Beeps	If program fails to start, carriages may be too far apart.	Remove the glass, slide the carriages together and reposition the glass.

NOTE: If you have a problem/issue with that falls outside the definitions of this troubleshooting section, contact the WPI Technical Support team at (941) 371-1003 or wpi-ts@wpiinc.com.

APPENDIX A: MY SEQUENCES

Name: ______________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
3				
4				

Name: ______________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
3				
4				

Name: ______________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
3				
4				

Name: ______________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
3				
4				

Name: ________________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
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2				
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Name: ________________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
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Name: ________________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
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Name: ________________________________

STEP	HEAT	FORCE	DISTANCE	DELAY
1				
2				
3				
4				

WORLD PRECISION INSTRUMENTS, LLC
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA
Telephone: (941) 371-1003 Fax: (941) 377-5428
E-mail: wpi@wpiinc.com

DECLARATION OF CONFORMITY

We: World Precision Instruments, Inc.
175 Sarasota Center Boulevard
Sarasota, FL 34240-9258 USA

As the **manufacture/distributor** of the apparatus listed, declare under sole responsibility that the product(s):
PUL-1000

To which this declaration relates is/are in conformity with the following standards or other normative documents:

Safety:
EN 61010-1:2010
EMC:
EN61326-2-3:2013, EN 61326-1:2013
EN 61000-3-2:2014, EN 61000-3-3:2013

And therefore conform(s) with the protection requirements of Council Directive 89/336/EEC relating to electromagnetic compatibility and Council Directive 73/23/EEC relating to safety requirements:

Issued on: **Aug 15, 2018**

Quality Department Manager

F-QC-006 Rev B

WARRANTY

WPI (World Precision Instruments, Inc.) warrants to the original purchaser that this equipment, including its components and parts, shall be free from defects in material and workmanship for a period of 30 days* from the date of receipt. WPI's obligation under this warranty shall be limited to repair or replacement, at WPI's option, of the equipment or defective components or parts upon receipt thereof f.o.b. WPI, Sarasota, Florida U.S.A. Return of a repaired instrument shall be f.o.b. Sarasota.

The above warranty is contingent upon normal usage and does not cover products which have been modified without WPI's approval or which have been subjected to unusual physical or electrical stress or on which the original identification marks have been removed or altered. The above warranty will not apply if adjustment, repair or parts replacement is required because of accident, neglect, misuse, failure of electric power, air conditioning, humidity control, or causes other than normal and ordinary usage.

To the extent that any of its equipment is furnished by a manufacturer other than WPI, the foregoing warranty shall be applicable only to the extent of the warranty furnished by such other manufacturer. This warranty will not apply to appearance terms, such as knobs, handles, dials or the like.

WPI makes no warranty of any kind, express or implied or statutory, including without limitation any warranties of merchantability and/or fitness for a particular purpose. WPI shall not be liable for any damages, whether direct, indirect, special or consequential arising from a failure of this product to operate in the manner desired by the user. WPI shall not be liable for any damage to data or property that may be caused directly or indirectly by use of this product.

Claims and Returns

Inspect all shipments upon receipt. Missing cartons or obvious damage to cartons should be noted on the delivery receipt before signing. Concealed loss or damage should be reported at once to the carrier and an inspection requested. All claims for shortage or damage must be made within ten (10) days after receipt of shipment. Claims for lost shipments must be made within thirty (30) days of receipt of invoice or other notification of shipment. Please save damaged or pilfered cartons until claim is settled. In some instances, photographic documentation may be required. Some items are time-sensitive; WPI assumes no extended warranty or any liability for use beyond the date specified on the container

Do not return any goods to us without obtaining prior approval and instructions from our Returns Department. Goods returned (unauthorized) by collect freight may be refused. Goods accepted for restocking will be exchanged or credited to your WPI account. Goods returned which were ordered by customers in error are subject to a 25% restocking charge. Equipment which was built as a special order cannot be returned.

Repairs

Contact our Customer Service Department for assistance in the repair of apparatus. Do not return goods until instructions have been received. Returned items must be securely packed to prevent further damage in transit. The Customer is responsible for paying shipping expenses, including adequate insurance on all items returned for repairs. Identification of the item(s) by model number, name, as well as complete description of the difficulties experienced should be written on the repair purchase order and on a tag attached to the item.

** Electrodes, batteries and other consumable parts are warranted for 30 days only from the date on which the customer receives these items.*

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