

SUTTER INSTRUMENT

2006

#### PRICES

Prices included herein are for items sold in the USA or Canada, F.O.B. Novato, California (exclusive of transportation, insurance, and applicable taxes), and are subject to change without notice. International prices are 5% higher. Please contact Sutter Instrument or your local representative for an overseas price quotation.

#### SHIPPING

Shipping charges are prepaid and added to our invoice. Unless otherwise specified when placing your order, we will use our best judgement in selecting a reliable and economical shipper of our choice.

#### RETURNS

Items ordered in error may be returned within 30 days of receipt and are subject to a 15% restocking fee. You are urged to retain the original shipping containers should there be a need to return the item. Please contact Sutter Instrument for a return authorization number.

#### QUALITY CONTROL

Sutter Instrument takes great pride in meeting the highest possible standards of quality and reliability. Each instrument undergoes a rigorous electronic and/or mechanical testing protocol during the production process. In the case of our micropipette pullers, every instrument is tested to assure its ability to consistently fabricate micropipettes with ultra-fine tips. A series of pipettes are pulled with each instrument and examined with our scanning electron microscope. No other manufacturer offers this level of quality control.

#### SERVICE & SUPPORT

We hope that our instruments and products continually meet your needs. However, should a problem arise, please contact our technical support staff to discuss the problem. If the instrument requires factory service, we will furnish shipping instructions. Items under warranty will be repaired free of any costs, for parts or service. Both delivery and return shipping costs are the responsibility of the owner.

#### WARRANTY INFORMATION

Sutter Instrument Company provides a limited warranty for one year from shipping date, on all Sutter made products and labor (except consumables and Uniblitz® shutter). To be covered under warranty, the instrument must have been operated in accordance with the instructions outlined in the instruction manual and in a manner that would be expected in the normal use of the product. Extended warranties may be purchased for an additional charge. Please contact Sutter for a quotation. Abuse, misuse, or unauthorized repairs will void any warranty.

#### PAYMENT METHODS

Payments may be made in U.S. Dollars in one of the following methods:

Major Credit Card: Master Card and VISA

Bank Draft drawn on a U.S. bank

International Money Order

Bank Wire Transfer

Irrevocable Letter of Credit (a processing fee will apply)

# INDEX

## MICROPIPETTE FABRICATION

Introduction 4

### PULLERS

P-2000 Laser-Based  
Micropipette Puller 6

P-97 Flaming/Brown  
Micropipette Puller 10

P-30 Vertical Puller 14

Filaments/Accessories 16

### BEVELER

BV-10 Microelectrode  
Beveler 18

### PRESSURE INJECTOR

Manual Microinjector 22

### BOOKS

Advanced Techniques in  
Micropipette Fabrication 24

### GLASS

Glass Capillary Tubing 26

Outdated prices. Please see AutoMate web store  
for current prices.



## MICROPIPETTE FABRICATION



Glass micropipettes are precisely constructed micro-tools forming the basis of a myriad of scientific investigative techniques. Yet, the simplicity of a piece of glass tubing belies the complexity of technique that is required to produce repeatedly and accurately the micropipette characteristics a researcher desires. Sutter Instrument Company has endeavored for more than 30 years to produce the most sophisticated instruments available for fabricating glass micropipettes. Our expertise in micropipette fabrication techniques has been utilized by countless numbers of individuals who have applied our knowledge to their particular research.

The **P-30** is our lowest cost and least sophisticated puller, based upon an NIH design from the 1950's. As a vertical puller, it offers all of the basic requisites for a pipette pulling device and provides a few additional features. It is intended for basic micropipette fabrication and is suitable for sharp electrode and microinjection work.

Evolution of the Flaming/Brown puller has led to the **P-97**. The **P-97** offers: microprocessor controlled programmability, constant current power supply, a self-contained precision air delivery system, and a patented velocity sensing system. Utilizing a velocity sensing scheme allows a means of selecting a precise

glass temperature as the point at which a hard pull is activated. This design feature has led to a significant improvement in pipette reproducibility when compared to other micropipette pullers. In addition, the **P-97** offers an environmental chamber to minimize the effects of humidity variation on tip formation.

The current state-of-the-art in micropipette puller technology is the **P-2000**. It incorporates the mechanical design and programmability of the Flaming/Brown pullers, but uses a CO<sub>2</sub> laser as the heat source. With the addition of the laser, quartz tubing can now be pulled in addition to other lower melting point glass compositions. Quartz pipettes have

helped eliminate some technical barriers in electrophysiological studies and have enhanced microinjection procedures as well as near field scanning microscopy (NSOM) and nanospray mass spectroscopy.

The **BV-10** micropipette beveler was the company's first product and to date remains the state-of-the-art in micropipette beveling technology. For precision beveling of pipette tip diameters from fractions of a micron, to tens of microns, it is the system of choice.

## P-2000 LASER BASED MICROPIPETTE PULLER



A significant advance in the technology of fabrication of micropipettes, optical fiber probes, and nanospray tips, is offered with the **P-2000** micropipette puller. The **P-2000** integrates a CO<sub>2</sub> laser-based heat source with the technology derived from our extensive experience with conventional pullers. This system offers capabilities unmatched by other pullers.

While the **P-2000** is suitable for working with most conventional glasses, its primary advantage is the ability to work with quartz glass (fused silica). Quartz offers superior material properties for a variety of research applications. Quartz is stronger than other glasses and can facilitate penetration through tough tissues which would normally break conventional

pipettes<sup>1</sup>. For applications requiring a low noise glass, users will find that quartz is the lowest noise glass available<sup>2,4</sup>. Quartz contains none of the metals used in conventional glasses<sup>3</sup>. Optically, quartz is virtually free from fluorescence when illuminated.

A CO<sub>2</sub> laser was selected as the heat source for the **P-2000** for several reasons: 1) The nominal emission wavelength of the laser approximates the resonant frequency of the SiO<sub>2</sub> lattice in glass. Thus, quartz and other conventional glasses can be melted when the appropriate laser power is supplied. 2) Laser heat is clean and leaves no metal residue on the pipette as do conventional heating filaments. 3) Laser heat can be turned off instantly, leaving no residual filament heat.

4) The user can program the amount and distribution of heat supplied to the glass.

The **P-2000** can store up to 100 separate programs, with each program consisting of up to 8 command lines. Programmable parameters include: laser power level, scan width, trip velocity, delay/laser on time, and hard pull strength.

One important consideration for the use of the **P-2000** is the diameter of the glass used. The optical design produces even heating on glass up to 1.2 mm in outside diameter. Larger diameter glasses can be used with the **P-2000** (up to 1.5 mm quartz and 1.8

mm conventional glasses), but the performance is best with glass that is 1.2 mm diameter or less.

The **P-2000** works well with small diameter glasses such as optical fibers, and with small diameter fused silica capillary commonly used for the manufacture of nanospray tips. Smaller diameter glass with an outer diameter in the range of 0.125 mm to 0.6 mm, require special puller bars as well as an optical alignment optimized for the smaller diameter material. **These modified components will be installed, if requested, at the time of purchase.** As with larger diameter glass, a wide range of

### FEATURES > P-2000

Capable of pulling quartz, borosilicate and aluminosilicate glass.

Fully programmable — including heating filament characteristics.

The laser has no melting point limit as with conventional metal filaments; and therefore, cannot be burned out.

Pulls electrodes with tip diameters that are less than 0.03µm.

Optimized velocity sensing circuit for maximized sensitivity and reproducibility.\*

Operating life of the CO<sub>2</sub> laser is expected to be in excess of ten years with normal use, after which the laser can be refurbished by the Sutter Instrument Company for a nominal charge.

Individual programs can be write-protected in order to secure them from inadvertent changes.

The total time that the heat is on during the pull is displayed for improved program development and troubleshooting.

A date and time stamp is displayed to show the last time that a program has been changed.

Preprogrammed sample programs for intra-cellular and patch pipettes. Special programming upon request.

\*Patent No.4,600,424

tip sizes and taper geometries can be produced with this modified **P-2000** and small diameter glass. We have drawn optical fiber tips ranging from less than 10nm to more than 5 $\mu$ m. Please consult our technical staff for further information.

### SPECIFICATIONS > P-2000

#### Dimensions

30in x 14.25in x 13.25in  
76cm x 36cm x 33.5cm

#### Weight

80lbs  
36kg

#### Electrical

115/230 Volts  
50/60 Hertz power line

CLASS I LASER PRODUCT



### US PRICES > P-2000

*International prices are 5% higher.  
Prices subject to change without notice.*

#### P-2000/G

Laser-based puller, outfitted for use with glass  
GREATER than 0.6mm outer diameter

**\$ 13,500**

#### P-2000/F

Laser-based puller, outfitted for use with glass  
LESS than 0.6mm outer diameter

**\$ 13,500**

*(Pullers include a sample box of Q100-70-7.5 glass)*

### ACCESSORIES

#### FPS

Spacer for special procedures

**\$ 25**

### REFERENCES P-2000

1. Munoz, J.L. and Coles, J. *Quartz micropipettes for intracellular voltage microelectrodes and ion selective microelectrodes*. Journal of Neuroscience Methods: 22:57-64, 1987.
2. Rae, J.L. and Levis, R. A. *A method for exceptionally low noise single channel recordings*. European Journal of Physiology - Pflügers Archiv: 420:618-620, 1992.
3. Zuazaga, C. and Steinacker, A. *Patch-clamp recording of ion channels: Interfering effects of patch pipette glass*. News in Physiological Science: 5:155- 159, 1990.
4. Levis, R. A. and Rae, J. L. *The use of quartz patch pipettes for low noise single channel recording*. Biophysical Journal: 65:1666-1677, 1993.

## P-97 FLAMING/BROWN MICROPIPETTE PULLER



The Model **P-97** micropipette puller is the latest generation of the Flaming/Brown type puller for fabrication of micropipettes, patch pipettes and microinjection needles. While retaining many of the features on the Model **P-87**, the **P-97** offers improvements in mechanical, electronic and software design. The result is better control of the pulling process and a higher degree of reproducibility. The **P-97** combines a proven mechanical system with a sophisticated, programmable microprocessor controller. This programmable control of the pulling parameters allows the investigator to design application specific pipettes from a wide range of glass compositions and sizes.

A number of new features have been incorporated in the design of the

**P-97**. One of the most apparent is the environmental chamber which houses the area surrounding the heating filament. The environmental chamber is designed to minimize the effect of changing humidity on the reproducibility of pulled pipettes. A 25% increase in power over the previous version allows for the use of larger heating filaments, larger diameter glass and multi-barreled glass. The metal jaws that clamp the heating filament have also been redesigned to minimize heat retention. A gas delivery mode switch provides for extended cooling for large diameter and multi-barreled glass. A spring-loaded clamping mechanism has been added for easier loading of glass. A vacuum fluorescent display has been added that allows easy viewing from any direction.

New software improvements on the **P-97** include a display of the total time that the heat is on to assist in program development and troubleshooting. Up to 100 programs can now be written and stored in memory, which makes the **P-97** suitable for multiple users. These programs can now be write-protected, adding security to prevent programs from being changed or altered inadvertently. When a program is written and saved, it includes the date it was written or edited. In addition, the air pressure is included as a programmable item.

The **P-97** contains a ramp test to overcome the difficulties of program adjustment when a new filament is installed or to help characterize a new glass and filament combination. This test allows for the rapid adjustment of heat values in established programs and provides estimates for establishing heat settings when using new sizes or compositions of glass capillaries. As with all Sutter instruments, the electronics have been carefully designed to maximize noise rejection.

\* Patent No. 4,600,424

### FEATURES

#### > P-97

Environmental chamber.

Programmable air pressure.

Memory storage for up to 100 programs.

Write protection lock and date stamp.

Two symmetrical pipettes with each pull.

Preprogrammed sample programs for intracellular and patch pipettes. Special programming on request.

Ramp test—self test for establishing program heat settings when a new filament or glass is introduced.

Vacuum fluorescent display.

Internal memory test.

Constant current power supply for filament and pull solenoid.

Looping pull cycle for fabrication of patch type micropipettes.


Self-contained air supply with filtration system and humidity control.

Consistent and reliable electrodes with tip diameters less than 0.1 $\mu$ m.

Control over the time and pressure at which the air is delivered.

Optimized velocity sensing circuit for maximized sensitivity and reproducibility.

Quality control, SEM photograph of a tip pulled with each puller; criterion is tip measurement less than 0.1 $\mu$ m and typically is ~0.06 $\mu$ m.

SPECIFICATIONS > P-97	
<b>Dimensions</b>	21in x 14in x 12in 53cm x 36cm x 30cm
<b>Weight</b>	62lbs 29kg
<b>Electrical</b>	115/230 Volts 50/60 Hertz power line
	

#### REFERENCES > P-97

These references describe the Flaming/Brown series of pullers and contain valuable information applicable to the **P-97**.

1. Brown, K.T. and Flaming, D.G. *Neurosciences Journal*: 2:813-827, 1977.
2. Flaming, D.G. and Brown, K.T., *Journal of Neuroscience Methods*: 6:91-102, 1982.
3. Brown, K.T. and Flaming, D.G., *Advanced Micropipette Techniques for Cell Physiology*. John Wiley and Sons. Great Britain, 1986.

US PRICES > P-97		<i>International prices are 5% higher. Prices subject to change without notice.</i>
<b>P-97</b>	Flaming/Brown type micropipette puller	<b>\$ 6,700</b>
<i>Pullers come with an assortment of 4 filaments and a sample box of BF100-50-10 glass. Sutter pre-programs the P-97 with a trough filament unless a box filament is requested.</i>		
<b>ACCESSORIES</b>		
<b>FILAMENT</b>	Custom platinum/iridium filament <b>(standard filaments listed on pages 16-17)</b>	<b>\$ 20</b>
<b>FPS</b>	Fire polishing spacer for P97 and P87 pullers.	<b>\$ 25</b>
<b>FS1875</b>	Platinum/iridium sheet, 18mm x 75mm x 0.05mm (0.002in)	<b>\$ 105</b>
<b>CTS</b>	Ceramic tile for scoring glass (large tips 20-200 microns)	<b>\$ 15</b>
<b>BX10</b>	Storage box and foam	<b>\$ 10</b>

## P-30 VERTICAL MICROPIPETTE PULLER



The Model **P-30** vertical micropipette puller is designed for the fabrication of basic micropipettes and patch-type pipettes. It will pull micropipettes with tip diameters as small as 0.3µm and moderate taper lengths (10 to 15mm). By using an included patching attachment, the **P-30** will pull the standard double pull patch-type pipette. Used with thin wall glass capillaries, it will generate pipettes or needles suitable for microinjection studies. The **P-30** is ideal for student laboratories and other situations which call for an economical, reliable pipette pulling device.

The **P-30** is available with either a platinum/iridium or a Nichrome filament. The Nichrome filament is suitable for many applications and is

### SPECIFICATIONS > P-30

#### Dimensions

18in x 10in x 9in  
46cm x 25cm x 23cm

#### Weight

35lbs  
16kg

#### Electrical

115/230 volts  
50/60 hertz power line



not prone to damage. The platinum filament is more efficient at heating and cooling, and, although it is more prone to damage than the Nichrome

filament, the platinum filament is recommended for thick wall and aluminosilicate glass and applications requiring shorter taper lengths.

### US PRICES > P-30

*International prices are 5% higher.  
Prices subject to change without notice.*

**P-30/P** Vertical micropipette puller with platinum/iridium filament **\$ 3,250**

**P-30/N** Vertical micropipette puller with Nichrome filament **\$ 3,250**

### ACCESSORIES

**P-30-NFL/M** Nichrome filament block assembly **\$ 200**

**P-30-PFL/M** Platinum/iridium filament block assembly **\$ 200**

### FEATURES > P-30

Pulls electrodes with tip diameters down to 0.3µm consistently and reliably.

A micrometer allows precision reproducibility of trip point settings in producing fine micro-electrodes.

Full three digit digital controls for accurate setting of heat and pull values.

Constant current power supplies for filament and pull solenoid.

Enclosed front to reduce variability caused by drafts.

Dual (manually) switched heat settings for patch pulling or two different types of micropipettes.

All working parts are made from corrosion resistant material.

Two heating assemblies available: platinum/iridium (recommended) or Nichrome coil.

Built in RFI filter and dual voltage/dual frequency operation.

Rubber padded jaws to minimize breakage of capillary tubing.

Designed to take up a minimum of bench space.

Slope of the front panel aids in preventing glass from entering cabinet/solenoid mechanism.

## PULLER FILAMENTS



### Minimum purchase of filaments is 4.

Appropriate filament selection depends on your research application, but a general guideline for filaments is as follows:

**Box Filaments** are recommended for large diameter, double barreled, or aluminosilicate glass. Box filaments are particularly suitable for slice preparations where long, parallel walls would aid penetration. When 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 that you will be using.

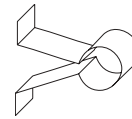
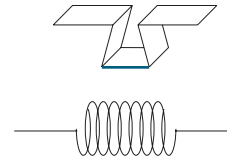
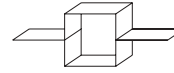
For IVF and ICSI applications, a 2.5mm x 4.5mm box filament is recommended. For pronuclear injection work,

we recommend a 2.5mm x 2.5mm box filament. Call for more specific advice or to request a combination of settings, filaments, and glass for your application.

**Trough Filaments** are an excellent general purpose filaments and are recommended for patch pipettes produced from either standard or thin wall glass.

*Sutter pre-programs the P-97 with a trough filament unless a box filament is requested.*

For either type of filament, increasing the filament width tends to increase the length of the pipette taper. If there are specific questions as to the sizes needed please call and our technical support staff will guide you in your choice.



## BOX FILAMENTS

P-97, P-87, P80PC, P80C, PC-84, P-77B

<b>FB215B</b>	2.0mm square box filament, 1.5mm wide	<b>\$ 15</b>
<b>FB220B</b>	2.0mm square box filament, 2.0mm wide	<b>\$ 15</b>
<b>FB230B</b>	2.0mm square box filament, 3.0mm wide	<b>\$ 15</b>
<b>FB255B</b>	2.5mm square box filament, 2.5mm wide	<b>\$ 15</b>
<b>FB245B</b>	2.5mm square box filament, 4.5mm wide	<b>\$ 15</b>
<b>FB315B</b>	3.0mm square box filament, 1.5mm wide	<b>\$ 15</b>
<b>FB320B</b>	3.0mm square box filament, 2.0mm wide	<b>\$ 15</b>
<b>FB330B</b>	3.0mm square box filament, 3.0mm wide	<b>\$ 15</b>

## TROUGH FILAMENTS

P-97, P-87, P80PC, P80C, PC-84, P-77B

<b>FT315B</b>	1.5mm wide trough filament	<b>\$ 15</b>
<b>FT320B</b>	2.0mm wide trough filament	<b>\$ 15</b>
<b>FT330B</b>	3.0mm wide trough filament	<b>\$ 15</b>
<b>FT345B</b>	4.5mm wide trough filament	<b>\$ 15</b>

## P-30 FILAMENTS

<b>P30T15</b>	1.5mm wide trough filament	<b>\$ 15</b>
<b>P30T20</b>	2.0mm wide trough filament	<b>\$ 15</b>
<b>P30T30</b>	3.0mm wide trough filament	<b>\$ 15</b>
<b>P30N</b>	Nichrome filament	<b>\$ 15</b>

## P-77A LOOP FILAMENTS

(Serial number 160 and above)

<b>FL315A</b>	3.0mm loop filament, 1.5mm wide	<b>\$ 15</b>
<b>FL320A</b>	3.0mm loop filament, 2.0mm wide	<b>\$ 15</b>
<b>FL325A</b>	3.0mm loop filament, 2.5mm wide	<b>\$ 15</b>
<i>(Serial number below 160)</i>		
<b>FL315X</b>	3.0mm loop filament, 1.5mm wide	<b>\$ 15</b>
<b>FL320X</b>	3.0mm loop filament, 2.0mm wide	<b>\$ 15</b>
<b>FL325X</b>	3.0mm loop filament, 2.5mm wide	<b>\$ 15</b>

## ACCESSORIES

<b>FILAMENT</b>	Custom platinum/iridium filament	<b>\$ 18</b>
<b>FPS</b>	Fire polishing spacer for P-2000, P-97, and P-87 pullers	<b>\$ 25</b>
<b>FS1875</b>	Platinum/iridium sheet, 18mm x 75mm x 0.05mm (0.002in)	<b>\$ 90</b>
<b>CTS</b>	Ceramic tile for scoring glass (large tips 20-200 microns)	<b>\$ 15</b>

## BV-10 MICROELECTRODE BEVELER



(BV-10-D with optional 80X stereo microscope)

Elegant and simple to use, the **BV-10** offers precision beveling of micropipette tips between 0.1 and 50 $\mu$ m. The unique abrasive plate drive system is vibration free for greater control of the beveling process. Beveling can be accomplished very rapidly and produces consistent tip diameters using the techniques as described by Brown and Flaming, *Science*, August 1974, Vol. 185.

Intracellular recording electrodes can benefit from beveling because of 1) a reduction in the tip diameter by creation of the sharp point on the electrode and 2) a lowered electrical resistance of the electrode due to the larger cross sectional area of the lumen. This greatly facilitates penetrating and holding very small

or difficult cells. Microinjection needles also benefit from beveling by promoting entry into cells with minimal damage while at the same time enhancing the flow of material through the needle.

The basic beveling system consists of a stationary pedestal, optically flat to a half wave (250nm), surface mounted on a heavy baseplate. This serves as a bearing for an abrasive coated glass grinding plate, which is also flat to half a wave. The flat abrasive plate is coupled to a low vibration, slow-speed motor by means of magnetic fields to provide a wobble-free flat grinding surface. The abrasive plates are fabricated with a proprietary process which insures a consistent abrasive coating.

A 2-axis micromanipulator holds the pipette to be beveled and permits controlled advancement onto the abrasive surface. The bevel angle and speed of advancement are adjustable. A halogen lamp with a gooseneck enhances the beveling operation by providing sharp illumination of the abrasive plate and pipette.

The basic system comes with two abrasive plates of your choice, a wick with holder (for wet beveling), pedestal oil, degreasing fluid, and manual.

Two **options** are available for monitoring the beveling process: an 80X, stereo microscope and an electrode impedance meter. Depending on your research application, one or both of these options may be desirable. For all micropipette applications, the swing mounted microscope enhances your control of pipette advancement onto the abrasive plate and allows for viewing of the beveling operation (scope resolution is not sufficient for viewing the actual bevel except in the case of very large tips). For microelectrode applications, the impedance meter is used to monitor the tip resistance during the beveling operation. The meter is an analog design, offering three resistance ranges (0-10, 0-100, 0-500 MOhm). Measurements are made at 12 Hz to minimize capacitive contributions to the impedance measured and provide a near-true DC resistance value. A rapid roll-off is used to reduce 50/60 Hz interference, allowing operation in a laboratory environment without screening.

### FEATURES > BV-10

Vibration-free, magnetically coupled beveling surface.

Abrasive surface optically flat to a half wave (250nm).

Finest abrasive surface commercially available.

Synchronous clock motor insures stable rotation rate.

7lb steel baseplate adds additional dampening.

Integrated halogen lamp.

Robust micromanipulator controls bevel angle and advancement.

## SPECIFICATIONS

### > BV-10

#### Beveling Range

0.1µm through 50µm finished electrodes depending on abrasive plate used

#### Grinding Surface Variation

less than 1.0µm

#### Grinding Speed

60 RPM

#### Beveling Angle Range

5-90 degrees - adjustable

#### Micromanipulator

Course drive:

0.075in / dial revolution

Fine drive:

0.0004in / dial revolution

#### Dimensions

19in x 9in x 8in

48cm x 22cm x 20cm

#### Weight

Approx. 45lbs/20kg

#### Electrical

120 volts - 50/60 Hz power line (220 volt option requires special modification, please see price list)

#### OPTIONS

80X stereo microscope

Impedance meter for real-time measurement of tip impedance

## US PRICES

### > BV-10

International prices are 5% higher.

Prices subject to change without notice.

#### SYSTEMS

<b>BV-10-B</b>	Micropipette beveler basic system <sup>1</sup>	<b>\$ 2,950</b>
<b>BV-10-C</b>	BV-10-B with electrode impedance meter	<b>\$ 3,750</b>
<b>BV-10-D</b>	BV-10-B with 80X stereo microscope	<b>\$ 3,750</b>
<b>BV-10-E</b>	BV-10-B with impedance meter and 80X stereo microscope	<b>\$ 4,450</b>

*1) Includes micromanipulator, reference wick, reference wick holder, pedestal oil, degreaser, manual, and two abrasive plates of your choice.*

#### ACCESSORIES

<b>BV-10M</b>	Electrode impedance meter with active and reference lead	<b>\$ 1,200</b>
<b>BV-10S</b>	80X stereo microscope	<b>\$ 950</b>
<b>104C</b>	Diamond abrasive plate - coarse ( 5.0 µm to 50 µm tip sizes )	<b>\$ 160</b>
<b>104D</b>	Diamond abrasive plate - fine ( 2.0 µm to 20 µm tip sizes )	<b>\$ 160</b>
<b>104E</b>	Diamond abrasive plate - very fine ( 0.7 µm to 2.0 µm tip sizes )	<b>\$ 160</b>
<b>104F</b>	Diamond abrasive plate - extra fine ( 0.2 µm to 1.0 µm tip sizes )	<b>\$ 160</b>
<b>007</b>	Degreaser (bottle)	<b>\$ 5</b>
<b>008</b>	Beveler pedestal oil	<b>\$ 4</b>
<b>220V-MOD</b>	Modification to 220 volts	<b>\$ 210</b>

#### REPLACEMENT PARTS

<b>101</b>	6-inch reference lead (body to meter)	<b>\$ 8</b>
<b>102</b>	2-inch active lead (platinum to pipette)	<b>\$ 8</b>
<b>003</b>	Reference wick	<b>\$ 3</b>
<b>003A</b>	Reference wick holder	<b>\$ 32</b>
<b>105</b>	Halogen bulb	<b>\$ 14</b>
<b>106</b>	Drive belt	<b>\$ 20</b>

## MANUAL MICROINJECTOR



The **Manual Injector** is a manual syringe driver for pneumatic or hydraulic control of injection needles or holding pipettes. It is suitable for injecting volumes in the nanoliter to microliter range. It is also widely used as a fluid control device for applications requiring sensitive manual control of the displacement of microneedle contents. The system is constructed from the highest quality parts. The base assembly is black anodized aluminum. A non-rotating Mitutoyo micrometer provides the drive to the gas-tight syringe<sup>1</sup>. A precision 3-way valve provides a convenient method for filling the fluid line and clearing air bubbles from the line. Teflon tubing, chromatography connectors and a pipette holder<sup>2</sup> complete the system.

SYRINGE VOLUME	VOLUME PER REVOLUTION	VOLUME PER DIVISION
10µl	106nl	4.2nl
25µl	267nl	10.6nl
50µl	529nl	21.2nl
100µl	1.06µl	42.3nl
250µl	2.65µl	105.8nl
500µl	5.29µl	211.7nl
1000µl	10.58µl	423.4nl

### US PRICES

*International prices are 5% higher.*

### > MANUAL MICROINJECTOR *Prices subject to change without notice.*

**MANUAL** Manual injector with non-rotating micrometer, 3-way valve, precision 50µl gas-tight syringe, teflon tubing, connectors and MI-10010 pipette holder assembly for 1.0mm capillary tubing.\*

**\$ 1,250**

### ACCESSORIES

**MI-10010** Pipette holder assembly (specify 1.0mm, 1.2mm, or 1.5mm OD glass) includes holder and mounting rod.

**\$ 58**

<b>V200050</b>	Teflon tubing	<b>\$4 per ft.</b>
<b>V001180</b>	10µl gas-tight syringe	<b>\$110.00</b>
<b>V001181</b>	25µl gas-tight syringe	<b>\$110.00</b>
<b>V001182</b>	50µl gas-tight syringe	<b>\$110.00</b>
<b>V001183</b>	100µl gas-tight syringe	<b>\$110.00</b>
<b>V001184</b>	250µl gas-tight syringe	<b>\$110.00</b>
<b>V001185</b>	500µl gas-tight syringe	<b>\$110.00</b>
<b>V001186</b>	1000µl gas-tight syringe	<b>\$110.00</b>

\* Other syringe volumes, and pipette holder sizes are available upon request.

The injection resolution is dependent on the volume of the syringe that is installed, as outlined in the table on the previous page. For example, with a 25µl syringe installed, one complete rotation of the micrometer (25 divisions) yields a displacement equivalent to a volume of 267nl and turning the micrometer one division (0.001in) yields 10.6nl.

**1** Please specify the syringe volume that you will be using. For animal IVF applications, 500µl and 1000µl syringes are commonly used.

**2** Unless specified otherwise, a pipette holder for 1mm outside diameter glass will be supplied. The diameter of the pipette holder is 0.25 inches (6.4mm). For micromanipulators that cannot accept this size holder, an adapter is optionally available. Please contact us for further information.

## MICROPIPETTE TECHNIQUES ADVANCED MICROPIPETTE TECHNIQUES FOR CELL PHYSIOLOGY

KENNETH T. BROWN

University of California at  
San Francisco

DALE FLAMING

Sutter Instrument Company,  
Novato, CA.



Fine glass micropipettes are extensively used in intra- and extracellular physiology as a means of recording electrical activity in cells and as channels for injecting a variety of substances for experimental purposes. In 1973, the authors began a course of systematic studies designed to help them improve the capabilities and efficiency of intracellular research using the micropipette technique. Here, they present for the first time their theory of how micropipette tips are formed, their methods of reducing tip size, and the implications of their work for research on small cells

of all kinds, especially cells within the central nervous system. This text not only incorporates this new work, but reviews and analyzes existing publications on micropipette methodology, including patch-clamping, in order to present as complete an account as possible of how micropipettes can be used efficiently and effectively in a wide variety of experimental situations. The information presented here should prove helpful to anyone performing research with micropipettes, from a graduate student conducting a first project to the most experienced investigator.

## CONTENTS

Early Methods of Fabricating  
Micropipettes

The Flaming/Brown Micropipette Puller:  
Its Background, Design and Underlying  
Principles

Techniques for Examining and  
Measuring Micropipette Tips by Scan-  
ning Electron Microscopy

Evaluation of Flaming/Brown  
Micropipette Puller

A Theory of Micropipette Tip Formation:  
Quantitative Prediction and Validation  
of the Effects of Capillary Wall Thickness  
Upon Tip Size

Effects of a Fused Internal Fiber  
(Omega Dot) Upon Micropipette Tips

Minimizing Tip Size With Borosilicate  
Tubing

Beveling Micropipette Tips: Techniques  
and Applications

Filling Micropipettes: Techniques and  
Solutions

Advancing Micropipettes Through Tis-  
sues and Into Cells

Ancillary Techniques for Conducting  
Intracellular Research

Evaluation of Improved Intracellular  
Recording Techniques in Vertebrate  
Photoreceptors

Evaluation of Tubing Designs for Intra-  
cellular Work

The Structure Properties of Glasses for  
Fabricating Micropipettes

Dual-Channel Micropipettes

The Burgeoning Field of Patch Clamping

Extension of the Flaming/Brown Micro-  
pipette Puller to Patch Clamping and  
Conveniently Handling  
Aluminosilicate Glass

References

Appendices

US PRICES  
> BOOK

*International prices are 5% higher.  
Prices subject to change without notice.*

ADVANCED MICROPIPETTE TECHNIQUES  
FOR CELL PHYSIOLOGY

**\$ 30**

## GLASS CAPILLARY TUBING



Sutter Instrument Company, in addition to the finest micropipette pullers available, offers a wide selection of high quality glasses in various sizes and materials. Though there are many types and sizes of glass available, we have carefully selected only those that pass our criteria. Our expertise in micropipette technology assures you of precision and high quality.

We offer capillary tubing in three different compositions: quartz, borosilicate and aluminosilicate. Each composition has its own unique properties and the selection will be determined by your application and your puller's capabilities.

### FIRE POLISHING

All borosilicate and aluminosilicate capillary glass offered by Sutter Instrument have fire-polished ends. This process eliminates any sharp edges, making it easier to insert into holders, and does not affect the electrical or mechanical properties of the glass.

### CUSTOM PIPETTES

Sutter Instrument Company can make custom pipettes and microtools not commonly available from other pipette manufacturers. The custom pipettes are considered non-sterile and are manufactured for research applications and non-human use. Please contact Sutter Instrument for further details.

### BOROSILICATE (SCHOTT 8340)

The most commonly used glass is borosilicate. Sutter Instrument offers only TYPE I-CLASS A borosilicate as described by ASTM Standard 3.1.2<sup>1</sup>. This glass softens at 825 degrees Celsius and, as it is pulled, maintains its ratio of inside diameter to outside diameter over the total taper length. Borosilicate softens at a lower temperature than our other glasses and has a wider working range. These unique properties allow for a greater variety of shapes used in microelectrodes, patch pipettes, microinjection needles and, in the case of solid rod, chromosome dissection tools.

### ALUMINOSILICATE (CORNING 1724 OR SCHOTT 8252)

Aluminosilicate softens at a higher temperature (935 degrees Celsius) than borosilicate and is workable over a much narrower range. It has a tendency to continuously thin out as it is drawn which allows extremely fine tips with very short tapers. For example, we have pulled aluminosilicate tips in the 200-300 Angstrom range with taper lengths of 5-6mm. Its resistivity is several orders of magnitude higher than borosilicate, thus reducing leakage currents when used in ion-selective micropipettes. Aluminosilicate is harder than borosilicate which results in a pipette that is more suitable for penetrating tough tissues.

### QUARTZ (HERAEUS HSQ300)

The finest and purest glass available is quartz. It is superior to all other glasses in its mechanical, electrical and optical qualities. It has the lowest dielectric constant, the lowest loss factor and the highest volume resistivity making it ideal for patch clamp recording. Its chemical purity virtually eliminates leakage of ions<sup>2</sup> and by using quartz in single channel patch clamp recordings the lowest background noise levels have been achieved<sup>3</sup>. Due to its high melting point, it cannot be pulled on conventional pullers, but can be easily pulled with the Sutter CO<sub>2</sub> laser-based P-2000.

### SIZES

Sutter Instrument capillary tubing is available in a broad range of wall thicknesses which allow you to select the size necessary for your application. The ratios of inside diameter to outside diameter typically run between 0.5 mm and 0.75mm with the lower end being referred to as thick wall tubing and the top of the range as thin wall tubing. All other factors being equal, the thicker wall capillaries produce pipettes with longer tapers and smaller tips which make it more suitable for intracellular microelectrodes. These thicker wall pipettes tend to reduce the noise contributions due to capacitance, which makes them more suitable for patch clamp pipettes. Thinner wall tubing allows for larger pore openings which makes it ideal for microinjection needles and low resistance microelectrodes.

<sup>1</sup> ASTM Designation E438-90 - April 1990.

<sup>2</sup> Zuazaga C., Steinacker A. Patch-clamp recording of ion channels: Interfering effects of patch pipette glass. *News in Physiological Sciences: International Union of Physiological Sciences and the American Physiological Society*: 5:155-158, August 1990.

<sup>3</sup> Rae, James L., Levis Richard A. A Method for exceptionally low noise single channel recordings. *Pflügers Archive; European Journal of Physiology*:420:618-620, Springer-Verlag 1992.

## STANDARD WALL BOROSILICATE TUBING

## WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>BF100-50-10</b>	1.00mm	0.50mm	10cm	225	<b>\$31</b>
<b>BF100-50-15</b>	1.00mm	0.50mm	15cm	225	<b>\$46</b>
<b>BF100-58-10</b>	1.00mm	0.58mm	10cm	250	<b>\$31</b>
<b>BF100-58-15</b>	1.00mm	0.58mm	15cm	250	<b>\$42</b>
<b>BF120-60-10</b>	1.20mm	0.60mm	10cm	225	<b>\$38</b>
<b>BF120-69-10</b>	1.20mm	0.69mm	10cm	250	<b>\$34</b>
<b>BF120-69-15</b>	1.20mm	0.69mm	15cm	250	<b>\$28</b>
<b>BF150-75-10</b>	1.50mm	0.75mm	10cm	225	<b>\$38</b>
<b>BF150-86-7.5</b>	1.50mm	0.86mm	7.5cm	250	<b>\$35</b>
<b>BF150-86-10</b>	1.50mm	0.86mm	10cm	250	<b>\$35</b>
<b>BF150-86-15</b>	1.50mm	0.86mm	15cm	250	<b>\$78</b>
<b>BF200-100-10</b>	2.00mm	1.00mm	10cm	225	<b>\$78</b>
<b>BF200-116-10</b>	2.00mm	1.16mm	10cm	250	<b>\$90</b>
<b>BF200-116-15</b>	2.00mm	1.16mm	15cm	250	<b>\$95</b>

## WITHOUT FILAMENT

Catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>B100-50-10</b>	1.00mm	0.50mm	10cm	225	<b>\$32</b>
<b>B100-50-15</b>	1.00mm	0.50mm	15cm	225	<b>\$73</b>
<b>B100-58-10</b>	1.00mm	0.58mm	10cm	250	<b>\$28</b>
<b>B100-58-15</b>	1.00mm	0.58mm	15cm	250	<b>\$39</b>
<b>B120-69-10</b>	1.20mm	0.69mm	10cm	250	<b>\$37</b>
<b>B120-69-15</b>	1.20mm	0.69mm	15cm	250	<b>\$27</b>
<b>B150-86-7.5</b>	1.50mm	0.86mm	7.5cm	250	<b>\$35</b>
<b>B150-86-10</b>	1.50mm	0.86mm	10cm	250	<b>\$37</b>
<b>B150-86-15</b>	1.50mm	0.86mm	15cm	250	<b>\$71</b>
<b>B200-116-10</b>	2.00mm	1.16mm	10cm	250	<b>\$58</b>
<b>B200-116-15</b>	2.00mm	1.16mm	15cm	250	<b>\$69</b>

## THIN WALL BOROSILICATE TUBING

## WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>BF100-78-10</b>	1.00mm	0.78mm	10cm	250	<b>\$28</b>
<b>BF100-78-15</b>	1.00mm	0.78mm	15cm	250	<b>\$45</b>
<b>BF120-94-10</b>	1.20mm	0.94mm	10cm	250	<b>\$34</b>
<b>BF120-94-15</b>	1.20mm	0.94mm	15cm	250	<b>\$48</b>
<b>BF150-110-10</b>	1.50mm	1.10mm	10cm	225	<b>\$34</b>
<b>BF150-117-10</b>	1.50mm	1.17mm	10cm	250	<b>\$30</b>
<b>BF150-117-15</b>	1.50mm	1.17mm	15cm	100	<b>\$33</b>
<b>BF150-110-7.5</b>	1.50mm	1.10mm	7.5cm	225	<b>\$35</b>
<b>BF200-156-10</b>	2.00mm	1.56mm	10cm	250	<b>\$37</b>
<b>BF200-156-15</b>	2.00mm	1.56mm	15cm	100	<b>\$39</b>

## WITHOUT FILAMENT

Catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>B100-75-10</b>	1.00mm	0.75mm	10cm	225	<b>\$24</b>
<b>B100-75-15</b>	1.00mm	0.75mm	15cm	225	<b>\$39</b>
<b>B120-90-10</b>	1.20mm	0.90mm	10cm	225	<b>\$27</b>
<b>B150-110-7.5</b>	1.50mm	1.10mm	7.5cm	225	<b>\$35</b>
<b>B150-110-10</b>	1.50mm	1.10mm	10cm	225	<b>\$29</b>

## MULTIBARREL BOROSILICATE\*

## WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>2BF100-50-10</b>	2 barrels	1.00/0.50	10cm	75	<b>\$45</b>
<b>2BF100-75-10</b>	2 barrels	1.00/0.75	10cm	75	<b>\$42</b>
<b>2BF150-86-10</b>	2 barrels	1.50/0.86	10cm	100	<b>\$50</b>
<b>2BF150-86-15</b>	2 barrels	1.50/0.86	15cm	100	<b>\$65</b>
<b>3BF100-50-10</b>	3 barrels	1.00/0.50	10cm	75	<b>\$39</b>
<b>3BF100-75-10</b>	3 barrels	1.00/0.75	10cm	75	<b>\$41</b>
<b>3BF120-69-10</b>	3 barrels	1.20/0.69	10cm	100	<b>\$45</b>
<b>3BF120-69-15</b>	3 barrels	1.20/0.69	15cm	100	<b>\$65</b>

\* Multibarrel borosilicate requires a custom filament.  
Please contact Sutter Instrument for more information when ordering.

## QUARTZ TUBING

## WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>QF100-50-7.5</b>	1.00mm	0.50mm	7.5cm	100	<b>\$109</b>
<b>QF100-50-10</b>	1.00mm	0.50mm	10cm	100	<b>\$158</b>
<b>QF100-60-7.5</b>	1.00mm	0.60mm	7.5cm	100	<b>\$100</b>
<b>QF100-60-10</b>	1.00mm	0.60mm	10cm	100	<b>\$153</b>
<b>QF100-70-7.5</b>	1.00mm	0.70mm	7.5cm	100	<b>\$126</b>
<b>QF100-70-10</b>	1.00mm	0.70mm	10cm	100	<b>\$153</b>
<b>QF100-70-15</b>	1.00mm	0.70mm	15cm	100	<b>\$168</b>
<b>QF120-60-7.5</b>	1.20mm	0.60mm	7.5cm	100	<b>\$158</b>
<b>QF150-75-7.5</b>	1.50mm	0.75mm	7.5cm	100	<b>\$113</b>

## WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>Q100-30-7.5</b>	1.00mm	0.30mm	7.5cm	100	<b>\$114</b>
<b>Q100-50-7.5</b>	1.00mm	0.50mm	7.5cm	100	<b>\$109</b>
<b>Q100-50-10</b>	1.00mm	0.50mm	10cm	100	<b>\$147</b>
<b>Q100-70-7.5</b>	1.00mm	0.70mm	7.5cm	100	<b>\$102</b>
<b>Q100-70-10</b>	1.00mm	0.70mm	10cm	100	<b>\$147</b>
<b>Q120-40-7.5</b>	1.20mm	0.40mm	7.5cm	100	<b>\$175</b>
<b>Q120-60-7.5</b>	1.20mm	0.60mm	7.5cm	100	<b>\$153</b>
<b>Q120-90-7.5</b>	1.20mm	0.90mm	7.5cm	100	<b>\$126</b>
<b>Q120-90-10</b>	1.20mm	0.90mm	10cm	100	<b>\$168</b>
<b>Q150-50-7.5</b>	1.50mm	0.50mm	7.5cm	100	<b>\$158</b>
<b>Q150-75-7.5</b>	1.50mm	0.75mm	7.5cm	100	<b>\$100</b>
<b>Q150-75-10</b>	1.50mm	0.75mm	10cm	100	<b>\$113</b>
<b>Q150-110-10</b>	1.50mm	1.10mm	10cm	100	<b>\$179</b>
<b>Q165-115-10</b>	1.65mm	1.15mm	10cm	100	<b>\$149</b>

## SOLID QUARTZ ROD

catalog number	style	outside diameter	overall length	pieces per package	price
<b>QR-100-7.5</b>	solid	1.00 mm	7.5cm	100	<b>\$67</b>
<b>QR-100-10</b>	solid	1.00 mm	10cm	100	<b>\$67</b>
<b>QR-100-15</b>	solid	1.00 mm	15cm	100	<b>\$67</b>

## QUARTZ WITH STAINLESS STEEL CORE

catalog number	outside diameter	overall length	pieces per package	price
<b>QS200-10</b>	0.20mm	10cm	100	<b>\$132</b>
<b>QS125-10</b>	0.12mm	10cm	100	<b>\$132</b>
<b>QS80-10</b>	0.08mm	10cm	100	<b>\$132</b>

## QUARTZ THETA TUBING

catalog number	O.D./I.D.	septum thickness	overall length	pieces per package	price
<b>QT120-90-7.5</b>	1.20/0.9mm	0.15mm	7.5cm	50	<b>\$72</b>

## MULTIBARREL QUARTZ

catalog number	number of barrels	OD/ID in mm	overall length	pieces per package	price
<b>7Q033-16-10</b>	7 barrel	1.00/[.33/.16ea]	10cm	100	<b>\$229</b>

## THIN WALL ALUMINOSILICATE TUBING

## WITH FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>AF100-68-10</b>	1.00mm	0.68mm	10cm	100	<b>\$37</b>
<b>AF120-85-10</b>	1.20mm	0.85mm	10cm	100	<b>\$39</b>

## WITHOUT FILAMENT

catalog number	outside diameter	inside diameter	overall length	pieces per package	price
<b>A100-68-10</b>	1.00mm	0.68mm	10cm	100	<b>\$36</b>
<b>A120-85-10</b>	1.20mm	0.85mm	10cm	100	<b>\$41</b>

## BOROSILICATE THETA TUBING

catalog number	O.D./I.D.	septum thickness	overall length	pieces per package	price
<b>BT-150-10</b>	1.50/1.17mm	0.165mm	10cm	100	<b>\$80</b>

## SOLID BOROSILICATE ROD

catalog number	style	outside diameter	overall length	pieces per package	price
<b>BR-100-15</b>	solid	1.00mm	15cm	250	<b>\$34</b>

