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An electro-pneumatic microelectrode puller

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An electro-pneumatic microelectrode puller

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Abstract. An instrument for making glass microelectrodes is described. The glass is drawn in two stages, the first pull by gravity, the second by an air cylinder. Use of an air cylinder allows the instrument to be more compact and simple than the previous ones, while equally versatile.

1. Introduction

Since the introduction of stable, low noise-level biological amplifiers, high resistance glass capillary microelectrodes have come into general use for physiological studies such as intracellular investigations and the measurement of membrane potentials.

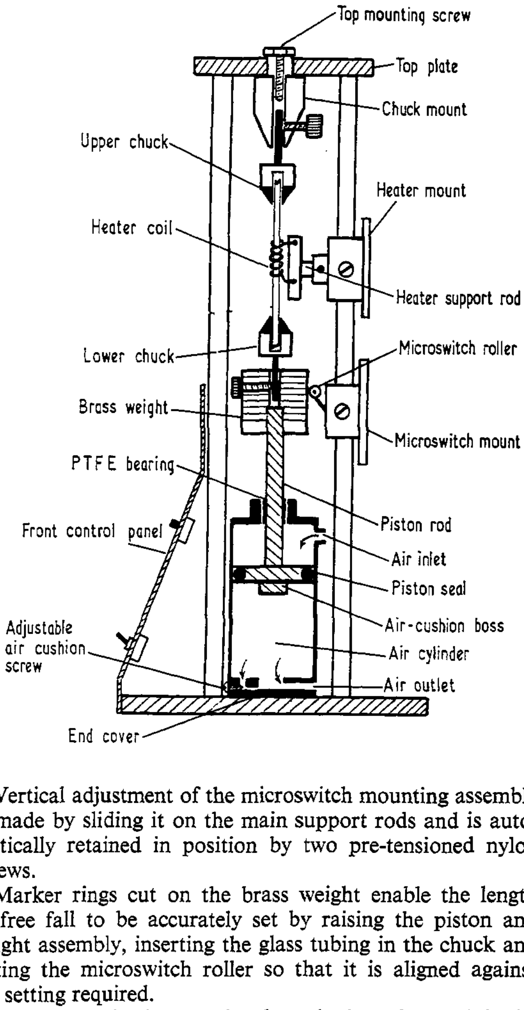
The instruments developed to produce glass electrodes (Alexander and Nastuk 1953, Winsbury 1956) draw the glass in two stages, which is necessary for obtaining fine bore tips to the electrodes. Alexander and Nastuk used a solenoid for both stages; Winsbury made the first pull by gravity and the second pull by a solenoid. The instrument described here uses gravity for the first pull and an air cylinder for the second pull with air-cushioning to give smooth braking at the end of the stroke.

2. Description

To ensure axial symmetry and uniform glass flow during the initial heating and free-fall period, this apparatus pulls vertically. The first pull is made by a 1½ lb concentric brass weight attached to the piston rod of the air cylinder (see figure).

Except for fitting a polytetrafluoroethylene bearing for the piston rod to minimize friction during the free-fall period, the air cylinder is a standard 'Martonair' product with a 1¼ in. bore, 2 in. stroke and adjustable air-cushioning. The second pull is started when the roller of the microswitch (see figure) is tripped by the passing of the weight attached to the piston rod; this energizes the midget solenoid valve and admits air to the upper side of the piston, forcing it down at a rate that depends on air flow and pressure. When the piston is nearing the bottom of its stroke, the air-cushion boss (see figure) enters a recess in the end cover, trapping the exhausting air and forcing it to pass through a small adjustable orifice; this cushions the piston to the end of its stroke.

The use of an air cylinder permits a compact apparatus with only a 9 in. square base, a total height of 18 in. and a central column 3 in. square. All electrical and pneumatic controls and components are mounted on this unit. The upper chuck can be extended or retracted within its mount, and the mount itself can be moved laterally by slackening the top mounting screw which passes through the oversize hole in the top plate. The heater assembly is screwed on to two hexagon brass blocks which can be slid up or down the main vertical rods; a pre-tensioned nylon screw in each of these blocks retains enough pressure on the rods to enable the heater assembly to be quickly positioned and automatically locked. The heater can be aligned relative to the glass tubing in both the horizontal and the vertical planes by sliding or turning the heater support rod in its housing.



Vertical adjustment of the microswitch mounting assembly is made by sliding it on the main support rods and is automatically retained in position by two pre-tensioned nylon screws.

Marker rings cut on the brass weight enable the length of free fall to be accurately set by raising the piston and weight assembly, inserting the glass tubing in the chuck and setting the microswitch roller so that it is aligned against the setting required.

The lower chuck can also be raised or lowered in its holder enabling different lengths of glass to be used. The chucks will accept glass tubing from 0·5 to 4 mm external diameter.

The six-turn platinum heater coil is formed from 0·048 in. diameter wire and wound on a ¼ in. diameter former with a spacing of 0·008 in between each coil. It is supplied from a transformer having an output of 3·5 v and a power rating of 150 VA. The primary of this transformer is series fed through a 200 Ω, 25 w fixed resistor and a 120 Ω, 25 w rheostat, adjusted to give a primary current of approximately 0·3 A when connected to a 230 V mains supply.

3. Operation

The electrode glass is inserted through the heater coil and clamped into the top chuck. (Tightening of the chucks by hand has proved satisfactory.) The lower chuck is then raised and attached to the lower end of the glass when the microswitch is set so that the microswitch roller is against the required free-fall distance setting engraved on the weight.

With the apparatus connected to the power supply and air gauge pressure 5–20 lb in^{-2}, adjusted to requirements, the initial heater current may be set by pressing a test button and turning the rheostat to give the required meter reading. When the main switch is moved to the ON position the heater is energized, and as the glass begins to flow the weight attached to the piston rod moves down until it passes the microswitch roller. The microswitch now cuts off current to the heater and energizes the solenoid, which admits air to the top face of the piston, driving it down to complete its stroke and form the two electrodes. As soon as the main switch is returned to the OFF position the formed electrodes can be removed.

4. Performance

Several combinations of air pressure, free-fall distances and heater-circuit currents were tried. The most sensitive variable proved to be the heater current.

Electrodes were formed from 2·0 mm Pyrex glass tubing with a wall thickness of approximately 0·5 mm. A free-fall distance of $\frac{1}{2}$ in., a heater-transformer primary current of 0·32 A and an air gauge pressure of 15 lb in^{-2} were used. The electrodes were filled with KCl and their resistance measured using a Cambridge pH meter, calibrator and resistance box. Each electrode was immersed in a saline bath and the deflection of a pH meter noted when a known potential from the calibrator was applied. Resistances were then inserted in parallel until the deflection was halved, i.e. the added parallel resistances were approximately equal to the electrode resistance. Sixty electrodes were drawn and their resistances are shown in the table.

mΩ	<1	1–5	5–10	10–100
%	7	21	18	40

Damage during forming or filling accounted for the other 14%.

Various combinations of free-fall distances, weights and final pull speeds will produce acceptable electrodes. However, to produce an electrode the heater-circuit current must be kept within fairly narrow limits.

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A pumpable vacuum valve for sealed-off metal cryostats

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Abstract. This note describes a valve which forms a connection for re-pumping and sealing off the vacuum space in metal cryostats and similar equipment and also acts as a safety valve. The part that is permanently fastened to the cryostat is designed for cheap and easy quantity production, and the attachment by which it is operated can be shared between many pieces of equipment.

In many cryogenic applications, such as cryostats and other containers for liquefied gas and for delivery and transfer tubes, there is a need for a simple vacuum connection which can be re-sealed under vacuum. Also, a safety device is often desirable so that if by accident liquid or solid condenses in the vacuum space at low temperature, the gas produced on re-warming to room temperature can be released and a dangerous overpressure avoided. This note describes a device which serves both purposes.

The device is shown in the figure. It consists of two main parts, the first of which is the vacuum valve itself, which is permanently attached to the cryostat or other equipment. The second is a detachable connection which is used only when the cryostat is being evacuated, and one of these can therefore be shared between many pieces of equipment.

The permanent part is shown as A in the figure. It is machined from solid brass and is designed to be soft-soldered into a $\frac{1}{4}$ in. diameter hole at a suitable place on the cryostat. In use the valve is held shut by the plug B being held against an O-ring in A by the external air pressure (the force is a little over one pound). In the event of gas release inside the vacuum space, the plug automatically lifts clear when the internal gas pressure reaches atmospheric.

The detachable connection is represented by the rest of the figure. In use, it is attached to the permanent part by means of the knurled sleeve C, and the joint is sealed by an O-ring. When the sleeve D is screwed down to a low position the screw at the bottom end of the spindle E may be engaged with the threaded part of B by rotating the spindle from its upper end F. The plug can then be lifted clear of its seating,