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GLASS CAPILLAR DRAWING MACHINE FOR ELECTROPHYSIOLOGICAL PURPOSES

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The glass microelectrode is one of the most important research tools for investigating the cell activity. Practical electrophysiological investigations require a high number of electrodes, so a suitable drawing machine is normally used to provide the glass capillars thus required. In this way, both quantita-

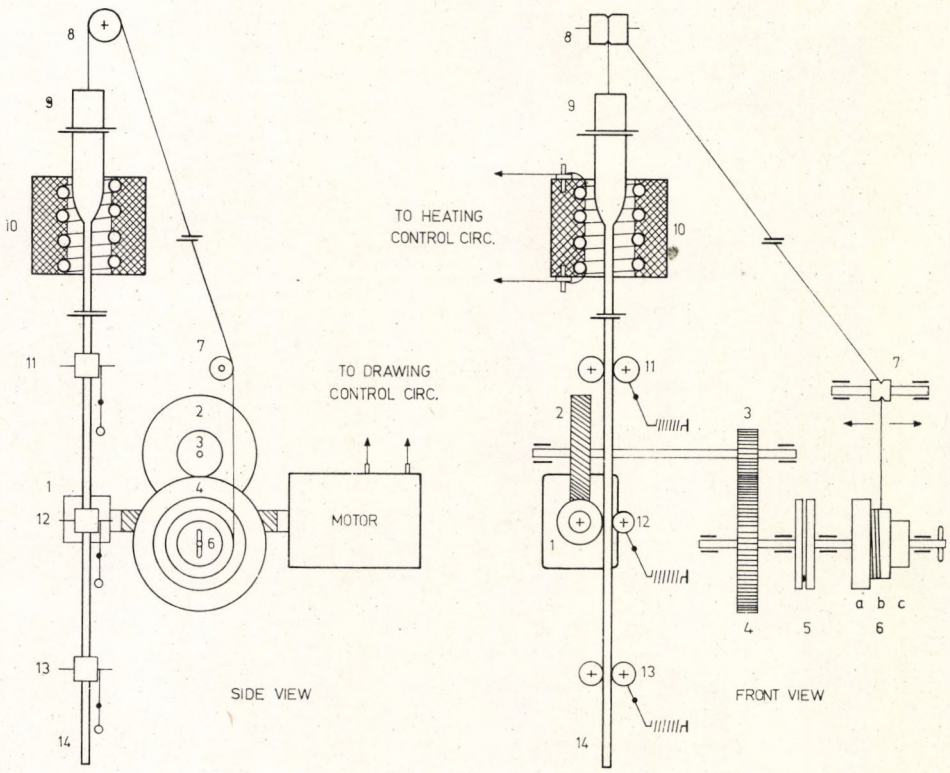

Fig. 1. Simplified functional arrangement of the capillar drawing machine

tive and qualitative requirements of the experiments are satisfied economically.

Locally fabricated drawing machines for providing microelectrodes are now applied in several laboratories instead of factory produced microelectrodes. A capillar drawing machine for this purpose has been developed in our Institute, involving vertical arrangement and providing suitable heating and drawing parameters. The simplified functional arrangement of this machine is shown in *Fig. 1.*

In the following, the arrangement will be explained in the sequence of operation steps. The starting position of the end of glass-tube (9) is within the

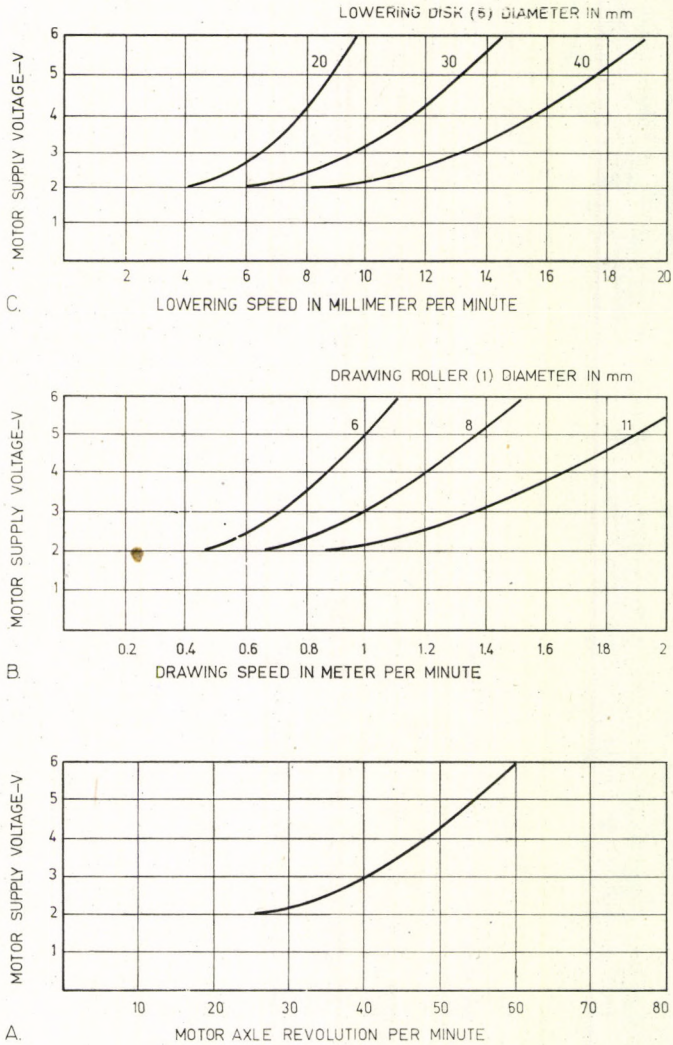

Fig. 2. Drawing parameter functions. *a)* Motor revolution, *b)* drawing speed, *c)* lowering speed

oven (10); 15 to 20 minutes after switching on the heating, the softening temperature of the glass is reached, and the glass may be slowly pulled out of the oven. The diameter of the pulled-out glass tube is reduced to 1. . 2 mm, and may thus be easily led through between the upper leading roller (11) and the drawing roller (1) and pressing roller (12). Switching on the supply voltage of the drawing motor, the continuous production of the capillar may now be started. The finished glass capillar (14) is available after passing between the lower leading rollers (13).

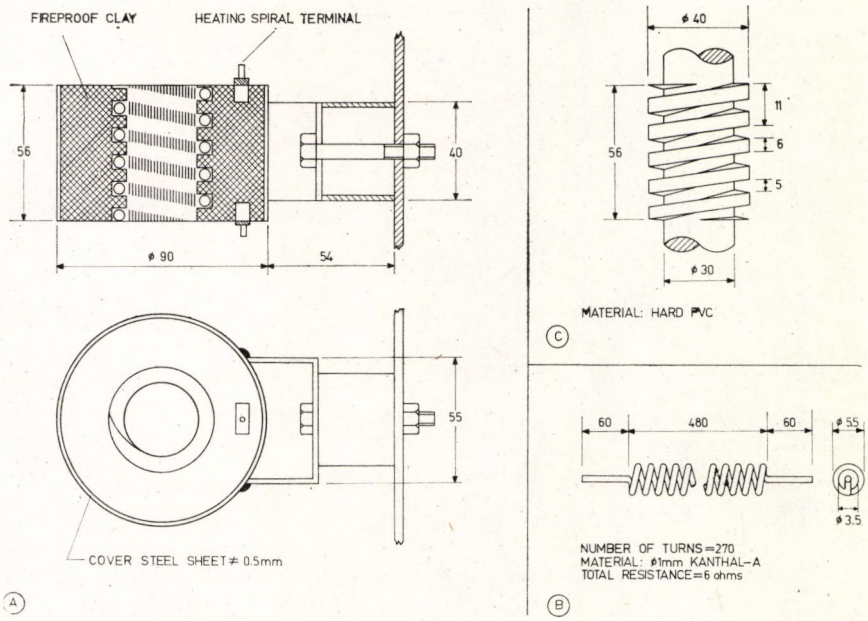

Fig. 3. Oven layout. *a)* Dimensional outlines of oven, *b)* heating spiral dimensions, *c)* forming tool for oven

During the capillar pulling-out process, the high diameter glass tube (9) has to be pushed in continuously into the oven (10), but with a reduced speed compared with the pulling-out speed. This task is provided by the 3-step lowering disk (6), lowering continuously the glass tube (9) into the oven (10) by means of a steel wire. The drawing roller (1) and the lowering disk (6) are engaged through a speed reducing cogwheel transmission (2, 3, 4) and a disconnecting clutch (5). Before the pulling is started, the position of the glass tube relative to the glass oven is adjusted by means of the clutch. The continuous pulling of the capillar is provided by a DC motor with a shaft on which drawing rollers (1) of different diameters may be fastened.

Fig. 2 a shows the revolution of the motor axle as a function of the supply voltage. The speed ranges available with drawing rollers (1) of different diameters are shown in *Fig. 2b*. *Fig. 2c* shows the speed ranges available with lowering disks of different diameters (6a, 6b, 6c).

The glass tube is melted in the oven illustrated in *Fig. 3a*. The oven contains fireproof clay within an iron shell. The clay is provided with a groove for holding the heating spiral. The spiral shown in *Fig. 3b* has been produced of Kanthal-A type material which has a maximum operating temperature of 1300 deg C, a melting point of 1510 deg C, and a specific resistance of 1.77 Ohms/m. The groove for holding the heating spiral has been pressed by means of the forming tool shown in *Fig. 3c*, embedded into the oven by means of fireproof clay mixed with glass-water. After drying, it has been turned out along the winding. Following this, the heating spiral was placed into the groove, and was heated to appr. 1000 deg C. The fireproof clay was thus drained totally and provided a high stability heating element.

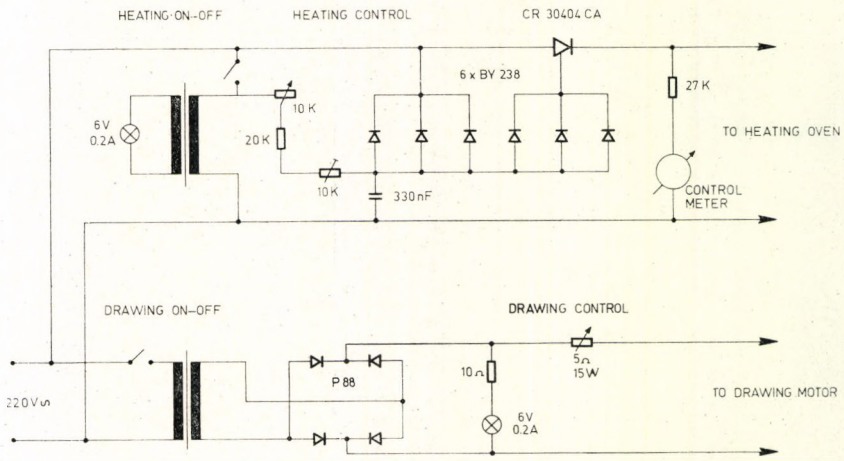

Fig. 4. Heater and drawing motor control circuit

The circuit diagram of the oven and the drawing motor control circuit is shown in *Fig. 4*. The heating power is controlled by a thyristor of type CR 30404 CA (AEI Semiconductors Ltd). At the beginning of the mains voltage negative half cycle, the thyristor is not conducting, and the 330 nF capacitor is charged to the negative peak voltage through the diodes. Following this, the capacitor voltage rises in the positive direction according to the RC time constant. During the mains voltage positive half cycle, the capacitor voltage reaches the level $U_{GT} + U_D = +3$ V needed for the thyristor ignition and for the conducting of the diodes connected to the thyristor control electrode, thus switching on the heating, and simultaneously disabling the control circuit. Heating power is controlled by the 10 kOhm potentiometer. Switched-on heating is indicated by a control lamp, and heating voltage is shown by a meter.

A 5 Ohm potentiometer serves for adjustment of the supply voltage of the drawing motor and thus for revolution control. Another control lamp serves for indicating the switched-on status of the drawing circuit.

The drawing machine is suitable for drawing capillars from glass tubes having diameters up to 25 mm. In our Institute, 17 mm glass tubes are used

from which capillars in the range between 0.5 and 4 mm may be drawn with suitably adjusted drawing, lowering and heating parameters. For electrophysiological investigations, glass materials having exceptionally good electrical properties are needed, so boro-silicate glass material is generally preferred.

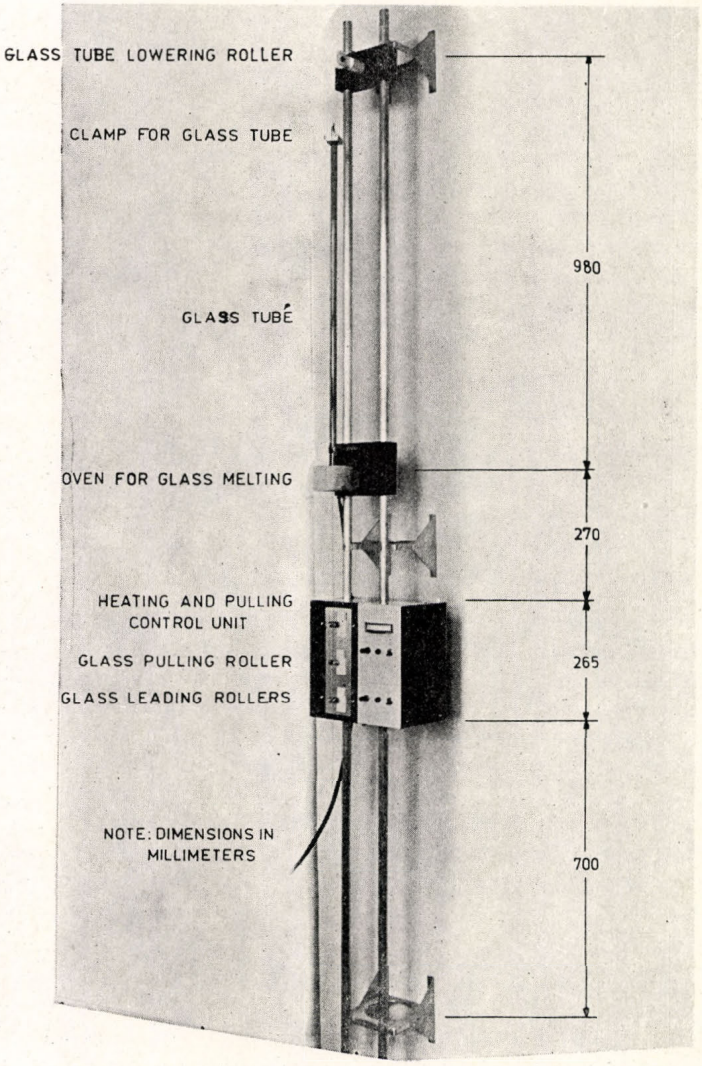

Fig. 5. Layout of the capillar drawing machine

Accordingly, Pyrex and Corning 7740 type glass material has been applied in our Institute (softening point at appr. 820 deg C) which proved to be suitable for microelectrodes having good electrical and mechanical properties.

The layout and more important dimensions of the capillar drawing machine developed in our Institute are shown in *Fig. 5*. The principle technical data are summarized in the following.

Specifications

Material to be drawn	glass tube which melts below 1300 deg C (Pyrex, Corning 7740), outer diameter max 25 mm, length max 900 mm
Drawing principle	drawing is accomplished by a lowering roller and a drawing roller which rotate at different speeds
Drawing ratio (typical data):	
increase of length (times)	50 80 100 150 250
decrease of diameter (times)	0.23 0.18 0.13 0.09 0.05
Adjustment of drawing ratio	by gears
Decrease of inner and outer diameters	at the same ratio
Non-uniformity of diameter	less than 5 % of the diameter
Drawing speed	48 cm/min min, 200 cm/min max
Lowering speed	4 mm/min min, 19 mm/min max
Electric oven temperature	1300 deg C max
Power requirement	220 volts AC, 10 A

Summary

A drawing machine of vertical arrangement, suitable for producing microelectrode capillars, is presented. Heating and drawing parameters of the machine are adjustable within wide ranges, and the machine is thus suitable for producing capillars from generally used glass materials meeting the measurement requirements. The required capillar diameter is easily adjustable, and the dimensions are reproducible with high accuracy during several drawing courses.

In the paper, mechanical and electrical performance of the machine, the control ranges of the drawing and heating parameters, the glass materials which may be applied, and the principle technical data are presented.

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ÜVEGKAPILLÁRIS HÚZÓ KÉSZÜLÉK ELEKTROFIZIOLÓGIAI MUNKÁKHOZ

Véró Mihály

Összefoglalás

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