METHODS

A NEW MODIFICATION OF A NEW VERTICAL AUTOMATIC MACHINE FOR THE PREPARATION OF GLASS MICROELECTRODES (MICROPIPETTES)

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Recently in our Department, in the Laboratory for the Preparation of Glass Microelectrodes (Micropipettes), a new automatic device has been used. To construct this machine we have used arrangements similar to vertical machines for the preparation of micropipettes, which have been proposed previously by several authors [1-7], and in which use is made of the force exerted by a solenoid to stretch the glass tube, which is heated by a platinum or tungsten spiral.

With our instrument batches of electrodes may be produced having predetermined dimensions.

For the researcher using glass microelectrodes the internal resistance of the electrodes is of great importance. Furthermore efforts must be made to reduce the resistance as far as possible. It is known that the internal resistance of a microelectrode is inversely proportional to the angle of constriction of the tip. This follows from the formula [3]:

$$R_{in} = \frac{4\rho_{in}}{\pi\varphi d} = \frac{73\rho_{in}}{\alpha d},$$

where α is the angle of the tip (in degrees); d is the diameter of the tip; ρ_{in} is the specific resistance of the electrolyte filling the electrode. There is therefore good reason to prepare microelectrodes having a large angle of constriction at the tip. It is rather difficult to prepare electrodes of this kind by means of existing automatic devices.

In the device used in our laboratory the special feature is that the glass tube may be stretched three times; when comparatively thick tubes are used – capillaries having a diameter of up to 1.2 mm, microelectrodes having a sharply constricted tip and a tip diameter of from 3-4 μ to fractions of a micron may be prepared.* Furthermore, in our instrument an original device is used which accurately centers the tongs which respect to the clamp; the device incorporates a cylinder within which is a polished piston. A diagram of the device and a sketch of its external appearance is shown in Figs. 1 and 2.

The working cycle of the instrument is as follows: the glass forma is clamped and is centered by the jaws of the clamp (1) and brought into relationship with a platinum spiral (2). The clamp (3) is opened and the knob switching on the instrument is pressed. Under the influence of the heat from the platinum spiral the tube begins to soften, and through the action of the weight (up to 150 g) of the mobile system of the lower clamp (tongs) and piston of the cylinder – 4, 5 begins to stretch slightly. Then the upper contact of ring (6) now operates the electromagnetic brake (7), and the latter now holds up the large 500 g core of the solenoid (8).

However the free sliding motion of the guiding piston in the cylinder (9) is still permitted on account of the flexible coupling of the piston and the core by means of the chain or cable (10). As soon as the upper contact of the ring (6) breaks contact the electromagnetic brake becomes open-circuited, the core falls sharply downwards and its weight now brings about a second extension of the electrode. As it falls the lower contact ring (11) momentarily completes the circuit of the solenoid and there then follows a break in the circuit of the solenoid (12), which may be regulated by means of the potentiometer; the result is that the electrode is made finer, and finally breaks.

* The first three-stage stretching of electrodes was carried out by A. L. Byzov.

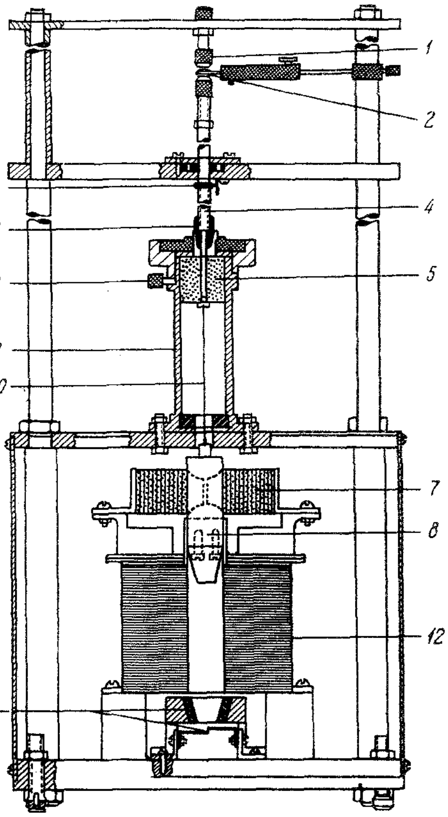

Fig. 1. Diagram of the device.

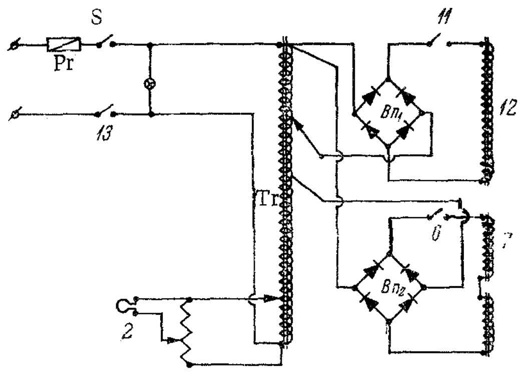

Fig. 2. Electrical circuit. Pr) Protector; S) mains switch; Tr) transformer; Bn_1 and Bn_2) selenium rectifiers; 2) platinium heating spiral; 6) microswitch for electromagnetic brake; 7) electromagnetic brake; 1)) microswitch of solenoid; 12) solenoid; 13) contacts for switching off instrument.

In falling downwards the core opens contacts (13) and so brings the whole apparatus to rest. The piston and core have their motion brought to rest by special layers of spongy rubber. For this reason in each of the clamps there remains a microelectrode completely ready for use.

We must also point out that the upper (6) and lower (11) contacts of the ring may be moved upwards or downwards on the stand so that the duration of the different stages of stretching may be regulated. Regulation of the temperature of the filament, the length before and after stretching, the power of the solenoid movement, and choice of appropriate glass will ensure the preparation of micropipettes to satisfy any requirements.

It can be seen from what we have said and from Figs. 3 and 4 that this automatic device is readily controllable and may be successfully used for the preparation of different kinds of glass microelectrodes. We must also point out that in the preparation of the device we made use of various parts of the components of the electrical circuit which are products of the Russian electrical engineering industry. For example, as a step-down transformer we used a school transformer of variable output; to reduce the potential for the heating circuit of the platinum spiral we employed a transformer designed for cautery and endoscopy in medicine; for rectification of the current for the solenoid and for the electromagnetic brake we used two miniature low-power selenium rectifiers.

The device for the preparation of glass microelectrodes is quite simple, and is convenient for use in a modern physiological laboratory.

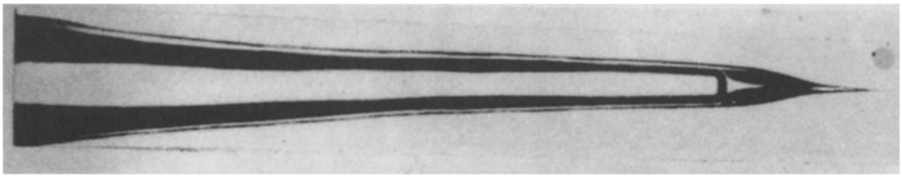

Fig. 3. Photograph of a production microelectrode; magnification 80 x (10 x 8). Owing to the method used in the laboratory the tip of the microelectrode has already been filled with distilled water during manufacture. In the photographs the two last stages of drawing out can be seen clearly. The first stage of extension cannot be shown in the photograph at this magnification.

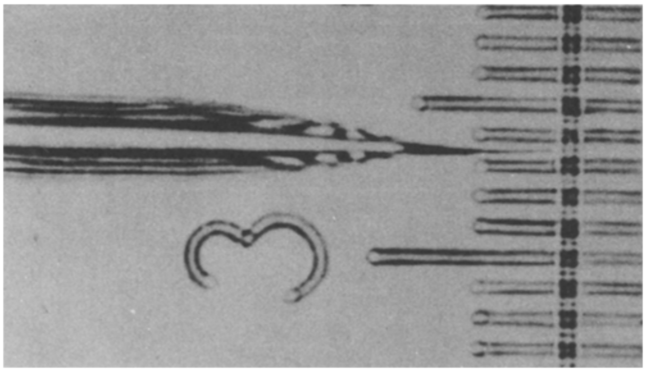

Fig. 4. Tip of a production microelectrode magnified 400 x (20 x 20). One division of calibration scale equals 1.85 μ. Diameter of tip of microelectrode is approximately equal to 0.4-0.3 μ.

SUMMARY

This paper describes a new modification of a vertical automatic device for the manufacture of glass microelectrodes (micropipettes).

By its means micropipettes may be prepared having a sharply narrowed end; the effect is that the internal resistance of the filled microelectrode is greatly decreased. The device allows serial production of microelectrodes to a prescribed size of tip diameter of 3-4 microns.

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