AN ELECTROMAGNETIC MICROELECTRODE PLUNGER

I. S. Gushchin and Yu. S. Sverdlov

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An electromagnetic microelectrode plunger for puncturing small cells in suspension is described. Movement of the microelectrode is strictly centered along its axis; the rate of movement is 4 μ/msec, and the thrust amplitude does not exceed 15 μ.

In microelectrophysiological investigations conducted on isolated small cells in suspension the need arises for a microelectrode to puncture the cell rapidly and with an assigned thrust amplitude, which is virtually impossible with the manual micromanipulator. Piezoelectric plungers have been suggested for this purpose [1-3], working on the principle that if a constant voltage is applied to piezocrystals they are deformed, and the motion is transmitted to the microelectrode fixed to them. However, it is extremely difficult to choose piezocrystals with an absolutely uniform degree of deformation, and without that condition it is impossible to ensure movement strictly centered along the axis of the microelectrode. Additional mechanical methods of axial centering of the microelectrode have thus to be resorted to [3], and this considerably reduces the rate of its movement.

The writers have used the principle of movement of an iron core in the magnetic field of a solenoid, ensuring the strictly centered axial thrust of the microelectrode fixed to the core at an adequate speed. In the plunger (Fig. 1) the coil 2 is fixed to the frame 1, made of transparent plastic, and copper wire 0.01 mm in diameter with a total ohmic resistance of 6.2 kΩ is wound on it. A glass tube 3 (outer diameter 1.8 mm, internal diameter 0.7 mm) is introduced into the coil, and the wire 8 with the nonpolarizing electrode and adapter for the microelectrode secured to it is inserted into the tube. The upper part of the tube 3 is rigidly fixed to the transparent plastic plate 4 (width 4 mm, thickness 1 mm), performing the role of a spring. A steel coupling (5), fixed to the tube 3, acts as the core. A brass tube 6, connected to the sleeve 5 and to a ground, acting together with the sleeve 5 as a screen, is placed over the lower part of the tube 3.

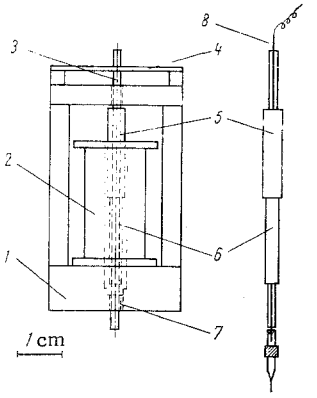

Fig. 1. The electromagnetic plunger. Explanation in text.

The glass coupling 7, in which the tube 3 slides (to reduce friction mineral oil can be introduced into the coupling) is housed in the bottom part of the frame 1.

When an electric current is passed through the coil 2 the core 5 is drawn into the coil together with the tube 3, carrying the microelectrode, fixed to it. When the current is switched off, the spring 4 returns the tube 3 to its original position. Square pulses of direct current (up to 70 V), applied to the coil, cause gradual thrusts of the microelectrode not exceeding 15 μ in amplitude. The deviation of the tip of the microelectrode from the axis of movement is negligible (under control of a microscope giving magnification of 600×). The rate of movement of the microelectrode is 4 μ/msec for a thrust amplitude of not more than 10-15μ, which corresponds approximately to the values obtained by the use of piezoelectric plungers [1-3].

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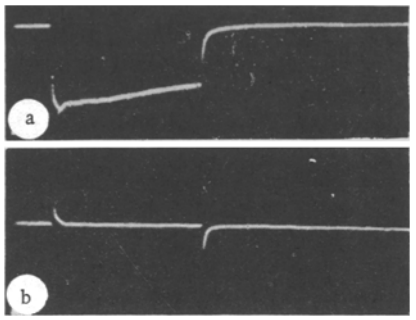

Fig. 2. Recording of potential shift arising on introducing the microelectrode into a mast cell and withdrawing it from the cell (a). Artifacts recorded when the electrode is extracellular in position at the moment of switching the current passing through the solenoid on and off (b). Downward deflection of the beam corresponds to negativity.

The plunger was tested in experiments on mast cells 10-15 μ in diameter obtained from a peritoneal cell suspension from rats. Glass microelectrodes filled with 3 M KCl solution and with a resistance of about 100 MΩ were used. An inverted microscope was used for the experiments.

A recording of membrane potential of a mast cell is illustrated in Fig. 2a, which shows that at the time of the thrust of the microelectrode and of its puncturing the cell, under visual control, a sharp jump of potential takes place, followed by a gradual decrease and sudden disappearance of the potential as the microelectrode is withdrawn from the cell. This potential was absent when the electrode was extracellular in position at the time of the thrust (Fig. 2b). The values of the potential recorded from mast cells varied between −5 and −15 mV, in agreement with the results obtained in experiments on erythrocytes [1] and spermatozoa [2]. The nature of this potential will be analyzed in a special communication.

LITERATURE CITED

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