FLOATING HYDRAULIC MICROMANIPULATOR FOR MICROELECTRODE INVESTIGATION OF BRAIN NEURONS

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Microelectrode techniques are widely used in neurophysiological investigations of the CNS [1, 2]. Extra- and intracellular recording of unit activity is complicated by the existence of respiratory and vascular pulsation of the brain, which constantly displaces the nerve tissue relative to the microelectrode tip. Various methods of abolishing brain pulsation have been suggested, but nevertheless they do not ensure complete immobility of the microelectrode relative to the test object [5, 7]. This problem can be resolved to some degree with the aid of a floating microelectrode [3-6], but this is very laborious to use. Microelectrode investigation of the ventral surface of the medulla, which has marked respiratory and vascular pulsation, has shown that the technique in which the microelectrode is inserted into the brain with the aid of a floating micromanipulator is the most universal solution. The advantages of such a system are based on synchronization of displacements of the brain and micromanipulator, with the result that maximal stability of the microelectrode tip is achieved close to or inside the neuron.

This paper discusses the design of a simple positive–positive pressure hydraulic micromanipulator, which is placed directly on the surface of the test object.

A diagram of the device, consisting of a micromanipulator 1, a supporting platform 3, and a pivot suspension 6, is shown in Fig. 1.

The micromanipulator (Fig. 2) consists of a body A in the form of a thin-walled metal cylinder 3 mm in diameter and 15-20 mm long. The hydraulic transmission pipe B is fixed in

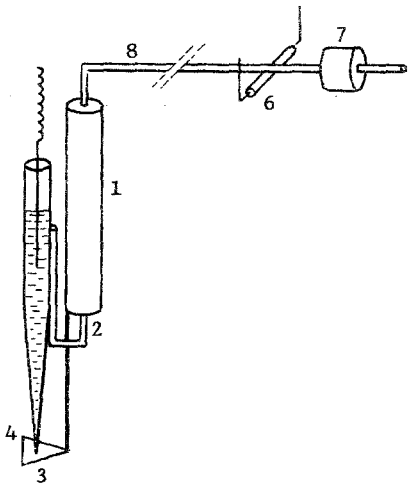

Fig. 1. Diagram of floating micromanipulator.

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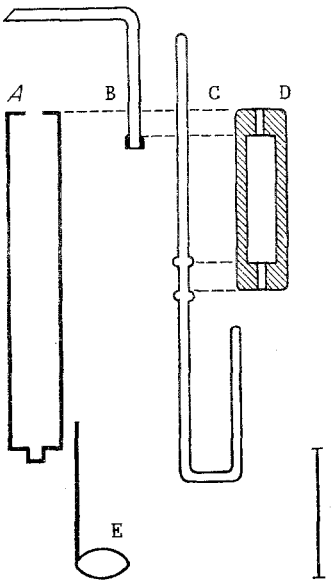

Fig. 2

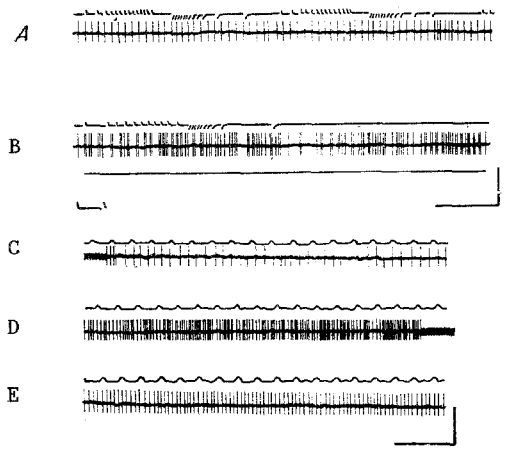

Fig. 3

Fig. 2. Construction of the micromanipulator. A) Body, B) hydraulic transmission pipe, C) electrode holder, D) elastic balloon, E) supporting platform. Scale: 1 cm.

Fig. 3. Traces of unit activity recorded in subpial portions of the bulbar chemosensitive zones under conditions of respiratory and vascular pulsation of the brain. A, B) Spirogram, neuronal spike discharge, during cooling of area S to +20°C (B). C, D, E) Traces of blood pressure and unit activity at 20th, 120th, and 180th minutes of recording. Calibration: 1 sec, 5 mV.

the hole at the top end of the body. An elastic balloon D, with a capacity of 3-4 μl, is located at the end of the hydraulic transmission pipe. The free end of the balloon is fixed to the electrode holder C. The way in which the elements of the micromanipulator fit together in the assembled form is shown by the broken lines in Fig. 2. The hydraulic transmission pipe 8 (Fig. 1) is connected to the pivot suspension 6, thus endowing the system with mobility in the vertical and horizontal planes. The weight of the micromanipulator is balanced by a counterpoise 7. The area of the supporting platform is determined by the nature of the brain region to be studied. The micromanipulator is connected to the hydraulic transmission by means of a thin polyethylene tube (not shown in Fig. 2).

The technique of microelectrode investigation of brain neurons is as follows. The microelectrode 4 is fixed to the electrode holder 2. The pivot suspension 6 is fixed in the stereotaxic head of an SÉZH apparatus and the micromanipulator 1 is set with its supporting platform 3 on the brain surface. In this position the micromanipulator and microelectrode begin to be displaced synchronously with fluctuations of the brain. The microelectrode is connected by a thin wire with a source follower. With an increase in pressure in the hydraulic system of the apparatus the free end of the balloon moves downward together with the electrode holder and the microelectrode. The microelectrode tip is applied to the brain surface and the search for unit activity commences. If the pressure falls in the hydraulic system the walls of the elastic balloon contract and lift the microelectrode upward. Because of the small volume of the balloon, the micromanipulator is able to advance and retract the microelectrode with an accuracy of 5 and 20 μ.

Traces of unit activity recorded in the subpial portions of the ventral surface of the medulla, with average respiratory and vascular pulsation of 44.2 ± 1.7 μ, are given in Fig. 3. The microelectrode investigation began at 0 μ from the surface and continued into the depth of the brain. It will be clear from Fig. 3 that the amplitude of extracellular neuronal ac-

tivity remained constant during spontaneous breathing and pulse fluctuations of the systemic arterial pressure. The average amplitude of the extracellular potentials of the neurons was 3.2 ± 0.1 mV. Thus compared with known methods of microelectrode investigation of neurons [1-6], the suggested method and apparatus ensure maximal stabilization of the position of the microelectrode tip in pulsating brain tissue.

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