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TECHNICAL NOTE

A SIMPLE SINGLE-UNIT MICROELECTRODE RECORDING SYSTEM*

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The electrode is a tungsten wire insulated with plastic, similar to that of HUBEL (1957) except that the highly tapered tip is retipped with insulating material to increase strength. Of the several insulating materials which we

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50 g NaOH

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The electrode is a tungsten wire insulated with plastic, similar to that of HUBEL (1957) except that the highly tapered tip is retipped with insulating material to increase its strength. Of the several insulating materials which we have tried, vinyl is used rather than glass or polymerizing plastics for several reasons. It is easier to apply than glass, even with the simplified technique of BALDWIN, FRENK and LETTVIN (1965). It dries at room temperature without special treatment. In addition to insulating, the coating adheres slightly to brain tissue, stabilizing the mechanical conditions of recording and making it easier to record from single units in either moving or paralyzed animals for several hours. Moreover, the extreme simplicity and reliability of the input stage and of the impedance measuring device, allowing impedance measurement even while recording from a unit, recommend the system for use by students or researchers without specialized electronics training.

MICROELECTRODES

Etching

Electrodes are etched on a 0·012 in. diameter prestressed tungsten wire in an electrolytic solution consisting of:

50 g NaOH
150 g $NaNO_2$
900 ml H_2O

The etching current is supplied by a variable autotransformer followed by a 10:1 step down transformer. This results in 0–12 V of 60 cycle AC between the tip of the tungsten wire and the solution. The circuit is completed by a carbon rod electrode in the electrolytic solution.

A cam attached to a 37 RPM motor (Fig. 1) controls a

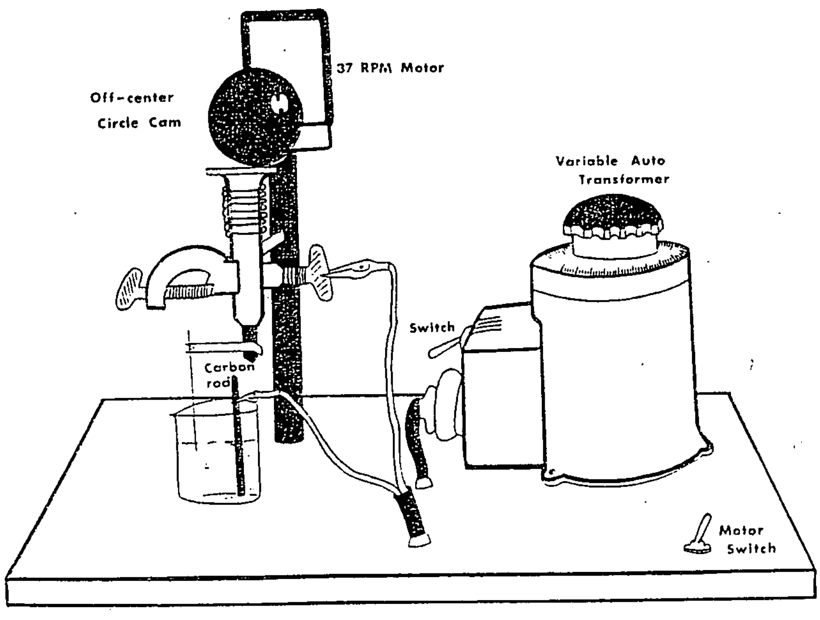

FIG. 1. Etching apparatus.

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piston which dips the electrode about 5 mm. into the solution. It is best to apply about 12 V to the electrode and continue dipping until the electrode arcs regularly on contact with the solution (about 3 min). This arc is quite small and is best seen in a darkened room. At this point the voltage is decreased to 1 V and the electrode dipped 15 times more to polish the tip. Under a microscope the tip of the electrode should measure less than $0 \cdot 5\ \mu$. The shape of the tip makes some difference; short blunt tips generally have higher impedance than long tapering ones.

Coating

Just before coating the electrodes are cleaned by dipping (just in and out) in the following liquids: (in order)

(1) 10% Acetic Acid	(4) Ether
(2) Distilled H_2O	(5) 90% Alcohol
(3) Acetone	(6) Stoner–Mudge Thinner

The freshly cleaned electrode is then coated with Stoner–Mudge vinyl. This vinyl and its thinner may be obtained from Mobil Chemical Company, Pittsburgh, Pennsylvania 15233. The vinyl is S-986-015 clear lab vinyl, and the thinner is number T-220. It is necessary to keep the vinyl at the consistency of honey by adding or evaporating thinner from time to time.

The electrode may be lowered rather quickly into the vinyl, but it must be raised slowly and evenly. Otherwise the coating will be uneven. To eliminate the jerkiness involved in dipping by hand, we move the electrode hydraulically with two 50 cm^3 hospital syringes (Fig. 2), so that the electrode moves out of the vinyl at no more than 4 cm/min.

After the electrode is coated by complete immersion in the vinyl, it should be stuck tip upward in foam rubber and allowed to dry for at least two days. Then, to insure high impedance, the tip of the electrode is touched quickly to the Stoner–Mudge vinyl (by hand) and allowed to dry for another two days before measuring its impedance.

TESTING AND RECORDING

Measuring impedance

The impedance tester (Fig. 3) is a blocking oscillator which generates rectangular pulses $0 \cdot 5$ ms long at the rate of 10/s. The pulses are scaled down to an amplitude of 100 mV by a voltage divider and applied to the input stage through a 100 MΩ resistor. This resistor and the microelectrode then form a voltage divider. The voltage is read by the same input stage as is used for physiological recording, each MΩ of microelectrode impedance generating 1 mV of signal.

The above system gives only an approximate measure of the compound resistive and capacitive characteristics of the microelectrode, but it has the advantage that impedance can be measured even while recording from a unit, without losing or damaging it.

While testing the impedance of an electrode in saline it is possible to pass a small current through it, thus lowering its impedance to the desired level of about 2 MΩ. This is done by instantaneously applying the negative pole of a 9 V battery to the electrode through a resistor of 10 MΩ or less.

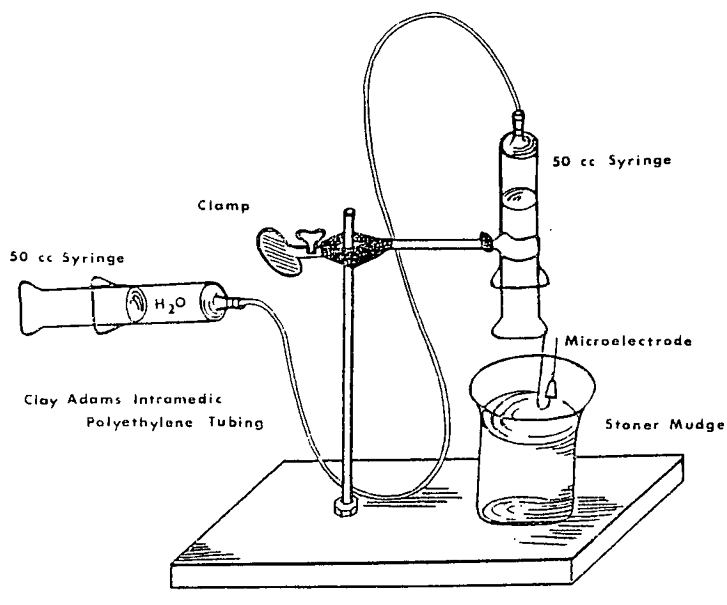

FIG. 2. Apparatus for coating microelectrodes.

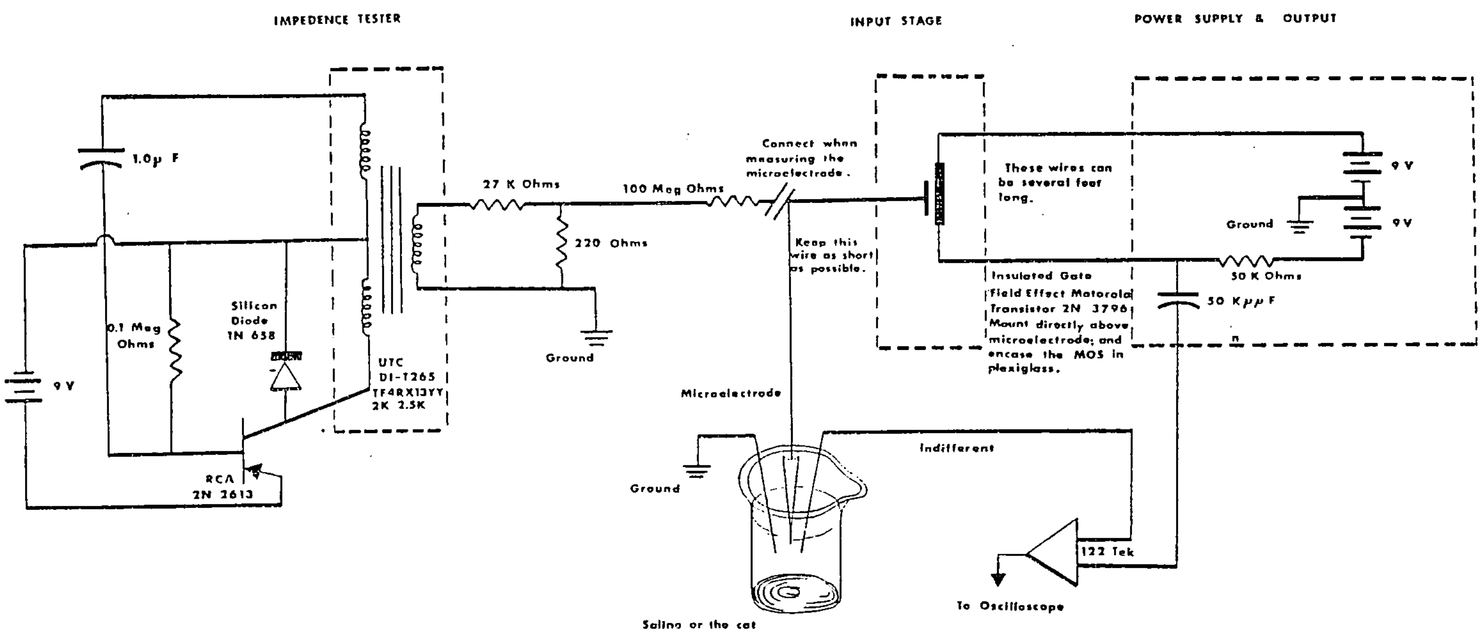

FIG. 3. Block diagram for microelectrode recording.

Input stage

The input stage (Fig. 3) is a source-follower circuit; the active element is an insulated-gate field effect transistor. Two 9 V batteries power the source-follower, the wattage used being so small that the life of the batteries is nearly equal to their shelf life.

Recording

Most of our recording is done on paralyzed animals, locally anesthetized at all surgical and pressure points. Animals are held in a Horsley–Clarke stereotaxic apparatus and given general anesthetic during preparation. After the brain is exposed, a small well is made from the skin flaps. An agar solution (1 g of agar in 50 cm^3 of saline) is poured into the well at 41°C. When the agar hardens, a microelectrode can be pushed through it into the brain. For cortical work the electrode can be positioned just above the cortex before the agar is poured.

Once inside the recording area the microelectrode should be advanced slowly, 20–30 μ at a time. Because the vinyl coating on the electrode adheres to the tissue, the stereotaxic apparatus must be tapped with a small metal object after each advance. This frees the tissue momentarily and allows the electrode to settle into a stable position.

With these techniques, large, clear single-unit spikes can be maintained for several hours.

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