SHORT COMMUNICATION

A LIGHT, PORTABLE APPARATUS FOR THE ASSESSMENT OF INVERTEBRATE HEARTBEAT RATE

BY PETER BUCHAN
AFRC Unit of Insect Neurophysiology and Pharmacology,
Department of Zoology, University of Cambridge, Downing Street,
Cambridge CB2 3EJ

LLOYD PECK
British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET

AND NATHAN TUBLITZ
Institute of Neuroscience, University of Oregon, Eugene, OR 97403, USA

Accepted 18 January 1988

A major problem for invertebrate physiologists is that most measurements of physiological parameters are made in the laboratory, rather than in the field, often because of restrictions imposed by equipment size and sensitivity. It is questionable as to how representative such results are of animals in their natural environment. One technique that has been employed in the laboratory involves the measurement of electrical impedance, for example to monitor heartbeat (Hoggarth & Trueman, 1967; Ansell, 1973; Tublitz & Truman, 1985). To allow such measurements to be made in the field as well as the laboratory, a small, light and portable apparatus has been designed.

The transducer described here was designed to measure changes of electrical impedance between two implanted electrodes. The electrodes were coupled to a 50kHz oscillator, so that, as the impedance changed, the oscillator output was amplitude modulated. The oscillator used a Neosid inductance type 10D/WR which had 50 turns of 30 gauge enamelled copper wire wound on the bobbin, and a second winding of 25 turns served to couple the oscillator to the electrodes.

The complete circuit less power supply is shown in Fig. 1. Oscillator output to the detector circuit was buffered by a single bipolar transistor. IC1 amplified the signal about 40 times, which was detected and rectified by IC2. IC1 and IC2 should be the high-frequency version of the ubiquitous 741. A 10kΩ variable resistor was used in the absolute value rectifier inverting input to balance out any diode difference. An RC integrator of time constant about 0.4 ms on the output of the rectifier removed the 50kHz component, leaving the modulation to be further amplified to about 25 times or as required by IC3. This amplifier also provided a wide range of d.c. offset. A moving coil meter was connected across the integrated output of the rectifier to set oscillator bias at the correct level.

Key words: invertebrate, impedance, heart rate, mollusc.
Fig. 1. Circuit diagram. On the left is the oscillator which uses a 2N3819 FET (TR1). VR1 is the bias control which is mounted on the front panel with VR4 (manual d.c. offset), and VR5 (output amplitude). TR2 isolates the oscillator from IC1 which amplifies the signal for the detector IC2. VR2 adjusts any difference between D1 and D2 as measured on pin 6 of IC2, M is a 1 mA FSD meter. S1 switches from manual to auto-offset, manual offset is adjusted by VR4 and, finally, output amplitude is set by VR5. All resistors are ±10%.

A characteristic of experiments which were carried out over long time periods is that the baseline often changed, sometimes to an extent sufficient to take the recording off scale. To eliminate this an additional circuit was added, IC4, which automatically compensated for baseline drift but left the modulation content for recording. The low-frequency cut-off of this circuit was 0.02 Hz.

Circuit layout is not critical, vero-board being perfectly satisfactory. IC1 should have power supply decoupling as shown. A ±15 V, 100 mA PSU was constructed and mounted in the same case. All components were obtained from R. S. Components with the exception of the adjustable inductance which was purchased from Neosid Ltd, Stonegills House, Welwyn Garden City, Herts. The whole apparatus fitted into a box 200 mm x 150 mm x 75 mm and the total mass was 1.65 kg.

Connecting wires between the impedance converter and the preparation were made with flexible insulated wire. They were not twisted together, and were only as long as was necessary to make the connection. Although the detector provided 3 V maximum output, 1 V was, in general, sufficient and gave good resolution. Sometimes it was possible to see modulation as small excursions of the meter pointer.

The equipment described here was tested by obtaining heartbeat measurements from three very different invertebrate species: the tobacco hawkmoth, Manduca sexta, the gastropod mollusc, Nacella concinna, and the brachiopod, Liothyrella uva, specimen traces of which are shown in Fig. 2.

We would like to thank the AFRC Unit of Insect Neurophysiology and Pharmacology and the British Antarctic Survey for supporting this work.
Fig. 2. (A) *Manduca sexta*: impedance recording of the heartbeat of a pharate adult. The recording shows periods of fast and slow heartbeat associated with heartbeat reversal. Rates range from 27 beats min\(^{-1}\) to 45 beats min\(^{-1}\). (B) *Liothyrella uva*: heartbeat trace of an individual at 0°C. Its length was 38.7 mm. Heart rate = 0.8 beats min\(^{-1}\). (C) *Nacella concinna*: a typical heartbeat trace. Rate of beat is approximately 12 beats min\(^{-1}\). The specimen was held at 0°C and was resting. Animal length was 24.1 mm.

References
