

TECHNICAL NOTE

INDUCTIVE ATTENUATOR FOR CONTINUOUS REGISTRATION OF RHYTHMIC AND PERIODIC ACTIVITY OF MUSSELS IN THEIR NATURAL ENVIRONMENT*

WHEN investigating behavioural phenomena, the maintenance of the natural environment of animals and the objective, continuous recording of the basic life processes are very important criteria. It is especially difficult to ensure corresponding experimental conditions for animals living under water, as Pelecypods do.

For recording rhythmic movements of the valves mechanical apparatus has been used (BARNES 1955; BROWN, 1957; SALÁNKI and BALLA, 1963). One of the drawbacks of these methods is that during recording of the shell activity the animal is fixed and data may differ from those of animals moving free in their natural environment. Another disadvantage is the fact that recording must take place under laboratory conditions, and the animals are inevitably exposed to the influence of artificial factors. Recently HOGGARTH and TRUEMAN (1967) worked out a method of applying an impedance pneumograph for the registration of the activity of free mussel, but no detailed technical description was published.

As it is well known, the contraction and relaxation of the close muscles (adductors) in mussels results in the closing and opening of the valves, and this behavioural phenomenon assures the basic mechanism for several important life processes (filtration, feeding, respiration, accommodation and protection) (BARNES, 1955; KOSHROYANTS and SALÁNKI, 1958; SALÁNKI, 1965, 1968). The apparatus constructed by us is suitable for any long lasting, continuous activity registration of adductors of free moving animals in their natural environment.

The block diagram of this apparatus is presented in Fig. 1. A sensor which does not affect the function of adductors in either the contraction or the relaxing phases is used in the new equipment. At the same time it permits free movement of the mussel inside a ring of 4 m dia., including burrowing into the sand or mud.

The most important part of the recording equipment is the motion sensor located on the outer side of the mollusc shell. The sensor may be regarded as an inductive attenuator having two parallel tuned circuits of the same frequency. Inductive coupling of the primary and secondary circuits is dependent on the distance of the two shells. Driving the primary circuit with a generator tuned to the resonant frequency, the secondary voltage will be proportional to the coupling between the two circuits and thus to the shell movement of the animal. The function of the inductive attenuator type sensor may be

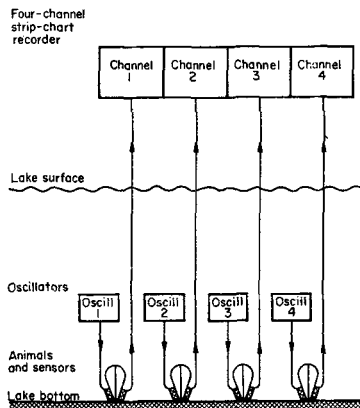


FIG. 1. Operating diagram.

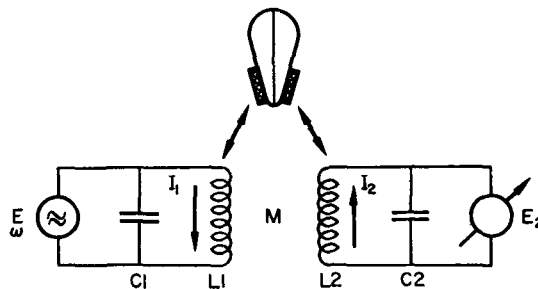


FIG. 2. Principle of inductive attenuator-type sensor.

seen from Fig. 2. If both circuits are tuned to the angular frequency ω and the primary current is I_1 , then the voltage induced in the secondary circuit will be given as follows:

$$E_2 = I_1 \omega M,$$

where M is the mutual inductance given by

$$M = k\sqrt{(L_1 L_2)}.$$

* Received 9 September 1968.

Here k denotes the coupling factor dependent on the distance between the two shells. It is important not to exceed the critical coupling as excessive closeness of the two coils may result in detuning of the resonant circuits.

The circuit diagram of the sensor used is shown in Fig. 3. The voltage induced in the secondary circuit is detected at the site of the circuit, so the signal connection to the

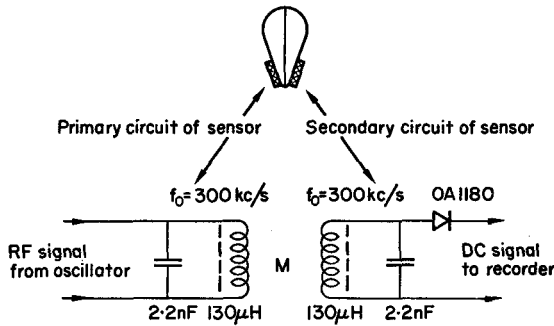


FIG. 3. Practical circuit of inductive attenuator-type sensor.

recorder is simplified. Sensor components are mounted on printed boards resulting in a compact, miniaturized device of high reliability. The finished assembly is filled with Araldite adhesive for trouble-free underwater operation. A sketch of the sensor layout is shown in Fig. 4, and the mounting of the sensor on the animal is depicted in Fig. 5. The mounting requires two holes of 1 mm dia. each; these are drilled carefully at the lower edge of the shells without damaging the soft parts of the animal.

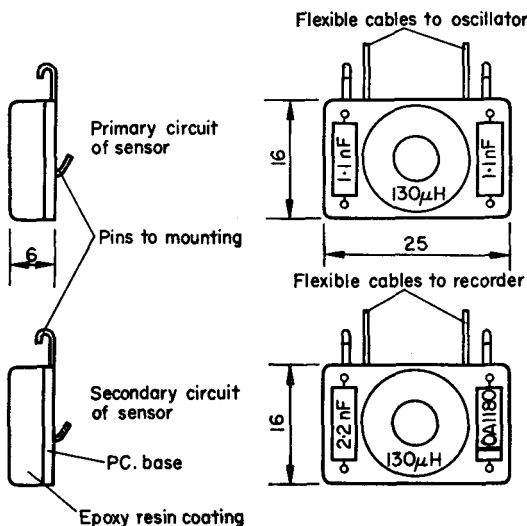


FIG. 4. Construction and size of practical sensor.

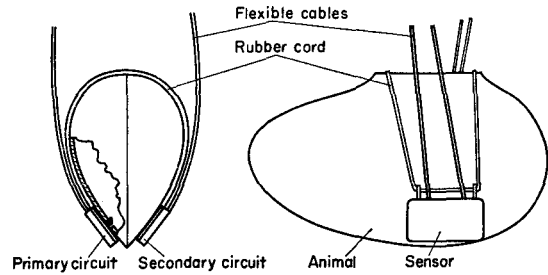


FIG. 5. Sensor mounting on the animal.

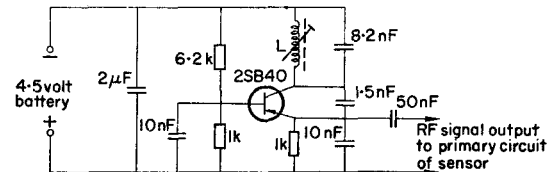


FIG. 6. The oscillator circuit.

The circuit diagram of the oscillator driving the primary circuit of the sensor is given in Fig. 6. Oscillation frequency is 300 kHz which is adjustable by tuning the inductance $L/100 \mu\text{Hy}$ by ± 10 per cent to correspond to the sensor resonant frequency. The oscillator is placed in a plastic cylindrical container. After switching on the battery, a water-tight seal is applied. The oscillator assembly is thus capable of being operated under the water, near the sensor. The two units are interconnected by a low capacity cable of 2 m length, assuring an appropriate Q-value for the tuned circuits. The detected signal from the sensor secondary circuit is carried through the oscillator assembly, serving as a mechanically fixed location, to the compensation circuit of the four channel recorder. Between the sensor and the recorder, a gain equalizer stage is inserted. The recorder is driven by the amplified error signal of the compensation circuit, thus plotting the periodic activity. The practical arrangement of the equipment is shown in Fig. 7.

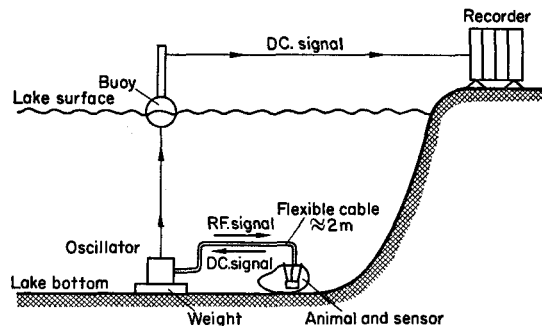


FIG. 7. Practical arrangement.

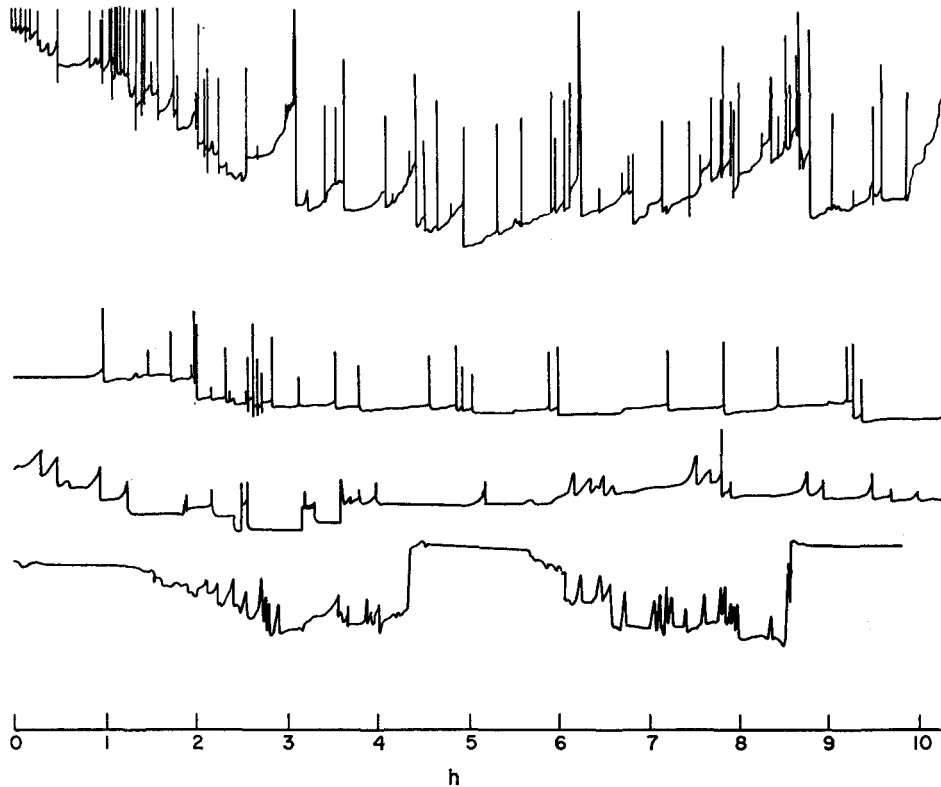


FIG. 8. Part of the registration of activity in four animals.

Figure 8 presents the activity of four animals recorded with our four channel apparatus. The size and time relations of the shell movements, proportional to the contraction and relaxation of the adductors, are well shown. Upward deflection corresponds to shell closure, downward deflection to shell opening. The appearance of periodicity in the activity can be seen on the last curve.

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