Pressure-Sensing Ultrasonic Transmitter for Tracking Aquatic Animals

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A small transmitter (7 × 1.6 cm) for telemetering swimming depth of aquatic animals was developed. The transmitter operates for 3 days with a signal range of about 1 km in sea water. It codes depth to 40 m or more as changes in pulse repetition rates, detectable by standard ultrasonic receivers.

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Nous avons mis au point un petit transmetteur (7 × 1.6 cm) permettant de télémesurer la profondeur de nage des animaux aquatiques. Le transmetteur peut opérer durant 3 jours avec une portée de 1 km dans l'eau de mer. Il codifie la profondeur jusqu'à 40 m sous forme de changements du taux de répétition des pulsations, décelables par des récepteurs ultrasoniques ordinaires.

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By methods previously reported for tracking aquatic animals by ultrasonic telemetry, only the horizontal components of movement could be studied (Stasko 1971) because swimming depth could not be measured directly except on very large animals. This shortcoming has limited the value of tracking studies in waters where temperature, salinity, oxygen concentration, chemical composition, illumination, and currents vary with depth.

The pressure-sensing transmitter described herein is the first unit small enough to be used in the gut of adult salmon and eels. It has performance characteristics similar to currently available location-only transmitters. The transmitter is a cylindrical capsule 7 × 1.6 cm (15 cc), weighing 17 g in water; it operates at 75 kHz with a battery life of about 3 days and signal range of about 1 km in sea water. Depth to 40 m is coded by pulse repetition rate of the signal (40–400 pulses/min); greater depths are possible with a different transducer. Pulse repetition rates vary linearly with depth. The range of pulse repetition rates can be compressed (e.g. 40–200 pulses/min) if counting up to 400 pulses/min proves too difficult.

Accuracy of the most recent prototype is ± 0.35 m over a range of depths from 0 to 40 m, maintained over temperatures 5–20 C. Cost of discrete components is approximately $80 for small quantities. A commercially manufactured version of the transmitter using thick film techniques will soon be available (Epitek Electronics, Ottawa). The acoustic signal radiation pattern in two planes is shown in Fig. 1; the units are db re 1 microbar at 1 m.

The pressure sensor (Kulite model TQL-360-50S; or model TQL-360-100S for depths to at least 70 m) uses a silicon diaphragm with diffused strain-gauge bridge mounted over a sealed reference air space. The transducer, as sold, is not compatible with salt water, but works well when protected by a 5-mm layer of silicone grease.

The tone-burst circuit in the transmitter (Fig. 2) is a squegging oscillator similar to that used by Thorson et al. (1969) with an output amplifier stage driving the piezoelectric transducer. Pulse repetition rate is varied by controlling the bias current to the oscillator transistor. The bridge output is interfaced to this control circuit by a difference amplifier with level shift. We use a Westinghouse WC788 micropower triple op-amp. The first two op-amps are connected as a high-gain difference amplifier with a gain of 101. As these amplifiers are a single integrated circuit their thermal drifts are closely matched and it can be shown that in this case the drifts of A1 and A2 cancel. The third op-amp has a gain of

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approximately 1.2 and gives a level shift of about -2 v with negligible thermal drift. The resistor controlling this level shift is the only component that has to be individually selected for each transmitter.

The pulse repetition rate is not very sensitive to battery voltage. Tests showed a shift corresponding to about 2 m depth for a one volt change, but the manufacturer's specifications for the 6.2-v silver-oxide battery show only a 0.2 v drop in the first 10% of rated life, a 0.1 v drop in the next 80% of life, and then a very rapid fall at the end.

Nine of these transmitters have been used to track 4-kg adult Atlantic salmon ascending an estuary (four fish for a total of 53 hr) and 2-kg adult American eels descending an estuary (five fish for a total of 64 hr); the longest single tracking lasted 34 hr. Field and laboratory tests showed that the transmitters register depth equally well from inside the fish's stomach and from outside the fish.

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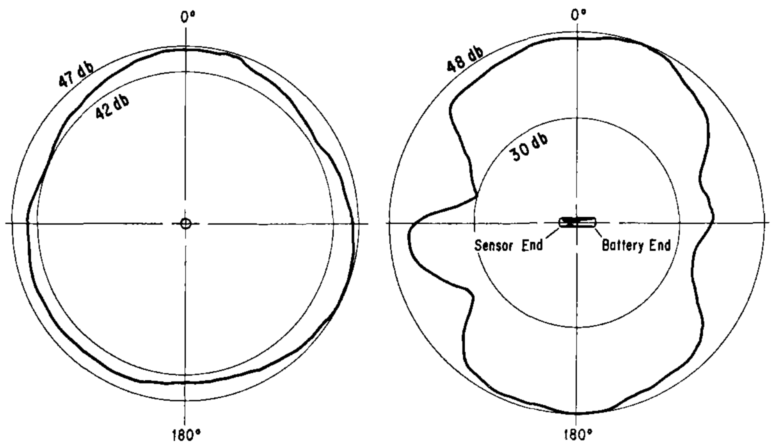

FIG. 1. End and side views of acoustic signal radiation pattern of transmitter (at center of each pattern).

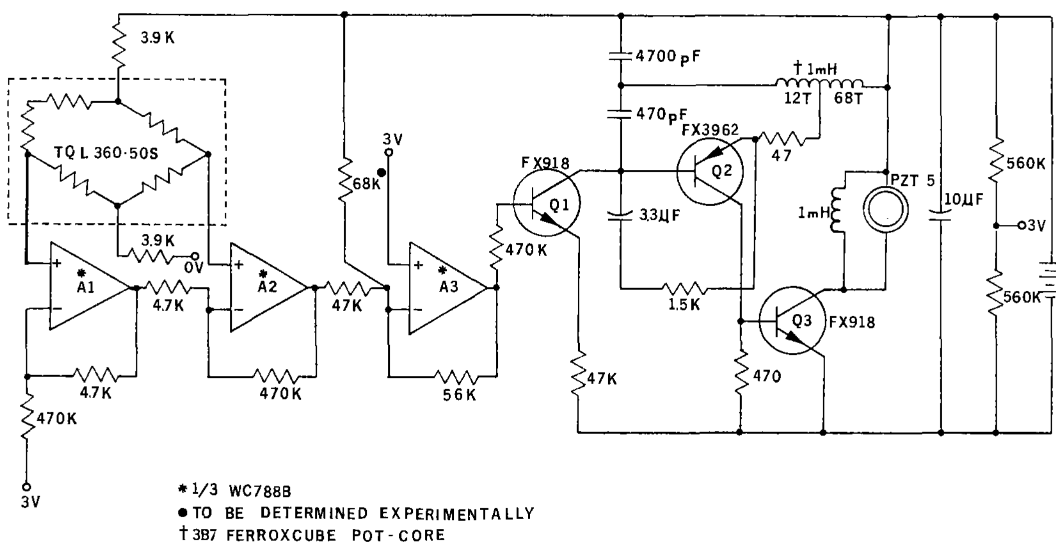

FIG. 2. Schematic of the transmitter.

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Addendum: Mercury Removal from Fish Protein Concentrate

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THE following statement was inadvertently omitted in the last paragraph on p. 1778, after "Since the normal process did not remove the mercury, a more severe system for extraction was tried": This was the method described by Zitko (1971), in which the benzene used in the extraction of methylmercury in the methods of Westöö (1966) and Gage (1961) is replaced with alcohol to remove the mercury compounds from the proteins in the presence of hydrochloric acid.

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