Construction of Transmitters for Radio-Tracking Hares and Mountain Beavers

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THIS PAPER describes construction, encapsulation, and attachment of miniature radio transmitters for hares and mountain beavers. The circuit is identical to that described by Tester, *et al.* (1964 J. Wildl. Mgmt. 28(1):42-45) but with significant changes in construction methods (Figure 3 shows this circuit). Bureau biologists Paul Martin and Dan L. Campbell contributed valuable suggestions and conducted the field trials leading to the final design.

Materials and Methods

Initial attempts to design a simple slip-on collar or harness transmitter for hares and mountain beavers were discouraging. A hare's neck is considerably smaller than its skull, and a collar of sufficient diameter to slip over its skull and ears was extremely loose. This looseness contributed to skin abrasions and permitted the animal to slip its forefeet through the collar. The neck and skull of the mountain beaver are approximately of the same diameter and hence these animals became very adept at "shucking" the slip-on collar. Harnesses were also tried, but both hares and mountain beavers immediately severed the straps by chewing. These problems were alleviated by designing break-open collars which closely encircled the animal's neck. The final design described here has proved to be satisfactory under field conditions.

Transmitter components, including the antenna, are mounted on a copper-laminated epoxy board (Figure 1) using a printed circuit technique. The board is cleaned with detergent, dried, and the copper surface immediately covered with pressure-sensitive tape to prevent oxidation of the surface to be etched away. The desired circuit/s is then drawn as in Figure 1. The diagonally hatched portion is removed and the board immersed in an etching bath (ferric chloride · hydrochloric acid; commercially available as etching solution from electronic distributors). Etching time varies with temperature but normally requires approximately 30 minutes at room temperature. The board is then washed with tap water, the remaining tape removed, and the board drilled (No. 60 drill) for mounting the components as indicated by the dots in Figure 1.

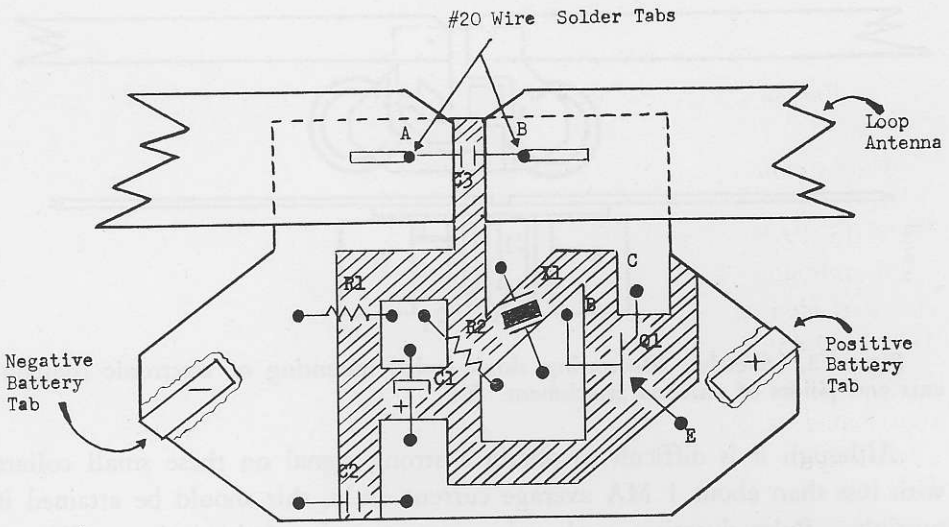

Figure 1. Dorsal view of circuit board with components indicated schematically. X4

The antenna-collar is two strips of soft copper flashing measuring ¼ inch wide, .025 inch thick, and 3 to 4 inches longer than the circumference of the subject animal's neck. The final length (including gap on circuit board) is approximately 4½ inches for hares and 6½ inches for mountain beavers. The two strips are soldered to the circuit board as depicted in Figure 2. It is desirable to drill the antenna and circuit board at points A and B (Figure 1) with a No. 60 drill and solder in 2-inch pieces of No. 20 bare wire to facilitate attaching the tuning capacitor (C_3) when fitting the transmitter to the subject animal.

All components are mounted, using a single-ended style, on the epoxy side of the board and soldered on the copper side (Figure 2). Good soldering techniques, using only rosin core solder, and heat sinking the heat-sensitive components are prime requisites for a suitable transmitter. Attachment sequence is not critical, but heat damage to the transistor can be avoided by mounting that component just prior to final tuning in the laboratory.

Transmitters are assembly-line constructed and initially resonated in the laboratory by using a 50 to 400 micromicrofarad variable capacitor (padder) and the diode detector and milliammeter as described by Verts (1963 J. Wildl. Mgmt. 27(3):325-329). The padder is temporarily soldered in the C_3 position, carefully tuned to resonance, removed and measured on a capacity bridge. Resonance is indicated by a pulsed MA drain and RF field. The range of capacitance is noted for various diameters of the loop as final tuning is conducted in the field.

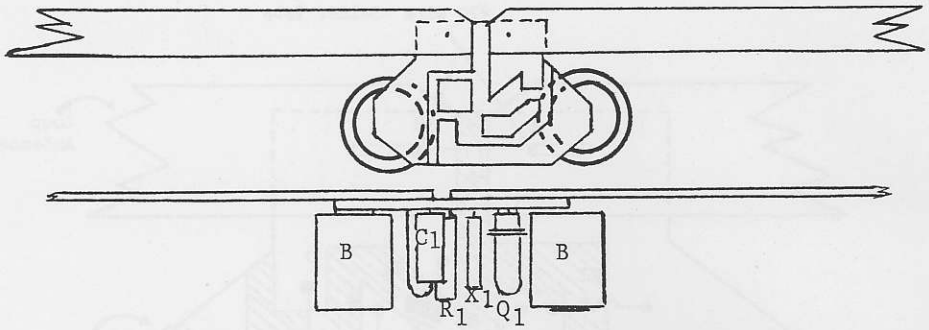

Figure 2. Sketches illustrating single-ended mounting of electronic components and points of antenna attachment. X1

Although it is difficult to obtain a strong signal on these small collars with less than about 1 MA average current drain, this should be attained if possible. Pulse duration, peak pulse current, and repetition time will vary with each transmitter due to component tolerances. For example, a transmitter with two series connected 1.35 volts (V), 350-milliampere-hour (MAH) batteries; a pulse time of 16 milliseconds; repetition time of 750 milliseconds; peak cycle current of 26 MA; and an average current of 0.5 MA will give an expected life of 700 hours or 29 days. This life expectancy can be increased by using four mercury cells in series-parallel, thus increasing the total MAHs available.

The cases of the transistor, electrolytic capacitor, batteries, and the crystal are insulated from each other by wrapping each with one layer of plastic electrical tape. The battery tabs are soldered as indicated in Figure 1 and suspended from the circuit board (Figure 2). A single layer of tape is wrapped completely around the circuit board and components in such a manner that components may be separated from the potting resin. The 2-inch bare wires are left exposed outside the potted transmitter for final field adjustment of C_3. Any light, quick-drying resin or rubber may be used for potting. The potted transmitter should be carefully inspected, since the smallest hole in the resin will permit enough moisture to enter to short out the transmitter.

Field attachment of the transmitter includes careful fitting to the animal's neck, adjustment for a maximum RF field by trial of dipped mica capacitors across the two bare wires, and soldering the antenna (an asbestos strip protects the animal). The excess copper antenna is then cut away, and the attachment is completed by wrapping the collar and tuning capacitor with additional tape. Careful potting around the exposed tuning leads is required to prevent shorting by moisture.

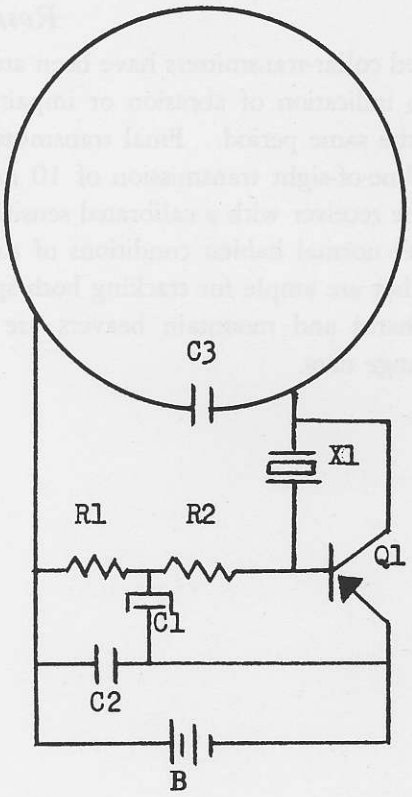

Figure 3. Pulsed transmitter circuit after Tester, *et al.* (1964).

TABLE 1. LIST OF PARTS REQUIRED FOR TRANSMITTER CONSTRUCTION

(X_1)	Type HC18/U subminiature crystal
(R_1)	47 K to 470 K, 1/10 W resistor
(R_2)	1 K to 2.2 K, 1/10 W resistor
(C_1)	1 mf to 20 mf, 10 WVDC miniature electrolytic capacitor
(C_2)	.01 mf ceramic disc capacitor
(C_3)	5 mmf to 350 mmf dipped silver mica capacitor
(Q_1)	2N588 or 2N1742 transistor
(B_1)	2, 1.35 V series connected, 350 MAH mercury batteries
	Copper laminated epoxy circuit board, .025-inch thick copper flashing

Results and Discussion

The above-described collar-transmitters have been attached to captive hares for 20 weeks with no indication of abrasion or impairment and have transmitted efficiently for the same period. Final transmitter weight ranges from 30 to 38 grams. A line-of-sight transmission of 10 miles has been attained using a superheterodyne receiver with a calibrated sensitivity of less than 1/10 of a microvolt. Under normal habitat conditions of rolling, forested terrain, signals are attenuated but are ample for tracking both species. At the present time, six free-living hares and mountain beavers are being monitored for acquisition of home-range data.