EQUIPMENT AND TECHNIQUES FOR RADIOTRACKING MOUNTAIN LIONS AND ELK

John C. Seidensticker IV
Maurice G. Hornocker
Richard R. Knight
Steven L. Judd

Idaho Cooperative Wildlife Research Unit
University of Idaho
Moscow, Idaho

September, 1970

Forest, Wildlife and Range Experiment Station
Bulletin No. 6

BULLETIN NO. 6

ERRATA

1. Table 1: C_1 should be C_3

   C_2 should be C_4

   C_3 should be C_1

   C_4 should be C_2

2. Figure 9 B: "1MHz Choke" should be "1MH choke"

   Figure 9 C: "1MHz Choke" should be "1MH choke"

   "Somma Match" should be "Gamma Match"

EQUIPMENT AND TECHNIQUES FOR RADIOTRACKING MOUNTAIN LIONS AND ELK

John C. Seidensticker IV
Maurice G. Hornocker
Richard R. Knight
Steven L. Judd

Idaho Cooperative Wildlife Research Unit[1]
University of Idaho
Moscow, Idaho

September, 1970

Forest, Wildlife and Range Experiment Station
Bulletin No. 6

[1] The University of Idaho, Idaho Fish and Game Department, U. S. Bureau of Sport Fisheries and Wildlife, and Wildlife Management Institute cooperating.

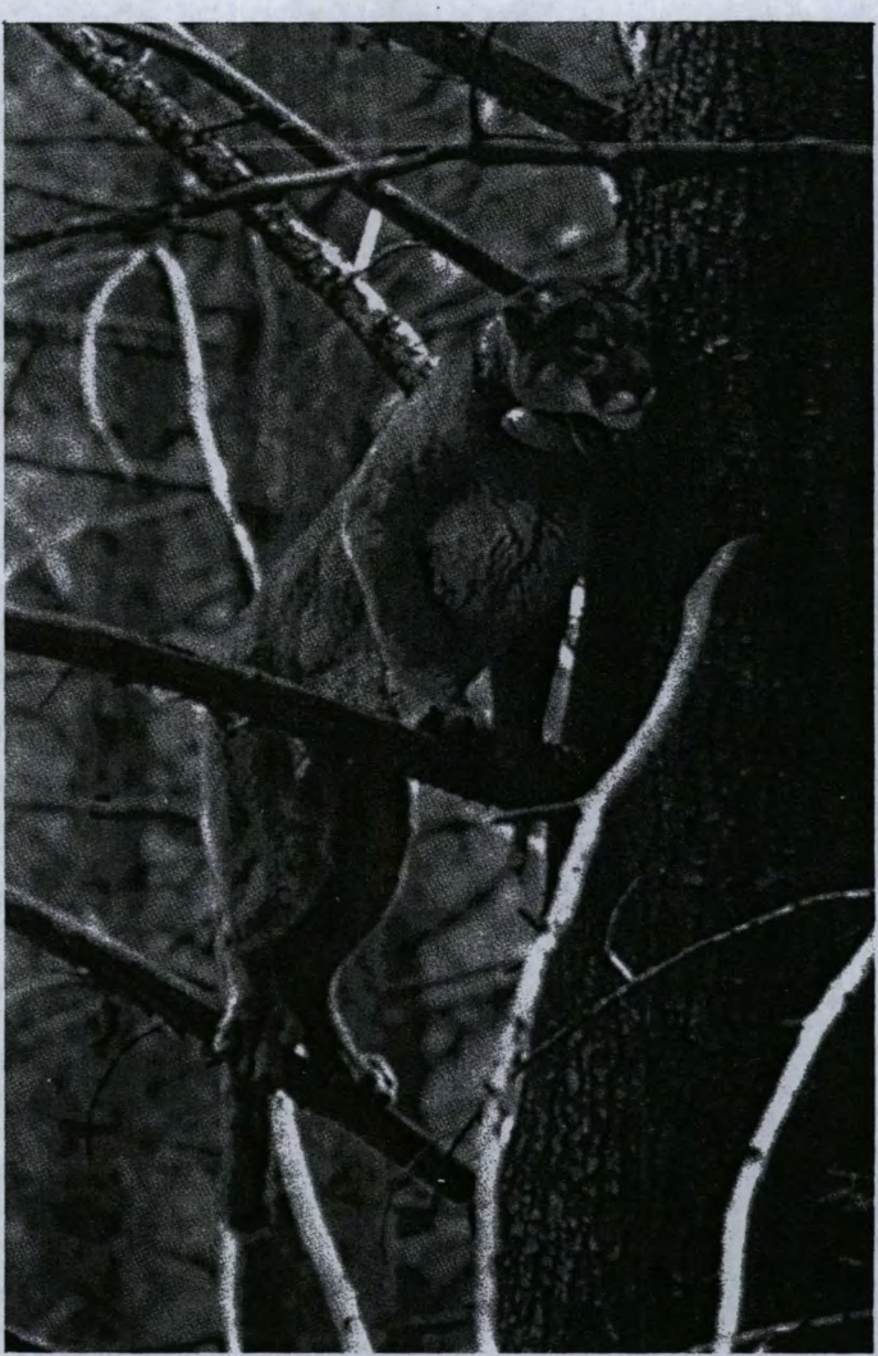


Figure 1. An adult female mountain lion with a radio transmitter collar. Radiotracking has provided information hitherto unobtainable from this species.

Acknowledgments

Funds for development and manufacture of radio-tracking equipment were initially granted to M. Hornocker by the Boone and Crockett Club and the New York Zoological Society. Further support for developing and perfecting the equipment and techniques described in this bulletin was provided by STAR(Short Term Applied Research) funds, Research Council, University of Idaho granted to M. Hornocker and R. Knight and a National Science Foundation Grant (No. GB-8734) awarded to M. Hornocker.

Albert Johnson of A. R. Johnson Electronics, Moscow, Idaho, working with the authors, designed the portable direction finder and modified circuits of other electronic equipment to suit our needs. This company produced most of the equipment that we used in our radio-tracking research.

Joel Varney, formerly of the Philco Corporation, gave advice on the basic design of the radiotracking system; Dr. K. Hungerford and A. Dyka helped with the design of some components. William Dorris, Johnson Flying Service, McCall, Idaho, assisted in planning radiotracking procedure from the air. We thank W. Wiles for help in the field.

Abstract

The radio equipment and tracking procedures used to gather quantitative data on the movements and other activities of mountain lions (*Felis concolor*) and elk (*Cervis canadensis*) in the mountains of central Idaho are described.

Introduction

We must have detailed knowledge of animal movement patterns if we are to expand ecological theory, preserve and intensively manage many species of large mammals. In the last decade, descriptions of numerous radiotracking systems appeared in the scientific literature (Barwick and Fullagar, 1967). With these systems researchers have a tool with a tremendous advantage over more conventional methods (Sanderson, 1966) of gathering quantitative data on animal movements.

Most radiotracking systems were designed to facilitate the gathering of movement data from small to medium sized animals living in comparatively small home ranges on flat terrain. Mountains have deep, narrow canyons, bluffs, escarpments, and similar landforms which act as barriers to a weak signal from a low power transmitter. A low-power emission is necessary because of weight and battery life considerations. This, the long movements made by large mammals, and the restricted mobility of an observer in the mountains were special problems which had to be overcome to make radiotracking an effective research tool.

In this bulletin, we describe the equipment and procedures we devised to follow the movements of mountain lions (*Felis concolor*) and elk (*Cervus canadensis*) in the mountains and deep canyons of central Idaho. We believe this equipment and procedure applied to the study of other large mammals occupying similar terrain will provide satisfactory results.

Slater (1965:81) defined biotelemetry as " . . . *the instrumental technique for gaining and transmitting information from a living organism and its environment to a remote observer*." We were interested primarily in transmitting signals from which locations and movements and other activities could be determined. This we term radiotracking. For our needs, it was necessary that the tracking system function so that individual animals could be located frequently enough during a specific time to place observations on a quantitative scale with little or no disturbance of the study animal.

A radiotracking system which will function satisfactorily as a tool in the study of an animal's ecology must be based on the biology and ecology of that animal. The requirements necessary to meet the objectives of the investigation must be transposed into specifications for the electronic equipment. The requirements provide a framework from which the ecologist and electrical expert can, through a joint effort, evolve a workable system for the field (Craighead et al., 1963).

A radiotracking system must include a transmitter with its power source and transmitting antenna which are attached to the study animal, a receiver with its power supply, and a direction-finding antenna. After considering the biology of the mountain lion and the elk, the terrain in the study areas, electrical problems, and after extensive testing (Hornocker and Seidensticker, 1970) we produced, and used the radiotracking system described below.

Description and Construction of the Radio Equipment

Frequencies

Craighead et al. (1963) point out that the choice of a radio frequency is a fundamental consideration in designing a radiotracking system since the radio frequency determines the specifications and capabilities of the tracking system components. Low frequency signals overcome shielding effect of terrain but require large antennas; high frequency signals tend to bounce and diffuse but require antenna sizes which are more ideally suited to portable direction finding equipment. Two frequency ranges were selected; each was considered the best compromise in light of the objectives of each study. For the lion work, frequencies in the 30 MHz range were utilized: 30.05, 30.07, 30.17, 30.19, 30.21, 30.23, 30.25 MHz. A permit for using these was obtained from the FCC through the U.S. Fish and Wildlife Service. Frequencies in the 47 MHz range were utilized in the elk investigation: 47.02, 47.03, 47.04, 47.05, 47.06, 47.07, 47.14, 47.15, 47.16, 47.17, 47.18 MHz. The permit to use these was secured from the FCC through the Idaho Fish and Game Department.

Transmitters

The transmitter circuit (Figure 2) is a modification of the constant wave type pulsed by a resistor-capacitor network described by Tester et al. (1964). From this basic circuit, 3 transmitters were developed: Models 1 and 2 transmit in the 30 MHz range and Model 3 transmits in the 47 MHz range (Figure 3). The component parts for the transmitters are listed in Table 1.

The 3 models of transmitters differ in effective radiated power (ERP) and current drain with approximately 0.5 mw and 0.9mw ERP for Models 1 and 3 and Model 2 respectively. Models 1 and 3 have a theoretical battery life of about 18 months while the battery life of Model 2 is computed to be approximately 9 months. A complete transmitter collar with batteries weighs about 24 oz.

When padded, the metal loop transmitting antenna acts as a collar for attaching the transmitter around the neck of the study animal The loops for Models 1 and 2 (30 MHz) are left open to be adjusted in size from 15 to hat individual animals could ime to place observations on the study animal.

satisfactorily as a tool in the ıe biology and ecology of that the objectives of the investi- or the electronic equipment. vhich the ecologist and elec- ɛ a workable system for the

ımitter with its power source the study animal, a receiver ntenna. After considering the : terrain in the study areas, Hornocker and Seidensticker, stem described below.

ruction
nent

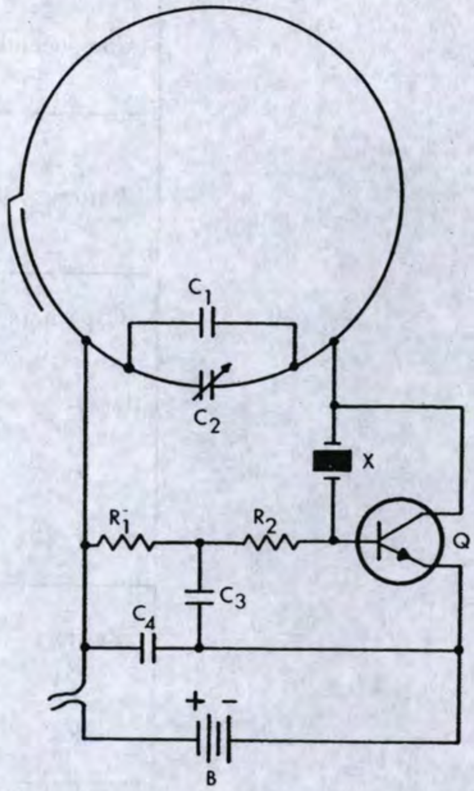
choice of a radio frequency ı radiotracking system since ons and capabilities of the nals overcome shielding effect uency signals tend to bounce ɛ more ideally suited to port- :y ranges were selected; each the objectives of each study. : range were utilized: 30.05, A permit for using these was nd Wildlife Service. Frequen- k investigation: 47.02, 47.03, 47.17, 47.18 MHz. The per- ıgh the Idaho Fish and Game

ification of the constant wave ribed by Tester et a1. (1964). ːloped: Models 1 and 2 trans- ts in the 47 MHz range (Fig- ıre listed in Table 1.

ɛctive radiated power (ERP) and 0.9mw ERP for Models d 3 have a theoretical battery ıf Model 2 is computed to be r collar with batteries weighs

antenna acts as a collar for the study animal The loops be adjusted in size from 15 to

Figure 2. Circuit diagram for the transmitter used for tracking mountain lions and elk.



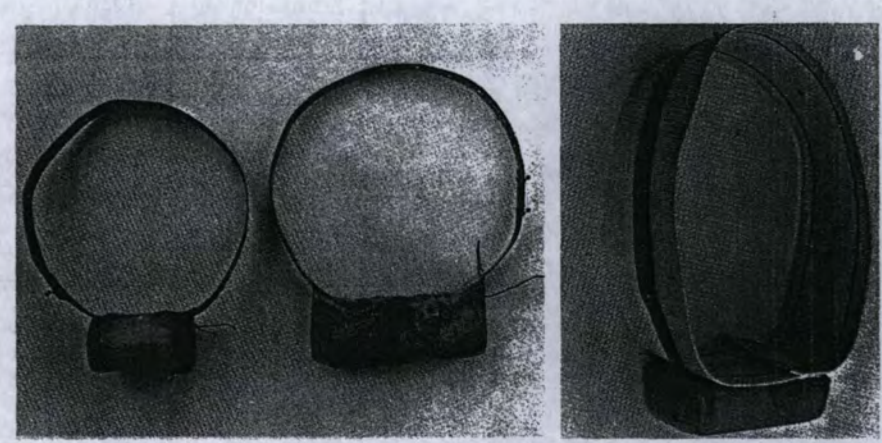


Figure 3. The fully assembled transmitters: A—Model 1 (30 MHz), B—Model 2 (30 MHz), and C—Model 3 (47 MHz).

Table 1. List of components used in constructing transmitters.

Components	Transmitter Model 1 (30 MHz)	Transmitter Model 2 (30 MHz)	Transmitter Model 3 (47 MHz)
Battery - B	Mallory RM-42RT-2 2-1.35V in series	Mallory ZRM4RT 7-1. 35 V in series	Mallory RM-42RT-2 2-1.35V in series
Capacitors			
C_1	10 mfd	10 mfd	10 mfd
C_2	.1 mfd	.1 mfd	.1 mfd
C_3	60 mmfd	60 mmfd	None
C_4	5-50 mmfd piston trimmer	5-50 mmfd piston trimmer	None
Resitors			
R_1	47K to 200K ohm[1]	47K to 200K ohm[1]	47K to 200K ohm[1]
R_2	1.5K ohm, 0.25W	1.5K ohm, 0.25W	
Transistor - Q	40235	2N5128	40235
Crystals - X	30.05, 30.07 30.17, 30.19 30.21, 30.23 30.25	30.05, 30.07 30.17, 30.19 30.21, 30.23 30.25	47.02, 47.03 47.04, 47.05 47.06, 47.07 47.14, 47.15 47.16, 47.17 47.18
Loop - L	copper strip 1 in wide, wt 32 oz/sq ft	copper strip 1 in wide, wt 32 oz/sq ft	copper strip 0.75 in wide, wt 32 oz/sq ft

[1]Depending on desired pulse

22 in. in circumference to fit the neck of the individual lion. This eliminates the need of backpacking several transmitters with various antenna circumferences. Closure is secured by overlapping the antenna ends and bolting them together. Since the capacitance of the animal's neck and changes in antenna circumference affect the tuning of the transmitter, final tuning for maximum output is achieved by adjusting the tuning capacitor after the transmitter has been fitted in place on the lion's neck.

The loop of Model 3 (47 MHz) is not adjustable. The metal loop, 31in. in circumference, was riveted to 2 ply, 4 in. wide neoprene-impregnated belting.[1] After the transmitter was fitted on the elk's neck, the tuning capacitor was adjusted for maximum output.

Nylon pipe couplings were used for the battery casing in all 3 transmitter types but the arrangements of batteries differ (Figure 3). For Models 1 and 3, a nylon coupling (1.5 x 4.25 in) was cut into two equal parts, the ridges were ground off and the two sections fused together with epoxy. The antenna was riveted to the battery casing and the transmitter components placed between the two ends of the metal loop. The tuning capacitor was placed on the underside of the battery casing (Figure 4). For Model 2, the nylon coupling was not cut but riveted whole to the loop. The transmitter components were placed between the ends of the loop on the battery casing and the tuning capacitor was placed on the underside.

Initially we embedded the transmitter collar in dental acrylic (Mech et al., 1965) but later we achieved more satisfactory results by wrapping the transmitter, battery pack, and a short section of the metal loop on both sides of the battery pack in fiberglas and coating it with 840 system epoxy resin.[2] Small multistrand wire leads were attached to the batteries and left exposed on most transmitters. The latest transmitters constructed for elk utilized a magnetic read switch embedded with the battery pack for greater moisture protection. An opening to the tuning capacitor was made by encasing it in a plastic straw before fiberglasing.

Portable receiver

A block diagram of the completely portable, double conversion superheterodyne receiver is shown in Figure 5. The circuit diagram and the component parts for receivers of both frequency ranges are shown in Figure 6. Ruggedly constructed, the receiver components fit into a 5 x 4 x 3 in. aluminum box. The power supply was 8 1.4 v penlight batteries (size AA, Mallory, ZM-9) which fit into the receiver's back. Component parts were arranged as illustrated in Figure 7. Receiver frequency ranges were divided into crystal controlled channels. Receiver sensitivity was 0.1 mv; audio output was 100 mw; the receiver with batteries weighed 34 oz.

The portable direction finder (portable receiver coupled with a tuned receiving antenna) is shown in Figure 8. The receiver was constructed with a standard coaxial cable fitting (50 ohm impedance) for coupling it to different antenna types. In addition, there were a headphone output receptacle and an input receptacle for an exterior power supply. For ground tracking, we used light 8 ohm headphones but in an aircraft an 8 ohm stereo headphone set was necessary to exclude outside noise. Receiver operation was improved in cold ambient temperatures by warming the power supply. This was done by carrying a battery pack in a shirt pocket and connecting it to the receiver when it was used.

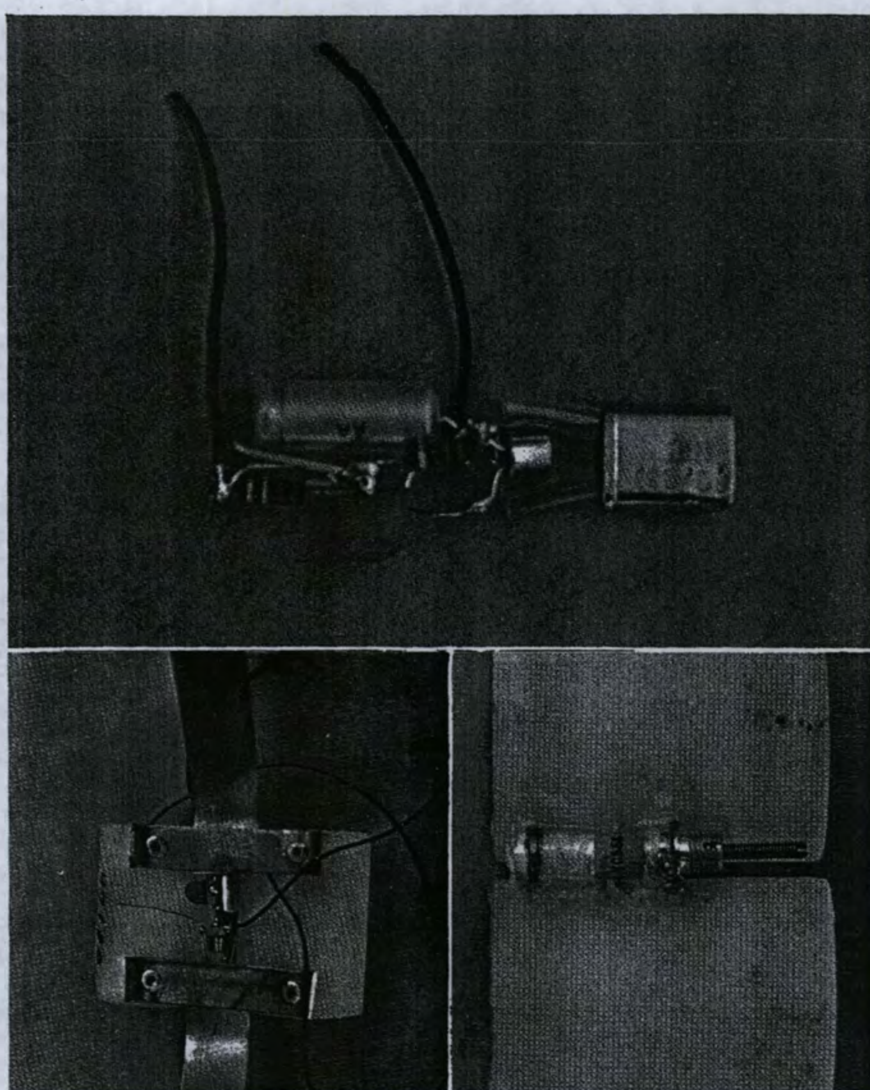


Figure 4. The arrangement of components in the transmitter.

Controls of the receiver include: (1) a channel selector switch, (2) a volume control which controls the power input into the audio amplifier, (3) a sensitivity control which regulates the R. F. gain, (4) a meter switch which switches the meter between the R. F. and A. F. circuits, and (5) a BFO pitch control which controls the audio tone through the beat frequency oscillator. The receiver controls were protected with a metal rim (see Figure 8).

Direction-finding antennas

Three types of antennas were used with the portable receiver: (1) tuned loops which were attached directly to the portable receiver or mounted on a

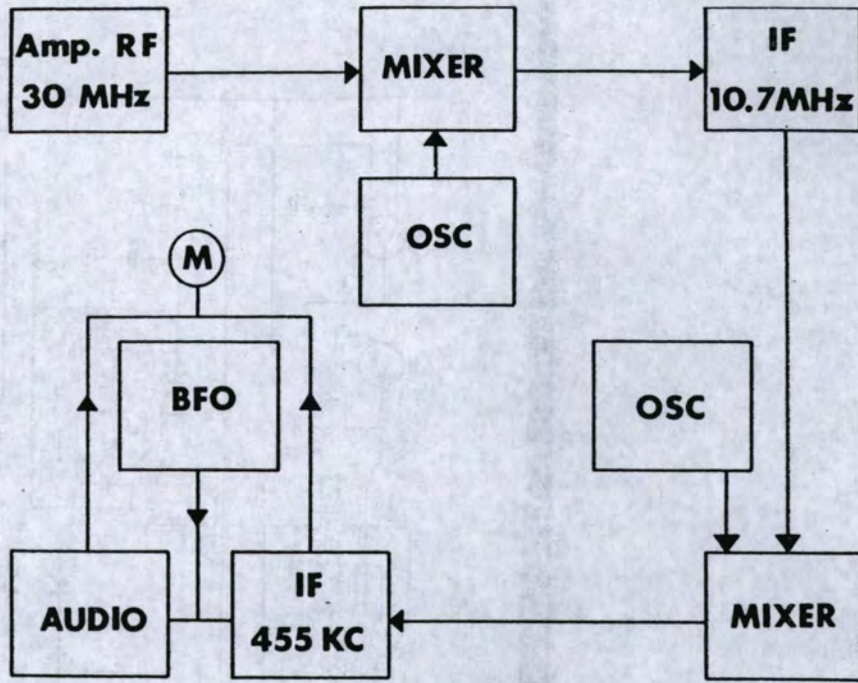


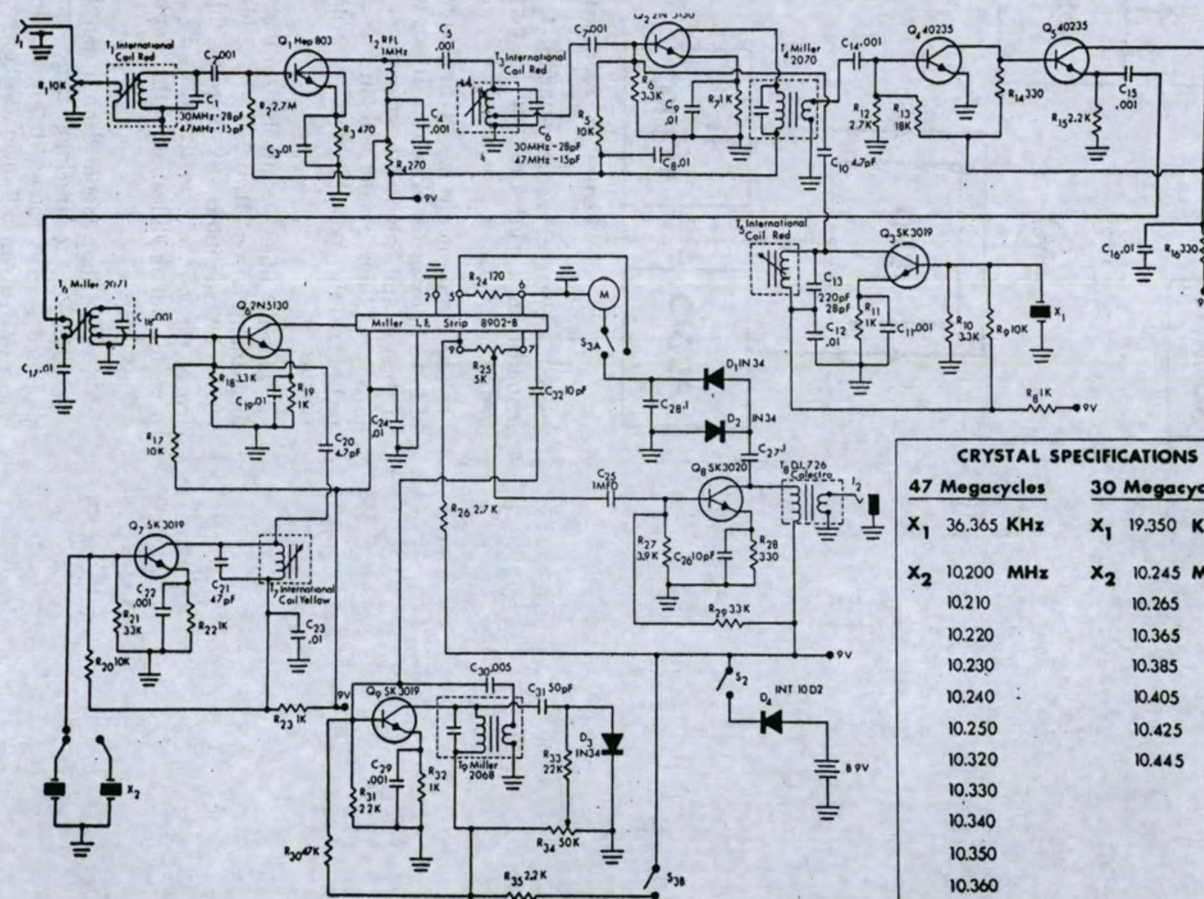
Figure 5. Block diagram of the receiver.

special moveable bracket attached to a light airplane, (2) whip antennas mounted on a truck cab, and (3) permanently stationed 3-element yagi antennas.

The loop antenna was a single turn loop, 12 in. in diameter constructed of 3/16 in diameter brass rod. It was tuned with a variable capacitor mounted at the top and balanced to ground (Figure 8 and 9-A). The loop was coupled to an amplifier circuit and after coupling the loop, this assembly was attached to the portable receiver with a standard coaxial cable connector (Figure 8).

The amplifier we attached to the loop antenna was designed by Hungerford and Johnson (In press) and field-tested and improved during the course of our investigations. By coupling this amplifier unit to the tuned loop antenna, the gain was increased by 15 db. The circuit diagram and component parts for our modification of the amplifier and its power supply are shown in Figure 9-B.

A tuned loop mounted on a movable bracket attached to a light airplane was the key to tracking large mammals in mountainous terrain. The mounted loop is shown in Figure 10. In flight, the shaft to which the loop was attached on a hinge was lowered and the loop was extended (Figure 11). Our bracket was a modified version of one devised by P. Schladweiler, Montana State Fish and Game Department (*in litt.*). The gain of this loop was also increased by 15 db with an amplifier modified to operate with the loop attached to the bracket (Figure 9-C).



CRYSTAL SPECIFICATIONS

	47 Megacycles		30 Megacycles
X_1	36.365 KHz	X_1	19.350 KHz
X_2	10.200 MHz	X_2	10.245 MHz
	10.210		10.265
	10.220		10.365
	10.230		10.385
	10.240		10.405
	10.250		10.425
	10.320		10.445
	10.330		
	10.340		
	10.350		
	10.360		

Figure 6. Circuit diagram for the portable receiver used for radiotracking elk and mountain lions.

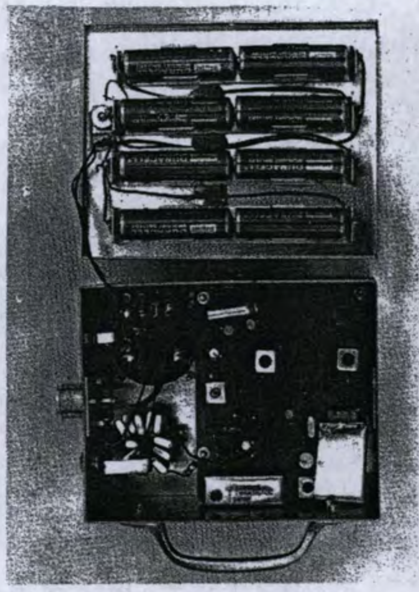


Figure 7. Arrangement of components in the receiver.

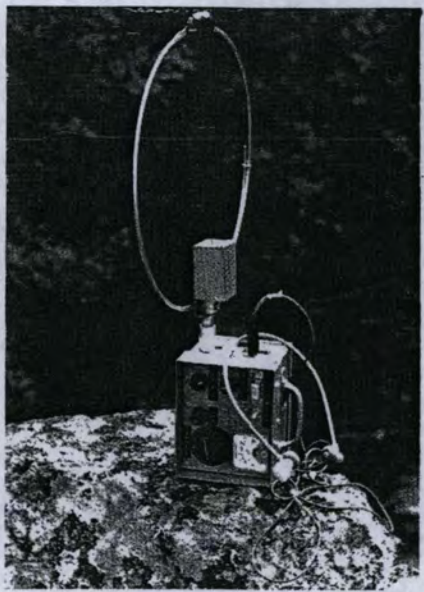


Figure 8. The portable direction finder.

The 3-element yagi antenna was mounted in a vertical position on top of a 20 ft. rotatable mast (Figure 12). The antenna was a citizens band type (Antenna Specialist Co. Model M-202[2]) modified for use at 30 MHz only. The element lengths are: reflector 216 in, receptor 184 in (upper half 91 and lower half 93), director 172 in with 40 in between the director and receptor elements and 53 in between the reflector and receptor. The gamma match was shortened 3 inches with an aluminum clip. This antenna had an original forward gain of 9 db and a front to back ratio of 22 db. The gain was increased by attaching an amplifier to the gamma match (Figure 9). The amplifier's power supply was attached directly to the receiver (Figure 12).

A whip antenna mounted on the cab of a truck facilitated rapid coverage of an area when an adequate road system was present. A base loaded whip (47 MHz only, Model ASPB-268[3]) was used as it came from the supplier in conjunction with an amplifier (Figure 9-C).

Construction procedure

In the account above our description has been such that a qualified radio technician working with the ecologist can construct the components of a radiotracking system for a specific species of large mammal. We have found this to be the most effective and efficient working arrangement. It also helps to keep orientation toward the research problem rather than toward the research method.

Attaching Radio Transmitter Collars

Final testing

Before attachment, each transmitter was tested in the lab and distance tests were conducted in the field to insure its proper operation.

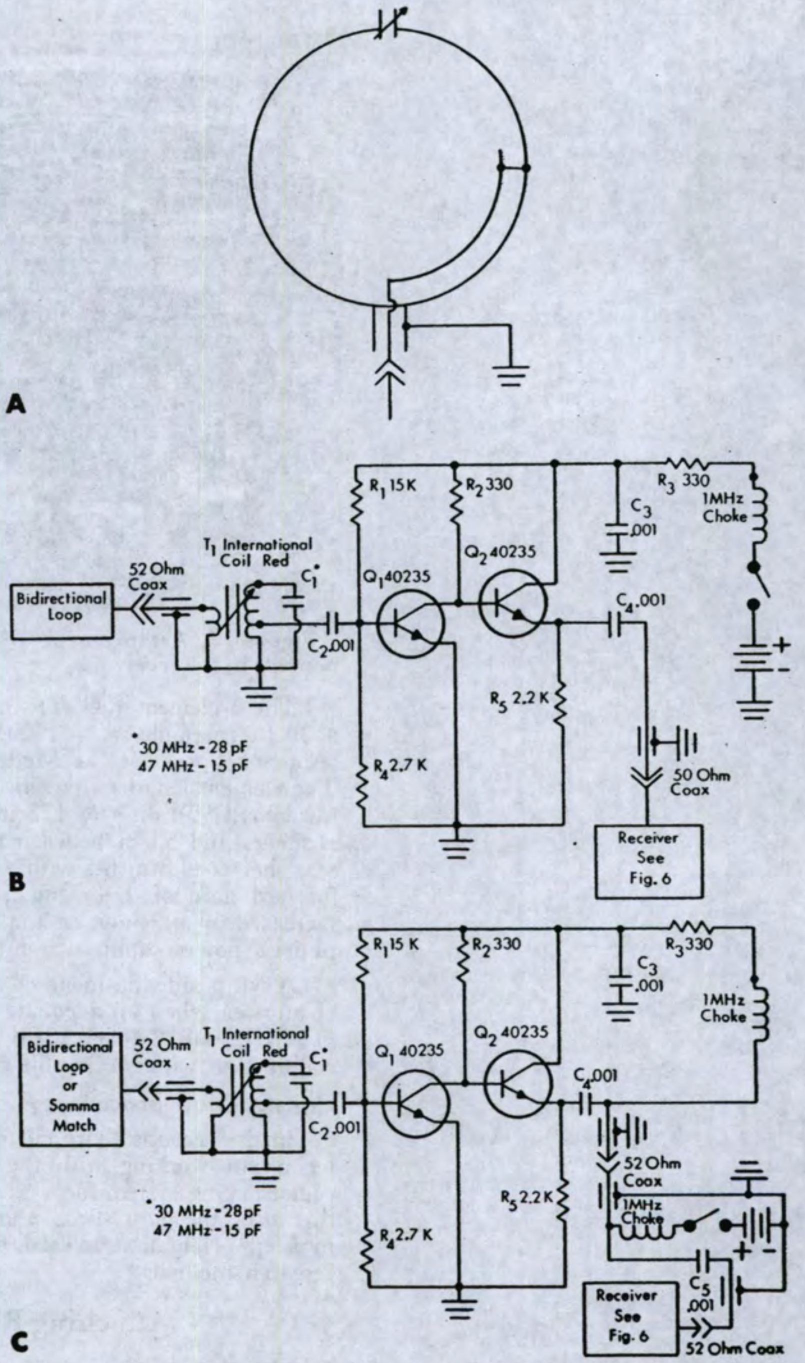


Figure 9. A—the circuit for the tuned loop receiving antenna; B—the circuit for the signal amplifier and its power supply for the tuned loop attached directly to the receiver; C—the circuit for the amplifier and its power supply for the aircraft loop, the 3-element yagi and the whip antenna.

Mountain lions

Mountain lions were captured using trained dogs (Hornocker, 1970), and were necessarily immobilized with an intramuscular injection of phencyclidine hydrochloride ("Sernylan") administed by Cap-Chur syringes fired from a specially designed powder-charged gun (Hornocker and Wiles, in press). A transmitter collar before and after it was placed on a lion's neck is shown in Figure 13 (also see Figure 1). The antenna loop was padded with split polyethylene garden hose covered with plastic electrical tape. As described above, the loop was left open to be adjusted in size to fit the individual lion. We closed the loop by bolting the two ends together; taping was completed after the collar was in place on the lion's neck. Battery leads were connected and soldered in the field using tape solder[4] and a kitchen match for heat. The leads were placed against the end of the battery pack and covered with "5-minute epoxy." Final tuning was done after the transmitter was in place on the lion by adjusting the antenna tuning capacitor and using the meter built into the portable direction finder or a small field strength indicator. The final step was to fill the end of the opening to the tuning capacitor with silicone rubber.

The transmitter t;pe we selected to attach to a lion (Models 1 or 2) was dependent on the data we sought. Tracking by air required a transmitter with less ERP than tracking from the ground. From above, the various landforms characteristic of mountains do not act as barriers to the radio signal. Hence, if we planned to gather information on lion movement from the air, we attached Model 1 with its lower ERP and battery drain (longer battery life) but Model 2 with its higher ERP was attached if we were to gather data on day to day movements and activities from the ground.

We believe that with only modification in collar size and attendant capacitors transmitter Models 1 and 2 will function satisfactorily on other large carnivores and medium to large-sized ungulates.

Elk

Elk were baited with hay and salt into corral traps. Transmitters were readied by closing, soldering and covering battery leads with epoxy as were

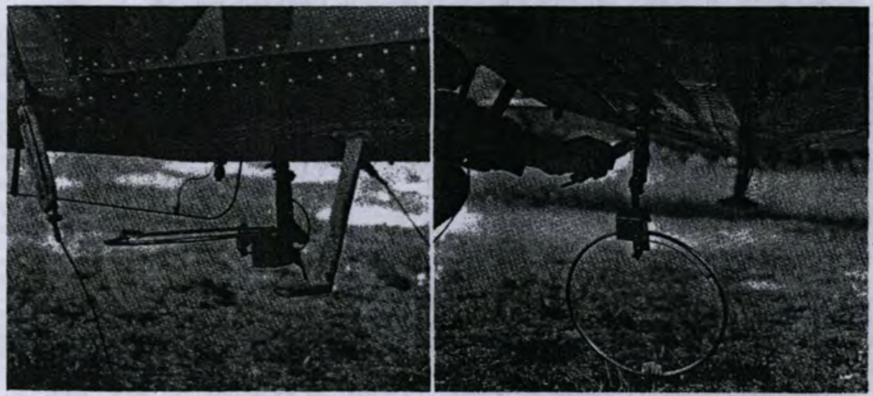


Figure 10. The Cessna 185 used for radiotracking mountain lions from the air. A—the loop is in the "up" position used for landing and taking off; B—in flight the shaft is lowered and the loop is extended.

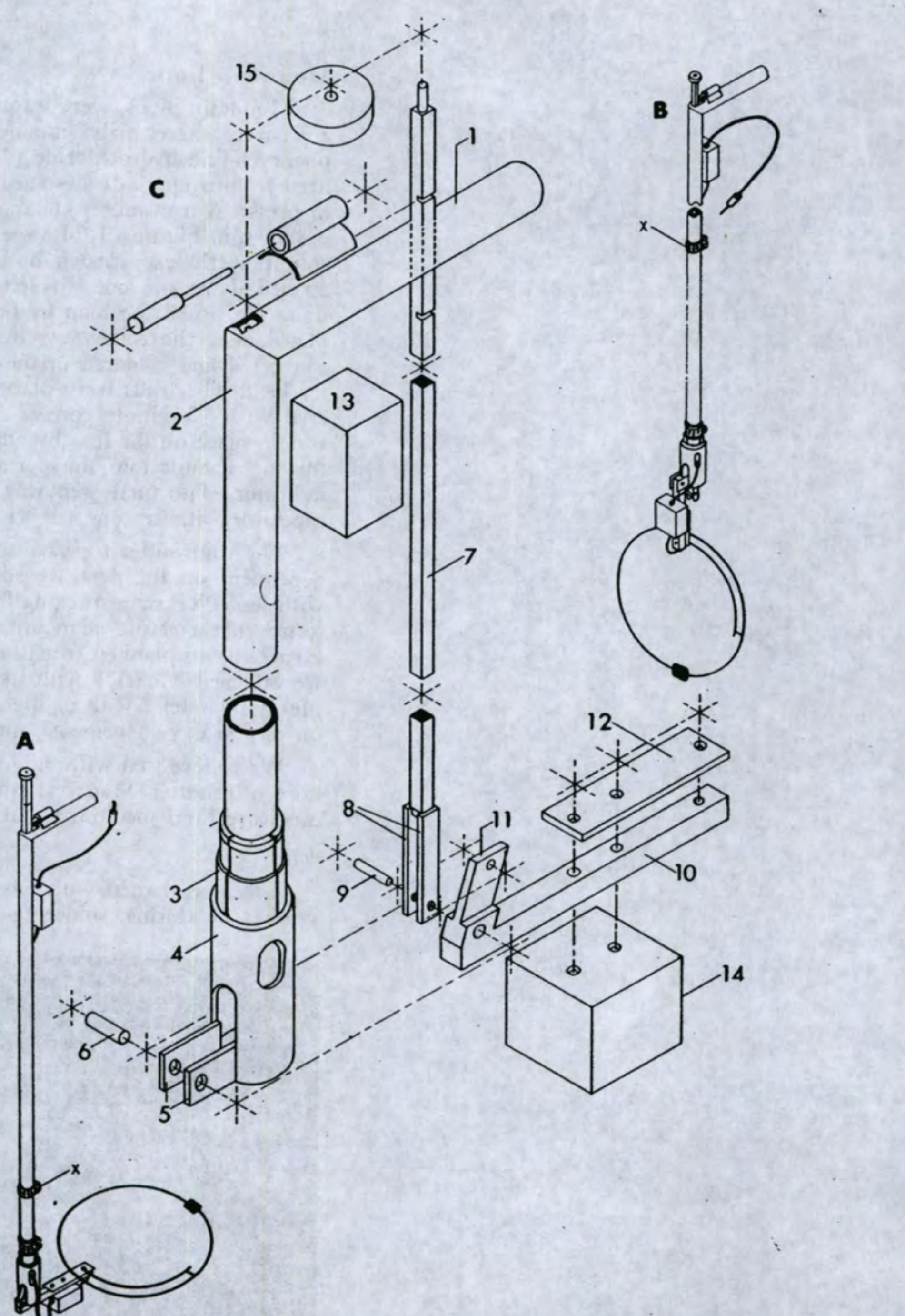


Figure 11. A—the loop antenna as mounted on the handle used in radiotracking from an airplane. Here the loop is in the "up" position for takeoff. B—the loop antenna is in the "down" position as it would be used during actual tracking. Note clamp x shown in A and B. This is a movable clamp used in changing the level of the antenna loop below the belly of the airplane. C—Detail of the handle used in radiotracking from an airplane. See Table 2 for a description of the parts.

Table 2. Part number and description for assembly used to attach the loop to the aircraft.

Part No.	Description
1	1 inch OD metal tubing 7 inches long.
2	1 inch OD metal tubing 37 inches long.
3	1 inch OD metal tubing 1 5/8 inches long.
4	1 1/4 inch OD metal tubing 3 1/8 inches long.
5	1 x 3/4 x 1/8 inch metal straps.
6	3/16 inch dia metal pin, 3/4 inch long.
7	1/4 inch square metal rod 42 3/4 inches long.
8	2 1/4 x 3/8 x 1/8 inch metal straps.
9	5/32 inch dia metal pin, 3/4 inch long.
10	1/2 inch square metal rod, 6 1/2 inches long.
11	1 3/4 inch long hook set at a 45 degree angle to 9.
12	3 1/2 x 1 x 1/8 inch metal strap.
13	Power supply
14	Amplifier
15	1 5/8 inch diameter, metal nob.

those on transmitter collars attached to lions. After capture, each elk was driven into a confining chute where it was tagged and then a transmitter collar (Model 3) was slipped over its head (Figure 14). As above, the transmitter was tuned for maximum output. The opening to the tuning capacitor was sealed with silicone rubber.

Radiotracking Procedure

Tracking procedure

Instrumented mountain lions were located from the ground using portable direction finders and stationary 3-element yagi antennas. For the elk work, a truck with a whip antenna mounted on the cab was employed together with a portable direction finder. From the air, we use a tuned loop attached to a Cessna 185 airplane. The approximate line-of-sight tracking distances for different antenna types and different transmitters are shown in Table 3. The effective ground-to-ground or ground-to-air range depends primarily on terrain.

To aid in the location of instrumented lions from the ground,[3] 3-element yagi antennas were placed on strategic high points on the Big Creek winter range, Idaho Primitive Area (see Hornocker, 1970). A portable receiver was coupled with the yagi antenna and the antenna array rotated. If a signal was

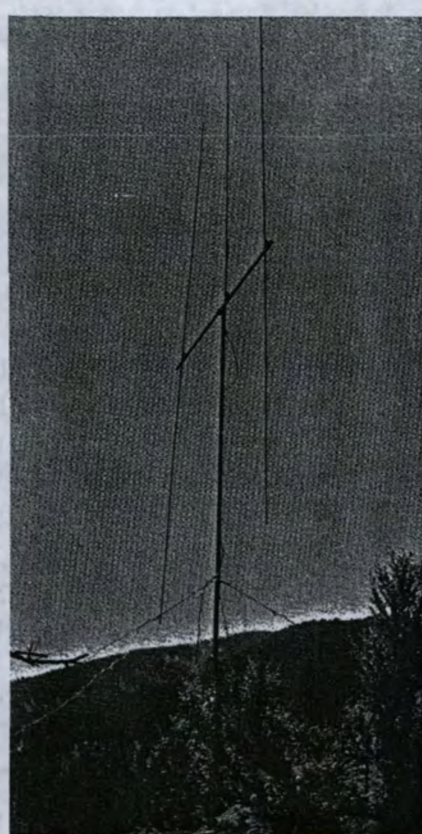


Figure 12. The 3-element yagi and the methods of attaching the amplifier and its power supply.

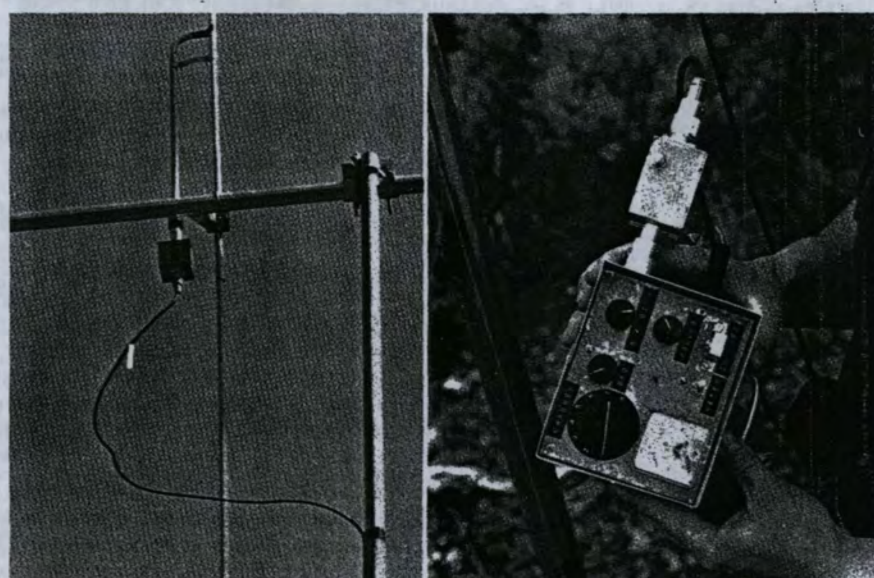


Figure 13. Attaching a radio transmitter collar to an adult male mountain lion.

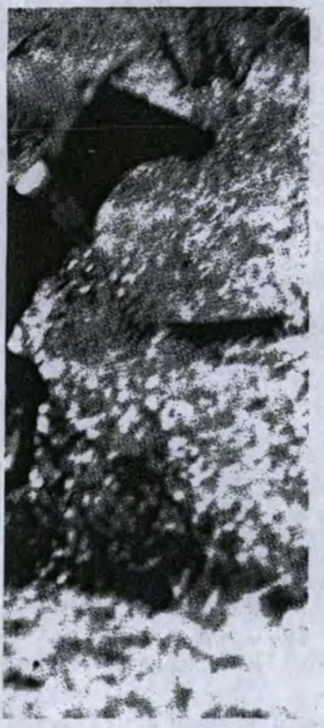
Figure 14. An elk with a radio transmitter collar.

heard, the approximate direction was obtained by rotating the antenna until the point of maximum aural signal was reached. We obtained a bearing by bisecting the angle subtended by the two nulls that occur symetrically on each side of the maximum lobe (Kolenosky and Johnston, 1967). From the bearing we moved toward the animal and established its location at close range by using a portable direction finder.

If we could not locate a lion with the 3-element antennas, we searched the study area with a portable direction finder, systematically checking each major drainage. The route traveled depended on terrain. Traveling ridges was in most cases more effective and easier than walking the creek bottoms. From a ridge, 2 drainages could be checked at once.

We used a truck with a whip antenna mounted in the center of the cab to search for instrumented elk. We listened for signals while driving over the roads on the Clearwater winter range. A whip has only limited directional properties and the actual location of instrumented elk was achieved with a portable direction finder once a signal was heard.

When a signal was detected with a portable direction finder, the animal's location was determined by rotating the loop until the point of minimum aural signal was reached or no signal was detected. This point (the null) occurred at right angles to the plane of the loop. The null gave sharper direction than the peak. When a null was determined, the instrumented animal could be in either direction, i.e. a 180 degree ambiguity existed. This was resolved by finding the null at a different location a few hundred yards distant



mitter collar.

/ rotating the antenna until We obtained a bearing by that occur symetrically on Johnston, 1967). From the ɔlished its location at close

ıt antennas, we searched the ⁄stematically checking each n terrain. Traveling ridges walking the creek bottoms. ɔnce.

d in the center of the cab to nals while driving over the has only limited directional ed elk was achieved with a

e direction finder, the ani- e loop until the point of ⁄as detected. This point (the loop. The null gave sharper ıined, the instrumented ani- ambiguity existed. This was a few hundred yards distant

Table 3. Performance of transmitters and antennas used for radiotracking mountain lions and elk.

Antenna Type	Range of reception in miles Transmitter type:		
	1 (30 MHz)	2 (30 MHz)	3 (47 MHz)
Aircraft tuned loop	10	15	10
Tuned loop (portable direction finder)	2.5	4	4
3-element yagi	6	8	-

Note: The distances recorded are essentially line of sight. The portable direction finder is held about 10 ft above the ground. The 3-element array is positioned vertically and attached to a 20 foot mast. The aircraft loop ranges are based on a 4,000 ft elevational difference.

and again from a third station. A fix was obtained by plotting the bearing on a map. Occasionally only one bearing was obtained because of topography and animal location. In these instances we followed Kolenosky and Johnston (1967) and estimated the distance between the investigator and the instrumented animal.

A variety of data were gathered from a distance but we also used the portable direction finders to put us in position to observe a particular instrumented animal and other animals that it was with. Craighead and Craighead (1965) point out that this may be the greatest asset of a portable radiotracking system.

From the air, our most effective search pattern was to fly an ever-widening pattern (square) at high altitudes above and beginning over the center of the study area. When we heard a signal, we flew in a semicircle around the area and by rotating the antenna and using the null we determined the approximate transmitter location. (For bearing reference the loop antenna was aligned at right angles to the handle on the movable shaft.) We then dropped to a lower altitude and approached the transmitter location, attempting to pass directly over the transmitter. By adjusting the sensitivity of the receiver and making several passes directly over the transmitter, we were able to accurately establish an instrumented animal's location. Instrumented elk were seen from the air in several cases but never did we observe an instrumented lion.

Different body movements produce variations in the signal pattern (Verts, 1963 and others). We used this variation and changes in transmitter location during an observation period to monitor animal activity. A steady signal pattern denotes a resting or unmoving animal while an interrupted signal pattern is indicative of an active animal. A change in transmitter location indicated that the animal had moved. This technique is qualitative and we plan to incorporate a motion transducer (Knowlton et al., 1968) into the transmitter circuit so that animal activity can be quantified.

Data recording

When an animal was located we recorded the following information: location, time, weather conditions, and habitat and activity. Data were recorded in coded form on prepared sheets. Data from these were punched onto cards and summarized using a digital computer.

Bulletin Footnotes

1. McMaster-Carr Supply Co., Box 54970, Los Angeles, CA
2. Titan Chemicals, Inc., Seattle, WA
3. The Antenna Specialists Co., Division of Allen Electric and Equipment Co., 12435 Euclid Avenue, Cleveland, OH
4. Ames Products (Solder Division), Brooklyn, NY
5. Devcon Corporation, Danvers, MD
6. Dow Corning Corporation, Midland, MI

Literature Cited

Barwick, R. E., and P. J. Fullagar. 1967. A bibliography of radio telemetry in biological studies. Proc. Ecol. Soc. Aust. 2:27-49.

Craighead, F. C. Jr., and J. J. Craighead. 1965. Tracking grizzly bears. BioScience 15(2):88-92.

Craighead, F. C. Jr., J. J. Craighead, and R. S. Davies. 1963. Radiotracking of grizzly bears. pp. 133-148. *In* L. E. Slater (ed.). Bio-telemetry. Pergamon Press, New York, NY.

Hornocker, M. G. 1970. An analysis of mountain lion predation upon mule deer and elk in the Idaho Primitive Area. Wildl. Monog. No. 21. 39 p.

Hornocker, M. G., and J. C. Seidensticker IV. 1970. Population dynamics and predator prey relations of *Felis concolor*. Report to Natl. Sci. Foundation. 40 p. Multilith.

Hornocker, M. G., and W. V. Wiles. In press. Immobilizing wild mountain lions with phencyclidine hydrochloride. International Zoo Yearbook.

Hungerford, K. E., and A. R. Johnson. In press. An improved directional loop for tracking radio marked animals. Univ. Idaho Forest Wildl. and Range Expt. Stat. Note.

Knowlton, F. F., P. E. Martin, and J. C. Haug. 1968. A telemetric monitor for determining animal activity. J. Wildl. Mgmt. 32(4):943-948.

Kolenosky, G. B., and D. H. Johnston. 1967. Radio-tracking timber wolves in Ontario. Am. Zoologist 7(2):289-303.

Mech, L. D., V. B. Kuechle, D. W. Warner, and J. R. Tester. 1965. A collar for attaching radio transmitters to rabbits, hares, and raccoons. J. Wildl. Mgmt. 29(4):898-902.

Sanderson, G. C. 1966. The study of mammal movements — a review. J. Wildl. Mgmt. 30(1):215-235.

Slater, L. E. 1965. Introduction: bio telemetry. BioScience 15(2):81-82.

Tester, J. R., D. W. Warner, and W. W. Cochran. 1964. A radio-tracking system for studying movements of deer. J. Wildl. Mgmt. 28(1):42-45.

Verts, B. J. 1963. Equipment and techniques for radio-tracking striped skunks. J. Wildl. Mgmt. 27(3):325-339.