DEVELOPMENT OF A RADIO TRANSMITTER FOR USE IN ANIMAL MOVEMENT STUDIES

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John R. Paul

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DEVELOPMENT OF A RADIO TRANSMITTER FOR USE IN ANIMAL MOVEMENT STUDIES

by

JOHN R. PAUL

AN ABSTRACT

Submitted to the College of Agriculture of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Department of Fisheries and Wildlife

1960

Approved
George A. Petrides
Professor

ABSTRACT

A miniature radio transmitter was designed for use in animal movement studies, operating on 27 megacycles. Two patterns of mounting the transmitter on animals were used, the block and the collar forms. Including battery, each weighed 38-40 grams.

A nine-volt battery provided sufficient power to operate the transmitter about three days. Optimum transmitting antennae were found to be 8 to 16 inch lengths of insulated wire. The range of transmission varied from 50 yards to four miles, depending primarily on the receiving apparatus. The presence of vegetation around the transmitter seemed to enhance signal reception. The transmitter proved to be durable under rough treatment.

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I wish to express my sincere gratitude to Dr. George A. Petrides, Professor, Department of Fisheries and Wildlife at Michigan State University, for his suggestion of this project and his aid and cooperation in carrying it out. Many thanks must go to Robert Altenhof for his considerable technical assistance in the development of the radio. I would also like to thank Dr. Peter I. Tack, Head of the Department, for his close interest and cooperation and to the several other staff and graduate students who gave help and advice.

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INTRODUCTION

Most studies of animal movements have been based on direct observations of marked animals or on observations of their signs. The recent development of miniature radio components, however, has provided the means by which accurate indirect observations of animals may be possible over continuous periods of time.

In one of the first studies of this nature, Ryan (1957) developed a transmitter to be used on deer. It was quite cumbersome, however, largely due to the use of vacuum type tubes. LeMunyan et al. (1959), using transistors, designed a circuit for use in a study of woodchuck populations. In that study, the transmitter was miniaturized and inserted within the animal's body. Its range of transmission was limited to 25 yards and, as that device was used, it would be of limited value in studies of wide-ranging animals.

The present effort was to develop a small and inexpensive transmitter that could be attached externally and be used in tracing the movements of wide-ranging animals such as deer and cottontail rabbits.

TRANSMITTER

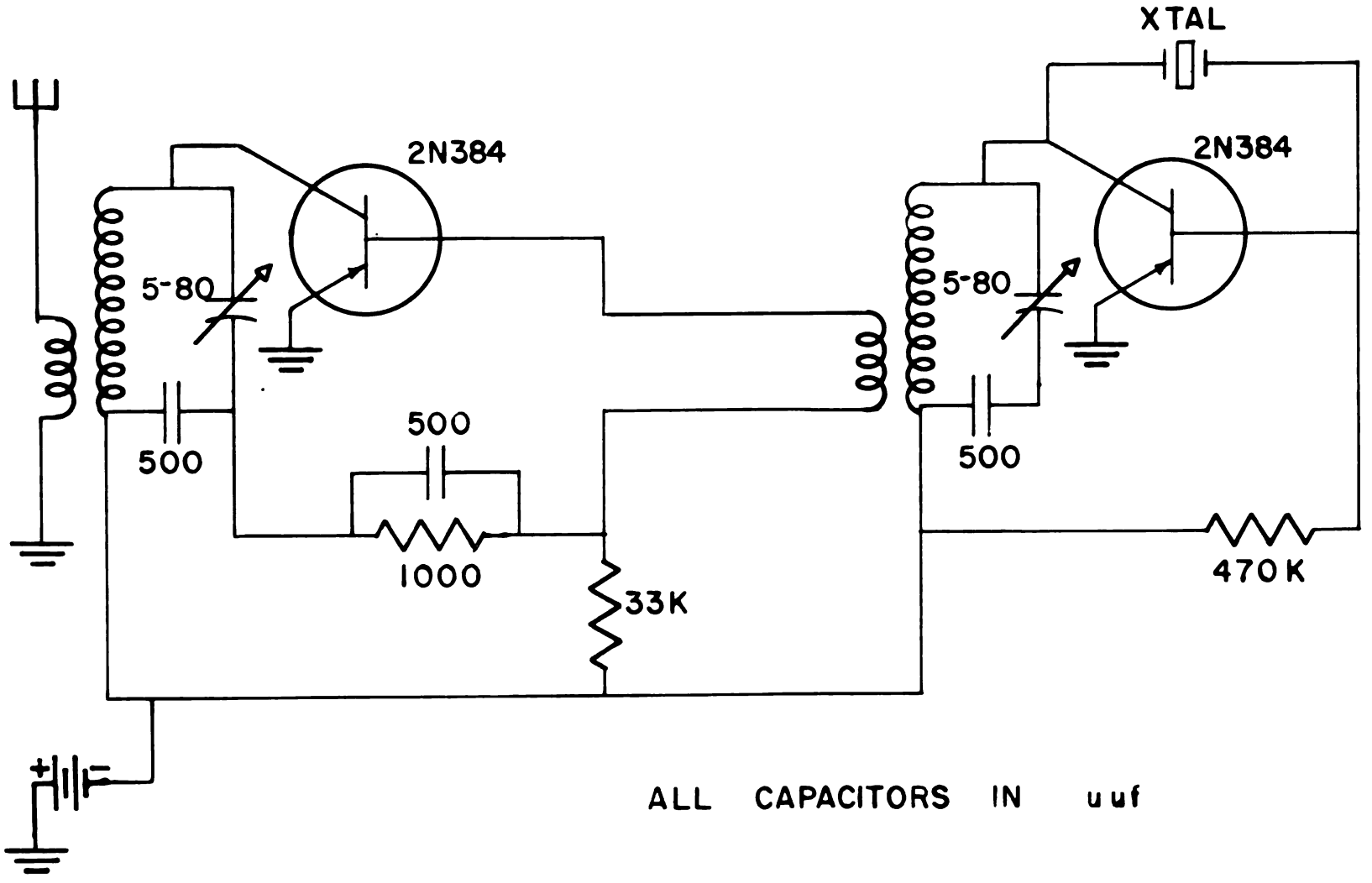
A miniature transmitter was developed using a circuit (Figure 1) modified from Von Wald (1958). It was essentially a continuous-tone, crystal-controlled oscillator.

A Class C communications license was secured from the Federal Communications Commission to use 26.995, 27.045, 27.095, 27.145, 27.195, and 27.255 megacycle frequencies, within the Citizens' Band.

The transmitter was constructed in two different patterns, the block and the collar (Figure 2). Each unit, including battery, weighed 38-40 grams (1.4 ounces). When constructed in the block pattern (Figures 3 and 4), the components were mounted on light plastic sheets or on fiberboards. The plastic sheeting or boards served to hold the components in a fixed position, adding to the transmitters stability and preventing short circuits across bare wires. The dimensions of the block transmitter were approximately 47 x 30 x 20 millimeters.

In the collar pattern (Figures 2 and 5), the components were connected in linear fashion, enabling the transmitter to be mounted on a leather strap. In this pattern, more care had to be taken in insulating

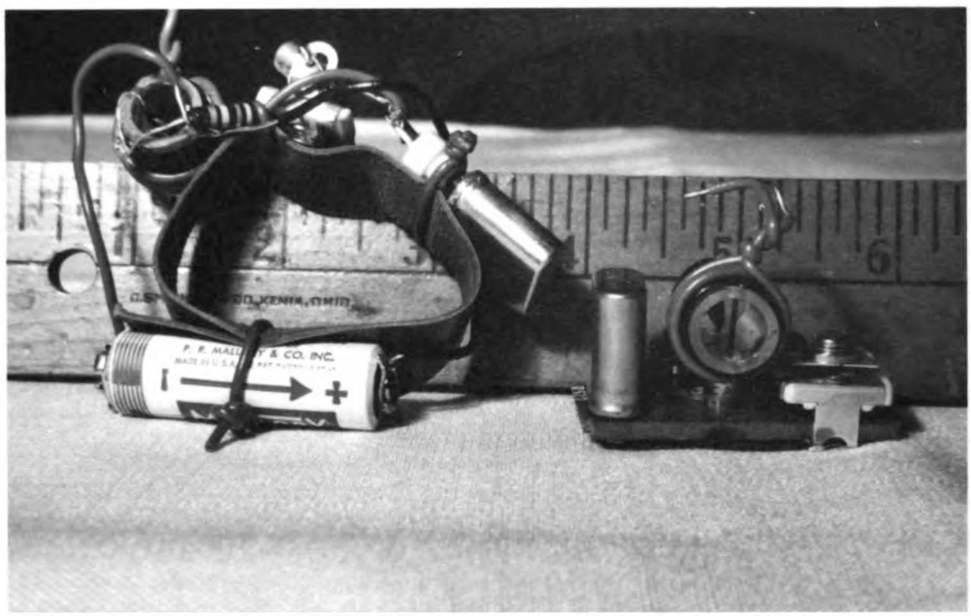
Figure 1. Schematic representation of oscillator and amplifier stages of miniature transmitter.



TRANSMITTER

Figure 2. Transmitter, collar and block forms.

Figure 3. Amplifier-oscillator combination and basic oscillator section.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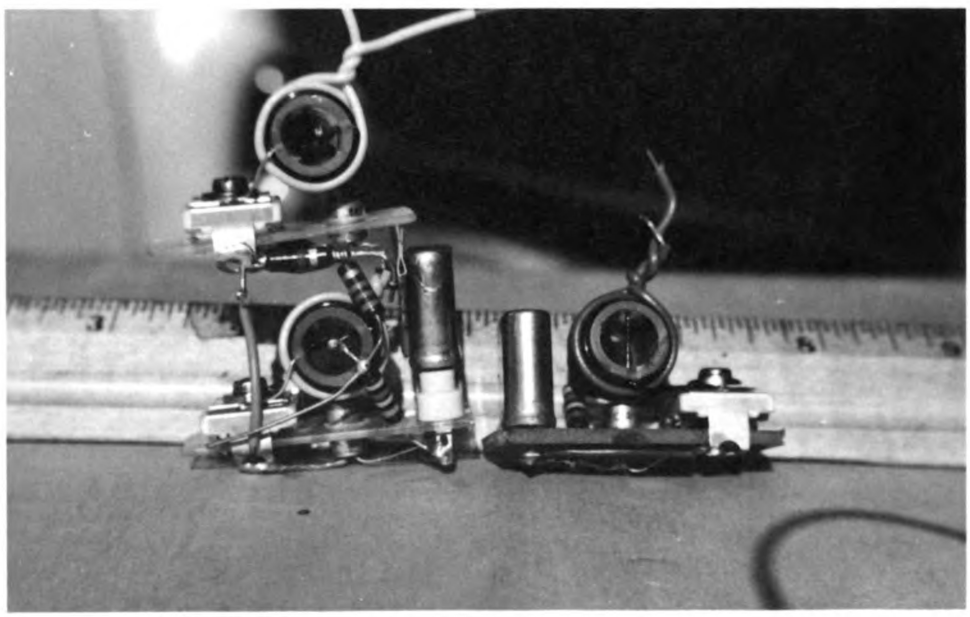
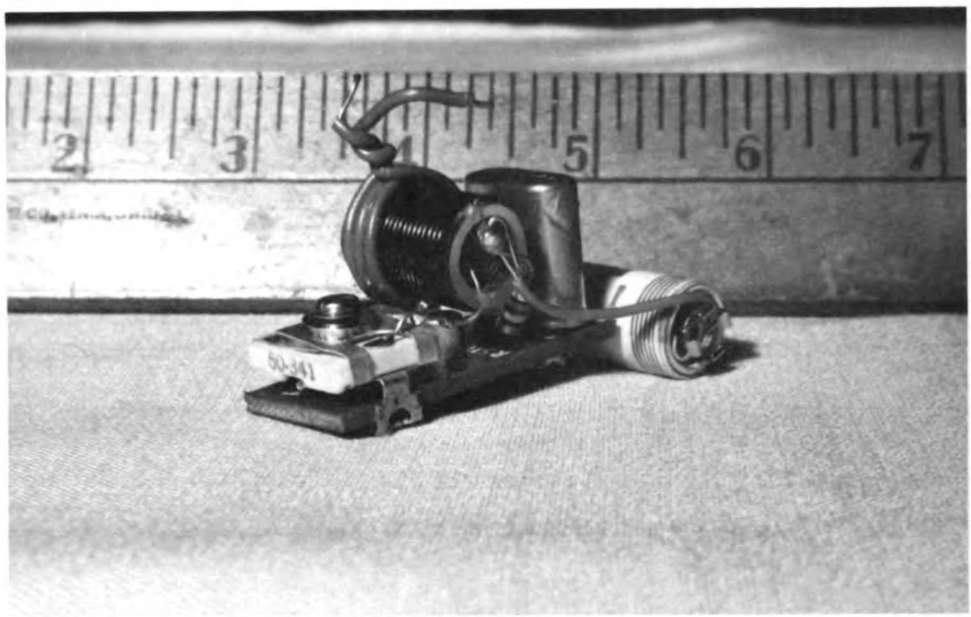


Figure 4. Transmitter, oscillator section.

Figure 5. Rabbit with collar transmitter mounted.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and protecting the components.

In constructing either unit, the fixed capacitor was mounted inside the coil to conserve space.

The power supply was furnished by a nine-volt battery. The smallest available of this voltage was the Mallory TR-177 mercury battery, which is especially designed for transistor application. It is cylindrical, 41 mm. x 13 mm. and weighs 18 grams.

Several transmitters operated intermittently during periods of 3-5 days showed little drop in the output of the batteries (as measured on a vacuum tube voltmeter), and in a continuous test, the oscillator transmitted for about three and a half days. Presumably, longer periods of operation could be attained by using additional batteries or by using a device to yield intermittent operation. Over a four month period, one transmitter was operated almost daily for periods of a few minutes to 24 hours each day. At the end of this period the battery had lost very little voltage.

One peculiar requirement in the placement of the parts was noted. If the resistor was placed closer than one-fourth inch from the crystal, the transmitter failed to work properly.

The transmitting antenna selected was merely a piece of light insulated wire, the base of which was wrapped around the coil. In testing the transmitter, a length of wire was fastened to one of the bare wire ends shown in Figure 4. When the antenna exceeded eight to sixteen inches in length, no appreciable increase in signal reception was noted until a length of five to six feet was reached. By adding some coils to the antenna, it was found that an increased length of wire could be used with little increase in the projecting length of antenna.

It was found that differences in the diameter of the transmitting antenna had no effect on the transmitted signal, but under field conditions it became evident that if the antenna was not made of spring steel or other durable material, it easily became broken in vegetation.

A supplementary amplifier circuit also was designed (shown also in Figure 1) but only the oscillator was tested in this study. The amplifier section, it was felt, could be added when more range and power was desired but these characteristics did not seem necessary in the earlier stages of development. Furthermore,

with the added bulk of the amplifier section, the transmitter would be useful primarily for larger animals (Figure 3). Parts lists for both oscillator and amplifier sections are given as appendices.

RECEIVING EQUIPMENT

Several different receivers were used to test the transmitter. It was found that any receiver would work so long as it had good sensitivity (approximately two microvolts) and was capable of receiving frequencies in the 27 megacycle range.

The receiver used for a majority of field tests was a battery-operated Heathkit "Mohican", model number GC-1A. This is a portable, all band receiver of moderate sensitivity and light enough (18 pounds) to be carried in the field. A detailed description of this receiver can be obtained from the manufacturer (Heath Company, 1960).

TESTS OF EQUIPMENT

The range of the transmitter varied, depending on the environment, the sensitivity of the receiver and the receiver's antenna characteristics. The biggest factor affecting reception appeared to be the receiving antenna. Large antennae always picked up the signal at greater distances than small antennae.

Ranges of one-half to three-fourths of a mile were usually obtained when a man carried the transmitter and the receiver was mounted with a 100-foot wire antenna or a two-element beam antenna. Using a 54-inch whip antenna, the range of reception was fifty yards. Many of these tests were made in residential areas where traffic was profuse, yet little radio interference was noted in receiving the signal.

When the portable receiver was raised from the ground to a higher position, the signal strength increased. When the receiver antenna touched the ground, the signal dropped. The higher the antenna was raised, the better the reception. If a coil shaped antenna was used, turning the antenna downward diminished the signal.

Further experimentation with the receiving antenna

apparatus will be necessary before extensive field use of the transmitter will be possible.

The transmitter was constantly submitted to shock and stability tests during the range determinations. Vigorous shaking and throwing of the transmitter to the ground failed to stop its operation. In one instance, the transmitter was dropped 15 feet from the top of a ladder, yet no interruption in signal reception occurred.

Touching the transmitting antenna to the ground had no effect on the signal, but if that antenna came in contact with bodies of water several feet or more in surface area, signal intensity was increased.

Early in the testing it was noted that when a person touched the transmitter or was very close to it, signal strength was increased. Tests showed that the range was increased thirty to fifty percent when the transmitter was held in the hand as opposed to being placed on the ground. Ranges of one-fourth to one-third mile were obtained, however, when the transmitter was placed on the ground and away from people. As a person approached the transmitter to within two to four inches of it, the volume of the signal increased. This indicated a probable decided advantage in using the

transmitter on larger animals.

The presence of vegetation around the transmitter markedly increased the range of reception. In a plowed field, the signal could not be received beyond 100 yards, yet with the same receiving apparatus and the transmitter placed in a field containing vegetation or brush, the range increased to in excess of one-fourth mile.

On two occasions the transmitters were fastened on dogs. The first was in the city and the dog was allowed to run free within a half-mile of the receiver. The transmitter was fastened to the dog's harness and the antenna was located on its back. Signal reception was easily maintained during this test. The receiving antenna then was a 150 foot wire.

The second time a hunting dog was used on a local farm with the transmitter fastened to the dog's collar. Upon release the dog hunted vigorously, thoroughly testing the transmitter's stability. Visual contact with the dog showed the range of the transmitter to be approximately one-fourth mile. Contact was lost sporadically as the dog ran outside of the transmitting radius of the radio, yet the transmitted tone was

easily picked up as the dog moved back within range. After about an hour contact was lost and later observation of the transmitter showed that the antenna was broken off at the base.

Other tests were made with cottontail rabbits. Several harnesses were tested, each with a simulated transmitter mounted on it:

Dog-style Harness - Three rabbits were trapped and a canvas harness similar in style to that worn by dogs was applied. One rabbit, kept in captivity, successfully removed the harness within four hours. Of the two released, one was subsequently recaptured two days later. The rabbit had chewed through the front strap, allowing the harness to twist around its body. This harness was judged to be unsuitable.

Vest-style Harness - Elasticized cloth was cut in vest fashion and drawn over a rabbit's head. This allowed full freedom of its front legs and positioned the transmitter over the shoulders. Of the three animals fitted with the vest, two were retrapped, one twice. All recaptures, occurring one, two and five days after release, revealed harnesses in good condition. One rabbit was observed in the field with this harness

and no apparent difficulties in movement were noted. This harness was judged satisfactory for mounting of the block transmitter.

Collar - The collar is the only method by which an actual transmitter was applied to a rabbit. The radio components were secured to a leather collar with several turns of insulated wire. Sponge rubber strips were placed between and around all components to serve as an insulator and shock absorber. Plastic electrician's tape was wrapped around the outside of the sponge rubber to hold it securely.

The rabbit with the transmitter mounted (Figure 5) was first placed in a wire cage and observed. The position of the transmitter seemed satisfactory since the rabbit was unable to beat it against the cage without doing itself physical damage. The animal's body thus tended to protect the transmitter. Slight variations in the signal were noted when the rabbit jumped about in the cage, but in general, there was no appreciable change in signal reception during a 48 hour period. A temperature range of 40 degrees during the experiment caused no apparent effects. This harness was judged to be satisfactory.

SUMMARY

A miniature radio transmitter was designed for use in animal movement studies, operating as a Class C station on 27 megacycles (Citizens' Band). It was crystal-controlled and emitted a continuous tone.

Two patterns for mounting the oscillator-transmitter on animals were used, the block and the collar. Their weights, including battery, were 38-40 grams each.

The power supply was furnished by a nine-volt mercury battery which maintained a radio signal for about three days. Tests indicated that the best transmitting antenna was a piece of wire eight to sixteen inches long, preferably of spring steel or some other durable material.

An amplifier section for the transmitter was designed to increase the range of transmission. This section was not tested at this time.

Signal reception ranges varied with the quality of the receiving apparatus and with the nature of the environment. The range varied from 50 yards to four miles. The larger the receiving antenna, the better the reception.

Shock tests failed to halt the transmitter's operation.

Ranges varied from one-half to three-fourths of a mile when the transmitter was carried in the hand and large receiving antennae were used. When a man carried the transmitter the range was increased thirty to fifty per cent over times when the transmitter was placed on the ground. Unheld transmitters had a range of one-fourth to one-third mile.

The presence of vegetation around the transmitter increased the range of transmission. When transmitters were placed in plowed fields, the ranges were sharply reduced.

Tests using dogs to carry the transmitter were made on two occasions. Ranges of about one-fourth mile were obtained in the dog tests, and the stability of the transmitter proved quite high. The necessity of making the transmitting antennae of strong material, such as spring steel, became evident.

Three styles of harness for fastening transmitters to rabbits were tested. Dog-style and vest harnesses were tested only with simulated transmitters. An actual transmitter was applied in collar form to a rabbit. Results indicated the vest and collar harnesses to be satisfactory.

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APPENDIX A

Parts list - Oscillator section

1 Crystal - one of the following frequencies: 26.995, 27.045, 27.095, 27.145, 27.195, and 27.255

1 Variable Capacitor - 5-80 micro-micro-farads

1 Fixed Capacitor - 500 micro-micro-farads

1 Transistor - RCA 2N384

1 Resistor - 470 K ohms, ½ watt

1 Coil - ½ inch in diameter, 22 turns of #20 wire

1 Battery - 9 volt, Mallory model TR-177

APPENDIX B

Parts list - Amplifier section

1 Transistor - RCA 2N384

1 Resistor - 33 K ohms

1 Resistor - 100 ohms

1 Variable Capacitor - 5-80 micro-micro-farads

2 Fixed Capacitors - 500 micro-micro-farads

1 Coil - $\frac{1}{8}$ inch in diameter, 22 turns of # 20 wire