

USE OF ELECTRONIC MARKERS TO RELOCATE SMALL FOREST FIRES

by

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The system was designed for relocating fires from both ground and air.

USE OF ELECTRONIC MARKERS TO
RELOCATE SMALL FOREST FIRES

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R. L. Ponto* and G. M. Lynch**

ABSTRACT

Following an extensive survey of the potential systems to aid initial attack crews in relocating confirmed "smokes", high frequency transmitters were selected as the most practical solution. A transmitter prototype suitable for airdropping was designed and built to the specifications of the common fireline portaphone. The system operates on the fireline frequency 26.920 MHz and was successfully tested from the ground, fixed-wing aircraft and helicopter. No mounted equipment is required on the aircraft, use is not limited to specific cover types or seasons, the system is simple to use, and transmitters are retrievable and relatively inexpensive (\$75 per transmitter). Optimum working range of the system was calculated to be 12.6 square miles on the ground, and 79.0 square miles from the air.

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INTRODUCTION

Small fires producing little smoke or smoking intermittently are often spotted and reported from patrol aircraft, but frequently cannot be relocated by initial attack crews travelling by helicopter or on the ground. Even with the estimated co-ordinates relayed from the patrol aircraft relocation is time consuming and the fire may not be found until it "blows up". Some adequate method for marking fire locations from the air is therefore necessary to minimize delay between detection and initial attack.

A literature review and field testing of methods for marking small fires was carried out at the Northern Forest Research Centre in late 1972. Existing and potential methods were assessed for:

(a) effectiveness in various cover types and terrain from both air and ground, (b) simplicity, (c) cost, and (d) suitability to a variety of aircraft.

REVIEW OF EXISTING AND POTENTIAL METHODS

Visual Markers

Although several visual markers have been used operationally, the so-called trail markers have been the most successful. Rolls of crepe paper, tissue paper, calculator paper, plastic flagging, aluminum foil or string are unrolled a few inches and tossed from the aircraft, flying about 200 feet above tree tops. The roll comes to rest in a more or less continuous trail in the direction of flight. However, quite often these markers fall below the tree tops and are not visible from the air or fall in such a way that the entire trail remains in the tree tops and is not visible from the ground.

Various glass and plastic containers filled with brightly colored paints, dyes and powders have been tested for marking fire locations. These containers seldom break upon impact with the tree crown, and generally fall below the tree top level where they are not visible from the air. Because of short duration in smoke emission and inherent fire hazard, the use of smoke bombs was given little consideration. Helium filled balloons dropped with an anchor were tested by the U.S. Forest Service. Wind tangled the balloons around the tree tops until they burst or dropped below the visible range. Parachutes have been tested with some success, however, they too, frequently fall or are blown below visible range. The Automatic Flagman, another marking device, was not designed for use in timbered areas. Strobe lights were also considered impractical for marking fires.

In areas where fire location can be tied in with topographical features, visual markers are often adequate. However, for the major portion of the boreal forest, co-ordinates cannot be estimated accurately enough to rely solely on this method. (An earlier account of small fire location methods, as described here in part, appeared in NFRC File Report NOR-Y-46, R. L. Ponto, 1973; "A survey of methods for marking and relocating small forest fires.")

Audio Generators

Noise generating devices are of little value for marking fire locations unless dropped in combination with a visual marker for eventual relocation from the air. Both audible distance and duration of signal are very limited.

Electronic Systems

Crash position indicators were field tested at the Forest Fire Research Institute, Canadian Forestry Service, Ottawa. Cost of this equipment is too high for purposes considered here, and excessive signal reflection from rocks, stumps and other surfaces was experienced. Distance measuring equipment was considered too costly for this specific use.

On the other hand, high frequency transmitters, similar to the units being used in wildlife movement studies, were tested with excellent results. Signal reflection is not a problem on the frequency 26.920 MHz and the cost of this equipment is much less than crash position indicators.

DESCRIPTION OF AN ELECTRONIC MARKING SYSTEM

Transmitter Design

An electronic fire marker must be: (1) compact, (2) durable enough to withstand the airdrop, (3) emit a signal of sufficient strength to permit easy contact by both air and ground crews, (4) employ a workable air to ground delivery mechanism, and (5) operate at a frequency which can penetrate heavy bush. L. & C. Enterprises¹ constructed several prototypes for field trials which met all these prerequisites.

The frequency 26.920 MHz was selected as it is one of the fire-line frequencies used by the Alberta Forest Service, making receiving equipment readily available. Bush attenuation is minimal on this frequency.

¹ L. & C. Enterprises, Box 391, Edson, Alberta. TOE OPO

NOTE: Use of trade names and company names does not imply endorsement by the Canadian Forestry Service.

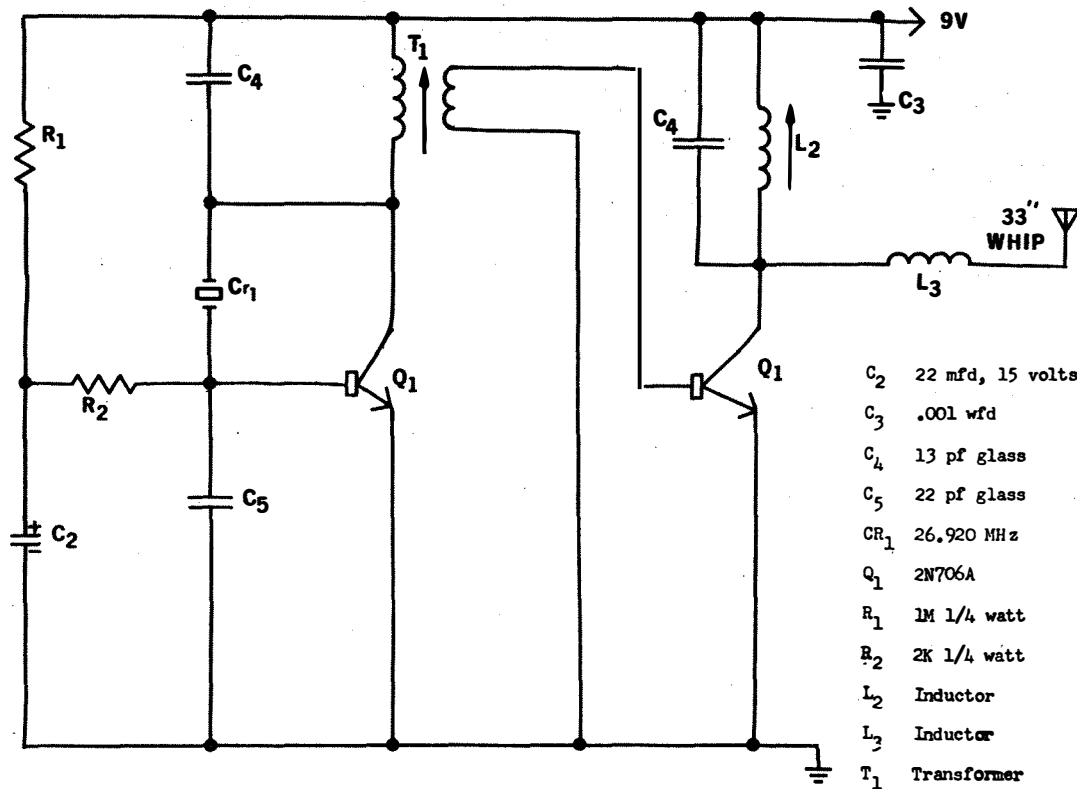


Figure 1. Schematic of transmitter.

The transmitters (Tables 1, 2, and 3) are a 2 stage, solid state design, assembled on printed circuit board (David R. Patton et al., 1970). Exact values of the components R₁ and C₂ (Figure 1) are not critical and can be varied to give a desired pulse width and repetition rate. The transmitter is embedded in epoxy resin in the centre of a 1½ inch diameter PVC pipe (Figure 2). A 9 volt transistor radio battery supplies adequate power for about 100 hours. Total weight of the transmitter is 800 grams (1-3/4 pounds).

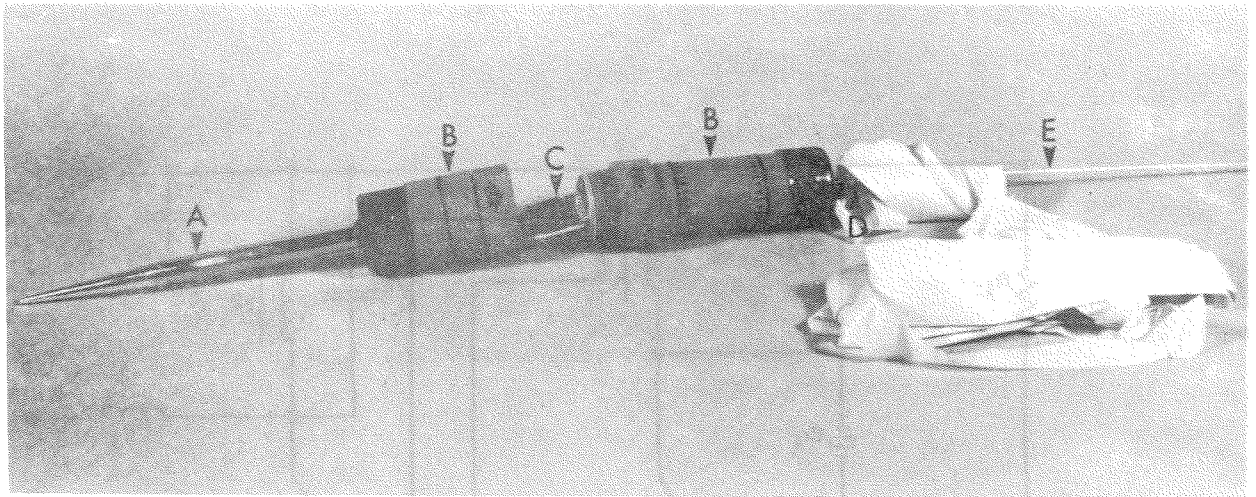


Figure 2. Transmitter designed for airdrop. (Patent for case pending)

- (A) metal point designed to absorb shock, yet capable of penetrating the ground and holding the transmitter in a vertical position after delivery from the aircraft (Figure 2).
- (B) $1\frac{1}{2}$ inch PVC plastic pipe filled with an epoxy resin to protect transmitter components.
- (C) battery is replaced by unscrewing pipe.
- (D) roll of surveyors flagging cut into 30 foot pieces, are fastened to the parachute ring to keep the unit falling point first during descent from the aircraft.
- (E) 33 inch steel whip antenna.

TABLE 1. OUTSIDE DIMENSIONS OF TRANSMITTERS

| | Length (cm.) | Width (cm.) |
|--------------------------------|-----------------|----------------|
| Total length including antenna | 130.3 | |
| Body | 25.9 | 5.0 |
| Antenna | 83.8 | |
| Point | 21.6 | 1.4 |

TABLE 2. TRANSMITTER CHARACTERISTICS

| | |
|-----------------------|--------------------|
| Frequency | 29.920 MHz |
| Output power | 100 mW, pulsed |
| Pulse width | 100-500 ms |
| Pulse repetition rate | 40-300 per minute |
| Antenna type | 33 inch steel whip |
| Battery type | 9V DC |

TABLE 3. PRICE LIST FOR TRANSMITTERS (Prices are less federal excise tax, F.O.B. Edson, Alberta.)

| | |
|---------|--------------------|
| 1-49 | units \$75.00 each |
| 50-99 | units \$70.00 each |
| 100-499 | units \$65.00 each |

Receiver

Field tests were carried out using a Johnson Messenger III 5BE 12CB receiver (Table 4), however, most other fireline radios can be adapted for use as direction finders with the following modifications.

- 1/ A beat frequency oscillator (BFO) should be incorporated into the unit to improve receiver audibility.
- 2/ A coaxial cable fitting installed in the receiver unit for coupling the receiving antennas.
- 3/ If desired, a sensitivity (s) meter may be installed for signal strength readout. Our trials indicated that a s meter was not necessary when the system was being used by experienced personnel.

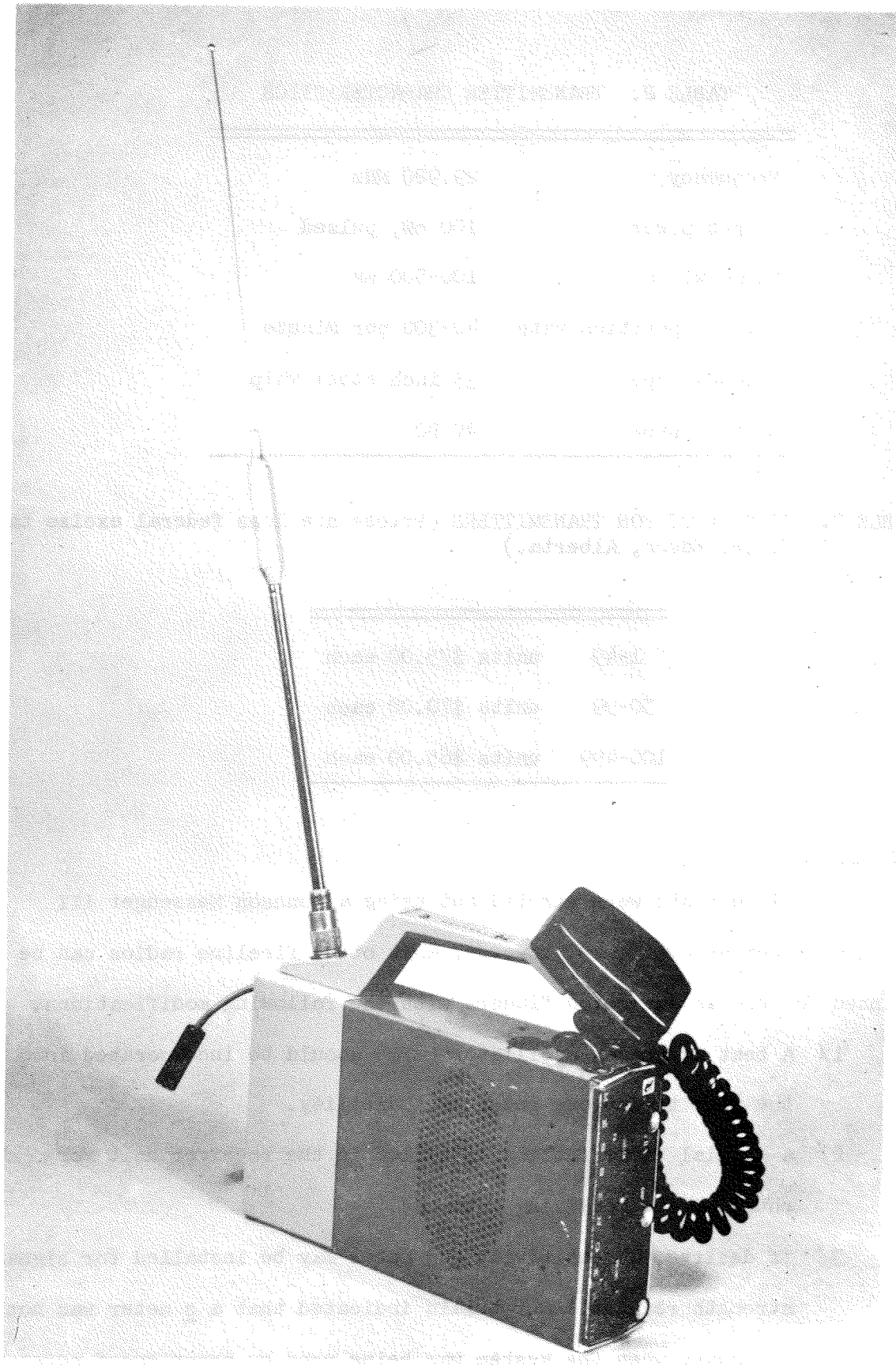


Figure 3. Johnson Messenger III 5BE 12CB receiver.

TABLE 4. JOHNSON MESSENGER III 5BE 12CB RECEIVER CHARACTERISTICS

| | |
|---------------------|------------------------------|
| Frequency tolerance | .0025 percent |
| Frequency stability | .001 percent |
| Sensitivity | 0.5 uV for 10 db StN/N |
| Selectivity | 6 db at 2.1 KH ₂ |
| | 50 db at 5.5 KH ₂ |

Receiving Antennas

A. Ground Application

A 18 inch diameter, single turn loop antenna, constructed of 3/16 inch diameter copper tubing was used for field trials (Figure 4). A stronger signal can be received by using a pre-amp on the loop antenna, but the unit can no longer be used for ground to ground communications. Larger loop antennas were more efficient, but too cumbersome in the bush.

A whip antenna mounted or taped on the cab of a truck can facilitate rapid coverage of an area when an adequate road system is present.

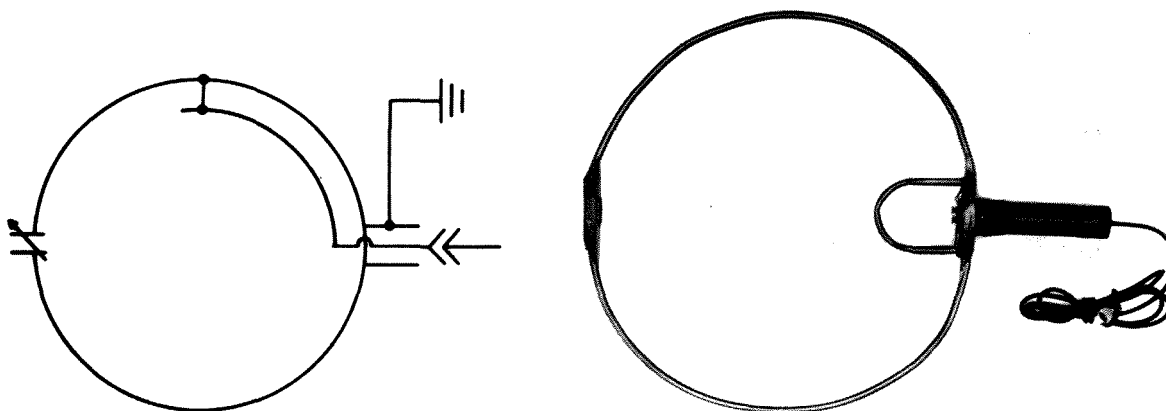


Figure 4. Loop antenna used during ground trials at Edson, Alberta, (a) circuit diagram, (b) working model.

B. Air Application

Either a permanent mounted aircraft antenna or an ordinary whip antenna tuned to 26.920 MHz taped to the undercarriage of the aircraft can be used for aerial detection (Figure 5). The coaxial cable on the antenna can be run through a window, door or vent to the receiver. The whip antenna should point down and away from the aircraft to be compatible with the vertically polarized transmitted signal.



Figure 5. A whip antenna taped to helicopter landing gear.

If the same aircraft is usually used to transport initial attack crews, a tuned loop mounted on a moveable bracket attached to the aircraft can be used (Figures 6 and 7) (Table 5).

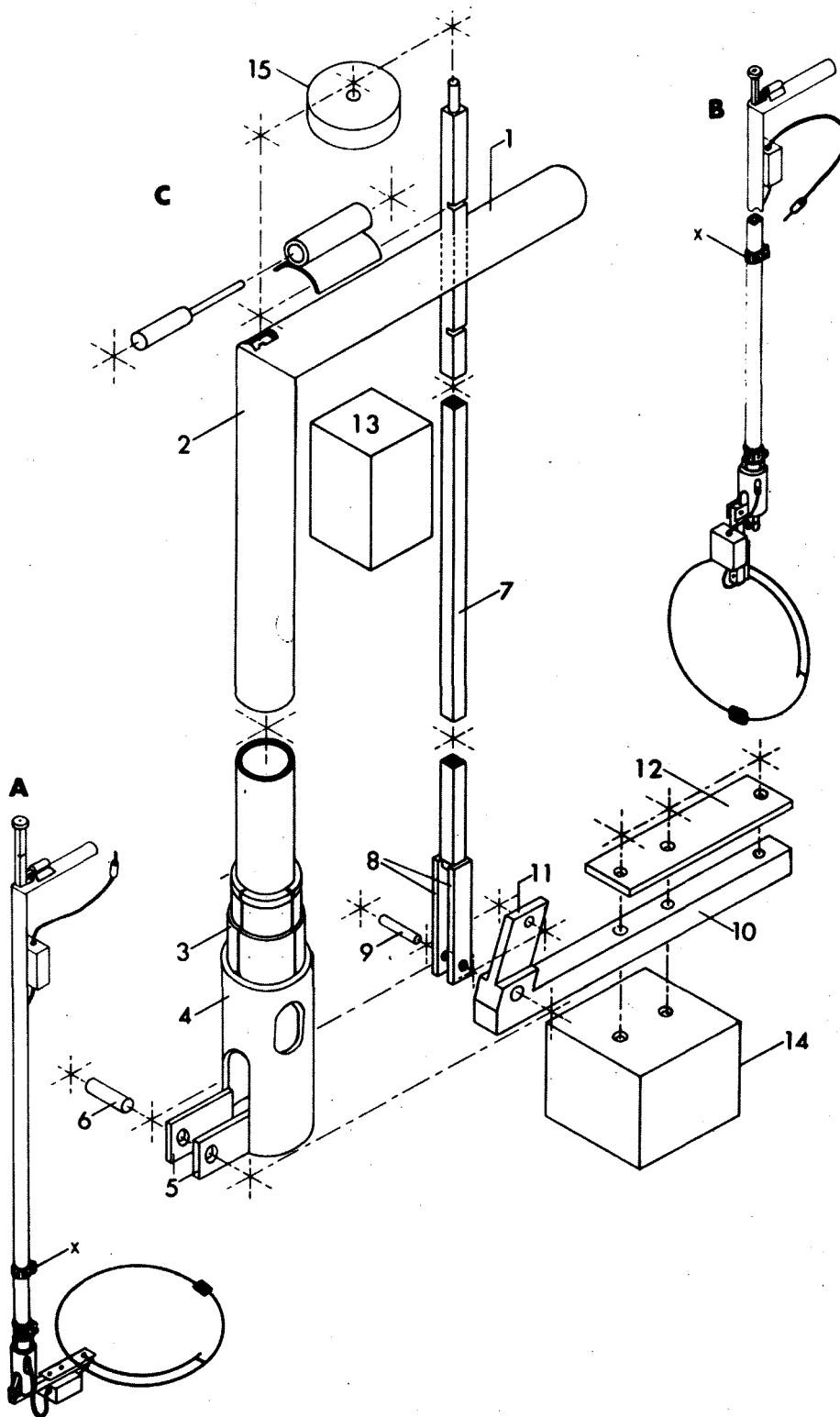


Figure 6. Loop antenna mounted on a moveable handle for aircraft use.
(A) - the loop is in the "up" position for takeoff.
(B) - the loop antenna is in "down" position as it would be used during locating.
(C) - detail of handle (Seidensticker IV et al.) (See Table 5 for a description of the parts.)

TABLE 5. 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 incl. 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 |

PROCEDURES FOR RELOCATING FIRES

The transmitter is identified through the receiver by production of an audible pulsed signal. Repetition rate and signal tone is slightly different for individual transmitters making multiple relocation possible when several fires are marked within receiving range.

Locating from the Air

The receiver can be connected to a mounted aircraft antenna tuned to 26.920 MHz, or to an ordinary whip antenna tuned to the same frequency and taped to the aircraft. The following precautions should be taken when taping an antenna to the aircraft:

- A/ The antenna should be fastened to the underpart of the aircraft with fibre glass strapping tape. It can be taped to the strut, wing or landing gear on fixed wing aircraft or to landing gear on helicopters.
- B/ The antenna should be taped so that it points straight down and away from the aircraft.
- C/ Metal on the antenna should not be allowed to touch any metal on the aircraft.
- D/ The antenna lead can be run through the window, vent or door.

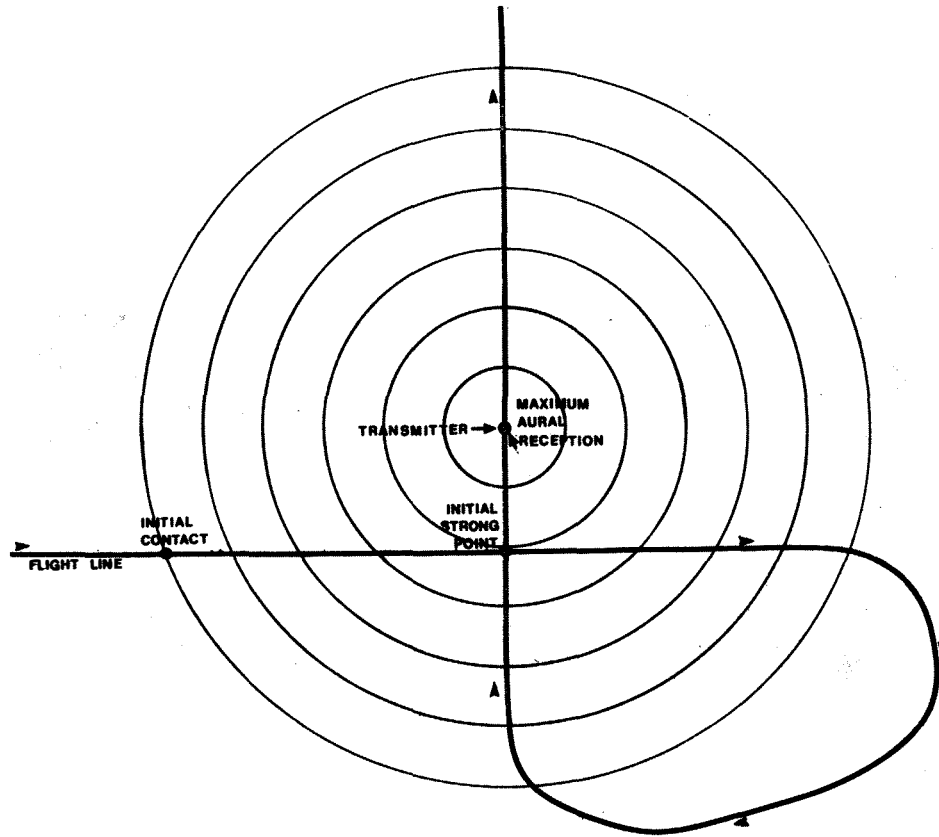


Figure 7. Fire location from the air by finding the point of maximum aural reception.

Fires can usually be located to within 100 yards from the air in a few minutes by following the procedures listed below.

- 1/ Fly in general vicinity of fire using estimated co-ordinates relayed from patrol aircraft, until transmitter signal is picked up (Figure 7).
- 2/ Continue flying in straight line after initial contact and note initial strong point.
- 3/ Circle and fly at right angles to first flight line crossing directly over initial strong point. The strong point on this

line should be very close to the transmitter.

- 4/ Make several passes from various directions until point of maximum aural reception is found.
- 5/ Bearing and approximate distance from drop off point to fire should be established before landing.

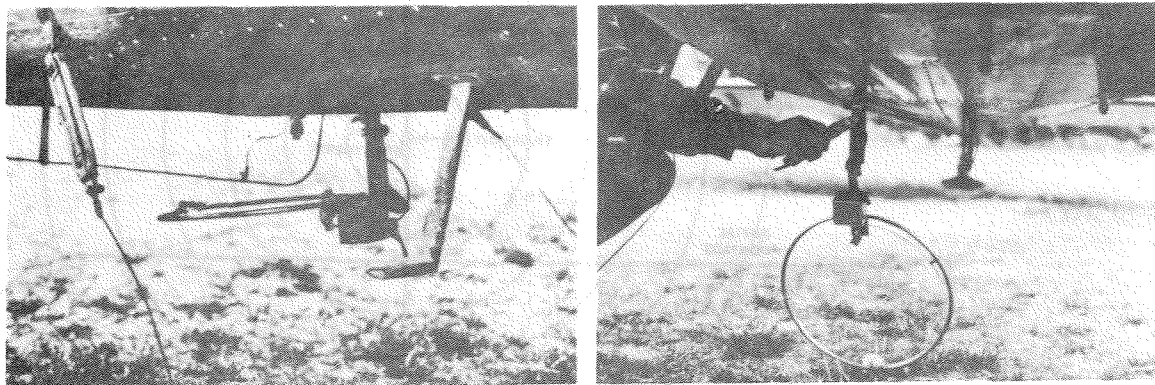


Figure 8. (A) Cessna 185 with loop antenna in the "up" position for landing and taking off, (B) in flight the shaft is lowered and loop is extended.

A mounted loop antenna (Figure 8) can also be used to locate marked fires from the air. The search begins at high altitudes until a signal is received. By flying in a semi-circle around the area and rotating the antenna, using the null to determine transmitter direction, the approximate location is determined. Then, dropping to a lower altitude and approaching the transmitter, an attempt is made to pass directly over it. Exact location is established by adjusting the sensitivity of the receiver and making several passes directly over the transmitter from various directions.

Locating From the Ground

A whip antenna tuned to 26.920 MHz mounted or taped on the cab of a truck may facilitate rapid coverage of an area where an adequate road system is present. The point along the road nearest to the fire can also be determined by obtaining bearings at several points along the road using a loop antenna. The fire is then marked on a map and the suppression crew can take the easiest and shortest route to the fire.

After crews have travelled as close to the fire as possible by aircraft or truck, they continue on foot toward the fire using the directional loop antenna to direct them to the transmitter. Direction to the transmitter is determined by rotating the loop antenna until finding the point of maximum sensitivity. The bearing is determined by bisecting the angle subtended by the two sharp nulls occurring symmetrically on each side of the maximum lobe. The null or point of lowest signal strength received is recommended for determining transmitter direction when the crew is fairly close to the transmitter since it gives sharper directivity than does the strong side of the loop antenna. The fire is located by following the established bearing. Upon arrival at the fire, the transmitter battery should be taken out and discarded.

If the signal becomes weaker instead of stronger, the "locator" is likely travelling directly away from the fire as the strongest signal is picked up on either side of the directional antenna.

FIELD TEST RESULTS

Signal strength data were recorded in s units as indicated on the signal strength meter of the receiving radio. The 18-inch loop antenna used in this study is not as sensitive as larger loops, but does provide adequate range and is easy to handle in the bush. Addition of a pre-amp to the receiving antenna enhances its performance, but the receiver can not be used as a transceiver for ground to ground communications.

The integral strength of the unit and a delivery system were tested by dropping the prototype transmitter from a fixed-wing aircraft (Cessna 172) flying at a speed of 70 miles per hour and at a height of 200 feet above the ground. The transmitter was dropped onto frozen ground covered by an 18 inch layer of light snow.

Operation of the transmitter was not impaired by the fall from the aircraft. The soft metal point bowed slightly by the impact. It did not penetrate the frozen ground, but bounced back out of the snow and lay within 12 inches of the point of impact.

The trailing streamers did not appear to slow the projectile during the drop, but did keep the unit falling perfectly point first. The transmitter quickly lost forward speed when ejected from the aircraft, arched over falling in a vertical line to the ground.

Pilot studies showed signal strength was significantly greater across open country than through bush when the transmitter was vertical on the ground or suspended in a tree (Appendix I). Signal strength was about the same through the bush as in the open when the transmitter was placed horizontal on the ground, but strength was seriously curtailed

compared to that recorded when in a vertical position. Beyond three miles there was little difference in signal strength between vertical on the ground in the open and vertical on the ground through bush. A stronger signal was recorded with the transmitter positioned in a tree in an open area (Appendix 2) as compared to signal received through the bush with the transmitter in a tree.

The signal was notably stronger with the transmitter placed vertically on the ground than when it was suspended vertically in a tree, particularly at fringe distances. There is some indication that the tree position permitted better reception when the receiver was in a low spot.

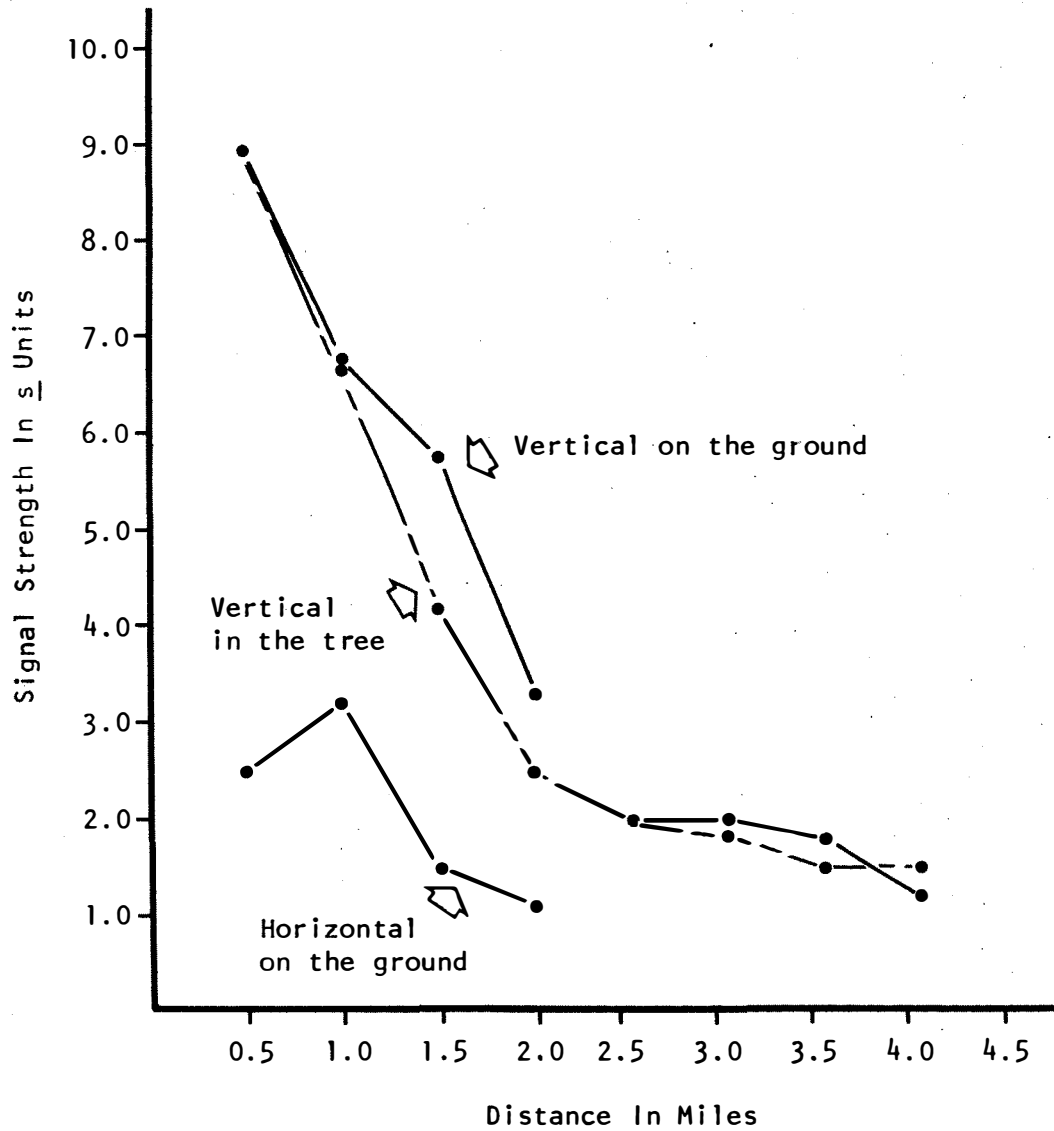
The signal was discernible beyond the four mile distance (Appendix 3). It was easily heard for a distance of up to 2 miles which probably represents the optimum working range for the system on the ground. Optimum working area of the system was calculated to be 12.6 square miles on the ground and 79.0 square miles from the air.

LITERATURE CITED

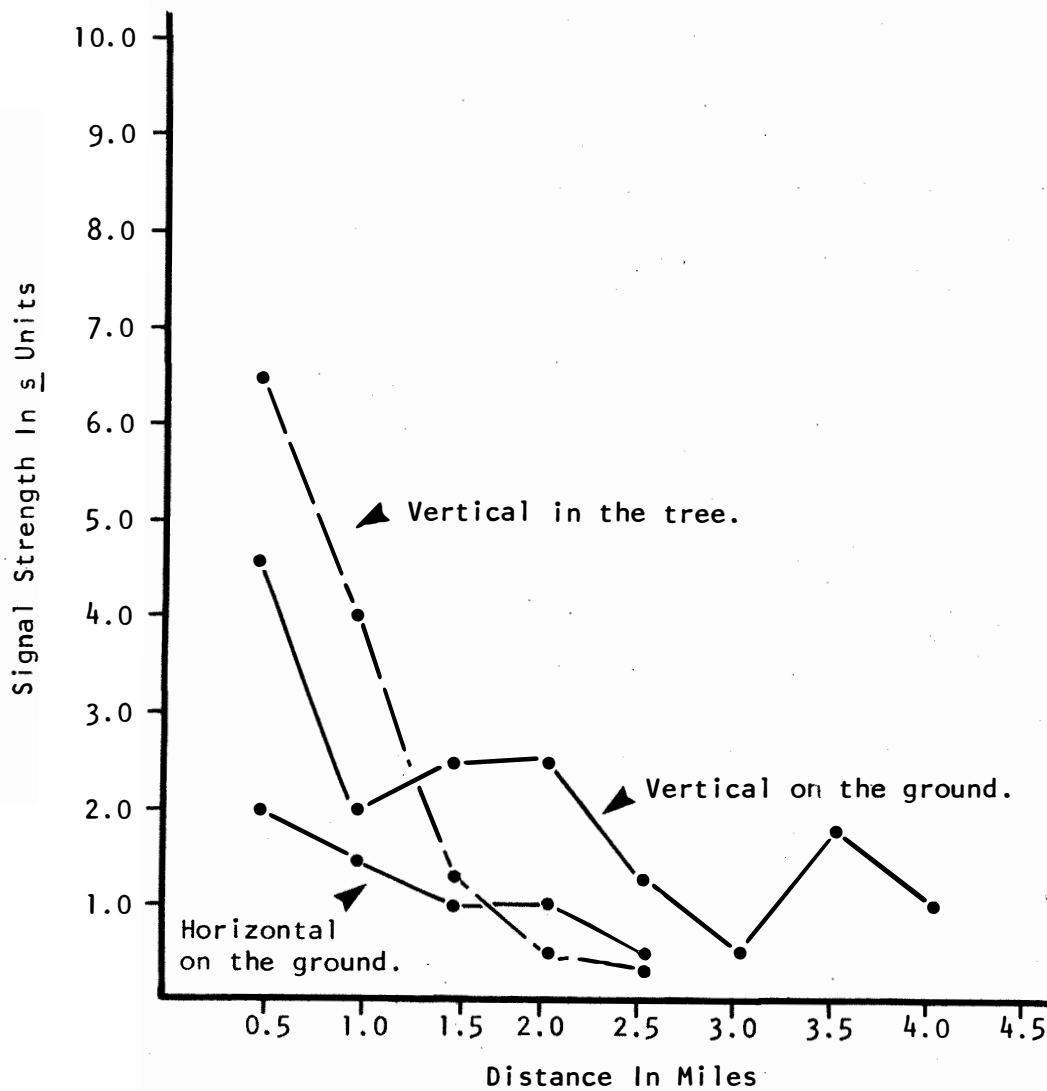
- Patton, D. R., R. T. Dickie, E. L. Boeker, V. E. Scott. 1970.
A Transmitter for tracking wildlife. Rocky Mountain Forest
and Range Experiment Station, Forest Service, U.S. Dept.
of Agriculture. Research Note R.M. 114. (Revised edition)
Denver.
- Seidensticker IV, J. C., M. G. Hornocker, R. R. Knight, S. L. Judd.
1970. Equipment and techniques for radiotracking mountain
lions and elk. Forest, Wildlife and Range Experiment
Station, Idaho Cooperative Wildlife Research Unit,
University of Idaho. Bul. No. 6. 20 p. (September) Moscow.

APPENDIX I. RESULTS OF SIGNAL STRENGTH TESTS
(topography was undulating to slightly hilly)

| Signal Strength in <u>s</u> Units | | | | | | |
|-----------------------------------|--------------------|------|----------------------|------|------------------|------|
| Distance (in miles) | Vertical on Ground | | Horizontal on Ground | | Vertical in Tree | |
| | Open | Bush | Open | Bush | Open | Bush |
| 0.5 | 9.0 | 4.5 | 2.5 | 2.0 | 9.0 | 6.5 |
| 1.0 | 6.8 | 2.0 | 3.0 | 1.5 | 6.5 | 4.0 |
| 1.5 | 5.8 | 2.5 | 1.5 | 1.0 | 4.2 | 1.3 |
| 2.0 | 3.3 | 2.5 | 1.1 | 1.0 | 2.5 | 0.5 |
| 2.5 | 2.0 | 1.5 | Tr. | 0.5 | 2.0 | 0.3 |
| 3.0 | 2.0 | 0.5 | | Tr. | 1.8 | Tr. |
| 3.5 | 1.8 | 1.8 | | | 1.5 | 1.0 |
| 4.0 | 1.2 | 1.0 | | | 1.5 | - |
| 4.5 | | Tr. | | | | |



APPENDIX 2. SIGNAL STRENGTH OF TRANSMITTER PROTOTYPE ACROSS OPEN TERRAIN.



APPENDIX 3. SIGNAL STRENGTH OF THE TRANSMITTER PROTOTYPE THROUGH A MIXED STAND (SwA).

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