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FOLLOW-ON TEST OF PROJECT FIRESCAN AS AN RTG HEAT SOURCE SEARCH AND DETECTION SYSTEM

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SUMMARY

The Firescan equipment was used in airborne tests to evaluate its ability to detect simulated radioisotope heat sources and to discriminate them from commonly occurring sources of heat. The Firescan equipment, which was mounted in a Beechcraft King Air, was flown at altitudes of 4000, 8000, 10,000, and 15,000 feet above terrain during both daylight and darkness.

The electrically simulated radioisotope heat sources (SRHS) and some commonly occurring sources of heat were placed in a fixed pattern along an east-west line. The thermal output and size of the SRHS's and other sources of heat were varied to determine the detection range of the Firescan equipment.

The results of these tests were better than the first Firescan tests, but they still indicated that, for this application, the Firescan system would have to operate with certain handicapping restrictions.

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Introduction

In recent years there has been a marked increase in interest in using radioisotopic materials both as instrumentation heaters and as heat sources for radioisotope thermoelectric generators (RTG's) for earth orbit satellites and interplanetary probes. This places added emphasis on the safety aspects of the utilization of these materials when they are out of the immediate control of trained personnel and subject to potentially hazardous environments. Through proper design and adequate spacecraft tracking, the radioisotope materials may be judged safe until they return to the earth's surface following completion of a normal mission or an abort of a mission. The recovery of the radioisotope materials by trained personnel would represent the ultimate in their safe utilization by the aerospace industry. The search, detection, and recovery of the heat sources (radioisotope material inside) after earth impact has been widely discussed. Some analyses[1] and tests[2,3,4] have been performed for recovery of land impacts.

A test similar to the one reported here was conducted in August 1969. A detailed account of that test can be found in Reference 4.

Test Objectives

The objective of this test was to re-investigate the ability of the U. S. Forest Service Project Firescan infrared equipment to detect electrically simulated radioisotope heat sources and to discriminate between the simulated radioisotope heat sources and commonly occurring sources of heat. The re-test of the Firescan system was necessary because equipment problems rendered the two-color system inoperable during the first test of the system.

General Test Information

The U. S. Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory, Missoula, Montana, is developing an airborne infrared line scanner which is specifically oriented to their requirements for the search, detection, and mapping of small single tree or bush fires so that they can be extinguished before they become major fires.

During the period of maximum fire hazard (July 1 to September 15),* the system is flown over an 8000 square mile area southwest of Missoula, Montana. Weather permitting, a mission is flown each day from midnight to 6:00 A.M., with supplemental missions being flown at other times of the day when warranted by fire activity. The flight paths are oriented north and south; they are flown at an altitude of 20,000 feet MSL. The scanned strips are overlapping and thus provide a multiple look at all terrain.

Project Firescan System

The Project Firescan system is composed of an infrared sensor, the electronics to convert the received signals to a photographic image and discriminate the hot spots from the rest of the image, and an airplane to carry the system. Figures 1 through 4 show the different parts of the system.**

One sensor was used for this test. It was a two-color sensor having a filtered indium antimonide element A channel with a 3- to 4-μm wavelength response and a filtered mercury-doped germanium B channel with an 8.5- to 11-μm wavelength response. The scan angle was 120 degrees, and the angular resolution was between 2 and 4 milliradians. The sensor was cooled inflight by a cryogenic liquid nitrogen system.

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*The Sandia tests were conducted in mid-April.

**Figures 1 through 4 courtesy of U. S. Forest Service.

The electronics system takes the signals from the infrared sensor and converts them into a photographic image and at the same time discriminates the hot spots, such as fires, from the rest of the image. The image is printed on a black and white positive film strip by an inflight photo-processor which shows an infrared map of the terrain and any hot spots plus a blip by the hot spot and another blip on the side in line with the hot spot. The image of a 24-hour clock is printed on the film to show the exact time during the flight at which a hot spot was detected. Results are available to the onboard operator in a matter of minutes because the film is continuously processed in flight.

The Project Firescan aircraft is a Beechcraft King Air. The aircraft was specially modified to carry the electronics and sensor, and it has a sliding belly door in the aft portion of the fuselage which is opened for the sensor to "look" through. The aircraft is powered by twin turboprop engines and cruises at approximately 200 miles per hour.

Test Specimens

The simulated radioisotope heat sources consisted of various sizes and combinations of Firerod* cartridge heaters. The test specimens represented typical radioisotope heat sources in size and temperature. The Firerod heaters were of two different sizes: (1) 3/4-inch diameter by 6 inches long and rated at 230 volts and 1000 watts, and (2) 3/4-inch diameter by 12 inches long and rated at 230 volts and 2000 watts. Figures 5 and 6 show two SRHS configurations. The "commonly occurring sources of heat" were represented by a 1000 watt electric floodlamp and charcoal fires (Figures 7 and 8).

Test Setup

The testing site was located at Sandia's Edgewood Bombing Range which is approximately 6 miles north of Edgewood, New Mexico. Four simulated radioisotope heat sources (SRHS), one electric floodlamp, two one-square-foot charcoal fires, and one two-square-foot charcoal fire comprised the complete setup. All specimens were laid out in a

*A commercial inconel sheathed Ni-chrome wire resistance heater.

generally east-west line. The test specimens were spaced to give adequate separation on the film. All the specimens were spaced approximately 500 feet apart, with the charcoal fires on the ends. Figure 9 is a schematic of the test setup.

Power for the SRHS specimens and the electric floodlamp was provided by an on-site powerline via variacs to control power input and temperature. The temperatures of the SRHS specimens were monitored by digital voltmeters and thermocouples.

Test Results

On the first testing day, a flight was made during the daylight hours. As in the previous test, only the large charcoal targets could be detected. This was attributed to the large difference in reflected solar energy between the A and B channels which prevented effective cancellation. Weather caused a three day delay, but after the weather cleared one set of night runs was made. Results from the night runs were encouraging and are given in Table I. Figures 10 through 13 are typical photographic results at the different altitudes. The actual photographic results are somewhat better than indicated by the figures because the photographs lose sharpness when reproduced. The results indicate that the Firescan system can, at night, reliably detect:
(1) 0.25-square foot, 1500°F targets 15,000 feet above terrain,
(2) 0.25-square foot, 1000°F targets 10,000 feet above terrain, and
(3) 0.25-square foot, 500°F and 0.125-square foot, 1000°F targets 4000 feet above terrain. Daytime detection of the small targets does not seem feasible, but daytime detection of targets on the order of 2 square feet at 1200°F may be reasonable.

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2. AFAL-TR-67-70, Locating Radioisotope Heat Sources by Airborne Infrared Detection, D. R. Perkins and L. M. Hedgepeth, Air Force Aero Propulsion Laboratory, Wright-Patterson AFB, Dayton, Ohio, July 1967.

3. NRDL-LR-69-3, An Airborne Infrared System for Locating Radioisotope Heat Sources (Preliminary Report), G. L. Abbott, U. S. Naval Radiological Defense Laboratory, San Francisco, California, January 9, 1969.

4. SC-DR-70-152, Evaluation of Project Firescan as an RTG Heat Source Search and Detection System, J. L. Entrekin and L. L. Keller, Jr., Sandia Laboratories, Albuquerque, New Mexico, March 1970.

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ABSTRACT

The U. S. Forest Service Firescan system was retested as an airborne detection system for use in the search, detection, and recovery of earth-impacted radioisotope heat sources. Test data and photographic results are presented.

The cutoff date for information in this report is January 31, 1971.

Key words: infrared, airborne, U. S. Forest Service

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TABLE I

Data From Night Flight on April 20, 1970, Sandia Edgewood Test Site
Test Site Elevation was 7000 Feet MSL

Slate Number	Altitude (ft)*	Heading	Charcoal Bucket-2 ft^2 at 1200°F	Charcoal Bucket-1 ft^2 at 1200°F	1000 W Light Bulb	Heater 3 x 12 in. 500°F	Heater 3 x 6 in. 1000°F	Heater 3 x 12 in. 1000°F	Heater 3 x 12 in. 1500°F	Charcoal Bucket-1 ft^2 at 1200°F
15	4,000	West	X	X	O	X	X	X	X	X**
16	4,000	East	X	X	O	O	X	X	X	X
17	4,000	West	X	X**	O	X	X	X	X	X**
18	Clouds, no data.									
19	8,000	East	X	X	O	O	O	X	X	X
20	8,000	East	X	X	O	X	O	X	X	X
21	15,000	East	X	X	O	O	O	O	X	X
22	15,000	West	X	X	O	O	O	O	X	X
23	15,000	East	X	X	O	O	O	O	X	X
24	15,000	West	X	X	O	O	O	O	X	X
25	Clouds, no data.									
26	15,000	West	X	X	O	O	O	O	X	X
27	Clouds, no data.									
28	10,000	West	X	O***	O	O	O	O	X	X
29****	10,000	East	X	O***	O	O	O	X	X	X
30	10,000	West	X	O***	O	O	O	X	X	X

*Feet above terrain.
**Target appears on imagery, but no TDM trips.
***Ground crew reported bucket was cooling.
****Light cloud skiff drifted in over area during this pass.

NOTE: X = detected
O = not detected

Figure 1. U. S. Forest Service Project Firescan aircraft

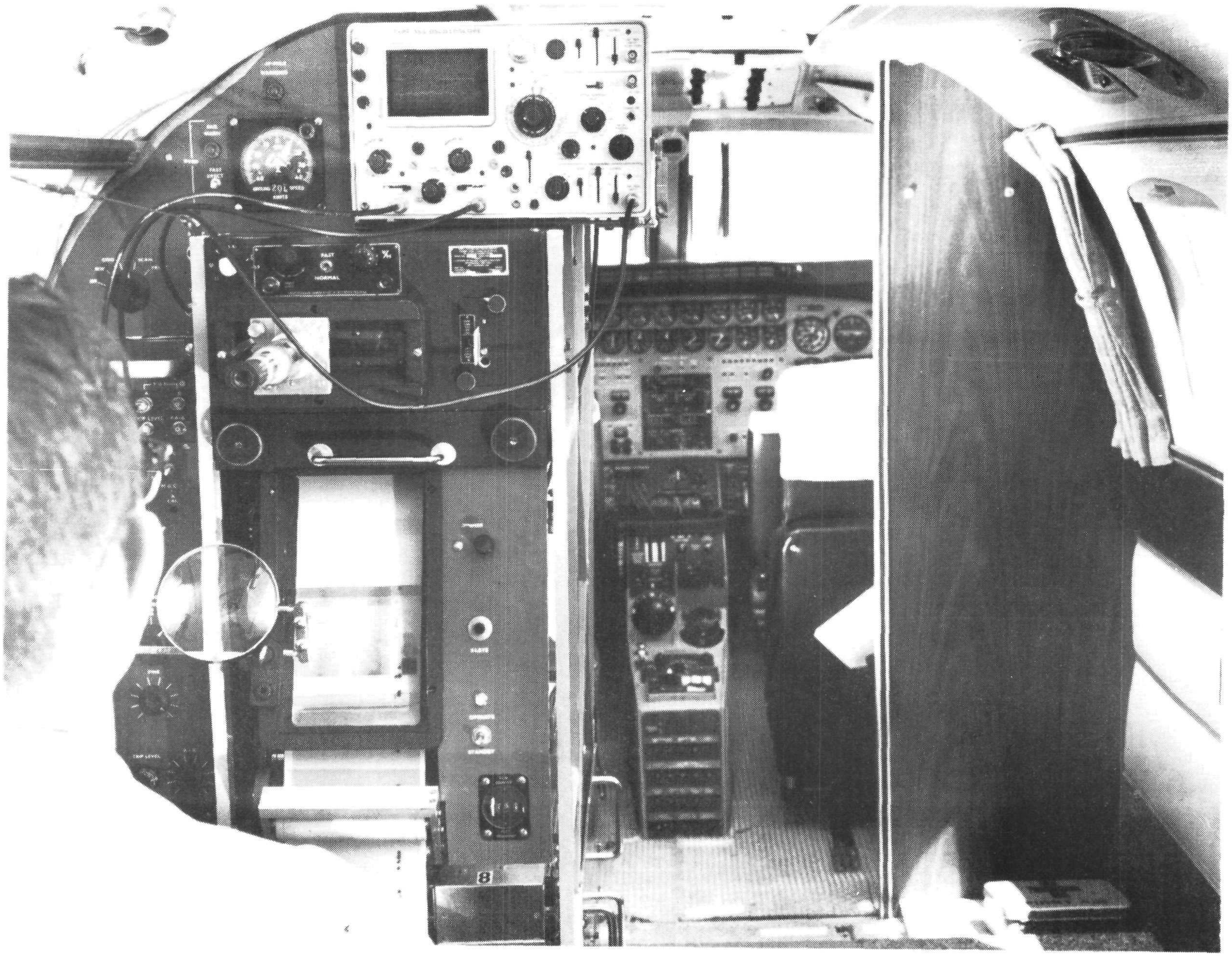

Figure 2. U. S. Forest Service Project Firescan operator's control panel

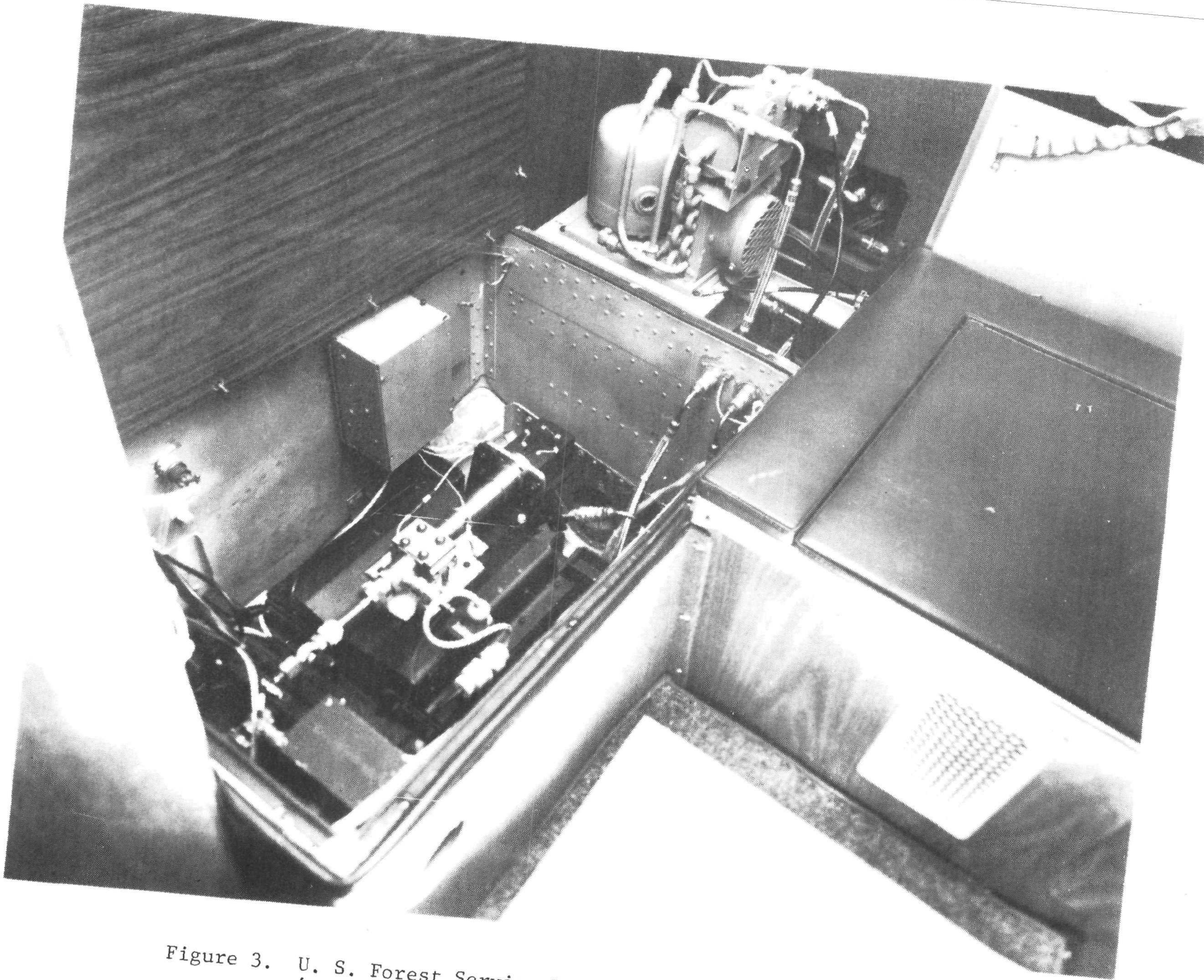

Figure 3. U. S. Forest Service Project Firescan infrared sensor installation in aircraft

Figure 4. Close-up of infrared "window" in belly of U. S. Forest Service Project Firescan aircraft

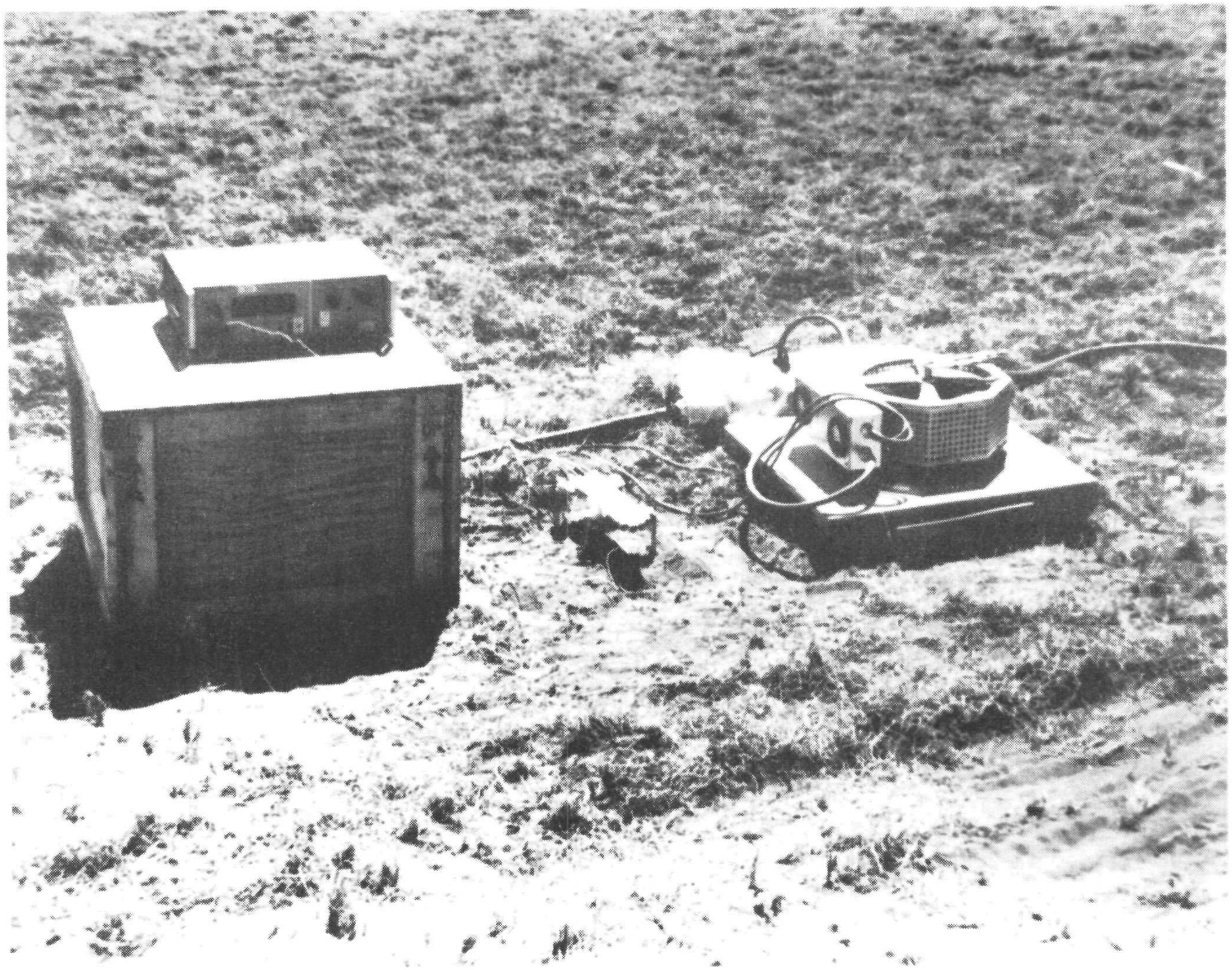

Figure 5. Simulated radioisotope heat source configuration

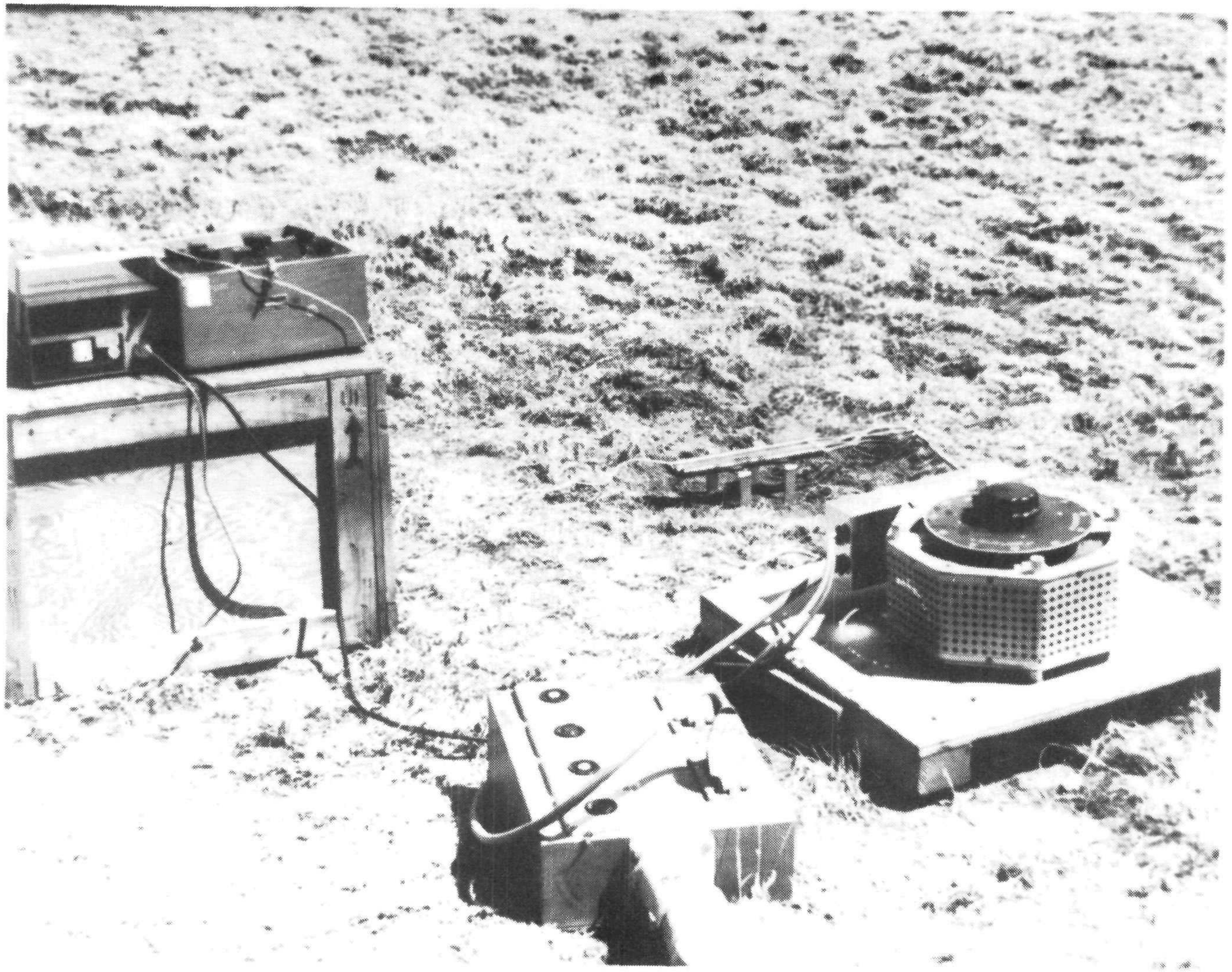

Figure 6. Simulated radioisotope heat source configuration

Figure 7. 1000 watt floodlamp

Figure 8. Charcoal fire

Test Setup

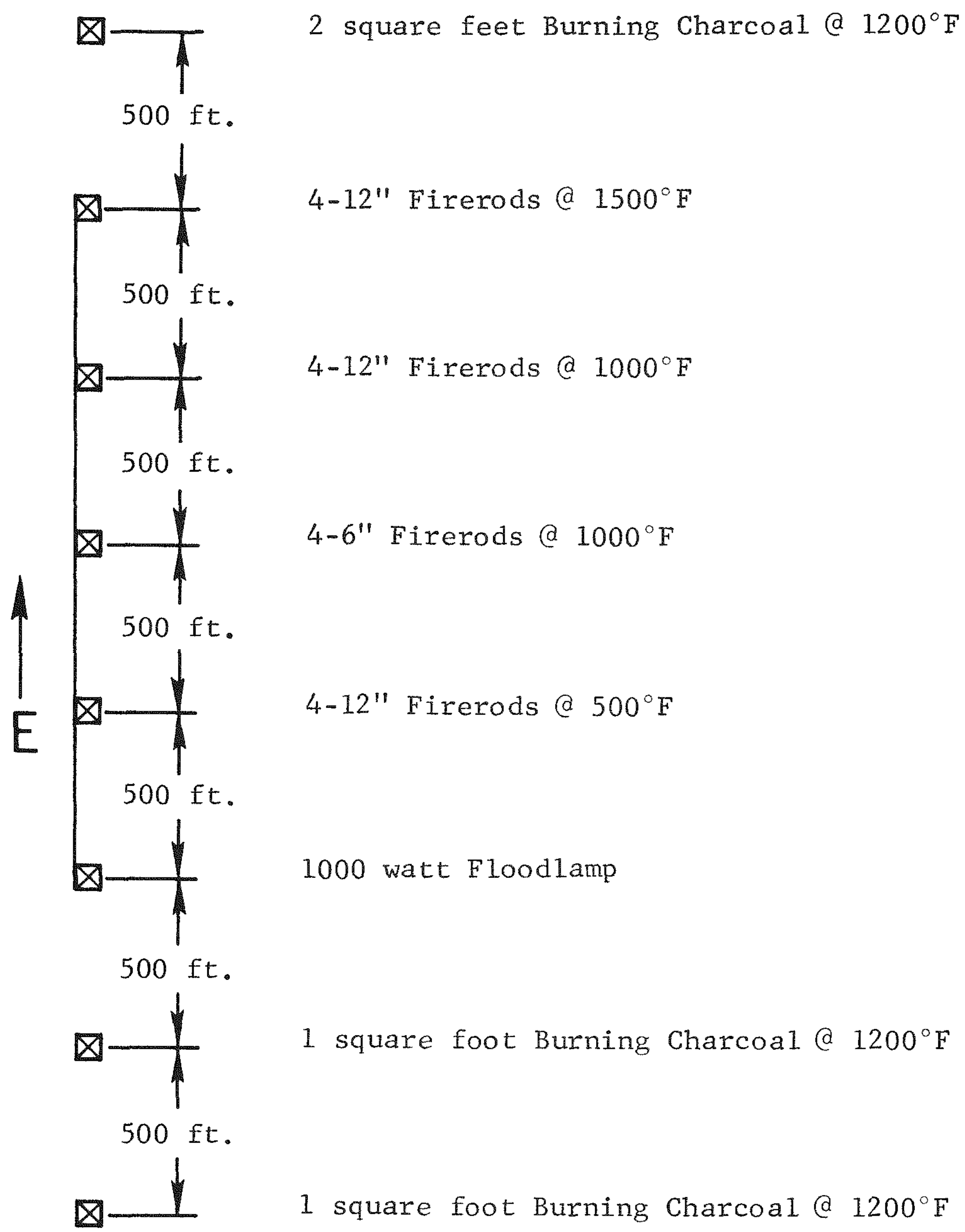

Figure 9. Schematic of Target Layout

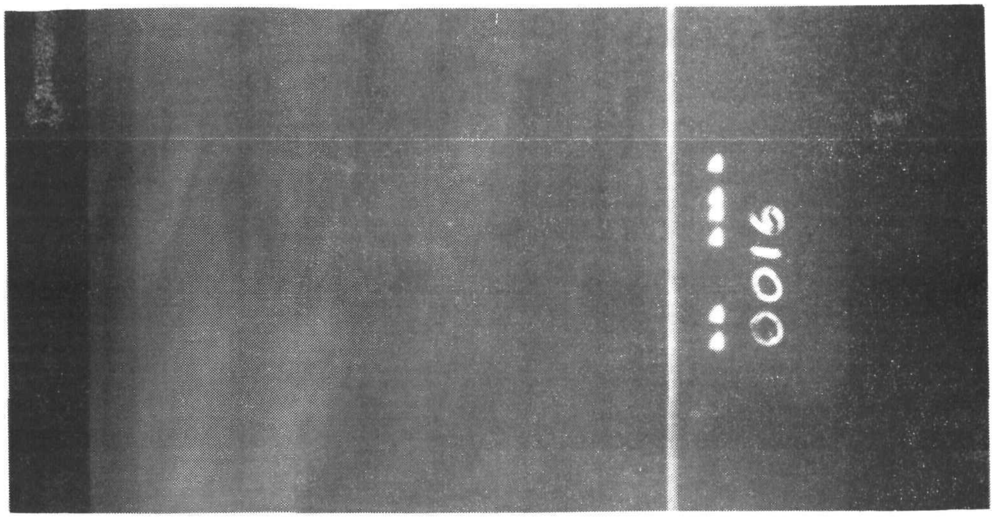

Figure 10. Typical night photograph from
4000 feet above terrain

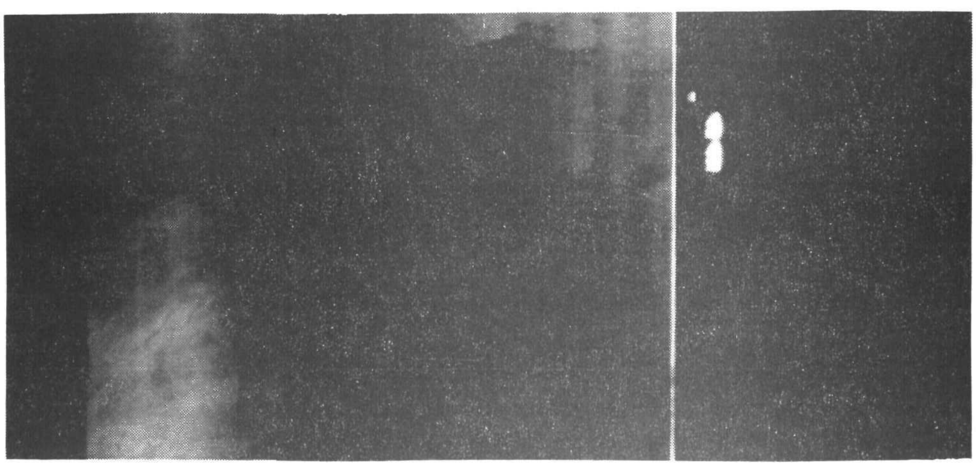

Figure 11. Typical night photograph from
8000 feet above terrain

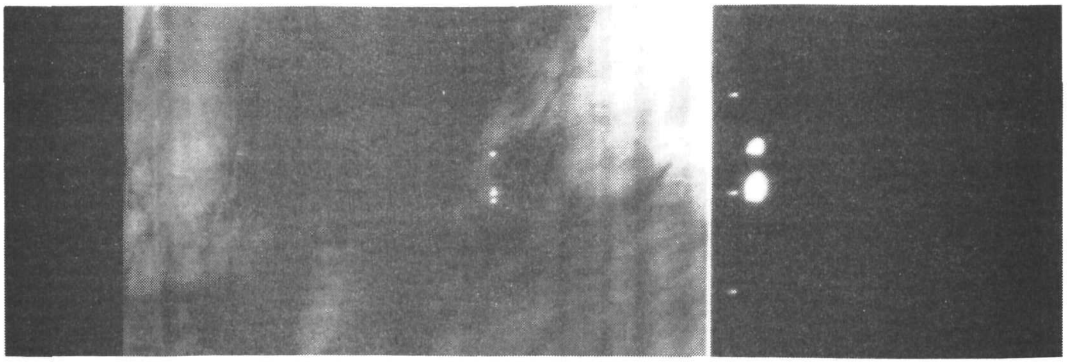

Figure 12. Typical night photograph from 10,000 feet above terrain

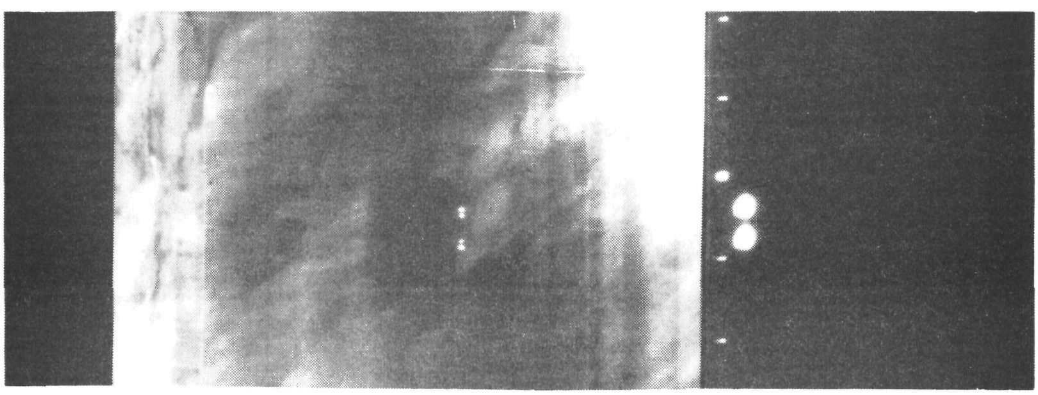

Figure 13. Typical night photograph from 15,000 feet above terrain

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