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EVALUATION OF PROJECT FIRESCAN AS AN RTG HEAT SOURCE SEARCH AND DETECTION SYSTEM

J. L. Entrekin, 9515
L. L. Keller, Jr., 9512

AEROSPACE NUCLEAR SAFETY DEPARTMENT 9510

SANDIA LABORATORIES

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J. L. Entrekin, 9512
L. L. Keller, Jr., 9512
Sandia Laboratories, Albuquerque

Approved by: A. J. Clark, Jr. (signature)
A. J. Clark, 9510

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ABSTRACT

The U. S. Forest Service Firescan system was evaluated 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.

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

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SUMMARY

The Firescan equipment was used in a series of 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 4,000, 8,000, 12,000, and 18,000 feet above terrain during both the day and night. Two types of sensors were used in the Firescan equipment.

The electrically simulated radioisotope heat sources (SRHS) and some commonly occurring sources of heat were placed in a fixed pattern along a normal flight path followed in Project Firescan. The thermal output and size of the SRHS's and other sources of heat were varied to determine the range of detectability of the Firescan equipment.

The results of these tests were encouraging but not optimum due to malfunctions in the Firescan equipment.

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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 heat sources for radioisotope thermoelectric generators (RTG) 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 within its container) after earth impact has been widely discussed. Some analyses[1] and tests[2,3] have been performed for recovery of land impacts.

Test Objectives

The objective of these tests was to 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.

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 8,000 square mile area southwest of Missoula, Montana. Weather permitting, a mission is flown each day from midnight

*The Sandia tests were conducted in mid-August.

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 the 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.*

Two sensors were used for these tests. A two-color sensor having a filtered indium antimonide element A channel with a 3- to 6-μm wavelength response and a filtered mercury-doped germanium B channel with an 8- to 14.5-μm wavelength response was flown first. Two days later a one-color sensor having an unfiltered indium antimonide element with a 1- to 6-μm wavelength response was flown. The scan angle is 120°, and the angular resolution is between 2 and 4 milliradians for both sensors. Both are cryogenically cooled in flight by a liquid nitrogen system.

The electronics used with both sensors are the same. 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 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** and Globar± 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 configurations. The Globar heater was

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

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

± A commercial silicon carbide resistance heater.

2 inches in diameter with a heated length of 8 inches. The "commonly occurring sources of heat" were represented by electric light bulbs and charcoal fires.

Test Setup

The testing site was located about 30 miles by car southwest of Missoula, Montana, about one mile north of Highway 12 on Petty Creek Road. Four simulated radioisotope heat sources (SRHS) one electric light bulb, two four-square-foot charcoal pots, and three smaller charcoal pots of one, one-half and one-fourth square foot sizes comprised a complete setup. Only the SRHS specimens, the electric light bulb, and the large charcoal pots were part of Sandia's tests. The U. S. Forest Service provided the small charcoal pots for their own interests. All specimens were laid out in two generally north-south lines, with the SRHS specimens and the light bulbs on one line and the charcoal pots on the other line. The two north-south lines were separated by approximately 200 feet, with the charcoal pots on the west line. The test specimens were spaced to give adequate separation on the film. Each of the SRHS specimens and the electric light bulb was spaced 200 feet apart and the large charcoal pots were spaced 500 feet from each end of the SRHS light bulb array. The smaller charcoal pots were spaced approximately 500 feet from each other and approximately 500 feet from the large charcoal pot on the north. The SRHS specimens were mounted on insulated steel test stands, with the exception of the buried unit. Figures 7 through 10 show the four setups.

Power for the SRHS specimens and electric light bulbs was provided by two 30 KW motor-generator units via variacs to control power input and temperature. The temperatures of the SRHS specimens were monitored by thermocouples and digital voltmeters.

Test Results

The two-color sensor was used first and was initially flown in the afternoon. Target setup number 1 was used for this test. The system was flown at altitudes of 4,000 and 8,000 feet above terrain. Figure 7 shows the layout. The system could detect only the two large charcoal pots used for marking the area. Figure 11 shows the best results from the test. That night another test was run using the same system. Target setup number 2 was used for this test. Figure 8 shows the layout. The system was flown at altitudes of 4,000, 8,000, and 12,000 feet above terrain. No tangible results were obtained at 12,000 feet above terrain. Photographic results showed that the four 12-inch Firerods at 1500°F, the four 6-inch Firerods at 1650°F, the 2-inch by 8-inch Globar, and the two charcoal markers were detected at altitudes of 4,000 and 8,000 feet above terrain (Figures 12 and 13).

The one-color sensor was installed next and was flown two nights later. Target setups numbers 3 and 4 were used for this test. Figures 9 and 10 show the layouts. In addition, the U. S. Forest Service provided three additional charcoal pots of one, one-half, and one-fourth square foot sizes for this test. The results were relatively good. Photographic results showed that all charcoal pots plus the four 12-inch Firerods at 1000°F, the four 12-inch Firerods at 1500°F, and the four buried 12-inch Firerods with a soil surface temperature of 850°F were detected up to the altitude of 12,000 feet above terrain. When the aircraft moved on up to 18,000 feet above the terrain, the Firerods at 1000°F could not be detected even though their number was doubled, and the buried Firerods could not be detected because they burned out. Figures 14 through 17 show the photographic results at the different altitudes.

Table I contains a summary of the test results.

Conclusions

The results from these infrared detection tests may not be representative of the capabilities of the Project Firescan system. What was thought to be a geometric optical problem was discovered in the two-color sensor two days prior to the commencement of testing, and therefore, results obtained while using the two-color sensor were far from optimum. Also, the one-color sensor used in the tests was not representative of the state-of-the-art, so results obtained while using that sensor were not optimum either.

Some of the test results were encouraging, and it is recommended that the test be rerun after the U. S. Forest Service perfects the two-color system. This system offers the most promise for the search, detection, and recovery needs of the aerospace industry.

TABLE I

TEST RESULTS

Two-color Sensor

Time	Alt. (MSL)	Charcoal, 4 ft.^{2}, 1200°F	Firerods, 4-12", 1500°F	Firerods, 4-12", 1000°F	Firerods, 4-12", 500°F	Firerods, 1-12", 1000°F	Firerods, 4-12" Buried, 1000°F	Firerods, 4-6", 1650°F	Globar, 2" x 8", 1800°F	Light Bulbs, 500 watt, -	Light Bulbs, 1000 watt, -
Afternoon	7,800'	X		0	0	0	0			0	
Afternoon	11,800'	X		0	0	0	0			0	
Night	7,800'	X	X	X			0	X			0
Night	11,800'	X	X	0				X	X		0

One-color Sensor

Time	Alt. (MSL)	Charcoal, 4 ft.^{2}, 1200°F	Charcoal, 1 ft.^{2}, 1200°F	Charcoal, $\frac{1}{2}$ ft.^{2}, 1200°F	Charcoal, $\frac{1}{4}$ ft.^{2}, 1200°F	Firerods, 4-12" Buried, 2150°F	Firerods, 4-12", 1500°F	Firerods, 8-12", 1000°F	Firerods, 6-12", 1000°F	Firerods, 4-12", 1000°F	Firerods, 4-12", 500°F	Bulb, 1000 watt, -
Night	7,800'	X	X	X	X	X	X			X	0	0
Night	11,800'	X	X	X	X	X	X			X	0	0
Night	15,800'	X	X	X	X	X	X			X	0	0
Night	21,800'	X	X	X	X		X	0	0		0	0

X - Denotes target detected at indicated altitude. 0 - Denotes target not detected at indicated altitude.

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1. ALO-2616-1, Infrared Recovery of Space Nuclear Systems, R. C. Ramsey, et al, TRW Systems, Redondo Beach, California, June 13, 1969.

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.

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

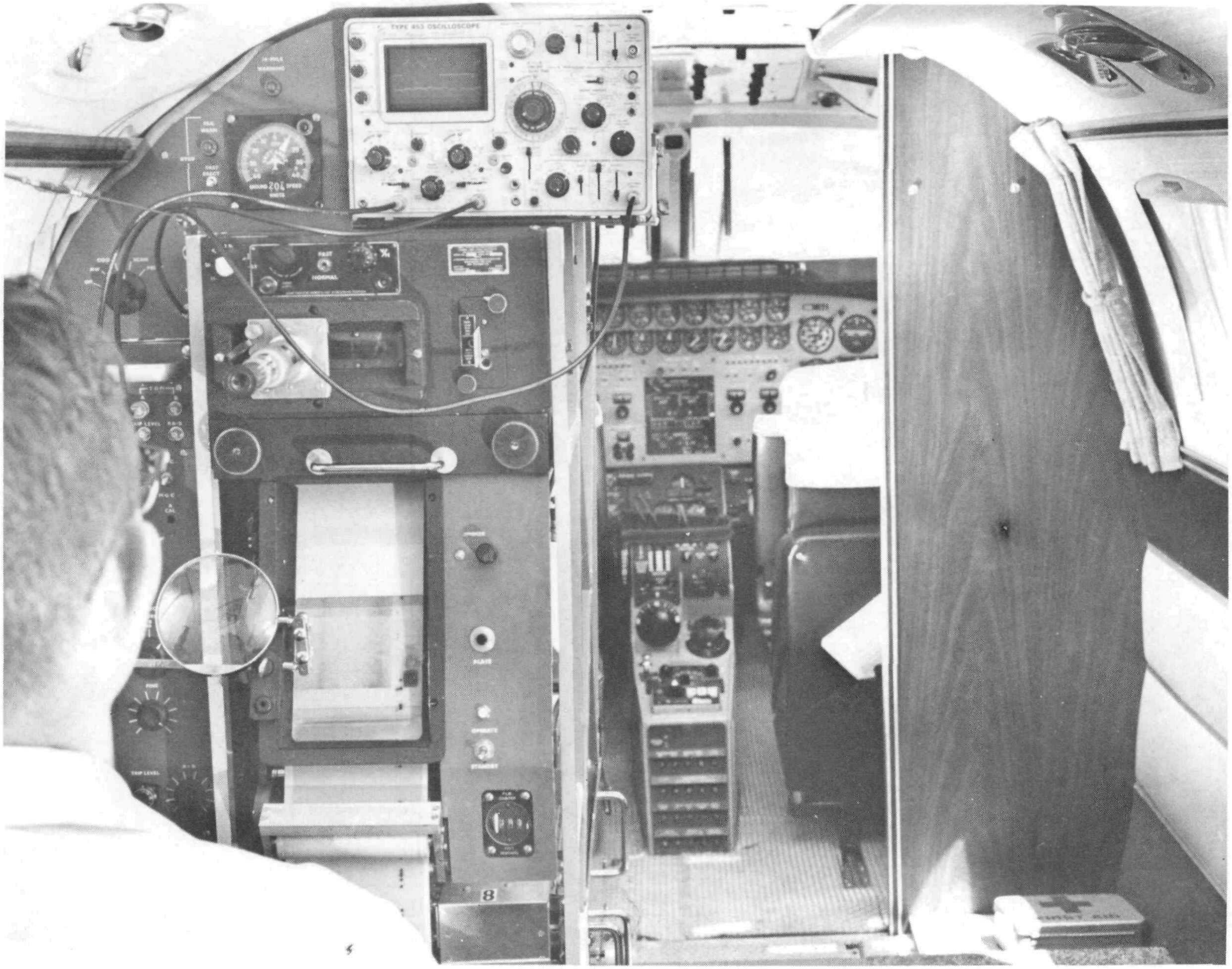

Figure 2. U. S. Forest Service Project Firescan operator's control panel

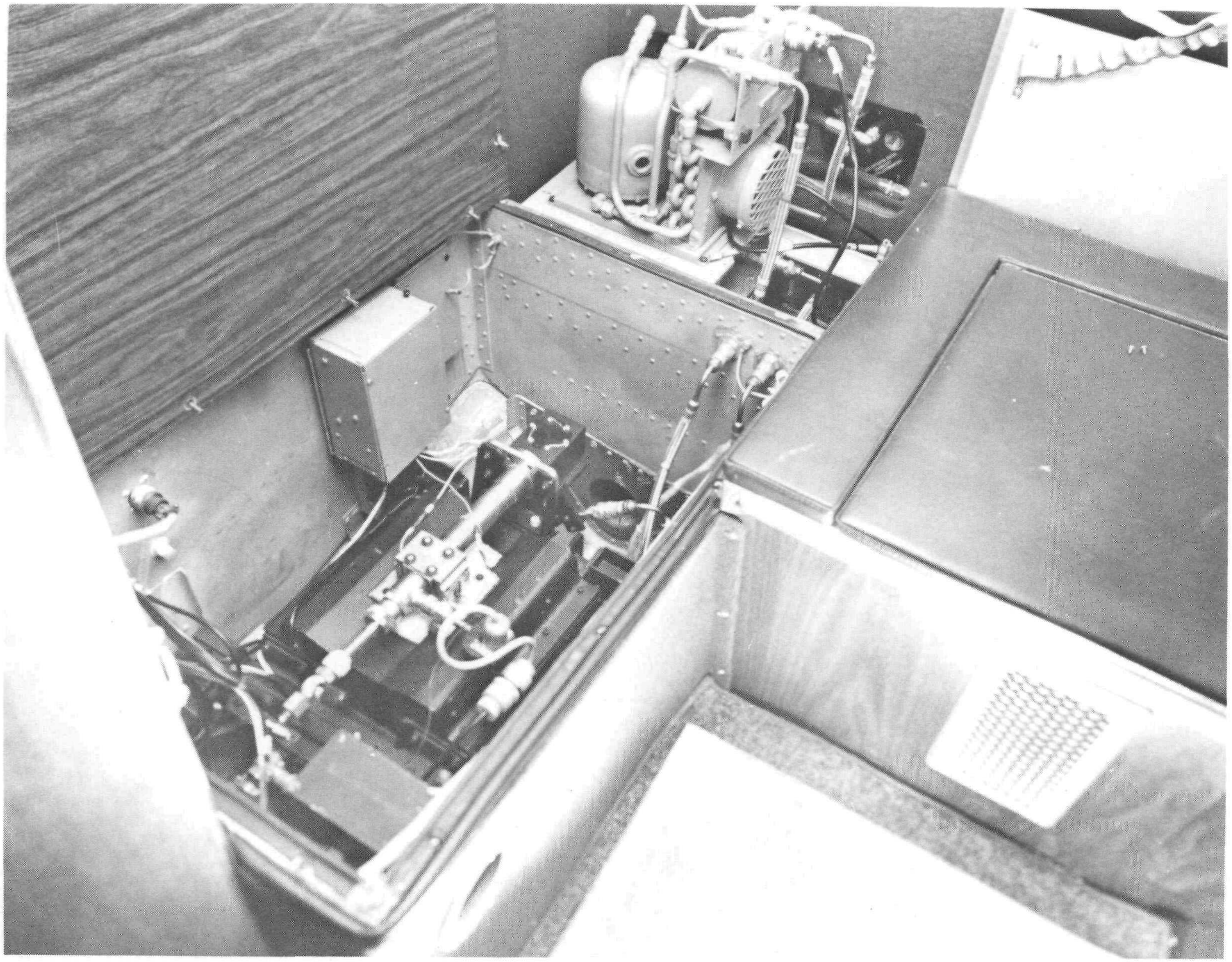

Figure 3. U. S. Forest Service Project Firescan infrared sensor installation in aircraft

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

Figure 5. Exposed SRHS showing Firerod heaters, monitoring thermocouple, protective rain shield, and variac power control.

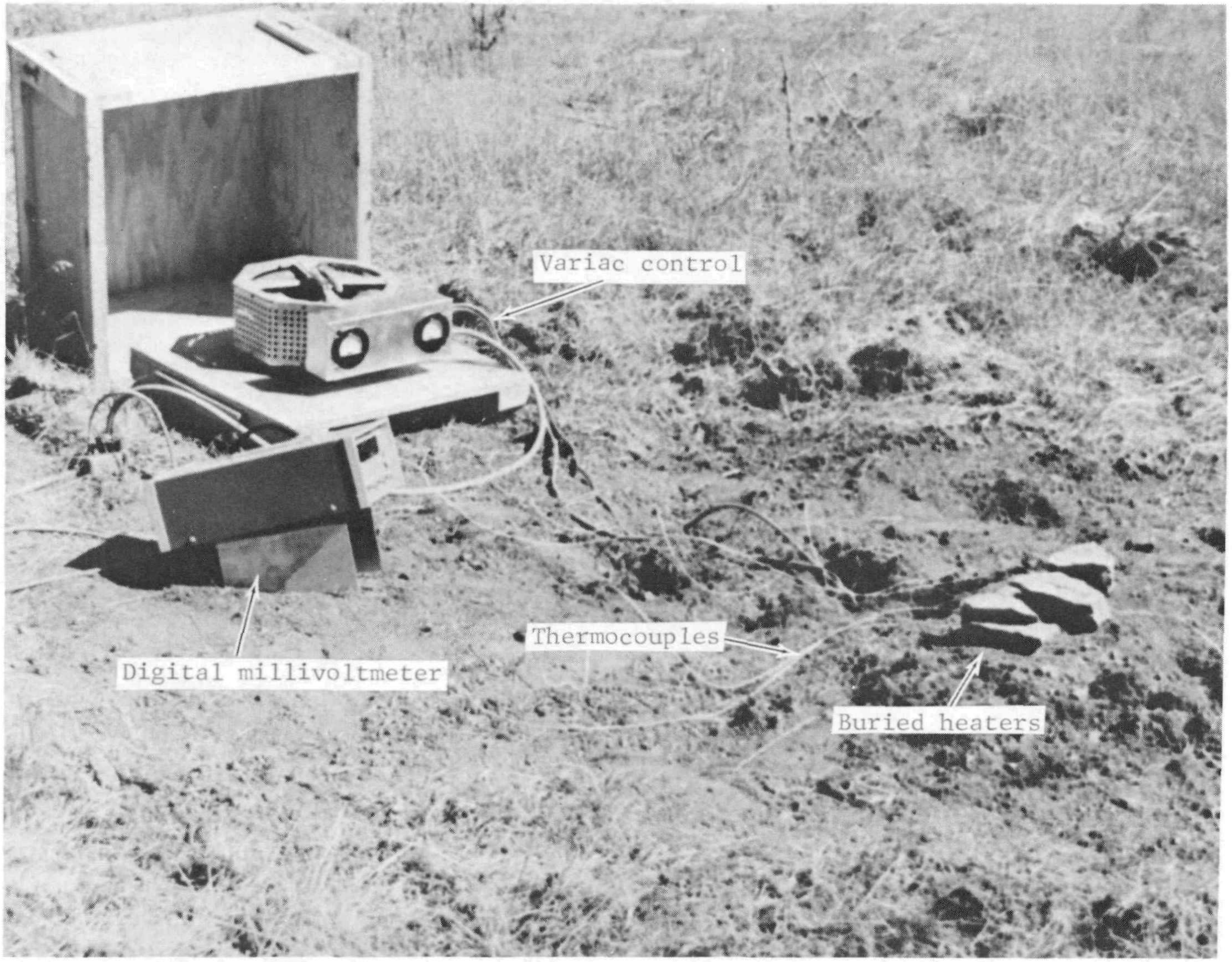

Figure 6. Buried SRHS showing buried heaters, monitoring thermocouples, and digital millivoltmeter, and variac power control.

Weather: Temp.- 55°F Humidity - 61% Wind - 2 knots Sky - Clear

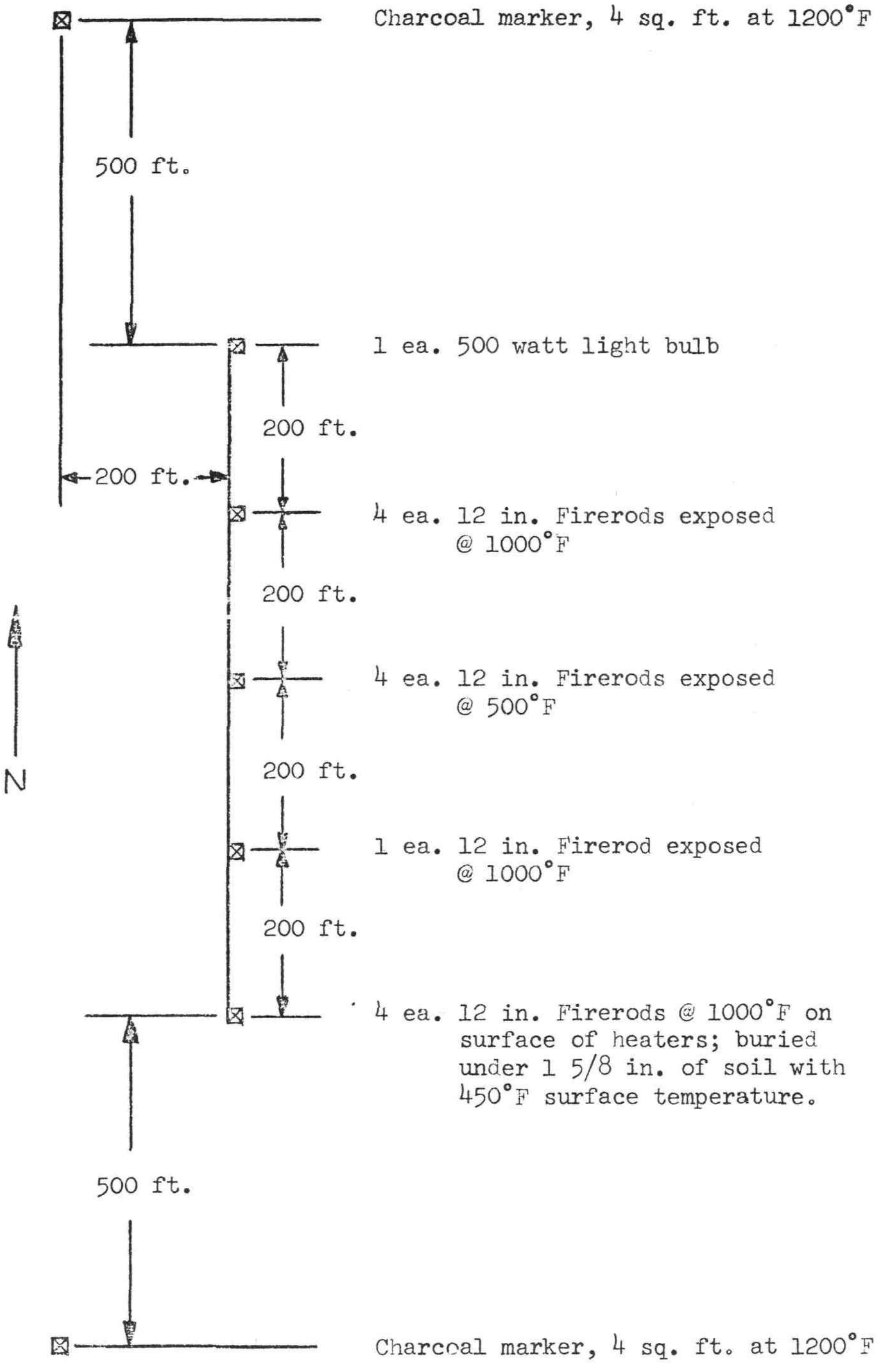

Figure 7. Setup No. 1 - 4,000 and 8,000 ft. above terrain-two-color system

Weather: Temp. - 45°F Wind - 2 knots
Humidity - 93% Sky - Clear

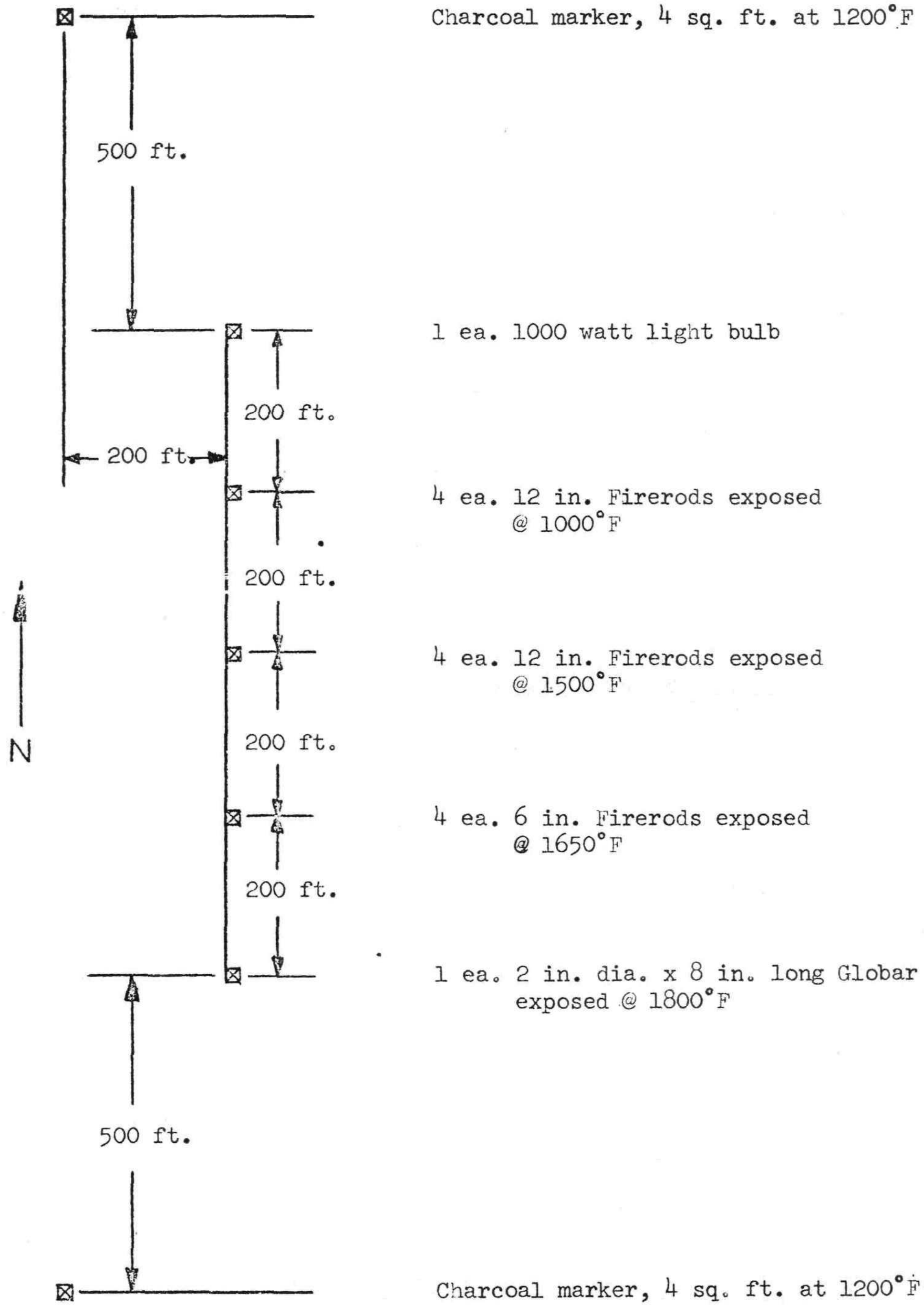

Figure 8. Setup No. 2 - 4000, 8000, 12000 ft. above terrain-two-color system

Weather: Temp.- 62°F Humidity - 45% Wind - Calm Sky - Clear

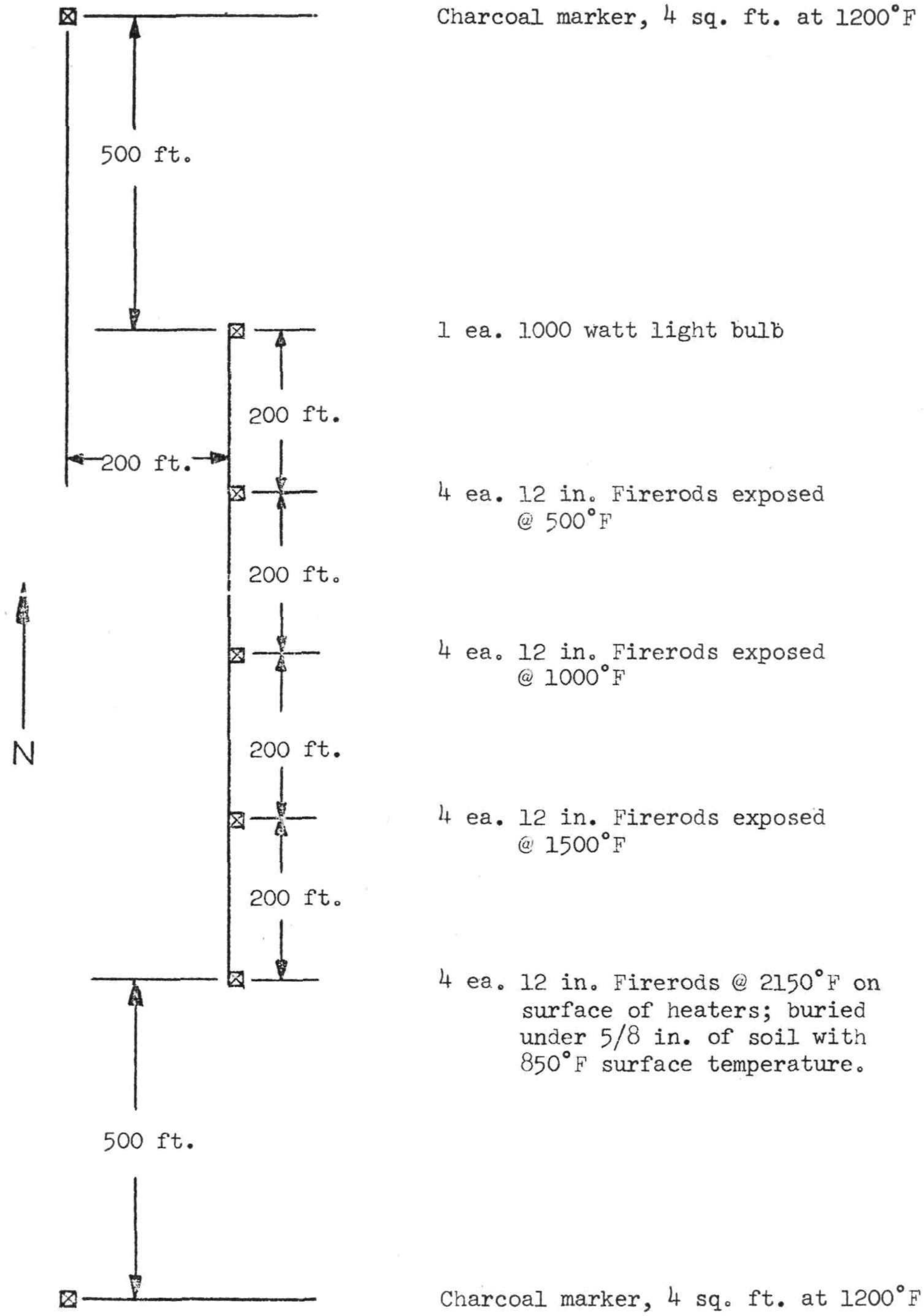

Figure 9. Setup No. 3 - 4000, 8000, 12000, 18000 ft. above terrain-one-color system

Weather: Temp. - 45°F Wind - Calm
Humidity - 63% Sky - Clear

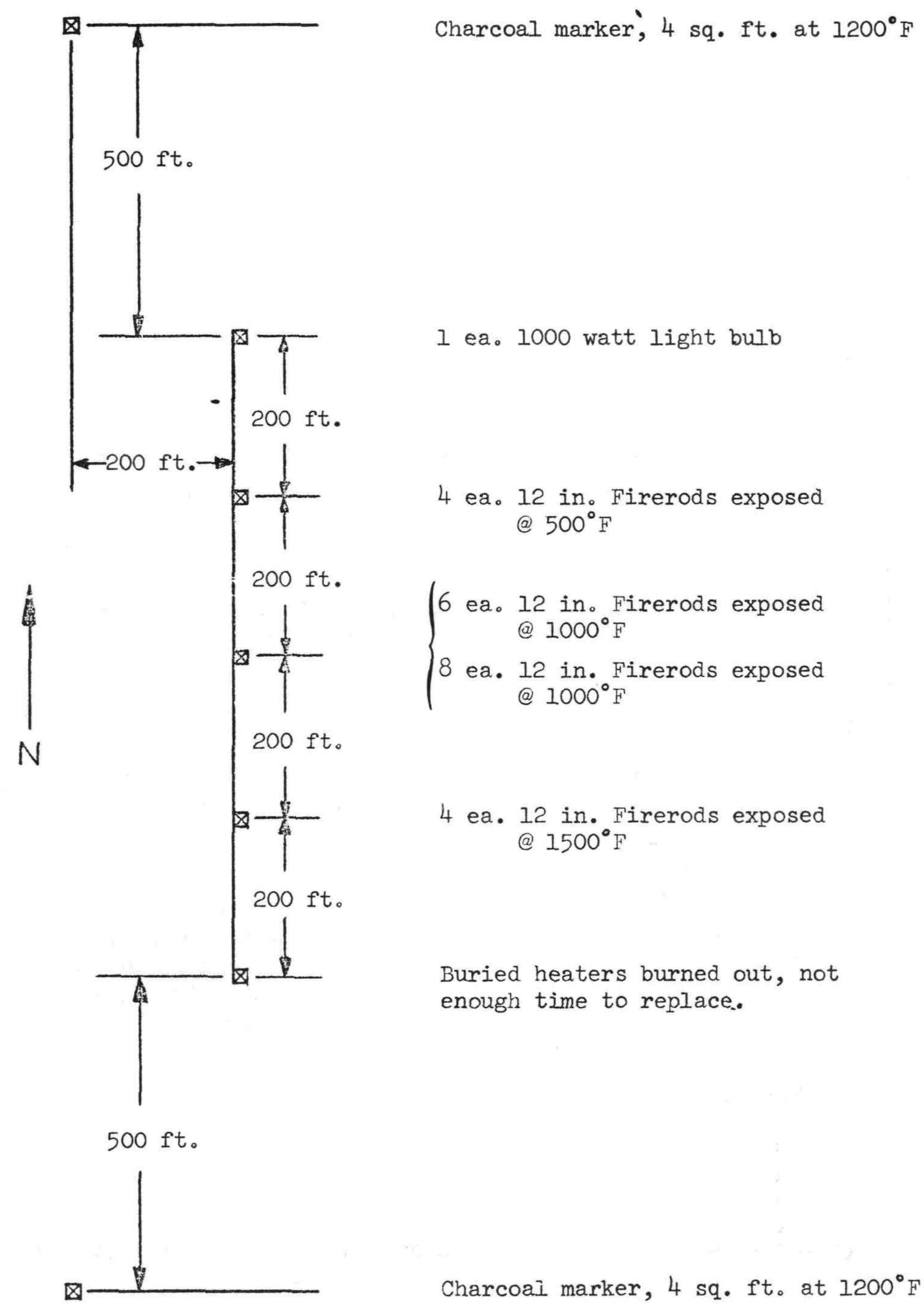

Figure 10. Setup No. 4 - 12000 and 18000 ft. above terrain-one-color system

Figure 11. Two-color system at 11,800 ft. MSL showing only the two large charcoal pots. Best results obtained in the afternoon. Time - 4:00 PM

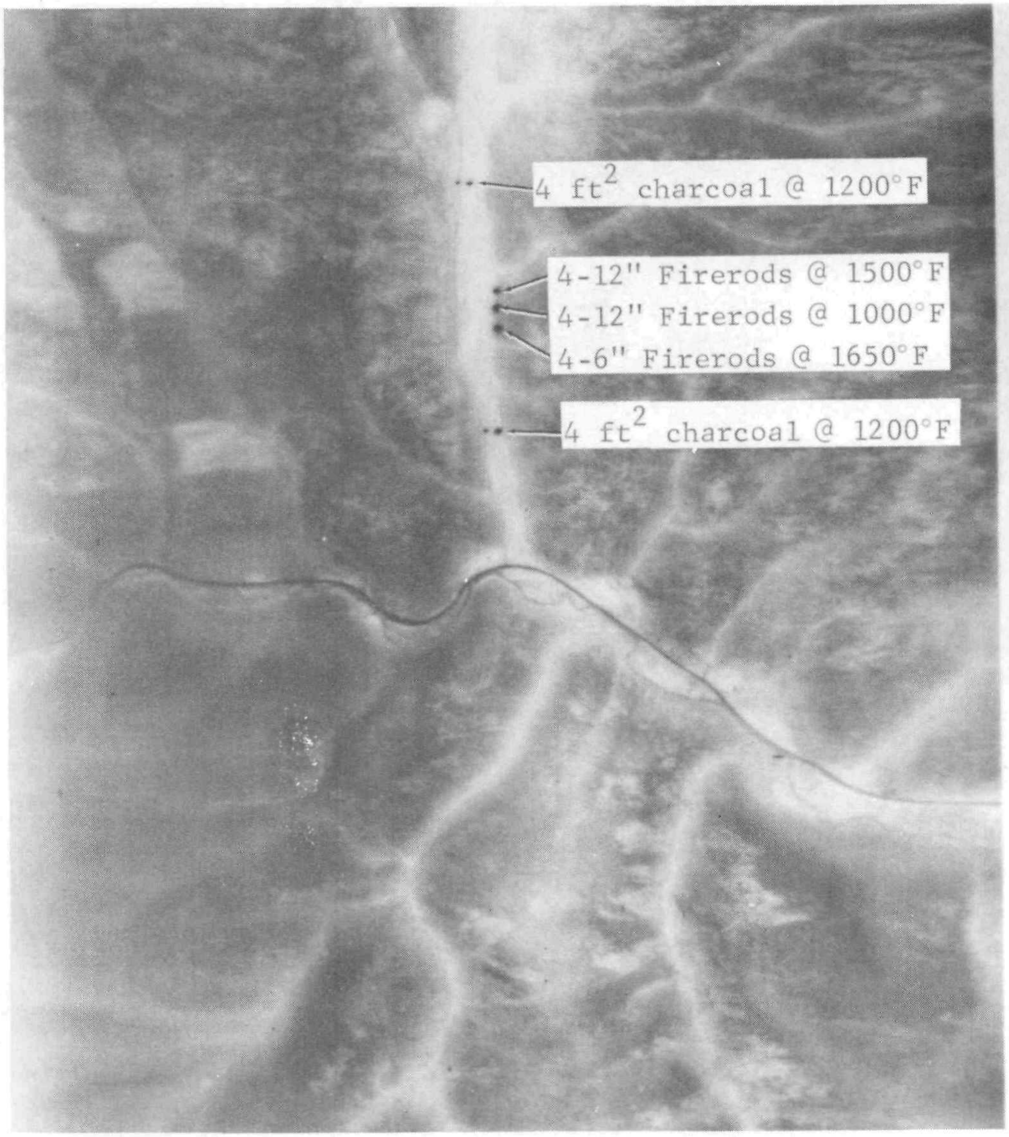

Figure 12. Two-color system at 7800 ft. MSL showing three SRHS and two large charcoal pots. Time - 10:50 PM

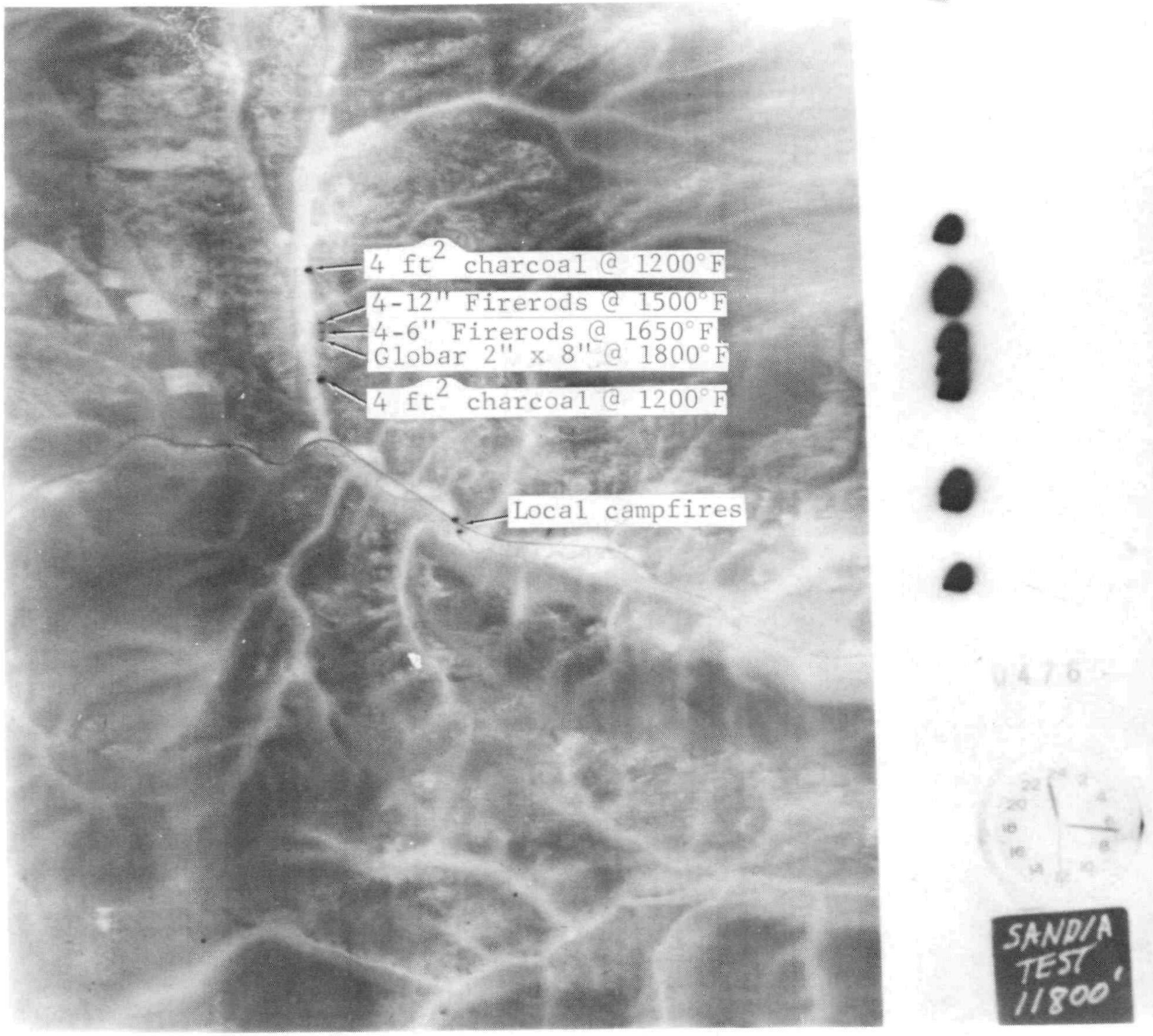

Figure 13. Two-color system at 11,800 ft. MSL showing three SRHS and two charcoal pots. Time - 11:17 PM

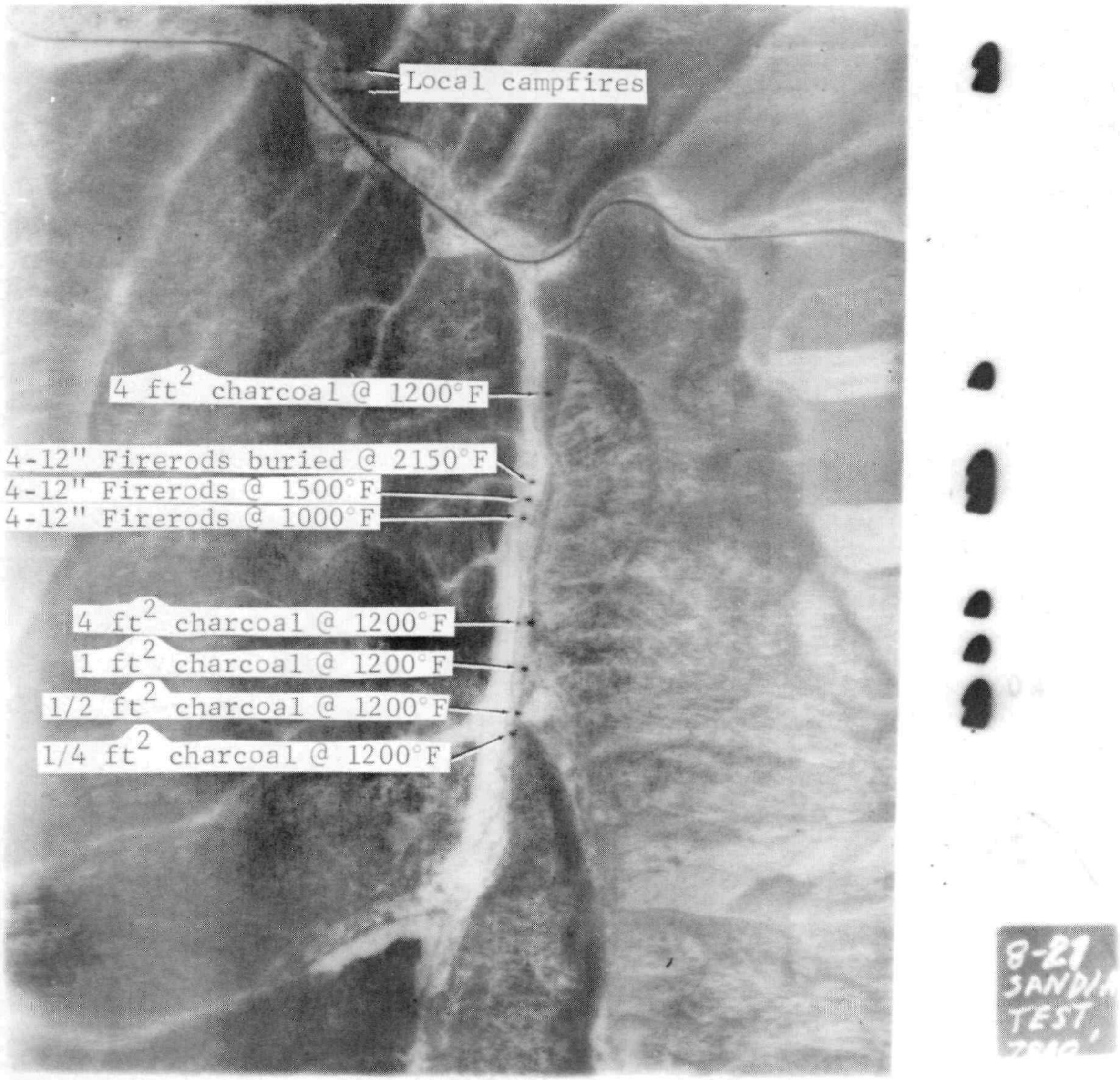

Figure 14. One-color system at 7800 ft. MSL showing three SRHS and all of the charcoal pots. Time - 8:25 PM

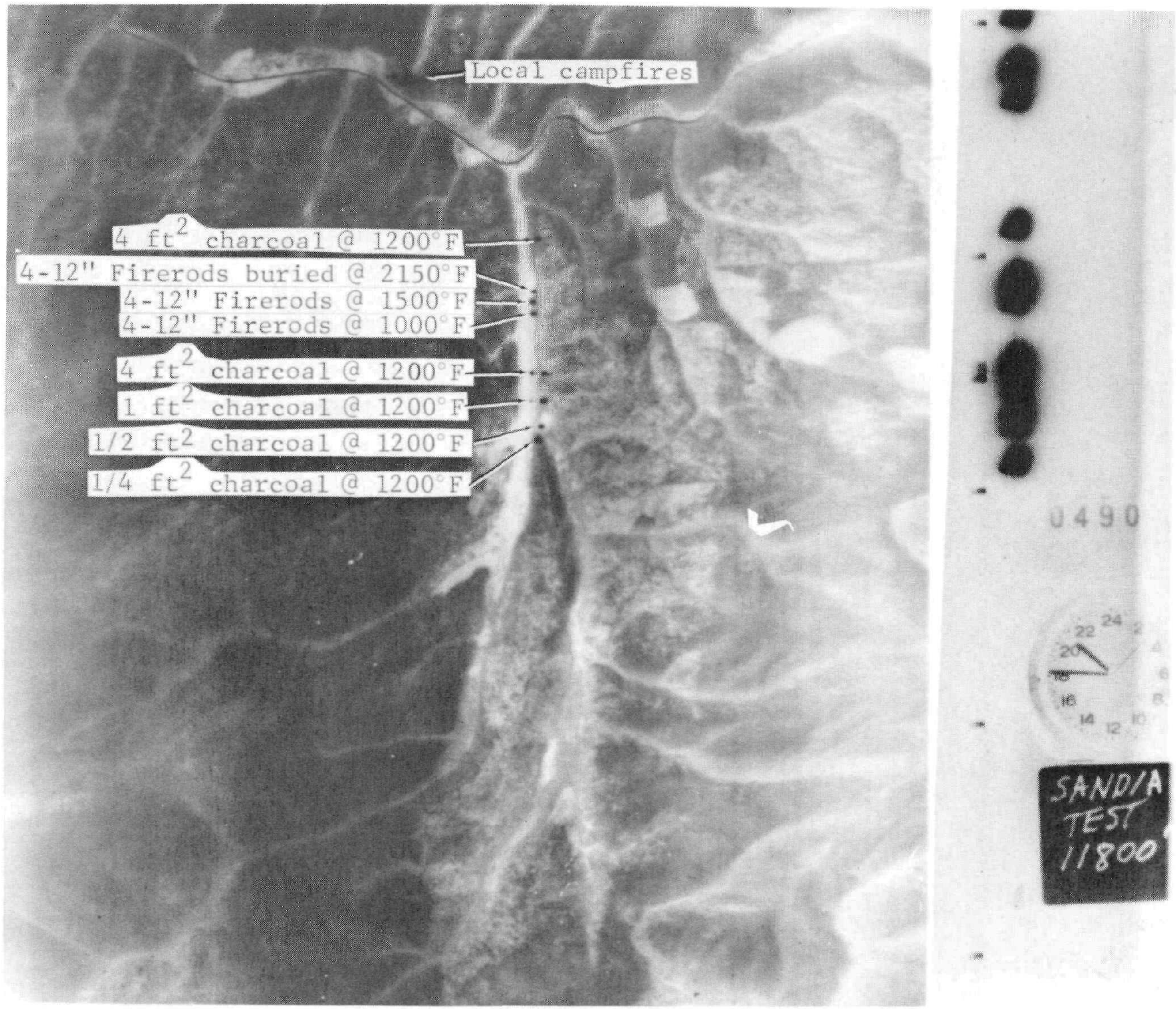

Figure 15. One-color system at 11,800 ft. MSL showing three SRHS and all charcoal pots. Time - 8:45 PM

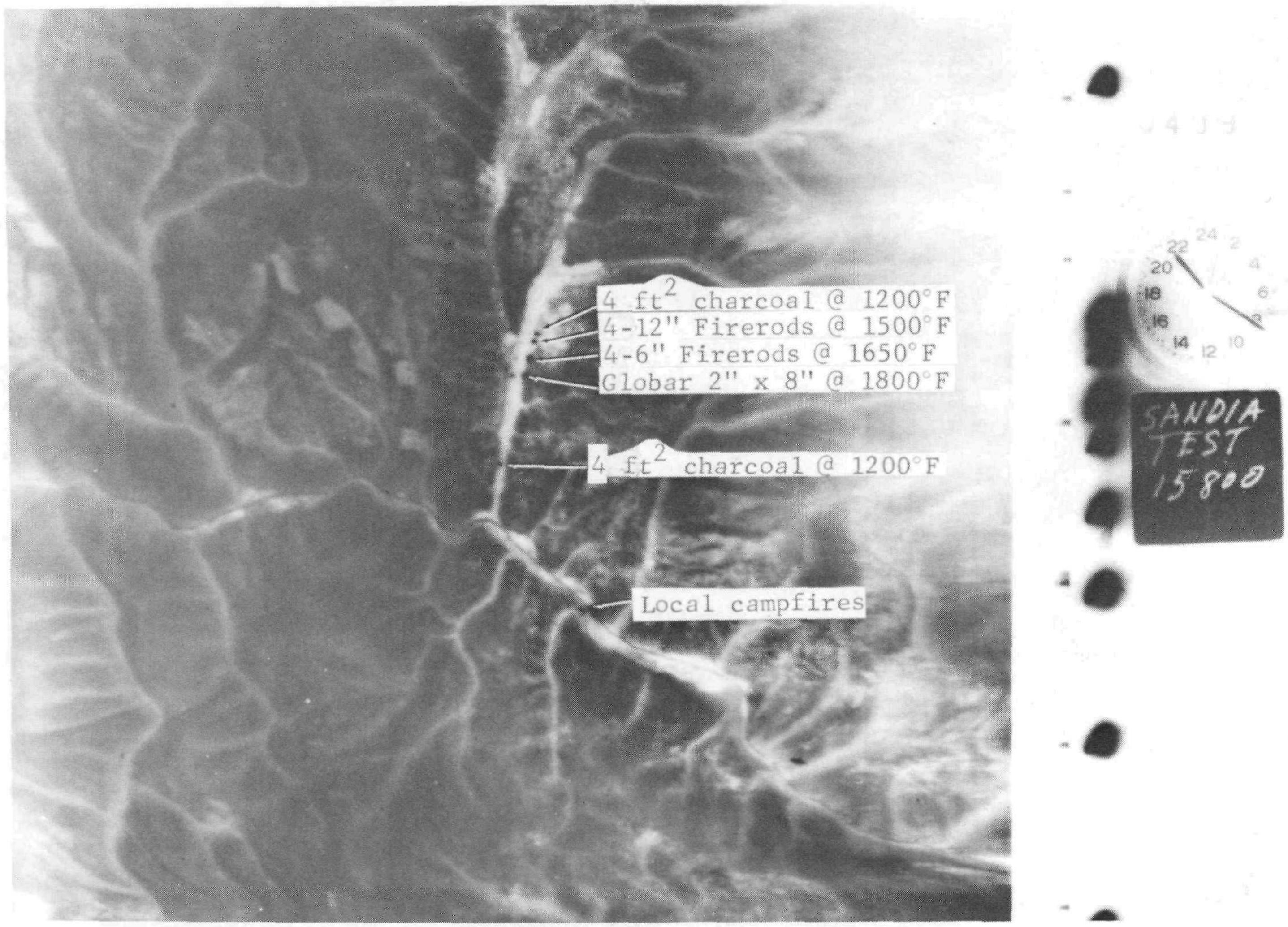

Figure 16. One-color system at 15,800 ft. MSL showing three SRHS and charcoal pots. Time - 9:20 PM

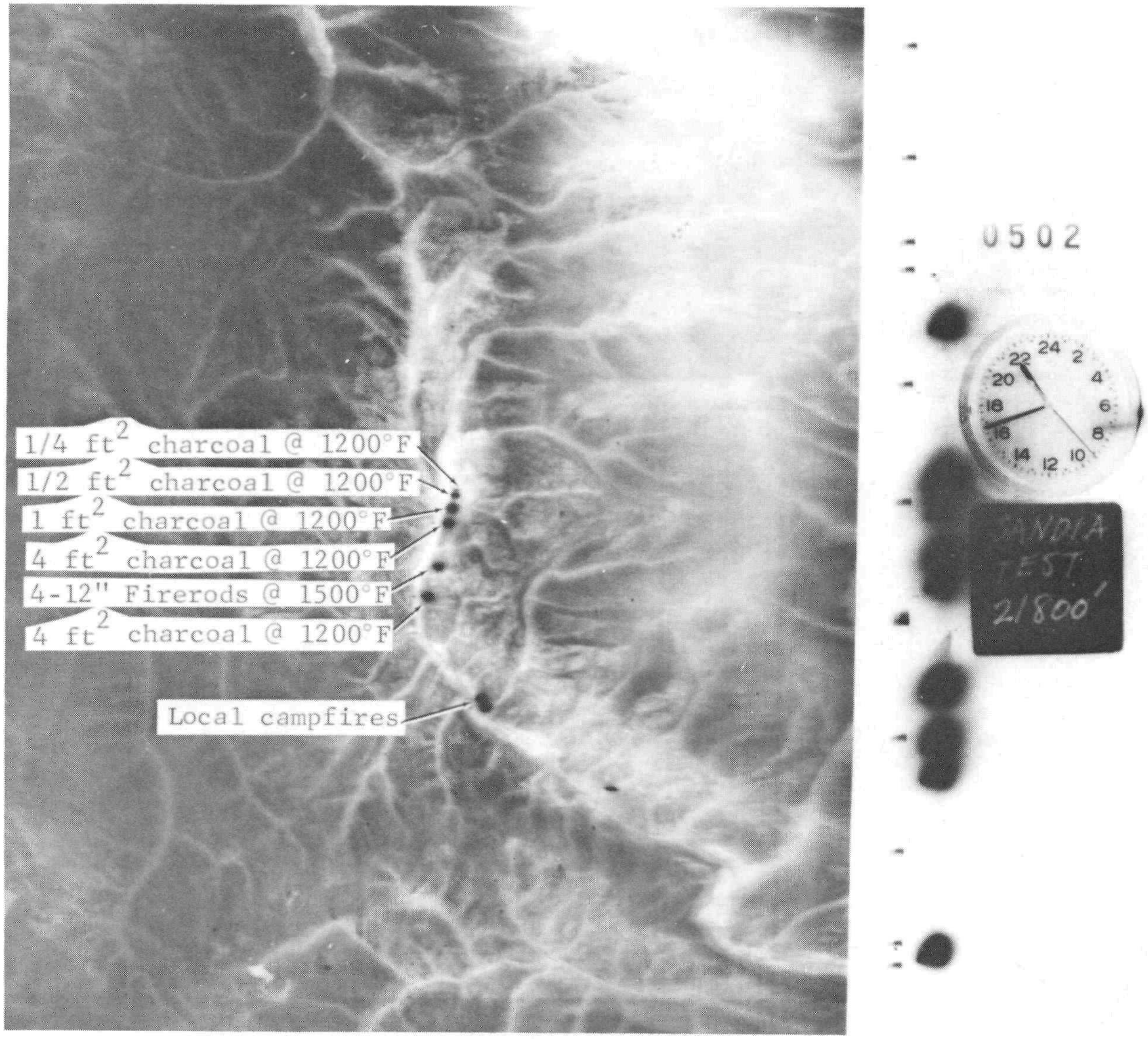

Figure 17. One-color system at 21,800 ft. MSL showing one SRHS and all charcoal pots. Time - 9:42 PM

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