REMOTE SENSING
OF
SOUTHEASTERN WASHINGTON

PART I
INFRARED SCANNING IMAGERY

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PART I

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INTRODUCTION

Industry is becoming increasingly interested in the design of facilities to withstand earthquakes. Problems exist, however, in defining exactly what architectural stresses might be expected since detailed geologic data are insufficient for most areas and are time consuming and expensive to obtain.

Essentially all earthquakes of interest are associated with fractures in the earth's crust (Reference 1). These fractures, when accompanied by a displacement, result in discontinuities which, if detectable, identify areas which could be investigated in detail prior to any construction activities.

In recent years, "remote sensing techniques" have been developed to monitor most portions of the electromagnetic spectrum. As can be seen in Figure 1, the electromagnetic spectrum extends from cosmic radiation in the short wave-length region to radio waves in the long wave-length region, and includes gamma radiation, x-radiation, ultraviolet radiation, visible light, infrared radiation, microwave, radar, and radio waves--the exact divisions are somewhat arbitrary (Reference 2).

This report presents data from a number of spectra which have been obtained on and adjacent to the Atomic Energy Commission's Hanford Reservation and which may be useful in identifying anomalies related to the seismic stability of the area. The objective of this report is to make available an extensive amount of remote sensing data that may be of value

FIGURE 1. Electro-Magnetic Spectrum
(wave lengths in Å)

to investigators interested in the area. However, for purposes of orientation to both the individual sensing techniques and the geographical area, some representative examples are presented and discussed.

The report is issued in several parts:

- Part I Infrared (IR) Scanning Imagery
- Part II Microwave Radiometry Contour Mapping
- Part III High Altitude Multi-spectral Photography
- Part IV Gamma Radiation Contour Mapping

Other parts may be added as the investigation continues.

SUMMARY

High altitude (10,000 feet) IR scan data were obtained over an area encompassing about 15,000 square miles in southeastern Washington. The resulting film imagery was mounted and reviewed from three points of view: (1) Can the existence of purported faulting be confirmed by the IR record?; (2) Can thermal lineaments observed in the IR record be attributed to faulting?; (3) Are there other geologic features which can be uniquely identified from the IR record?

CONCLUSIONS

1. As is the case with most other geophysical techniques, there appears to be no unique correlation between lineaments appearing in IR imagery and geologic features which might be due to fractures.
2. Though seldom mentioned in the literature, the existence of wind patterns has a dominant effect on IR imagery and should be carefully considered during the planning of any large scale IR monitoring effort.

3. Infrared imagery, when combined with a detailed knowledge of the local geology and other geophysical data, may be useful for locating structural anomalies.

DISCUSSIONS

BACKGROUND

Part I of this document deals with the infrared or IR portion of the electromagnetic spectrum. By definition, the IR region extends from the visible region to the microwave region, Figure 1.

Two types of detection are of interest: Monitoring energy which is emitted from a source and reflected from a subject is referred to as an active detection system; while monitoring energy which is emitted directly by the subject being observed is referred to as a passive detection system. The optical equivalent would be taking a picture with a flash bulb (active) versus taking a picture of a flash bulb (passive). This document specifically deals with the results of a passive IR radiation survey, i.e., the sensing of infrared radiation emitted by the earth's surface.

The "sensing" of radiation in the IR region, was first accomplished in the early nineteenth century by Sir Frederic Herschel who used a laboratory thermometer to monitor solar energy below the red band of light in the rainbow produced by a prism (Reference 3).

If one were to scan the complete IR region, while looking at the earth from an airplane, it would be apparent that much of the radiation emitted is absorbed by the atmosphere (Reference 3). As can be seen in Figure 2, a major exception occurs in the wave lengths from 8 to 14 microns where the atmosphere is relatively transparent to IR radiation. This and similar areas, notably one at 3 to 5 microns, are referred to as "atmospheric windows" and essentially all infrared remote sensing takes place through one of these windows.

FIGURE 2. Atmospheric Transmission in Infrared Region.
(Reference 3)

The Stefan-Boltzmann equation (Reference 4) indicates that the amount of energy radiated by a body in the IR region is a function of the effective emissivity of the body and its temperature to the fourth power.

$$e = \epsilon CT^4$$

e = radiated energy

where: ϵ = effective emissivity

C = Stefans-Boltzmann constant

T = temperature

Therefore, when an area is "mapped" at a time when no incident IR radiation is present, as at night, the result is a map or image of the surface temperature of the terrain. As can be seen, variations in the resulting signal can occur due to changes in either the effective

emissivity of the area being observed or in its temperature, and in interpreting IR imagery both possibilities must be taken into account (References 5, 6, and 7).

Commercially available monitoring systems consist of a mirror rotating on a shaft with its axis parallel to the axis of an aircraft. As the mirror scans the terrain below, the reflected image impinges on a sensor amplifier system which in turn records it either on magnetic tape or photographic film. A simplified schematic of such a device is shown in Figure 3.

FIGURE 3. Schematic Diagram of Rotating Mirror Scanner System (Reference 3)

A thermal lineament, as can be observed in some areas along the San Andreas fault trace, can be the result of any discontinuity in physical or chemical properties which affects either the emissivity or the temperature of the terrain (Reference 8). One type of mechanism occurs when movement shifts along the fracture system result in the displacement of aquifers causing the water table on one side of the fault zone to be higher than the other. Because of water's high heat capacity, areas where the water is closer to the surface tend to be more thermally stable than areas with a deeper water table and depending on the time of year, such an area will appear warmer or cooler than the adjacent area. A thermal lineament may also be the result of such things as differences in rock types, vegetation types (which are often a manifestation of different soil types), slope of the terrain, or differences in the thicknesses of the top soils (Reference 8a).

DATA COLLECTION

In Fiscal Year 1971, the Atlantic Richfield Hanford Company (ARHCO) contracted with EG&G, Incorporated, to obtain IR imagery of the Hanford Reservation and the adjacent area (Reference 8A). This imagery was obtained from an altitude of 10,000 feet using a Bendix radiometer in the 8 to 14 micron region with the readout recording directly onto 70 mm photographic film. The equipment was mounted in a Martin-404 aircraft owned by the Atomic Energy Commission (AEC) and the missions were carried out during May and June of 1971 generally between midnight and 6:00 a.m. The film was developed and enhanced where necessary by altering the developing and/or printing procedures. The area covered consists of a square approximately 120 miles on a side with Ellensburg, Washington in the extreme northwest corner and Imbler, Oregon, in the extreme southeast (Figure 4). Figure 5 shows the imagery as it has been mounted. The resulting nearly 15,000 square miles of contiguous coverage is, as far as has been determined, the largest single block of non-satellite IR imagery ever obtained (References 9 and 10).

FIGURE 4. Infrared Imagery Coverage

FIGURE 5. Mosaic of Mounted IR Imagery

ARH-2251

A characteristic of night time imaging systems is their dependence on the aircraft's navigation system. Instrument drift on a long mission as well as perspective distortion resulting from the oblique angle at which everything except the nadir is viewed, prohibits a match in the output of adjacent passes which is sufficiently good for a mosaic fit.

While it is true that some detail is lost as a result of the relatively high altitude, the features of interest in this study tend to be regional in nature and thus, more easily recognized at the smaller scale.

In viewing the imagery, it should be remembered that the contrast observed is due to thermal differences, the darker areas being warmer. Thus, the areas showing a lack of thermal contrast are relatively homogeneous in temperature, usually as a result of winds at ground level. In the mounted imagery, two general wind patterns can be observed. The first, trends from the Ellensburg area southeasterly across the Hanford Reservation. This pattern is attributed to the prevailing winds in the 100 and 200 Areas of the project. A second wind pattern trends from the southwest corner of the image eastward along the Columbia River to Boardman then northeast to the Tri-Cities.

Examples of features which show up as marked contrasts in the imagery are illustrated on the following figures:

The dramatic effect produced by a localized wind pattern in the vicinity of the Yakima Airport is shown in Figure 6 (Reference 11). Note particularly in the figure that the wind cannot homogenize such features as thermostatically controlled building temperatures. As a result, the contrast between the heated buildings and the surrounding area is enhanced by the surface wind; while in the adjacent area of little or no wind, the buildings can be observed only with difficulty since the agricultural features are dominant.

Figure 7 illustrates a large warehousing area at the confluence of the Snake and Columbia Rivers near Pasco. The heated portions of the individual warehouses are readily discernable as is the line of demarcation between the relatively warm Snake River water and the cooler Columbia River water.

FIGURE 6. Wind Pattern at the Yakima Airport Flight Line Number 15

ARH-2251

ARH-2251

FIGURE 7. Warehousing Area at Confluence of Snake and Columbia Rivers Flight Line Number 10

The effect of soil moisture concentrations in the immediate vicinity of continuous circular irrigation projects is easily seen in Figure 8. The black surface of paved highways radiates off thermal energy during the early evening hours and by midnight is cooler than the surrounding areas as shown in Figure 9. An automobile is discernible in the same figure from an altitude of nearly two miles as the result of the engine heat. The planned harvesting of timber is detectable in Figure 10 as a result of different types of vegetation; while springs or seeps which are relatively warmer (at the time of the imagery) than the surrounding ground stand out on the side of a desert hill (Figure 11).

Another significant effect seen in the imagery occurs when the aircraft passes over scattered cloud cover as shown in Figure 12.

IDENTIFICATION OF THERMAL LINEAMENTS

A relatively large number of linear thermal features can be identified in the imagery which was obtained. Only a small number of these, however, have the possibility of being associated with geologic features which would be of interest. Several types of thermal linears are shown in the following figures:

A stream bed through a forested area (Figure 13) stands out due to the relatively warm water flowing in it while a dry gulley pattern which is probably discernible because of variations in the soil moisture can be seen in Figure 14. Individual agricultural units are usually identifiable by their regular geometric shapes; however, the edge of large cultivated areas could sometimes be mistaken for a geologic feature because they traverse a variety of topographic features (Figures 15 and 16).

Wind patterns have already been identified as being a source of thermal linears, sometimes quite sharp (Figure 6). They are often difficult to identify in a single pass but are usually obvious when viewing a broad area. The slope of the terrain being observed bears on the effective emissivity of the area, and as a result ridge crests and rim-rock areas often give rise to linear patterns (Figure 17). Similarly, a pattern, as shown in Figure 18, is sometimes seen at the top of a hill and could be the result of a number of phenomena which would require extensive ground truthing to identify.

FIGURE 8. Soil Moisture Variations on Circular Irrigation Project Flight Line Number 17

ARRH-2251

FIGURE 9. Automobile on Paved Highway Flight Line Number 18

FIGURE 10. Planned Harvesting of Timbers Flight Line Number C

FIGURE 11. Seeps or Springs on Side of Rattlesnake Hill Flight Line Number 12

ARH-2251

FIGURE 12. IR Imagery Over Scattered Cloud Cover Flight Line Number 9

FIGURE 13. Stream Bed Through A Forested Area Flight Line Number E

ARH-2251

FIGURE 14. Dry Gulley Pattern Flight Line Number 13

FIGURE 15. Edge of Large Dry Farm Area Flight Line Number 8

ARRH-2251

FIGURE 16. Edge of Large Irrigation Development Flight Line Number 9

FIGURE 17. Ridge Crest and Rim-Rock Area Flight Line Number 19

FIGURE 18. Cold Creek Valley Flight Line Number 12

By their nature, some of these features could be expected to be seen as photo linears observable in aerial photographs. On the other hand, as would be expected, not all photo linears have any corresponding features in the IR image as shown in Figures 19 and 20 (see Reference 12).

FIGURE 19. Oblique Photo of Plastic Relief Map. The large circle centers on Devil's Canyon near Kahlotus and the small circle centers on Baxter Canyon near the Hanford Reservation.

A review of the thermal imagery did identify two thermal linears occurring at the surface which could be related to underlying geologic features. The first, shown in Figure 21 (see Page 27) is an east-west trending lineament in the vicinity of McNary Dam which extends eastward from Hat Rock State Park. A topographic map of the same area, shown in Figure 22 (see Page 29) indicates the thermal lineament has little or no relation to surface terrain features. The second lineament observed occurs near Patterson, Washington, Figure 23 (see Page 28). The flat contrast seen in the image would normally lead to the conclusion of the cool area was the result of a wind pattern. However, upon closer inspection, it is noted that the same relative flatness occurs in the darker or warmer area

FIGURE 20. Devil's Canyon Near Kahlotus (compare with Figure 19) Flight Line Number 15

FIGURE 21. Thermal Lineament Near Hermiston, Oregon
Flight Line Number 5

FIGURE 23. Thermal Lineament Near Patterson, Washington
Flight Line Number 5

and is broken only by the sharp contrast of the heated buildings adjacent to the irrigated area. The scale in both images is indicated by the one-fourth mile diameter circular irrigated areas. Interestingly, discussions with the developers of each of the large commercial irrigated farms adjacent to these thermal lineaments indicate that both areas were selected specifically because of locally noted differences in the number of frost-free days per year, relative to the immediately surrounding areas (Reference 13). In this case, the IR imagery confirmed what had been previously locally observed and exploited.

FIGURE 22. Oblique Photo of Plastic Relief Map. Circles center on the thermal lineament near Hermiston and Patterson - See Figures 21 and 23.

COMPARISONS WITH EXISTING LITERATURE

There are a number of reports by various authors, that postulate possible faults in the area covered by the imagery and particular attention was paid to reviewing the data from these areas.

- (1) Gable Mountain, Figure 24 (see Page 31) was purported to be the site of thrust faulting (Reference 14, 15 and 16). The IR imagery, however, shows no lineaments corresponding to the purported fault trace which tends to confirm later field work in the area (Reference 14). The tonal differences seen in the imagery may be attributable to emissivity differences as seen in areal photographs; the light areas being basalt outcrops with the darker shades being sage and greasewood covered sandy soil (References 15 and 17).
- (2) Horn Rapids, Figure 25 (see Page 33) was purported to be the site of faulting (Reference 18). The north portion of the area is traversed by a dry stream bed (Cold Creek) where a perched water table might be expected (see Figure 18). Except for the Cold Creek Valley itself, no thermal lineaments can be seen in the IR record.
- (3) Badger Canyon, Figure 26 (see Page 32) has been purported to contain two faults (Reference 18) neither of which correspond to lineaments in the IR record.
- (4) A fourth area of interest occurs on the east bank of the Columbia River across from the Hanford project, generally in the area of Wooded Island. When Figure 27 is compared with a topographic map of the area, (Figure 19), it can be seen that the thermal lineament generally follows a northwest-southeast trending canyon. While the type of thermal linear seen in Baxter Canyon, is not uncommon in other canyons, Figure 28, the fact that Baxter Canyon is (1) at the axis of a structural trend in the underlying basalt (Reference 19), (2) that the elevation of the adjacent anticline is changing at a relatively high rate (Reference 20), and, (3) since the canyon itself and Wooded Island appear to be the focus or relatively shallow

FIGURE 24. Gable Mountain Flight Line Number 15

FIGURE 26. Badger Canyon Flight Line Number 9

FIGURE 25. Horn Rapids Lineament Area Flight Line Number 11

FIGURE 27. Unnamed Canyon Flight Line Number 13

FIGURE 28. Baxter Canyon Flight Line Number 13

seismic noise as indicated by the Hanford geophone network (Reference 15), the particular thermal lineament observed becomes of more interest. It should be pointed out, however, that without the accompanying data regarding the geological structure of the area and the seismic noise associated with it, Baxter Canyon would be of little or no interest and in fact, could not be differentiated from other similar canyons on the basis of IR scanner data.

- (5) The Saddle Mountains indicate an infrared lineament (Figure 17) which corresponds to crest of the anticline (Reference 14), but it is not clear that the lineament is the result of anything other than a sharp change in viewing angle of the terrain or the direction of the slope (Reference 9).

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Jack Doyl	Operations Manager

The following personnel provided the actual data gathering support in the field:

George Ragland	Chief Pilot
Ed Rashke	Captain Pilot
Ron Waagmeester	Captain Pilot
Ralph Barrett	Flight Mechanic
Cecil McManis	Flight Mechanic
Phil Boynes	Senior Scientist
Mike Severt	Senior Technician
Bill Markland	Senior Technician
Bob Mazurkewiz	Senior Technician

The following personnel were responsible for reducing the field data to its final form for evaluation by ARHCO:

Bob Miebbaum	Senior Scientific Specialist
Joel Jobst	Senior Scientific Specialist

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APPENDIX A

BENDIX THERMAL MAPPER SPECIFICATIONS

APPENDIX A

BENDIX THERMAL MAPPER SPECIFICATIONS

Operating Times

Film running time	1 hr at maximum film speed 2 hr or more at average film speed
Liquid nitrogen hold time	3.5 hr

Performance

Instantaneous field-of-view (resolution)	2.5 milliradians
Lateral Scan Angle	120 degrees
Temperature difference sensitivity	0.5 °C
Total available spectral coverage with mercury germanium detector (Manual setting of choice of one of 4 filters available in flight.)	8 to 14 microns
Maximum v/h (aircraft velocity in f.p.s./altitude in feet)	0.250 radians/sec
Detector	Mercury doped germanium
Detector cooling	Liquid nitrogen
Power requirements (with roll compensation)	10 a at 24-28 v DC
Scan head weight	35 lb
Weight of control box electronics	20.0 lb
Recording	70 mm tri-x film
Film capacity	100 ft
Roll compensation - compensates for aircraft roll up to ± 6 degrees	
Tape recorded output	
Real time display	

APPENDIX B

FLIGHT LOG

APPENDIX B

FLIGHT LOG

May 20, 1971 - NATS Aircraft (Martin-404) arrived at the Pasco Airport.

May 21, 1971 - An instrument calibration flight was made in the afternoon.

May 22, 1971 - Flight lines 5 through 10 were flown between 0025 and 0530.

<u>Flight Line</u>	<u>Local Time</u>	<u>v/h Dial</u>	<u>DC Dial</u>	<u>Signal Dial</u>	<u>Marker Number</u>	<u>Remarks</u>
5	0025	0.030	46	8	MK1	Line Number 5 East to West
	0026	0.032	46	8	MK2	Changed V/H
	0028	0.024	46	8	MK3	Changed V/H
	0051	0.026	46	8	MK4	Changed V/H
	0058				MK5	End Line Number 5
6	0103	0.024	46	8	MK1	Line Number 6 East to West
	0104	0.031	46	8	MK2	Changed V/H
	0119	0.021	46	8	MK3	Changed V/H
	0135					Signal went to weak Level D6 almost zero - 15m: From End of Line
7	0203	0.027	57	7	MK1	Line Number 7 East to West
	0210	0.024	57	7	MK2	CH V/H
	0226	0.024	57	11	MK3	CH Gain
	0230	0.024	57	7.5	MK4	CH Gain
	0236	0.032	57	7.5	MK5	CH V/H
	0237	0.032	59	7.5	MK6	CH DC Level
	0239				MK7	End Line Number 7

<u>Flight Line</u>	<u>Local Time</u>	<u>v/h Dial</u>	<u>DC Dial</u>	<u>Signal Dial</u>	<u>Marker Number</u>	<u>Remarks</u>
8	0244	0.032	63	11	MK1	Start Line Number 8 West to East
	0247	0.029	63	11	MK2	CH V/H
	0252	0.024	63	11	MK3	CH V/H
	0254	0.024	59	11	MK4	CH DC Level
	0300	0.020	59	11	MK5	CH V/H
	0303	0.020	63	10	MK6	CH DC & Gain
	0308	0.020	61	9	MK7	CH DC Gain
	0320				MK8	End Line Number 8
9	0340	0.23	64	10	MK1	Start Line Number 9 East to West
	0352	0.23	61	12	MK2	Ch Dc and Sig-Saturating Signal couldn't get settings right - over a city
	0355	0.23	60	12	MK3	Another city Ch DC Level
	0358	0.023	58	10	MK4	Another city
	0410	0.023	63	10	MK5	Ch DC Level
	0411	0.026	63	10	MK6	CH V/H
	0414					End Line Number 9
10	0453	0.025	61	7	MK1	Start Line Number 10 West to East
	0500	0.023	59	7	MK2	Ch V/H & DC Level
	0509	0.020	59	7	MK3	Ch V/H
	0528				MK4	End Line Number 10
	0530				MK1	Ran Step Wedge
	0012	100	0	0 to 96	MK1	Step Wedges
	0013				MK2	End Step Wedges

<u>Flight Line</u>	<u>Local Time</u>	<u>v/h Dial</u>	<u>DC Dial</u>	<u>Signal Dial</u>	<u>Marker Number</u>	<u>Remarks</u>
11	0033	021	61	11	MK1	Line Number 11 East to West
	0039	021	66	11	MK2	CH DC
	0041	023	63	11	MK3	CH DC & V/H Dial
	0051	023	63	13	MK4	CH Gain
	0056	023	66	13	MK5	CH DC Level
	0101				MK6	End Line Number 11
12	0121	021	66	12	MK1	Line Number 12 West to East
	0133	021	71	12	MK2	CH DC Level
	0136	021	66	14	MK3	CH DC Level & Gain
	0144	019	66	14	MK4	CH V/H
	0147	019	73	13	MK5	CH DC & Gain
	0155					End Line Number 12
13	0216	022	66	12	MK1	Start Line Number 13 East to West
	0223	023	66	11	MK2	CH V/H & Gain
	0232	023	64	12	MK3	CH DC & Gain
	0237	023	64	12-1/2	MK4	CH Gain
	0245	023	64	10	MK5	CH Gain
	0250					End Line Number 13
14	0317	020	62	5	MK1	Start Line Number 14 West to East
	0323	020	62	10	MK2	Ch Gain
	0335	020	65	9	MK3	Ch DC & Gain
	0403					End Line Number 14
15	0436	0.022	64	10	MK1	Start Line Number 15 East to West
	0444	0.023	64	10	MK2	CH V/H
	0456	0.024	65	11	MK3	CH V/H & DC & Gain
	0505	0.024	70	11	MK4	Ch DC
	0507					End Line Number 15

Flight Line	Local Time	v/h Dial	DC Dial	Signal Dial	Marker Number	Remarks
15	0512	0.022	64	9	MK1	Line Number 15 West to East
	0520	0.021	62	9	MK2	CH V/H & DC
	0523	0.027	64	8	MK3	CH V/H & DC & Gain
	0525	0.021	62	8	MK4	CH V/H & DC
	0527	0.021	61	8	MK5	CH DC
	0537	0.020	63	9	MK6	CAV/H & DC & Gain
	0546	0.020	64	9-1/2	MK7	CH DC & Gain
	0540					End Line Number 15
						Ran Step Wedges
	2350	100	0	0 to 96		Ran Step Wedges
17	0058	020	63-1/2	10-1/2	MK1	Start Line Number 17 East to West
		0.021	64-1/2	9	MK2	Ch V/H - Gain - DC
		0.021	63	9	MK3	Ch DC Level
		0.023	65-1/2	9	MK4	Ch V/H & DC Level
						End Line Number 17
18	0200	0.028	73	12	MK1	Start Line Number 18 West to East
		0.025	69-1/2	12	MK2	Ch V/H & DC
		0.023	69-1/2	12	MK3	Ch V/H & DC
		0.023	72	11-1/2	MK4	Ch DC & Gain
						End Line Number 18
19	0310	0.022	71	11-1/2	MK1	Start Line Number 19 East to West
	0316	0.021	71	11	MK2	Ch V/H & Gain
	0324	0.021	66-1/2	11-1/2	MK3	Ch Gain & DC
	0330	0.020	64-1/2	11	MK4	Ch V/H & DC 7 Gain
	0338	0.020	72-1/2	11	MK5	Ch DC
	0347					End Line Number 19

<u>Flight Line</u>	<u>Local Time</u>	<u>v/h Dial</u>	<u>DC Dial</u>	<u>Signal Dial</u>	<u>Marker Number</u>	<u>Remarks</u>
20	0412	30	69	9	MK1	Start Line Number 20 West to East
	0423	22	69	10-1/2	MK2	Ch V/H & Gain
	0436	22	71	9-1/2	MK3	Ch DC & Gain
	0446					End Line Number 20
21	0452	0.022	69	9	MK1	Start Line Number 21 East to West
	0506	0.021	66	10	MK2	Ch V/H & Gain & DC
	0510	0.021	71	10	MK3	Ch DC
	0516	0.023	71	10	MK4	Ch V/H
	0526					End Line 21
		100	0	0 to 96	MK1	Ran Step Wedges

- May 25, 1971 - Attempts to make IR runs were terminated by rainy weather with no usable data obtained.
- May 26 through 27, 1971 - The aircraft was diverted to a gamma survey mission; the results of which are reported elsewhere.
- May 28, 1971 - Electronic problems were found during the attempted mission. No usable data were obtained. The aircraft returned to Las Vegas. A defective "serial memory unit" was subsequently replaced in the IR scanner unit.
- June 17, 1971 - NATS aircraft returned to Pasco.
- June 18 through 19, 1971 - Inclement weather prevented any flights.
- June 20, 1971 - Flight Lines A and B were flown between midnight and 0122.

<u>Flight Line</u>	<u>Local Time</u>	<u>v/h Dial</u>	<u>DC Dial</u>	<u>Signal Dial</u>	<u>Marker Number</u>	<u>Remarks</u>
A	2335	100	0 to 70	0	MK1	Step Wedges every 1/2 Volt
	2353	35	64	8	MK1	Line (A) East to West
	0003	30	64	8	MK2	Ch V/H
	0005	30	62	8	MK3	Ch DC Level
	0008	26	62	8	MK4	Ch V/H
	0010	26	62	8	MK5	Few clouds off to left Ch V/H
	0017	21	62	8	MK6	In & out of clouds for 865 miles
	0021	21	62	9	MK7	Ch Gain
	0026	21	62	9	MK7	In rain 3 miles
	0028					End Line (A) - outside air temperature 7.2 °C
B	0049	24	62	9	MK1	Line (B) West to East
	0054				MK2	In clouds 1 mile
	0057	24	62	10-1/2	MK3	Ch Gain
	0059					In clouds 7 miles air temperature 6 °C
	0105	21	67	10-1/2	MK4	Ch V/H
	0106				MK5	In clouds approximately 7 miles
	0110	22	62	10-1/2	MK6	Ch V/H
	0114	30	62	10-1/2	MK7	Ch V/H - possible ground haze or fog Gain went up override in terrain DC level down
	0118	39	64	10-1/2	MK8	Ch DC Level
	0122					End Line (B) Topped off Dewar 0130

June 21, 1971 - Flight Lines C, Ca, D, E, 1 and 2 were flown between 0022 and 0505.

Flight Line	Local Time	v/h Dial	DC Dial	Signal Dial	Marker Number	Remarks
C	2350	100	0 to 100	0		Step Wedges - 1/2 volt steps
	0022	37	62-1/2	8	MK1	Line (C) East to West
	0033	21	63-1/2	8	MK2	Ch V/H & DC Level
	0037	21	63-1/2	8-1/2	MK3	Ch Gain
	0045	22	63-1/2	8-1/2	MK4	Ch V/H
	0051				MK5	Cloud off to right
	0050				MK6	End Line (C)
Ca	0121	24	63-1/2	8	MK1	Refly Line (Ca) West to East
	0129	24	63-1/2	7-1/2	MK2	Ch Gain
	0137	23	63-1/2	8	MK3	Ch V/H & Gain
	0150	32	63-1/2	7-1/2	MK4	Ch V/H & Gain
	0156				MK5	End Line (C)
D	0201	35	63-1/2	7-1/2	MK1	Line (D) East to West
	0209	22	64-1/2	8	MK2	Ch V/H-DC-Gain
	0217	22	64-1/2	7-1/2	MK3	Ch Gain
	0220	20	64-1/2	7-1/2	MK4	CH V/H
	0232	21	64-1/2	7-1/2	MK5	Ch V/H
						Toward end of West End of Line (D) some turbulence
						Approximately 15 miles - Couldn't see any cloud activity
	0236					End Line (D)
E	0253	23	64-1/2	7-1/2	MK1	Line (E) West to East
	0310	22	70	9	MK2	CH V/H & Gain & DC
	0316	22	70	8-1/2	MK3	CH Gain
	0319	26	68-1/2	8-1/2	MK4	CH V/H & DC
	0325				MK5	End Line (E)

Flight Line	Local Time	v/h Dial	DC Dial	Signal Dial	Marker Number	Remarks
1	0330	26	68	9	MK1	Start Line Number 1 East to West
	0335	22	68	9	MK2	Ch V/H
	0337	22	68-1/2	3	MK3	CH Gain & DC
	0350	20	69	9-1/2	MK4	CH V/H - Gain - DC
	0357	20	72	9	MK5	CH Gain & DC
	0403				MK6	End Line Number 1
2	0432	24	70-1/2	9	MK1	Start Line Number 2 West to East
	0437	23	67-1/2	9	MK2	Ch V/H & DC
	0444	22	68	8-1/2	MK3	Ch V/H & DC & Gain
	0451	22	69-1/2	8-1/2	MK4	Ch DC
	0457	35	69-1/2	9	MK5	Ch V/H & DC
	0503	35	70	9	MK6	Ch Gain & DC
	0505				MK7	End Line Number 2
	0510	100	0 to 100	0		Ran Step Wedges 1/2 volt steps
	2345	100	0 to 70	0		Step Wedges 1/2 volt steps
June 22, 1971 - Flight Line 3 was completed before the IR scanner drive motor failed. The NATS aircraft returned to Las Vegas.						
3	0005	36	64-1/2	7-1/2	MK1	Line Number 3 East to West
	0006	36	64-1/2	8-1/2	MK2	Ch Gain
	0010	22	64-1/2	9	MK3	Ch V/H & Gain
	0012	22	67	9	MK4	Ch DC
	0020	21	66	9	MK5	Ch V/H & DC
	0034	21	65	9	MK6	Ch DC
	0037	21	67	9	MK7	Ch DC
	0039	21	69	9	MK8	Ch DC
						Saturating Last 5 miles of, Line
	0041					End Line Number 3

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