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PHOTOGRAPHIC EVALUATION REPORT MISSION 4018 28 MAY - 1 JUNE 1965

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PHOTOGRAPHIC INTERPRETATION REPORT

PHOTOGRAPHIC EVALUATION REPORT
MISSION 4018
28 MAY - 1 JUNE 1965

OCTOBER 1965

NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER

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SYNOPSIS

Mission 4018, a satellite photographic reconnaissance mission, was launched into a retrograde polar orbit on 27 May 1965 at 2048Z. The system included a 77-inch focal length main camera and a stellar/index unit. The mission was an overall success, accomplishing 83 revolutions over a 5-day period. Good quality photography was recovered from each of the 3 cameras aboard. Recovery of the payload capsule was made in an air catch on pass 83D.

Some frames of photography from the main camera are equal to the best quality ever gained from this system. Experiments involving the main camera were made intermittently throughout the mission. Among the experiments were: exposure tests, slit comparisons in the stereo mode, and a test designed to calculate the influence of the ionisphere on the camera system optical elements. The results of the mission and the experiments are included in the text of this report.

The stellar and index cameras each recorded 2,044 frames. A variety of anomalies resulted in problems of considerable magnitude in the reduction of data recorded by the stellar camera. In addition, the roll angles of the vehicle at times made it impossible to use the stellar field for mensuration.

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GENERAL FLIGHT DATA

Launch and Recovery Dates

Launch Date	27 May 1965/2048Z
Recovery Date	1 June 1965/2237Z

Orbital Parameters (Planned)

Period	88.44 min
Perigee	84.01 nm
Apogee	153.36 nm
Eccentricity	0.0086
Inclination Angle	134.148°

Photographic Operations

Operational	44 Passes -- 727 Frames
	5 Partial Passes* -- 19 Frames

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PART I. CAMERA OPERATIONS

1. Main Camera No FM-20

The main camera was operational throughout the mission, recording good quality photography in each mode of camera operation. Three operational exposure slits and a fourth slit designed for testing were used during the mission. The slit widths are 0.0085 inches, 0.0169 inches, 0.0337 inches, and 0.1600 inches.

Image smear at the beginning and end of each frame is less than on previous missions. The smearing at the beginning of a frame represents the imagery exposed before the camera system overcomes inertia. The smeared imagery at the end of a frame is caused by the camera slowing down in preparation for stopping.

Image degradation caused by the looper loading action is present for 4-9 inches after each 26 inches of continuous camera operation. The image degradation resulting from the looper loading action is less pronounced and extends over a shorter length of film on the first 50 percent of this mission than on most previous missions. However, as the mission progressed the result of the looper loading action became more pronounced and by the end of the mission was more severe than on most recent missions. By pass 65D the film is severely degraded by bands of varying density and image motion is apparent on approximately 9 inches of film following each continuous camera operation of 26 inches.

In addition to the image degradation described in the preceding paragraph, all imagery on passes 64D and 65D is out of focus. Also, the imagery acquired after pass 65D is variable in quality and is generally not as acute as that which was acquired prior to pass 64D. The image degradation is apparently the result of thermal distortion of the primary mirror caused by the camera door being programmed to open following frame 6 of pass 63D and remain open through pass 65D. The purpose of the "open door experiment" was to calculate the effect of the orbital environment over an extended period of time on the camera optical system. In addition, de-focusing experiments conducted intermittently after pass 65D introduced some intentional degradations. Imagery equal to the best ever attained by a satellite system appears on frame 6, pass 63D; but weather degrades the following frames of the pass. The first 11 frames of pass 64D are also cloud covered to a large extent. However, frame

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12, pass 64D, is relatively clear and is highly degraded by an out-of-focus condition. All imagery of pass 65D contains a similar degradation. The quality of the remainder of the mission is variable. While it is consistently better than the imagery on passes 64D and 65D, it does not appear to be as consistently good as the photography prior to pass 64D.

There are from 3 to 5 distinct slit images at each frame line. It appears that the camera start-up is interrupted by pronounced hesitations in the film advance system. These slit images are more pronounced on this mission than on most previous missions. An example of the images is present on frame 7, pass 27D. In addition to the slit images, there is a rectangular pattern of fog near the supply end of several frames. It appears near the center of the format and is approximately 0.5 inches long and 0.25 inches wide. The density of the fog is such that it can only be detected in the absence of high contrast or heavy density imagery. It is probably the result of a light leak in the vicinity of the aperture plate. Frame 6, pass 36D, contains an example of the fog. The presence of the fog does not constitute a serious degradation because it occurs at the end of a frame in the area normally degraded by image smearing associated with the slowing of the film in preparation for stopping.

Slit number 1 appears to have consistently provided image quality superior to that exposed through slits 2 or 3. The imagery exposed through slit 4 cannot be considered in this regard because it was used as a research experiment and was not employed in areas benefiting from a favorable solar elevation. Most imagery exposed through it was underexposed. On the stereo pairs where one-half of the pair was exposed through slit 1 and the other half through slit 2 the frame exposed through slit 1 was invariably better; however, this observation does not single out the slit aperture as the cause, since it is generally felt that the interval between the mirror position change and the exposure of the second half of a stereo pair is not sufficient to allow settling of the mirror vibrations. In the experiments conducted on this mission, the second frame of the stereo pair was always exposed through slit 2. The effects of the slit aperture and the suspected mirror vibrations are subtle.

Minus density streaks parallel to the major axis of the film are continuous in conjunction with the slit being used. These streaks are caused by foreign matter in the slit aperture. The streaks are most pronounced and numerous on the photography exposed through slit 1.

FIGURE 1. DEFINITION OF PHOTOGRAPHIC DATA

The data pertaining to the photographic illustrations contained in this publication are defined as follows:

PASS: A pass is the operational portion of an orbital revolution. A suffix D indicates that the photography was acquired during the descending portion; a suffix A indicates that the photography was acquired during the ascending portion; and a suffix M indicates that the photography was acquired during a pass that includes both ascending and descending portions. An additional suffix E indicates that the pass was an engineering operation (no imagery detectable) or that a portion of the photography has been edited.

DATE OF PHOTOGRAPHY: The date of photography indicates the day, month, and year (GMT) that the photography was acquired.

UNIVERSAL GRID COORDINATES: These coordinates are included to locate the illustrated photography within the format.

INDEX: A mark placed along the titled edge, numbered consecutively within a pass and spaced approximately every 18 inches. It is used to orient the Universal Grid on the photography.

ENLARGEMENT FACTOR: The enlargement factor is included to indicate the number of diameters the original material has been enlarged in the photographic illustration.

GEOGRAPHIC COORDINATES: These coordinates are included to indicate the latitude and longitude of the photographic illustration.

ALTITUDE: This measurement is the vertical distance from the vehicle to the reference ellipsoid at the time of the acquisition of the photography.

VEHICLE ROLL: This is the roll programmed for the acquisition of the target.

CONE ANGLE: The angle between the principal axis of the camera optical system and the vehicle gravity gradient vector.

TYPE OF COVERAGE: This indicates whether the photography was acquired in the stereo or monoscopic mode.

MIRROR POSITION: The stereo mirror may be pitched to one of three positions to produce forward, vertical, or aft looking photographs.

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SLIT NUMBER: Three operational slits were used and a fourth slit was designed for testing. The slit widths are: (1) 0.0085 inches, (2) 0.0169 inches, (3) 0.0337 inches, and (4) 0.1600 inches. The slit number designates which slit was used for the exposure of the photograph.

EXPOSURE: This is the duration of the photographic exposure expressed in fractions of a second and is computed from the slit width and film speed.

DEVELOPMENT LEVEL: This indicates whether the original material received primary, intermediate, or full development.

LOCAL SUN TIME: This time is included to present to the viewer a realistic time of the acquisition of the photography illustrated.

SOLAR ELEVATION: The angular height of the sun above a plane tangent to the surface of the earth at the center of the photographic format. A negative solar elevation indicates that the sun is below the plane.

SOLAR AZIMUTH: The solar azimuth is the angular measurement of the rays of the sun measured from true north clockwise.

AZIMUTH OF THE PRINCIPAL RAY: The angular distance of the principal ray measured clockwise from true north.

SOLAR BEARING FROM THE PRINCIPAL RAY: The angular distance of the solar azimuth measured clockwise from the azimuth of the principal ray.

PHOTO ORIENTATION: All photographs in this report with the exception of Figure 3 are oriented with the title edge at the top. Figure 3 is oriented with top toward the film supply.

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FIGURE 2. CAMERA SLIT IMAGES AT REST POSITION

This pattern of slit images appears between most frames of the mission. The photograph also shows the rectangular pattern of fog which appears near the supply end of several frames.

NPIC K-5136 (10/65)

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Pass 27D
Frame. 7
Date of Photography. . . . . 29 May 1965
Universal Grid Coordinates . . . . 55.5 - 12.0
Index. 15
Enlargement Factor . . . . . Contact

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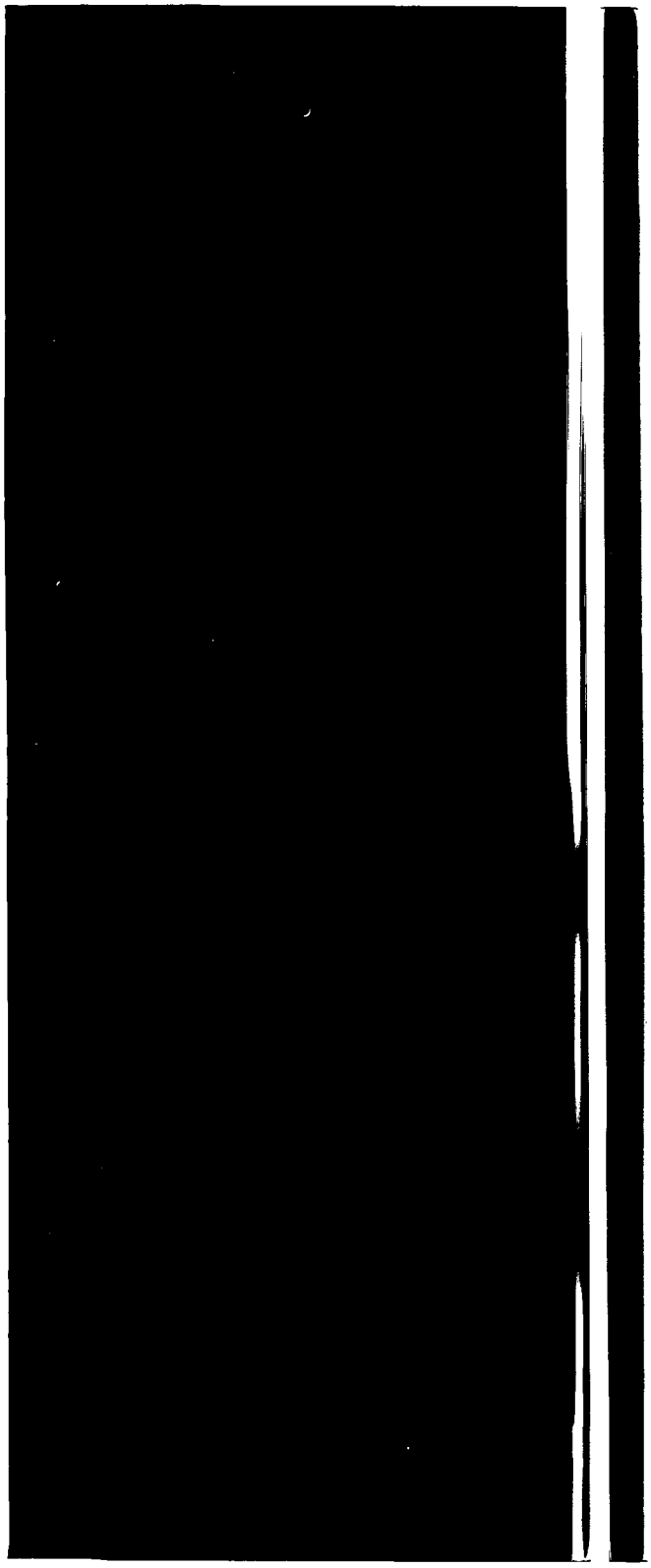
25X1

25X1



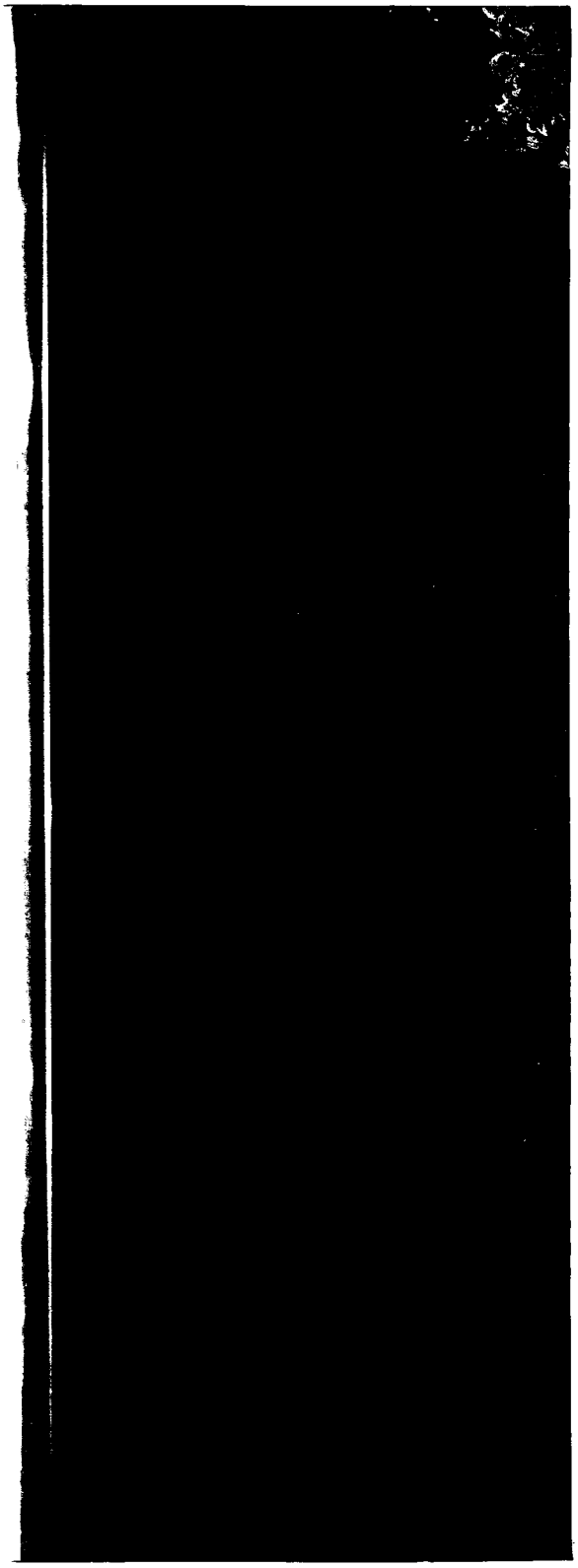


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FIGURE 3. BANDING, EARLY IN THE MISSION

Banding associated with the looper loading action was less apparent through the first half of the mission than the last. See Figure 4.

NPIC K-5137 (10/65)

25X1

25X1

Pass 34D
Frame. 1
Date of Photography. . . . . 29 May 1965
Universal Grid Coordinates . . . . 67.0 - 12.0
Index. 3
Enlargement Factor . . . . . Contact

25X1

25X1

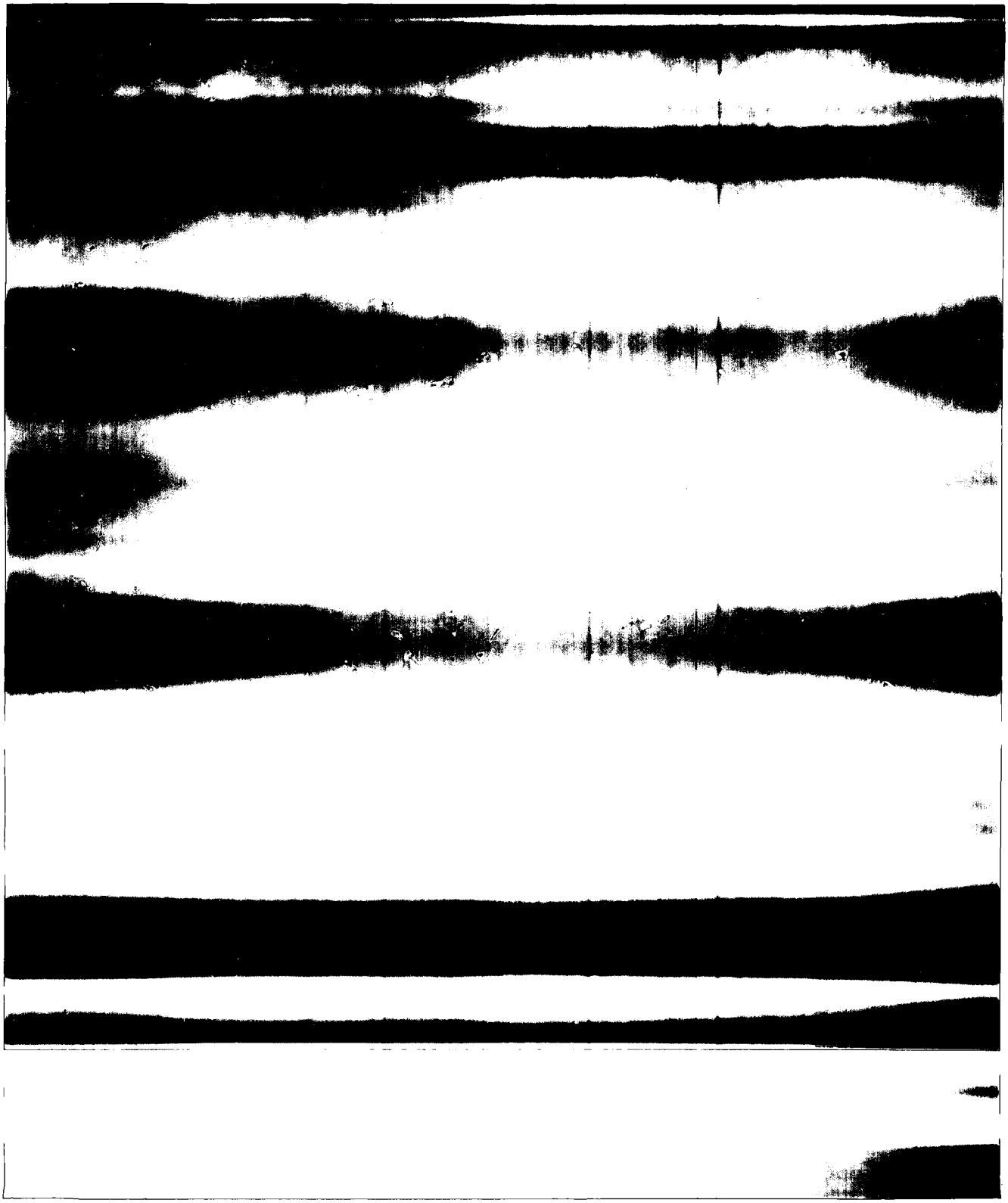

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FIGURE 4. BANDING, LATE IN THE MISSION

This photograph illustrates the image degradation introduced by the looper loading action late in the mission. See Figure 3.

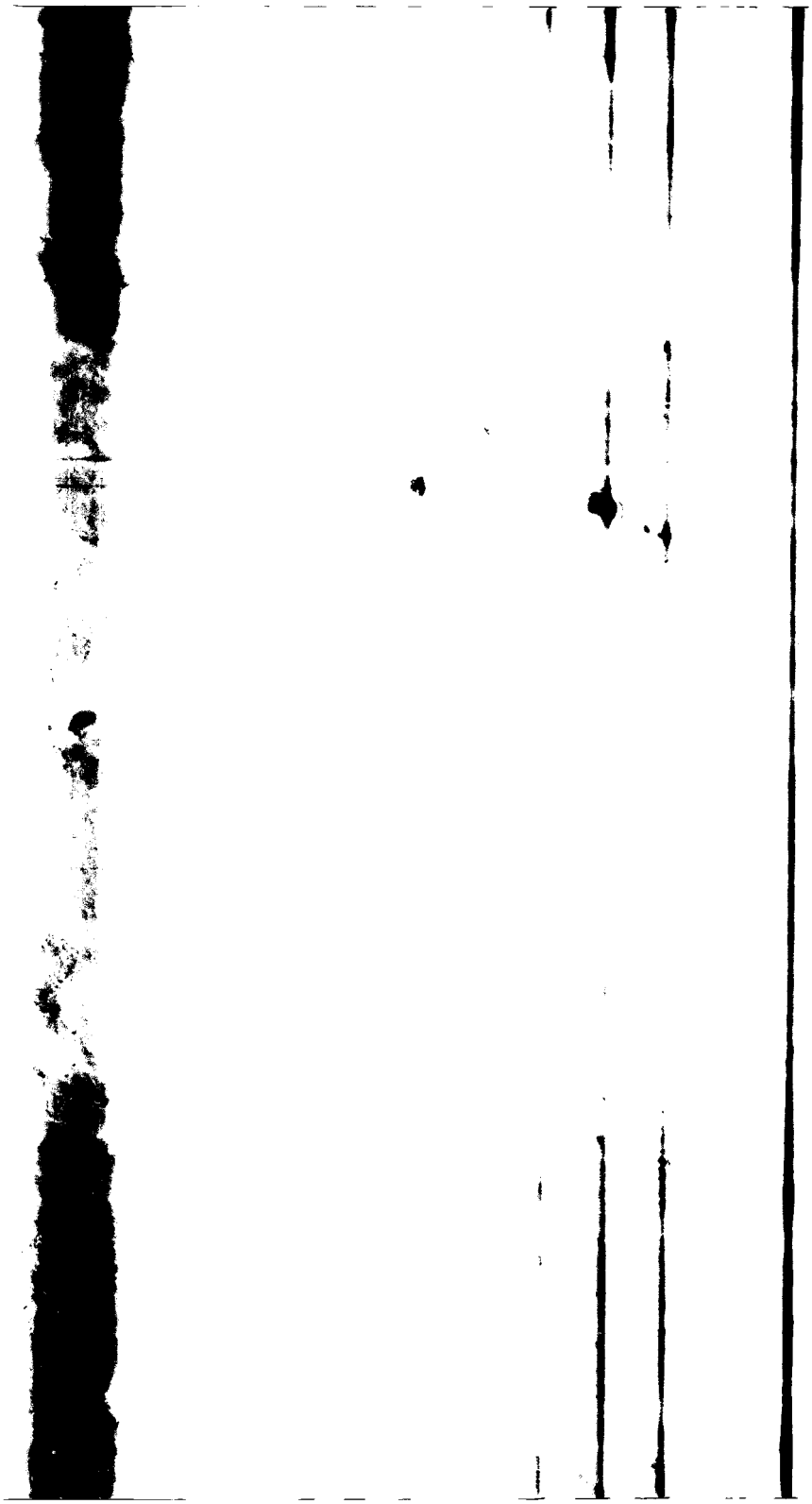
NPIC K-5138 (10/65)

25X1

Pass	80D
Frame	1
Date of Photography	1 June 1965
Universal Grid Coordinates	47.5 - 12.0
Index	3
Enlargement Factor	Contact

25X1

25X1



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2. Stellar Camera No S-13

This is the first mission utilizing the new stellar camera capable of being operated independent of the main camera and providing a capacity of 2,500 frames.

The first frame of the mission was double exposed. Several subsequent frames were grossly overexposed and unusable for mensuration because the vehicle roll angle during exposure was such that the camera lens was at an angle which allowed earth flare to enter the lens. In addition, most stellar images are smeared and on 8 frames are double imaged. The smearing is believed to be caused by vehicle instability during exposure. The double images probably are the result of a shutter bounce (shutter opening/closing after the prescribed interval and partially opening again as a bouncing action). The double stellar images and the image smearing cause complications that delay the stellar reduction process; however, these problems do not render the film useless. The minimum flare pattern engrossed approximately 10 percent of a frame. The final analysis of the stellar camera film revealed 833 frames with stellar images adequate for attitude determination and 1,211 frames that were unsuitable for attitude determination because of earth flare.

3. Index Camera No S-13

This camera is half of the stellar/index unit as described in paragraph 2 above (providing the ability to acquire photography either in conjunction with or independent of the main camera). This camera also has a capacity of 2,500 frames. On this mission, as with the stellar camera, 2,044 frames were exposed. Each frame of the index camera correlates with (was exposed at the same time as) a stellar frame.

The first frame is a double exposure. All subsequent frames received relatively good exposure. The image acuity near the center of the frames is good, but there is a distinct fall-off toward all corners.

Newton rings are numerous throughout the mission. They apparently occurred during exposure.

Obstructions caused by foreign particles on the reseau plate are present throughout the mission and increase in number as the mission progresses. The extremely small scale of this photography makes the presence of these obstructions particularly undesirable.

Edge fog is present at both film edges at intervals of 40 inches. Each occurrence of the fog extends from 2 to 6 inches along the edge and varies in width up to 0.2 inches. The presence of the fog alternates from one edge to the other, but appears consistently, beginning in the pre-flight, at intervals of 40 inches at each edge. The pattern of this fog suggests a film tracking problem.

Each frame is vignetted at the camera number edge and take-up end. The vignetting is minor and obscures only the camera number, rendering it unreadable.

There is an emulsion scratch, approximately 0.5 inches long, 0.05 inches from and parallel to the format edge opposite the camera number side at the supply end of each frame through frame 38. The position of the scratch relative to the format edge is approximately identical on each frame, suggesting that it was camera induce(

The metering is erratic through the first 25 percent of the mission. The space between frames varies from 0.15 to 0.85 inches. There were no instances of overlapping exposures. The metering on the last 75 percent of the mission is reasonable and consistent.

4. Associated Equipment

The time track is distinct and readable throughout the mission.

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FIGURE 5. STELLAR CAMERA FLARE PATTERN

This photograph was made from a negative not degraded by roll angle. The flare pattern here is typical throughout the mission.

NPIC K-5139 (10/65)

25X1

Frame. 163
Date of Photography. . . . . 28 May 1965
Enlargement Factor 6X

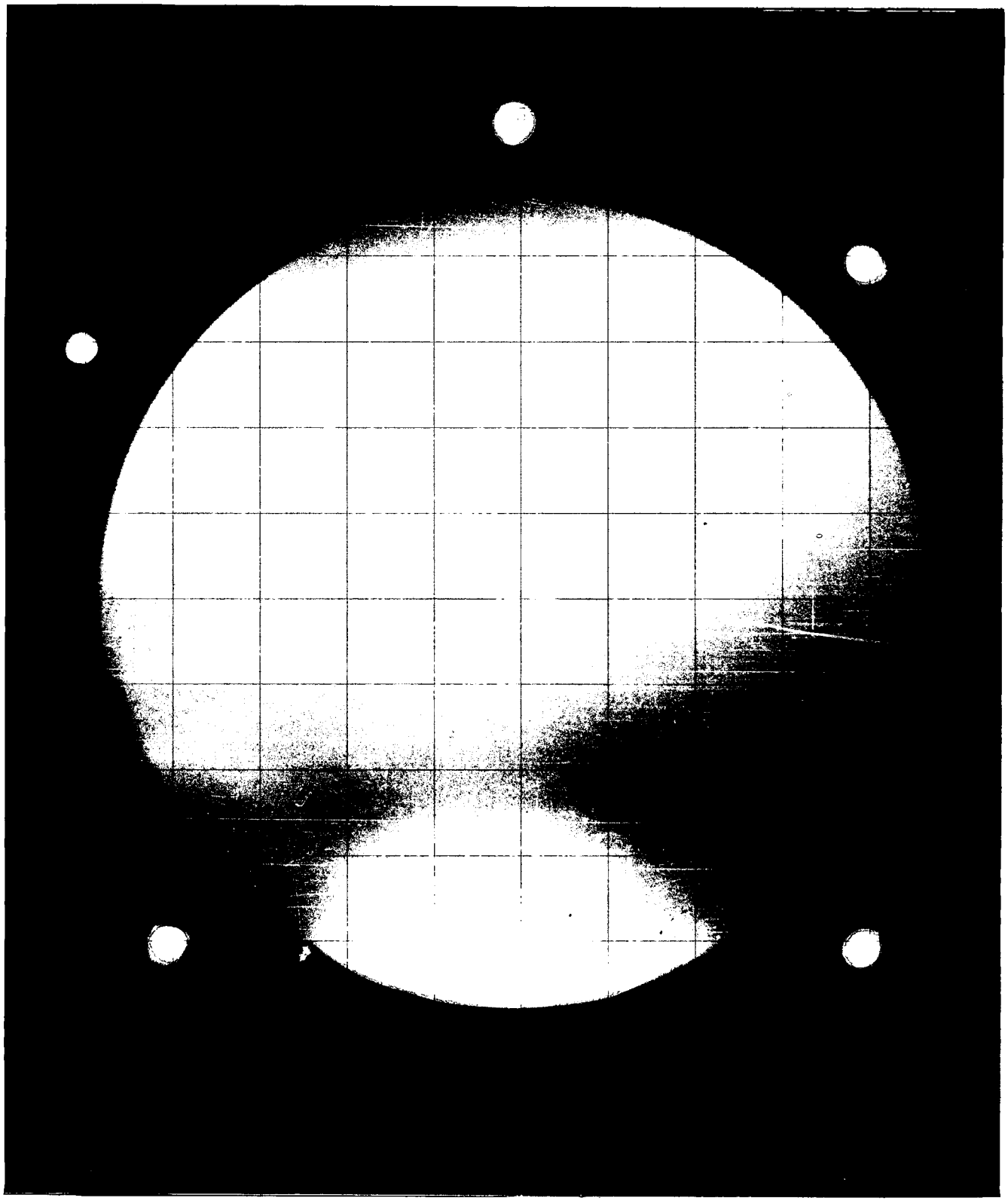

FIGURE 6. INDEX CAMERA PHOTOGRAPHY

This is a typical index camera frame of this mission. Note the vignetting.

NPIC K-5140 (10/65)

25X1

Frame. 270
Date of Photography. . . . . 28 May 1965
Enlargement Factor 2.5X

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25X1

25X1

25X1

FIGURE 7. OBLIQUE INDEX CAMERA FRAME

The quality of this frame is typical of the index photography of this mission in a roll attitude.

NPIC K-5141 (10/65)

Frame. 448
Date of Photography. . . . . 28 May 1965
Enlargement Factor 2.5X

25X1

PART II. FILM

1. Film Footage

	Main Camera	Stellar Camera	Index Camera
Total Footage Processed	2,965	258	504
Total Frames	841	2,044	2,044

Of the main camera film recovered, 213 feet is pre-flight, 2,589 feet operational, and 163 feet runout.

2. Film Processing

The film of the main camera was processed in the Yardleigh processor. The processor functioned well according to its design and the density of the negatives with respect to the level of process was good. On 12 frames the infrared densitometer of the Yardleigh dictated a change in process within the format. This is not an anomaly but rather a design characteristic of the machine. Frame 1, pass 34D, is an example of a frame which received all 3 possible levels of development.

A major processing error is apparent in frame 8, pass 58D. It is one-half of a stereo pair and was processed at the primary level. The other half of the stereo pair (frame 9) was processed at the full level of development. Frame 8 is grossly underdeveloped, while frame 9 received the proper development.

Most processing changes are within 0.7 inches of the frame division, resulting in no degradation to the imagery.

Following are the number of frames processed at each level of development:

Primary	226
Intermediate	72
Full	531

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Twelve frames received more than one level of development.

A splice used to attach the stellar camera thread-up to the mission film was not detected in the inspection procedure prior to development and subsequently separated in the processing machine, necessitating a processor cut between frames 725/726. As a result, 21 frames are degraded by static fog, abrasions and chemical fog.

3. Physical Film Degradations

a. Main Camera Film - The film of the main camera is severely scratched and abraded intermittently from head to tail. A great majority of this damage has been inflicted since processing. The film was inspected immediately after processing and only minor random emulsion abrasions were detected. It is obvious from the physical condition of the film that it is being improperly handled. In addition to the scratches and abrasions, there is foreign matter adhering to the surface of the film on several frames. The magnitude of the foreign particles is such that valuable terrain imagery is obscured. Frame 15, pass 56D, is an example of a frame containing foreign particles imbedded in the emulsion. Chemical stains appear randomly throughout the mission. The stains are pink and are probably associated with film handling rather than processing. For instance, the stains on frames 8 and 10, pass 10D, have the configuration of fingerprints.

b. Stellar Camera Film - In the vicinity of frames 725/726 where a processing cut was made because a splice separated in processing, there is a variety of physical degradations as described in the processing section of this report. Frames 1290 through 1299 contain heavy fog induced by dendritic static discharges. Minor fog due to dendritic static discharges appears at the camera number edge of frames 704/705.

c. Index Camera - Edge fog, which is suspected to have been caused by mistracking in the camera, appears at intervals of 40 inches along both edges throughout the mission (refer to Part I. Camera Operation). An emulsion scratch on each of the first 38 frames of the mission is also thought to be camera induced and is described in the aforementioned section. The physical condition of the film is good.

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FIGURE 8. FORWARD HALF OF STEREO PAIR PROCESSED AT THE INTERMEDIATE LEVEL OF DEVELOPMENT

FIGURE 9. AFT HALF OF STEREO PAIR PROCESSED AT THE FULL LEVEL OF DEVELOPMENT

The following 2 photographs were made from negatives of a stereo pair which were processed at different levels of development.

NPIC K-5142 (10/65) NPIC K-5143 (10/65)

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	FIGURE 8	FIGURE 9
Pass	75D	75D
Frame	21	22
Date of Photography	1 June 1965	1 June 1965
Universal Grid Coordinates	52.2 - 11.3	51.3 - 5.6
Index	48	50
Enlargement Factor	40X	40X
Geographic Coordinates	12-13N 013-07E	12-06N 013-04E
Altitude (nm)	88.1	88.3
Vehicle Roll (Planned)	-9.2°	9.2°
Cone Angle (Planned)	16.0°	15.7°
Type of Coverage	Stereo	Stereo
Mirror Position	1 FWD	1 AFT
Slit Number	1	1
Exposure	1/398 sec	1/398 sec
Development Level	Intermediate	Full
Local Sun Time	1121	1121
Solar Elevation	77.3°	77.2°
Solar Azimuth	38.1°	38.2°
Azimuth of Principal Ray	26.2°	164.9°
Solar Bearing from Principal Ray	348.1°	126.7°
Pitch	14.9567°	-14.6305°
Yaw	-3.4626°	-3.4626°

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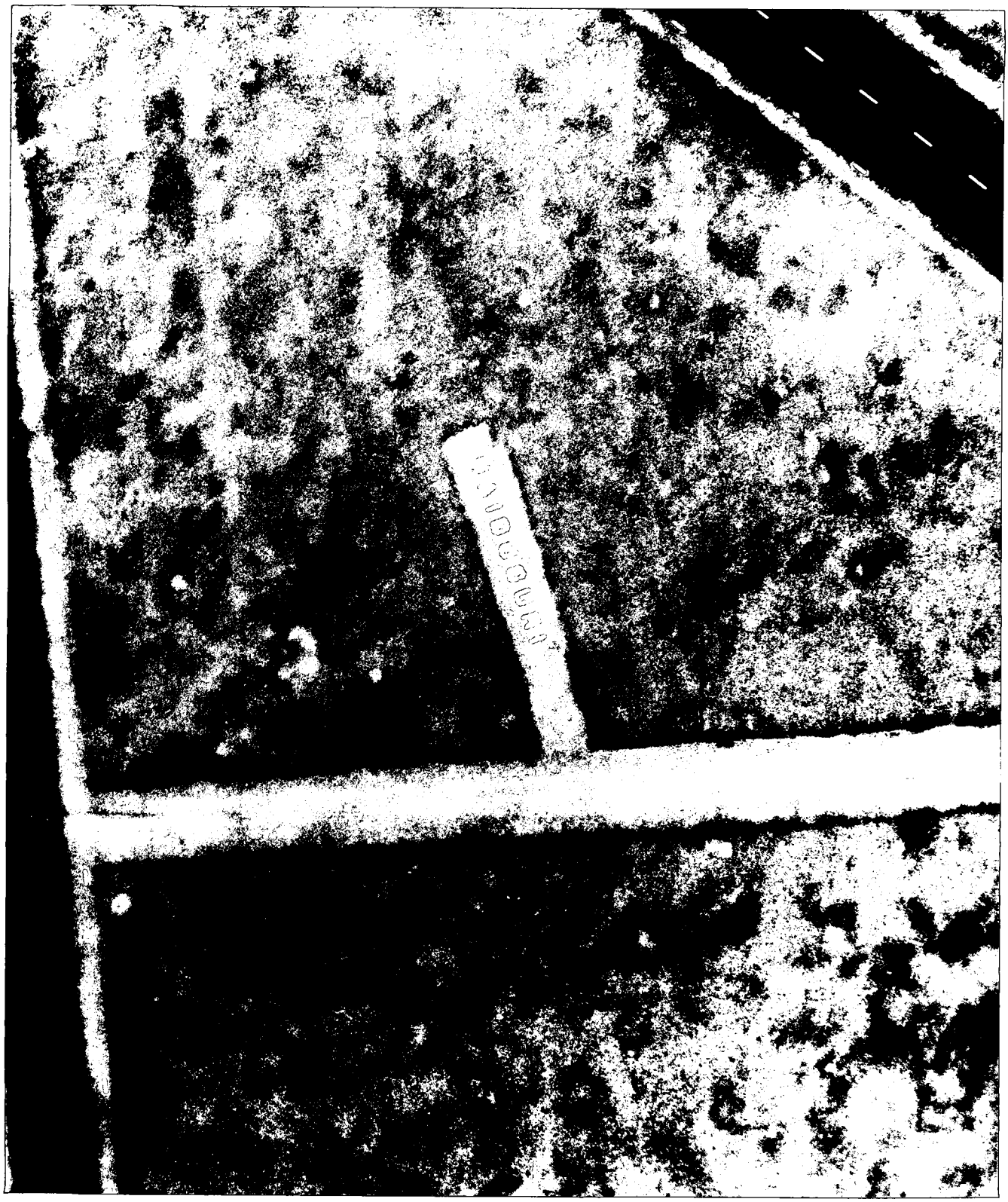

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FIGURE 10. RESULT OF UNDERDEVELOPMENT

FIGURE 11. SAME TARGET PROPER LEVEL OF DEVELOPMENT

Figure 10, the first half of the stereo pair, was made from a negative processed at the primary level of development. Figure 11, displaying much better image quality, is the other half of the stereo pair and was made from a negative processed at the full level of development. The cause of this processing anomaly is not apparent.

NPIC K-5144 (10/65) NPIC K-5145 (10/65)

25X1

	FIGURE 10	FIGURE 11
Pass	56D	56D
Frame	8	9
Date of Photography	31 May 1965	31 May 1965
Universal Grid Coordinates	55.5 - 13.0	50.5 - 11.0
Index	12	14
Enlargement Factor	Contact	Contact
Geographic Coordinates	57-13N 085-45E	57-17N 085-44E
Altitude (nm)	85.6	85.4
Vehicle Roll (Planned)	24.1°	24.1°
Cone Angle (Planned)	29.8°	29.7°
Type of Coverage	Stereo	Stereo
Mirror Position	1 FWD	1 AFT
Slit Number	1	1
Exposure	1/371 sec	1/367 sec
Development Level	Primary	Full
Local Sun Time	1201	1202
Solar Elevation	54.7°	54.6°
Solar Azimuth	181.4°	181.5°
Azimuth of Principal Ray	312.5°	250.8°
Solar Bearing from Principal Ray	228.9°	69.3°
Pitch	14.9567°	-14.6305°
Yaw	-2.0094°	-2.0094°

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4. Density Readings, Stellar/Index Material

The following density readings were made from the first and last frame of each operational pass of the stellar/index camera. They were made with a McBeth QuantaLog Densitometer model EP1000 with an ET 20 attachment and 0.5 millimeter aperture and are presented here in the interest of further analysis.

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Mission 4018

		STELLAR CAMERA				INDEX CAMERA						
						LIMITING				TERRAIN		
Pass	Frame	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta
4D	1	2.36	1.58	0.78	0.37	1.80	0.67	1.13	0.07	1.50	0.67	0.83
	36	1.44	0.61	0.83	0.22	1.50	0.13	1.37	0.07	0.18	0.13	0.05
5D	37	2.58	2.00	0.58	0.20	1.39	0.88	0.51	0.07	1.39	0.88	0.51
	75	1.89	0.96	0.93	0.24	1.02	0.25	0.77	0.07	0.32	0.25	0.07
6D	76	2.82	2.04	0.78	0.23	1.44	0.73	0.71	0.07	0.82	0.73	0.05
	119	2.13	1.18	0.95	0.22	1.54	0.14	1.40	0.07	0.44	0.14	0.30
7D	120	2.65	1.69	0.96	0.21	1.26	0.72	0.54	0.07	1.26	0.72	0.54
	156*	3.84	3.79	0.05	NR	1.30	0.82	0.48	0.07	1.30	0.82	0.48
8D	157*	3.84	3.80	0.04	NR	1.25	0.45	0.80	0.07	1.25	0.45	0.80
	167	1.60	0.98	0.62	0.27	1.30	0.45	0.85	0.07	1.30	0.45	0.85
9D	168*	3.88	3.78	0.04	NR	1.25	0.88	0.37	0.07	1.25	0.88	0.37
	260	2.10	1.27	0.83	0.28	1.12	0.14	0.98	0.07	0.29	0.14	0.15
10D	261*	3.92	3.88	0.04	NR	1.34	0.82	0.52	0.07	1.34	0.82	0.52
	294*	3.94	3.94	0.00	NR	1.46	0.20	1.26	0.07	0.60	0.20	0.40
11D	295	2.57	1.75	0.82	0.23	1.34	0.75	0.59	0.07	1.34	0.75	0.59
	328	2.44	1.61	0.83	0.21	1.58	0.23	1.35	0.07	0.72	0.23	0.49
12D	329	2.24	1.42	0.82	0.23	1.70	0.24	1.46	0.07	0.75	0.24	0.51
	339	1.93	1.11	0.82	0.21	1.58	0.22	1.36	0.07	0.38	0.22	0.16
13D	340	2.61	1.77	0.84	0.22	1.40	0.78	0.62	0.07	1.40	0.78	0.62
	446	1.39	0.65	0.74	0.21	0.62	0.17	0.45	0.07	0.62	0.17	0.45
14D	447	1.62	0.45	1.17	0.23	1.35	0.35	1.00	0.07	0.60	0.35	0.25
	477	2.11	1.24	0.87	0.21	1.14	0.18	0.96	0.07	0.62	0.18	0.44
15D	478	2.12	1.17	0.95	0.23	1.35	0.20	1.15	0.07	0.82	0.29	0.53
	482	2.50	1.30	1.20	0.22	1.76	0.38	1.38	0.07	0.56	0.38	0.18
16D	483	2.84	2.08	0.76	0.22	1.55	1.00	0.55	0.07	NR	NR	NR
	491	2.54	1.64	0.90	0.23	1.53	0.30	1.23	0.07	0.33	0.30	0.03
17D	492	2.82	2.02	0.80	0.24	1.65	0.45	1.20	0.07	0.56	0.45	0.11
	495*	3.80	3.72	0.08	NR	1.65	0.23	1.42	0.07	0.42	0.23	0.19
19D	496	2.47	1.20	1.27	0.33	1.65	0.75	0.90	0.07	0.75	0.75	0.00
	497	2.40	1.16	1.04	0.27	1.65	1.15	0.50	0.07	1.15	1.15	0.00
20D	498	2.78	1.86	0.92	0.29	1.55	0.32	1.23	0.07	1.55	0.32	1.23
	516	1.98	1.06	0.92	0.28	1.38	0.13	1.25	0.07	0.23	0.13	0.10
21D	517	2.72	1.84	0.88	0.29	1.40	0.29	1.11	0.07	1.40	0.29	1.11
	557	2.08	1.34	0.74	0.28	1.35	0.18	1.17	0.07	0.21	0.18	0.03
22D	558*	3.84	3.80	0.04	NR	1.34	0.53	0.81	0.07	0.80	0.53	0.27
	585*	3.84	3.80	0.04	NR	1.30	0.15	1.15	0.07	0.48	0.17	0.31
23D	586*	3.90	3.90	0.00	NR	1.53	0.38	1.15	0.07	1.53	0.38	1.15
	596*	3.78	3.78	0.00	NR	1.73	0.40	1.33	0.07	0.82	0.40	0.42

NR - Denotes No Reading Made

Mission 4018 (Continued)

	STELLAR CAMERA					INDEX CAMERA						
						LIMITING				TERRAIN		
Pass	Frame	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta
24D	597	2.48	1.21	1.27	0.26	1.37	0.46	0.91	0.07	1.37	0.46	0.91
	614	1.66	0.69	0.97	0.22	1.20	0.15	1.05	0.07	0.52	0.42	0.10
25D	615	2.62	1.79	0.83	0.23	1.40	0.70	0.70	0.07	NR	NR	NR
	649*	3.90	3.70	0.20	NR	1.28	0.21	1.07	0.07	0.55	0.21	0.34
26D	650*	3.86	3.64	0.22	NR	1.32	0.78	0.54	0.07	1.32	0.78	0.54
	686*	3.99	3.92	0.07	NR	0.60	0.16	0.44	0.07	0.60	0.16	0.44
27D	687*	3.88	3.80	0.08	NR	1.34	0.65	0.69	0.07	1.34	0.65	0.69
	703	2.10	1.04	1.06	0.19	1.36	0.40	0.96	0.07	1.10	0.40	0.70
28D	704	2.18	1.14	1.04	0.19	1.35	0.38	0.97	0.07	1.30	0.38	0.92
	723	2.07	1.24	0.83	0.14	1.00	0.15	0.85	0.07	0.45	0.15	0.30
29D	724	2.34	1.36	0.98	0.14	1.24	1.00	0.24	0.07	1.18	1.05	0.13
	821	2.04	1.08	0.96	0.25	1.22	0.14	1.08	0.07	0.22	0.14	0.08
30D	822	2.73	1.97	0.76	0.25	1.50	0.34	1.16	0.07	0.75	0.34	0.41
	879	2.60	1.52	1.08	0.29	1.50	0.35	1.15	0.07	0.75	0.35	0.40
31D	880	2.00	1.08	0.92	0.27	0.84	0.12	0.72	0.07	0.78	0.40	0.38
	889	2.87	1.95	0.92	0.27	1.80	1.00	0.80	0.07	NR	NR	NR
32D	890	2.07	1.10	0.97	0.26	1.04	0.50	0.54	0.07	0.60	0.50	0.10
	958	2.14	1.45	0.69	0.25	1.40	0.37	1.03	0.07	0.85	0.37	0.48
33D	959	2.76	1.90	0.86	0.25	1.35	1.10	0.25	0.07	1.35	1.10	0.25
	1000*	3.80	3.76	0.04	NR	1.39	0.12	1.27	0.07	0.40	0.12	0.28
36D	1001	2.67	1.78	0.89	0.25	1.55	0.28	1.27	0.07	1.55	0.28	1.27
	1045	2.52	1.77	0.75	0.25	1.21	0.12	1.09	0.07	0.40	0.18	0.22
37D	1046	2.00	1.12	0.88	0.24	1.51	0.97	0.54	0.07	1.51	0.97	0.54
	1074	2.02	1.52	0.50	0.30	1.50	0.17	1.33	0.07	0.33	0.24	0.09
38D	1075*	3.90	3.74	0.16	NR	1.38	0.45	0.93	0.07	1.28	0.45	0.83
	1104*	3.84	3.72	0.12	NR	1.31	0.29	1.02	0.07	0.95	0.40	0.55
39D	1105*	3.80	3.72	0.08	NR	1.52	0.31	1.21	0.07	1.45	0.31	1.14
	1114*	3.82	3.74	0.08	NR	1.55	0.40	1.15	0.07	0.75	0.40	0.35
40D	1115*	3.82	3.74	0.08	NR	1.60	1.20	0.40	0.07	1.60	1.20	0.40
	1130	2.25	0.86	1.39	0.25	1.76	0.31	1.45	0.07	1.76	0.31	1.45
41D	1131	2.42	0.86	1.56	0.25	1.42	0.55	0.87	0.07	1.42	0.55	0.87
	1155	1.52	0.42	1.10	0.24	1.15	0.23	0.92	0.07	0.70	0.25	0.45
42D	1156	2.47	1.32	1.15	0.25	1.37	0.58	0.79	0.07	1.37	0.58	0.79
	1200	1.97	1.10	0.87	0.34	1.25	0.15	1.10	0.07	NR	NR	NR
43D	1201*	3.88	3.72	0.16	NR	1.26	0.55	0.71	0.07	1.05	0.55	0.50
	1222	2.28	0.95	1.33	0.28	1.57	0.54	1.03	0.07	0.84	0.54	0.30

NR - Denotes No Reading Made

Mission 4018 (Continued)

		STELLAR CAMERA				INDEX CAMERA						
						LIMITING				TERRAIN		
Pass	Frame	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta
44D	1223	2.64	1.80	0.84	0.28	1.19	0.98	0.21	0.07	1.19	0.98	0.21
	1240	2.41	1.34	1.07	0.26	1.70	0.27	1.43	0.07	1.65	0.75	0.90
45D	1241	1.44	0.64	0.80	0.26	0.55	0.18	0.37	0.07	0.55	0.18	0.37
	1259	1.78	0.74	1.04	0.26	0.89	0.15	0.74	0.07	0.89	0.20	0.69
46D	1260	2.37	1.33	1.04	0.26	1.73	0.30	1.43	0.07	1.10	0.36	0.74
	1277	2.34	1.48	0.86	0.24	1.37	0.37	1.00	0.07	NR	NR	NR
47D	1278*	3.82	3.78	0.04	NR	1.77	0.19	1.58	0.07	0.63	0.29	0.34
	1287*	3.82	3.78	0.04	NR	1.28	0.16	1.12	0.07	0.64	0.48	0.16
48D	1288	2.77	2.00	0.77	0.21	1.58	1.39	0.19	0.07	NR	NR	NR
	1294	2.40	1.62	0.78	0.21	1.37	0.65	0.72	0.07	0.70	0.65	0.05
49D	1295	2.82	2.00	0.82	0.23	1.67	1.37	0.30	0.07	NR	NR	NR
	1319	2.20	1.50	0.70	0.22	1.08	0.24	0.84	0.07	0.30	0.25	0.05
50D	1320	2.75	2.05	0.70	0.21	1.54	0.93	0.61	0.07	1.54	0.93	0.61
	1337	2.33	1.55	0.78	0.20	1.61	1.30	0.31	0.07	NR	NR	NR
52D	1338	2.25	1.60	0.65	0.21	1.61	0.32	1.29	0.07	1.61	0.32	1.29
	1357	1.66	1.00	0.66	0.25	1.40	0.17	1.23	0.07	NR	NR	NR
53D	1358*	3.84	3.78	0.06	NR	1.42	0.30	1.12	0.07	1.42	0.30	1.12
	1363	2.12	0.76	1.36	0.23	1.40	0.23	1.17	0.07	1.17	0.34	0.83
54D	1364	2.42	1.26	1.16	0.21	1.45	0.53	0.92	0.07	1.10	0.60	0.50
	1398*	3.32	3.26	0.06	NR	1.40	0.12	1.28	0.07	0.84	0.12	0.72
55D	1399	2.77	1.94	0.83	0.21	1.60	0.50	1.10	0.07	0.93	0.52	0.41
	1415*	3.73	2.28	1.45	NR	1.77	0.16	1.61	0.07	0.57	0.40	0.17
56D	1416*	3.84	3.78	0.06	NR	1.41	0.90	0.51	0.07	NR	NR	NR
	1437*	3.85	3.78	0.07	NR	0.88	0.30	0.58	0.07	0.88	0.30	0.58
57D	1438*	3.84	3.78	0.06	NR	1.26	0.07	1.19	0.07	NR	NR	NR
	1486	1.57	0.75	0.82	0.20	0.83	0.10	0.73	0.07	0.57	0.15	0.42
58D	1487	2.27	0.74	1.53	0.21	1.30	0.90	0.40	0.07	NR	NR	NR
	1565	1.90	1.20	0.70	0.22	1.35	0.17	1.18	0.07	0.45	0.25	0.20
59D	1566*	3.88	3.78	0.10	NR	1.30	0.84	0.46	0.07	1.30	0.84	0.46
	1591*	3.82	3.70	0.12	NR	1.67	0.32	1.35	0.07	0.50	0.32	0.18
60D	1592	2.20	1.25	0.95	0.22	1.50	0.22	1.28	0.07	1.50	0.30	1.20
	1620	2.50	1.50	1.00	0.21	1.90	0.20	1.70	0.07	NR	NR	NR
61D	1621	2.22	1.24	0.98	0.21	1.18	0.25	0.93	0.07	0.84	0.32	0.52
	1634	1.40	0.50	0.90	0.20	1.15	0.14	1.01	0.07	0.50	0.18	0.32
62D	1635	2.65	1.80	0.85	0.20	1.35	0.45	0.90	0.07	1.35	0.45	0.90
	1660	2.19	1.22	0.97	0.20	0.94	0.20	0.74	0.07	0.62	0.20	0.42

NR - Denotes No Reading Made

Mission 4018 (Continued)

	STELLAR CAMERA					INDEX CAMERA						
						LIMITING				TERRAIN		
Pass	Frame	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta	Gross Fog	Dmax	Dmin	Delta
63D	1661	2.80	1.64	1.16	0.20	1.67	0.53	1.14	0.07	NR	NR	NR
	1687	2.00	0.98	1.02	0.20	0.90	0.55	0.35	0.07	0.60	0.55	0.05
64D	1688	2.76	1.94	0.82	0.22	1.50	0.60	0.90	0.07	1.47	0.64	0.83
	1700	2.90	2.10	0.80	0.21	1.72	0.49	1.23	0.07	1.63	0.49	1.14
68D	1701	2.80	1.86	0.94	0.20	1.64	1.02	0.62	0.07	NR	NR	NR
	1723	1.60	0.66	0.94	0.20	1.54	0.12	1.42	0.07	0.57	0.27	0.30
69D	1724	2.22	0.90	1.32	0.21	1.48	0.20	1.28	0.07	0.75	0.25	0.50
	1731*	3.84	3.80	0.04	NR	1.77	0.15	1.62	0.07	NR	NR	NR
70D	1732	2.70	1.84	0.86	0.21	1.56	0.75	0.81	0.07	1.05	0.75	0.30
	1752*	3.86	3.80	0.06	NR	1.80	0.14	1.66	0.07	0.95	0.39	0.56
71D	1753	2.70	1.86	0.84	0.22	1.54	0.83	0.71	0.07	1.28	0.92	0.36
	1763*	3.86	3.80	0.06	NR	1.48	0.12	1.36	0.07	0.47	0.17	0.30
72D	1764	2.70	1.65	1.05	0.23	1.43	0.47	0.96	0.07	1.43	0.47	0.96
	1777*	3.85	3.81	0.04	NR	1.47	0.27	1.20	0.07	1.00	0.42	0.58
73D	1778*	3.85	3.84	0.01	NR	1.45	0.88	0.57	0.07	1.32	1.04	0.28
	1794	1.81	0.98	0.83	0.20	1.27	0.49	0.78	0.07	1.27	0.56	0.71
74D	1795*	3.84	3.76	0.08	NR	1.47	0.51	0.96	0.07	1.47	0.51	0.96
	1833	1.95	1.40	0.55	0.20	1.05	0.35	0.70	0.07	0.95	0.35	0.60
75D	1834*	3.84	3.78	0.06	NR	1.28	0.90	0.38	0.07	1.28	0.38	0.90
	1867	2.31	1.35	0.96	0.21	1.17	0.40	0.77	0.07	0.67	0.47	0.20
76D	1868*	3.89	3.77	0.12	NR	1.23	0.25	0.98	0.07	0.60	0.34	0.26
	1886	2.63	1.69	0.94	0.21	1.54	0.20	1.34	0.07	NR	NR	NR
78D	1887	1.98	1.12	0.86	0.20	1.17	0.17	1.00	0.07	0.44	0.24	0.20
	1909	1.43	0.68	0.75	0.20	1.21	0.22	0.99	0.07	0.53	0.22	0.31
79D	1910	2.63	1.69	0.94	0.21	1.44	0.12	1.32	0.07	1.44	0.30	1.14
	1954	2.03	0.98	1.05	0.21	1.13	0.15	0.98	0.07	0.68	0.15	0.53
80D	1955	2.63	1.66	0.97	0.22	1.26	0.75	0.51	0.07	1.26	0.75	0.51
	2044	2.03	1.20	0.83	0.21	1.48	0.20	1.28	0.07	1.01	0.31	0.70

NR - Denotes No Reading Made

Average Dmax 2.25
Average Dmin 1.37

Dmax Range 1.39 - 2.90
Dmin Range 0.42 - 2.10

Gross Fog Average 0.23
Gross Fog Range 0.14 - 0.37

Limiting Dmax Average 1.38
Limiting Dmin Average 0.44
Limiting Dmax Range 0.55 - 1.90
Limiting Dmin Range 0.07 - 1.39
Gross Fog Average 0.07
Terrain Dmax Average 0.93
Terrain Dmax Range 0.22 - 1.76
Terrain Dmin Average 0.43
Terrain Dmin Range 1.18 0.12 - 1.20

*The extreme density of these frames is the result of programmed vehicle maneuvers causing the stellar camera film to be affected by excessive flare from albedo. These readings are not considered in the averages.

TOP SECRET RUFF
NO FOREIGN DISSEM

PART III. IMAGE QUALITY

1. Definition of Photographic Interpretation (PI) Suitability

The PI suitability is an assessment of the information content of photographic reconnaissance material and its interpretability. A number of interrelated factors are involved, such as the quality of the photography, the extent of target coverage, scale, and weather limitations. However, the fundamental criteria for assigning a PI suitability rating may be reduced to (a) the scope of the photographic coverage and (b) the degree to which a photographic interpreter may extract useful and reliable information from the material.

PI suitability ratings are categorized as Excellent, Good, Fair, Poor, and Unusable. These ratings refer to the overall interpretive value of the photography obtained from a particular reconnaissance mission. Individual targets may also be assigned PI suitability ratings. The standards that determine assignment of the various ratings are:

Excellent: The photography is free of degradations by camera malfunctions or processing faults and the weather conditions are favorable throughout. The imagery contains sharp, well defined edges and corners with no unusual distortions. Contrast is optimum and shadow details, as well as details in the highlight areas, are readily detectable. Observation of small objects and a high order of mensuration are made possible by the consistently good quality of the photography.

Good: The photography is relatively free of degradation or limiting atmospheric conditions. Edges and corners are well defined. No unusual distortions are present. Detection and accurate mensuration of small objects are feasible, but to a lesser degree than in material rated as "Excellent."

Fair: Degradation is present and the acuity of the photography is less than optimum. Edges and corners are not crisply defined and there is loss of detail in shadow and/or highlight areas. Detection and identification of small objects are possible, but accuracy of mensuration is reduced by the fall-off in image quality and the less-than-optimum contrast that prevails.

Poor: Camera-induced degradations and/or weather limitations severely reduce the effectiveness of the photography. Definition of edges and corners is not sharp. Only gross terrain features and culture may be detected or identified and distortion of form may exist. Accurate mensuration of even large objects is doubtful.

Unusable: Degradation of photography completely precludes detection, identification, and mensuration of cultural details.

2. PI Suitability for Mission 4018

The PI suitability of this mission is good. More targets were covered than on any mission to date. In addition, the resolution of the photography is equal to the best ever attained by the system. An estimated 55 percent of the mission is cloud covered. This high percentage of cloud cover, together with the atmospheric attenuation that exists in air masses conducive to cloud formations, caused the apparent image quality to be less consistent on this mission than on most previous missions. In addition, an experiment conducted after the operational portion of pass 63D caused the primary mirror to warp, seriously degrading the imagery of passes 64D and 65D. The passes subsequent to 65D also appear to have been adversely affected and in some cases were purposely degraded as other experiments were made.

Photo interpreters reported 41 highlights during the analysis of Mission 4018. A highlight is defined as a discovery on the film of a new target or significant information about an established target. The highlights of this mission included: the discovery of a new missile launch pad; confirmation of a missile launch site construction; a camouflage effort at a known launch site; construction of a new launch site at a known launch facility; submarines in a port not normally serving these vessels; confirmation of an additional launch site; discovery of a nuclear weapons production plant previously thought to be a research and development facility; and discovery of an electronics facility not formally known to exist.

As a result of this mission, information was provided on 619 targets. Of the total, photo interpreters classified 35 as being of poor image quality. The following list provides the identification of the target type, the frames on which it appears, and the reason each was rated poor.

Pass	Frame	Target Type	Poor Quality Reason
20D	7	Navy Storage Area	The target is degraded by haze, scattered clouds and cloud shadows. The roll angle is -42°.
20D	7	Navy Support Facility	Same as above.
20D	8	Navy Base	Same as above.
58D	36	Missile Site	The target is covered with haze. The roll angle is 34°.
20D	8	Submarine Base	The target is degraded by weather conditions. The target is located near the edge of the frame and the roll angle is -42°.
20D	8	Submarine Base	Same as above.
10D	11	Missile Site	The target is degraded by scattered clouds and the imagery is smeared due to the looper loading operation. The roll angle is -20°.
21D	4	Airfield	The image is severely degraded in association with the looper loading operation. The roll angle is -43°.
38D	11	Army Barracks	The target image is smeared due to the looper loading operation and the roll angle is -31°.

25X1

Pass	Frame	Target Type	Poor Quality Reason
38D	11	Barracks	The target image is smeared in association with the looper loading operation. The roll angle is -31°.
43D	19	Army Barracks	The target is degraded by haze. The roll angle is 41°.
43D	17	Army Base	The target image is degraded by scattered clouds and cloud shadows. The roll angle is 38°.
41D	20 and 21	Airfield	The target image is degraded by haze, its location is near the edge of the frame. The roll angle is -41°.
58D	33	Military Area	The target image is overprocessed and of low contrast. The roll angle is 43°.
58D	33	Military Area	Same as above.
58D	33	Command Post	Same as above.
41D	12	RR MFG Facility	The target image is located on the edge of the frame and the roll angle is 43°.
37D	8	Army Barracks	The target image is smeared in association with the looper loading action. The roll angle is 17°.
69D	7 and 8	Army Barracks	The frame is 70% cloud covered. The roll angle is 38°.

25X1

25X1

Pass	Frame	Target Type	Poor Quality Reason
69D	7 and 8	Army Barracks	Same as above.
37D	8	Army Depot	The target image is degraded by haze. The roll angle is 17°.
41D	20 and 21	Army Depot	The target image is degraded by haze. The roll angle is -41°.
41D	12	Military Area	The target image is degraded by haze. The roll angle is 43°.
24D	5 and 6	Military Barracks	The photography is degraded by clouds and haze. The roll angle is 13°.
24D	5 and 6	Manuver Area	The target image is covered with clouds and haze. The roll angle is 13°.
55D	15	Complex	The imagery is covered by heavy haze. The roll angle is 5°.
75D	9	Army Barracks	The imagery is covered with haze. The roll angle is -8°.
75D	9	Army Barracks	The imagery is covered with haze. The roll angle is -8°.
75D	6	Army Barracks	The photography of the area is degraded by clouds, cloud shadows, and haze. The roll angle is 38°.
75D	9	Army Training Area	The target image is degraded by haze. The roll angle is -8°.

25X1

Pass	Frame	Target Type	Poor Quality Reason
10D	18	Army Barracks	The target image is degraded by haze. The roll angle is -23°.
10D	18	Army Barracks	The target image is degraded by haze and scattered clouds. The roll angle is -23°.
75D	14	Army Depot	The target image is degraded by cloud shadows and haze. The roll angle is -19°.
41D	20 and 21	Airfield	The imagery of this target is degraded by haze, its location is near the edge of the frame. The roll angle is -41°.
58D	33	Military Area	The target is low in contrast and is over-processed. The roll angle is 43°.

3. Analysis of Resolution Targets on Mission 4018

Fourteen resolution targets were photographed during this mission. Their location and a list of all factors affecting their photographic quality is included in the following summary. The summary also includes the ground resolution of each target on the original negative and on a first generation positive as determined by each of 3 experienced photographic analysts.

25X1

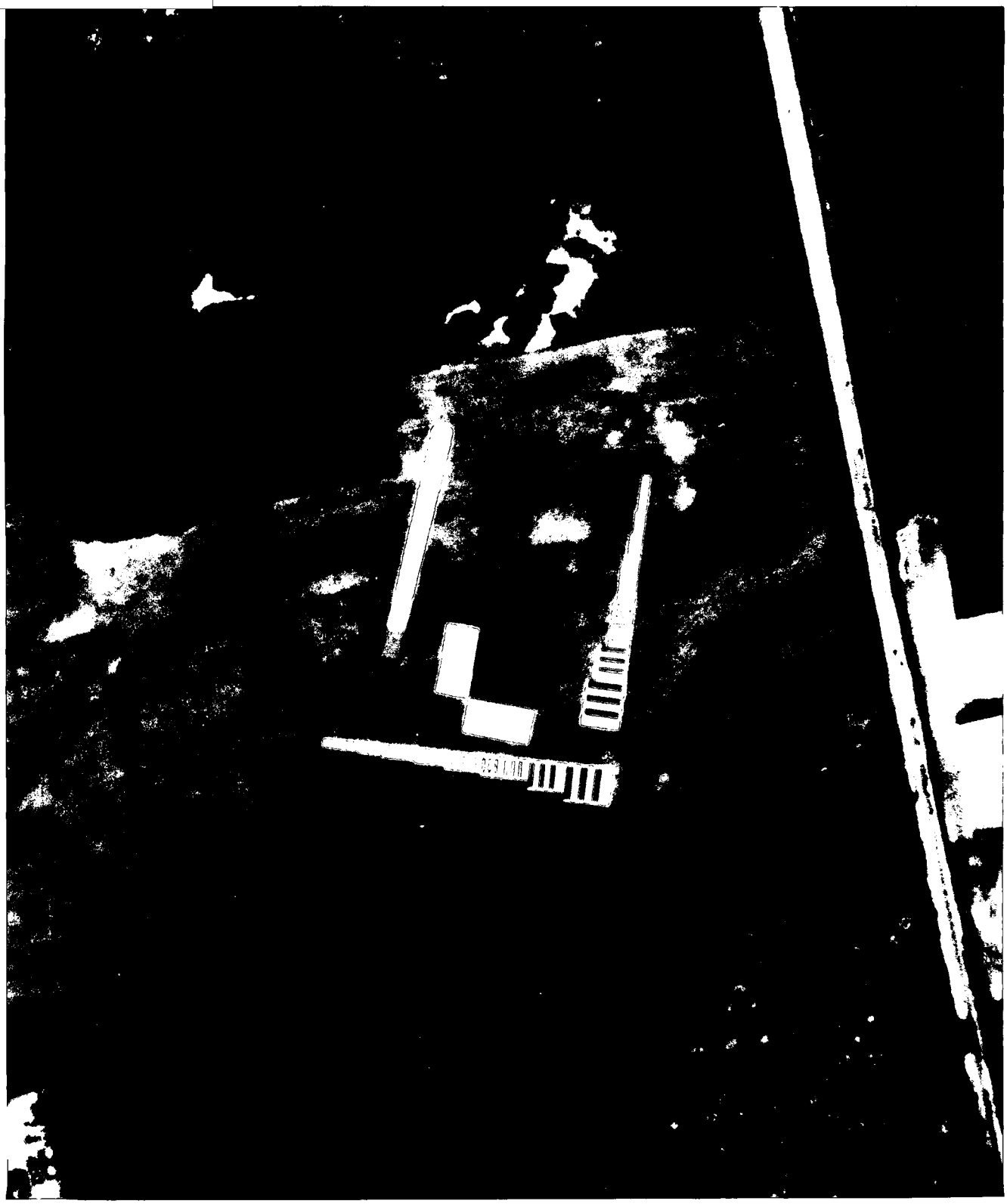
FIGURE 12. RESOLUTION TARGET

This target was also analyzed objectively through microdensitometry and isodensitometry. The results of the objective analysis are contained in the microdensitometry section of this text.

Pass	31D
Frame	2
Date of Photography	29 May 1965
Universal Grid Coordinates	55.2 - 5.0
Index	24
Enlargement Factor	40X
Geographic Coordinates	42-44N 086-12W
Altitude (nm)	84.37
Vehicle Roll (Planned)	-2.836°
Cone Angle (Planned)	3°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/448 sec
Development Level	Full
Local Sun Time	1140
Solar Elevation	68.7°
Solar Azimuth	170.1°
Azimuth of Principal Ray	60.8°
Solar Bearing from Principal Ray	250.7°
Pitch	.0.0439°
Yaw	-2.5019°

25X1

25X1



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Target No 1

Pass 31D
Frame. 2
Index. 24
Universal Grid Coordinates . . . . 55.3 - 5.0
Analyst. . . . . A B C

[redacted]

Slit No. 1
Exposure . . . . . 1/448 sec
Mirror Positions . . . . . 2 Vertical
Vehicle Altitude (nm). 84.4
Roll . . . . . -2.836°
Vehicle Azimuth. . . . . 187.8°
Sun Time 1140
Solar Elevation. . . . . 68.7°
Solar Azimuth. . . . . 170.1°
Azimuth of Principal Ray . . . . . 60.8°
Geographic Coordinates 42-44N 086-12W
Process Level. . . . . Full
Target Description . . . . . Medium Contrast "T" Bar Target

An isodensitrace of this target appears in Section 3, Appendix D, of this report.

Target No 2

Pass	31D
Frame	3
Index	36
Universal Grid Coordinates	72.2 - 17.8
Analyst	A B C

[redacted]

Slit No.	1
Exposure	1/448 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	84.2
Roll	-0.709°
Vehicle Azimuth	187.6°
Sun Time	1140
Solar Elevation	70.3°
Solar Azimuth	168.7°
Azimuth of Principal Ray	284.9°
Geographic Coordinates	41-04N 086-32W
Process Level	Full
Target Description	Medium Contrast, Portable Resolution Target.

An isodensitrace of this target appears in Section 3, Appendix D of this report.

Target No 3

Pass	47D
Frame	3
Index	8
Universal Grid Coordinates	72.9 - 13.1
Analyst	A B C
Slit No.	1
Exposure	1/452 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.7
Roll	-0.709°
Vehicle Azimuth	187.3°
Sun Time	1124
Solar Elevation	72.9°
Solar Azimuth	165.1°
Azimuth of Principal Ray	284.6°
Geographic Coordinates	38-27N 081-42W
Process Level	Full
Target Description	Medium Contrast, Portable Resolution Target.

25X1

Target No 4

Pass	63D
Frame	3
Index	30
Universal Grid Coordinates	48.7 - 6.5
Analyst	A B C

25X1

Slit No.	1
Exposure	1/367 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.6
Roll	-36.86°
Vehicle Azimuth	187.5°
Sun Time	1132
Solar Elevation	70.9°
Solar Azimuth	163.2°
Azimuth of Principal Ray	96.8°
Geographic Coordinates	40-27N 077-00W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target.

25X1

25X1

Target No 5

Pass	63D
Frame	3
Index	30
Universal Grid Coordinates	49.4 - 6.3
Analyst	A B C

25X1

Slit No.	1
Exposure	1/367 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.6
Roll	-36.86°
Vehicle Azimuth	187.5°
Sun Time	1132
Solar Elevation	70.9°
Solar Azimuth	163.2°
Azimuth of Principal Ray	96.8°
Geographic Coordinates	40-27N 077-00W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target.

*E-W unresolved due to cloud coverage.

25X1

Target No 6

Pass	63D
Frame	3
Index	30
Universal Grid Coordinates	50.6 - 6.3
Analyst	A B C

[redacted]

Slit No.	1
Exposure	1/367 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.6
Roll	-36.86°
Vehicle Azimuth	187.5°
Sun Time	1132
Solar Elevation	70.9°
Solar Azimuth	163.2°
Azimuth of Principal Ray	96.8°
Geographic Coordinates	40-27N 077-00W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target.

*E-W unresolved due to weather conditions.

25X1

Target No 7

Pass	63D
Frame	3
Index	30
Universal Grid Coordinates	51.2 - 6.0
Analyst	A B C

25X1

Slit No	1
Exposure	1/367 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.6
Roll	-36.86°
Vehicle Azimuth	187.5°
Sun Time	1132
Solar Elevation	70.9°
Solar Azimuth	163.2°
Azimuth of Principal Ray	96.8°
Geographic Coordinates	44-27N 077-00W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target.

*Unresolved

25X1

25X1

Target No 8

Pass	64D		
Frame	12		
Index	47		
Universal Grid Coordinates	52.8 - 12.8		
Analyst	A	B	C
Ground Resolution On Original Negative. N-S	*	*	*
E-W	*	*	*
Ground Resolution On Positive N-S	*	*	*
E-W	*	*	*
Slit No.	1		
Exposure	1/439 sec		
Mirror Positions	2 Vertical		
Vehicle Altitude (nm)	83.9		
Roll	-1.418°		
Vehicle Azimuth	186.8°		
Sun Time	1132		
Solar Elevation	78.2°		
Solar Azimuth	153.0°		
Azimuth of Principal Ray	284.6°		
Geographic Coordinates	32-37N 099-30W		
Process Level	Full		
Target Description	Medium Contrast, Portable Resolution Target.		

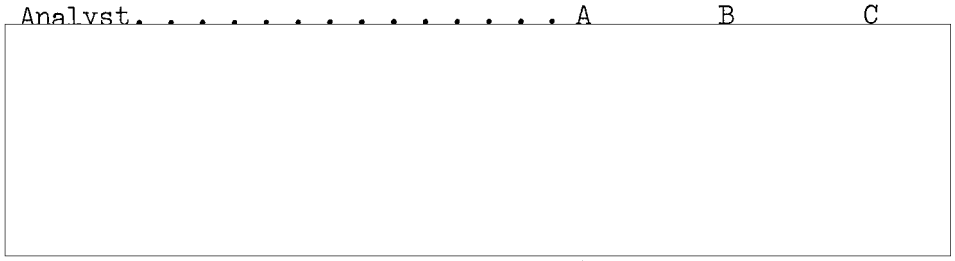
*Two groups of bars used. Both can be seen clearly, but no resolution measurements can be given for this type of target.

25X1

Target No 9

Pass	48D
Frame	7
Index	35
Universal Grid Coordinates	64.5 - 8.8
Analyst	A B C

25X1



Slit No.	1
Exposure	1/329 sec
Mirror Positions	2FWD
Vehicle Altitude (nm)	83.7
Roll	-39.704°
Vehicle Azimuth	186.9°
Sun Time	1128
Solar Elevation	76.9°
Solar Azimuth	150.8°
Azimuth of Principal Ray	72.8°
Geographic Coordinates	33-27N 106-17W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

25X1

Target No 10

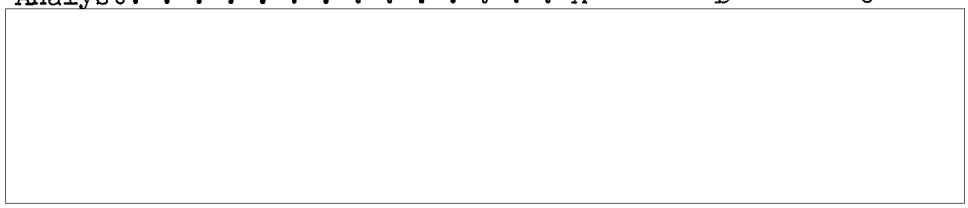
Pass	48D
Frame	7
Index	35
Universal Grid Coordinates	68.0 - 9.1
Analyst	A B C

[redacted]

Slit No	1
Exposure	1/329 sec
Mirror Positions	2 FWD
Vehicle Altitude (nm)	83.7
Roll	-39.704°
Vehicle Azimuth	186.9°
Sun Time	1128
Solar Elevation	76.9°
Solar Azimuth	150.8°
Azimuth of Principal Ray	72.8°
Geographic Coordinates	33-27N 106-17W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

Target No 11

Pass	48D
Frame	7
Index	35
Universal Grid Coordinates	72.2 - 9.9
Analyst	A B C



Slit No.	1
Exposure	1/329 sec
Mirror Positions	2 FWD
Vehicle Altitude (nm)	83.7
Roll	-39.704°
Vehicle Azimuth	186.9°
Sun Time	1128
Solar Elevation	76.9°
Solar Azimuth	150.8°
Azimuth of Principal Ray	72.8°
Geographic Coordinates	33-27N 106-17W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

Target No 12

Pass	48D
Frame	7
Index	35
Universal Grid Coordinates	75.6 - 10.4
Analyst	A B C

[redacted]

Slit No.	1
Exposure	1/329 sec
Mirror Positions	2 FWD
Vehicle Altitude (nm)	83.7
Roll	-39.704°
Vehicle Azimuth	186.9°
Sun Time	1128
Solar Elevation	76.9°
Solar Azimuth	150.8°
Azimuth of Principal Ray	72.8°
Geographic Coordinates	33-27N 106-17W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

[redacted]

Target No 13

Pass	48D
Frame	7
Index	35
Universal Grid Coordinates	78.5 - 10.8
Analyst	A B C

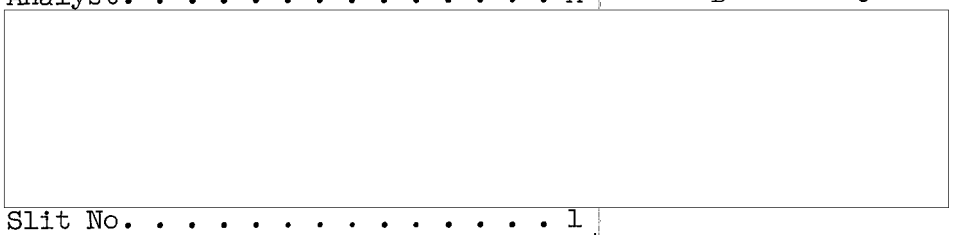
25X1

Slit No	1
Exposure	1/329 sec
Mirror Positions	2 FWD
Vehicle Altitude (nm)	83.7
Roll	-39.704°
Vehicle Azimuth	186.9°
Sun Time	1128
Solar Elevation	76.9°
Solar Azimuth	150.8°
Azimuth of Principal Ray	72.8°
Geographic Coordinates	33-27N 106-17W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

25X1

Target No 14

Pass	48D
Frame	8
Index	37
Universal Grid Coordinates	53.7 - 11.8
Analyst	A B C



Slit No.	1
Exposure	1/448 sec
Mirror Positions	2 Vertical
Vehicle Altitude (nm)	83.8
Roll	-0.709°
Vehicle Azimuth	186.8°
Sun Time	1128
Solar Elevation	78.7°
Solar Azimuth	152.1°
Azimuth of Principal Ray	282.1°
Geographic Coordinates	31-56N 105-14W
Process Level	Full
Target Description	Medium Contrast, Fixed CORN Target

APPENDIX A. MENSURATION

a. The mensuration on this mission was very good. [redacted] The availability of good attitude reduced from the stellar photography of the mission provided the necessary inputs for the mensuration processes. Because of earth flare, image smearing, and double imagery the stellar data was less than optimum.

b. The film speed of this mission was less consistent than on missions 4016 and 4017. Excursions from the programmed speed occasionally exceeded 1 percent. However, the film speed of the mission usually was within 0.5 percent of the programmed speed.

Banding caused by the looper loading action is less apparent in the first 50 percent of this mission than on any of the recent missions. The last 50 percent of the mission, however, contains more evidence of banding than is normal for the system and exceeds that which has been experienced on most missions. The photographic interpreters reported that several targets were degraded by the image smearing associated with the bands. An account of the targets rated as poor by the photo interpreters because of banding and other anomalies is included in Part III, Section 2, of this report.

APPENDIX B. EXPERIMENTAL OPERATIONS

The following experiments were conducted during this mission:

a. Pass 14D, frames 1 and 2 -- Stereo pair, slit 1 on frame 1, and slit 2 on frame 2.

RESULT: The image quality of frame 1 is considerably better. Frame 1 was processed at the full level of development, rendering a good combination of contrast and density. Frame 2 was processed at the primary level and appears to be somewhat underdeveloped. A further complication in the analysis of slit 1 compared to slit 2 is the second part of a stereo pair may have been exposed before the mirror vibrations settled.

b. Pass 15D, frames 1 and 2 -- High roll stereo pair.

RESULT: Cloud cover obscures the target area, negating the possibility of evaluation.

c. Pass 15D, frame 3; Pass 16D, frame 1; Pass 18D, frame 1; Pass 31D, frame 1; Pass 31D, frame 3; Pass 32D, frame 1; Pass 34D, frame 1; Pass 48D, frame 1; Pass 51D, frame 1; Pass 63D, frame 2; Pass 64D, frame 3; Pass 64D, frame 13; and Pass 65D, frame 4 -- Focus sensor activated for period of 100 seconds on each occasion.

RESULT: The result of these experiments cannot be analyzed subjectively. Indications are that meaningful data were gained from the experiment.

d. Pass 15D, frames 4 and 5 -- Stereo pair.

RESULT: Heavy cloud cover obscures the target. No evaluation made.

e. Pass 17D, frames 1 and 2 -- Frame 1 exposed through slit 1 and frame 2 exposed through slit 2.

RESULT: Each frame is approximately 90 percent cloud covered. No evaluation made.

f. Pass 34D, frames 2 and 3 -- Stereo pair.

RESULT: Stereo pair of good quality. The image quality of the 2 frames is approximately equal.

g. Pass 47D, frames 4 and 5 -- Stereo pair.

RESULT: Good quality stereo pair. The image quality of the 2 frames is comparable.

h. Pass 47D, frames 6 and 7 -- Lateral pair.

RESULT: Good image quality on both frames. Overlap in the lateral direction is approximately 38 percent.

i. Pass 48D, frames 5 and 6 -- Stereo pair.

RESULT: Stereo pair of only fair image quality. Degradation due to atmospheric attenuation.

j. Pass 63D, frames 4 and 5 -- Stereo pair.

RESULT: Heavy cloud cover precludes evaluation of the image quality of these frames.

k. Pass 63D, frame 6 -- Mono strip.

RESULT: Frame 6 contains image quality equal to the best of the mission.

l. Pass 64D, frames 8 and 9; 10 and 11 -- Stereo pairs.

RESULT: Cloud cover of approximately 95 percent precludes evaluation of the imagery.

m. Pass 71D, frame 1 -- Night photography, slit 4.

RESULT: The exposure was insufficient to record imagery.

n. Pass 71D, frame 2 -- Night photography, slit 4.

RESULT: The exposure was insufficient to record imagery.

o. Pass 71D, frame 3 -- Illumination test, 100 second strip, slit 4.

RESULT: The density of the frame increases from beginning to end; however, the test was not significant because of heavy cloud cover.

p. Pass 71D, frame 4 -- Illumination test, 100 second strip, slit 4.

RESULT: Cloud cover of approximately 100 percent precludes image evaluation.

q. Pass 79D, frames 1,2,5; Pass 89D, frames 1,2,3,4,5,6,7,8; and Pass 81D, frame 1 -- Focus experiment.

RESULT: The frames indicated were intentionally defocused to evaluate the effect of focal distance changes. Much of the imagery accomplished in the out-of-focus condition was of clouds, which precludes an evaluation. In addition, some of the photography was of wooded terrain and offered little

25X1

imagery suitable for evaluation. The experiment on passes 63D, 64D, and 65D adds further confusion to analysis of this test because it is difficult to ascertain if the mirror warpage apparent on the photography of those passes was fully compensated for in the cooling of the stereo mirror on subsequent passes.

FIGURE 13. PHOTOGRAPH OF STEREO PAIR EXPOSED THROUGH CAMERA SLIT NUMBER 1

FIGURE 14. PHOTOGRAPH OF STEREO PAIR EXPOSED THROUGH CAMERA SLIT NUMBER 2

NPIC K-5147 (10/65) NPIC K-5148 (10/65)

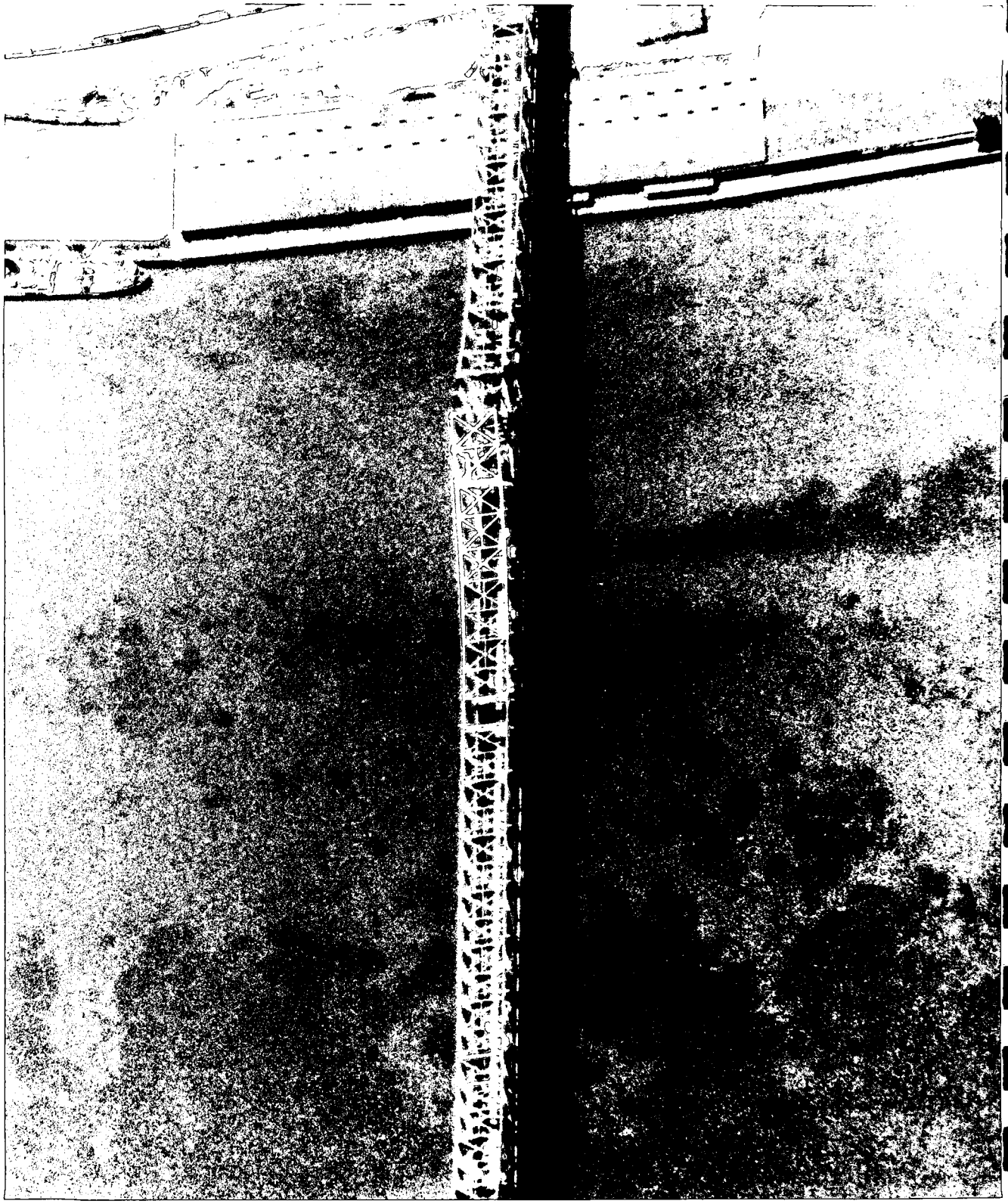
These two photographs represent the result of an experiment in which one-half of a stereo pair was exposed by camera slit number 1 and the other half through camera slit number 2.

	FIGURE 13	FIGURE 14
Pass	31D	31D
Frame	4	5
Date of Photography	29 May 1965	29 May 1965
Universal Grid Coordinates	65.5 - 9.5	70.2 - 6.3
Index	48	49
Enlargement Factor	40X	40X
Geographic Coordinates	30-11N 090-01W	30-12N 090-05W
Altitude (nm)	83.9	84.0
Vehicle Roll (Planned)	-36.9°	-36.9°
Cone Angle (Planned)	37.1°	37.0°
Type of Coverage	Strip	Strip
Mirror Position	2 FWD	2 AFT
Slit Number	1	2
Exposure	1/343 sec	1/174 sec
Development Level	Full	Full
Local Sun Time	1128	1129
Solar Elevation	79.4°	79.4°
Solar Azimuth	142.2°	142.3°
Azimuth of Principal Ray	70.9°	20.9°
Solar Bearing From Principal Ray	288.7°	238.6°
Pitch	14.9567°	-14.6305°
Yaw	-2.5019°	-2.5019°

25X1

X1

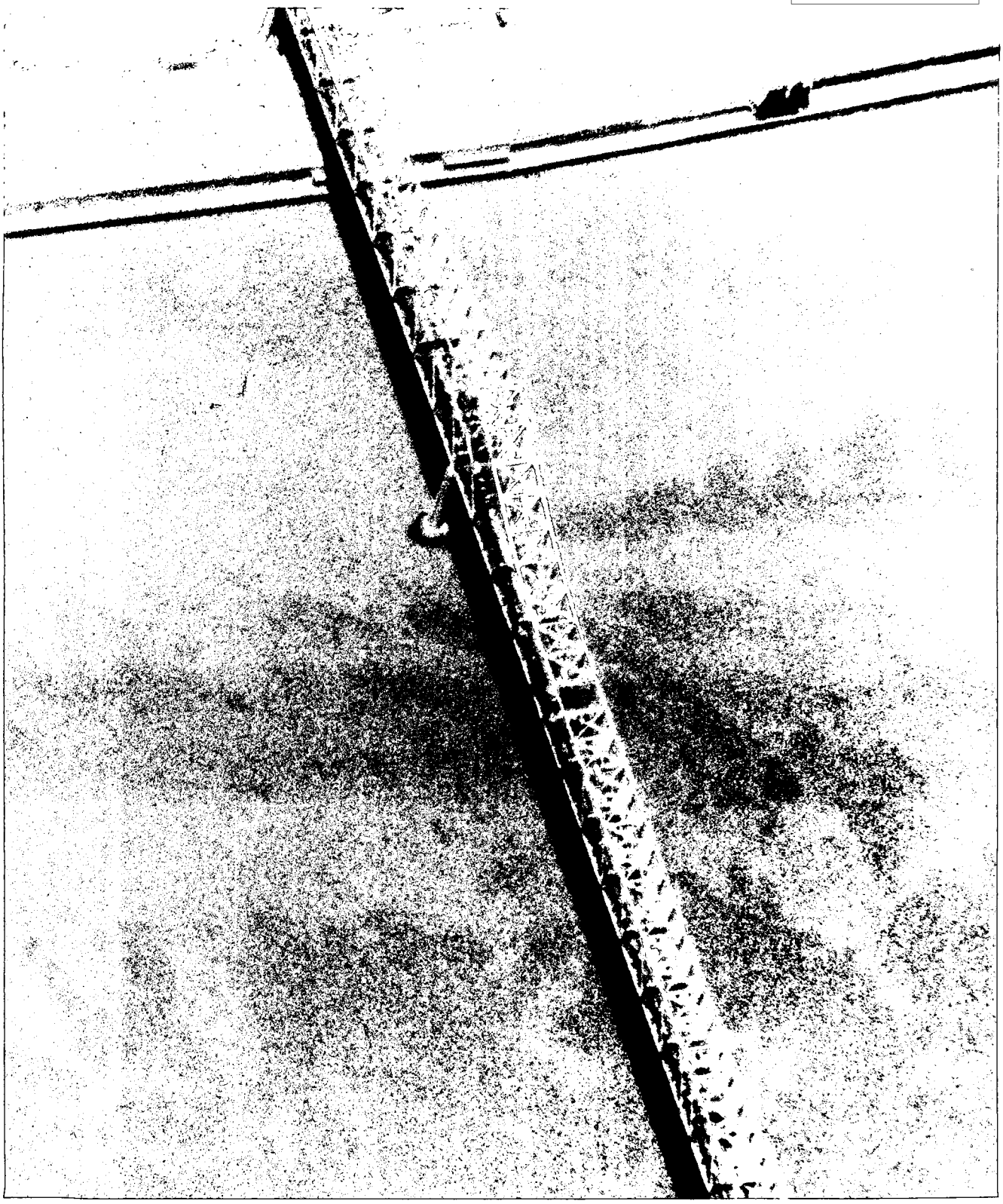
25X1



25X1

25X1

25X1



25X1

FIGURE 15. GOOD QUALITY HIGH RESOLUTION PHOTOGRAPHY

NPIC K-5149 (10/65)

The negative from which this print was made was exposed just before the experiment which caused the stereo mirror to warp. The following 7 photographs illustrate the progression of image quality associated with the progression of the mission. (See Figures 16-21).

25X1

Pass	63D
Frame	6
Date of Photography	31 May 1965
Universal Grid Coordinates	75.5 - 12.5
Index	36
Enlargement Factor	40X
Geographic Coordinates	37-04N 076-15W
Altitude (nm)	83.7
Vehicle Roll (Planned)	4.9°
Cone Angle (Planned)	7.5°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/405 sec
Development Level	Full
Local Sun Time	1136
Solar Elevation	74.3°
Solar Azimuth	163.0°
Azimuth of Principal Ray	279.1°
Solar Bearing from Principal Ray	116.1°
Pitch	0.0439°
Yaw	-2.5019°

25X1

25X1

25X1

25X1

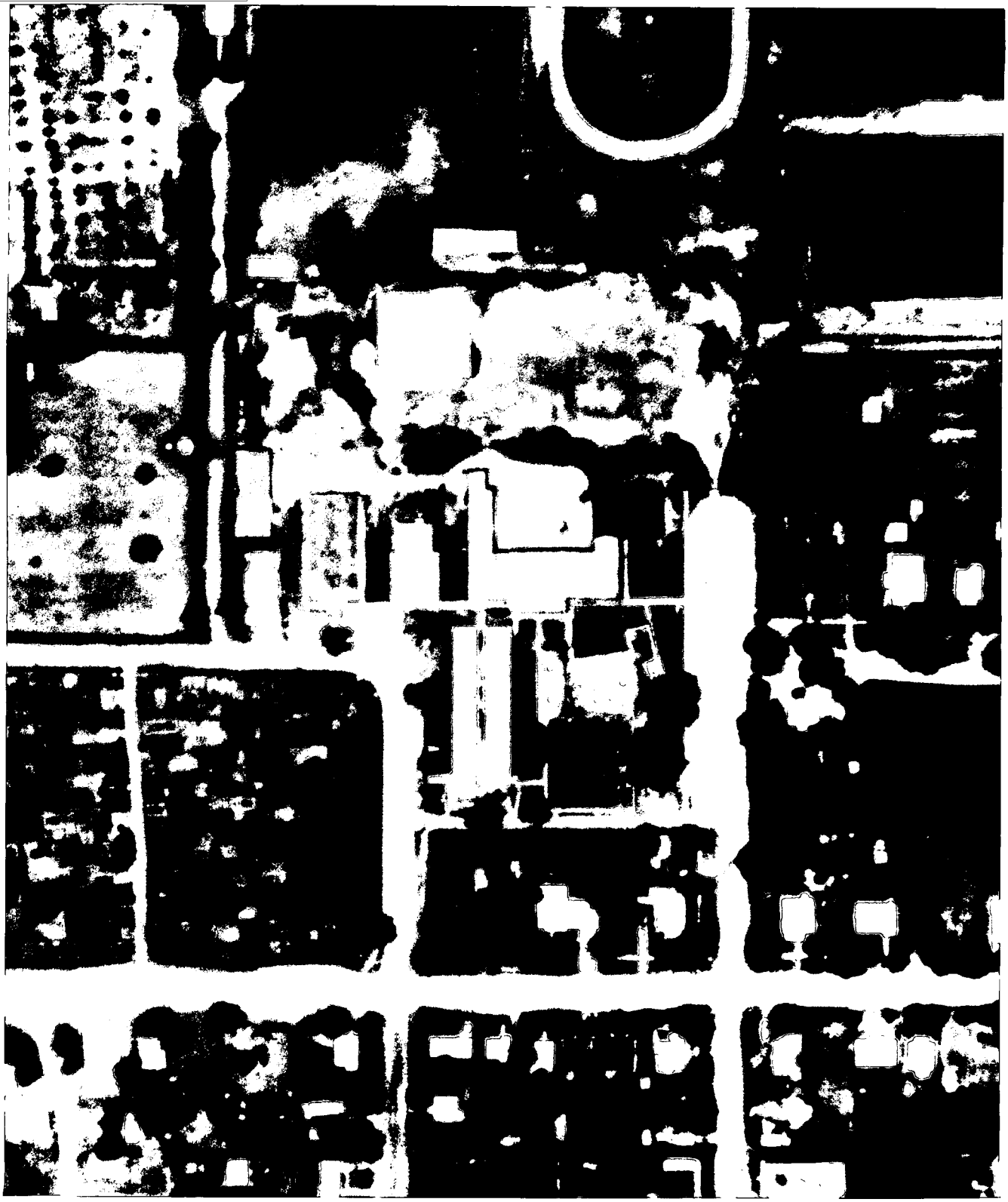
FIGURE 16. IMAGERY DEGRADED BY THERMAL CHANGES OF THE STEREO MIRROR

This out-of-focus imagery was exposed after the camera door had been allowed to remain open since frame 6 of this pass. The degradation was caused by warpage of the stereo mirror (See Figures 15, 17-21).

NPIC K-5150 (10/65)

Pass	64D
Frame	12
Date of Photography	31 May 1965
Universal Grid Coordinates	75.7 - 5.5
Index	48
Enlargement Factor	40X
Geographic Coordinates	32-37N 099-31W
Altitude (nm)	83.9
Vehicle Roll (Planned)	-1.418
Cone Angle (Planned)	1.6°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/439 Sec
Development Level	Full
Local Sun Time	1132
Solar Elevation	78.2°
Solar Azimuth	153.0°
Azimuth of Principal Ray	284.6°
Solar Bearing from Principal Ray	131.6°
Pitch	0.0439°
Yaw	-2.9929°

25X1



25X1

FIGURE 17. IMAGERY DEGRADED BY THERMAL CHANGES OF THE STEREO MIRROR

When the negative from which this print was made was exposed, the camera door had been continually open for 2 orbits. (See Figures 15, 16, 18-21)

NPIC K-5151 (10/65)

25X1

Pass	65D
Frame	4
Date of Photography	31 May 1965
Universal Grid Coordinates	52.4 - 4.8
Index	18
Enlargement Factor	40X
Geographic Coordinates	47-27N 118-07W
Altitude (nm)	84.0
Vehicle Roll (Planned)	0.0°
Cone Angle (Planned)	2.5°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/393 sec
Development Level	Full
Local Sun Time	1143
Solar Elevation	64.4°
Solar Azimuth	173.3°
Azimuth of Principal Ray	283.8°
Solar Bearing from Principal Ray	110.5°
Pitch	0.0439°
Yaw	-2.5019°

25X1

25X1

FIGURE 18. IMAGERY DEGRADED BY THERMAL CHANGES OF THE STEREO MIRROR.

See Figures 15-17, 19-21.

NPIC K-5152 (10/65)

Pass	69D
Frame	1
Date of Photography	1 June 1965
Universal Grid Coordinates	53.3 - 12.0
Index	2
Enlargement Factor	40X
Geographic Coordinates	68-57N 161-31E
Altitude (nm)	87.25
Vehicle Roll (Planned)	-25.5°
Cone Angle (Planned)	28.5°
Type of Coverage	Stereo
Mirror Position	1 FWD
Slit Number	1
Exposure	1/364 sec
Development Level	Full
Local Sun Time	1210
Solar Elevation	43.0°
Solar Azimuth	184.7°
Azimuth of Principal Ray	72.4°
Solar Bearing from Principal Ray	247.7°
Pitch	14.9567°
Yaw	-1.0168°

25X1

25X1

25X1

FIGURE 19. IMAGERY DEGRADED BY THERMAL CHANGES OF THE STEREO MIRROR AND LOOPER LOADING VIBRATIONS.

See Figures 15-18, 20, and 21.

NPIC K-5153 (10/65)

25X1

Pass	64D
Frame	13
Date of Photography	31 May 1965
Universal Grid Coordinates	66.6 - 10.6
Index	69
Enlargement Factor	20X
Geographic Coordinates	24-24N 101-04W
Altitude (nm)	85.0
Vehicle Roll (Planned)	0.709°
Cone Angle (Planned)	2.3°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/431 sec
Development Level	Full
Local Sun Time	1128
Solar Elevation	83.3°
Solar Azimuth	109.9°
Azimuth of Principal Ray	280.9°
Solar Bearing from Principal Ray	171.0°
Pitch	0.0439°
Yaw	-2.9929°

25X1

FIGURE 20. IMAGE QUALITY EXAMPLE

This imagery was made from a negative exposed after the camera door had been closed for five passes. (See Figures 15-19, 21).

NPIC K-5154 (10/65)

25X1

Pass	70D
Frame	7
Date of Photography	1 June 1965
Universal Grid Coordinates	72.3 - 10.8
Index	15
Enlargement Factor	40X
Geographic Coordinates	50-00N 129-55E
Altitude (nm)	84.2
Vehicle Roll (Planned)	-42.5°
Cone Angle (Planned)	41.0°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/335 sec
Development Level	Full
Local Sun Time	1134
Solar Elevation	61.8°
Solar Azimuth	171.0°
Azimuth of Principal Ray	97.9°
Solar Bearing From Principal Ray	286.9°
Pitch	0.0439°
Yaw	-1.5155°

25X1

25X1
25X1

25X1

FIGURE 21. IMAGE QUALITY EXAMPLE

This photograph illustrates the image quality late in the mission. (See Figures 15-20).

NPIC K-5155 (10/65)

25X1

Pass	74D
Frame	21
Date of Photography	1 June 1965
Universal Grid Coordinates	73.7 - 10.5
Index	38
Enlargement Factor	40X
Geographic Coordinates	45-19N 041-11E
Altitude (nm)	83.7
Vehicle Roll (Planned)	-24.1°
Cone Angle (Planned)	21.6°
Type of Coverage	Strip
Mirror Position	2 Vertical
Slit Number	1
Exposure	1/418 sec
Development Level	Full
Local Sun Time	1138
Solar Elevation	66.6°
Solar Azimuth	169.4°
Azimuth of Principal Ray	97.3°
Solar Bearing From Principal Ray	287.9°
Pitch	0.0439°
Yaw	-2.5019°

5X1

25X1

25X1

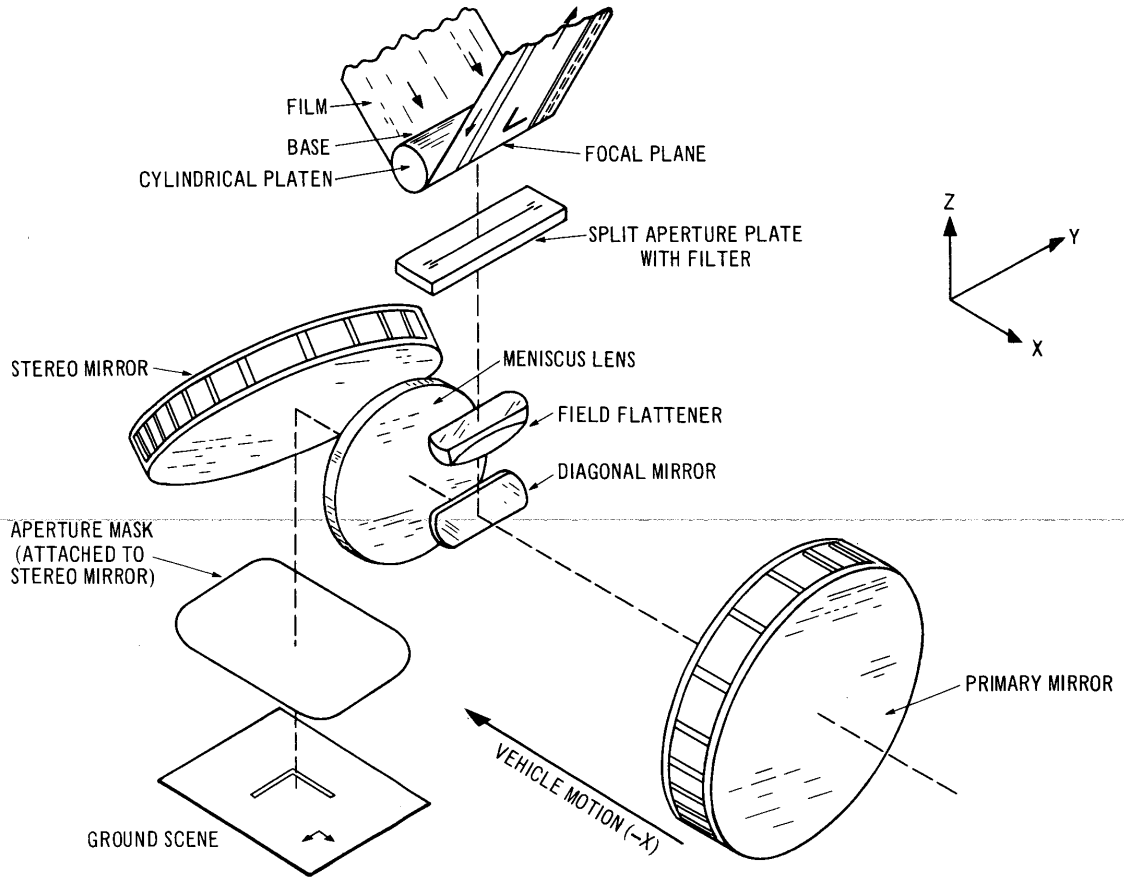
APPENDIX C. SYSTEM SPECIFICATIONS

1. Main Camera Data

Camera Number	FM-20
Focal Length	77.028 inches
Filter	B&L Y-10
Slit Widths	(1) 0.0085 inches
	(2) 0.0169 inches
	(3) 0.0337 inches
	(4) 0.1600 inches*
Effective T Stop	6.2 with filter
Stereo Mirror Positions	Forward
	Vertical
	Aft
Film Type & Number	4404; 95-3-2-5
Film Load	2965.7 feet

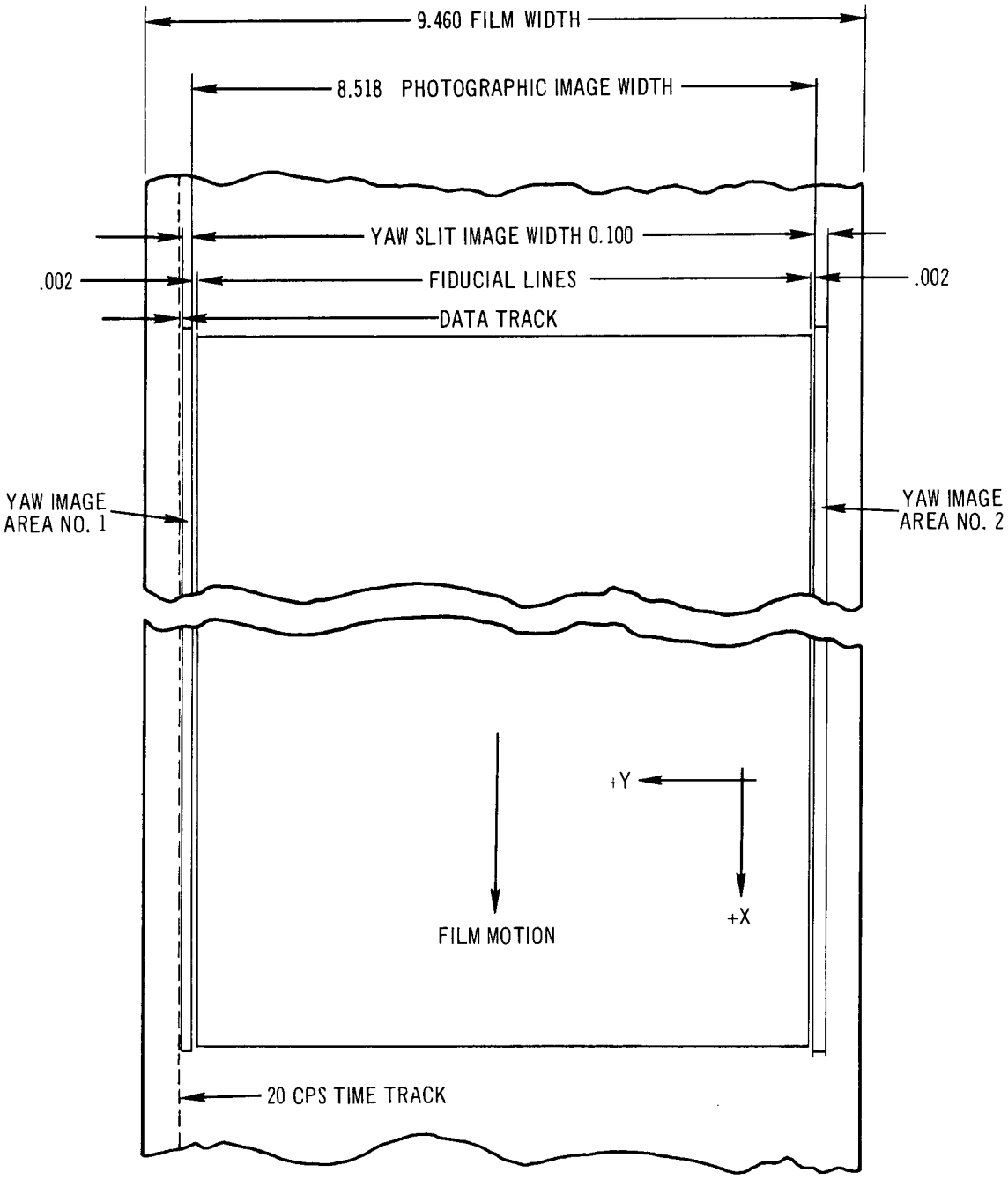
*Special slit for experimental purposes.

25X1



NPIC J-2530 (8/64)

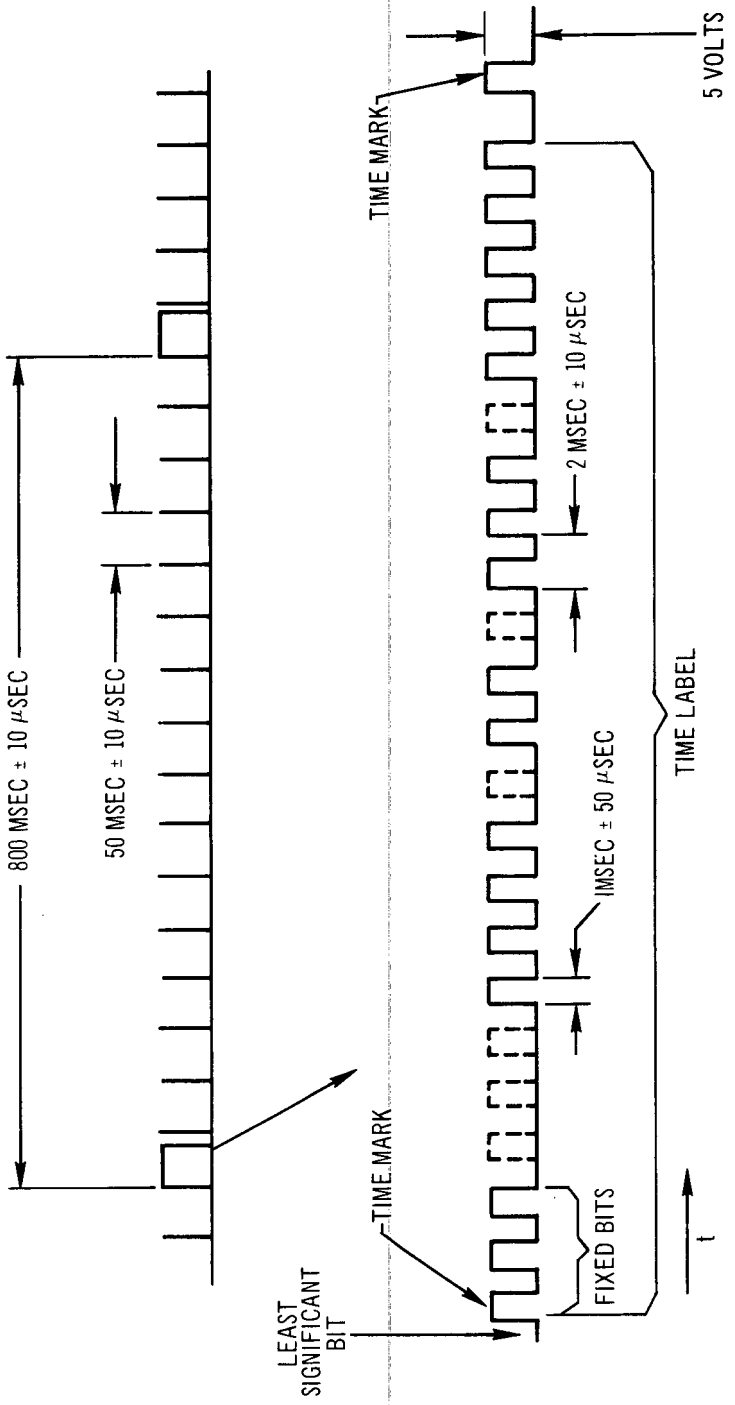
2. EXPANDED SCHEMATIC OF OPTICAL COMPONENTS



NPIC J-2531 (8/64)

3. MAIN CAMERA FORMAT DIMENSIONS
(Viewed from emulsion side)

25X1



4. TIME-TRACK FORMAT

NPIC J-2532 (8/64)

25X1

APPENDIX D. MICRODENSITOMETRY

1. Edge Spread Function

The technique of obtaining the spread function from microdensitometer edge traces is used as an objective measure of the image quality in mission photography. The spread function curve represents a summation of the separate elements of the photographic system. By taking the Fourier Transform of the spread function the modulation transfer function of the system may be obtained.

To satisfy the desire to express image quality in terms of a value, a single number is determined from the spread function curve by measuring its width at 50 percent amplitude. This width is expressed as a micron distance in image space and may be converted to a distance on the ground. On domestic passes, where three bar resolution targets have been available the ground distance determined from edge trace analysis and from the targets has been found to be comparable.

The microdensitometric analysis of edges in the image requires that the object edge fulfill the conditions of a unit step function, i.e., exist for an appreciable distance at a fixed brightness level and change abruptly to a new level which exists for an appreciable distance. This requirement is usually achieved by rooftops of buildings in large-scale photography, and aircraft runways or taxiways in small-scale photography.

The mission is examined to determine the MIP frame (Mission Information Potential) which is a subjective selection of the best photography. Straight edges in this imagery meeting the criteria of a step function for a length of at least 120 microns are selected for scanning with the microdensitometer.

The microdensitometer used for the traces in this report is located at the SPPL facility. The location of the traces was directed by representatives from NPIC and SPPL. The instrument is the Mann-Data Micro-Analyzer used with an effective slit of 1 micron by 80 microns. A scan speed of 0.05 millimeter/minute and a chart speed of 4 inches/minute was used for a recording-to-specimen expansion of 2032:1. One inch on the recording equals 12.5 microns on the specimen. The traces produced represent a plot of deflection versus distance. The deflection of the pen is essentially linear with density and the horizontal lines on the chart numbered 1 to 7 equal 0 to 3.0 density. At the same time the traces were made, the electronic output signals from the instrument were digitized as density values and recorded on paper tape for direct analysis by an IBM 1710 computer.

In the table on the next page the following computer outputs are listed for each edge traced: The 50 percent amplitude width of the Line Spread

Function in microns, the reciprocal of the 50 percent width in millimeters, the computer determined reciprocal edge spread (Machine RES), and the intersection point of the modulation transfer curve and the aerial image modulation curve. The procedure used in the derivation of these values is described in the SPPL Technical Report No. 101-31 (page 79-82). The edge orientation angle is determined in the microdensitometer and is 0^{o} when the edge is parallel to the major axis of the film and 90^{o} when the edge is perpendicular to the major axis of the film.

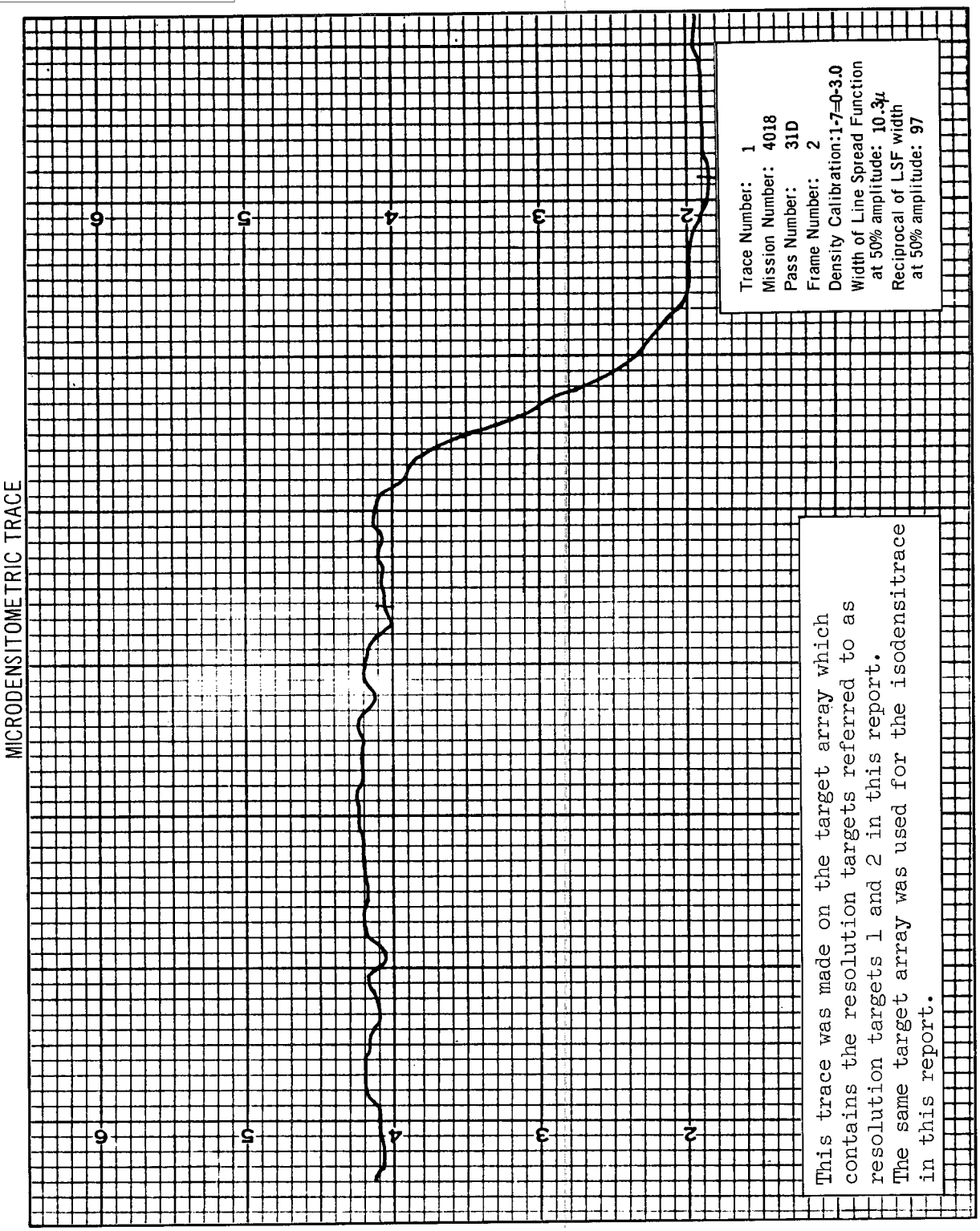
The edge traces were made on the original negative of this mission. The imagery traced is contained in the frames considered to be typical of the best in the mission.

25X1

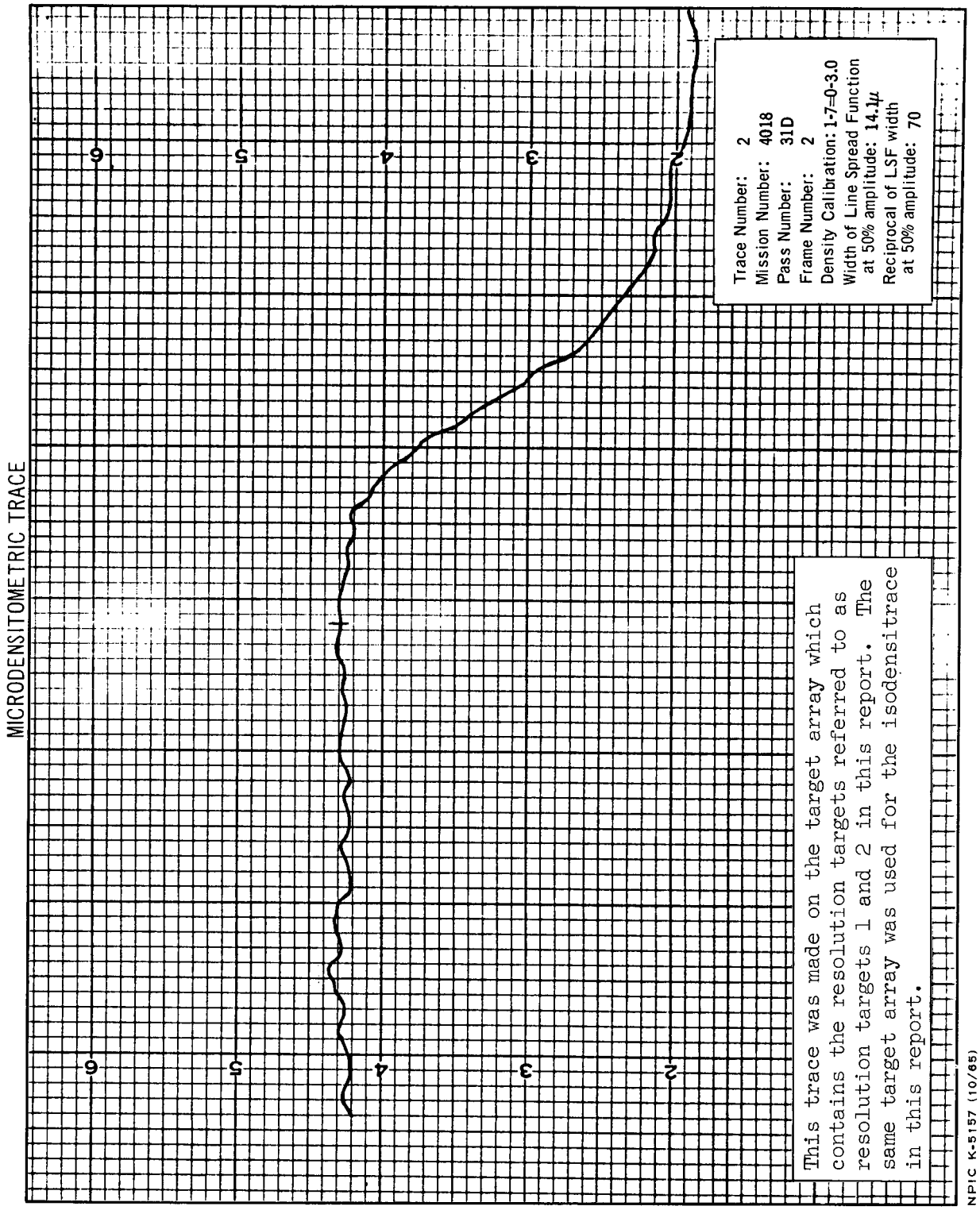
1. Edge Traces, Mission 4018

Trace Number	Pass/ Frame	LINE SPREAD FUNCTION 50% Width	1000/50% Width	Machine RES	MTF/AIM Intersect	Edge Orientation
1	31D/002	10.3	97	90	94	81°
2	31D/002	14.1	70	55	64	170°
3	31D/003	12.6	79	72	72	80°
4	31D/003	11.2	89	67	100	169°

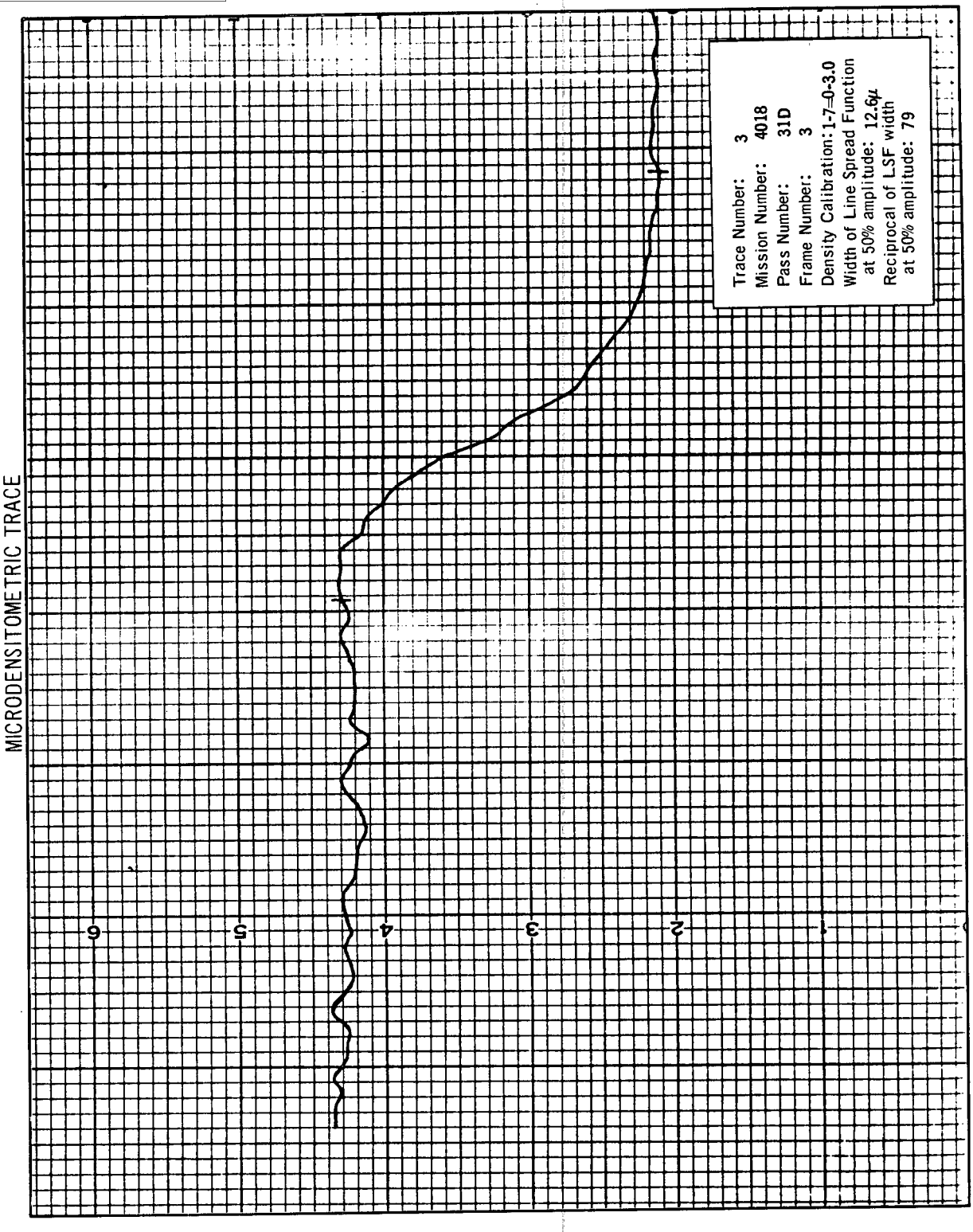
25X1



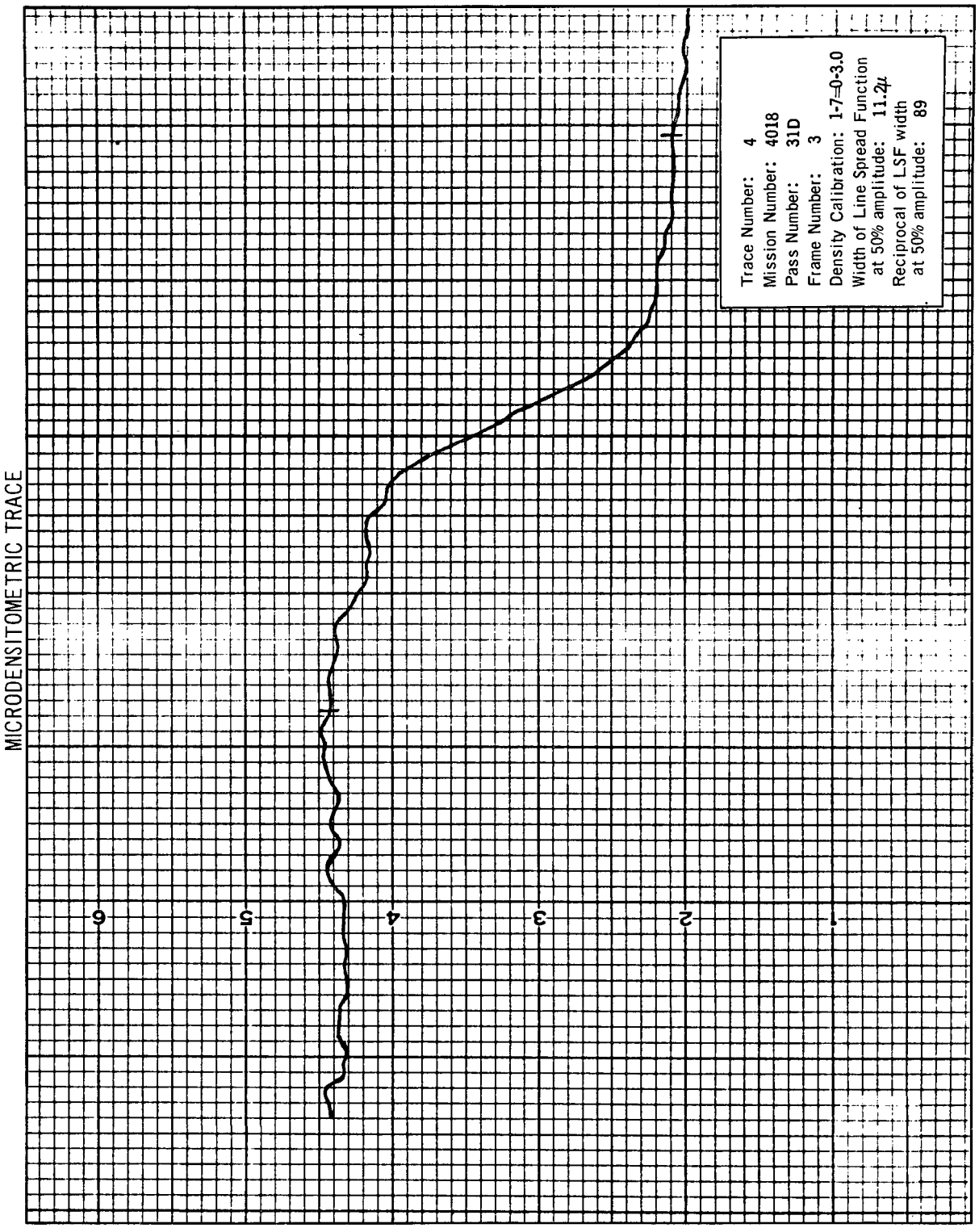
25X1



25X1



25X1



25X1

3. ISODENSITRACER

A. Introduction

The Joyce-Lobel Double Beam Microdensitometer has been adapted to include the recently developed isophotometer equipment made by Tech/Ops. When used with the attachment it is properly called an Isodensitracer (IDT).

The optical system of the IDT automatically makes a series of closely spaced parallel scans. For each scan of the specimen a corresponding coded parallel line is recorded, forming a contour map of the scanned area.

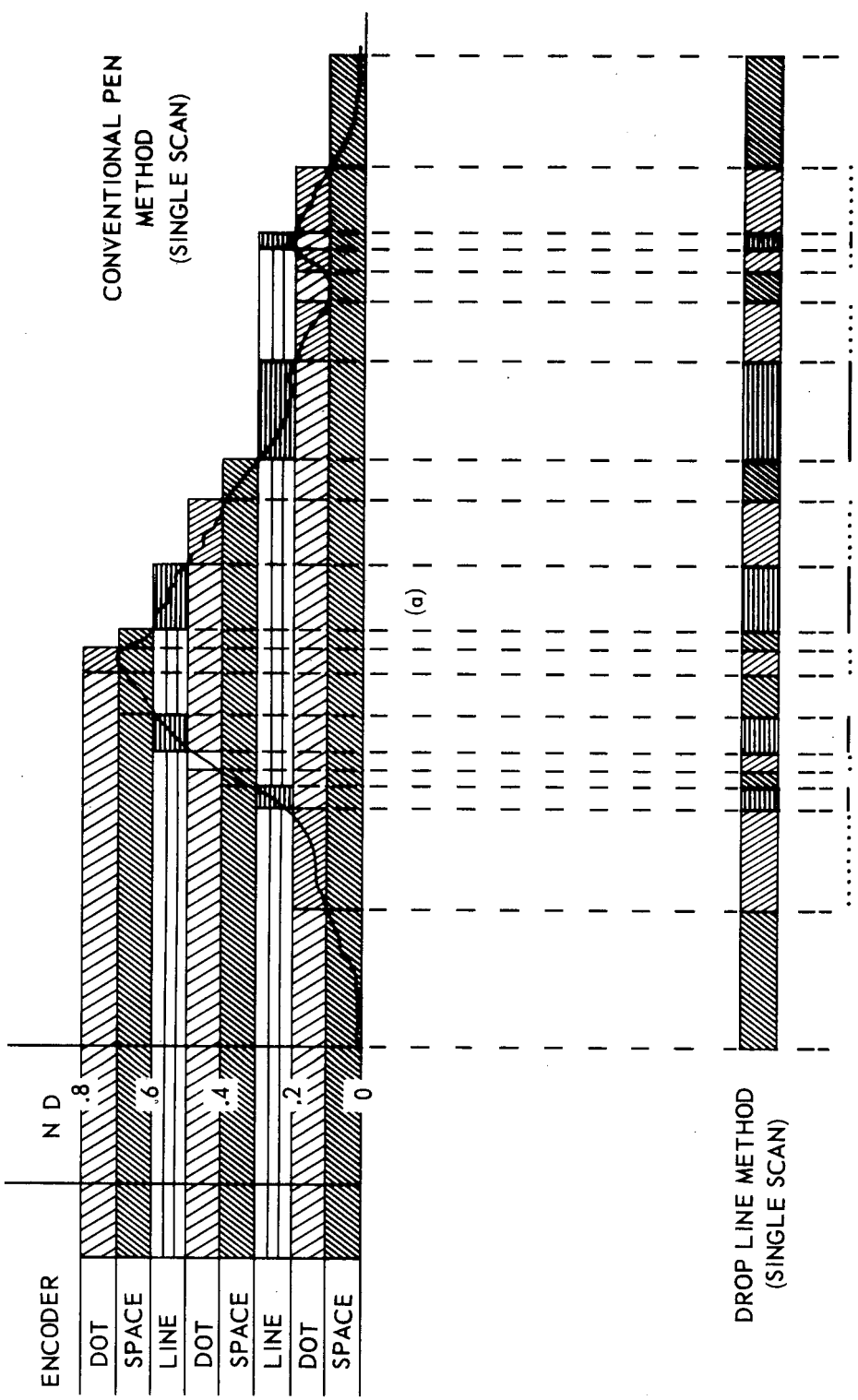
The code in the recorded lines indicates the amount of density change in known preset increments and also shows whether the density is increasing or decreasing. When density is increasing, the three-symbol code line is printed in the sequence: blank-dot-line-blank-dot-line. Whenever the density is decreasing the symbol sequence changes to: line-dot-blank-line-dot-blank. Each symbol in the sequence represents a density increment and is continuously plotted until the density in the specimen changes by that increment; then the next symbol in the sequence is plotted.

When the IDT has completed a scan, recording the density profile along that single scan line in code, the pen lifts from the recording paper and both the specimen table and the recording table return to the starting X position. At the same time the specimen table and the recording pen step in the Y direction, then the next scan is begun. This sequence is repeated automatically until the instrument has mapped the density of the specimen area. Contours are thus formed by adjacent like symbols.

Precise specimen-to-record magnifications can be set at from 1:1 to 1:1000 in the X direction as in the basic Joyce-Lobel instrument and at from 1:1 to 1:3100 in the Y direction. The X and Y ratios can be set separately.

The following illustration shows how a conventional microdensitometric trace is portrayed as a three-symbol code line by the IDT. Each successive scan is a code line and is printed parallel to (b).

25X1



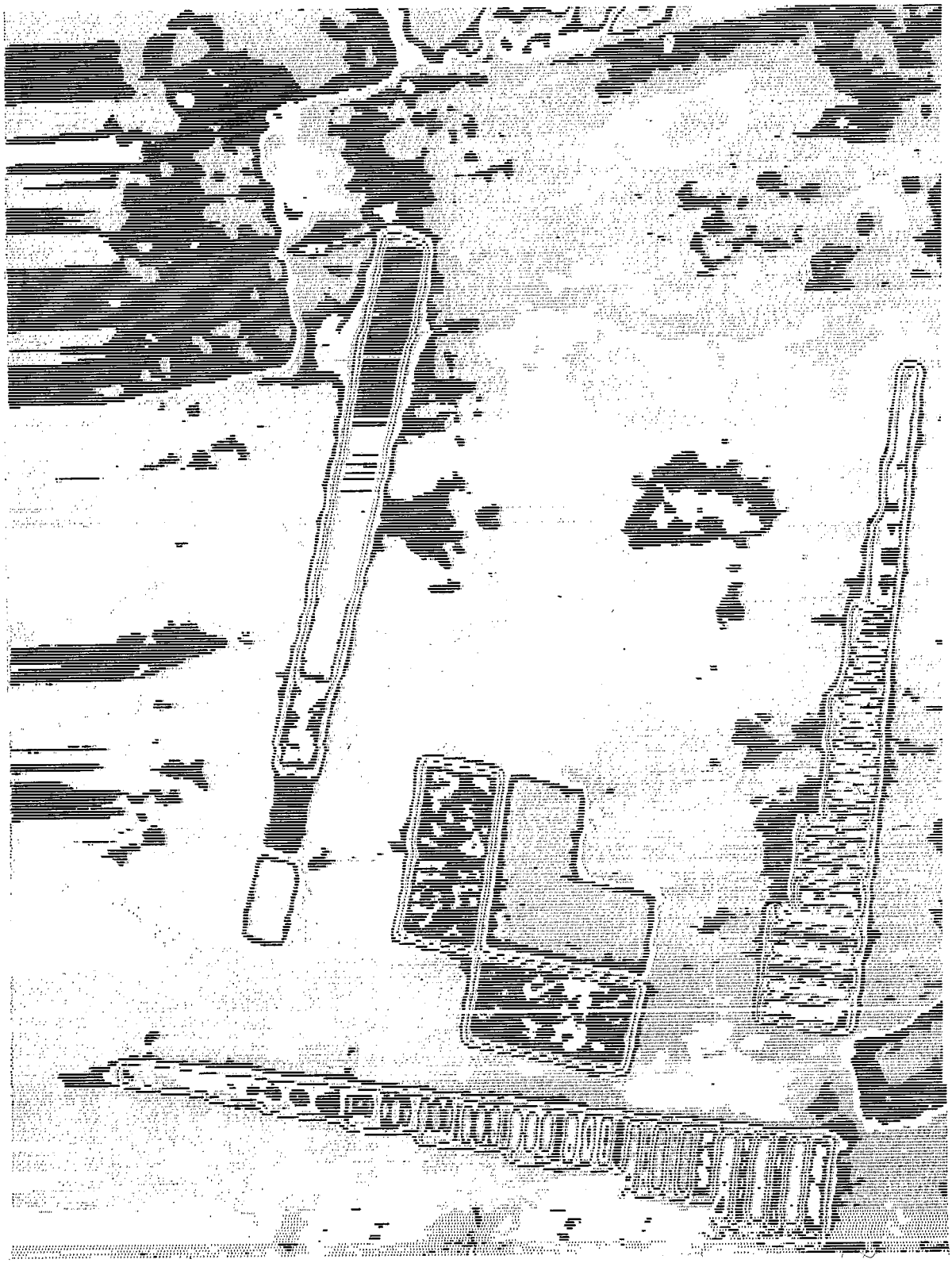
DESCRIPTION OF ISODENSITOMETRIC CODE.

25X1

4. Isodensitrace, Mission 4018

Spot Height	10 microns	Wedge Number	1-3	Magnification	100→
Spot Width	10 microns	ΔD Increment	0.12		100↑
Objective	40x				
Condenser	20				

The following isodensitrace was made from the target array containing the resolution targets referred to as 1 and 2 in this report.



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