CORONA J

PERFORMANCE EVALUATION REPORT

MISSION 1104-1 and 1104-2

FTV 1644, CR-4

Approved [redacted]
Manager
Advanced Projects

Approved [redacted]
Manager
Program [redacted]

92 Pages

6 March 1969

TO: [redacted]

THRU:

FROM:

SUBJECT: MISSION 1104 FINAL REPORT (CR-4)

Enclosed is the Final Evaluation Report for Mission 1104.

[redacted] Man[redacted]ger
Advanced Projects

FOREWORD

This report details the performance of the payload system during the operational phase of the Program [redacted] Flight Test Vehicle 1644.

Lockheed Missiles and Space Company has the responsibility for evaluating payload performance under the Level of Effort and "J" System contracts.

This document is the final payload test and performance evaluation report for Missions 1104-1 and 1104-2 which were launched on 7 August 1968.

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INTRODUCTION

This report presents the final performance evaluation of Missions 1104-1 and 1104-2 of the Corona Program. The purpose of this report is to define the performance characteristics of the CR-4 payload system and to identify the source of in-flight anomalies.

The performance evaluation was jointly conducted by representatives of Lockheed Missiles and Space Company (LMSC) and ITEK at the facilities of NPIC and AFSPPF. The off-line evaluation using Corona engineering photography acquired over the United States was performed at the individual contractors plants.

The quantitative data used for this report is obtained from government organizations. The diffuse density data, and MTF/AIM resolution are produced by AFSPPF. The vehicle attitude error values, frame correlation times are made at NPIC who also supply the Processing Summary reports published by [redacted]

Computer programs developed by A/P are utilized to calculate and plot the frequency distribution of the various contributors to image smear to permit analysis and correlation of the conditions of photography to the information content and quality of the acquired pictures. Computer analysis of the exposure, processing and illumination data provides the necessary data to analyze the exposure criteria selected for the mission.

This report contains certain data summarized from [redacted] Processing Summary, C-38-200613, and from AFSPPF TERO Report, 101-1-116.

SECTION 1

MISSION SUMMARY

A. MISSION OBJECTIVES

The payload section of Mission 1104, placed into orbit by Flight Test Vehicle #1644 and THORAD Booster #522, consisted of two panoramic cameras, one DISIC camera, two Mark 5A recovery capsules and a space structure to enclose the cameras and provide mounting surfaces for all equipment. Figure 1-1 presents an inboard profile of the CR-4 payload system. The Corona "J" system is designed to acquire search and reconnaissance photography of selected areas of the earth from orbital altitudes. A seven day -1 mission and an eight day -2 mission was planned.

B. MISSION DESCRIPTION

The payload was launched from Vandenberg Air Force Base (VAFB) at 2136:55Z (1436:55 PDT) on 7 August 1968. Ascent and injection were normal and the achieved orbit was within nominal tolerances. Tracking and command support was effected by the Air Force Satellite Control Facility [redacted] under central control of the Satellite Test Center at Sunnyvale, California. Mission 1104-1 consisted of a 7 day operation and was completed by air recovery on 14 August 1968. Mission 1104-2 was completed with an air recovery on 22 August 1968 following an 8 day photographic operation.

The comparison of the planned and actual orbit parameters is tabulated as follows:

ORBITAL PARAMETERS

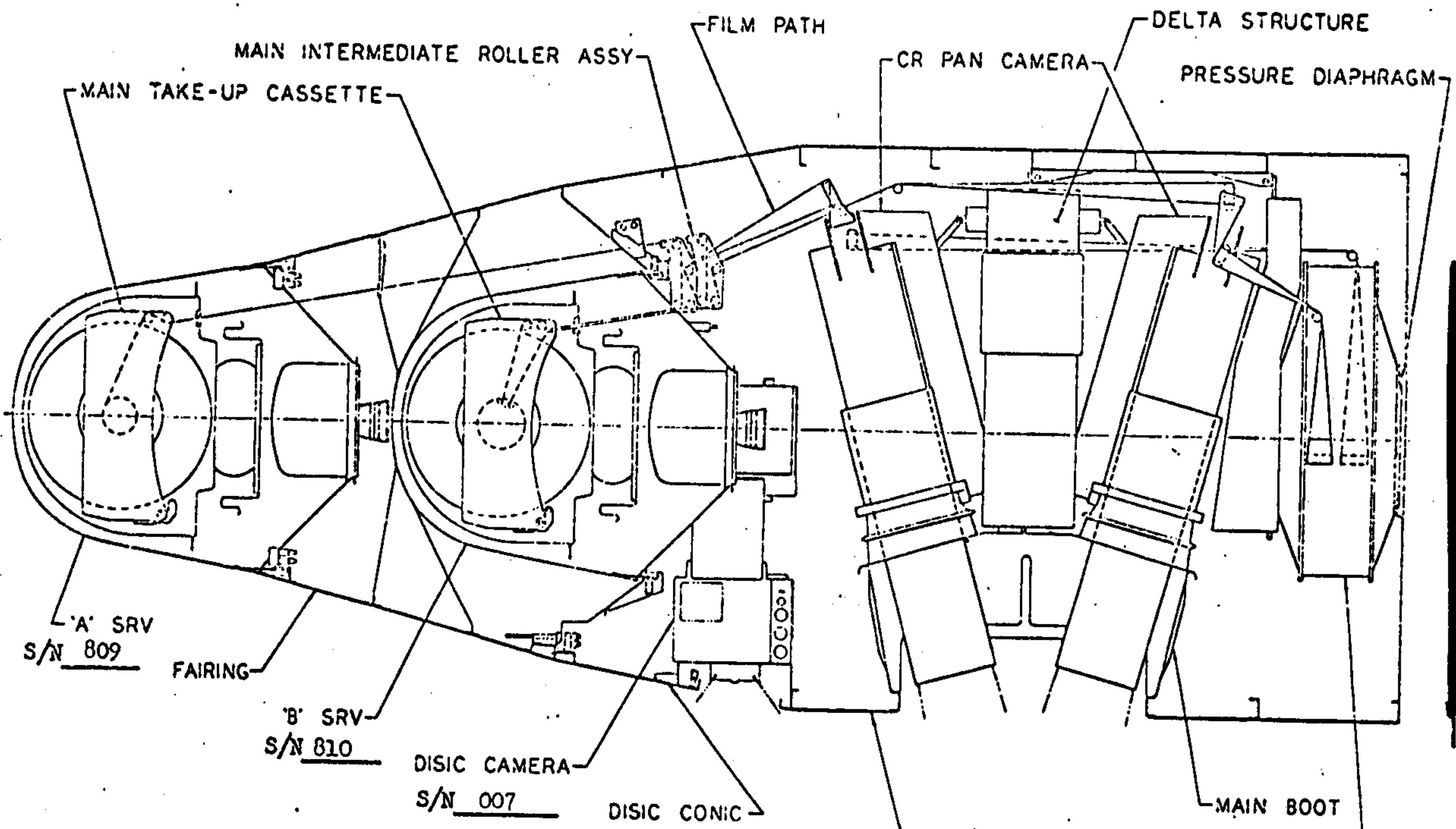
Parameter	Planned	Orbit 2 Actuals
Period (Min.)	88.67	88.72
Perigee (N.M.)	84.96	84.3
Apogee (N.M.)	142.83	143.7
Inclination (Deg.)	82.0	82.11
Perigee Latitude (Deg. N)	20.56	5.70
Eccentricity	0.008175	0.0084

Three drag make-up rockets were fired during Mission 1104-1, and seven during 1104-2. An eleventh rocket was fired after the second recovery.

C. PANORAMIC CAMERAS

Both instruments operated satisfactorily throughout both missions, and produced very good image quality except where degraded by atmospheric attenuation. This was considered to be the best of any Corona system to date.

PAYLOAD PROFILE AND SERIAL NUMBERS



SYSTEM NO. CR-4

TEST Flight

PMU S/N 1005

SLOPE PROGRAMMER S/N 203

CLOCK S/N 618

FIGURE 1-1

D. DISIC CAMERA

The DISIC camera operated satisfactorily throughout both the -1 and -2 missions. Most Stellar images appear as points rather than the common odd shaped stars. A minor light leak caused a few instances of obscured imagery.

E. OTHER SUB-SYSTEMS

The clock, command and thermal control subsystems performed satisfactorily. The 1104-2 SRV tape recorder failed after only one instrument operate. The pressure make-up system functioned erratically and was disabled from Rev. 124 to Rev. 200. The failure permitted significant degradation of the special color film imagery from the panoramic instruments.

F. COMPONENT IDENTIFICATIONS AND SETTINGS

1. Forward Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	309
Main Camera Lens	I205
Supply Horizon Camera Lens	E23759
Take-up Horizon Camera Lens	E23779

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5
Slit Widths	
S_1	0.199"
S_2	0.232"
S_3	0.298"

S_4	0.298"
F/S	0.238"

Filter Types

Primary	Wratten 25
Secondary	Wratten 15 + 0.9 N.D.

Film Types

Primary	Eastman Type 3404 (15,200 Ft.)
Secondary	Eastman Type SO-180 (800 Ft.)

Supply (Port) Horizon Camera:

Lens	55 mm f/6.3
Aperture Setting	f/6.3
Exposure Time	1/100 second
Filter Type	Wratten 25 (NG-3 Auxiliary)

Take-up (Starboard) Horizon Camera:

Lens	55 mm f/6.3
Aperture Setting	f/8.0
Exposure Time	1/100 second
Filter Type	Wratten 25 (NG-3 Auxiliary)

2. Aft Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	308
Main Camera Lens	I 183
Supply Horizon Camera Lens	23766
Take-up Horizon Camera Lens	E 23786

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5
Slit Widths	
S_1	0.151"
S_2	0.163"
S_3	0.205"
S_4	0.256"
F/S	0.210"
Filter Types	
Primary	Wratten 21
Secondary	SF05
Film Type	Eastman Type 3404 (16,300 Ft.)

Supply (Starboard) Horizon Camera:

Lens	55 mm f/6.3
Aperture Setting	f/8.0
Exposure Time	1/100 second
Filter Type	Wratten 25

Take-up (Port) Horizon Camera:

Lens	55 mm f/6.3
Aperture Setting	f/6.3
Exposure Time	1/100 second
Filter Type	Wratten 25

3. <u>DISIC Camera</u>

a. Component Assignment

Component	Serial Number
Camera	007
Index Reseau	107
Stellar Reseaus	
Port	10P
Starboard	8

b. Camera Data and Flight Settings

Stellar Cameras:

Lens	3 in. f/2.8
Exposure Time	1.5 second
Filter Type	None
Film Type	Eastman Type 3401 (2000 ft.)

Index Camera:

Lens	3 in. f/4.5
Exposure Time	1/500 second
Filter Type	Wratten 12
Film Type	Eastman Type 3400 (2000 ft.)

SECTION 2

PRE-FLIGHT SYSTEMS TESTS

As a standard procedure, the CR payload systems are subjected to a series of tests which demonstrates a satisfactory level of confidence that the systems will indeed perform as required in their respective missions. The tests include an operational-type exposure to simulate thermal/altitude environment, a light-leak evaluation, and a dynamic measure of the photographic performance capabilities. Significant baseline levels and anomalies experienced with this system during the pre-flight testing are as follows:

A. ENVIRONMENTAL TEST

The CR-4 payload system was subjected to an environmental HIVOS chamber test from 27 April through 3 May 1968. Payload performance, from instrumentation analysis, was satisfactory throughout the "A" and "B" missions.

The test film consisted of three types of material for each camera for the purpose of adding further dimension into the corona marking evaluations. During the "B" mission the automatic film change detector switched the No. 1 and 2 instrument filters to the alternate filter each time the alternate material was detected. The MCD units operated with no anomalies. Instrument 308 contained film types 3404, 3400 (1600 ft.) and SO-340 (1600 ft.), and Instrument 309 contained 3404, 3401 (1600 ft.) and SO-180 (1600 ft.).

The primary 3404 film showed no evidence of corona induced marking throughout the test. However, the other four, more sensitive materials exhibited a very distinct, repeatable corona marking pressure profile. The 3400, 3401, SO-180 and SO-340 films recorded virtually identical patterns of marking, differing only in extent and magnitude in direct proportion to their relative emulsion sensitivities. Each of the materials experienced objectionable marking over the full range of pressure (0 to 200 x 10^{-3} Torr) except for the region approximately 10 to 20 x 10^{-3} Torr. The SO-340 exhibited a relatively minor level of marking in this region also, which is suspected to be a result of the combined influences of a very much more sensitive emulsion and a much thicker material overall. The very high sensitivity of the SO-340 material also revealed minor system light transmission characteristics, which can be degrading to SO-340 photography, but are undetectable with the more conventional films. There are some instances of continuous density streaks along the film (very distinct on the SO-340), most probably associated with the take-up puck arm.

The DISIC terrain camera experienced only minor corona marking throughout the test. Very few frames were affected, and density levels were acceptable. The stellar record exhibited random corona marking throughout, with approximately 15 to 20% of the frames affected. However, the extent and density level of the marking is very minor and would not destroy the utility of stellar imagery. This test appeared to exhibit the least amount of corona marking in any DISIC unit to date.

The high pressure valve in the pressure make-up system (PMU) failed to open periodically throughout the portions of the test in which the PMU was enabled. The consumption rate averaged 10.3 lbs./min., which is approximately 20 percent lower than nominal. Subsequent testing of the PMU components at various environmental conditions failed to identify the anomaly, and the system was accepted for flight. The apparent anomaly experienced in the chamber test is opposite to the performance characteristics evident during

Mission 1104 where the valve appeared to fail in closing properly resulting in a very high gas consumption rate. (Ref. Section 3)

Both the Switch and Slope Programmers operated satisfactorily throughout the test. No anomalies were reported.

The Command System operated satisfactorily except for UNCLE 101 commands. The time restriction of 3 seconds between commanding from Position 11 to Position 1 was not observed. This problem occurred two times in the "A" mission and one time in the "B" mission.

Payload Tape Recorder data was processed and computer outputs analyzed. All T/M anomalies, analyzed from Sanborn records, were reverified using tape recorder data.

Temperature profiles indicate that thermal limitations were not exceeded at any time during altitude testing. Special thermocouples installed on the rail of No. 2 instrument were recorded at 5 minute intervals during the 20 minute operates at Beta +65 and at 70° soak. The instrumentation indicated insignificant levels of thermal gradient across the rail and of thermal rise during camera operation.

During the switching functions of KZ-38, KZ-39, Arm, Transfer and Electrical Disconnect, T/M indicated no anomalies occurred except for the "B" SRV water seal. During "B" Arm Command, T/M indicated the water seal did not close. Post inspection verified the seal did close and, due to a sticky switch, T/M indication was in error.

As a result of the corona marking characteristics observed in this environmental test, the CR-4 pressure make-up system was modified to provide a nominal pressure of 16×10^{-3} Torr during the portion of the 1104 mission in which SO-180 film would be used. The standard 50 x 10^{-3} Torr pressure regulation was retained for use with the 3404 film.

B. RESOLUTION TEST

Initial resolution and theodolite tests were performed on 29 April 1968. Results of the thru-focus resolution tests of pan instruments 308 and 309 show the following characteristics:

Aft-Looking Instrument No. 308

Maximum high contrast resolution 234 lines/mm at 0.000 focal position.

Maximum low contrast resolution 136 lines/mm at +0.001 focal position.

Fwd-Looking Instrument No. 309

Maximum high contrast resolution 248 lines/mm at 0.000 focal position.

Maximum low contrast resolution 168 lines/mm at 0.000 focal position.

Additional Boston investigations of the film dynamics in the CR-4 camera system (Dr. "A" tests) induced an excessive shift in the peak focus position for Instrument 309. A 0.001" shim was removed and a final resolution run performed on 6 June 1968, demonstrating the following results:

Aft-Looking Instrument No. 308

Maximum high contrast resolution 212 lines/mm at 0.000 focal position.

Maximum low contrast resolution 141 lines/mm at 0.000 focal position.

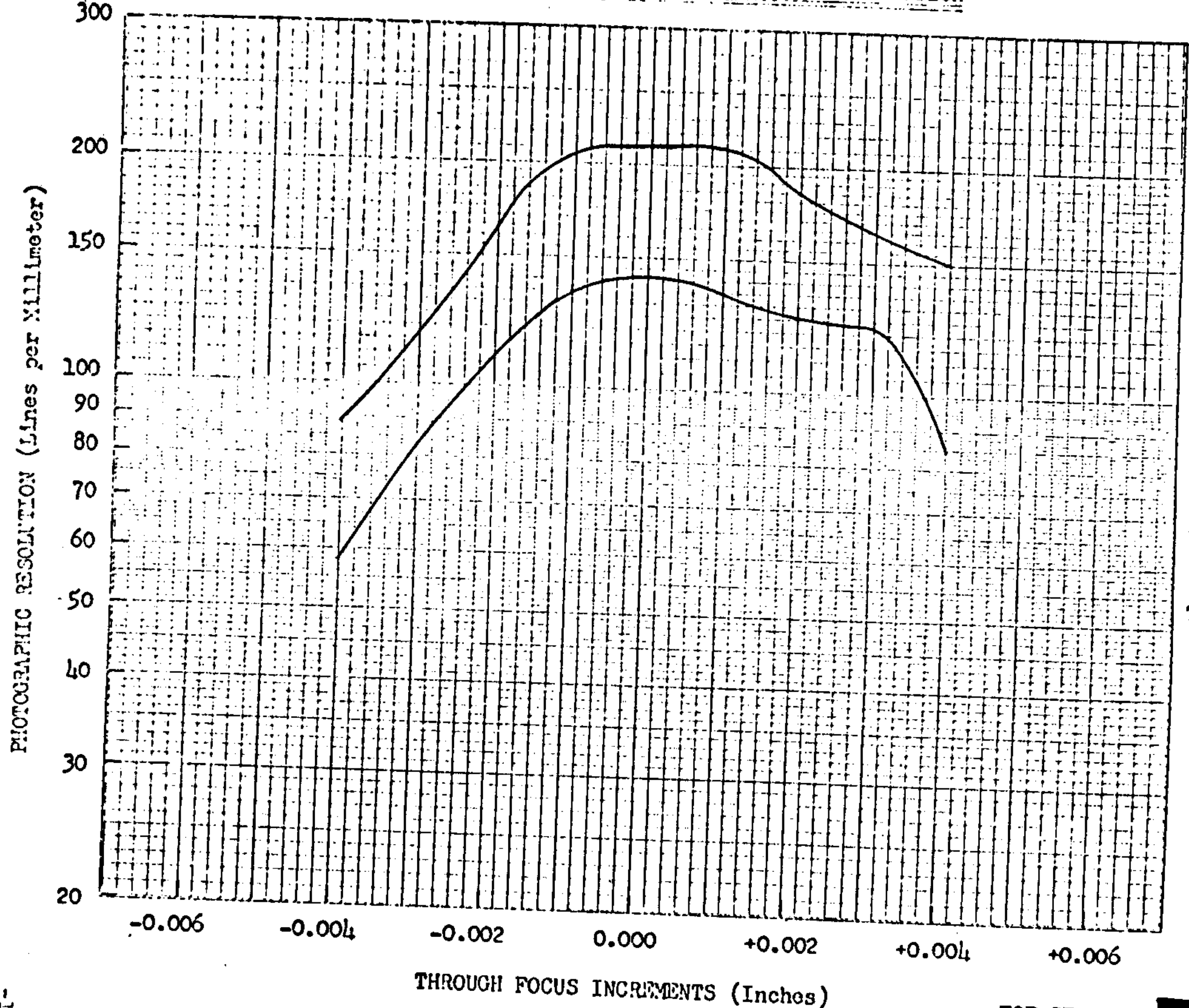
Fwd-Looking Instrument No. 309

Maximum high contrast resolution 254 lines/mm at -0.001 focal position.

Maximum low contrast resolution 172 lines/mm at -0.001 focal position.

The final test data for both instruments is shown in Figures 2-1 and 2-2. Both instruments met the system requirements specification.

PRE-FLIGHT DYNAMIC RESOLUTION



Camera No: 308

Payload No: CR-4

Resolution (1/mm)

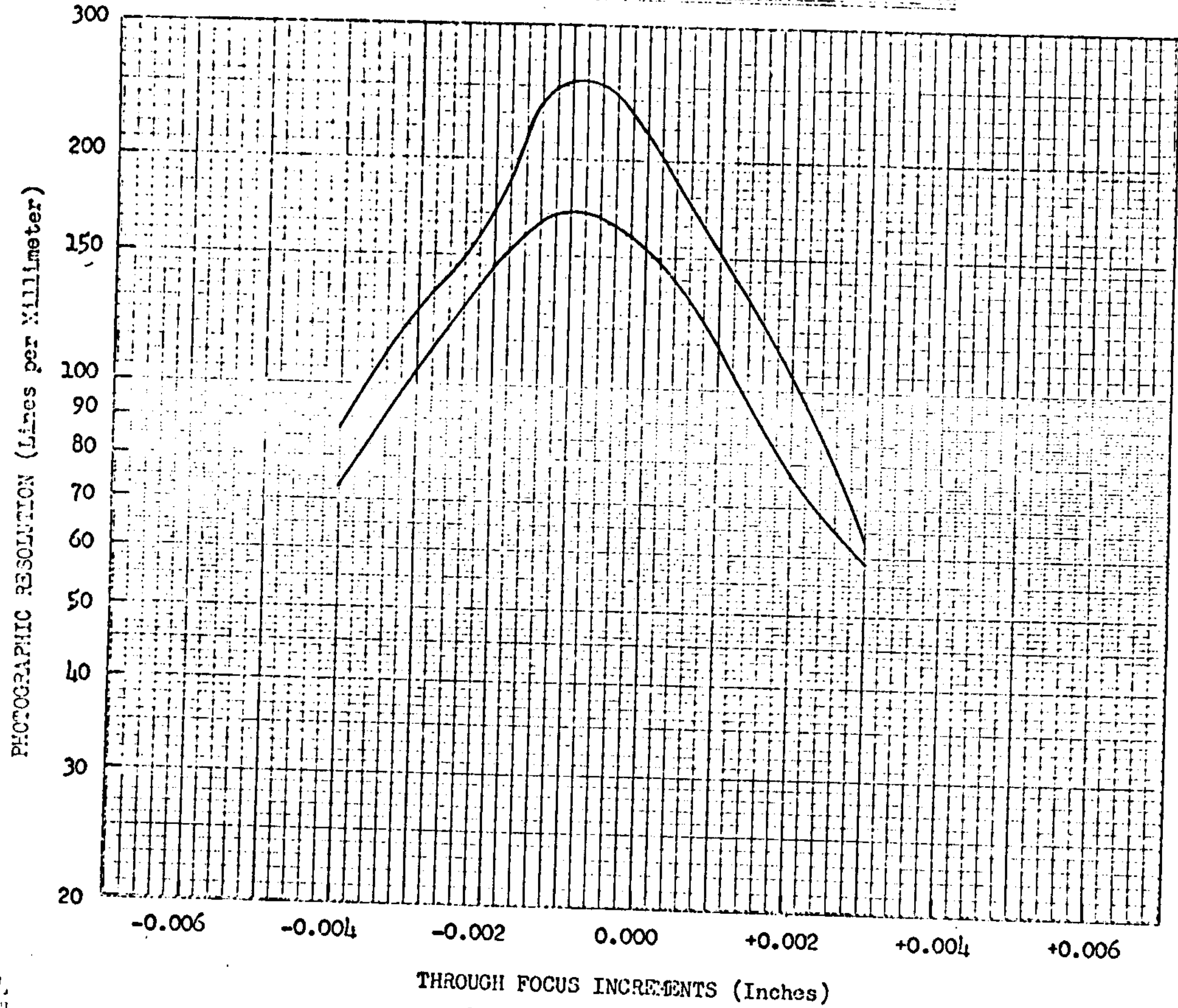
High Contrast: 212

Low Contrast: 141

Film Type: 3404

Test Date: 6 June 1968

PRE-FLIGHT DYNAMIC RESOLUTION



Camera No: 309

Payload No: CR-4

Resolution (1/mm)

High Contrast: 254

Low Contrast: 172

Film Type: 3404

Test Date: 6 June 1968

C. LIGHT LEAK TEST

A live film light leak test of the CR-4 system was performed on 6 June 1968, revealing heavy density marks on the records from both instruments in the vicinity of the "A" SRV capsule cover. These marks were similar to forebody leak problems experienced in recent systems. No other leaks were detected.

Extensive testing of the forebody failed to detect any source of light fogging. Subsequent examination of the fairing revealed an apparent leak at a teardrop fitting near the forebody interface. The leak was plugged and verified by photomultiplier light search. For lack of supporting evidence to the contrary, it was assumed that this apparent leak was the cause of the marking in the live film test. The flight results indicate that there was indeed a forebody leak that escaped detection (ref. Section 4). Testing procedures have been implemented to reduce the possibility of flying a system with a potential light-leaking forebody on future missions.

D. FLIGHT LOADING AND CERTIFICATION

Loading of flight film was accomplished on 29 July 1968, and final preflight acceptance tests performed 1 August 1968. All functions were normal, with no indications of light leaks (using photomultiplier sensing techniques) or other sources of performance degradation.

SECTION 3

FLIGHT OPERATIONS

A. SUMMARY

Lift-off occurred at 1436:55 PDT (system time 77814.70) on 7 August 1968 from the SLC-3, West launch pad. All launch, ascent, and injection events occurred as programmed. The orbit achieved was within the predicted 3 Sigma dispersions.

Both Panoramic cameras operated satisfactorily throughout the flight. Average cycle periods for both cameras were within 1% of the pre-flight calibrations.

Telemetry monitors indicated the DISIC system operated normally throughout the flight.

The clock and A/P command systems operated satisfactorily throughout the flight.

The FMC programmer and exposure control programmer operated satisfactorily throughout the flight.

A malfunction of the PMU high pressure regulator resulted in excess consumption and the PMU was disabled from Rev. 124 to Rev. 200.

Ascent vibrations appeared normal and were within qualification levels. The thermal environment of the Panoramic cameras was within predicted tolerances and ranged from an average high of 75°F for the -1 mission to an average low of 56°F for the -2 mission. The No. 1 DISIC temperature sensor was biased by an approximate +27 degrees throughout the flight.

KIK-ZORRO 38 (Panoramic camera take-up switchover) was commanded during Rev. 103. Cut, wrap, and transfer from the -1 to the -2 recovery system occurred normally. However, the No. 2 instrument did not stow; this problem is presented in detail in Paragraph B, below.

KIK-ZORRO 39 (DISIC camera take-up switchover) was commanded during Rev. 104. Cut, splice, and transfer to the -2 recovery system occurred normally.

Both recovery systems were successfully recovered by air-catch with all events occurring as programmed. The impact point was within predicted limits for both systems.

Eleven (11) drag make-up rockets were utilized during the active portion of the flight. Three (3) rockets were fired during the -1 mission for period recovery and seven (7) rockets were fired during the -2 mission. The eleventh rocket was fired after the second recovery. Rocket number 12 was not fired. The following is a summary of DMU rocket performance:

DMU ROCKET PERFORMANCE

DMU	Rev. No.	Velocity Change (FPS)	Period Change (Sec.)
1	46	14.8	9.2
2	69	15.3	9.6
3	99	15.0	9.3
4	117	17.2	10.7
5	139	16.2	10.3
6	150	17.0	10.6
7	174	17.0	10.6
8	194	16.6	10.3
9	211	16.8	10.4
10	234	17.2	10.7
11	244	19.2	12.0
12	Not used		

Figures 3-1 and 3-2 are plots of orbit history and operation distribution data.

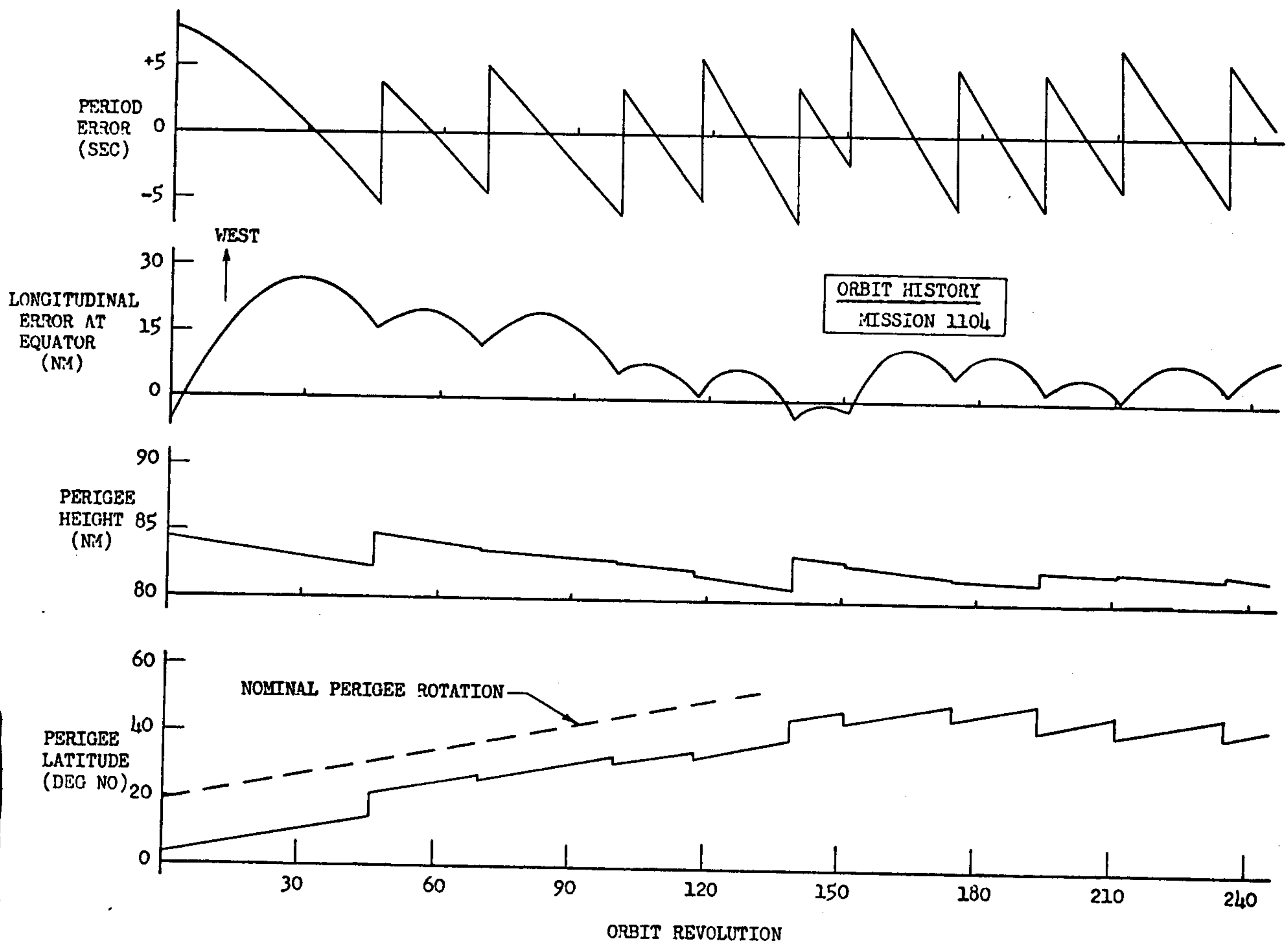
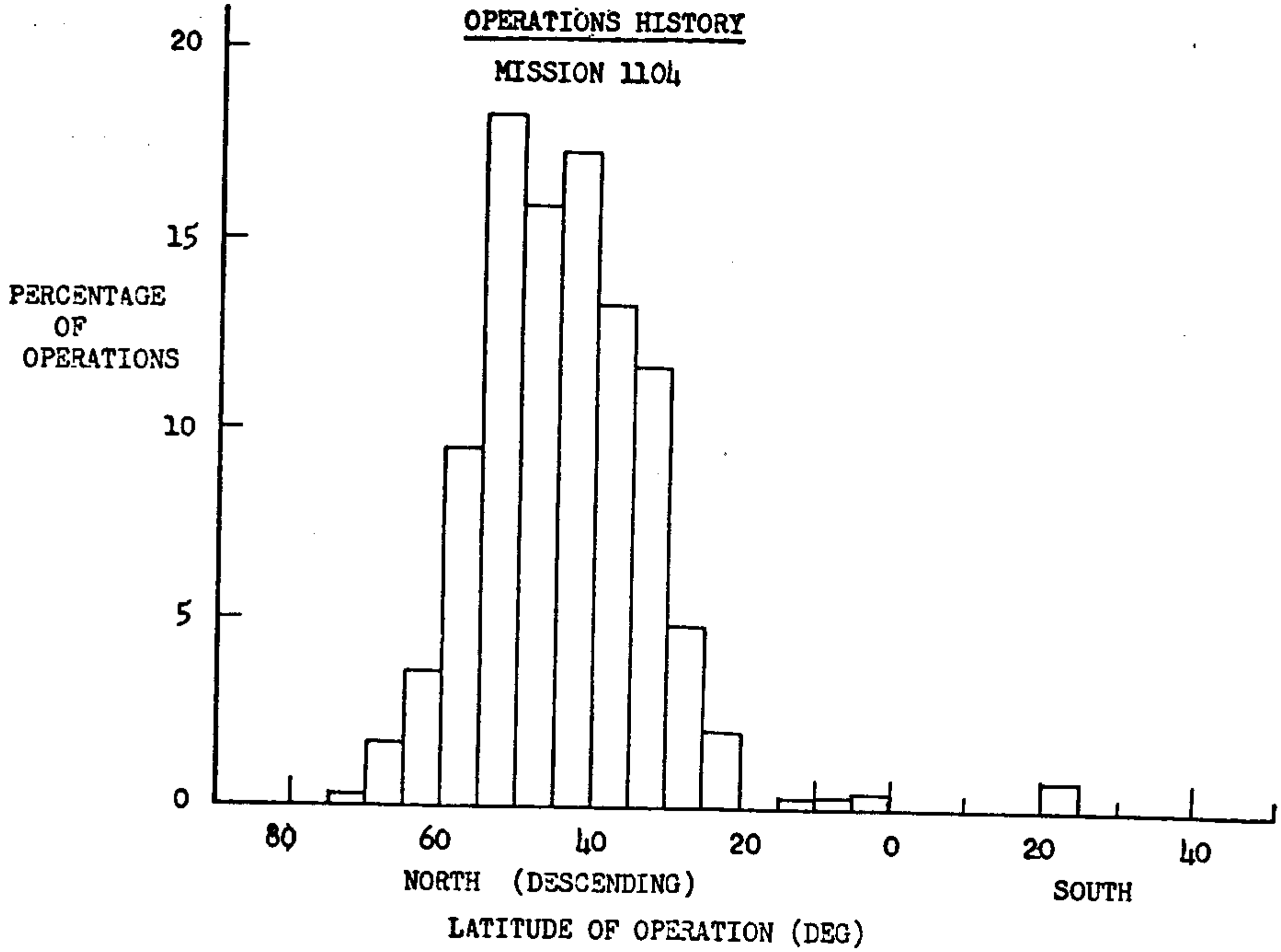

PERIOD ERROR (SEC)
+5
0
-5
WEST
LONGITUDINAL ERROR AT EQUATOR (NM)
30
15
0
ORBIT HISTORY
MISSION 1104
PERIGEE HEIGHT (NM)
90
85
80
PERIGEE LATITUDE (DEG NO)
60
40
20
0
NOMINAL PERIGEE ROTATION
30
60
90
120
150
180
210
240
ORBIT REVOLUTION

FIGURE 3-1

OPERATIONS HISTORY

MISSION 1104



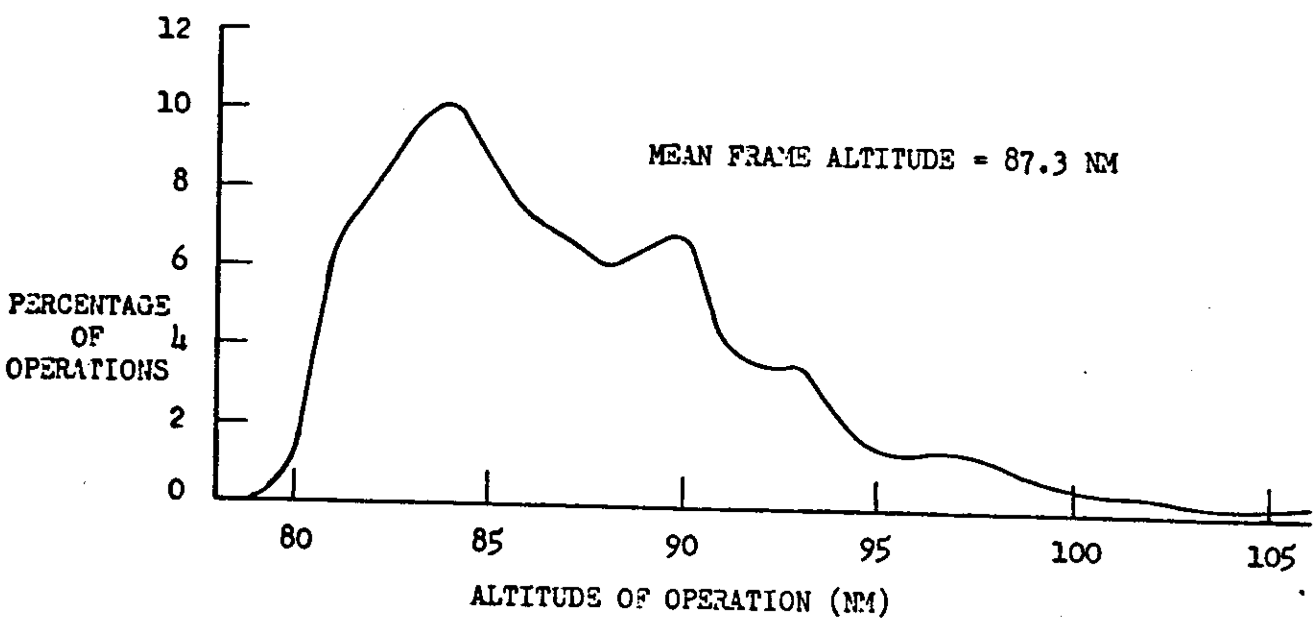


FIGURE 3-2

The -1 SRV tape recorder system functioned satisfactorily throughout the mission. The -2 tape recorder recorded only the first operate after KZ-38; this problem is presented in detail in Paragraph D, below.

There were no post-mission test requirements for this flight.

B. PANORAMIC CAMERA PERFORMANCE

Both Panoramic cameras operated normally throughout the flight. Camera system dynamic operation, 99/101 percent clutch operation, start-up, and transport functions were normal for all passes indicated by available telemetry data. Telemetry analysis indicated the Slave camera lens failed to stow on three(3) operations during the flight. However, the failure to stow on the KZ-38 operation was the only instance which produced detrimental effects on the film.

Instrument vibrations repeated the pattern recorded in Mission 1103. The greatest disturbance was again caused by the clamping and capping shutter functions. The A.O. solenoid firing was noticeable, but not prominent.

The average vibration level during scan was 0.1 g at 800-1000 cps. Maximum "g" values during the scan portion of a typical instrument cycle were as follows:

	Peak g's	
	X-Axis	Y-Axis
A.O. clamp	0.33 (peak)	0.33 (peak)
Capping shutter open	0.33 (peak)	0.33 (peak)
A.O. solenoid actuate	---	0.13
A.O. solenoid release	---	0.13
Capping shutter closed	0.16	---
A.O. unclamp	0.28	---

Power Spectral Density (PSD) plots of the instrument vibration through the scan area of instrument rotation produced the following peak "g's" at the indicated frequencies:

	AXES (g's)					
	X		Y		Z	
Freq. (cps)	Mono	Stereo	Mono	Stereo	Mono	Stereo
395					.0037	
475						.0135
520						.0134
560		.026				
580	.0185				.0076	
645					.0048	
780	.0173		.021			
795		.0136		.0187		.0129
800					.00324	
935				.017	.0044	
960		.0261				
985	.0167		.0123		.0063	
1050				.013		
1055	.0097		.013			

The general resonance build-ups occurred between 500 and 1100 cps. These values are well below the levels that would induce detectable degradation to the photographic quality of current systems.

The mission film supply was exhausted with the exception of the stellar film, which was in excess of flight programming.

Film Consumption - Cycles

	Pan 308	Pan 309	Stellar	Terrain
Sample Off-Spooling	16	13	72	43
Pre-Launch	109	109	104	120
-1 Mission	2989	2978	2127	2134
-2 Mission	3056	2962	2588	2465
Total	6170	6062	4927	4762

FMC Match

A satisfactory ramp to orbit match was maintained throughout the entire mission, 90% photography being exposed at less than 1.25% error. The V/h match performance is statistically summarized in Figures 3-3 through 3-6.

Y V/H RATIO ERROR - PERCENT (Y) VERSUS FREQUENCY - PERCENT (Y)

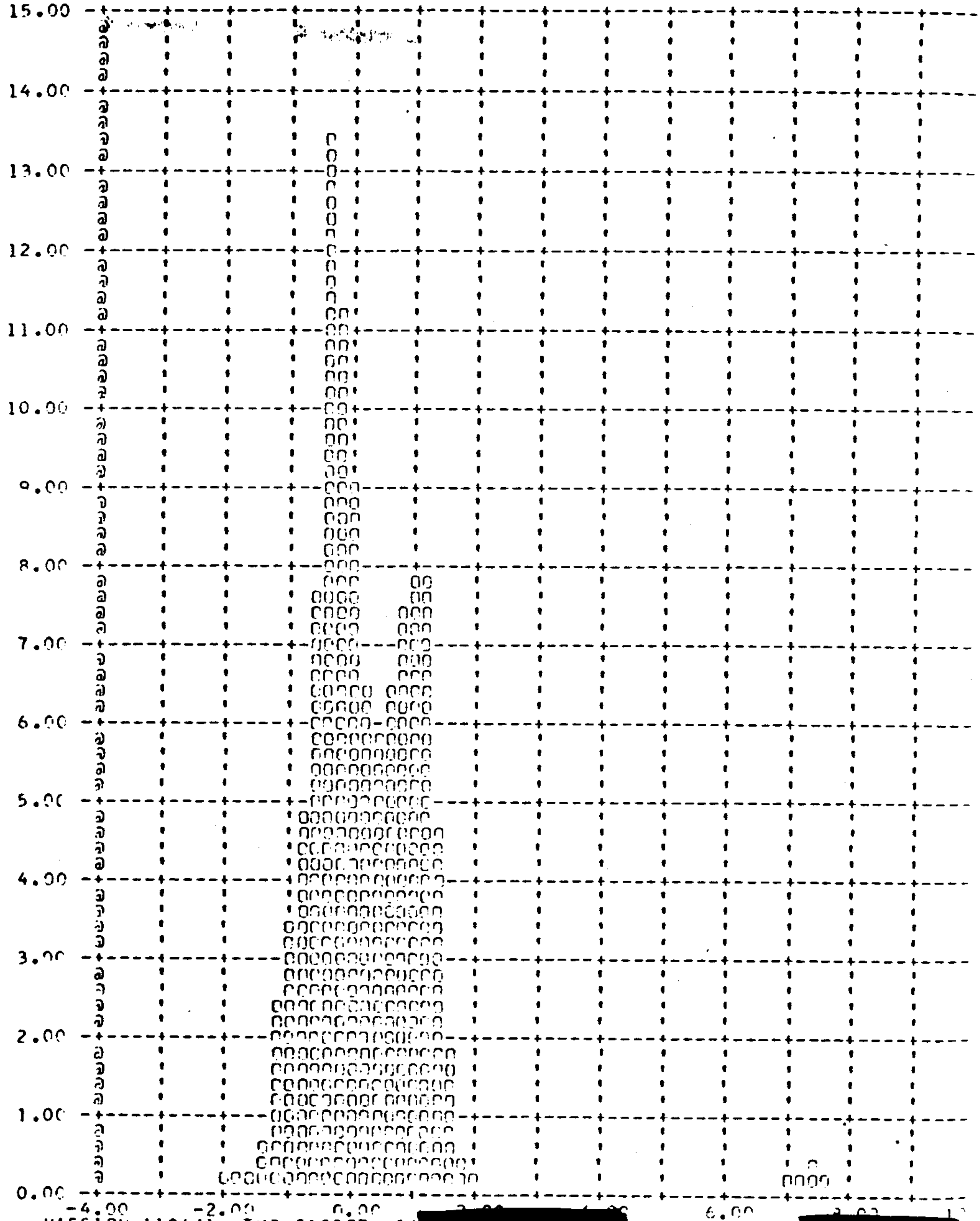
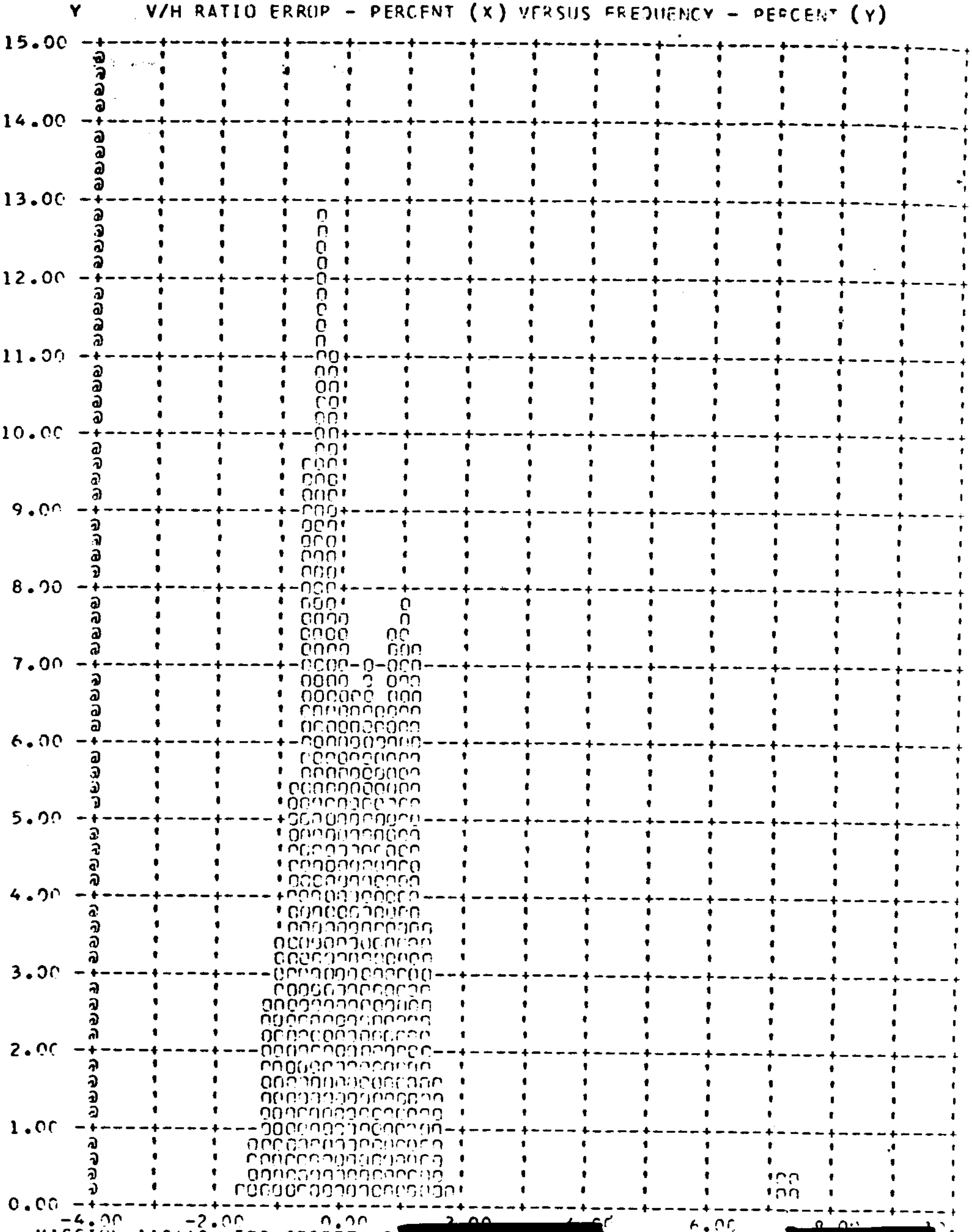


FIGURE 3-3

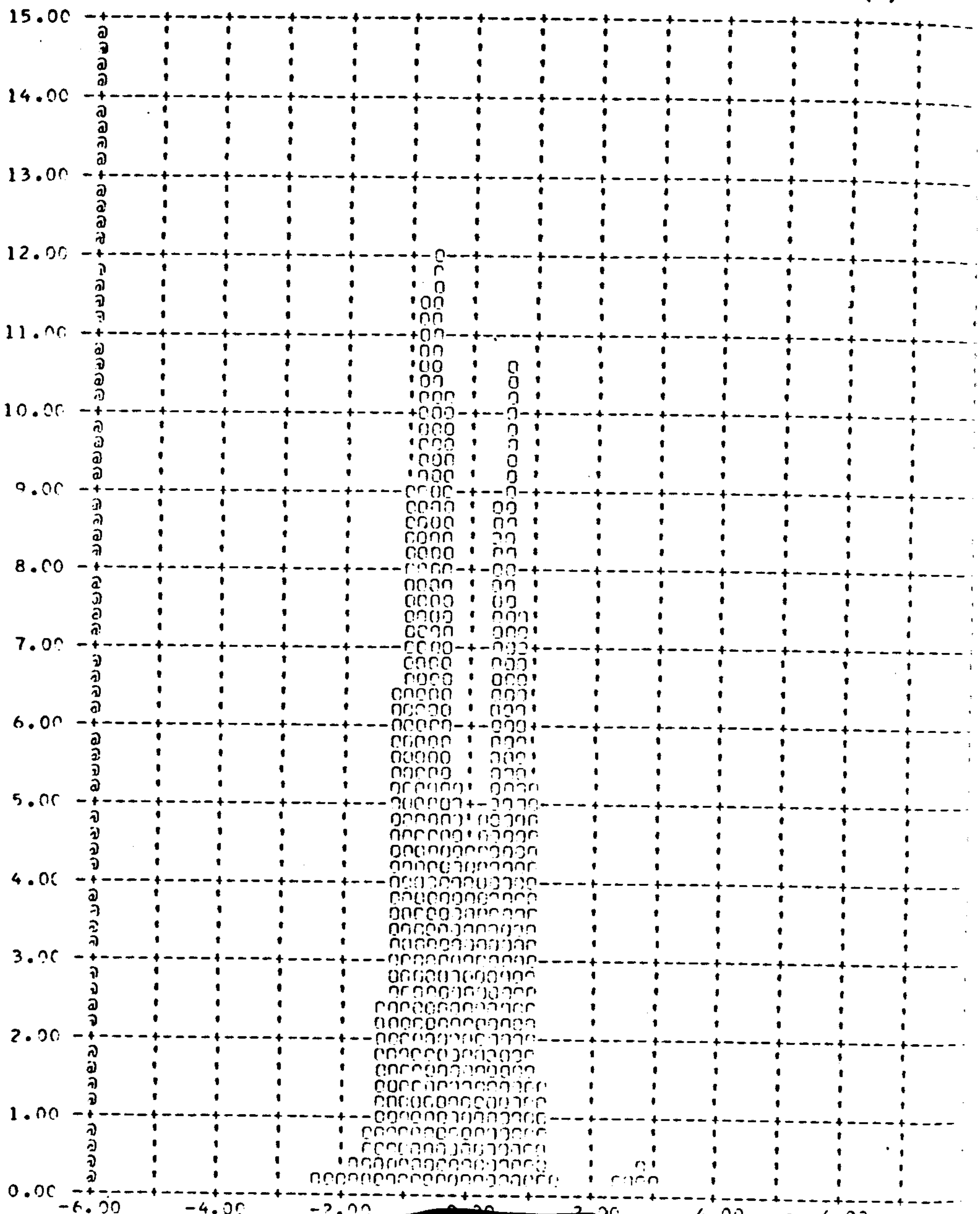
AFT LOOKING CAMERA



MISSION 1104A2 ~~TOP SECRET~~ C[redacted] - CONTROL NO. [redacted]

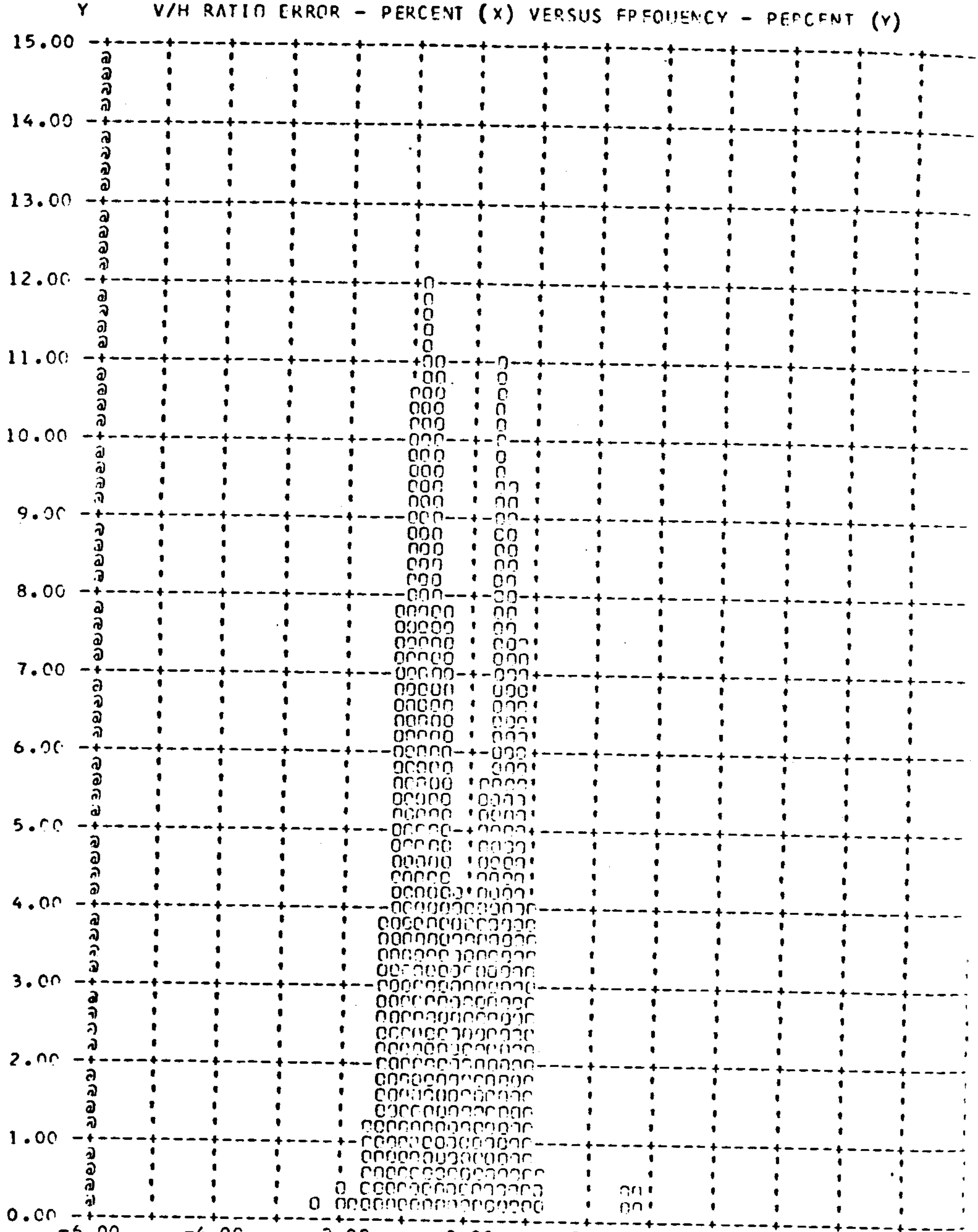
FIGURE 3-8

V/H RATIO ERROR - PERCENT (X) VERSUS FREQUENCY - PERCENT (Y)



MISSION 1104B1 ~~TOP SECRET~~ C[redacted] - CONTROL NO. [redacted]

FIGURE 3-5



MISSION 110482 ~~TOP SECRET~~ C/[redacted] - CONTROL NO. [redacted]

FIGURE 3-6

C. DISIC PERFORMANCE

Telemetry monitors indicated the DISIC system operated normally throughout the flight. Cut, splice, and transfer to second recovery system was initiated by KZ-39 during Rev. 104. All events occurred as programmed and were satisfactory.

The DISIC shutter-speed change mechanism (1/250 second exposure control) and the T2 timer function were disabled prior to flight.

D. INSTRUMENTATION AND COMMAND SYSTEM PERFORMANCE

The instrumentation system operated satisfactorily throughout the flight. Several tracking stations reported loss of sync of Link 2, Channels 15 and 16 with periodic commutator repetitive rates of 330-350 pulses per second. The normal rate of the 60 pin commutator is 300 pps or 5 RPM. This anomaly was first noted during pad checkout and corrective action was not considered necessary.

The payload command system operated satisfactorily throughout the flight. The UNCLE command system was utilized as the primary command link.

E. EXPOSURE CONTROL SYSTEM PERFORMANCE

The exposure control system functioned satisfactorily throughout the flight. There was no indication of a recurring malfunction of the exposure programmer relay K4 as experienced during Mission 1103.

F. CLOCK SYSTEM PERFORMANCE

The clock system operated normally throughout the flight. Satisfactory correlation between clock time and system time was obtained. However, a higher than normal drift rate was noticed throughout the flight. Correlation equations are as follows:

First Order Fit

System time = $A_0 + A_1$ (clock time)

where

$A_0 = -93019.53281 \quad A_1 = 0.9999996815$

Sigma = 0.00281

Second Order Fit

System time = $A_0 + A_1$ (clock time) + A_2 (clock time)^2

where

$A_0 = -93019.54308 \quad A_1 = 0.9999997127 \quad A_2 = 0.1881024688939$ D-13

Sigma = 0.00157

G. PRESSURE MAKE-UP SYSTEM PERFORMANCE

The Pressure Make-Up System did not function properly. The malfunction of the system was first noticed during Rev. 32 when pressure dropped 310 psi in 3.5 minutes of instrument operate time (90 psi/min.).

The observed abnormalities associated with the PMU system were:

1. Stabilized pressures of 56 microns, 69 microns, and greater than 100 microns were observed during some operates, even when the lower range (16 micron) control was supposed to be in effect. Refer to Figure 3-7.
2. Supply pressure dropped 160 psi and 575 psi on two (2) operates and 100 to 150 psi per operate on several other instrument operates. Refer to Figure 3-9.
3. Pressure buildup, on occasion, exceeded 100 microns (gage limit) within 2 seconds. Refer to Figure 3-8.
4. Internal pressure fluctuated during instrument operation. During one such operate the pressure went to 66 microns, decreased to 62 microns, then increased to 70 microns at the "OFF" command.

PAYLOAD INTERNAL PRESSURE PROFILE

MISSION 1104

REV. 210 ACQUISITION

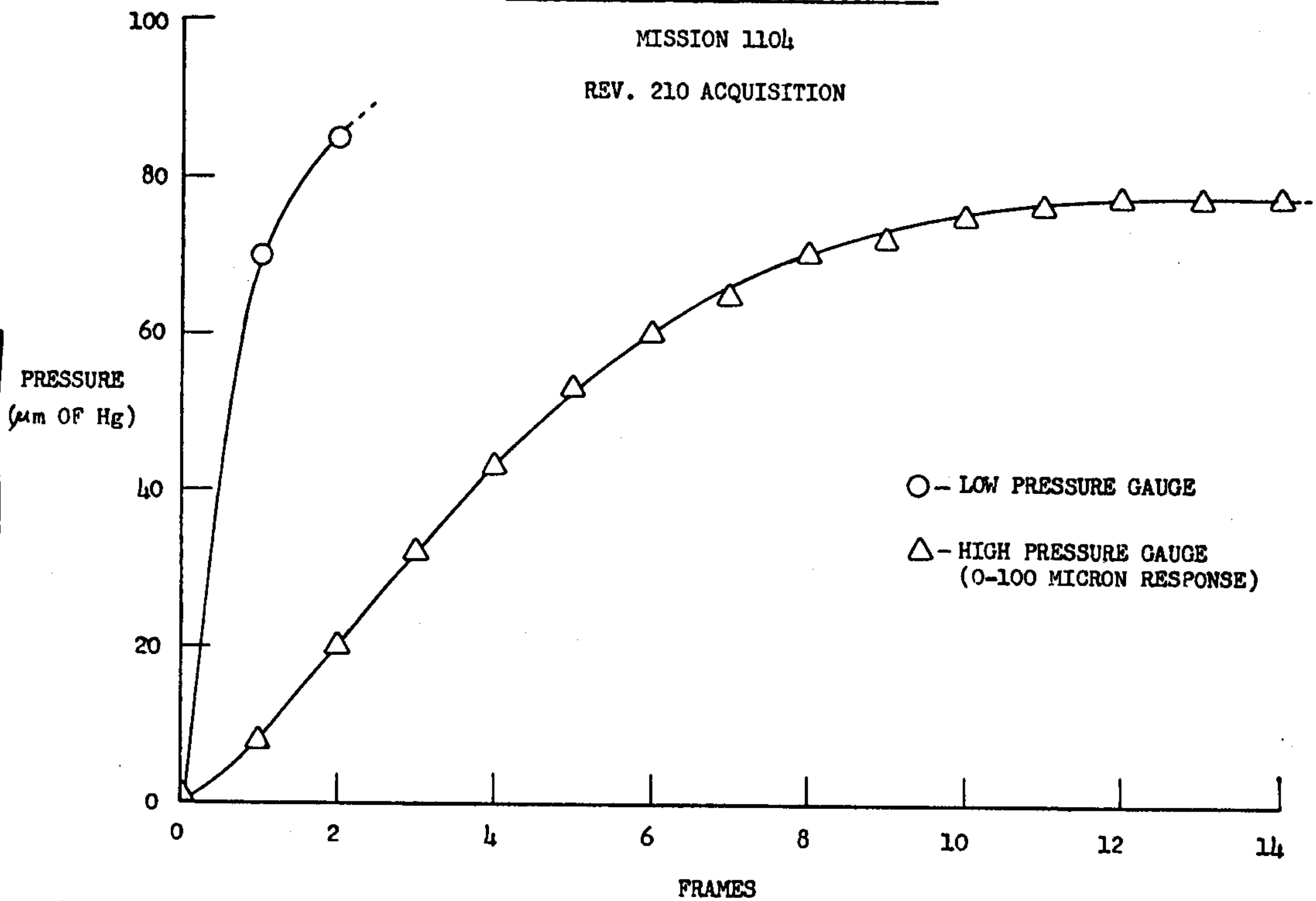


FIGURE 3-7

PAYLOAD INTERNAL PRESSURE PROFILE

MISSION 1104

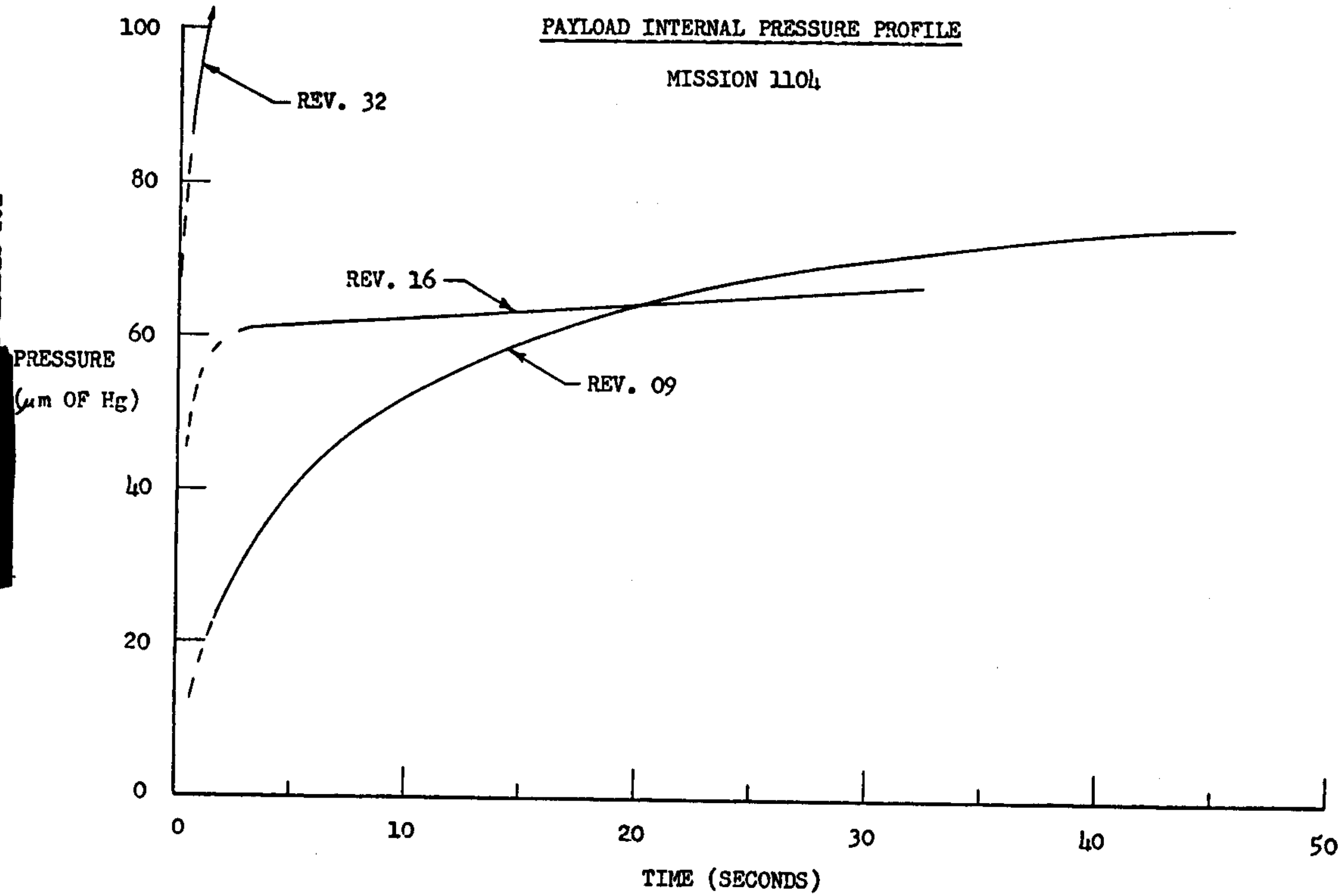


FIGURE 3-8

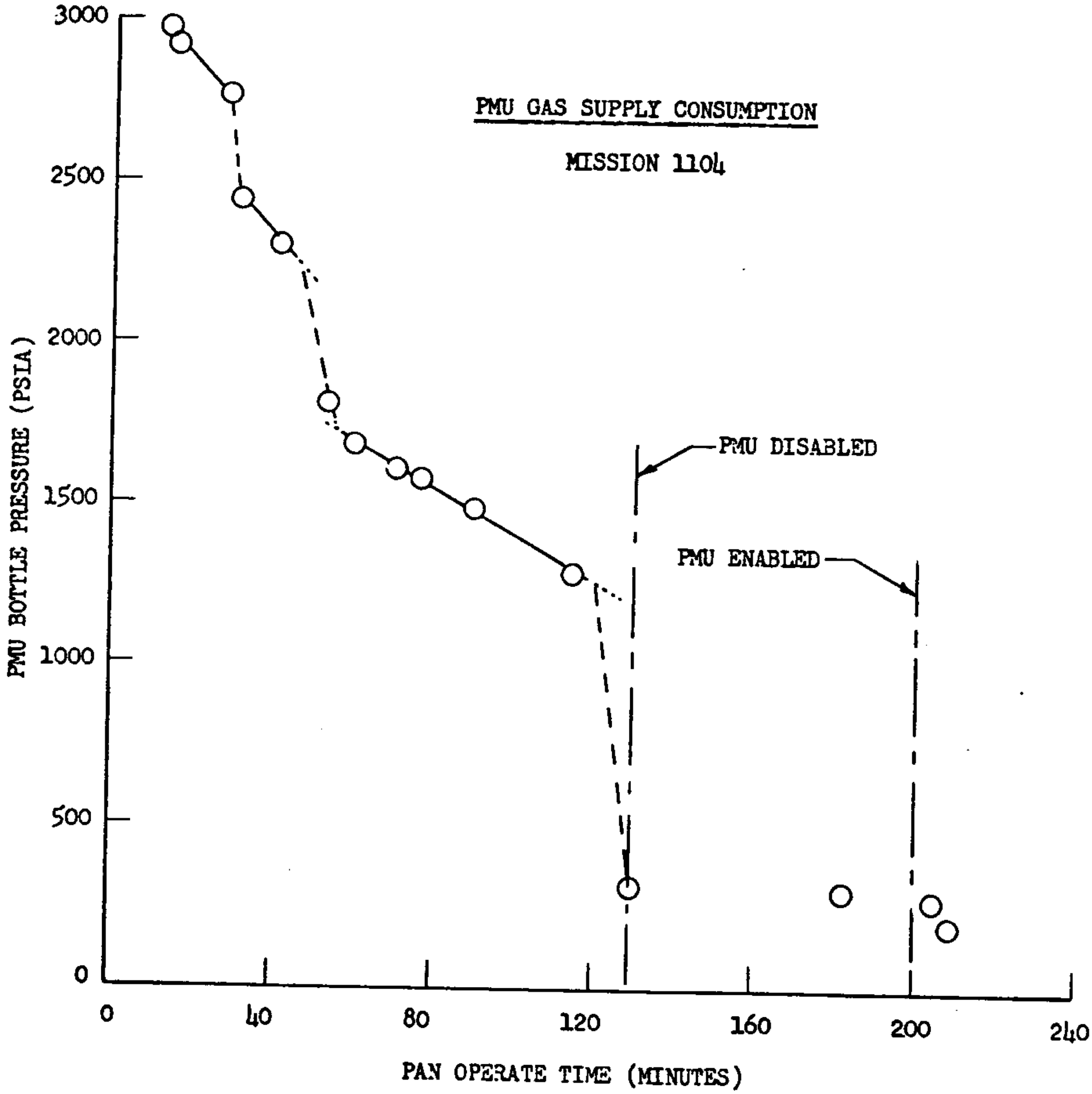

PMU GAS SUPPLY CONSUMPTION
MISSION 1104
PMU DISABLED
PMU ENABLED
PMU BOTTLE PRESSURE (PSIA)
3000
2500
2000
1500
1000
500
0
0
40
80
120
160
200
240
PAN OPERATE TIME (MINUTES)

FIGURE 3-9

The problem was attributed to a faulty high pressure regulator. The PMU was disabled during Rev. 124, after 130 minutes of operate time, with a pressure of 350 psi remaining. The system was re-enabled during Rev. 200 and remained on for the balance of the flight, with the exception of Rev. 211. The supply pressure remaining at the end of the mission was 200 psi. Refer to Figure 3-9. The system apparently did not perform as desired for the SO-180 film employed in Instrument 309 at the end of Mission 1104-2. This condition was evidenced by the predominance of corona discharge marking recorded on this special material.

H. THERMAL ENVIRONMENT

The camera system temperatures were within pre-flight predictions. DISIC temperatures fell slightly below predictions during the -2 mission. The No. 1 DISIC temperature sensor indicated 20-30 degrees higher than the No. 2 sensor. Because of the close physical proximity of the two sensors and vendor calibration data, it is believed the No. 1 sensor was damaged during installation and/or testing. Temperature versus Beta Angle shift is graphically presented in Figures 3-10 to 3-12.

Thermal data obtained from the Agena tape recorder were analyzed to provide an estimate of Panoramic camera rail temperatures during any camera operation. The temperature data presented in Figures 3-13 and 3-14 were obtained at five (5) minute intervals during selected revs and is plotted versus vehicle orbital position (quadrant-latitude). The rail temperatures for any camera operation can be interpolated from these figures.

The rail temperatures recorded during this flight were on the average slightly (2-5 degrees) higher than those observed during Mission 1103. The accuracy of any absolute temperature value is estimated at $\pm$ 5°F, and the accuracy of a temperature change on a sensor is estimated at $\pm 1\frac{1}{2}$°F.

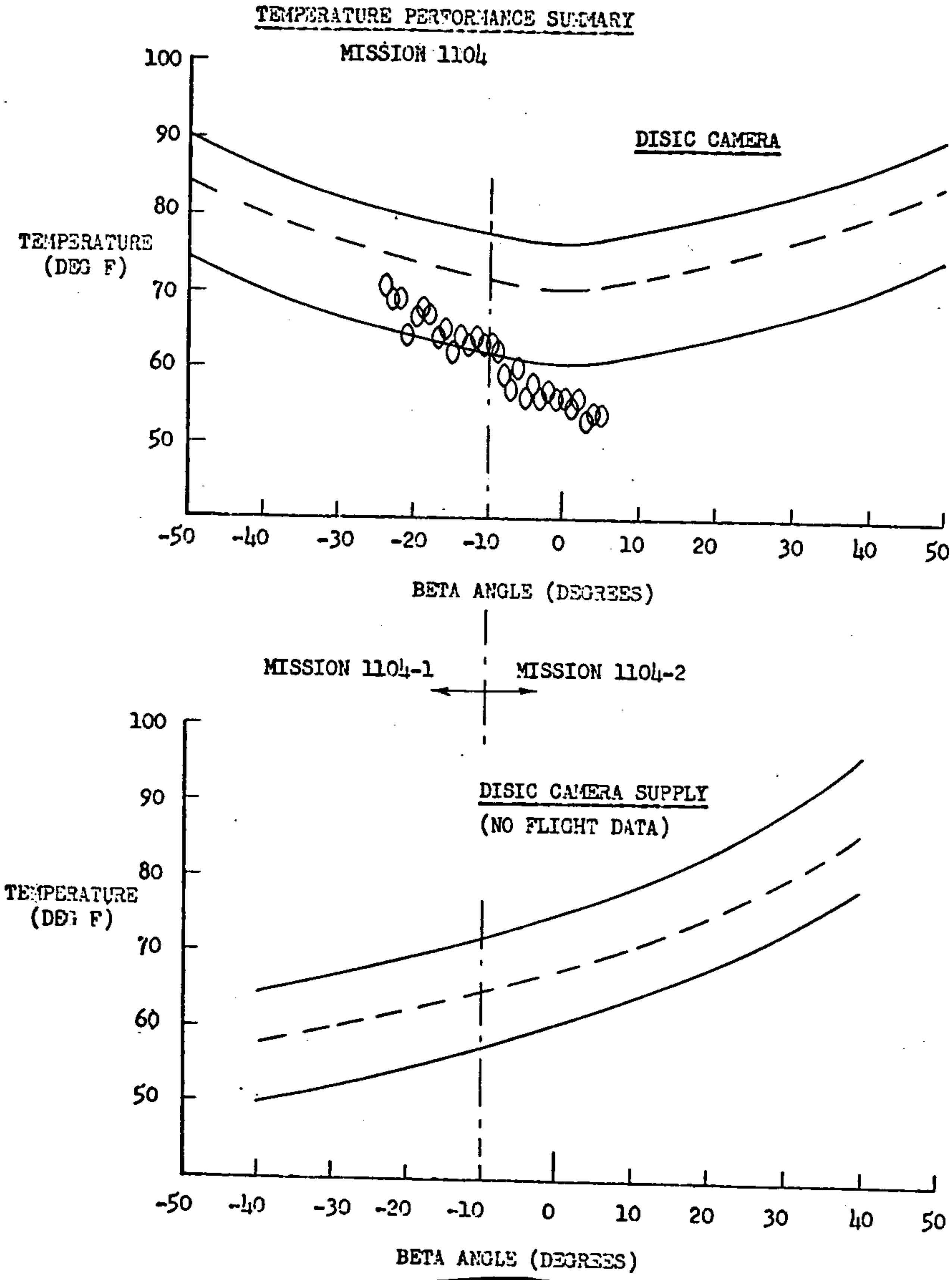

TEMPERATURE PERFORMANCE SUMMARY
MISSION 1104
DISIC CAMERA
TEMPERATURE (DEG F)
100
90
80
70
60
50
-50 -40 -30 -20 -10 0 10 20 30 40 50
BETA ANGLE (DEGREES)
MISSION 1104-1
MISSION 1104-2
DISIC CAMERA SUPPLY
(NO FLIGHT DATA)
TEMPERATURE (DEG F)
100
90
80
70
60
50
-50 -40 -30 -20 -10 0 10 20 30 40 50
BETA ANGLE (DEGREES)

FIGURE 3-10

TEMPERATURE PERFORMANCE SUMMARY

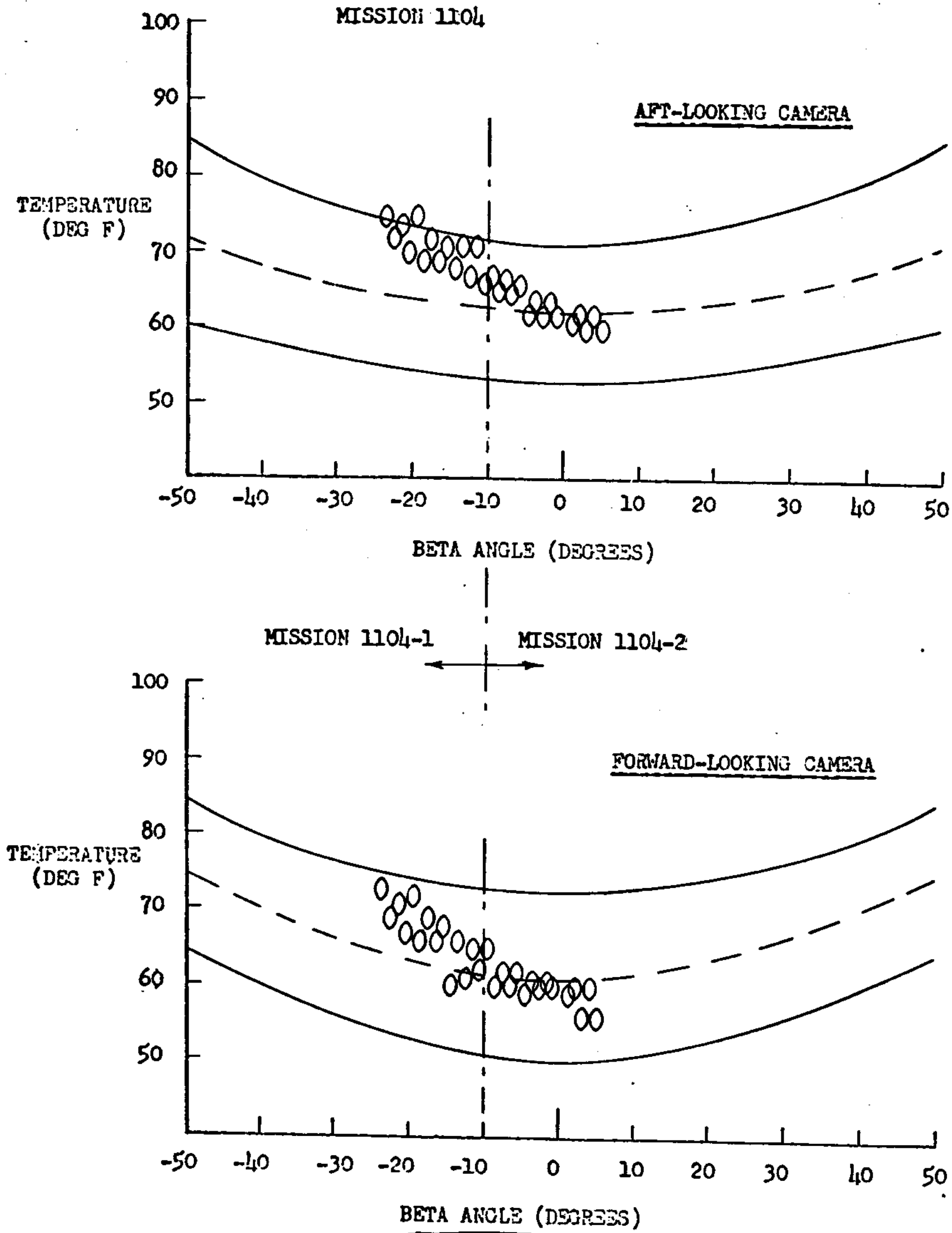


FIGURE 3-11

TEMPERATURE PERFORMANCE SUMMARY

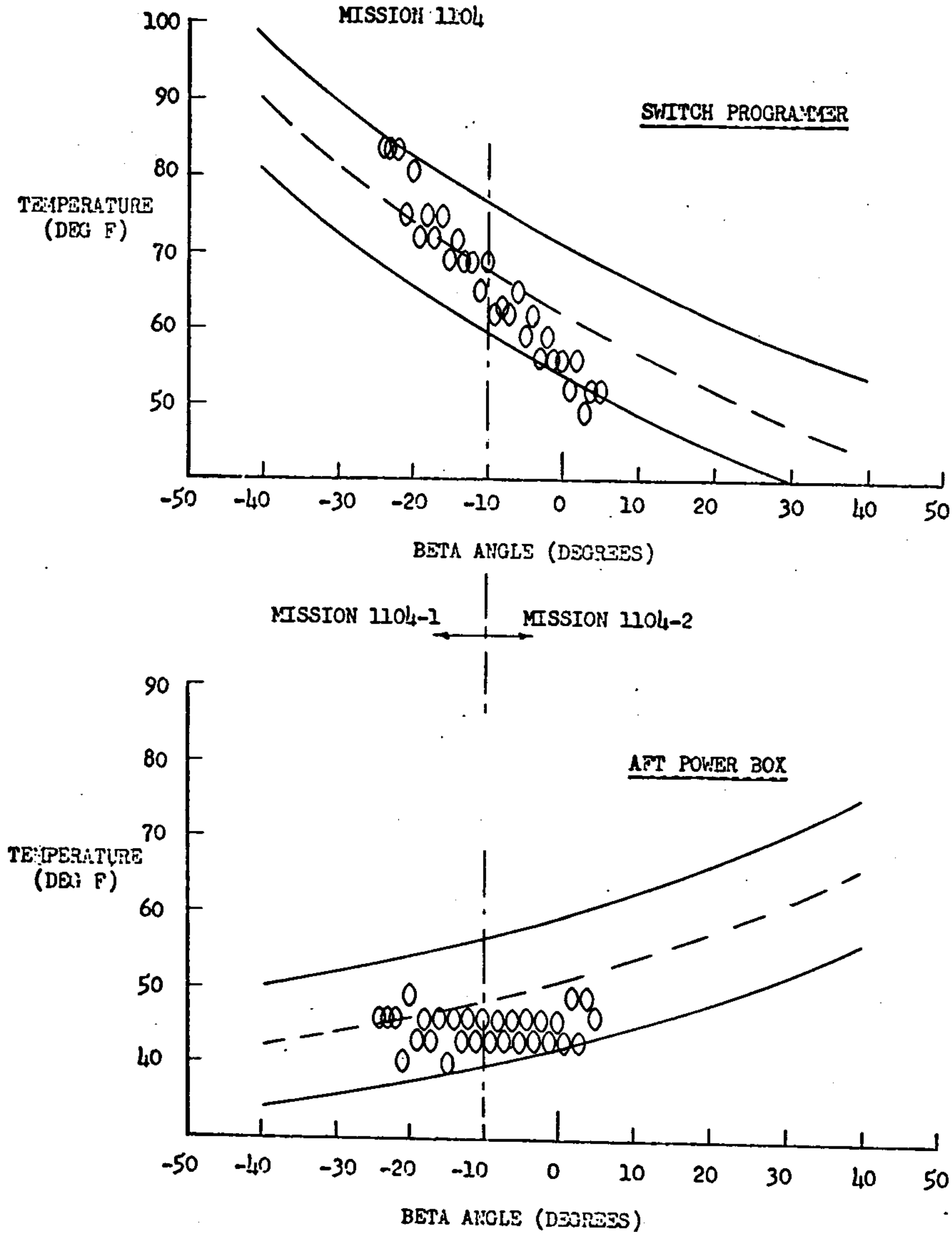


FIGURE 3-12

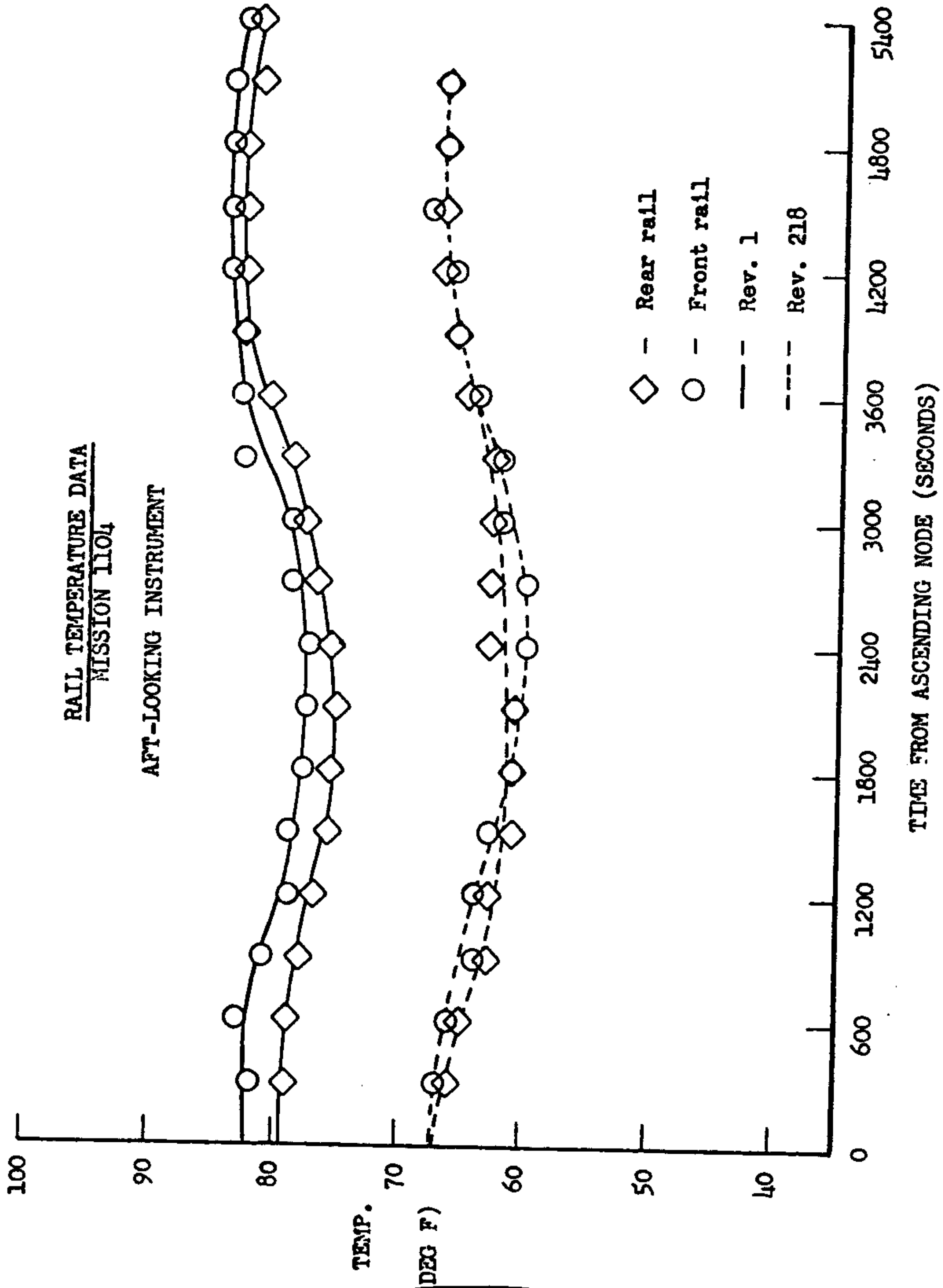

RAIL TEMPERATURE DATA
MISSION 1104
AFT-LOOKING INSTRUMENT
◇ - Rear rail
○ - Front rail
—— Rev. 1
- - - Rev. 218
TEMP.
(DEG F)
100
90
80
70
60
50
40
0
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (SECONDS)

FIGURE 3-13

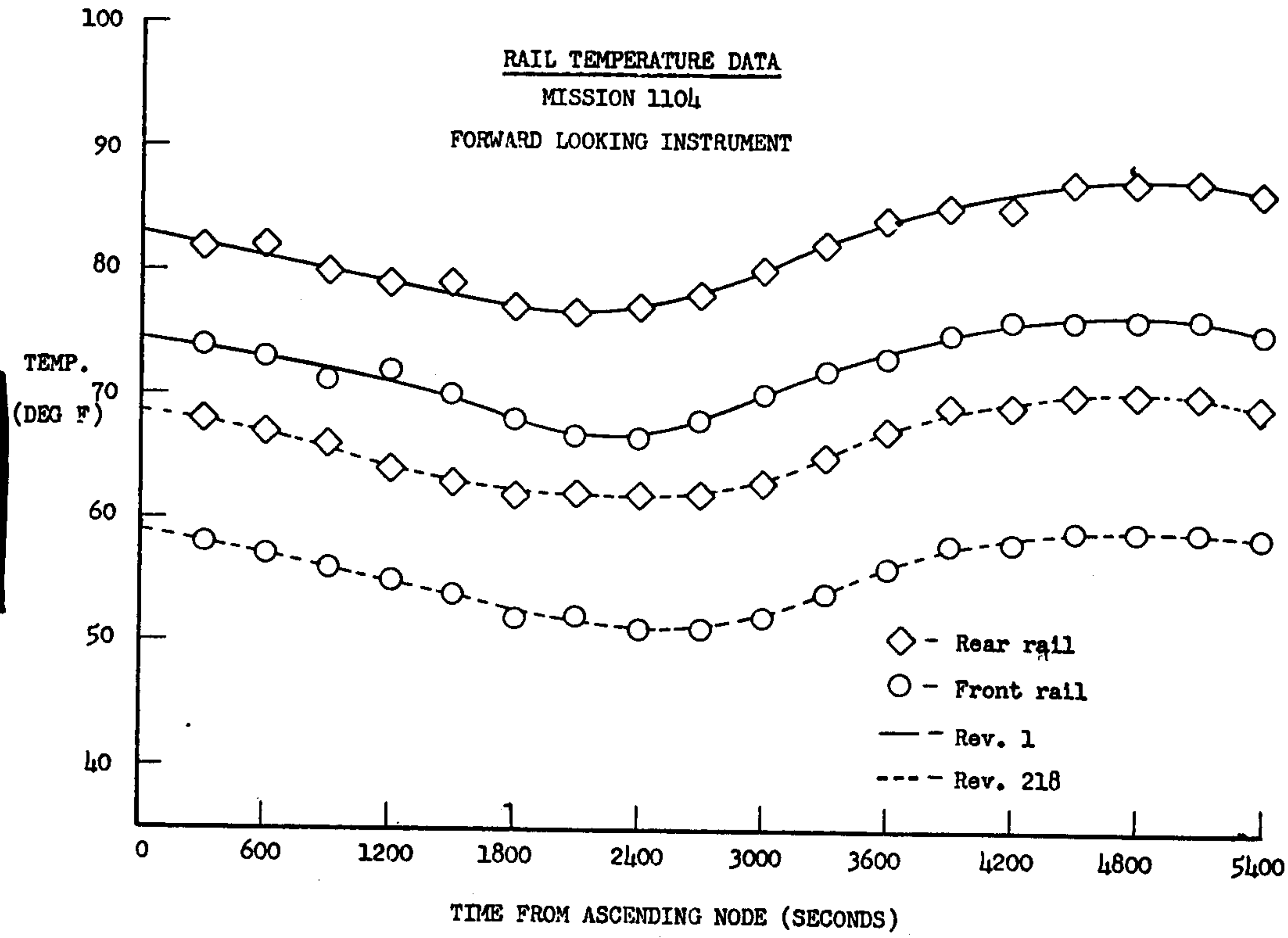

RAIL TEMPERATURE DATA
MISSION 1104
FORWARD LOOKING INSTRUMENT
TEMP.
(DEG F)
100
90
80
70
60
50
40
0
600
1200
1800
2400
3000
3600
4200
4800
5400
TIME FROM ASCENDING NODE (SECONDS)
◇ - Rear rail
○ - Front rail
— - Rev. 1
--- - Rev. 218

FIGURE 3-14

I. RECOVERY SYSTEM PERFORMANCE

The re-entry capsules were recovered by air-catch during Revs. 115 and 244. Rev. 115 occurred on 14 August and Rev. 244 on 22 August 1968. All re-entry events occurred as programmed and within tolerance. A sequence of events and event times are presented in Table VII. Predicted versus actual impact points are as follows:

	-1 Mission		-2 Mission	
Predicted Impact	25°32.7'N	162°23.2'W	18°28.1'N	156°37.2'W
Actual Impact	25°47'N	162°28'W	18°42'N	156°27'W

J. SRV TAPE RECORDER PERFORMANCE

The -1 SRV Tape Recorder System functioned satisfactorily throughout the -1 mission.

The -2 SRV Tape Recorder System failed to record after the first two operations of the -2 mission. The recorded data indicated proper tape recorder operation with normal start-up and shutdown. Post recovery testing failed to indicate the cause of the in-flight failure. However, it appears the tape recorder itself did not fail, but the failure occurred in either the peripheral power or control systems. The prime failure mode is a defective three (3) amp fuse located in the operate circuitry within the transfer box.

K. POST MISSION TEST RESULTS

There was no requirement for a post-mission test plan. The "H" Timer tape depleted during Rev. 245. The vehicle re-entered during Rev. 312 on the 27th of August 1968.

L. RADIATION DOSAGE

Each recovery system flown on a Corona mission contains a sealed packet of Eastman Type 3401 and Royal X Pan emulsions to determine the total radiation received at the take-up cassette. Both film types have been irradiated by LMSC at various levels and the base plus fog densities recorded after controlled processing.

Following recovery the film dosimeter packets are removed at A/P and processed with a pre-flight sample of the same film type and sensitometric control film. The resulting base plus fog density measurement of the dosimeter strips is used to ascertain the total radiation level. The table below presents the base plus fog readings for the dosimeter strips and the radiation level equivalents.

	Mission 1104-1		Mission 1104-2	
Emulsion	B + F Density	Radiation	B + F Density	Radiation
Type 3401	0.16	0.4 R	0.19	0.6 R
Royal X Pan	0.23	0.4 R	0.26	0.5 R

These levels are below that which will degrade the photography.

M. YAW PROGRAMMER

The vehicle Yaw Programming functioned properly throughout the mission. However, there is an unresolved, minor disparity between the yaw angles achieved and those required. Efforts are continuing in an attempt to isolate the source of this error and to perfect the yaw programming performance in subsequent missions.

SECTION 4

PHOTOGRAPHIC PERFORMANCE

The photographic imagery obtained during Missions 1104-1 and 1104-2 was considered to be the best of any Corona system to date. The overall image quality was judged to be generally very good where not degraded by atmospheric attenuation; however, there was a predominance of cloud cover over the highest priority targets.

A. PANORAMIC INSTRUMENTS

The Forward-Looking camera produced 2946 frames (7942 feet) of photography during Mission 1104-1, and 2969 frames (7815 feet) during Mission 1104-2. The Aft-Looking camera produced 2984 frames (7968 feet) during Mission 1104-1, and 3063 frames (8062 feet) during Mission 1104-2. The Forward-Looking camera used, for the first time, a third generation lens, and resulted in slightly better image quality than that obtained by the Aft-Looking camera. The mission was given an MIP rating of 115.

Several fixed and mobile resolution targets were recorded throughout Missions 1104-1 and 1104-2. The best system resolution performance was judged to be five feet for the Forward-Looking camera and approximately six feet for the Aft.

A malfunction of the starboard horizon camera shutter on the Forward-Looking camera caused it to remain open during the film metering cycle on one occasion during Mission 1104-1 and once during 1104-2. The result was heavy fogging in two frames for each occurrence of the anomaly. This is the normal mode of failure for this device, i.e., to fail open for one horizon camera shutter cycle (equal to two main instrument cycles) and thence to close on the next H.O. shutter command. No further action was undertaken.

Fog patterns were present on the seventh from last frame of the Forward-Looking camera and on the sixth from last frame on the Aft-Looking camera for most operations throughout the 1104-1 mission, attributed to a light leak in the vicinity of the 1104-1 recovery system cover. The patterns varied in density from light to very heavy, commensurate with camera sit periods, and in some instances obscured imagery. This leak was observed in pre-flight live film testing, but subsequent attempts to identify the source were unsuccessful (ref. Section 2). A second light leak became noticeable intermittently during Mission 1104-2, apparently emanating from an access cover fitting in the center of the main barrel structure.

On the take-up end of the first frame on both cameras, a small (one inch square, maximum) start-up corona mark was occasionally detected. In all cases the marking was very minor with no loss of imagery. An entirely new pattern, which on the O.N. looks like pencil marks that on occasion separate or fork, was observed on Pass D169 starting with Frame 24 and stopping prior to the last two frames. The marking did not degrade imagery. Further investigation at A/P demonstrated this phenomenon to be a result of the "air twists" in the camera film path and is very sensitive to film tension and system pressure. The ultra thin base materials are much more susceptible to this marking behavior.

B. DISIC CAMERA

The DISIC film recovered from the 1104-1 mission consisted of 625 feet of stellar photography (2118 starboard frames and 2113 port), and 947 feet of terrain (2122 frames). The 1104-2 mission contained 691 feet of stellar film (2581 starboard frames and 2588 port), and 1035 feet of terrain (2465 frames).

The stellar cameras functioned properly throughout the mission and recorded a full field of stars on both the port and starboard cameras. Most starboard frames have greater than 100 star images; most port frames contain more than 70 star images. Stars are recorded as point images. The terrain camera image quality is good and compares favorably with Mission 1103 terrain imagery.

In addition to common, minor anomalies such as skew-bead marks, dendritic edge static marks and dirt particles, there was a light leak apparently emanating from the "patio-pin" hole which created a fog pattern on the stellar record varying in density from light to very heavy, commensurate with camera sit periods. In some instances stellar imagery was obscured. A specific check-out of the "patio-pin" hole sealing has been added to written field test procedures to eliminate this source of degradation in future systems.

The terrain SLP data varied in density from normal to non-existent. Redundant data provided on the stellar record were machine readable throughout the mission. Since terrain data are redundant to stellar data, no stellar-terrain set is missing time data. This behavior resulted from intermittent and improper seating of the SLP head during exposure, most likely caused by a variation in SLP cable position. Improved SLP cable tie-downs and field check procedures are being investigated. The DISIC SLP data recording functioned properly throughout pre-flight testing.

C. ENGINEERING OBSERVATIONS

1. Bicolor: Mission 1104 acquired a very limited amount of bicolor photography (4 domestic passes, 1 denied area pass). The photointerpreters reported that, "the aft camera imagery, exposed through the SF-05 filter is poor". The image quality is poor because of the use of a poor quality filter and is not inherent in the bicolor process. Bicolor (SF-05)

photography has been acquired on Missions 1102, 1103 and 1104. Mission 1102, employing a high quality filter produced imagery which has been comparable with normal J-1 performance. With good SF-05 filters, this is the kind of performance that can be expected from the bicolor mode. The following points should be made relative to the SF-05 filter used on Mission 1104.

(a) This filter was flown because it was the only SF-05 available at the time. It was determined just prior to launch that the filter was poor. For this reason, only minimal bicolor was recommended, particularly over denied areas; only one operational bicolor pass (Rev. 7) was taken.

(b) Pre-flight tests had indicated that the SF-05 had a loss in resolution of approximately 30 percent as compared to previously used filters. This was the major problem with the filter on 1104.

(c) The spectral band pass of this filter was not as it should have been. In particular, the long wavelength cut-off was 590 millimicrons instead of 610 millimicrons. This has three effects. First, it caused the filter factor to be increased from 2.8 to 3.0. This itself is not a significant problem. Secondly, it caused a reduction in contrast by eliminating the 590-610 millimicron region. This also is only a minor contributor to quality degradation. Thirdly, and more important, the shift in the filter's band pass toward the shorter wavelengths caused an additional loss in resolution due to poorer lens performance in that spectral region.

Action has been taken to procure additional SF-05 filters. These filters will be extensively tested for optical quality and spectral transmission prior to inclusion in the system. In the future, only high quality SF-05 filters will be employed.

2. SO-180 Engineering Test: This mission contained 800 feet of type SO-180, Ektachrome infrared aero color film, on the end of the forward camera. This test was run as part of the J-3 system capability studies and had the prime purpose of investigating the capability of the Corona system to handle type SO-180 film. Portions of the SO-180 film exhibited excellent exposure, color balance and resolution compatible with the maximum that could be achieved with this film/camera combination. (The limiting performance factor was the recognized lower resolution capability of type SO-180 film compared to 3404.) When the weather conditions were favorable, and there were no degrading effects (i.e., static marking). It was estimated that the ground resolved distance of film type SO-180 was approximately 25 feet. It has been reported previously that significant portions of the test were degraded by electrostatic discharge which recorded as a red image on film type SO-180. There was a second anomaly that caused a heavy bluish/green cast on film type SO-180 over the entire format on the first few frames of each operation. The corona discharge degradations can be attributed directly to the failure of the pressure make-up unit (PMU) (ref. Section 3).

(a) Static Marking: Some of the imagery contains corona and electrostatic fog which appears red on film type SO-180. This condition varies from no marking to extremely severe marking. This condition occurs on those operations when the PMU provided system pressures other than the desired 10 to 20 x 10^{-3} Torr range.

Ordinarily red imagery on the material is the result of exposure to subjects that have a high near-infrared reflectivity. This is not necessarily the case with the red corona static marks. All three emulsion layers of SO-180 are also sensitive to blue light. The infrared sensitive layer is, however, of a higher sensitivity than the remaining two layers in the blue spectral region. Corona static is bluish/green in color and therefore fogs the IR layer before the other two and results in the red color. The photography is acquired through a yellow Wratten No. 15 filter which effectively eliminates this sensitivity in the normal exposure mode. The film itself though, has no protection from the blue light created within the camera system, which causes the red fogging.

(b) Effect of Sit Time: As discussed earlier, the first three and one-half frames of each operation had a noticeable bluish/green cast to the imagery. This effect was directly relatable to the sit time between camera operations. During very long sit periods, the blue/green cast became heavy and during short sit periods it is not as severe. The blue/green cast was due to a loss in infrared layer sensitivity during these sit periods. It is likely that the loss of moisture, from the IR layer during the sit period, caused a loss in photographic speed. Further analysis of this phenomenon is being pursued.

3. Third Generation Lenses: The performance summary reported that the forward looking camera imagery was superior to that of the aft looking and that this is directly attributable to the use of a third generation

Petzval lens in the forward unit. The third generation lens was designed specifically to be used with the Wratten 25 (Vice Wratten 21) filter. This provides an improvement in performance for the third generation lens of approximately 20 percent (2:1 low contrast resolution under dynamic conditions) over the second generation lenses. In the future all CR systems will have a third generation lens in the forward camera, with Units CR-10, 13 and up having third generation lenses in both cameras. It should be noted that the improved design of the third generation lens also provides improved performance (compared with second generation lenses) with the Wratten 21 filter.

4. Dual Gamma Processing: The type 3404 film in both 1104-1 and 1104-2 was processed using the dual gamma process. This was the first mission where the entire black and white film load of the main camera was processed with this technique. It is felt that the advantages of this process contributed to the general good quality of the photographic imagery.

5. Cross-Track Smear: The level of performance of the forward looking lens (third generation) was sufficiently high to occasionally enable detection of cross-track smear in the imagery. The most obvious instance being the CORN display on Pass D16 where ground resolution was five feet along track and eight feet across track. In many operations the aft camera performance was also sufficient to identify cross-track smear contributions. In such instances, it was observed that the cross-track smear recorded in the aft photography was less than that in the forward. This relationship is directly related to the shorter exposure time of the aft camera. This is a graphic example of the desirability to reduce cross-track smear by reductions in exposure time through use of more

sensitive films. The theoretical smear contributions presented in Section 8 correlate directly with these observations.

It should also be pointed out that the yaw angle error experienced in this mission (ref. Section 7) provided a contribution to the observed smear. This cause of image smear contribution will be eliminated as the ideal yaw performance is achieved.

D. PERFORMANCE MEASUREMENTS

A summary of MTF/AIM resolution values measured by SPPF is tabulated below. The microdensitometer slit used was 1 micron by 80 microns.

Mission	Camera	Cycles/mm	Avg	Ground Resolution
1104-1	Fwd	118	114	7½'
1104-2	Fwd	109		
1104-1	Aft	88	96	9'
1104-2	Aft	103		

The details of the measurement and computing techniques, targets measured and target locations are fully reported in the evaluation report published by AFSPPF and are not included in this report. These values were determined by using the "Interim MTF/AIM Program" technique.

SECTION 5

PANORAMIC CAMERA EXPOSURE

The forward-looking camera contained a Wratten 25 filter for use with 3404 film, plus a special Wratten 15 filter, modified in density for proper exposure with SO-180 film. The corresponding exposure control system provided slit widths of 0.199-, 0.232-, and 0.298-inch. The aft-looking camera utilized a Wratten 21 filter in the primary position, and an SF-05 filter as an alternate for the purpose of bispectral photography. The aft camera exposure control slits were 0.151-, 0.163-, 0.205-, and 0.256-inch.

The nominal exposure times of the Panoramic cameras are shown as a function of latitude for passes D-40, D-120, and D-200 in Figures 5-1 to 5-6. Superimposed on these plots are relative distributions of camera operations for the portion of the mission represented by each plot.

Because of combined tolerances in the slit control mechanism and in the manufacture of the cam, the actual slits achieved represented noticeable deviations from the desired profiles. The significance of these deviations is apparent from the exposure curves. Instrument 309 experienced an exposure history very close to the desired nominal, whereas Instrument 308 created a relative slight overexposure. The density data presented in Section 6 verifies that this, indeed, was the performance achieved. It should be pointed out that the desired exposure profile, based on Project Sunny recommendations, was to maintain average exposure levels approximately 1/4 to 1/3 stop less than that indicated for the nominal diffuse density based criteria. This latter criteria is the curve shown in Figures 5-1 to 5-6.

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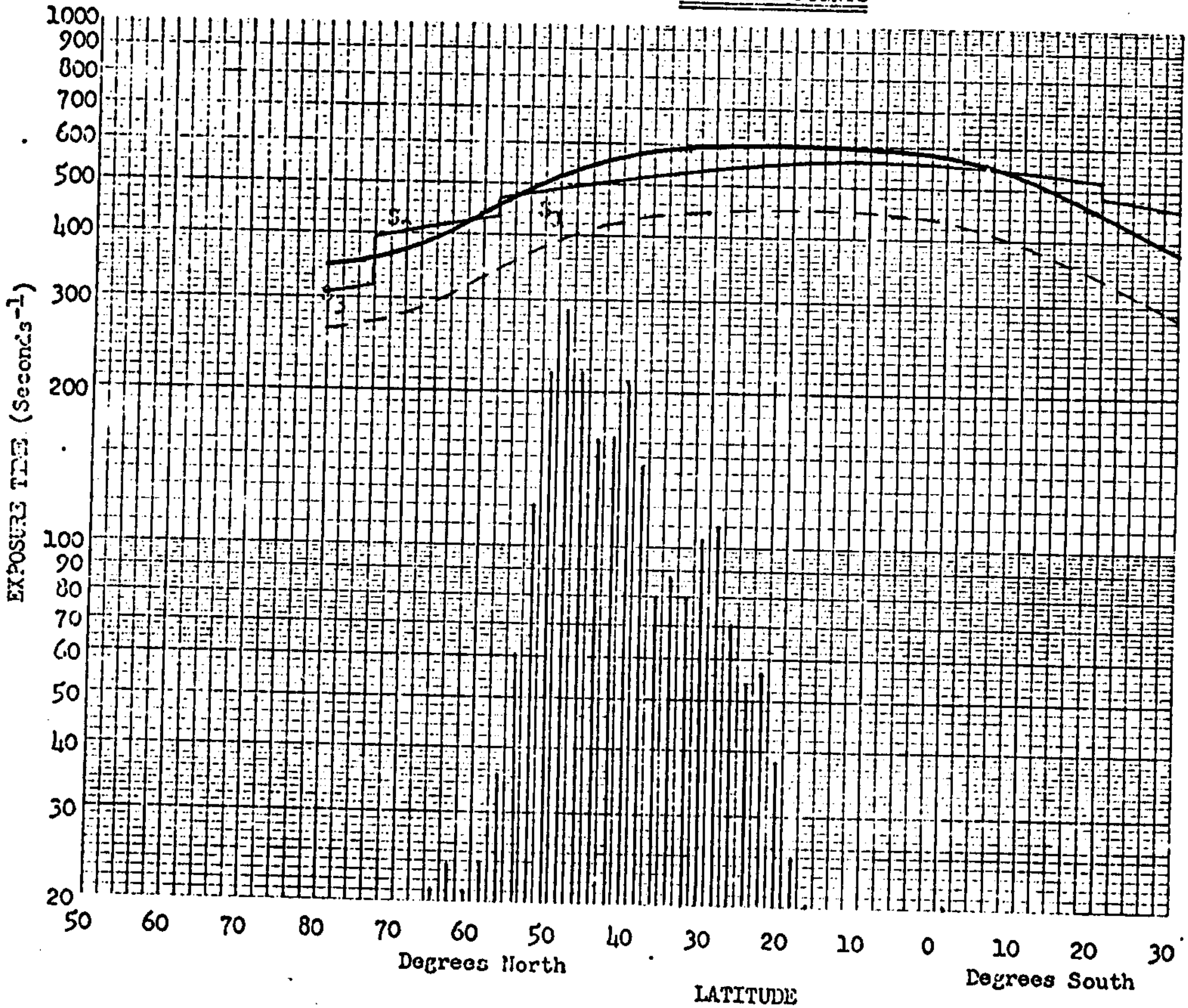
EXPOSURE POINTS



Mission No: 1104

Payload No: CR-4

Camera No: 308

Pass No: 40

Launch Date: 8-7-68

Launch Time: 2137Z

Slit Width: 0.151/.163/.20

Filter Type: W/21, SF05(D

Film Type: 3404

FIGURE 5-1

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EXPOSURE POINTS

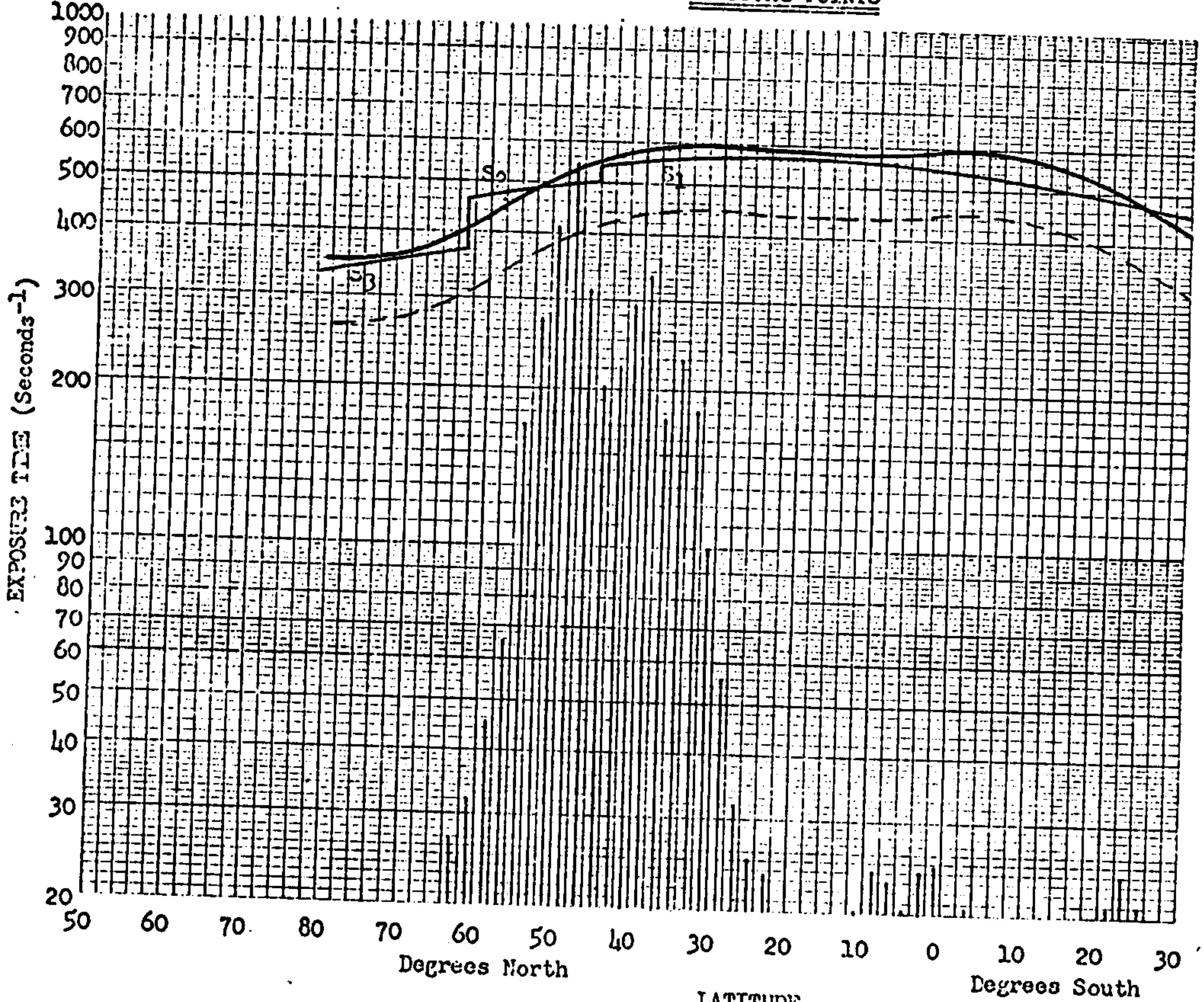


FIGURE 5-2

Mission No: 1104

Payload No: CR-4

Camera No: 308

Pass No: 120

Launch Date: 8-7-68

Launch Time: 2137 Z

Slit Width: .151/.163/.205/

Filter Type: W/21, SF05(Das 1

Film Type: 3404

[redacted]

C [redacted]

[redacted] POINTS

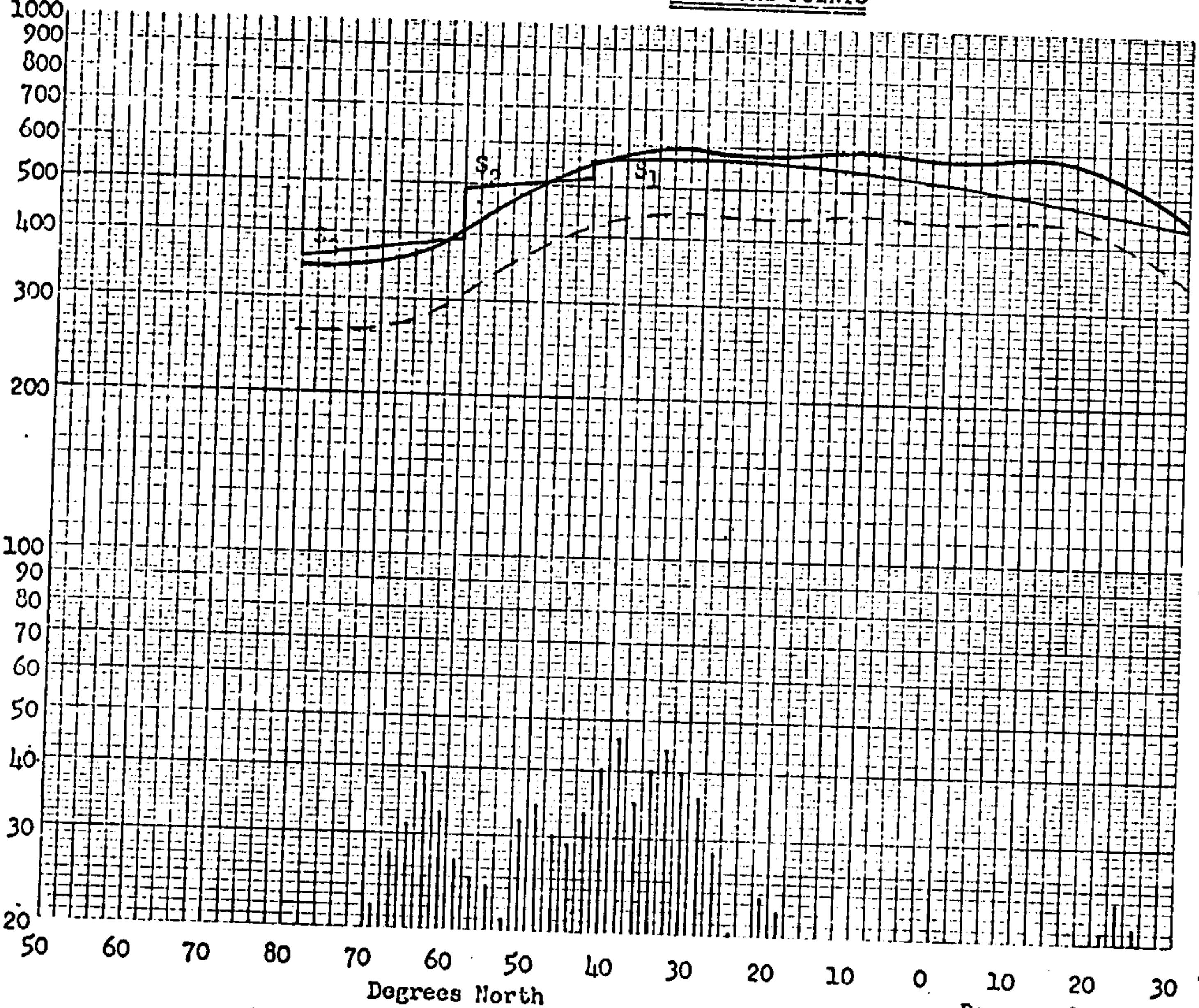


FIGURE 5-3

Mission No: 1104

Payload No: CR-4

Camera No: 308

Pass No: 200

Launch Date: 8-7-68

Launch Time: 2137 Z

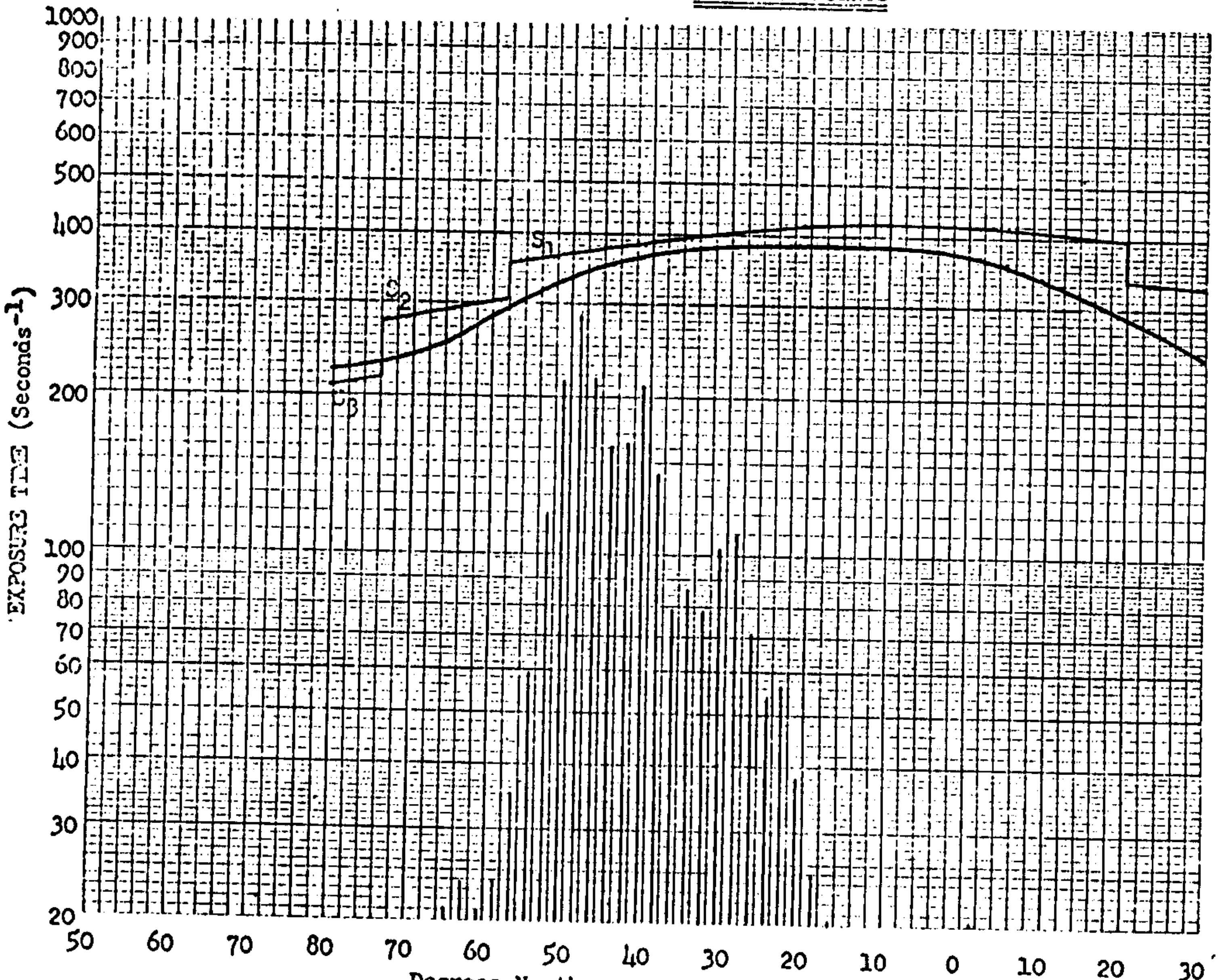
Slit Width: .151/.163/.205

Filter Type: W/21, SF05(Da

Film Type: 3404

[redacted]

EXPOSURE POINTS



Mission No: 1104

Payload No: CR-4

Camera No: 309

Pass No: 40

Launch Date: 8-7-68

Launch Time: 2137 Z

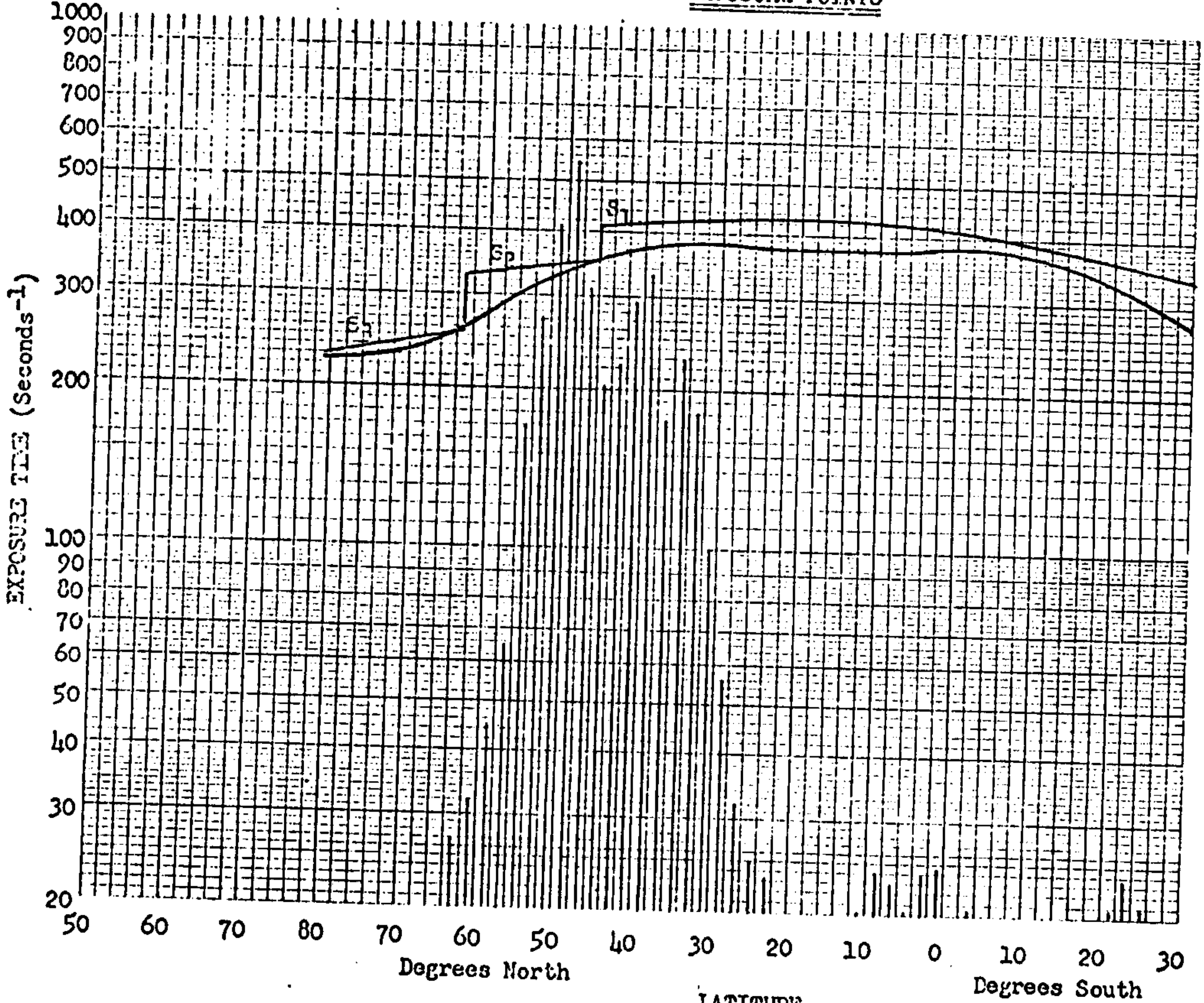
Slit Width: .199/.232/.298/

Filter Type: W/25

Film Type: 3404

FIGURE 5-4

EXPOSURE POINTS



Mission No: 1104

Payload No: CR-4

Camera No: 309

Pass No: 120

Launch Date: 8-7-68

Launch Time: 2137 Z

Slit Width: .199/.232/.298

Filter Type: W/25

Film Type: 3404

FIGURE 5-5

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C[redacted]

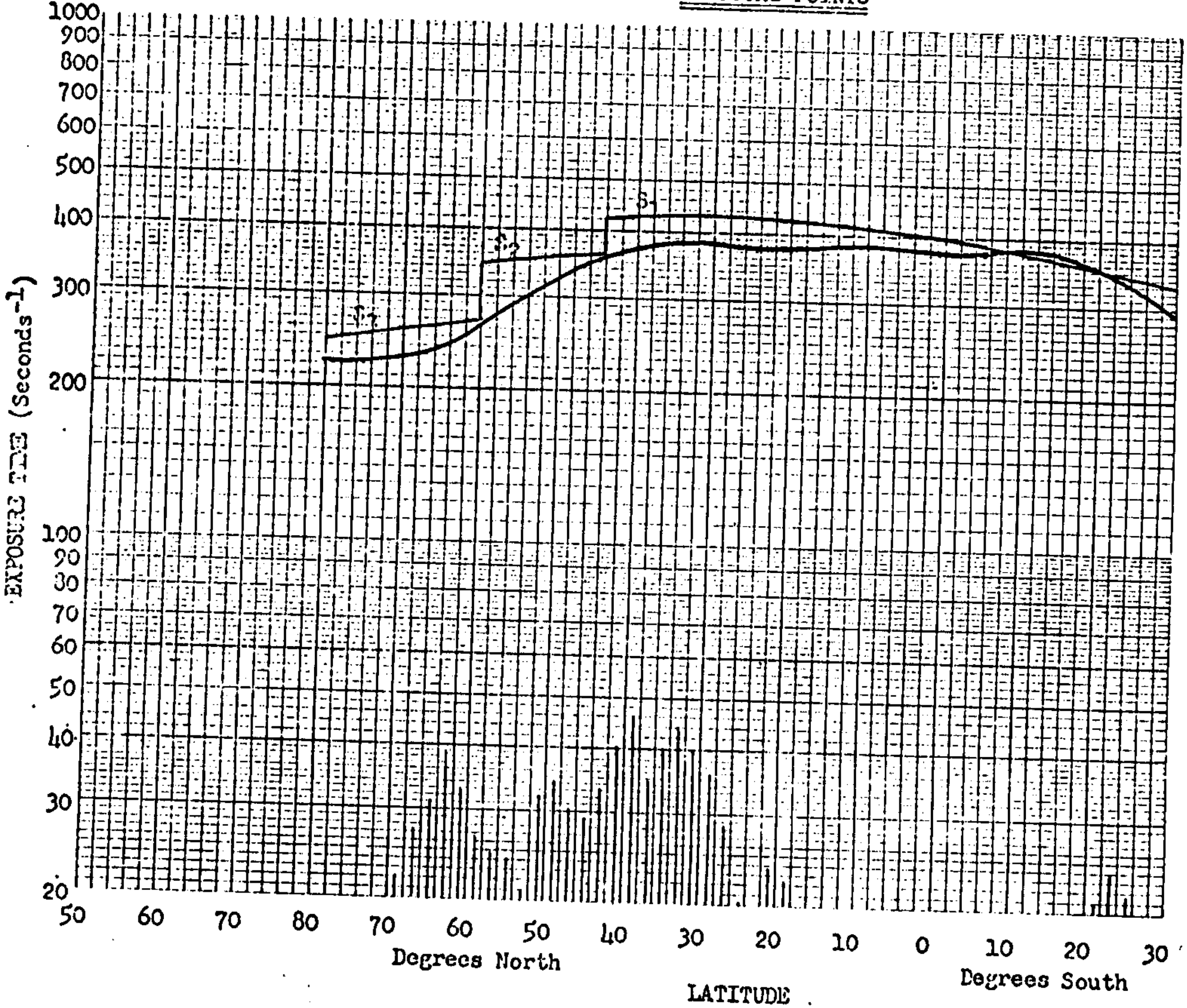

FIGURE 5-6

Mission No: 1104

Payload No: CR-4

Camera No: 309

Pass No: 200

Launch Date: 8-7-68

Launch Time: 2137 Z

Slit Width: .199/.232/.298/

Filter Type: W/25, W/15+0.9

Film Type: 3404, SO-180

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SECTION 6

DENSITY MEASUREMENTS

Mission 1104 was the first flight in which the viscous, single level, dual gamma processing was employed on an operational basis. Coincident with this, the processing agency discontinued reporting of terrain diffuse densities, and instituted a procedure for systematic reporting of select target microdensitometer readings. The AFSPPF will continue to compile terrain diffuse density measurements, which will be summarized in these final reports.

The differences between the previously used full processing characteristics and the new dual gamma process is graphically depicted in Figure 6-1. The lowered levels of D_{max} values for terrain and cloud densities resulting from these differences is evident from the frequency distributions presented in Figures 6-3 through 6-14.

As illustrated in Section 5, the actual exposure achieved was very close to the nominal desired criteria used for Mission 1104. A sample of fourteen microdensitometer measurements of specific targets indicated that the exposure performance was well controlled at proper levels. The target density analysis may be summarized as follows:

Forward-Looking Camera	Target D_{min}	Target D_{max}	Target* D_{nom}	Recommended* ΔE_v
1	0.32	1.26	0.83	0
2	0.44	1.23	0.87	0
3	0.76	1.65	1.03	-1/3
4	0.55	1.46	0.83	0
5	0.30	1.65	0.72	0
6	0.30	1.73	0.74	0
7	0.44	1.42	0.82	0

Aft-Looking Camera	Target D_{min}	Target D_{max}	Target* D_{nom}	Recommended* ΔE_v
1	0.46	1.46	1.17	-2/3
2	0.70	1.26	1.18	-2/3
3	0.92	1.69	1.25	-1
4	0.57	1.45	0.81	0
5	0.40	1.69	0.65	0
6	0.37	1.57	0.67	0
7	0.68	1.49	0.99	-1/3

* The "nominal" target densities and exposure recommendations are subjective values provided by the processing agency, and do not necessarily represent the consensus of the community.

The tendency for the aft-looking camera to be over-exposed is readily apparent from examination of the exposure profiles in Section 5. The shortcomings imposed by the mechanical tolerances experienced in the manufacture and operation of the slit control mechanisms significantly contributed to the observed deviations. Additional lead time has been incorporated into the ordering of flight exposure control cams so as to better assure performance in keeping with the design criteria.

The terrain density measurements summarized in Table 6-1 and in Figures 6-3 through 6-14 also illustrate the expected results of the exposure profile differences, as well as providing an example of the disparity between terrain-density based criteria and Project Sunny type performance results.

The curves illustrated in Figure 6-2 describe an apparent disparity in the dual-gamma process which has yet to be resolved. Comparison of these curves with those in Figure 6-1 indicates that the mission material indeed exhibited sensitometric properties very close to the control standard; however, the R-2 samples show significant deviations, with the fog level being much closer to the conventional full process than the higher dual-gamma standard. It is anticipated that these undesirable performance and control characteristics will be corrected as the operational application of this new process is further developed.

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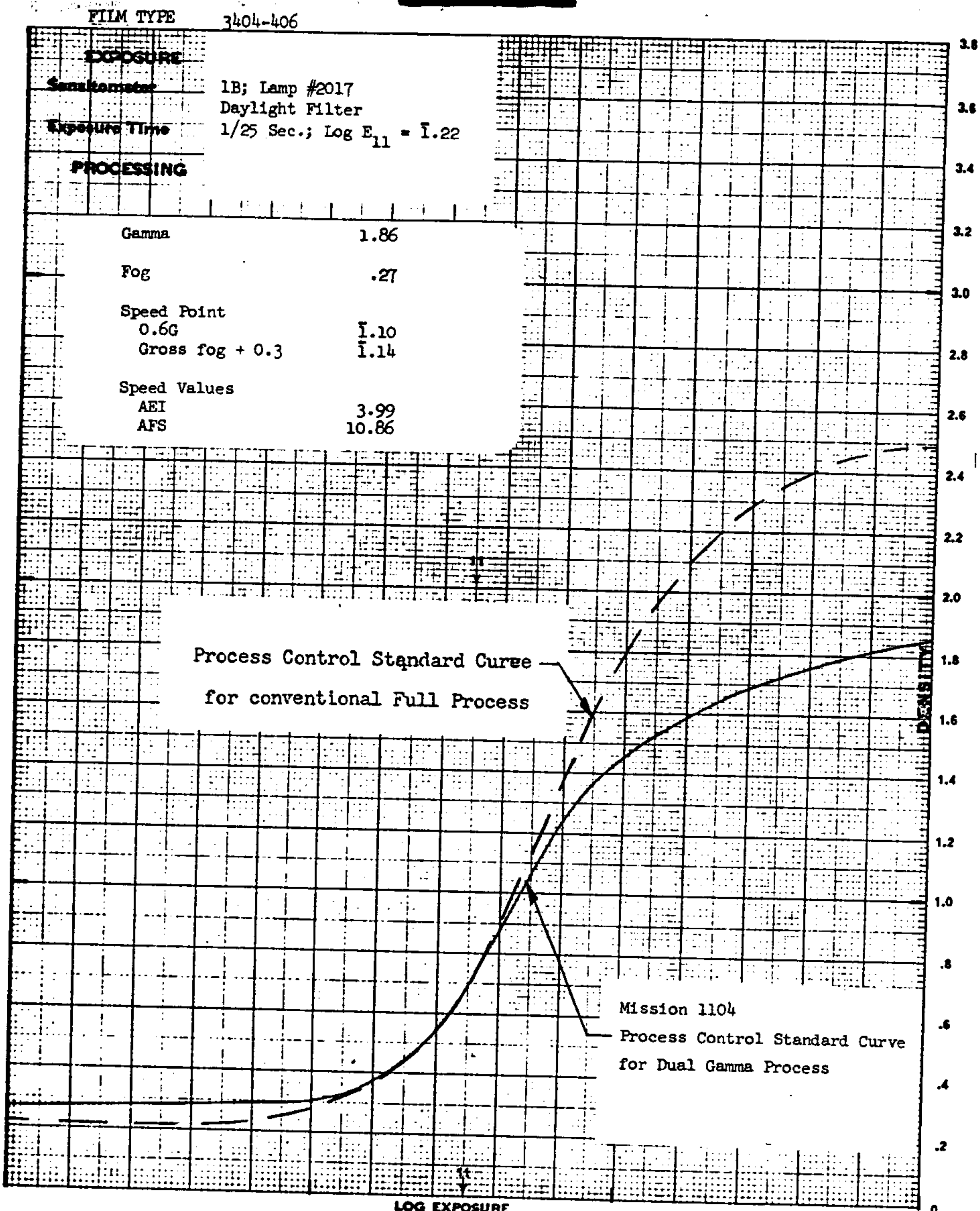
TOP SECRET

[redacted]



[redacted]

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FIGURE 6-1

[redacted]

TOP SECRET

[redacted]

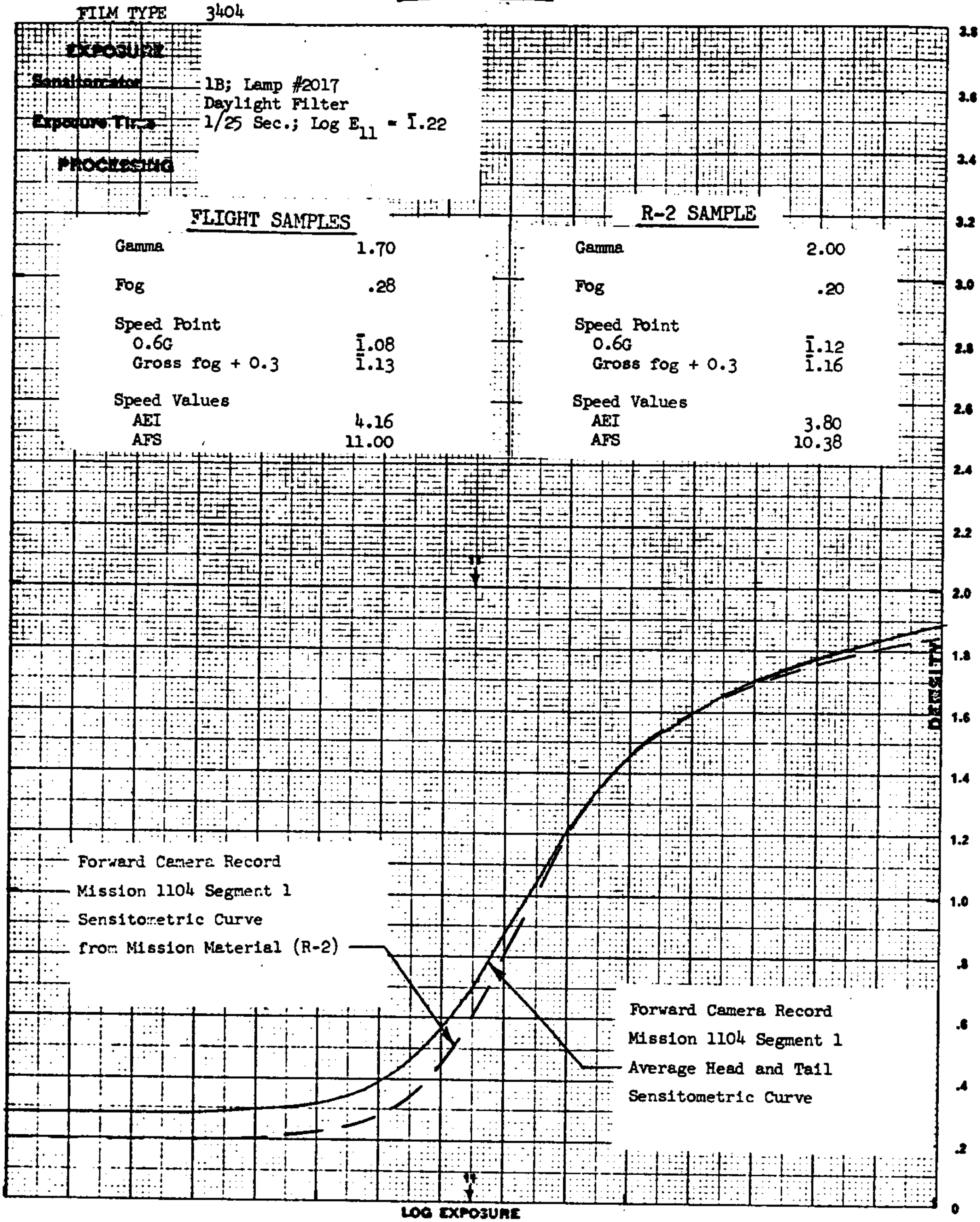

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FIGURE 6-2

TABLE 6-1

TERRAIN DENSITY ANALYSIS OF EXPOSURE

Instrument		Sample Size	Percent Underexposed ($D_{min} < 0.4$)	Correct Exposure	Percent Overexposed ($D_{min} > 0.9$)
1104-1	Fwd	281	53	40	7
1104-1	Aft	305	15	73	12
1104-2	Fwd	247	48	47	5
1104-2	Aft	291	20	73	7

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MISSION * 1104-1 * INSTR * FWD * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.47 * MEDIAN * 0.38 * STD DEV * 0.23 * RANGE * 0.23 TO 1.25 WITH 281 SAMPLES

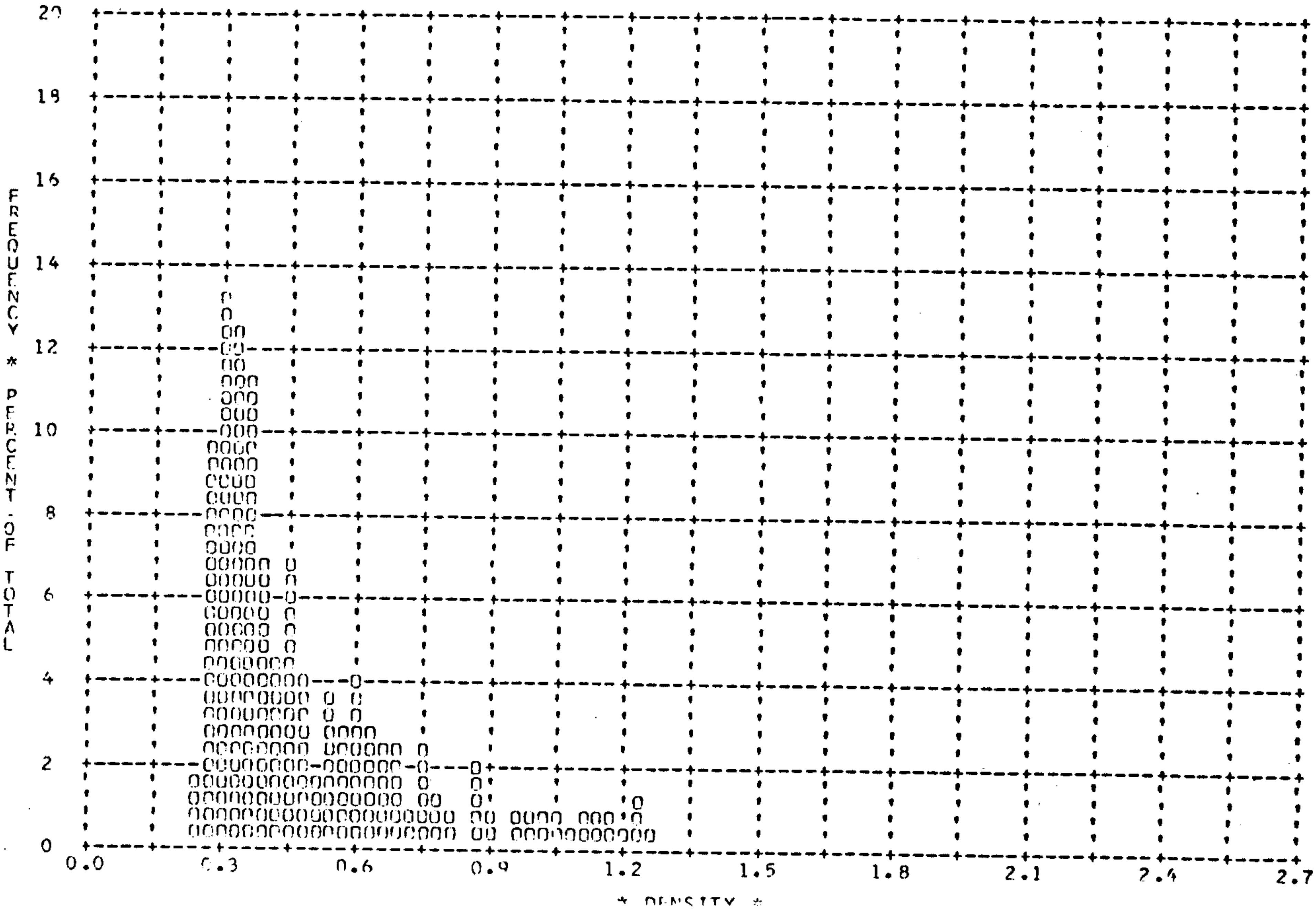

FIGURE 6-3

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MISSION * 1104-1 * INSTR * FWD * PLOT OF D MAX * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 1.08 * MEDIAN * 1.12 * STD DEV * 0.29 * RANGE * 0.34 TO 1.60 WITH 282 SAMPLES

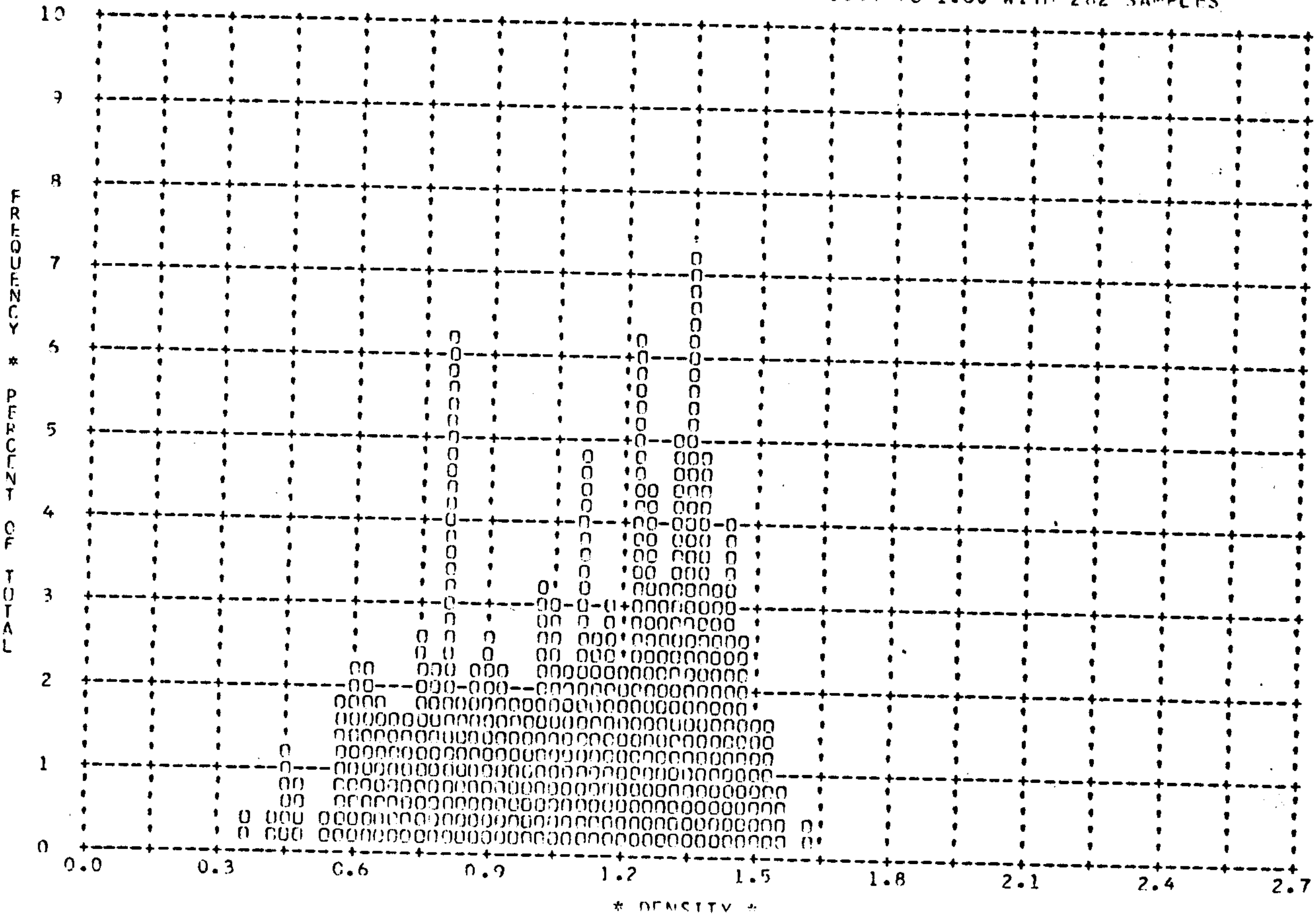

FIGURE 6-4

~~TOP SECRET~~ C[redacted]

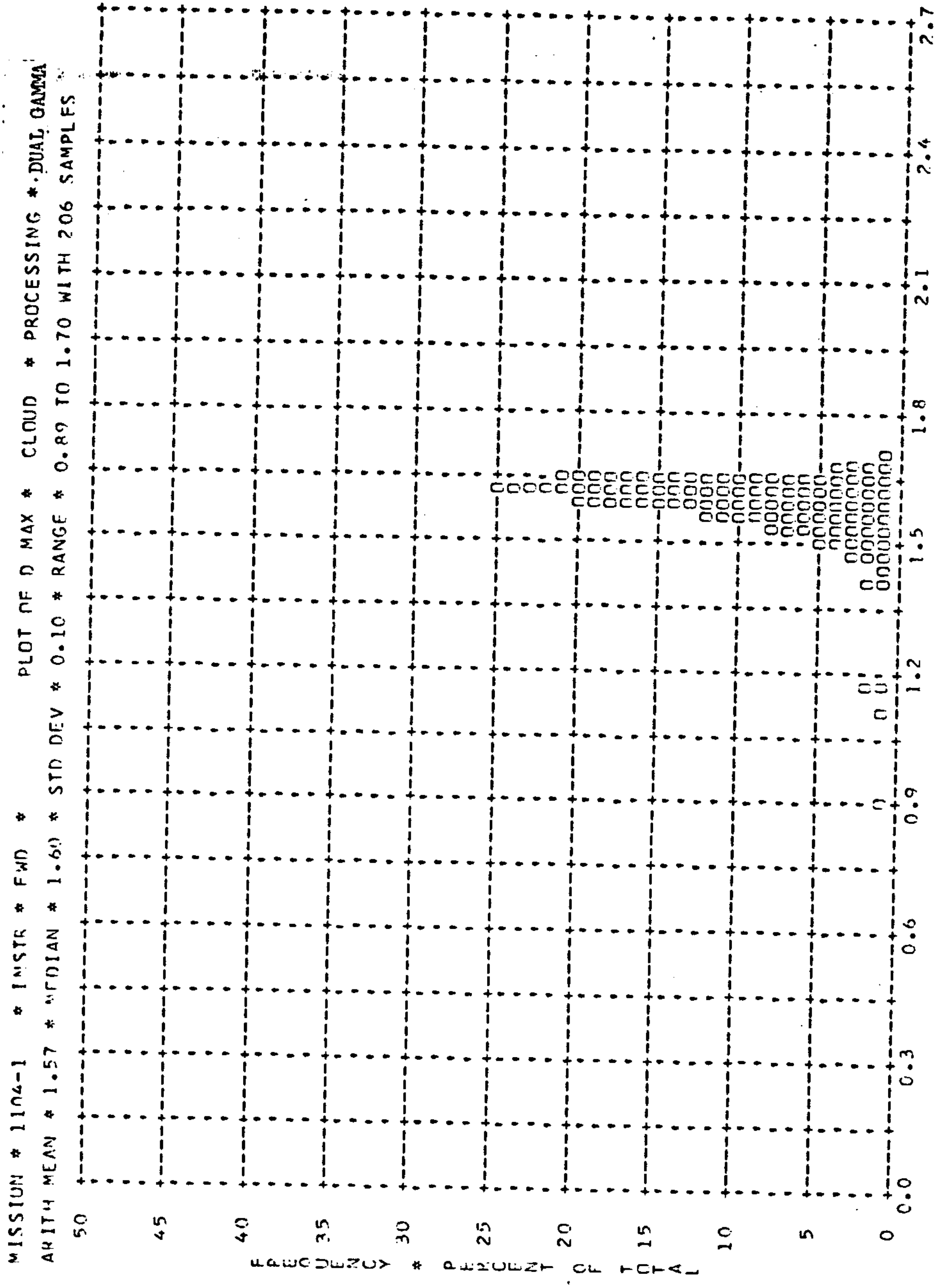

FIGURE 6-5

MISSION * 1104-1 * INSTR * AFT * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.61 * MEDIAN * 0.53 * STD DEV * 0.23 * RANGE * 0.28 TO 1.36 WITH 305 SAMPLES

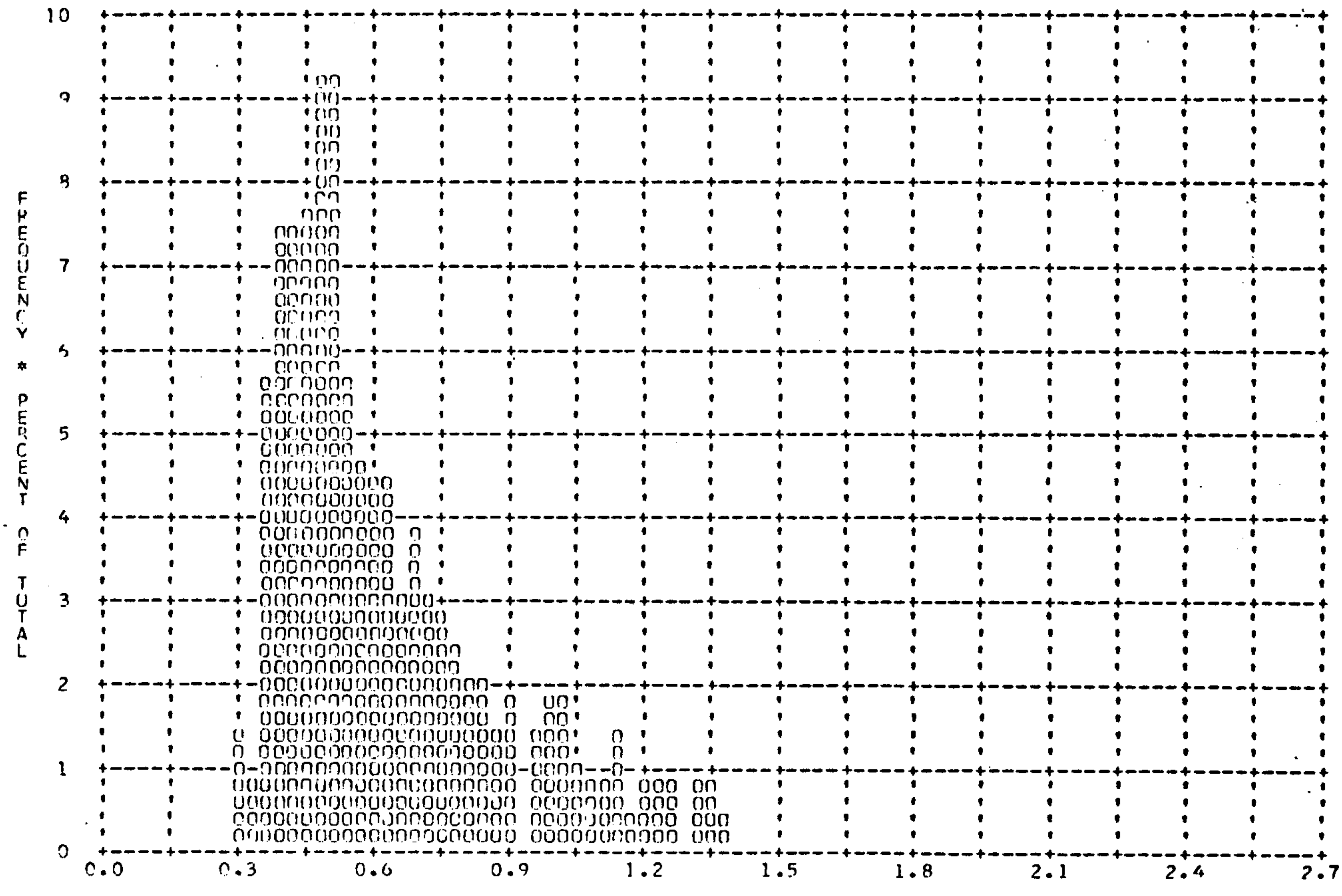

FIGURE 6-6

~~TOP SECRET~~ C [redacted]

MISSION * 1104-1 * INSTR * AFT * PLOT OF D MAX * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 1.13 * MEDIAN * 1.13 * STD DEV * 0.25 * RANGE * 0.49 TO 1.67 WITH 305 SAMPLES

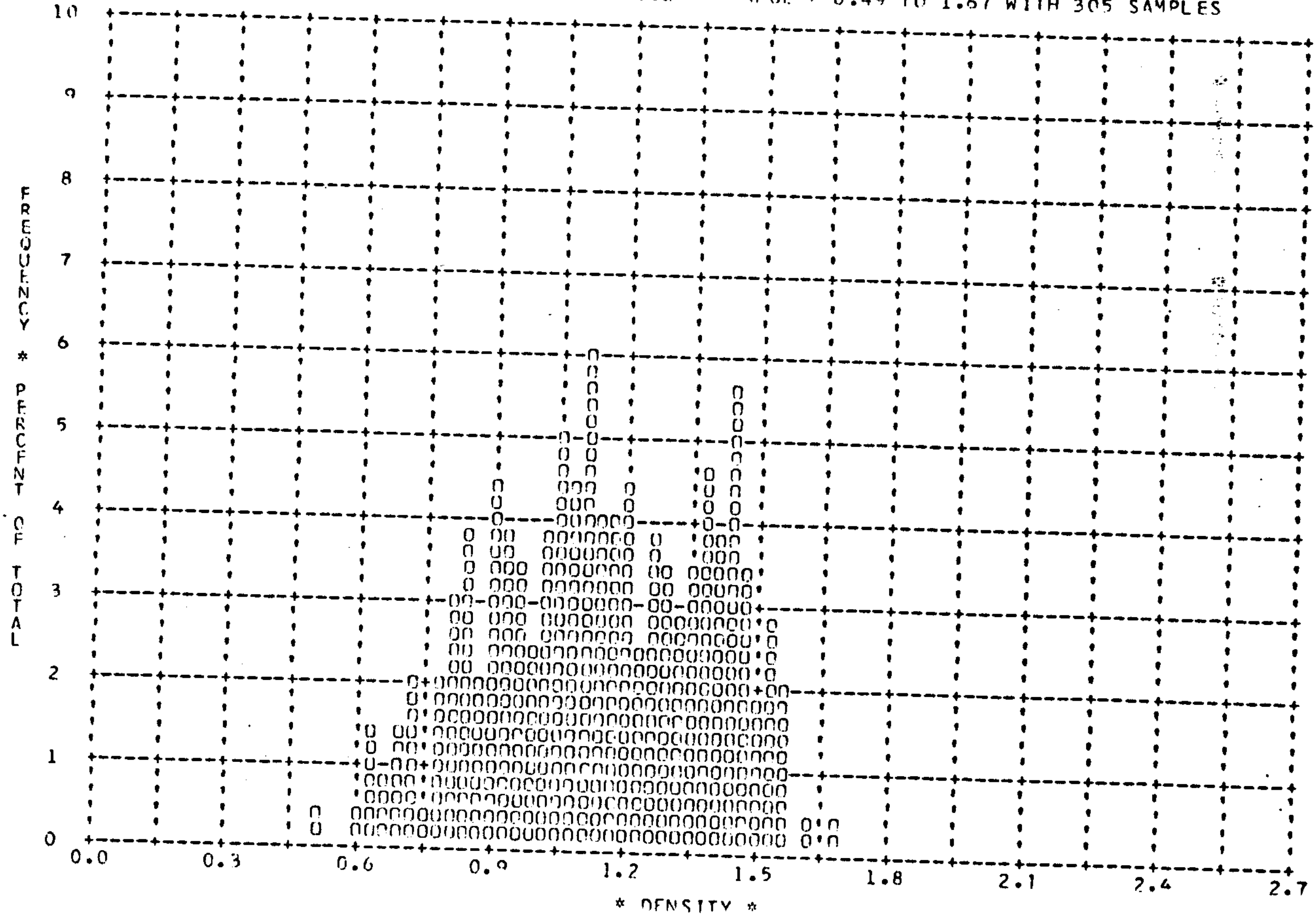

FIGURE 6-7

MISSION * 1194-1 * INSTR * AFT * PLOT OF D MAX * CLOUD * PROCESSING * DUAL GAMMA

ARITH MEAN * 1.60 * MEDIAN * 1.62 * STD DEV * 0.08 * RANGE * 1.22 TO 1.74 WITH 227 SAMPLES

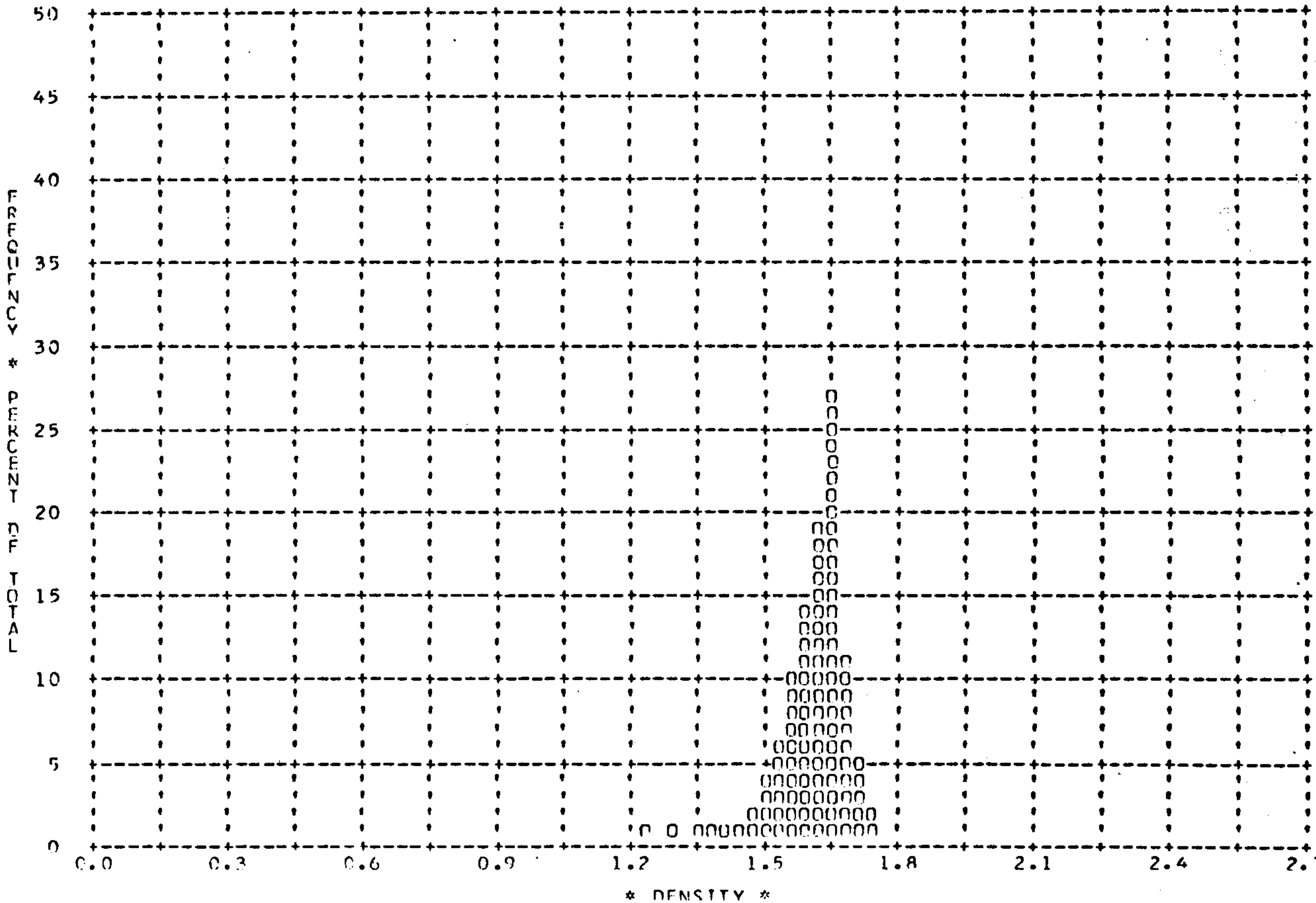

FIGURE 6-8

~~TOP SECRET~~ C[redacted]

MISSION * 1104-2 * INSTR * FWD * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.46 * MEDIAN * 0.40 * STD DEV * 0.20 * RANGE * 0.24 TO 1.23 WITH 247 SAMPLES

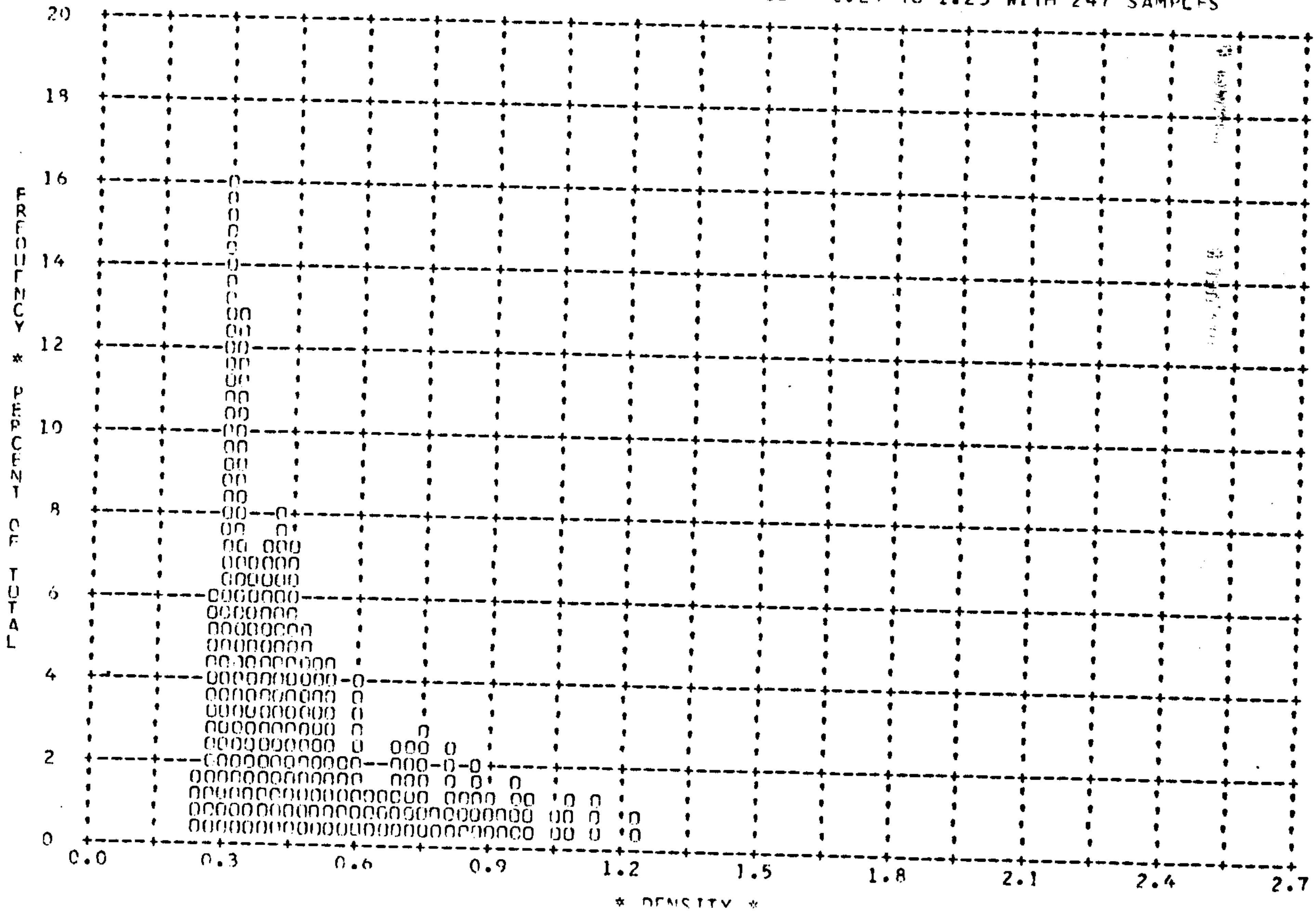

FIGURE 6-9

~~TOP SECRET~~ C [redacted]

MISSION * 11^4-2 * INSTR * FWD * PLOT OF D MAX * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 1.19 * MEDIAN * 1.16 * STD DEV * 0.32 * RANGE * 0.41 TO 1.73 WITH 247 SAMPLES

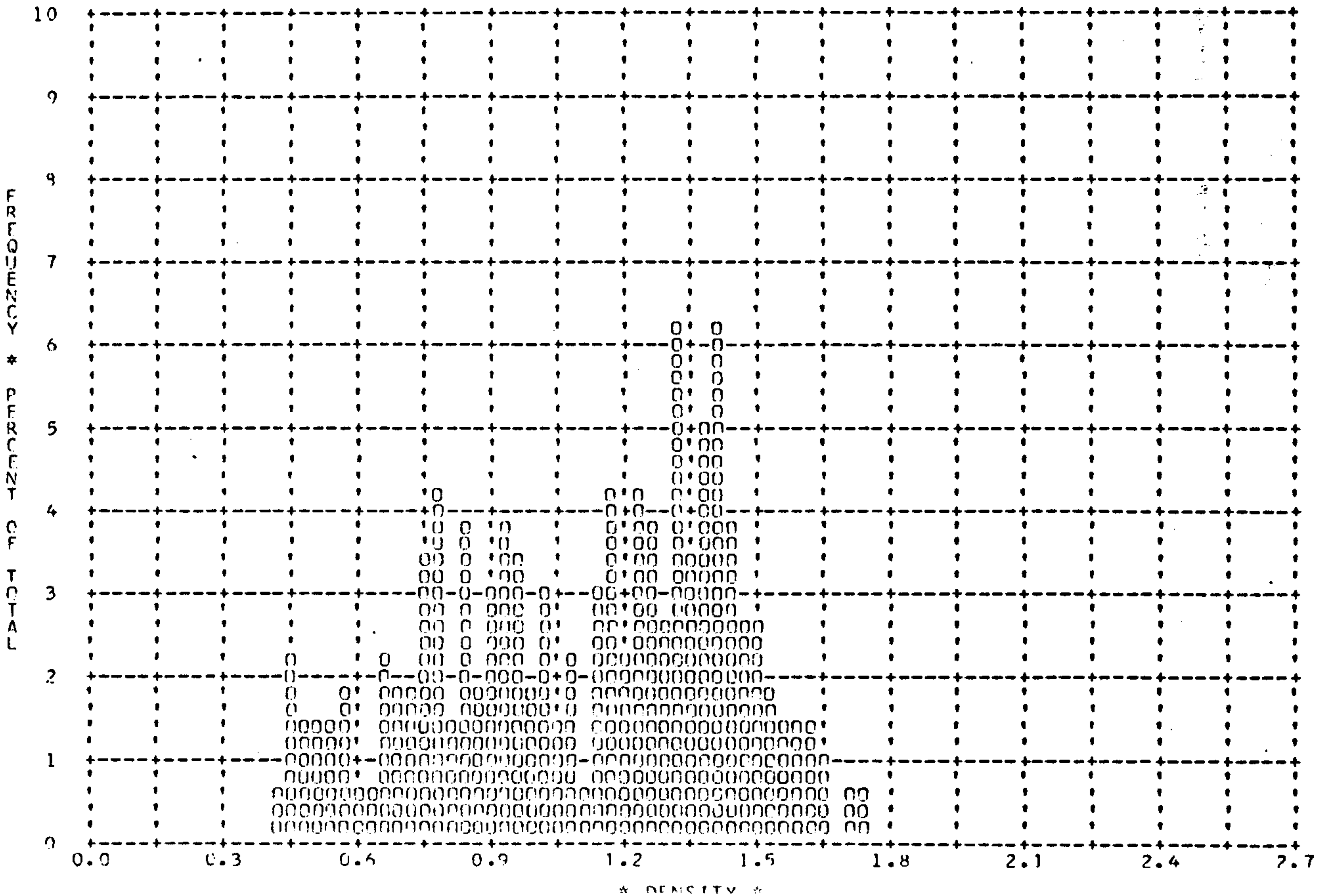

FIGURE 6-10

MISSION * 1104-2 * INSTR * FWD * PLOT OF D MAX * CLOUD * PROCESSING * DUAL GAMMA
ARITH MEAN * 1.60 * MEDIAN * 1.63 * STD DEV * 0.14 * RANGE * 0.63 TO 1.78 WITH 167 SAMPLES

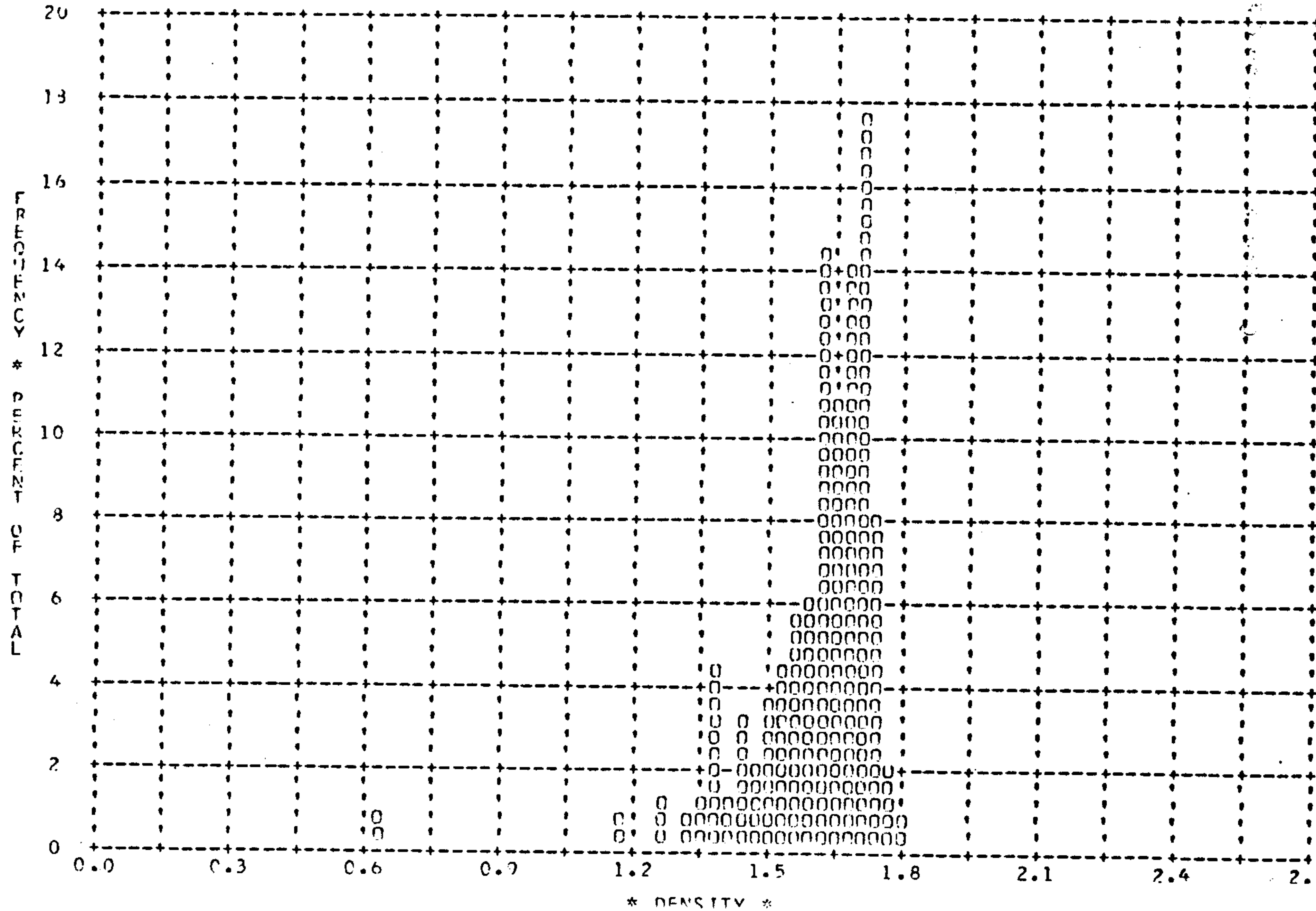

FIGURE 6-11

~~TOP SECRET~~ C [redacted]

MISSION * 1104-2 * INSTR * AFT * PLOT OF D MIN * TERRAIN * PROCESSING * DUAL GAMMA

ARITH MEAN * 0.55 * MEDIAN * 0.50 * STD DEV * 0.20 * RANGE * 0.26 TO 1.26 WITH 291 SAMPLES

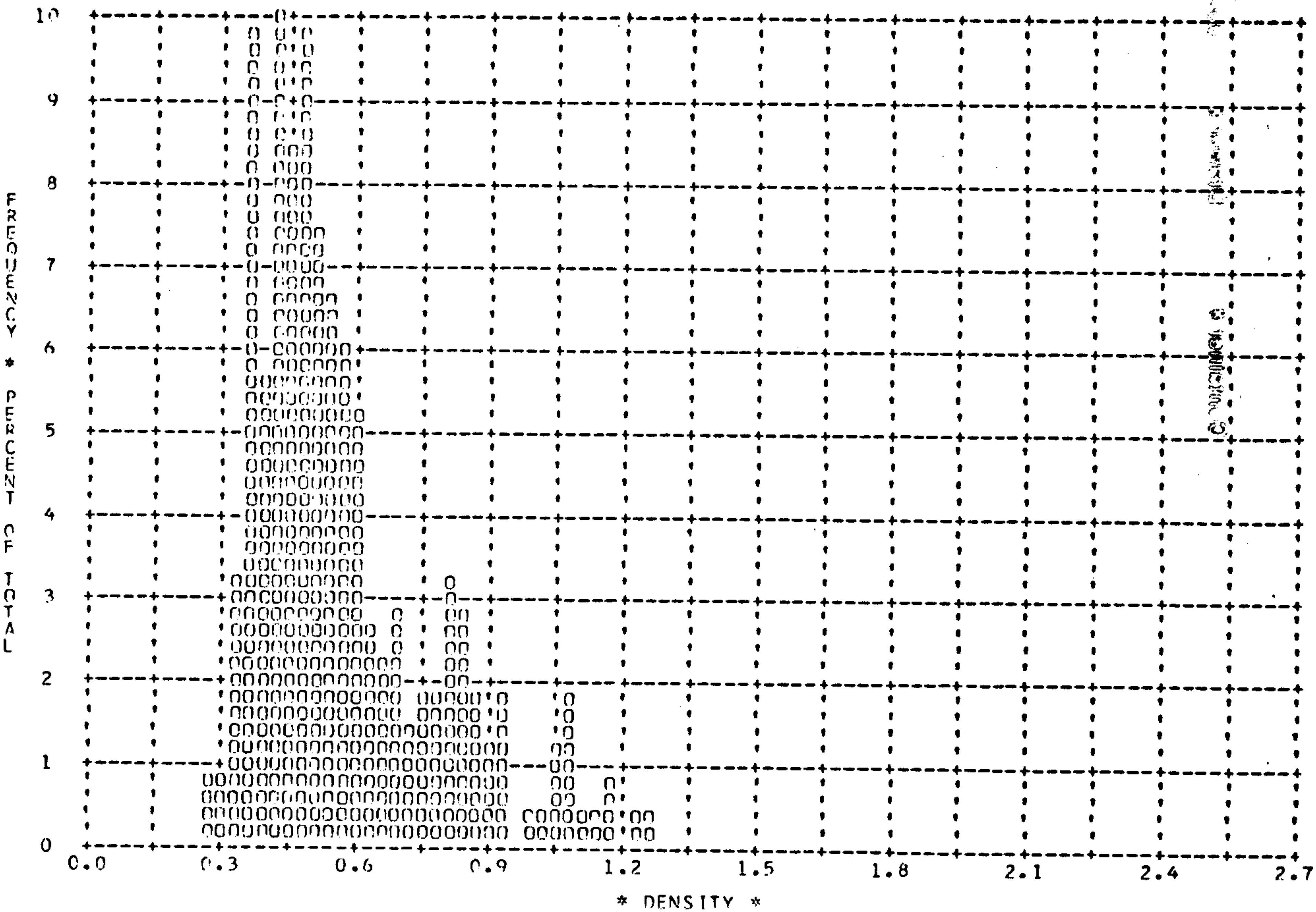

FIGURE 6-12

TOP SECRET C/[redacted]

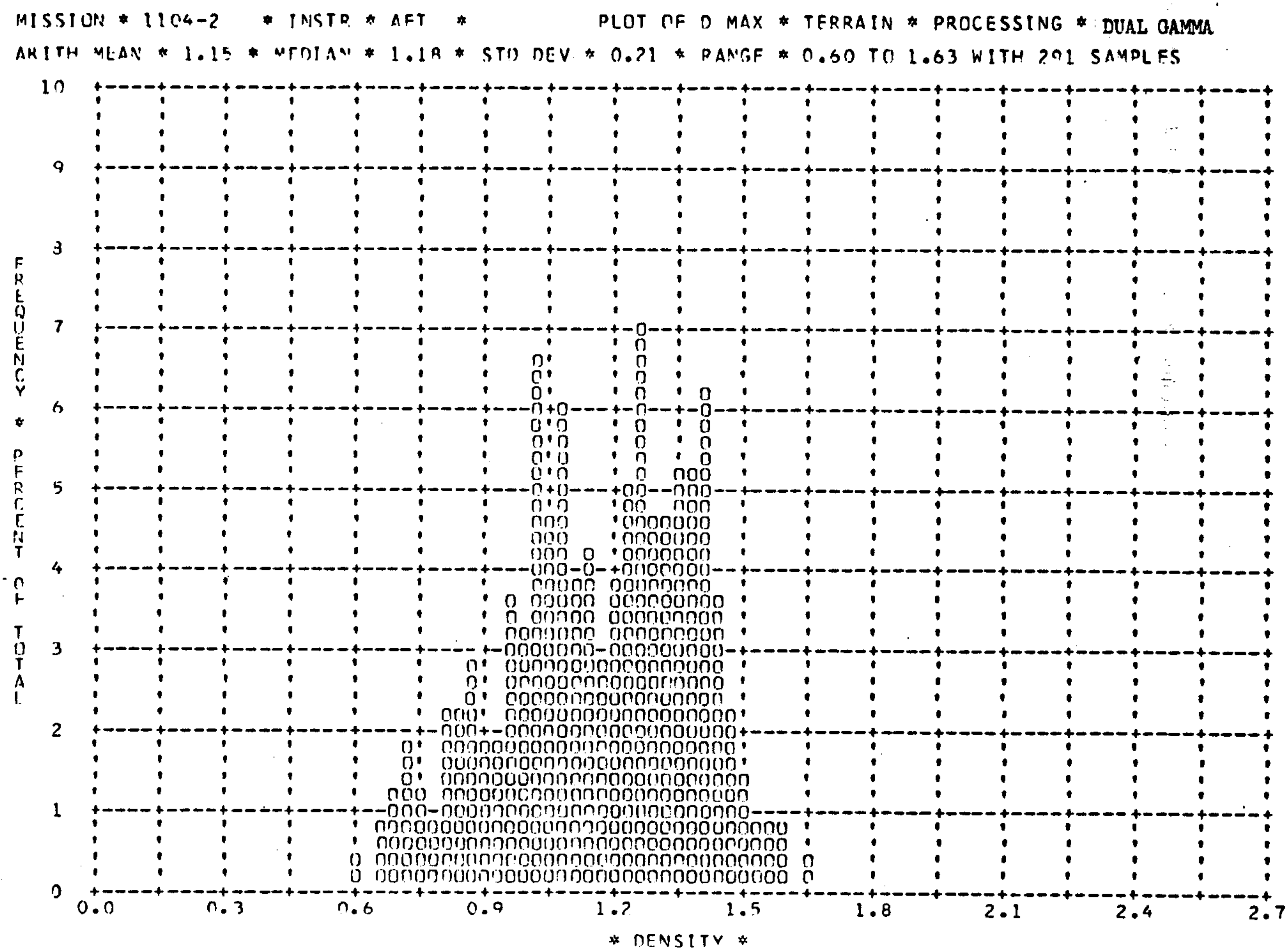

FIGURE 6-13

~~TOP SECRET~~ [redacted]

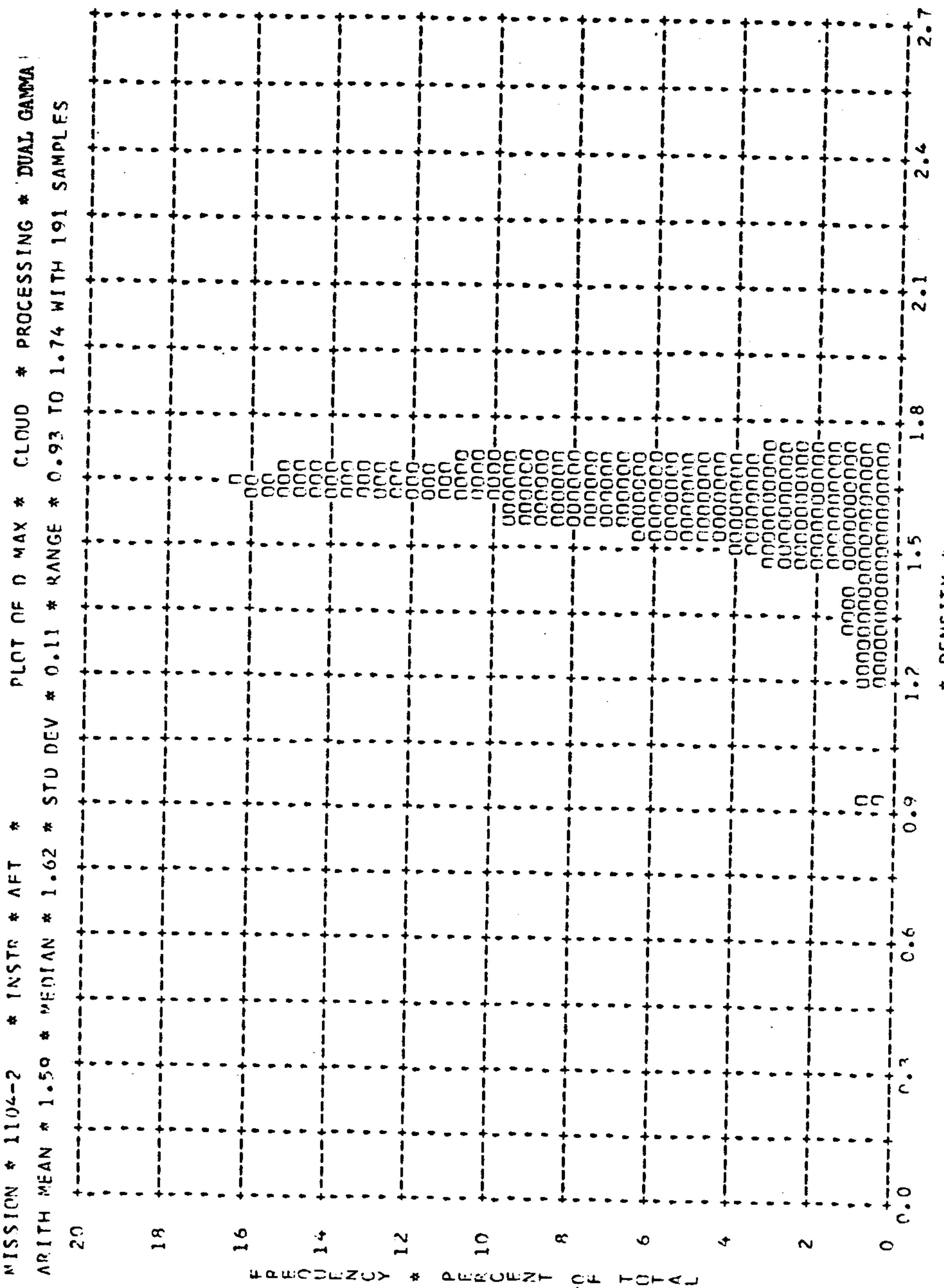

FIGURE 6-14

SECTION 7

VEHICLE ATTITUDE

The vehicle attitude errors for both Mission 1104-1 and 1104-2 were derived from the reduction of the Stellar camera photography. This attitude data is supplied to A/P by NPIC.

The attitude errors for each frame and the attitude control rates are calculated at the A/P computer facility. The computer also plots the frequency distribution of the rates and errors. These plots are no longer included as a part of this report, but are maintained at A/P and are available for reference as desired.

The summary table below lists the maximum attitude errors and rates that were experienced during 90 percent of the forward camera photographic operations, excluding the first six frames of each operation, and the total range of the errors and rates.

	Mission 1104-1		Mission 1104-2	
Value	90%	Range	90%	Range
Pitch Error (°)	0.33	-0.60 to + 0.20	0.24	-0.50 to + 0.24
Roll Error (°)	0.21	-0.40 to + 0.13	0.18	-0.31 to + 0.25
Yaw Error (°)	0.83	0.0 to + 1.15	0.75	0.0 to + 0.84
Pitch Rate (°/hr.)	23.93	-50 to + 90	21.61	-70 to + 90
Roll Rate (°/hr.)	23.38	-60 to + 75	23.85	-50 to + 65
Yaw Rate (°/hr.)	33.37	-80 to + 80	30.43	-80 to + 60

The yaw angle error represents the difference between the actual vehicle yaw attitude and the ideal yaw angle that would provide correct ground image motion. A graphic description of the actual and ideal yaw angles (Figure 7-1) indicates that the cause of the significant yaw error is a disparity in the phasing of the yaw programmer. New methods are being developed to command the complex control relationships in such a way as to better achieve the desired performance. The effects of this mismatch on image quality are discussed in Section 4.

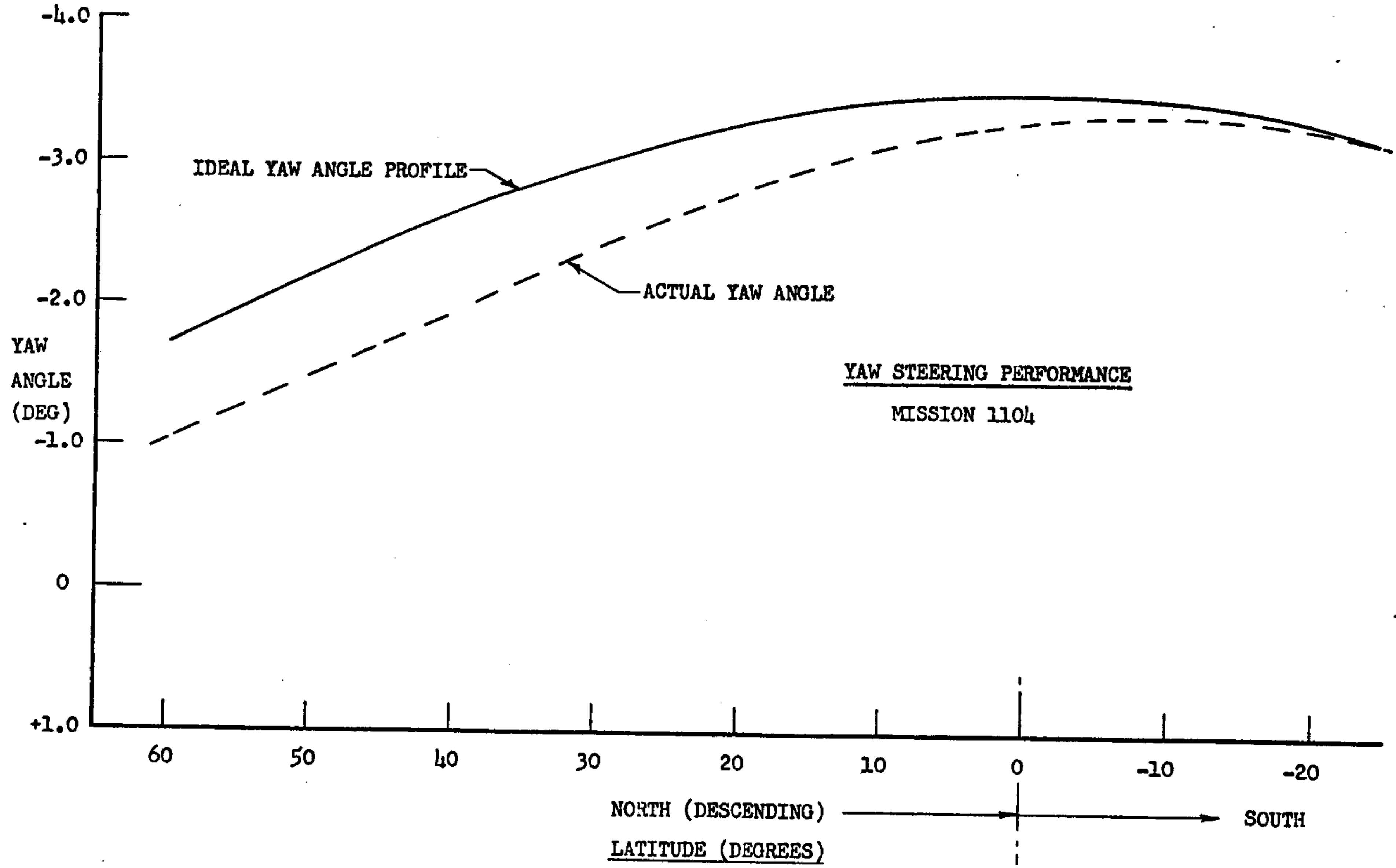
-4.0
-3.0
-2.0
-1.0
0
+1.0
YAW
ANGLE
(DEG)
IDEAL YAW ANGLE PROFILE
ACTUAL YAW ANGLE
YAW STEERING PERFORMANCE
MISSION 1104
60
50
40
30
20
10
0
-10
-20
NORTH (DESCENDING)
SOUTH
LATITUDE (DEGREES)

FIGURE 7-1

SECTION 8

IMAGE SMEAR ANALYSIS

The frame correlation tape supplied to A/P by NPIC contains the binary time word of each frame of photography. A computer program has been assembled at A/P which calculates the exposure time of each frame and compares the camera cycle rate with the ephemeris to calculate the V/h mismatch (Section 3), which is then combined with the vehicle attitude error and rate values of each frame and the crab error caused by earth rotation at the latitude of each frame. The program outputs the net IMC error and the total along track and cross track limit of ground resolution that can be acquired by a camera regardless of focal length and system capabilities.

The computer rejects the first three frames of all operations as the large V/h error induced by camera start-up is not representative of the overall system operations. The computer plotted frequency distributions of IMC errors and resolution limits are no longer included in this report, but are maintained at A/P for reference, as desired.

The summary table 8-1 presents the maximum IMC errors and resolution limits that existed during 90% of the photographic operations and the total range of values during all operations that were computed.

The somewhat high values of the cross track limits reflect the contribution of an imperfect yaw programming performance as discussed in Section 7. The consistent difference in resolution limit values between the forward and aft looking instruments is in reality an illustration of the relative influence of the difference in exposure time when coupled with smear contributing V/h and attitude errors.

MISSION 1104

IMC RATIO AND RESOLUTION LIMITS

VALUE	UNITS	CAMERA	MISSION 1104-1 90%	MISSION 1104-1 RANGE	MISSION 1104-2 90%	MISSION 1104-2 RANGE
IMC Ratio Error	%	Fwd	1.30	-2.2 to +2.0	1.41	-2.8 to +2.4
		Aft	1.26	-1.6 to +2.2	1.19	-2.2 to +1.6
Along Track Resolution Limit	Feet	Fwd	1.17	0.2 to 2.4	1.29	0.2 to 2.5
		Aft	0.89	0.2 to 1.6	0.82	0.2 to 1.6
Cross Track Resolution Limit	Feet	Fwd	1.49	0.2 to 6.2	1.35	0.2 to 2.6
		Aft	1.03	0.2 to 1.8	0.89	0.2 to 1.3

TABLE 8-1

SECTION 9

SYSTEM RELIABILITY

Reliability calculations for the payload are based on a sample beginning with M-7. Hence both the major part of the Mural program and the "J" program are covered in the calculation. Appropriate adjustments have been made to reflect the distinctive aspects of the CR systems, e.g., the stellar-index camera has been replaced by the new DISIC system. The sample size for the primary mission function is consistent with reliability reporting for the vehicle.

The reliability estimates of this section deal exclusively with the payload. Failures to achieve orbit or vehicle induced failures are thereby excluded. Recoveries before a complete mission has been completed are considered as full missions providing that early termination was caused by reasons not connected with payload operation. Film quality is not considered in the reliability estimate calculation. Hence, only electrical and mechanical functioning are considered.

The reliability estimate is also divided into primary and secondary functions. The primary functions are operation of the panoramic cameras, main camera door operation, operation of the payload clock, and recovery operations. The secondary mission functions are horizon camera operation excluding catastrophic open shutter failure mode, auxiliary data recording, and DISIC camera operation. A summary of estimated reliability is shown in Table 10-3.

Panoramic Camera Reliability

Sample Size - 219 opportunities to operate

Two failures - S/I Programmer on System J-19

Film Transport on System J-42

Assume - 3000 cycles per camera per mission.

Estimated Reliability = 98.8% at 50% confidence level

Main Camera Door Reliability

Sample Size - 68 vehicles x 2 doors = 136 opportunities to operate

Estimated Reliability = 99.5% at 50% confidence level

Payload Command and Control

Sample Size - 13,490 hours operation in sample

Two failures

Estimated Reliability = 96.7% at 50% confidence level

Payload Clock Reliability

Sample Size - 13,490 hours operation in sample

No failures

Estimated Reliability - 99.1% at 50% confidence level

Estimated Reliability of Payload Functioning on orbit = 97.0% at 50% confidence level

Recovery System Reliability

101 opportunities to recover

1 failure - improper separation due to water seal - cutter failure

Estimated Reliability - 98.3% at 50% confidence level

DISIC Camera Reliability

Sample begins with CR-1 (does not include S/I units in 1000 series systems)

Sample Size = 27,365 cycles

One failure

Estimated Reliability = 74.4 % at 50% confidence level

Horizon Camera Reliability

Sample begins with J-5 - 133,000

Estimated Reliability of Single Camera - 99.2% at 50% confidence level

Estimated Reliability of Four Horizon Cameras at a Parallel Redundant System = 99.9% at 50% confidence level

SECTION 10

SUMMARY DATA

The comparison of the operating parameters and the performance achieved by previous missions has been difficult due to the large volume of data that results from each mission. Some of the pertinent characteristics from prior missions have been summarized in Tables 10-1 through 10-3.

The summary data was started with Mission 1004 as the J-05 camera system was the first to incorporate the major modifications of the titanium drum and scan arm, four roller scan head and Corona J capabilities. Only those missions that culminated in the recovery of some photography have been listed, therefore Missions 1003, 1005 and 1032 are deleted.

MISSION SUMMARY

TOP SECRET C/[redacted]

MISSION NUMBER	PAYLOAD NUMBER	VEHICLE NUMBER	LAUNCH DATE	LAUNCH TIME	ORBIT INCLINATION (°)	PERIGEE ALTITUDE (NM)	PERIGEE LOCATION (°N)	RECOVERY PASS	MASTER CAMERA: CAMERA NUMBER	MASTER CAMERA: SLIT (")	MASTER CAMERA: FILTER TYPE	SLAVE CAMERA: CAMERA NUMBER	SLAVE CAMERA: SLIT (")	SLAVE CAMERA: FILTER TYPE	STELLAR-INDEX CAMERA NUMBER
1029	J-27	1623	2/2/66	2132 Z	75.1	99.5	22.5	81 / 160	178	0.275	W-25	179	0.175	W-21	
1030	J-29	1622	3/9/66	2202 Z	75.0	97.5	18.7	81 / 159	182	0.275	W-25	183	0.175	W-21	D79/94/91 / D76/70/94
1031	J-30	1627	4/7/66	2202 Z	75.1	104.5	23.3	113 / 177	184	0.225	W-23A	185	0.150	W-21	D94/100/107 / D82/195/102
1032	J-28	1625	5/3/66	1925 Z	—	—	—	— / —	180	0.150	W-21	181	0.150	W-21	D83/101/89 / D86/106/86
1033	J-33	1630	5/24/66	0213 Z	66.1	102.0	60.7	82 / 178	194	0.200	W-21	195	0.200	W-21	D81/97/101 / D80/73/100
1034	J-31	1626	6/21/66	2131 Z	80.1	108.4	18.2	81 / 161	186	0.200	W-23A	187	0.150	W-21	D91/105/109 / D84/102/78
1035	J-36	1628	9/20/66	2114 Z	85.0	99.5	29.1	81 / 160	188	0.225	W-23A	189	0.175	W-21	D86/109/76 / D87/107/105
1036	J-32	1631	8/9/66	2046 Z	100.0	102.4	22.9	115 / 212	190	0.200	W-23A	191	0.150	W-21	D95/112/113 / D96/104/116
1037	J-38	1632	11/8/66	1957 Z	100.0	91.8	14.5	66 / 197	198	0.225	W-23A	199	0.175	W-21	D89/110/111 / D88/108/106
1038	J-34	1629	1/14/67	2128 Z	80.1	96.9	29.2	81 / 193	192	0.225	W-23A	193	0.175	W-21	D101/128/128 / D106/136/134
1039	J-39	1635	2/22/67	2202 Z	80.0	97.0	30.2	81 / 177	206	0.225	W-23A	207	0.175	W-21	D93/86/112 / D90/111/108
1040	J-35	1636	3/30/67	1854 Z	85.1	99.7	28.3	81 / 145	196	0.175	W-21	197	0.225	W-23A	D103/131/132 / D100/125/125
1041	J-40	1634	5/9/67	2152 Z	85.1	100.1	33.0	93 / 215	208	0.225	W-23A	209	0.175	W-21	D78/95/96 / D92/79/110
1042	J-37	1633	6/16/67	2135 Z	80.0	96.5	29.1	97 / 240	204	0.200	W-23A	205	0.150	W-21	D105/134/133 / D102/127/127
1043	J-42	1637	8/7/67	2144 Z	80.0	102.1	16.3	113 / 240	200	0.200	W-23A	201	0.150	W-21	D97/120/117 / D98/121/118
1101	CR-1	1641	9/15/67	1941 Z	80.0	84.8	5.7	97 / 208	302	*	W-21 / W-23A	303	*	W-23A / W-25	D107/135/135 / D112/143/139
1044	J-41	1639	11/2/67	2131 Z	81.5	98.9	18.4	97 / 144	202	0.225	W-23A	203	0.175	W-21	DISIC NO. 3
1102	CR-2	1642	12/9/67	2226 Z	81.6	86.4	19.0	83 / 212	304	*	W-21 / SF05	305	*	W-25 / SF09	D99/122/120 / D104/132/131
1045	J-45	1640	1/24/68	2226 Z	81.5	96.8	7.8	112 / 223	214	0.225	W-23A	215	0.175	W-21	DISIC NO. 4
1046	J-48	1638	3/14/68	2200 Z	83.0	99.9	30.0	113 / 240	220	0.140**	W-23A	221	0.110**	W-21	D109/137/138 / D108/139/141
1103	CR-3	1643	5/1/68	2131 Z	83.0	87.2	19.0	115 / 228	306	*	W-21 / SF05	307	*	W-25 / W-12	D119/151/157 / D120/153/158
1047	J-47	1645	6/20/68	2146 Z	85.0	100.6	15.7	129 / 240	218	0.150	W-23A	219	0.130	W-21	DISIC NO. 5
1104	CR-4	1644	8/7/68	2136 Z	82.1	84.3	5.7	115 / 244	308	*	W-21 / SF05	309	*	W-25 / W-15+ND	D117/149/146 / D118/150/154
															DISIC NO. 7

TOP SECRET C[redacted]

**SO-230 FILM USED IN MISSION 1046.

* 300 SERIES INSTRUMENTS USE VARIABLE SLIT EXPOSURE CONTROL. REFER TO FINAL REPORT, SECTION 2.

REC/JOM 1/66

TABLE 10-1

PERFORMANCE SUMMARY

TOP SECRET C/[redacted]

MISSION NUMBER*	CAMERA	SERIAL NUMBER	M.I.P. VALUE	AFSPPF MTF/AIM AVERAGE (INTERIM)	AFSPPF MTF/AIM SLIT (μ)	AFSPPF MTF/AIM AVERAGE (STANDARD)	90% ATTITUDE ERROR (°) PITCH	90% ATTITUDE ERROR (°) ROLL	90% ATTITUDE ERROR (°) YAW	90% ATTITUDE RATES (°/HR.) PITCH	90% ATTITUDE RATES (°/HR.) ROLL	90% ATTITUDE RATES (°/HR.) YAW	90% V/H ERROR (%)	90% RESOLUTION LIMIT (FEET) ALONG TRACK	90% RESOLUTION LIMIT (FEET) CROSS TRACK	I.M.C. ERROR
1045-1	FWD	214	90	68	80	—	0.23	0.47	0.26	20.3	27.1	25.8	3.5	4.0	1.0	3.4
	AFT			72			0.26	0.45	0.26	21.0	24.9	24.3	3.5	3.4	0.7	3.8
1045-2	FWD	215	90	68			0.42	0.25	0.63	25.2	37.9	28.8	2.6	3.2	2.1	2.7
	AFT			72			0.46	0.23	0.80	26.5	35.3	29.0	4.0	4.2	1.1	4.4
1046-1	FWD	220	90	87	80	—	0.21	0.52	0.88	44.3	18.0	24.0	2.2	1.8	1.4	2.3
	AFT			86			0.23	0.54	0.90	44.8	16.4	21.2	1.7	1.1	0.9	1.9
1046-2	FWD	221	85	70			0.26	0.15	0.78	47.3	17.6	19.2	1.8	1.7	1.2	2.2
	AFT			84			0.29	0.15	0.78	40.4	14.9	18.0	1.7	1.1	0.8	1.8
1103-1	FWD	306	95	89	80	—	0.25	0.31	0.69	27.4	38.8	30.7	1.9	1.1	0.8	2.1
	AFT			79			0.24	0.31	0.68	27.5	38.8	32.8	2.0	1.3	0.9	2.1
1103-2	FWD	307	95	85			0.26	0.23	0.66	24.0	37.6	24.9	2.6	2.4	1.2	2.7
	AFT			80			0.25	0.23	0.65	24.8	37.8	27.2	2.7	1.9	0.8	2.9
1047-1	FWD	218	85	63	80	—	0.18	0.23	0.52	24.2	23.8	23.1	2.0	1.7	0.9	2.1
	AFT			75			0.16	0.22	0.52	25.4	20.6	22.8	1.6	1.3	0.6	1.8
1047-2	FWD	219	85	66			0.25	0.27	-	34.3	30.6	-	3.7	3.3	4.5	4.1
	AFT			76			0.23	0.27	-	34.8	27.7	-	2.9	2.1	3.8	3.0
1104-1	FWD	308	115	118	80	—	0.33	0.21	0.83	23.9	23.4	33.4	1.2	1.2	1.5	1.3
	AFT			88			0.33	0.22	0.80	23.9	23.5	33.6	1.2	0.9	1.0	1.3
1104-2	FWD	309	115	109			0.24	0.18	0.75	21.6	23.9	30.4	1.2	1.3	1.4	1.4
	AFT			103			0.24	0.18	0.73	22.3	24.1	31.2	1.3	0.8	0.9	1.2

TOP SECRET C[redacted]

TABLE 10-2

REC/JON 8/67

ESTIMATED RELIABILITY SUMMARY

C/[redacted]

(AT 50% CONFIDENCE LEVEL)

MISSION NUMBER	PRIMARY FUNCTIONS																SECONDARY FUNCTIONS					
	PANORAMIC CAMERA			PANORAMIC CAMERA DOORS			COMMAND & CONTROL SYSTEM			PAYLOAD CLOCK			ON-ORBIT FUNCTIONS	RECOVERY SYSTEM			STELLAR - INDEX CAMERAS			HORIZON CAMERAS		
	SAMPLE	FAILURES	RELIABILITY	SAMPLE	FAILURES	RELIABILITY	SAMPLE	FAILURES	RELIABILITY	SAMPLE	FAILURES	RELIABILITY	RELIABILITY	SAMPLE	FAILURES	RELIABILITY	SAMPLE	FAILURES	RELIABILITY	SAMPLE	FAILURES	RELIABILITY
1101	191	2	98.6	122	0	99.4	11,208	2	** 96.1	11,208	0	** 98.9	** 96.5	87	1	98.1	12,965	0	* 77.2	112,000	0	99.1
1044	195	2	98.6	124	0	99.5	11,424	2	96.1	11,424	0	99.0	96.5	89	1	98.1	28,480	4	93.3	115,000	0	99.1
1102	199	2	98.7	126	0	99.5	11,736	2	96.2	11,736	0	99.0	96.6	91	1	98.2	17,765	1	* 63.5	118,000	0	99.1
1045	203	2	98.7	128	0	99.5	12,072	2	96.3	12,072	0	99.0	96.8	93	1	98.2	29,330	4	93.5	121,000	0	99.1
1046	207	2	98.7	130	0	99.5	12,432	2	96.4	12,432	0	99.1	96.8	95	1	98.2	30,180	4	93.6	124,000	0	99.2
1103	211	2	98.7	132	0	99.5	12,768	2	96.5	12,768	0	99.1	96.9	97	1	98.3	22,565	1	* 89.9	127,000	0	99.2
1047	215	2	98.8	134	0	99.5	13,130	2	96.6	13,130	0	99.+	97.0	99	1	98.3	30,680	1	92.5	130,000	0	99.2
1104	219	2	98.8	136	0	99.5	13,490	2	96.7	13,490	0	99.1	97.0	101	1	98.3	27,365	1	* 74.4	133,000	0	99.2

** CALCULATIONS ADJUSTED TO NOMINAL 14-DAY MISSION STANDARD

[redacted]

* DISIC REPLACES S/I CAMERAS ON 1100 SERIES SYSTEMS

DISTRIBUTION:

COPY NO.	TO
[redacted]	[redacted]