16

CORONA J

PERFORMANCE EVALUATION REPORT

MISSION 1117-1 and 1117-2

FTV 1663, CR-8R

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Advanced Projects

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Manager
Program [redacted]

FOREWORD

This report details the performance of the payload system during the operational phase of the Program [redacted] Flight Test Vehicle 1663.

Lockheed Missiles and Space Company, Inc. has the contractual responsibility for evaluating payload performance. This document is the final payload test and performance evaluation report for Mission 1117-1 and 1117-2 which was launched on 25 May 1972.

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INTRODUCTION

This report presents the final performance evaluation of Missions 1117-1 and 1117-2 of the Corona Program. The purpose of this report is to define the performance characteristics of the CR-8R payload system and to identify the source of in-flight anomalies. The letter "R" has been added to the payload system designation to distinguish the condition since complete refurbishment. The refurbishment was necessitated by extensive vibration and other testing conducted at LMSC to investigate slack film conditions in Corona systems.

As the last system in the Corona program, the usual post-flight analysis and evaluation procedures were minimized or eliminated. The conclusions noted in this report are based on routine flight records and post-flight processing records.

SECTION 1

MISSION SUMMARY

A. MISSION OBJECTIVES

The payload section of Mission 1117, placed into orbit by Flight Test Vehicle 1663 and THORAD Booster #571, consisted of two panoramic cameras, 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-8R payload system. The Corona "J" system is designed to acquire search and reconnaissance photography of selected areas of the earth from orbital altitudes. An eight day -1 mission and an eleven day -2 mission were planned.

B. MISSION DESCRIPTION

The payload was launched from Vandenberg Air Force Base (VAFB) at 1841Z(1141 PST) on 25 May 1972 from SLC-3 west pad. 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 consisting of tracking and command stations at [redacted] under central control of the Satellite Test Center at Sunnyvale, California. Mission 1117-1 consisted of a 2-day operation and was completed by air recovery on Rev 45 at 1450 PDT on 27 May 1972. Mission 1117-2 was completed with an air recovery on Rev 98 at 1352 PDT on 31 May 1972 following a 4-day photographic operation. The shortened mission was necessitated by failure of the solar array to deploy and a high loss of vehicle control gas.

PAYLOAD PROFILE AND SERIAL NUMBERS

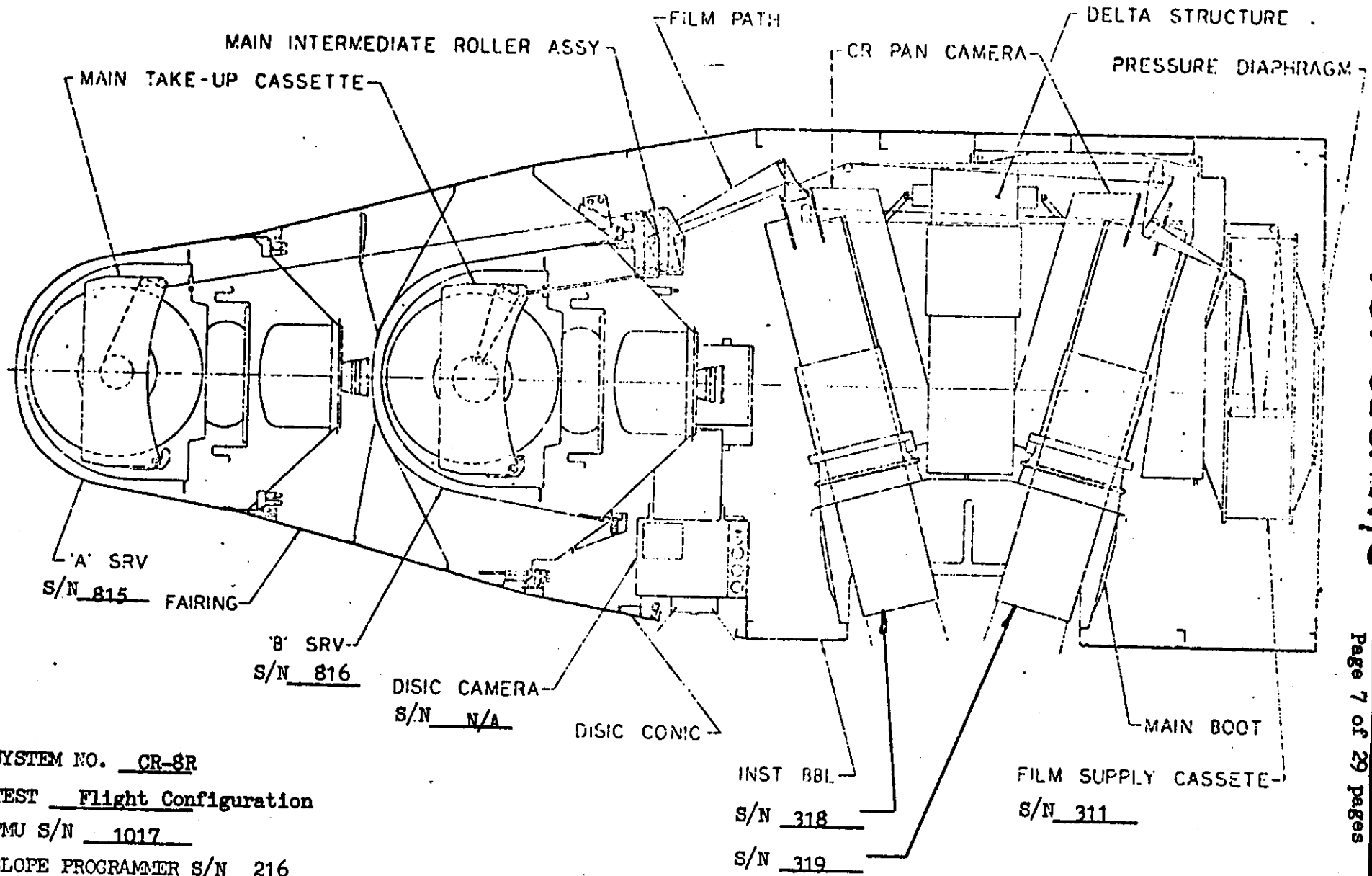


FIGURE 1-1

SYSTEM NO. CR-SR

TEST Flight Configuration

PMU S/N 1017

SLOPE PROGRAMMER S/N 216

CLOCK S/N 615

SWITCH PROGRAMMER S/N 216

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

ORBITAL PARAMETERS

Parameters	Predicted	Orbit 2 Actuals
Period (Min.)	89.00	88.91
Perigee (N.M.)	84.8	87.5
Apogee (N.M.)	163.0	159.2
Inclination (Deg.)	96.4	96.36
Eccentricity	0.0111	0.00947

DMU Operation. The DMU rocket fired on Rev 2 increased the orbit period from 88.9 (approximately one rocket low) to 89.2 min. The DMU rocket fired on Rev 7 was utilized unsuccessfully to aid the deployment of the solar array. In addition, abnormal vehicle control gas usage shortened the mission life and prohibited the firing of DMU rockets for normal ground track and period control. Refer to Tables 3.1 and 3.2.

The ground track error at the ascending node ranged from 11 nautical miles east to 100 nautical miles west of nominal.

DMU Performance

Rocket No.	Rev No.	System Time (Sec)	Period Change (sec)	Velocity Change (Ft/Sec)	Period at Firing (Min)	Impulse Lb/Sec)
1	2	78199	14.95	23.54	89.07	3084
2	7	18637	10.15	16.1	89.51	2075

Note: Only two of the available 12 rockets were fired due to the vehicle anomalies.

C. PANORAMIC CAMERAS

Both panoramic cameras operated satisfactorily throughout both missions. The imagery from both cameras was rated very good for both mission segments. The film supply for both cameras was exhausted on Rev 91.

D. OTHER SUBSYSTEMS

The pressure make-up unit, the clock, command and instrumentation, and the thermal control subsystems performed satisfactorily throughout both missions.

The slope programmer and exposure control programmer functioned normally throughout the missions. The tape recorders from both missions performed normally with all data extracted.

E. COMPONENT IDENTIFICATIONS AND SETTINGS

1. Forward Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	319
Main Camera Lens	I209
Supply Horizon Camera Lens	E23767
Take-up Horizon Camera Lens	E23789

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5

Slit Widths

S_1	0.115"
S_2	0.134"
S_3	0.171"
S_4	0.205"
F/S	0.119"

Filter Types

Primary	Wratten 25, 0.037" glass
Secondary	Wratten 25, 0.040" glass

Film Types

Primary	Eastman Type 3414 (16,300 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

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

2. Aft Looking Panoramic Camera

a. Component Assignment

Component	Serial Number
Main Camera	318
Main Camera Lens	I218
Supply Horizon Camera Lens	E40787
Take-up Horizon Camera Lens	E23778

b. Camera Data and Flight Settings

Main Camera:

Lens	24"f/3.5
Slit Widths	
S_1	0.119"
S_2	0.146"
S_3	0.177"
S_4	0.214"
F/S	0.130"
Filter Types	
Primary	Wratten 25, 0.037" glass
Secondary	Wratten 25, 0.040" glass
Film Types	
Primary	Eastman Type 3414 (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

SECTION 2

PRE-FLIGHT SYSTEMS TEST

The CR-8R system, originally designated CR-08, received extensive standard testing and special testing and required refurbishment by the manufacturer. After refurbishment, the preflight test procedures were conducted as though the system were totally new. The "R" designation distinguishes post-refurbishment testing from that performed earlier. The post-refurbishment testing is the only testing described in this report.

The CR payload systems are subjected to a sequential series of tests required to demonstrate a satisfactory confidence level in the flightworthiness of the systems. These tests include static verification, dynamic performance, operation in simulated thermal-altitude environment, light leak evaluation and dynamic photographic performance measurements.

After concluding the satisfactory performance of preliminary baseline adjustments to the camera systems and other flight systems; a light leak test and pre-chamber vibration test were successfully performed and the CR-8R flight system was prepared for environmental testing. Significant baseline levels and anomalies experienced during the environmental testing are as follows:

A. ENVIRONMENTAL TESTING

The CR-8R payload system was environmentally tested in the Sunnyvale HIVOS chamber between April 21 and April 27, 1971.

The console 400 cycle power supply failed on Rev 6 and the backup power switched in causing some anomalies to occur on the slope programmer output. The power supply was changed before starting Rev 7.

Pan Instruments. The test was conducted with 3414 type film normally used in the panoramic cameras. There was no DISIC subsystem installed in the system.

Examination of the test film indicated three groups of anomalies. Minor corona and other electrostatic marking was detected on both camera films. The degree and extent of the marking, as well as the pressures at which it occurred, indicated that there was no flight hazard involved. A second group of anomalies involved rubbing and minor mechanical damage to the film. These conditions were corrected in post-chamber testing. A third group of anomalies involved density adjustments and other defects in data recording. These conditions were corrected during post-chamber testing.

B. ASCHENBRENNER GRID TESTS

During the period 17-21 May 1971, a series of 16 AGT film flatness tests were conducted. Evaluation of processed film demonstrated that required flatness (within ± 0.0007" of center area) had been achieved on both instruments.

C. RESOLUTION TESTS

Initial resolution tests were conducted in June 1971. These tests demonstrated acceptable performance for the No. 2 pan camera (S/N 319). However, the No. 1 camera (S/N 318) with a "second generation lens" provided a peak low contrast value of only 113 lines per millimeter with the usual W-23A filter. Since another lens (third generation) was available it was decided to install it and re-evaluate performance. This necessitated rerunning the AGT film flatness tests in September 1971. After successful

completion of these tests, resolution tests were performed. Since the new lens was a third generation type, it was decided to test with both W-23A and W-25 films. It was found that the W-25 filter provided distinctly superior performance compared with the W-23A filter. Low contrast peak resolution values were 20- to 25- percent higher with the W-25 filters. It was therefore recommended by LMSC that this instrument be flown with W-25 filters rather than the W-23A filters that would normally be used for a No. 1 camera position. Final pan camera low-contrast resolution test data was as follows:

Instrument #318, W-25 filter

174 lines per millimeter

Instrument #319, W-25 filter

186 lines per millimeter

SECTION 3

A. SUMMARY

Mission 1117 was the last of the Corona missions and utilized a Thorad booster (SLV-2H) S/N 571, Agena vehicle 1663, and Payload system CR-08. The CR-08 payload system contained panoramic cameras S/N 318 and 319.

Liftoff occurred at 1141 PDT on May 25, 1972 from Vandenberg SLC-3 west pad. All payload ascent events were normal with In-flight Reset (door ejection), AP to orbit mode, instrumentation switchover, and panoramic camera transfer to orbit mode occurring as programmed. The orbit attained was within the three sigma of predicted.

The normal mission plan was 8/11 days. However, due to failure of the Solar Array to deploy and a high loss of vehicle control gas, the mission was shortened to 2/4 days.

Panoramic cameras S/N 318 and 319 performed satisfactorily throughout the flight with the film supply of both instruments exhausted on Rev 91.

The panoramic camera A to B transfer sequence was performed on Rev 28 Guam with all events occurring normally. The -1 mission recovery capsule was recovered by air catch on Rev 34 at 1450 PDT on May 27, 1972. The -2 mission capsule was recovered by air catch on Rev 98 at 1352 PDT on May 31, 1972.

The -1 and -2 mission SRV tape recorder systems performed normally with all data extracted.

The command system, instrumentation, clock system, pressure make-up system, slope programmer, switch programmer, and the thermal environment were normal throughout the flight.

B. PANORAMIC CAMERAS

Panoramic cameras S/N 318 and 319 performed normally during the -1 and -2 missions. Film consumption and type were as follows:

Film Consumption	Frames	
	Pan 318	Pan 319
Sample	23	23
Pre-launch	118	119
-1 Mission	3023	3035
-2 Mission	3006	2995
Total	6170	6172

Film Supply Length and Type		
	Pan 318	Pan 319
	16,300 FT/3414	16,300 FT/3414

C. COMMAND AND CONTROL SUBSYSTEMS

Command System. The command system performed satisfactorily throughout the -1 and -2 missions.

FMC Match. The ramp to orbit match was maintained satisfactorily throughout the flight. Approximately 77.1% of the first mission operations and 80.0% of the second mission operations were less than ± 1.0% mismatch error.

Exposure Control System. The slit width control programmer performed satisfactorily throughout the -1 and -2 missions.

D. DATA SYSTEMS

Instrumentation. The instrumentation system performed normally throughout the -1 and -2 missions.

Clock System. The payload system clock performed normally throughout the -1 and -2 missions. The coefficients for the system time/clock time correlation are:

Second Order Fit

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

A_o = -0.1403495363 + 06

A_1 = 0.999999947479 + 00

A_2 = 0.9362447117082 - 14

Sigma = 0.00063

Number of Points = 10

SRV Tape Recorder. The -1 SRV tape recorder performed normally with 102.4 minutes of data retrieved satisfactorily. The -2 SRV tape recorder performed normally with 109.2 minutes of data extracted satisfactorily.

E. RECOVERY

-1 Mission. The -1 recovery capsule was successfully recovered by air catch on Rev 34 at 1450 PDT on May 27, 1972. All re-entry events were within tolerance with the impact close to nominal.

	Actual	Predicted
Impact Location	24°53.0'N/161°23.0'W	24°35.7'N/161°24.1'W

-2 Mission. The -2 recovery capsule was successfully recovered by air catch on Rev 98 at 1352 PDT on May 31, 1972. All re-entry events were within tolerance with the impact 18 miles from the nominal

	Actual	Predicted
Impact Location	19°32'N/147°51'W	19°14.7'N/148°11.5'W

F. ORBITAL PARAMETERS

The orbit achieved was within the predicted 3 sigma dispersion. The following tabulation describes the orbital parameters based on Rev 2, both predicted and actual.

Orbital Parameters.

Parameter	Predicted	Tolerance	Actual(STC)	Actual(APF)
Period(Min)	89.00	+.32,-.33	88.91	88.91
Perigee(N.M.)	84.8	+7,-6	87.5	87.7
Apogee(N.M.)	163.0	+11,-15	159.2	159.3
Eccentricity	0.0111	+.0020,-.0027	0.00947	0.0098
Inclination(Deg)	96.4	+.19,-.15	96.36	96.35
Arg. of Perigee(Deg)	148	+54,-44	135.8	138

Orbital history of perigee altitude, perigee latitude, period error and longitudinal error are shown in graphs 3.1 and 3.2. The latitudes and altitudes of operations are shown on graph 3.3.

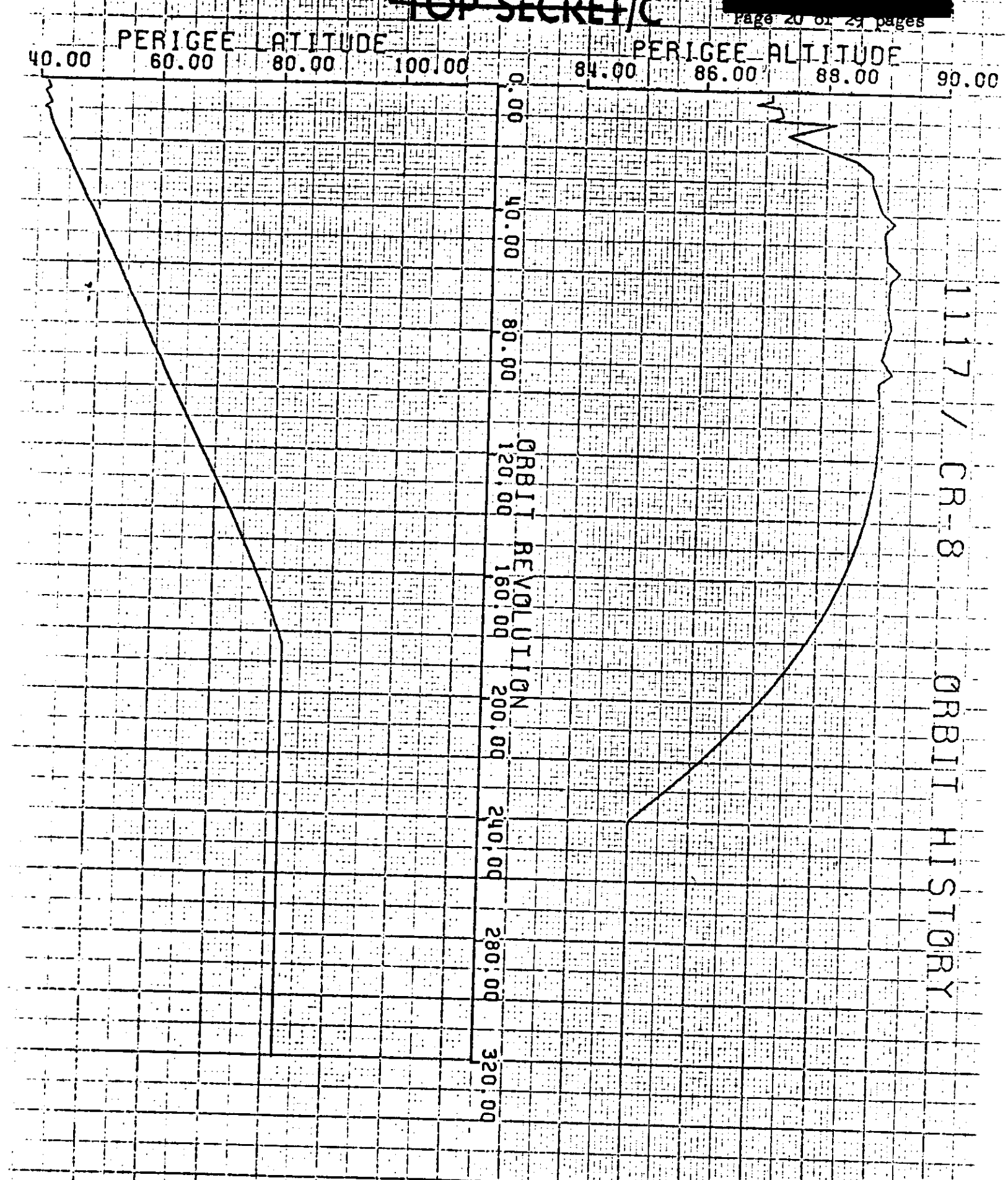

PERIGEE LATITUDE
40.00
60.00
80.00
100.00
PERIGEE ALTITUDE
84.00
86.00
88.00
90.00
0.00
40.00
80.00
120.00
160.00
200.00
240.00
280.00
320.00
ORBIT REVOLUTION
1117 / CR-8 ORBIT HISTORY

FIGURE 3-1

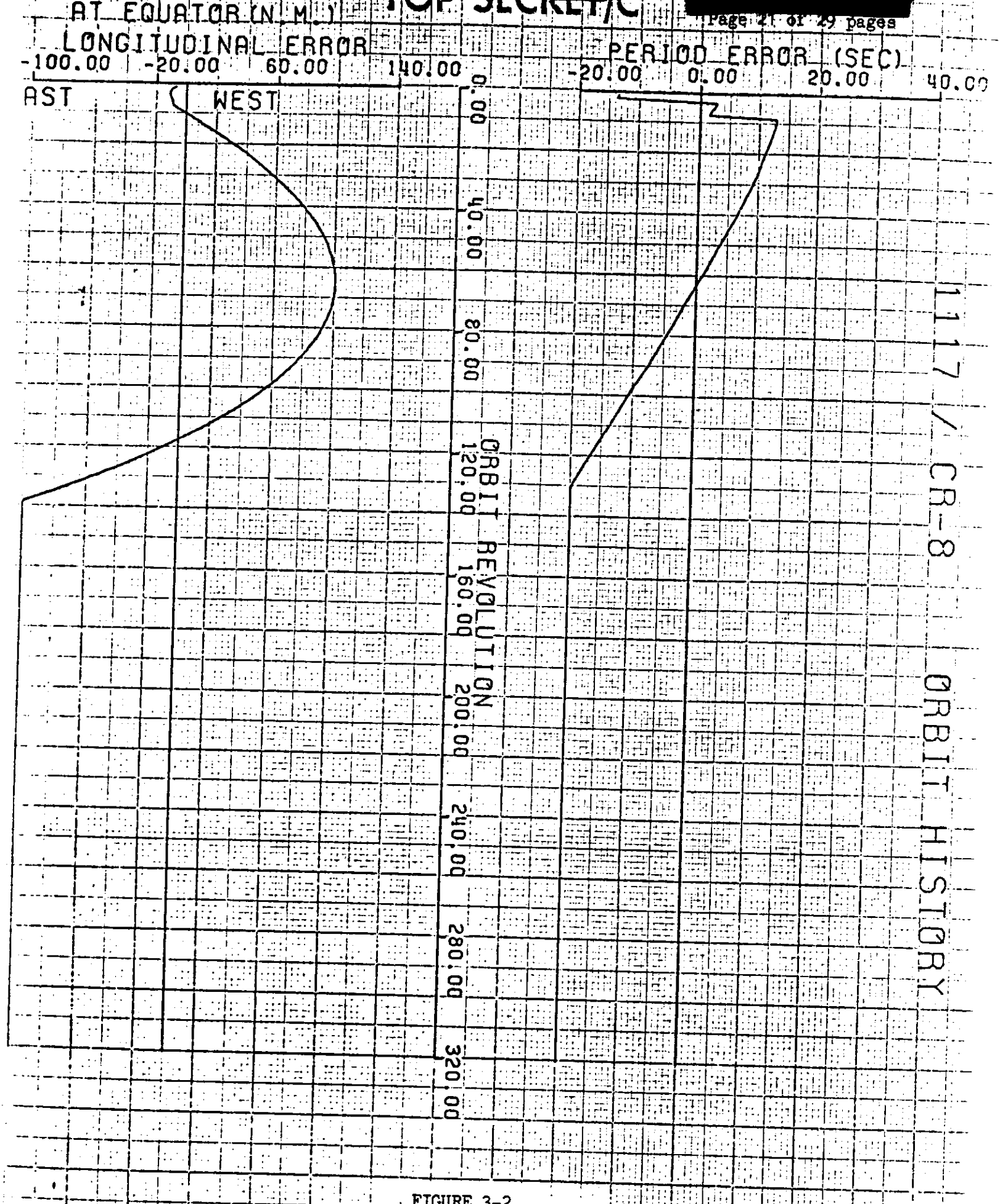
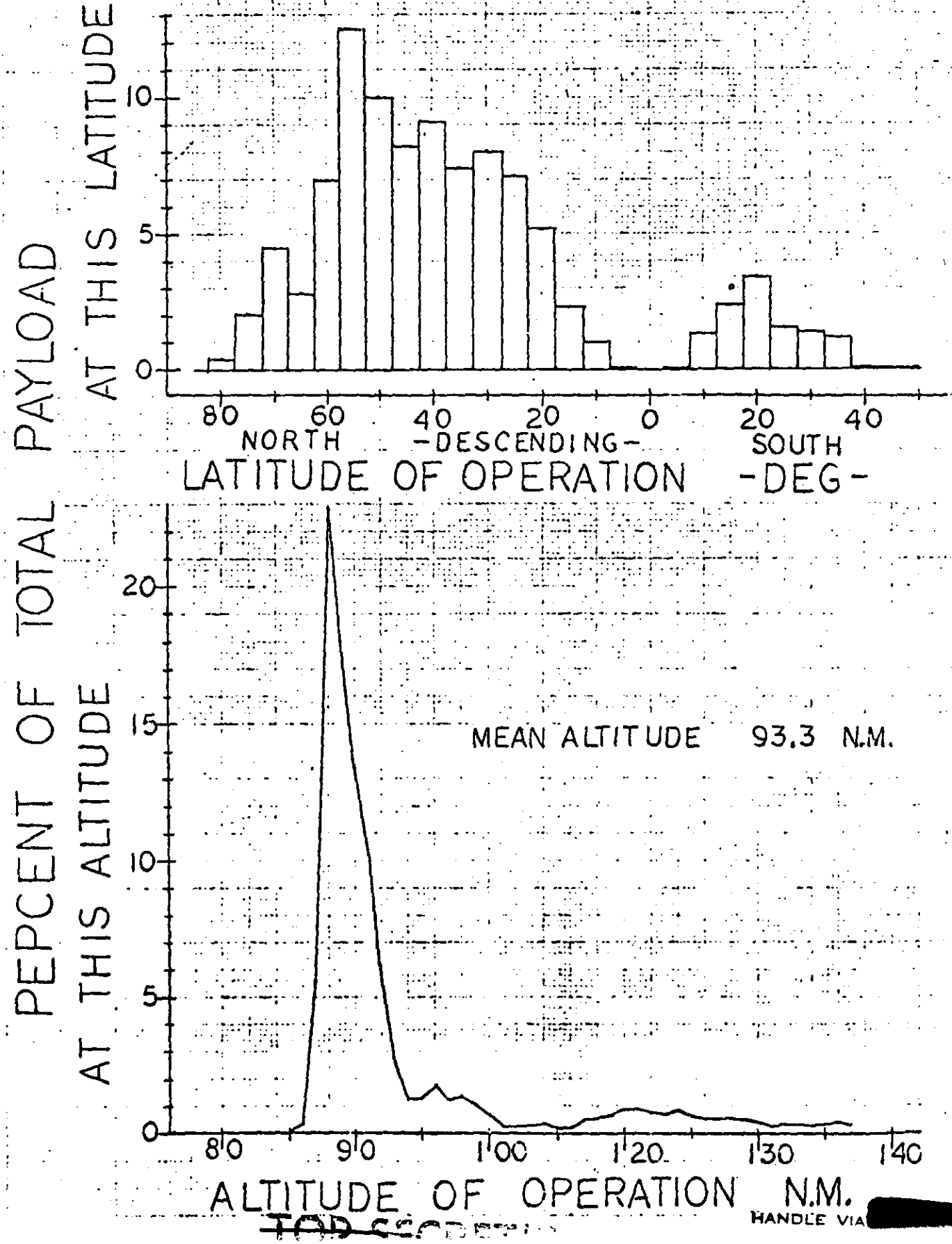


FIGURE 3-2

1117/CR 17/1663

FIGURE 3-3



G. DMU OPERATION

Only two DMU rockets were used on this mission. Details are given in Section 1B.

H. ENVIRONMENTAL CONTROL

Pressure Make-up System. The pressure make-up system (PMU) operated properly throughout the flight. There were 103 panoramic camera operates for a total of 205 minutes which resulted in a gas consumption rate of 5.8 PSI/min. of operate time.

Thermal Environment. The temperature data obtained indicated the temperature environment was within the pre-flight predictions. The averages of the panoramic camera temperatures ranged from 57°F to 62°F for instrument S/N 318 and 57°F to 60°F for instrument S/N 319. The orbit was a constant Beta angle of plus 18 degrees.

I. POST EVENT 2 TESTING

Due to lack of vehicle power and control gas, no post event 2 testing was performed.

SECTION 4

PHOTOGRAPHIC PERFORMANCE

Both panoramic cameras were operational throughout both missions. The film supply for the forward-looking camera #319 was exhausted on frame 61 of Rev 91 and the aft-looking camera #318 supply was exhausted on frame 78 of Rev 91.

An MIP rating of 115 was assigned to frame 62 of Rev D011 from the forward-looking camera for the 1117-1 mission. The image quality of the aft-looking instrument records for the -1 mission was comparable to that of the forward records. An MIP rating of 115 was assigned to frame 34 of Rev D059 of the forward camera for the -2 mission. Aft looking instrument records were reported to be of comparable quality.

No contractor examination has been made of the film records. Accordingly, no analysis of these records is included in this report. However, it is noted that user reports indicate no significant photographic anomalies.

SECTION 5

PANORAMIC EXPOSURE

A. INTRODUCTION

Exposure of the CR systems is a function of scan rate, filter, slit width and scene luminance. Since scan rate is adjusted in flight to compensate for forward image motion, exposure control is exercised during flight only by the selection of the filter and slit opening.

The Wratten filter is selected prior to flight and is therefore fixed for a given film type. The slit width is selectable by real-time command in flight. Four different slit widths may be selected by automatic sequencing or any one of five fixed slits may be selected.

B. EXPOSURE ANALYSIS

The filters for the forward-looking camera, #319, as well as the aft-looking camera, #318, were all Wratten 25's. The filters selected for both primary and secondary positions were all glass. Since the filters in both cameras provided the same filtration, the slit widths for both cameras were substantially the same. An intentional spread in failsafe slit widths was provided to allow greater capability under possible failure conditions.

The exposure slits selected for the forward and aft-looking cameras were as follows:

	Slit Width (inches)	
Slit	Fwd (#319)	Aft (#318)
S_4	0.205	0.214
S_3	0.171	0.177
S_2	0.134	0.146
S_1	0.115	0.119
F/S	0.119	0.130

The automatic slit sequencing system was adjusted to accommodate either predicted snow or no-snow conditions. Although a flight at this time of year normally does not encounter snow, the condition was encountered on this mission and the capability of using narrower slits was useful in providing effective exposure.

SECTION 6

VEHICLE ATTITUDE AND IMAGE SMEAR

A. VEHICLE ATTITUDE

The vehicle attitude errors for Corona Missions are normally derived from the reduction of the Stellar camera photography. This attitude data is supplied to A/P by NPIC. Since a DISIC subsystem was not used on this mission, these data are not available.

The attitude errors for each frame and the attitude control rates are normally calculated at the A/P computer facility. Since objective measurements are not available, the analysis is limited to subjective examination. Since the mission produced excellent photography, it is evident that attitude and rate errors were minimal.

SECTION 7

RELIABILITY

MISSION 1117 (CR-8R)

With the recovery of the Mission 1117-2 payload and the receipt of the user processing report, final reliability estimates for the Corona Program have been computed.

These reliability estimates deal entirely with the payload. Only electrical and mechanical functions are included. Vehicle failures are not included. To the extent that it is applicable, data samples begin with the Mural Program, M-7 system. As a result, most of the Mural Program and all of the "J" Program data are included. All estimates are adjusted to the 50 percent confidence level. Adjustments have also been made to reflect the increased operational requirements that existed at the end of the program. For example, the total combined on-orbit reliability estimate for a four-day mission segment, as used during the early "J" program, would be 96.02 percent. The corresponding item in the following tabulation is 93.88 percent, but is based on a nine and one-half day average mission segment.

System Function	Sample Size	Failures	Estimated Reliability
Panoramic Cameras	1,698,000(cycles)	5	98.02%
Panoramic Camera Doors	164 (segments)	0	99.58%
Command and Control	19680 (hours)	2	96.95%
Clocks	19680 (hours)	0	99.20%
Combined on-orbit functions	-	-	93.88%
Recovery systems	135 (segments)	1	98.75%
Horizon Cameras	134,000 (cycles)	0	99.43%

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