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op 3444

VWZE 4-2-01

LAUNCH REPORT

LV-2A/389 SS-01A/1174

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Vandenberg Air Force Base, California

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PREFACE

This report presents the launch evaluation and detailed analysis of the launching of LV-2A, 389 and SS-01A, 1174 from Vandenberg Air Force Base, California. The report was prepared by the Evaluation Office, Deputy for Space Systems, 6595th Aerospace Test Wing, under the technical cognizance and concurrence of the Lockheed Missile and Space Company Flight Test Evaluation Staff. This report replaces the Launch Report normally published by Lockheed Missiles and Space Company for the Aerospace Test Wing.

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SECTION I

LAUNCH SUMMARY

Launch Code Name: Garden Party
PMR Operations Number: 3444

A. A space vehicle consisting of LV-2A Booster No. 389 and SS-01A orbital stage No. 1174 was launched on the first attempt from Vandenberg AFB, California, launch complex 75-3, pad 4, at 1338:23.10 PST on 15 February 1964.

B. The nominal launch objectives were to place the payload in orbit with a 100 nautical mile perigee, a 234 nm apogee and with an inclination angle of 75 degrees. The orbit achieved had a perigee of 101.1 nm, an apogee of 248.4 nm, and an inclination angle of 74.98 degrees.

C. The 575 minute countdown was initiated at 0355 PST and proceeded without interruption to T-15 minutes (1315 PST) when an eight-minute hold was imposed because of train traffic.

D. Liftoff was normal and all aspects of the ascent trajectory were near nominal.

E. All first and second stage booster systems performed satisfactorily. The first stage solid motor burn time and jettison were normal. LV-2A main engine cut-off (MECO) was normal and resulted from guidance command. SS-01A separation was normal. The SS-01A thrust phase was normal. However, due to a slow shutdown of the SS-01A engine, the injection velocity was slightly greater than that required for the specified orbit.

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SECTION II

Conclusions and Recommendations

A. CONCLUSIONS.

1. The booster was successfully counted down and launched. The performance of Stage I subsystems were normal.

2. An abnormally slow SS-01A shutdown is attributed to: (a) a malfunctioning fuel valve or (b) a malfunctioning pilot operated solenoid valve. The result was a 22 fps excess post-shutdown velocity gain. The fuel valve was 15 months old when installed at LMSC, Sunnyvale. A new pilot operated solenoid valve was installed at LMSC/VAFB. The only previous anomaly of this nature in the last fourteen vehicles occurred on vehicle 1169; this was also the only other vehicle of the previous fourteen which had a replacement solenoid valve installed at LMSC/VAFB. (See Section V, B.)

3. There were large current transients at start of separation and during ullage rocket burn. (See Secion V, C.)

4. Data indicated that the transducer range for the Gyro Block temperature was not high enough. (See Section V, E.)

5. The Program Test Operations Order stated that links 3 and 4 should be measured during launch while the originator intended it to be a prelaunch check only. (See Section VI, I.)

B. RECOMMENDATIONS.

1. Recommend LMSC investigate and determine -

   a. Effective fuel valve shelf life.

   b. Effects of solenoid valve installation techniques on valve operation.

[redacted]

[redacted]

B. RECOMMENDATIONS. (Continued)

2. Recommend LMSC continue to investigate the cause of short circuits at separation and the possibility of installing switching circuitry to remove power from ullage rockets after ullage thrust terminations; also consider possible lead placement or shielding change to correct this malfunction.

3. Transducers be selected so that critical parameter readings would still be within the range of calibration.

[redacted]

SECTION III

Launch Evaluation

A. LAUNCH OBJECTIVES vs RESULTS ATTAINED

The objectives listed below are for the checkout and ascent phase of the test. The orbit phase lies beyond the scope of this report. A complete listing of the objectives can be found in the Systems Test objectives (STO) for Program 162, document number LMSC-B001081-A.

TABLE 1

Launch Objective Attainment

Objective	Results	Comment
Primary Test Objectives		
1. Place payload in desired orbit	Achieved	
2. Secure Telemetered data for evaluation	Achieved	Agena fuel pump inlet pressure not obtained
3. In order to achieve the primary objectives it is mandatory that the 162 System shall provide or demonstrate the following capabilities:		
a. 162 Booster		
(1) Attain correct position at MECO	Achieved	

[redacted]

TABLE 1 (Continued)

Launch Objective Attainment

Objective	Results	Comment
(2) Attain correct velocity direction at MECO	Achieved	
(3) Attain correct velocity magnitude at MECO	Achieved	
(4) The BTL guidance system must maintain correct guidance and functional commands to the vehicle	Achieved	
b. SS-01A Airframe and Adapter		
(1) Withstand guidance maneuvers and flight environment	Achieved	
(2) Provide compatibility between booster and satellite stages	Achieved	
c. SS-01A Propulsion System		
(1) Proper retro-rocket operation	Achieved	
(2) Obtain impulse for orbital velocity	Achieved	22 fps excess post-shutdown velocity gain

[redacted]

[redacted]

TABLE 1 (Continued)

Launch Objective Attainment

Objective	Results	Comment
(3) Control vehicle telemetry and S-band beacon operation	Achieved	
(4) Accept and act upon ground commands	Achieved	
g. Aerospace Ground Equipment		
(1) Check out booster and satellite stages	Achieved	
(2) Control, monitor and power the 162 satellite and booster during countdown	Achieved	
h. 162 System Facilities		
(1) Monitor vehicle functions to insure satisfactory flight	Achieved	
(2) Produce adequate telemetry records of inflight data	Achieved	
(3) Properly transmit and verify reception of all commands	Achieved	

[redacted]

[redacted]

[redacted]

TABLE I (Continued)

Launch Objective Attainment

Objective	Results	Comment
(4) Determine an orbit ephemeris	Achieved	
(5) Provide interstation and intrastation communications	Achieved	
Secondary Test Objectives		
5. The 162 personnel must demonstrate the capability to:		
a. Calibrate and operate system checkout equipment	Achieved	
b. Operate SS-01A and payload consoles and related equipment	Achieved	
c. Transport, check out, mate, fuel, and launch the 162 vehicle	Achieved	
d. Communicate within and between operating locations	Achieved	
e. Accomplish checkout, launch, orbital, and recovery, normal and emergency procedures	Achieved	

[redacted]

TABLE I (Continued)

Launch Objective Attainment

Objective	Results	Comment
6. Determine temperature of satellite structure and components	Achieved	
7. Execute specialized tests	Achieved	

[redacted]

B. COUNTDOWN.

1. Launch was accomplished on the second attempt for booster 389. Booster 389 was formerly mated with SS-01A/1170. The first countdown was aborted at 1130 PST, 20 Jan 64, in task 12, after umbilical disconnect was initiated prematurely by high winds and the loss of the vehicle's blanket at 1041 PST.

2. Because of second stage damage, another second stage vehicle, SS-01A/1174, was substituted. The second countdown was initiated at 0355 PST on 15 Feb 64, and proceeded to liftoff with one hold being imposed from 1315 to 1323 PST for range clearance (trains in the area.)

3. Task 3 (see appendix B for task breakdown) was delayed because the Douglas Aircraft Co. (DAC) destruct battery was not connected (R-1 day tasks were still in progress). In task 6, command 3 (item 117) was sent 20 seconds early so the sequence had to be recycled.

4. In task 4, the Lockheed Missile and Space Co. (LMSC) control gas trailer developed a leak in a regulator; therefore, a backup trailer was used. The fuel vent regulator ranged too high and had to be reset in task 16.

5. The terminal count proceeded to liftoff with no anomalies.

C. PAD DAMAGE.

Pad damage was normal for a LV-2A launch and pad turnaround time will not be affected.

D. FLIGHT ANALYSIS.

In the following summary of events, the times for command guidance sequences are derived from the SS-01A telemetry; other event times are derived from both the LV-2A and SS-01A telemetry and referenced to the receipt of the liftoff signal. Injection conditions and orbital parameters were obtained from guidance equipment printout and observation of orbital passes, respectively.

[redacted]

TABLE 2

Significant Events

Item	Predicted	Actual
Liftoff		
System Time		77903.10
PST		1338:23.10
Solid Motor Burnout		
Web Burnout (Mean)	27.00	28.08
Thrust Termination (Mean)	40.00	41.50
Solid Motor Jettison (Mean)	65.00	65.03
Begin LV-2A Steering	92.00	92.41
End LV-2A Steering	144.85	143.97
MECO (S1 Command)		147.50
MECO	148.85	147.58
VECO	157.85	156.52
Separation (S2 Command)	161.85	160.94
Separation Complete	164.35	163.44
Ullage Rocket Ignition	166.85	165.39
SS-01A Ignition	169.85	168.39
SS-01A Thrust Attainment (90% P_c)	171.15	169.54

TABLE 2 (Continued)

Significant Events

Item	Predicted	Actual
Begin SS-01A Steering	179.85	180.05
End SS-01A Steering	353.88	352.41
Enable Velocity Meter	355.38	354.97
SS-01A Engine Shutdown Command	414.25	414.14
VTS Verlort Radar Loss		404 sec
VTS Telemetry Data Fade (Link 1)		441 sec
VTS Telemetry Data Fade (Link 2)		449 sec

[redacted]

TABLE 3

Injection Conditions

Parameter	Unit	Predicted	Guidance Evaluation	Actual
Injection Altitude	nm	100.060	101.369	101.09
Flight Path Angle	deg	-0.001	+0.0092	Not Available
Period	min	90.686	90.681	90.862
Inclination Angle	deg	75.00	74.988	74.98
Inertial Velocity	fps	25811.814		25,833

TABLE 3A

Orbital Parameters

Parameter	Unit	Predicted	Actual
Apogee Altitude	nm	234.65	248.39
Perigee Altitude	nm	100.50	101.09
Eccentricity	deg	0.018614	0.02037
Period	min	90.67	90.862
Inclination Angle	deg	75.00	74.98

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E. COMMAND GUIDANCE SYSTEM.

1. General - The command guidance system performed satisfactorily during ascent to fulfill primary objectives. During active guidance, the vehicle responded normally to the steering orders transmitted by the command guidance system and the desired trajectory was achieved. All commands were transmitted within specified time tolerance and no beacon transmitter pulse dropouts occurred during guidance participation.

2. Guidance -

a. Command guidance of the LV-2A vehicle was initiated at T+92.41 seconds. The first steering orders were yaw-right and pitch-down of maximum amplitude, reducing to moderate amplitude after 5 seconds of steering correction. Termination of booster guidance was at T+143.97 seconds. MECO was effected by the guidance command S1 at T+147.50 seconds.

b. Separation of the SS-01A from the booster was initiated by the guidance command S2 at T+160.94 seconds. The inertial reference gyros, after uncaging at T+156.52 seconds, produced proper signal outputs to the flight control system and provided short term attitude references. Second stage telemetry data shows that steering began at T+180.04 seconds with very light pitch-up and yaw-left orders. Steering remained extremely light until termination at T+352.41 seconds. The final guidance command S3 enabled the velocity meter at T+354.97 seconds. Table 2 summarizes the pertinent guidance system event times.

c. During an evaluation phase immediately following the S3 command, the guidance equipment computed certain injection conditions and orbital parameters that should result, based on trajectory dispersions from nominal values at the time of the evaluation. The evaluation results are compared with predicted and actual values in Table 3.

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SECTION IV

LV-2A SYSTEMS ANALYSIS

A. AIRFRAME.

1. Environmental Conditions.

a. Structural Loading - All transient and steady state loads were normal for a TAT vehicle. Maximum acceleration was 6.44g's occurring at MECO and the maximum combination loading due to acceleration plus vibration was 6.92g's at T+136.5 seconds.

b. Vibrations - 17 to 20 cps structural oscillations occurred from T+120 to T+143 seconds. Maximum peak-to-peak amplitude was 3.7g's at T+136.5 seconds. All vibrational measurements were within specified limits.

c. Skin and Internal Temperatures - All skin and internal temperatures monitored during the ascent flight were normal.

d. Pressures - All tank pressures were within limits.

2. Functional Conditions.

a. Separation - Refer to Section V, A-3a.

b. Solid Motor Jettison - The separation process was initiated by the booster programmer command at T+65.03 seconds. Satisfactory separation was evidenced by Sequence II, channel 10 of the LV-2A telemetry.

B. PROPULSION.

1. System Designations. The propulsion systems in this flight consisted of a Rocketdyne YLR 79-13 liquid propellant main engine with baffled injector, two LR 101-11 vernier engines, and three Thiokol model TX 33-52 solid propellant motors.

2. Main Engine Performance.

a. Start Sequence - The start sequence was nominal. See Table 4 for start sequence event times.

[redacted]

[redacted]

b. Events - Fuel and LOX float switch actuation occurred at T+137.18 and T+140.91 seconds respectively. Main engine cutoff (MECO) occurred at T+147.58 seconds as a result of BTL command.

c. Propellant Utilization - The residual propellants at MECO were 440 pounds of LOX and 300 pounds of fuel. Propellant consumption based on total fuel and LOX remaining in the tanks was 99.3 percent.

d. Pressurization and Propellant Supply - The pressurization and propellant supply systems performed satisfactorily during flight.

e. Thrust Chamber Performance -

(1) Chamber Pressure - Main engine chamber pressure was satisfactory during flight. 17 to 20 cycle per second vibrations were recorded from T+120 to T+143 seconds with an approximate 25 psia peak-to-peak level at T+137.5 seconds.

(2) Flow Rates - The fuel and LOX average flow rates from liftoff to float switch actuation were 217.73 and 457.85 pounds per second respectively; from float switch actuation to MECO they were 217.08 and 412.85 pounds per second. This is normal because of the decreasing oxidizer flow rate history.

(3) Mixture Ratio - The average mixture ratio from liftoff to float switch actuation was 2.11.

(4) Thrust - Thrust was determined from chamber pressure data. Total and main engine thrust were 354,100 and 182,800 pounds respectively.

f. Table 5 lists power plant parameters, expected values at T+25 seconds, actual values and times of occurence.

3. Vernier Engine Performance.

a. VECO occurred at T+156.52 seconds. This was 9.02 seconds after MECO command as controlled by the vernier engine timer.

b. The start sequence was nominal. See Table 4 for event times.

c. Thrust Chamber Performance -

(1) Vernier engine chamber pressure was higher than the expected value. Thrust was determined from chamber pressure data.

[redacted]

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(2) Vernier engine thrust at T+25 seconds was 1,100 pounds per engine. Although only vernier engine number two was being monitored, it is assumed as a result of normal operations that number one produced the same thrust.

4. Solid Motor Performance. Solid motor performance was satisfactory.

a. Average times for significant parameters -

(1) Web Burnout - 28.08 seconds

(2) Solid Motor Thrust Termination - 41.50 seconds

(3) Solid Motor Jettison - 65.03 seconds

b. Solid Motor Thrust at T+25 seconds -

(1) SM #1 - 55,400 pounds

(2) SM #2 - 57,600 pounds

(3) SM #3 - 56,100 pounds

5. Overall Evaluation of System Performance. Performance of the propulsion system was satisfactory throughout the flight.

[redacted]

TABLE 4

Engine Start Sequence

Channel	Event	Time (Sec)
	Propellant transfer complete	0.000
2	Start tanks pressurizing signal	9.490
3	Missile tanks pressure switches pick-up	10.089
4	Vernier engine ignition signal	10.095
7	Vernier engine lock-in signal	10.100
15	Lox valve control signal	10.100
8	Vernier engine propellant valve control signal	10.101
19	Gas generator igniters firing signal	10.107
11	Vernier engine #2 propellant valve leaves closed position	10.151
16	Main lox valve leaves closed position	10.170
9	Vernier engine #1 propellant valve leaves closed position	10.182
17	Main lox valve arrives at open position	10.233
10	Vernier engine #1 propellant valve arrives at open position	10.262
12	Vernier engine #2 propellant valve arrives at open position	10.272
20	Gas generator ignition links broken	10.485
18	Main engine ignition detector links broken	10.590

TABLE 4 (Continued)

Engine Start Sequence

Channel	Event	Time (Sec)
13	Vernier engine fuel injector pressure switches picks up	10.670
39	Main fuel tank pressurizing	10.680
21	Gas generator blades and main fuel valve control signal	10.681
24	Gas generator blade valve leaves closed position	10.725
25	Gas generator blade valve arrives at open position	10.740
22	Main fuel valve leaves closed position	10.814
23	Main fuel valve arrives at open position	10.940
	Liftoff	11.568

TABLE 5

Values of Selected Parameters

Parameter (units)	Time From Liftoff (in seconds)	Expected Value (at 25 seconds)	Measured Value
Vernier Engine #2 Chamber Pressure (psia)	-2		16
	5		356
	25	355	368
	100		362
	147		326
(SOLO)	153		300
	160		16
Main Engine Chamber Pressure (psia)	-2		18
	5		590
	25	598	604
	100		575
	147		549
	160		4
Fuel Pump Inlet Pressure (psia)	-2		57
	-0.53		30
	5		61
	25	54	55
	100		42
	147		65
	160		10
LOX Pump Inlet Pressure (psia)	-2		58
	5		57
	25	62	60
	100		43
	147		39
	160		31

TABLE 5 (Continued)

Values of Selected Parameters

Parameter (Units)	Time From Liftoff (in seconds)	Expected Value (at 25 seconds)	Measured Value
LOX Pump Inlet Temperature (°F)	-2		-291.2
	5		-293.2
	25		-293.2
	100		-288.0
	147		-282.8
	160		-281.8
Hydraulic Supply Pressure (psia)	-2		3015
	5		3180
	25	3200	3115
	100		3100
	147		3100
	160		2330
Hydraulic Return Pressure (psia)	-2		106
	5		53
	25	50 to 90	53
	100		79
	147		79
	160		89
Turbopump Speed (rpm)	-2		0
	5		6220
	25	6240	6350
	100		6260
	147		6050
	160		75

TABLE 5 (Continued)

Values of Selected Parameters

Parameter (Units)	Time From Liftoff (in seconds)	Expected Value (at 25 seconds)	Measured Value
Turbine Inlet Temperature (°F)	-2		70
	5		1140
	25	1200	1160
	100		1130
	147		1070
	160		790
Fuel Tank Top Pressure (psia)	-2		41
	5		34
	25	24	22
	100		11
	147		9
	160		9
LOX Tank Top Pressure (psia)	-2		48
	5		39
	25	43	42
	100		33
	147		33
	160		33
Solid Motor #1 Chamber Pressure (psia)	-2		12
	5		488
	15		482
	25	510	492
	28.1		496
	45		3

TABLE 5 (Continued)

Values of Selected Parameters

Parameter (Units)	Time From Liftoff (in seconds)	Expected Value (at 25 seconds)	Measured Value
Solid Motor #3 Chamber Pressure (psia)	-2		19
	5		498
	15		490
	25	510	498
	28.08		505
	45		13
Solid Motor #2 Chamber Pressure (psia)	-2		23
	5		502
	15		497
	25	510	510
	27.76		510
	45		14
Gas Generator Lox Injector Pressure (psia)	-2		-5
	5		635
	25	650	643
	100		643
	147		623
	160		-13

[redacted]

C. ELECTRICAL.

All first stage electrical equipment operated satisfactorily. The missile battery voltage was 30 volts before liftoff. It dropped to 27.2 at ignition of the solid motors and recovered in 1.5 seconds to 29 volts and remained above this value for the remainder of the booster phase. The missile 400 cps inverter voltage level was about 112.6 volts at liftoff. For the first 15 seconds after liftoff, data indicated the inverter output fluctuated approximately once per second with an excursion of about 1 volt. These surges reached a maximum of 113.6 volts. The 112.6 volt output value gradually rose to about 113.0 volts at MECO. Telemetry battery voltage was 27.6 volts throughout the flight. Actuator potentiometer positive and actuator potentiometer negative were about 25.4 and 25.3 volts respectively. Both actuator voltages reflect the voltage fluctuations that appear in data for the missile inverter voltage. (See Table 6)

D. FLIGHT CONTROL.

Performance of the control system was satisfactory. Liftoff transients were small. Thrust misalignments at liftoff were -0.02 degrees in pitch and -0.05 degrees in yaw. Roll moment caused by solid motor misalignment was 538 foot pounds counterclockwise. Maximum main engine deflections during the period of highest aerodynamic load were -0.8 degrees in pitch and +1.35 degrees in yaw. Maximum attitude errors after initiation of BTL guidance were +1.5 degrees in pitch, -1.5 degrees in yaw and +0.3 degrees in roll; maximum attitude rates were -1.0 deg/sec in pitch, +2.15 deg/sec in yaw, and negligible in roll. Thrust misalignments at MECO were -0.06 degrees in pitch and -0.04 degrees in yaw. Attitude errors at SS-01A gyro uncage were +0.4 degrees in pitch, +0.1 degrees in yaw and negligible in roll. Attitude rates at SS-01A separation were $\pm$0.1 deg/sec in pitch and negligible in yaw and roll. Twenty cycles per second oscillations were apparent in the yaw and roll rate data from T+125 to T+142 seconds. All programmer events were executed satisfactorily in both value and time.

[redacted]

[redacted]

TABLE 6

LV-2A Electrical Summary

Component	Liftoff	Jettison Solids	Steering Initiated	MECO	Separation
Missile Battery Voltage	30/27.2v	29.1v	29.3v	28.7v	28.8v
Telemetry Battery Voltage	27.6v	27.6v	27.6v	27.6v	27.6v
Actuator Pot Positive	25.4v	25.4v	25.4v	25.3v	25.5v
Actuator Pot Negative	-25.3v	-25.3v	-25.3v	-25.3v	-25.2v
Control Inverter 400cps	*112.6/113.6v	112.7v	112.6v	113.0v	112.8v
5 Volt absolute	5.0v	5.0v	5.0v	5.0v	5.0v
Instrumentation Ground	0v	0v	0v	0v	0v

*Surges at a little less than one cycle per second for the first 15 seconds of flight.

[redacted]

E. HYDRAULICS/PNEUMATICS.

The hydraulic/pneumatic systems functioned properly throughout the flight. No leaks were detected.

F. INSTRUMENTATION.

Instrumentation returned satisfactory data for all monitored functions. Valid data was also received from special temperature sensors installed in the engine section and transition section.

G. AEROSPACE GROUND EQUIPMENT.

The aerospace ground equipment concerned with the first stage satisfactorily supported checkout and launch of the vehicle.

SECTION V

SS-01A System and Analysis

A. SPACEFRAME.

The environmental and functional performance of the spaceframe was satisfactory throughout the ascent phase.

1. Environmental Conditions.

a. Structural Loading - All transient and steady state loads were normal for a TAT vehicle. Refer to Section IV, A-2a.

b. Vibrations - All vibration loads were normal. Refer to Section IV, A-2b for maximum longitudinal vibrations. Maximum oscillations in the "Y" Axis (yaw) with a peak-to-peak amplitude of 2.22g's and frequency of 49 cps occurred at T+414.5 seconds.

c. Temperatures - All vehicle skin, structural, and component temperatures were normal throughout the ascent phase. A maximum nose fairing temperature of 250°F was reached at T+150 seconds.

d. Pressures - All vehicle pressures were normal during the ascent phase.

2. Functional Conditions.

a. Pyrotechnic - All critical pyrotechnics functioned satisfactorily.

b. Separation - Clean, complete separation occurred at T+163.44 seconds with a separation time of 2.5 seconds. Satisfactory separation was evidenced by the gas valve current.

c. Alignment - All alignments were within limits except for the SS-01A turbine exhaust duct misalignment of approximately 18.9 min (specification ± 15 min). The degree of misalignment is minor compared to most previous SS-01A vehicles.

[redacted]

B. PROPULSION.

1. System Designation. The SS-01A propulsion system used in this flight consisted of a USAF Model XLR81-BA-9 rocket engine. The pressurization system utilized a 900 cubic inch storage sphere. There was one burn period.

2. System Performance. The SS-01A vehicle performed satisfactorily to achieve orbit. However, an excess post shutdown velocity gain appears to be responsible for a somewhat higher-than-expected energy level of the final orbit. This conclusion is substantiated by orbital data.

a. Events - The SS-01A engine was ignited at T+168.39 seconds, reached thrust attainment at T+169.54 seconds, and was shut down by velocity meter command at 414.14 seconds.

b. Pressurization System - The helium pressurization system operated satisfactorily during engine operation. The helium bottle pressure was 3092 psig at ignition and nearly zero at shutdown.

c. Transients - The start transient was normal. Fuel valve and pressure switch actuations occurred 0.95 and 1.15 seconds after main power relay, respectively. The shutdown signal occurred 245.75 seconds after ignition, and 244.60 seconds after thrust attainment. The shutdown transient was slow in that a post shutdown velocity gain of 22 fps above expected was encountered. The problem is ascribed to a malfunction of either the fuel valve or the pilot operated solenoid valve. The latter is de-energized at shutdown, thereby stopping fuel pressure to the opening side of the fuel valve. While contamination or obstruction in the pilot operated solenoid valve is a plausible cause for the slow shutdown transient, the valve was new when installed on the vehicle. The fuel valve, on the other hand, was 15 months old. Conclusions and recommendations for this malfunction are give in Section II.

d. Thrust Chamber Operation - Steady state average chamber pressure was 505.9 psia. Propellant flow rate during steady state operation was 54.59 lb/sec. Average thrust during steady state operation was 15,978 lb.

[redacted]

e. Specific Impulse - Specific impulse, as determined from velocity meter data by the inverse acceleration method, was 291.36 seconds. The value determined from statistical correlation of acceleration, chamber pressure, and turbine speed data was 292.7 seconds.

f. Data Summary - Performance of the propulsion system is summarized in Table 7.

TABLE 7

Propulsion System Performance

Parameter	Actual	Expected
Average Thrust (lb)	15978	15973
Average Chamber Pressure (psia)	505.9	505.8
Average Flow Rate (lb/sec)	54.59	54.61
Average Oxidizer Flow Rate (lb/sec)	39.19	39.21
Average Fuel Flow Rate (lb/sec)	15.40	15.40
Average Mixture Ratio	2.545*	2.545
Specific Impulse (sec)	292.7	292.5
Oxidizer Tank Pressure (psig)		
Liftoff	32.1	30
Shutdown	9.2	10
Fuel Tank Pressure (psig)		
Liftoff	39.4	38
Shutdown	9.7	13

TABLE 7 (Continued)

Propulsion System Performance

Parameter	Actual	Expected
Helium Supply Pressure (psig)		
Liftoff	3044	3000
Shutdown	≈ 0	≈ 0
Burn Duration (sec)	244.60	243.15
Post Shutdown Velocity Gain (ft/sec)	48	26
Propellant Residual at Shutdown Signal (lb)	114	189

*Based on expected value.

[redacted]

C. ELECTRICAL.

1. The SS-01A vehicle electrical system performance was satisfactory to accomplish the launch phase of the flight. Missile battery voltage was within specifications and had a maximum of about one volt drop during a current surge at the T+160.94 seconds separation command. The current surge at the separation command (LV-2A from SS-01A) was a 300 milli-second in duration reaching a peak of about 54 amperes. Data indicated a possible pyrotechnic bus to pyrotechnic return short circuit. No other equipment is known to have malfunctioned at this time.

2. A second current surge occurred just after separation was complete. This was a 180 milli-second surge of two pulses reaching 47 amperes maximum. With this surge, there was about a 0.5 volt drop in the missile battery voltage reading. The project office determined that at this time this was a normal payload power requirement; therefore, a normal current surge.

3. A third high current drain occurred during the ullage rocket burn period and reached 28 amperes maximum total current. This current drain was characteristic of that normally associated with ullage rocket igniter shorts.

TABLE 8

SS-01A Electrical Summary

Component	Liftoff	MECO	Separation	Ignition	Steering Terminated	Shutdown
+28 VDC Supply Unregulated	27.2v	27.0v	1 v drop 26.7/25.7	26.5v	26.5v	26.5v
+28 VDC Supply Regulated	28.3v	28.3v	28.4v	28.4v	28.3v	28.3v
-28 VDC Supply Regulated	-28.2v	-28.2v	-28.2v	-28.2v	-28.2v	-28.2v

[redacted]

[redacted]

TABLE 8 (Continued)

SS-01A Electrical Summary

Component	Liftoff	MECO	Separation	Ignition	Steering Terminated	Shutdown
+28 VDC Current Monitor	19.0 amps	19.0 amps w/surge to 23.6 amps	*Large current surges	18 amps increasing to 28 amps	24 amps	21 amps
+28v Pyro Bus	28.6v	28.6v	28.4v	28.1v	28.1v	28.1v
28 VDC Reg DC/DC Converter	28.0v	28.3v	28.0v	28.1v	28.3v	28.0v
400 CPS 1 Phase Power Ampl	117.0v	117.0v	117.3v	117.7v	117.0v	117.0v
400 CPS 3 Phase Inverter #1	116.3v	117.4v	116.8v	117.5v	116.3v	116.3v
Inverter Type 1A No. 1 D/P	108.1v	106.1v	106.1v	107.6v	107.8v	107.8v
400 CPS 3 Phase Bus Phase AB	116.3v	116.3v	116.3v	116.7v	116.3v	116.3v

* There were large current surges at separation command and again at separation complete. A two-pulse current surge at separation complete lasted a total 180 milli-seconds and reached a peak value of 47 amperes. The other surge was at separation command and lasted about 300 milli-seconds and reached approximately 54 amperes maximum.

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D. FLIGHT CONTROL.

1. General. Available data indicates that the second stage guidance and control system performed satisfactorily during ascent, providing proper responses to ground guidance commands, attitude and velocity control, and sequencing of inflight events.

2. Attitude Control. The inertial reference package gyros, operating in the caged mode, sensed changes in attitude throughout first stage powered flight. After uncaging at VECO, T+156.52 seconds, the gyros began indicating second stage deviations about the inertially referenced gyro input axis triad. Transients resulting from stage I/II separation, ullage rocket ignition and pitch programming were negligible and normal recoveries were experienced. At second stage engine ignition, T+168.39 seconds, the induced transients resulted in the following maximum excursions of gyro demodulator outputs and engine gimbal positions:

Pitch Demodulator	-1.24 degrees
Yaw Demodulator	+1.52 degrees
Roll Demodulator	3.50 degrees
Pitch Engine Gimbal Angle	-1.19 degrees
Yaw Engine Gimbal Angle	-1.02 degrees

After damping of the initial engine ignition transients, the control system stabilized in pitch and yaw with the following offsets due to the normal thrust vector misalignments:

Pitch Demodulator	+0.25 degrees
Yaw Demodulator	+0.35 degrees
Pitch Gimbal Angle	+0.64 degrees
Yaw Gimbal Angle	-0.59 degrees

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