FLIGHT HISTORY

AS-501 (APOLLO 4)

The first Apollo/Saturn V launch vehicle, the AS-501, performed all of its vehicle mission objectives. The vehicle was launched at 7 a.m. EST on November 9, 1967 from Launch Complex 39 at the NASA-Kennedy Space Center, Fla. The countdown proceeded smoothly and the launch came exactly on time. All vehicle systems and subsystems performed "nominally" and ground support equipment performance was satisfactory.

Prime mission objectives, with respect to the rocket, included an all-up test of the vehicle with its three stages and instrument unit, the first in-orbit restart of the third (S-IVB) stage, and the first use of Launch Complex 39 and ground support equipment.

Flight of the three stages was near nominal. The trajectory was near the expected and all three propulsion systems performed with no apparent anomalies. The instrument unit systems were all stable during the flight.

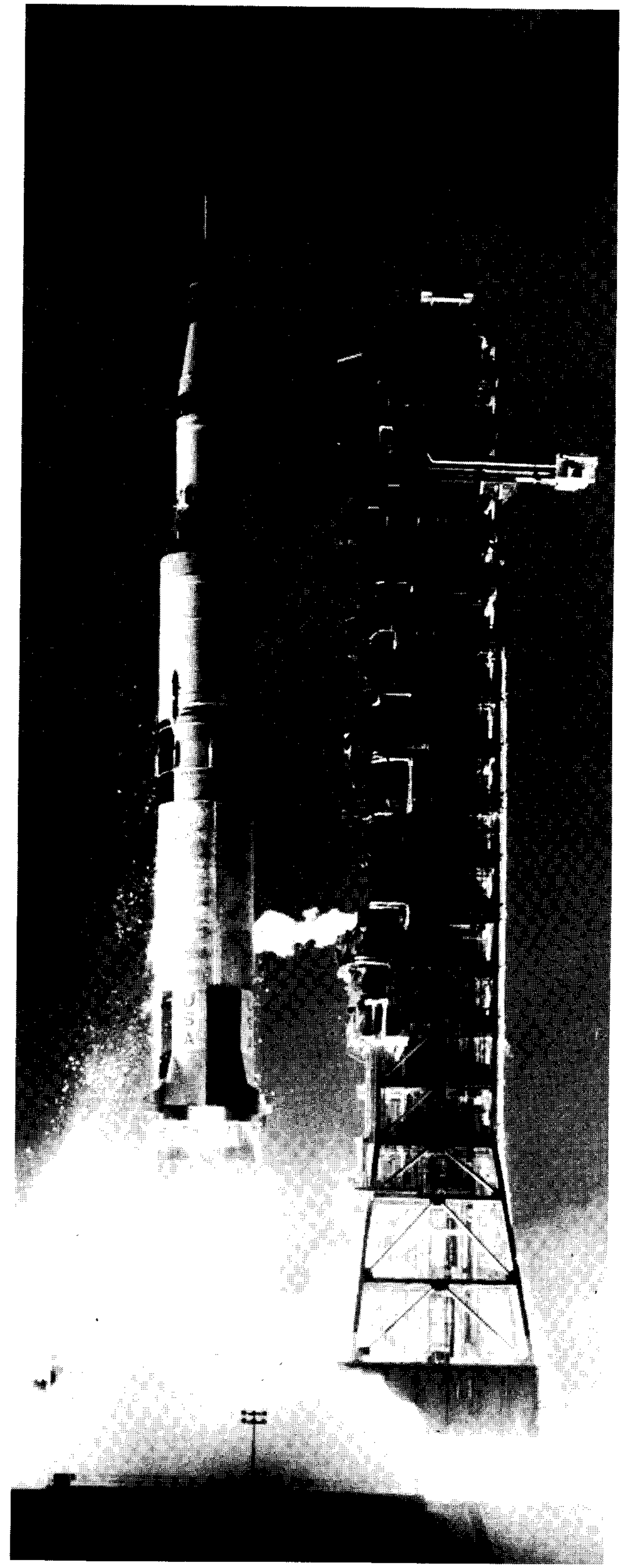
First (S-IC) stage flight was near the expected. S-IC center F-1 engine cutoff was given by a timer at 135.5 seconds. S-IC outboard engine cutoff came by liquid oxygen depletion at 150.8 seconds with the vehicle at 38.3 miles altitude traveling at 6,024.6 miles per hour. Booster and second (S-II) stage first and second plane separations each occurred within 1.2 seconds of the predicted times. Cameras on the S-II photographed a smooth separation.

Propulsion and other systems, including propellant utilization, the pressurization, and the pneumatic control pressure system, operated within expected tolerances.

The S-II engines, stage propellant utilization system, pressurization system, pneumatic control pressure system, camera ejection system, and the helium injection system operated properly and within expected tolerances.

All five J-2 engines operated properly during engine start and burn. Ground controllers noted that the thrust chamber jacket temperature heat-up rate was slightly higher than predicted, and the engine start bottle pressures were slightly higher than predicted but both were within required limits. S-II stage cutoff came at 519.8 seconds, 3.5 seconds later than predicted. The S-II stage's liquid hydrogen tank insulation performed satisfactorily with no defects noted during countdown or in flight.

The third (S-IVB) stage first and second burns were 6.2 seconds longer and 15.2 seconds shorter,



B-P42396

Apollo 4 (AS-501)Launch, November 9, 1967 respectively, than predicted. The first burn began at 520.7 seconds. The J-2 engine was cut off by the guidance system at 665.6 seconds. This was 9.6 seconds later than expected. The vehicle was traveling 17,428.2 miles per hour and was at an altitude of 118.6 miles.

The S-IVB was reignited over the eastern United States after two revolutions in earth orbit. The second burn operation was cut off by guidance and was 15.2 seconds shorter than predicted, which was attributed primarily to 37 seconds of burn time at the high thrust level operation of the J-2 engine during second burn. A low liquid hydrogen ullage pressure reading was recorded at the Kennedy Space Center immediately before J-2 engine restart. The reading was 28 pounds and the expected minimum pressure was 31 pounds. This had no effect on engine operation.

The pressure in the helium repressurization spheres was apparently lower than expected during S-IVB restart preparations but reignition was achieved without difficulty.

Hydraulic systems on all three stages performed without evidence of out-of-tolerance conditions. Maximum engine deflection was 0.6 degree on the S-IC and 0.8 degree on the S-11.

Structurally, the Saturn V vehicle performed with no problems. Maximum bending occurred between 70 and 80 seconds. Longitudinal loads were near nominal throughout flight, and longitudinal acceleration at S-IC center engine cutoff was 4.15 G, which was very near the expected value.

The instrument unit on this flight was the first to be flight tested since an external structural stiffener was added to reduce vibration effects on the inertial platform. Vibrations in the area were lower than those on previous flights of the Saturn IB. The instrument units on the Saturn IB and Saturn V are essentially the same.

Telemetry taken during the first 560 seconds of powered flight showed guidance and control to be nominal.

The emergency detection system was flown "open loop" on this flight. All indications were that the system operated satisfactorily. The EDS was developed for the manned Apollo flights so that astronauts and ground controllers could know of impending troubles in the rocket in time to take corrective action.

Apollo 4 experienced only a few measurement failures. Two known measurement failures and 40 questionable measurements were identified out of the approximately 2,862 taken on the flight. This is a loss of less than two per cent.

Both onboard cameras viewing first and second stage separation recorded excellent quality pictures. The cameras were recovered shortly after being ejected into the Atlantic Ocean.

AS-502 (APOLLO 6)

The second Saturn V launch vehicle, AS-502, was not totally successful although it achieved most of its objectives and placed more than 264,000 pounds into earth orbit. The vehicle was launched from Complex 39 at the NASA-Kennedy Space Center on April 4, 1968. The launch occurred on schedule at 7 a.m. EST after a smooth countdown.

The first (S-IC) stage performed as planned and hydraulic system performance was satisfactory. Stage thrust was essentially the same as predicted during the first portion of the flight. However, a longitudinal oscillation ("Pogo" effect), measured at five cycles per second, was experienced during the latter portion of first stage burn. The phenomenon was also noted on the first Saturn V flight, AS-501, but on AS-502 it was much greater.

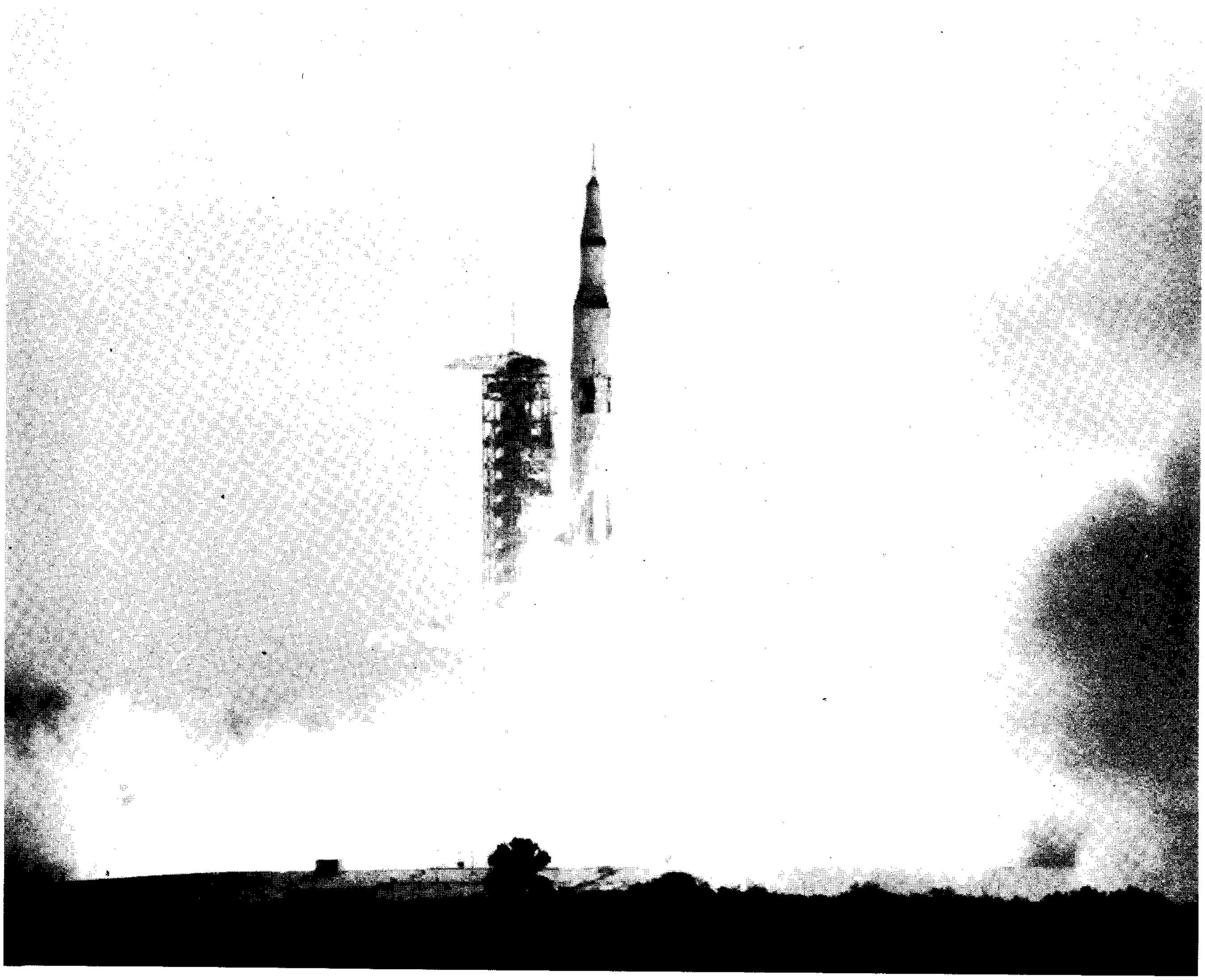
Second stage engines numbered 2 and 3 cut off prematurely at 408.7 and 410 seconds after liftoff, respectively, causing a 58-second longer than normal second stage burn and larger than expected deviations from second stage flight end conditions.

S-II performance was satisfactory through first stage boost, S-II ignition and the early portion of S-II powered flight. The earliest observed deviations were decreasing temperatures on the main oxidizer valve and its control line on engine number 5 and a steady increase in engine number 2 yaw actuator pressure, occurring at 278.4 seconds.

A sudden 5,000 pound thrust decrease and other deviations at 318 seconds preceded a cutoff signal to engine number 2. That cutoff signal also caused engine number 3 to shut down, because the wires carrying cutoff commands to engines numbered 2 and 3 were interchanged.

Hydraulic system performance was satisfactory on the second stage until about 140 seconds before premature shutdown of the two engines. At this time the increase in the yaw and pitch actuator differential pressures occurred.

First burn of the third (S-IVB) stage was 29.2 seconds longer than planned to compensate for the early cutoff of the two second stage engines. The result was a high cutoff velocity and an elliptical parking orbit. The attainment of this orbit was a demonstration of the unusual flexibility designed into the Saturn V.



Apollo 6 (AS-502)Launch, April 4, 1968

All engine and stage restart conditions appeared normal but the S-IVB's J-2 engine did not restart in orbit. The restart was to have propelled the S-IVB and Apollo spacecraft into a simulated trans-lunar trajectory.

The third stage performed satisfactorily through first burn and orbital coast. Shortly after orbit insertion a cold helium supply leak was observed but bottle pressure was sufficient to meet second burn requirements. Even though normal engine and stage prestart conditions were observed, the engine received the start signal and the engine valves opened properly, the engine did not reignite.

Study of data relating to the S-IVB reignition problem indicated a leak in one of the two propellant lines leading to the J-2 engine's augmented spark igniter (ASI). In such a case, propellants reaching the spark plugs were insufficient, or inadequate in mixture, to achieve the proper start conditions.

Third stage hydraulic system performance was normal through first burn. Shortly before spacecraft separation, a programmed command to initiate the auxiliary hydraulic pump was given but the pump failed to operate. Ground commands after spacecraft separation also failed to start the system. Pump operation was not a requirement for engine restart.

Guidance and other instrument unit functions were satisfactory. Flight profile was nominal up to the loss of engine number 2 on the second stage. At second stage cutoff the altitude was high and velocity low. This led to a longer burn of the third stage and a velocity slightly higher than normal, causing the third stage and spacecraft to go into an elliptical orbit.

Prior to launch 29 measurements were waived. During flight there were nine known failures and 19 questionable measurements of the approximately

2,800 measurements planned originally. Telemetry performance was good on all links.

Onboard television cameras gave good data. Only two of the six on-board film cameras were recovered. Both these cameras viewed the separation of the first and second stages.

A study of data relating to the failure of the number 2 J-2 engine on the second stage and the single J-2 on the third stage indicated that in each case a propellant line leading to the engine's augmented spark igniter (ASI) ruptured. Those lines have been redesigned to remove the flexible sections where the breaks occurred. The new lines have been tested and proven adequate with a sufficient safety margin. All J-2's in the future will use the new lines.

The oscillations in the first stage also prompted an extensive investigation which led to the decision to create "shock absorbers" in the large liquid oxygen (LOX) lines leading to four of the five F-1 engines. This was done by injecting helium into cavities in the existing LOX prevalves to damp out LOX surges.