VI. AGENA VEHICLE SYSTEM PERFORMANCE

VEHICLE STRUCTURE SYSTEM

by Robert N. Reinberger

Description

The Agena vehicle structure system (fig. VI-1) consists of four major sections: the forward section, propellant tank section, aft section, and the booster adapter assembly. Together they provide the aerodynamic shape, structural support, and environmental protection for the vehicle. The forward section is basically an aluminum structure with beryllium and magnesium panels. This section encloses most of the electrical, guidance, and communication equipment and provides the mechanical and electrical interface for the spacecraft adapter and shroud. The propellant tank section consists of two integral aluminum tanks, with a sump below each tank to insure the supply of propellants for engine starts in space. The aft section consists of an engine mounting cone structure and an equipment mounting rack. The magnesium alloy booster adapter section supports the Agena and remains with the Thorad after Thorad-Agena separation.

Performance

The measured dynamic environment of the structure system was within design limits. The maximum longitudinal oscillation (POGO effect at T + 209.14 sec), measured at Agena station 226 on the spacecraft adapter, was 3.91 g's (zero-to-peak). Longitudinal oscillation (POGO effect) data and other significant dynamic data are presented in appendix D.

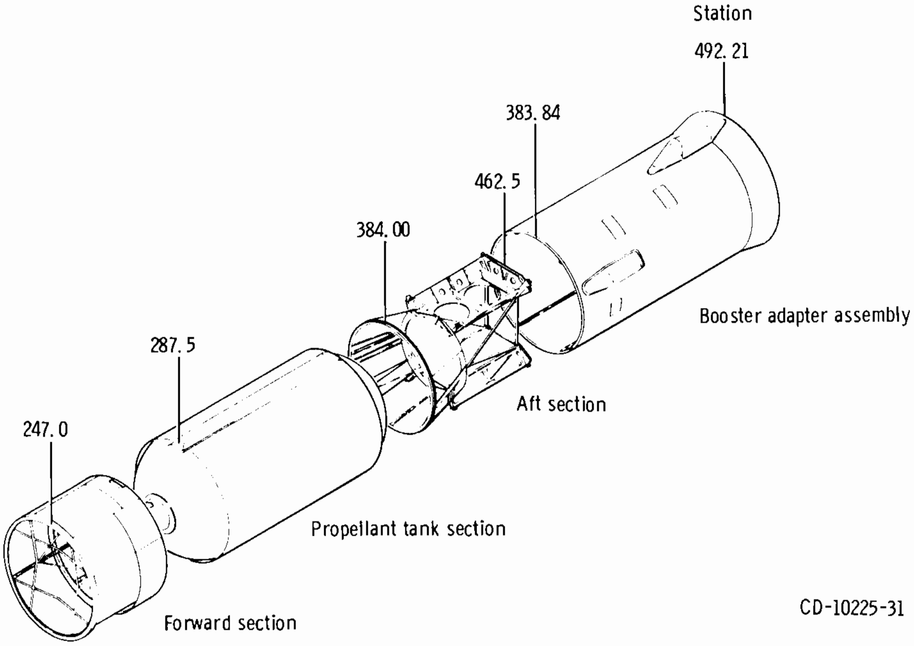

Figure VI-1. - Agena vehicle structure system, Nimbus III.

SHROUD SYSTEM

by Robert N. Reinberger

Description

The shroud system used for the Nimbus III flight was a standard Agena clamshell (SAC) shroud with minor modifications incorporated for this mission. It provides environmental protection for the spacecraft before launch and during ascent. The SAC shroud shown in figure VI-2 is 5.72 meters (18.78 ft) long and weighs 328 kilograms (723 lbm). It consists of an aluminum transition ring and two shroud halves. The two shroud halves form a fairing with a 1.65-meter (5.42-ft) diameter cylindrical section, a 15° half-angle conical section, and a 0.61-meter (2-ft) diameter, hemispherical nose cap. The shroud halves are constructed of laminated fiberglass strengthened by internal aluminum longerons at the split lines and semicircular frames. Microquartz thermal insulation blankets in the cylindrical section of each shroud half and foil covering in the conical section of each shroud half provide thermal protection for the spacecraft. The shroud halves are held together by a nose latch, two flat bands around the cylindrical section, and a V-band around the base of the cylindrical section. The top, middle, and bottom bands are tensioned to 22 250, 11 570, and 35 600 newtons (5000, 2600, and 8000 lbf), respectively.

The V-band clamps the shroud to the transition ring, which is approximately 0.051 meter (0.17 ft) high and is bolted to the forward end of the Agena. Both the shroud and the spacecraft adapter are attached to the transition ring. A metal diaphragm attached to the transition ring isolates the shroud cavity from the Agena. During ascent this cavity is vented through four ports, equipped with flappers, in the cylindrical section of the shroud.

Shroud jettison is commanded by the Agena timer 10 seconds after Agena engine first start. At this time, Agena electrical power is used to fire two pyrotechnic bolt cutters in the nose latch assembly and two explosive bolts in each of the three bands. The firing of one bolt cutter in the nose latch and one bolt in each of the bands will effect shroud separation. When the nose latch and the bands are released, two pairs of springs in each shroud half thrust against the transition ring and provide the energy to rotate each shroud half about hinges mounted on the transition ring. At the time of shroud separation, the Agena has a longitudinal acceleration of approximately 1 g. At this acceleration level, each shroud half rotates through an angle of about 75° before it leaves the hinges and falls free. The shroud separation springs provide sufficient energy to jettison the shroud halves at vehicle (Agena) longitudinal acceleration levels up to 3.5 g's.

The shroud system is instrumented with a single pressure transducer, which measures the differential pressure across the shroud diaphragm. This pressure transducer is located at approximately Agena station 247.0.

Performance

The history of the shroud diaphragm differential pressure ($\Delta P = P_{shroud} - P_{Agena\ forward\ section}$) is presented in figure VI-3. Shortly after lift-off the differential pressure became positive and increased to a value of 0.26 newton per square centimeter (0.37 psi) at the onset of the transonic phase of flight. During the transonic phase, the differential pressure became negative and decreased to a value of -0.61 newton per square centimeter (-0.89 psi). After the transonic phase, the differential pressure again became slightly positive, decreased to essentially zero at T + 177 seconds, and remained at that level for the remainder of the flight.

Shroud pyrotechnics were fired at T + 266.3 seconds, and the shroud was satisfactorily jettisoned. At this time the Agena roll and yaw rates were very nearly zero, and the pitch rate was at the programmed value. No measurable Agena roll or yaw rates or change in pitch rate developed as a result of shroud jettison.

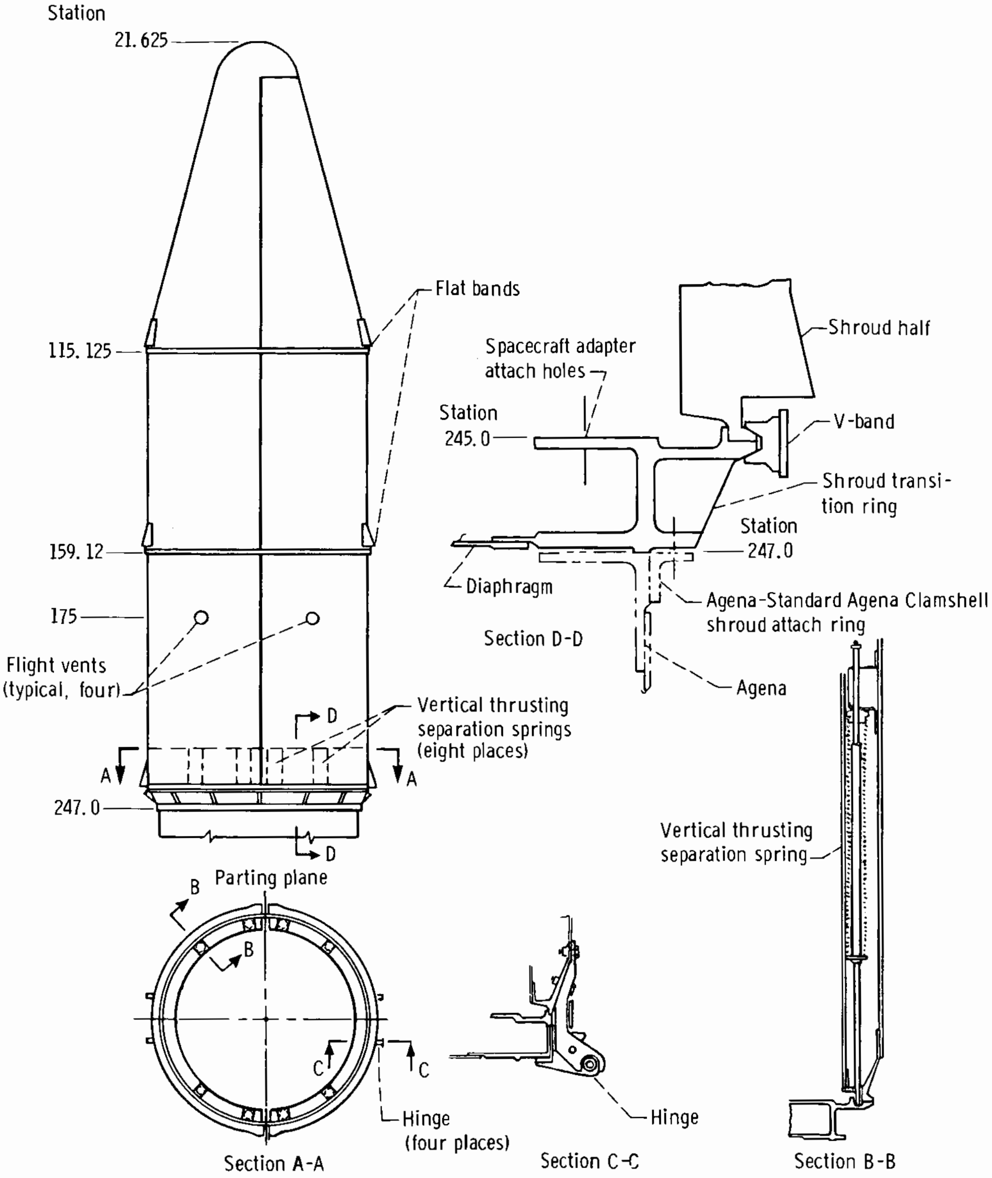

Figure VI-2. - Standard Agena Clamshell shroud, Nimbus III.

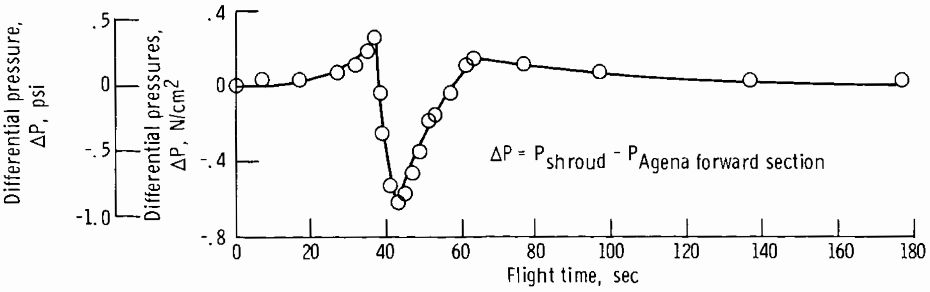

Figure VI-3. - Diaphragm differential pressure, Numbus III.

PROPULSION SYSTEM

by Robert J. Schroeder

Description

The Agena propulsion system (fig. VI-4) consists of a propellant tank pressurization system, a propellant management system and an engine system. Also considered part of the propulsion system are the Agena cold gas retrothrust system, the Thorad-Agena separation system, and the Agena vehicle pyrotechnic devices.

The propellant tank pressurization system provides the required propellant tank pressures and consists of a helium supply tank and a pyrotechnically operated helium control valve. Before lift-off, the ullage volume in the propellant tanks is pressurized with helium from a ground supply source. The helium control valve is activated 1.5 seconds after initiation of the Agena engine first start to permit helium gas to flow from the supply tank through fixed-area flow orifices to each propellant tank. After the Agena engine first cutoff, the helium control valve is again activated to isolate the oxidizer tank from the helium supply. This prevents the mixing of oxidizer and fuel vapors that could occur if pressures in the propellant tanks were permitted to reach the same level. Pressurization during the second powered phase of the Agena engine is provided by the residual pressure in the propellant tanks.

The propellant management system consists of the following major items: propellant fill disconnects to permit the loading of fuel and oxidizer, feed lines from the propellant tanks to the engine pumps, tank sumps to retain a sufficient amount of propellants for engine restart in a zero-gravity environment, and an electric motor driven propellant isolation valve in each feed line. The propellant isolation valves are open at lift-off, closed after the Agena engine first cutoff, and opened 2 seconds before the Agena engine second start. When closed, these valves isolate the propellants in the tanks from the engine pump inlets and provide an overboard vent for propellants trapped in the engine pumps.

The Agena engine system consists of a liquid bipropellant engine which uses unsymmetrical dimethylhydrazine as fuel and inhibited red fuming nitric acid as oxidizer. Rated thrust in a vacuum is 71 172 newtons (16 000 lbf) with a nozzle expansion area ratio of 45. The engine has a regeneratively cooled thrust chamber, a radiation-cooled nozzle extension, and a turbopump propellant flow system. Turbine rotation is initiated for each engine start by igniting a solid-propellant start charge. The turbine is driven during steady-state operation by hot gas produced in a gas generator. Propellants to the gas generator are supplied by the turbopump. An oxidizer fast-shutdown system, which consists of a pyrotechnically operated valve and a high-pressure nitrogen storage cylinder, is used to rapidly close the main oxidizer valve at engine first cutoff. Engine thrust vector control in pitch and yaw is provided by the gimbal mounted thrust chamber in response to signals produced by the Agena guidance and flight control system.

The Agena retrothrust system (fig. VI-5) provides the impulse to lower the altitude of the Agena orbit after Nimbus III separation. This is accomplished with two operations of the retrothrust system. The impulse for the first operation of the retrothrust system is provided by 3.97 kilograms (8.75 lbm) of gas in the retrothrust storage sphere. The impulse for the second operation of the retrothrust system is provided by the gas remaining in the attitude-control gas storage sphere. Based on a nominal gas consumption of the attitude control system during the ascent phase of the flight, approximately 8.48 kilograms (18.7 lbm) of residual gas are available for the second operation of the retrothrust system. The first operation of the retrothrust system is initiated 193 seconds after Nimbus III separation, and the second operation of the retrothrust system occurs 2700 seconds after Nimbus III separation. Each operation of the retrothrust system is initiated by activating a normally closed pyrotechnic valve which permits a regulated flow of gas from the appropriate storage sphere to a fixed retrothrust nozzle. The retrothrust nozzle is alined through the vehicle center of gravity to minimize disturbing torques. An electrically operated valve in the fill line to each storage sphere permits both spheres to be loaded through a common fill coupling and provides isolation between the spheres during flight.

The Thorad-Agena separation is accomplished by firing a Mild Detonating Fuse which severs the booster adapter circumferentially near the forward end. The Thorad with booster adapter is then separated from the Agena by firing two solid-propellant retrorockets mounted on the booster adapter. Rated average sea-level thrust of each retrorocket is 2180 newtons (490 lbf) with an action time of 0.93 second. Rollers on the Agena aft section are guided by rails on the booster adapter to maintain clearance and alinement during separation.

Pyrotechnic devices are used to perform a number of functions on the Agena. These devices include squibs, igniters, detonators, and explosive bolt cartridges. Squibs are used to open and close the helium control valve, to eject the horizon sensor fairings, to activate the oxidizer fast shutdown system, to activate the retrothrust system, and to activate shroud bolt cutters. Igniters are used for the main engine solid-propellant start charges, and the retrorockets. Detonators are used for the self-destruct charge and the Mild Detonating Fuse separation charge. Explosive volt cartridges are used to rupture release devices for shroud jettison.

Performance

The Thorad-Agena separation system performance was normal. Separation was commanded by the radio-guidance system at T + 238.1 seconds. The command resulted in the ignition of the Mild Detonating Fuse and the two retrorockets. The booster adapter guide rails cleared the last rollers on the Agena aft rack at T + 240.7 seconds.

Agena engine first start was initiated by the Agena timer at T + 256.2 seconds. The engine switch group monitor data indicated a normal start sequence of the engine control valves. Ninety-percent combustion chamber pressure was attained at T + 257.4 seconds. The average steady-state thrust produced by the Agena engine was 72 177 newtons (16 226 lbf) compared with an expected value of 71 857 newtons (16 154 lbf). Agena engine cutoff was commanded by the velocity meter at T + 488.0 seconds. The engine thrust duration, measured from 90-percent chamber pressure to velocity meter cutoff command, was 230.6 seconds. This was 0.22 second less than the expected value of 230.82 seconds. The actual thrust duration and thrust level indicate that engine performance was within the allowable limits.

The propellant tank pressurization system supplied the required tank pressures. The fuel and oxidizer pump inlet pressures were within 1.4 newtons per square centimeter (2 psi) of the expected values during the Agena engine first powered phase.

The propellant isolation valves closed normally after Agena engine first cutoff and opened normally prior to engine second start, as evidenced by the valve position measurement and the changes in pump inlet pressures.

Agena engine second start was initiated at T + 3261.2 seconds. The engine switch group monitor data indicated a normal start sequence of the engine control valves. Ninety-percent combustion chamber pressure was attained at T + 3262.3 seconds. The average steady-state thrust produced by the Agena engine was 73 580 newtons (16 544 lbf) compared with an expected value of 72 167 newtons (16 224 lbf). Agena engine second cutoff was commanded by the velocity meter at T + 3267.4 seconds. The engine thrust duration, measured from 90-percent combustion chamber pressure to velocity meter cutoff command, was 5.1 seconds. This was 0.18 second less than the expected value of 5.28 seconds. The actual thrust duration and thrust level indicate that engine performance was within the allowable limits.

The propellant tank pressures during the second burn were adequate for satisfactory engine operation. The pump inlet pressure measurements were within 1.4 newtons per square centimeter (2 psi) of the expected values.

After Nimbus III separation, the Agena performed a conical turn which placed the vehicle in a nose-aft position with respect to the trajectory vector. The first operation of the retrothrust system was initiated at T + 3710.2 seconds. Immediately, the Agena began an unexpected pitch-up (positive pitch) which continued until the gas in the retrothrust sphere had been nearly depleted. A postflight evaluation indicated that the unexpected pitch-up was the result of a disturbing torque, which was most probably caused by the exhaust gas from the retrothrust nozzle impinging on the Agena engine nozzle extension. This disturbing torque exceeded the correction capability of the attitude control system which was in the low thrust mode during the first operation of the retrothrust system. (See the Agena GUIDANCE AND FLIGHT CONTROL section for discussion of the vehicle attitude during the first retrothrust.)

The second operation of the retrothrust system was initiated at T + 6217.2 seconds. At the same time the attitude control system was transferred from the low thrust mode to the high thrust mode. Approximately 8.94 kilograms (19.7 lbm) of gas was in the attitude control sphere at the start of the second operation of the retrothrust system. During this operation of the retrothrust system, the attitude control system was able to compensate for the disturbing torque produced by the exhaust gas from the retrothrust nozzle impinging on the Agena engine extension.

In addition to the unexpected disturbance torque produced by the retrothrust system, the duration of each operation of the retrothrust system was approximately twice as long as predicted. Correspondingly, the actual weight flow rates for each operation of the retrothrust system were approximately one-half of the expected values. This change in the retrothrust system operation had no adverse effect on the Agena vehicle since the actual total impulse supplied during each operation of the retrothrust system was the same as predicted.

A postflight evaluation to determine the cause of the increased thrust duration revealed that the design calculations did not include allowance for system line losses due to friction. Subsequent incorporation of these friction losses into the analysis resulted in weight flow rates which were consistent with those experienced in flight.

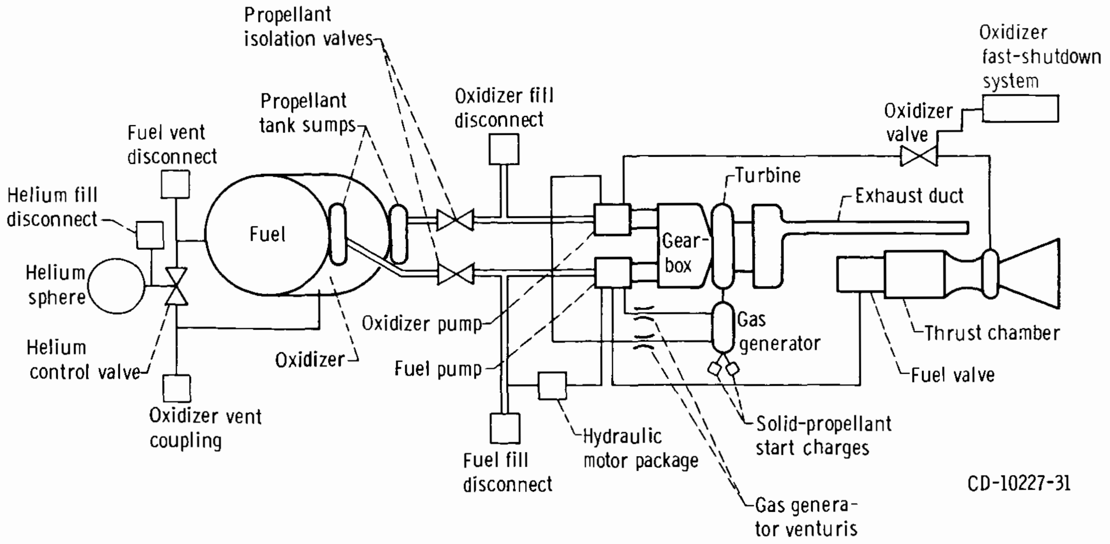

Figure VI-4. - Agena propulsion system, Nimbus III.

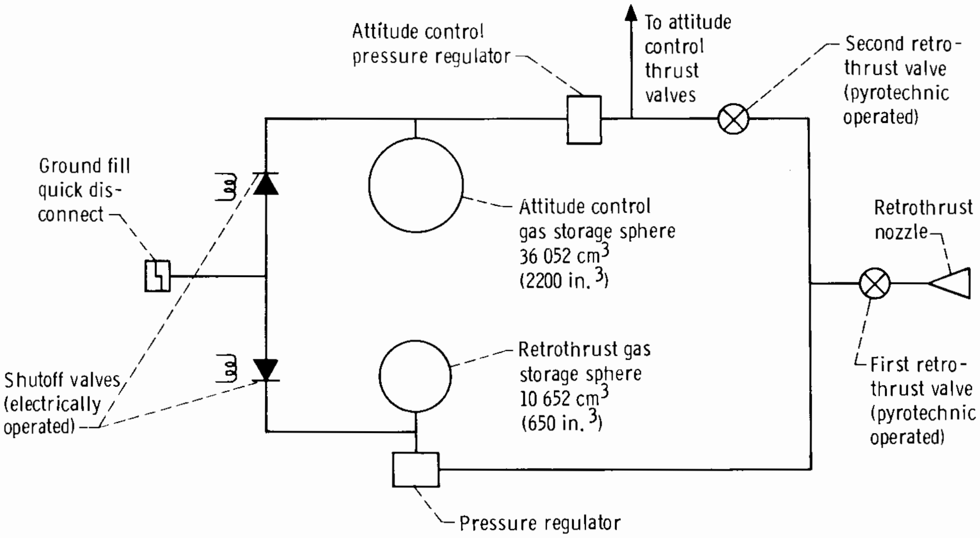

Figure VI-5. - Agena retrothrust system, Nimbus III.

GUIDANCE AND FLIGHT CONTROL SYSTEM

by Howard D. Jackson

The Agena flight path is controlled by two interrelated systems: the Agena guidance and flight control system and the radio-guidance system. The Agena guidance and flight control system directs the Agena, after Thorad-Agena separation, in a preprogrammed open-loop mode. The radio-guidance system will supply, if needed, pitch and yaw steering commands during a major portion of the Agena first powered phase. The radio-guidance system also issues a discrete command to enable the Agena velocity meter about midway through the Agena first powered phase. The radio-guidance system description, location of components, and use during the Thorad phase of flight is provided in the Thorad GUIDANCE AND FLIGHT CONTROL SYSTEM (section V).

Description

The Agena guidance and flight control system consists of three subsystems: a guidance subsystem, a control subsystem, and a timer to provide flight programming. A block diagram of the system is shown in figure VI-6.

The Agena guidance subsystem consists of an inertial reference package (IRP), horizon sensors, a velocity meter, and a guidance junction box. All components of the guidance subsystem are located in the guidance module in the Agena forward section. Primary attitude reference is provided by three orthogonal rate-integrating gyros in the IRP. (These gyros are uncaged at shroud vernier engine cutoff.) The infrared horizon sensors, consisting of a left and right optical sensor (head) and a mixer box, provide pitch and roll error signals to the IRP. For this mission the pitch horizon sensor signal is inhibited until after Agena engine first cutoff. The Agena yaw attitude is referenced to the attitude of the vehicle at the time of Thorad vernier engine cutoff and is then corrected by gyro-compassing techniques during long (greater than 10 min) coast periods. The velocity meter consists of an accelerometer, an electronics package, and a counter. The velocity meter accelerometer senses vehicle longitudinal acceleration. The velocity meter electronics processes the acceleration information and produces an output pulse each time the velocity increases by a known increment. The velocity meter counter generates an engine cutoff command when a predetermined number of pulses (i. e., when the sum of the velocity increments equals the total velocity to be gained) have been received. The guidance junction box serves as a center for guidance signals and contains relays for control of operating modes and gains.

The Agena flight control subsystem, which controls vehicle attitude, consists of a flight control electronics unit, a cold-gas attitude control system, a hydraulic attitude control system, and a flight control junction box. Attitude error signals from the IRP are conditioned and amplified by the flight control electronics to operate the cold-gas and hydraulic systems. During Agena coast periods, the cold-gas system consisting of six thrusters provides roll, pitch, and yaw control. These thrusters are located in the Agena aft section and operate on a mixture of nitrogen and tetrafluoromethane. During the Agena powered flight, the hydraulic system provides pitch and yaw control by means of two hydraulic actuators which gimbal the Agena engine thrust chamber; and the cold-gas system provides roll control. A patch panel in the flight control junction box provides the means for preprogramming the interconnections of the guidance and flight control system to meet mission requirements.

The Agena timer programs the flight events. This timer provides 22 usable discrete event times with multiple switch closure capability and has a maximum running time of 6000 seconds. The Agena timer is started at Thorad main engine cutoff.

The radio-guidance system airborne control package transfers steering control from the Thorad to the Agena at Thorad-Agena separation. The capability of the Agena guidance and flight control system to accept radio-guidance system pitch and yaw steering commands is enabled 8 seconds before and is disabled 141 seconds after Agena engine first start, by the Agena timer. During this 149-second period of Agena flight all radio-guidance system pitch and yaw steering commands (generated by the ground-based computer and transmitted to the Agena) are routed to the Agena guidance and flight control system to provide corrections for deviations from the programmed trajectory.

The radio-guidance system also provides the discrete command to the Agena for enabling the Agena velocity meter. The ground-based computer determines the time for this discrete command based on inflight performance of the Thorad and the Agena. With nominal Thorad and Agena performance, this discrete command occurs 133 seconds after Agena engine first start.

After the radio-guidance system has completed its planned period of operation, the airborne components are turned off to conserve Agena power. The Agena timer performs this function 264 seconds after Agena engine first start (about 32 sec after first cutoff).

Performance

The guidance and flight control system performance was satisfactory through both operations of the Agena engine, Nimbus III separation, and the conical turn prior to the first retrothrust. During the first operation of the retrothrust system, the cold-gas attitude control system was preprogrammed to operate in a low thrust mode and was not capable of counteracting the torque introduced by the retrothrust system. (See the Agena

PROPULSION section for discussion on the cause of this torque.) The torque caused by the operation of the retrothrust system acted primarily in the pitch plane and caused the vehicle to pitch-up approximately 160° with respect to the desired attitude. At the end of first retrothrust the vehicle was stable with about 150° pitch-up error.

All events initiated by the Agena timer were within tolerance. A comparison of the expected and actual times of programmed events is given in appendix A. The rates imparted to the Agena at Thorad-Agena separation (T + 238.1 sec) and the attitude errors at cold-gas activation (T + 240.7 sec) were within the range of values experienced on previous flights and are shown as follows:

Rates imparted to Agena at separation, deg/sec			Attitude errors at cold-gas activation, deg		
Yaw	Roll	Pitch	Yaw	Roll	Pitch
0.154 right	0.328 CCW[a]	0.263 down	1.46 right	0.53 CCW	2.06 down

[a] Counterclockwise (CCW). See fig. VI-7 for reference orientation.

The cold-gas attitude control system reduced these errors to within the deadband limits of ±0.2° pitch, ±0.18° yaw, and ±0.6° roll in 6 seconds.

At T + 248.2 seconds, the Agena initiated a programmed pitch down of 10.4° at a rate of 90 degrees per minute. The pitch-down rate was then decreased to 0.955 degree per minute at Agena engine first start. For the Agena first powered phase the radio-guidance steering was enabled in pitch and yaw with the horizon sensors controlling only the roll gyro. At the time of Agena engine first start (T + 256.2 sec), the pitch attitude was approaching null with an error of 1.08° pitch-up, and the vehicle was stable in the roll and yaw.

Gas generator turbine spin-up at Agena engine first start resulted in a roll rate and induced a maximum roll error as follows:

Roll rate, deg/sec	1.74 [a]CW
Maximum roll error, deg	2.64 CW
Time to reverse initial rate, sec	1.7

[a] Clockwise. See fig. VI-7 for reference orientation.

Minimal attitude control was required during the Agena engine first powered phase, and the vehicle attitude remained very close to gyro null positions. The attitude control activity (hydraulic and cold gas) was normal throughout this phase. Radio-guidance system steering commands were slight in pitch and negligible in yaw during the period programmed for use.

The velocity meter was enabled by the radio-guidance system at T + 390.5 seconds and commanded Agena engine first cutoff at T + 488.0 seconds, when the vehicle had attained the required velocity increment. The roll transients caused by engine cutoff (i.e., turbine spindown and turbine exhaust decay) were as experienced on previous flights. The time required to reduce the roll excursion to within the attitude control deadbands was 15 seconds.

Approximately 5.5 seconds after Agena engine first cutoff, a programmed geocentric pitch rate of 3.69 degrees per minute was applied, and the pitch horizon sensor was connected to the pitch gyro. The airborne components of the radio-guidance system were turned off (at T + 520.2 sec) about 32 seconds after first cutoff. Horizon sensor, gyro, and attitude control data showed that the vehicle maintained the proper attitude during the 46-minute coast.

Gas generator turbine spin-up at Agena engine second start (T + 3261.2 sec) resulted in a roll rate and induced a maximum roll error as follows:

Roll rate, deg/sec	2.31 [a]CW
Maximum roll error, deg	1.69 CW
Time to reverse initial rate, sec	1.5

[a] Clockwise. See fig. VI-7 for orientation reference.

Minimal attitude control was required during the Agena engine second powered phase. Engine cutoff was commanded by the velocity meter at T + 3267.4 seconds when the vehicle had attained the required velocity increment.

At T + 3421.2 seconds the Agena was commanded to pitch-up 75° from local horizontal at a rate of 56 degrees per minute to position the vehicle for the Nimbus III separation. The horizon sensors were disconnected from the pitch and roll gyros at the start of this pitch maneuver. The vehicle was stable for Nimbus III separation, which occurred at T + 3517.1 seconds. Two seconds after Nimbus III separation, a conical turn maneuver (simultaneous rates of 40 deg/min left yaw and 40° deg/min clockwise roll) was initiated. This maneuver oriented the vehicle in a nose-aft attitude, with respect to the velocity vector, with the horizon sensors viewing the Earth.

At T + 3710.2 seconds, the conical turn rates were stopped, the horizon sensors were reconnected to the pitch and roll gyros, and the first operation of the retrothrust system was initiated. However, during this operation of the retrothrust system, the unexpected torque occurred which resulted in the Agena pitching up. This unexpected torque was about 56.5 newtons-centimeter (5 in.-lb) greater than the pitch correction capability of the attitude control system. The attitude control system is designed to operate either a low-pressure or a high-pressure mode. It was preprogrammed to operate in the low-pressure mode during the first operation of the retrothrust system. The following table presents the pitch force level and the corresponding pitch torque level for the low and high modes of operation of the attitude control system.

Type mode	Pitch force level		Pitch torque level[a]	
	N	lbf	N-cm	in.-lb
Low pressure mode	2.22	0.5	678	60
High pressure mode	44.5	10	13 560	1200

[a] Distance from attitude control thruster nozzle to c.g., of Agena is approximately 304.8 cm (120 in.).

Shortly after the Agena began the unexpected pitch-up, the pitch horizon sensor and the pitch gyro error signals reached their maximum telemetry outputs (5° for the pitch horizon sensor and 10° for the pitch gyro). The pitch thrust valve was on full time in response to these error signals. The horizon sensor telemetry output remained at 5° for about 104 seconds. At this time the Agena had pitched up about 105° and both horizon sensor heads lost their Earth reference. Consequently, the horizon sensors could no longer detect any attitude error and provide correction signals. The pitch gyro error remained at 10°, and the pitch thrust valve remained on full time until near the end of the first operation of the retrothrust system.

At this time the pressure in the retrothrust sphere had decreased sufficiently so that the corresponding torque was within the correction capability of the attitude control system, and the Agena had been pitched up about 160°. The 10° pitch gyro error was then corrected. At the end of the first operation of the retrothrust system, the Agena was stable in attitude at an approximately 150° pitch error, the pitch gyro was at null, and the horizon sensors were viewing space.

The second operation of the retrothrust system was initiated by the Agena timer at T + 6217.2 seconds. At this time the attitude of the Agena was essentially the same as its attitude at the end of the first operation of the retrothrust system. The attitude control system was preprogrammed to operate in the high-pressure mode for the second operation of the retrothrust system. In this mode the attitude control system correction capability exceeded the unexpected torque produced by the retrothrust system. Consequently, the attitude of the Agena was stable during the second intended retrothrust. Since the Agena was improperly oriented (due to the 150° pitch-up error) at the start of the second operation of the retrothrust system, the velocity of the Agena and the EGRS-13 was increased; whereas, according to mission plan, the velocity should have been decreased. The EGRS-13 was successfully separated from the Agena at T + 6384.6 seconds during the second operation of the retrothrust system.

The effects of the intended retrothrusts on the Agena orbit and the EGRS-13 orbit are discussed in the TRAJECTORY AND PERFORMANCE (section IV).

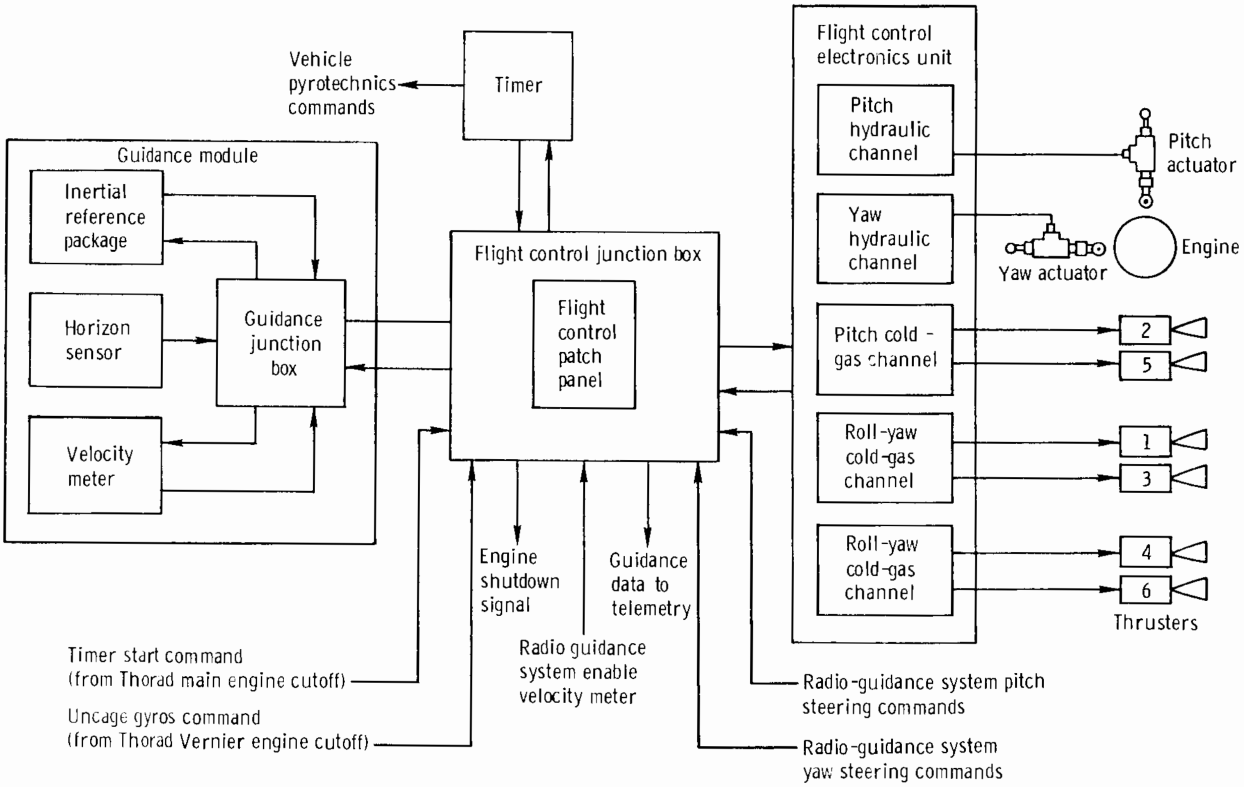

Figure VI-6. - Agena guidance and flight control system block diagram and radio-guidance system functions, Nimbus III.

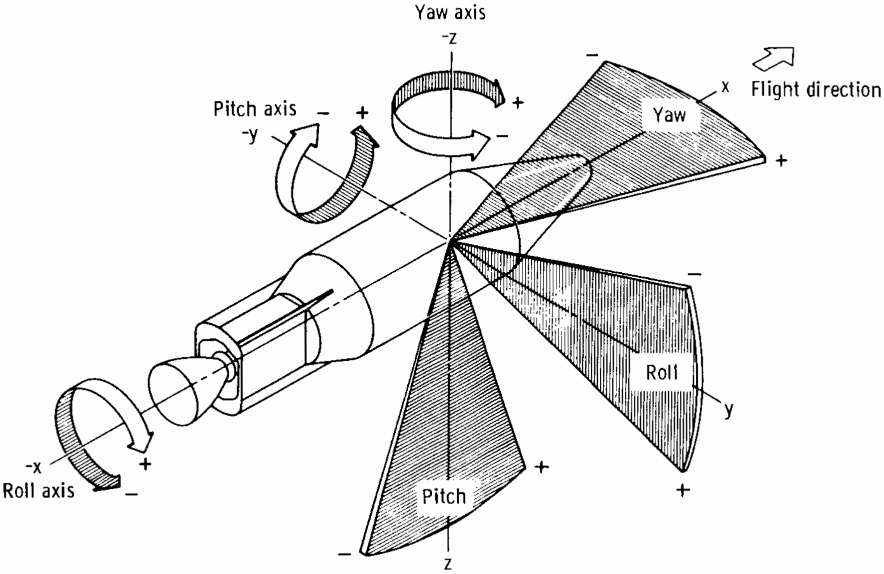

Figure VI-7. - Agena vehicle axes and vehicle movement designations, Nimbus III. Clockwise (CW) and counter clockwise (CCW) roll reference applies when looking forward along Agena lontitudinal axis.

ELECTRICAL SYSTEM

by Edwin R. Procasky

Description

The Agena electrical system (fig. VI-8) supplies all power, frequency, and voltage requirements for the pyrotechnics, propulsion, flight termination, inertial guidance, radio guidance, and telemetry systems. The electrical system consists of the power source equipment, power conversion equipment, and the distribution network.

The power source equipment consists of two silver-zinc primary batteries (minimum design rating of 966 W-hr each) and two nickel-cadmium secondary type batteries. One primary type battery (the main battery) supplies power to the vehicle loads that use unregulated power and to the power conversion equipment. The other primary type battery (the pyrotechnic battery) supplies power to all Agena vehicle pyrotechnics except the destruct charges in the flight termination system. The pyrotechnic battery is also connected to the main battery through a diode so that it can support the load on the main battery. However, the diode isolates the main battery loads from pyrotechnic transients and from pyrotechnic loads. The two secondary type batteries are used with the flight termination system.

The power conversion equipment consists of one static inverter and two dc-dc converters and converts unregulated dc power to regulated ac and regulated dc power. The inverter supplies 115 volts (rms) at 400 hertz (±0.02 percent) to the guidance and flight control system. One dc-dc converter supplies regulated ±28 volts dc to the guidance and flight control system. The second dc-dc converter, which has two regulated outputs, supplies 28 volts dc to the radio-guidance system and the telemetry system.

Performance

The Agena electrical system voltages and currents were as expected at lift-off, and the system satisfactorily supplied power to all electrical loads throughout the flight.

The battery (main and pyrotechnic) load profile was as expected for this mission. The inverter and converter voltages were within specification at lift-off and remained essentially constant throughout flight.

The inverter frequency was not monitored on the Agena; however, performance of the guidance and flight control system indicated that the inverter frequency was normal and stable. The electrical system performance data are summarized in table VI-I.

TABLE VI-I. - AGENA ELECTRICAL SYSTEM FLIGHT PERFORMANCE SUMMARY, NIMBUS III

Measurement	Range	Measurement number	Lift-off	At first ignition	At first shutdown	At second ignition	At second shutdown	First orbital pass
Pyrotechnic battery voltage	22.5 - 29.5 V	C-141	26.5 V	25.9 V	25.9 V	25.9 V	25.9 V	29.9 V
Main battery voltage	22.5 - 29.5 V	C-1	25.9 V	25.4 V	25.7 V	25.2 V	25.3 V	25.3 V
Battery current	-----------------	C-4	12 A	15 A	12 A	15 A	12 A	10 A
Converter output (guidance and flight control)								
+28.3 V dc regulated	27.7 - 28.9 V dc	C-3	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc
-28.3 V dc regulated	-27.7 - -28.9 V dc	C-5	-28.5 V dc	-28.5 V dc	-28.5 V dc	-28.5 V dc	-28.5 V dc	-28.5 V dc
Inverter output								
Phase AB rms	112.7 - 117.3 V ac	C-31	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac
Phase BC rms	112.7 - 117.3 V ac	C-32	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac	114.6 V ac
Converter output, +28.3 V dc regulated								
Telemetry	27.7 - 28.9 V dc	C-2	27.8 V dc	27.8 V dc	27.8 V dc	27.8 V dc	27.8 V dc	27.8 V dc
Radio guidance	27.7 - 28.9 V dc	BTL-6	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc	28.2 V dc

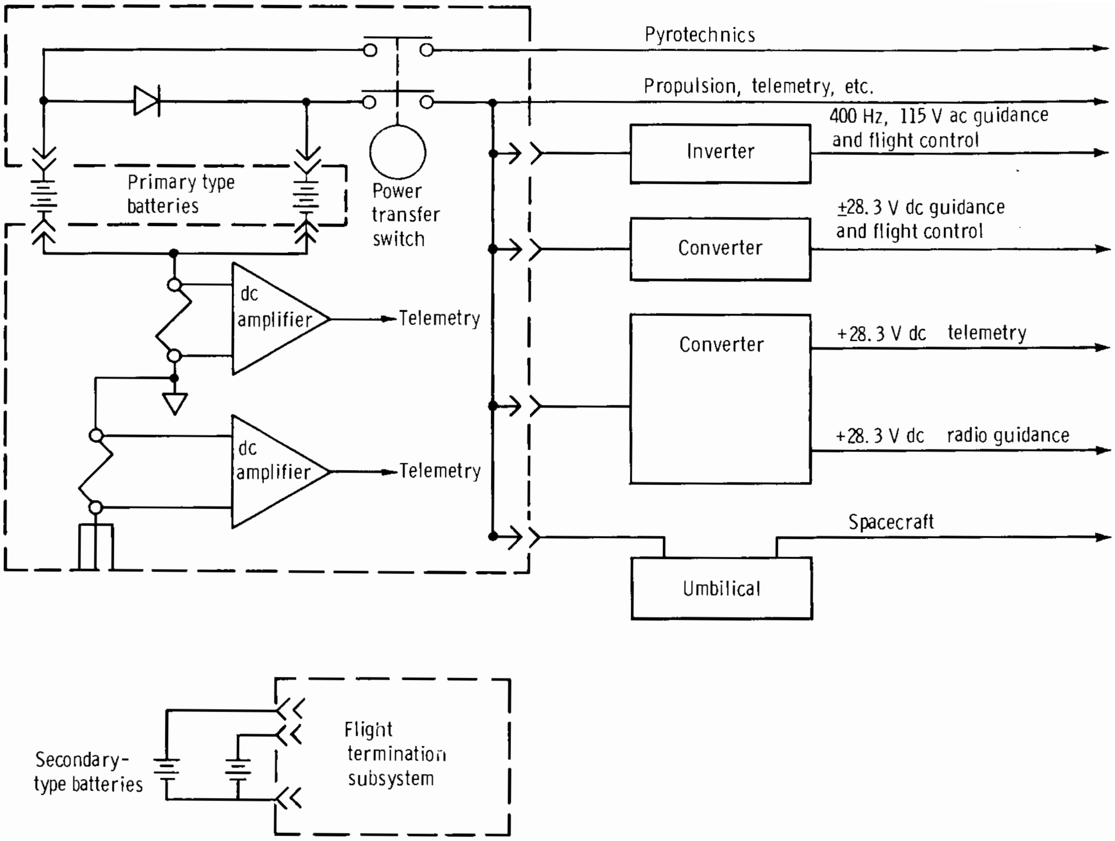

Figure VI-8. - Agena electrical system, Nimbus III.

COMMUNICATION AND CONTROL SYSTEM

by Richard L. Greene

Description

The Agena communication and control system consists of telemetry, tracking, and flight termination subsystems with associated power supplies and cabling.

The telemetry subsystem is mounted in the Agena forward section. It monitors and transmits the Agena functional and environmental measurements during flight. The frequency modulation/frequency modulation (FM/FM) telemetry unit contains a very high frequency (VHF) transmitter, voltage controlled oscillators, a commutator, a switch and calibrate unit, a radiofrequency switch, and an antenna. Regulated 28 volts dc power for telemetry is supplied from a dc-dc converter. The radiofrequency switch connects the telemetry output to either the umbilical for ground checkout or the antenna for flight. The transmitter operates on an assigned frequency of 244.3 megahertz at a power output of 2 watts. The telemetry subsystem consists of nine continuous subcarrier channels and two commutated subcarrier channels.

Fifty-nine measurements are telemetered from the Agena vehicle. Appendix B summarizes the launch vehicle instrumentation by measurement description. Four continuous subcarrier channels are used for monitoring acceleration and vibration data at the spacecraft adapter; three continuous channels are used for radio-guidance system measurements; one continuous channel monitors the gas thruster valve activity; and one continuous channel is time shared by the velocity meter accelerometer and the velocity meter counter. The turbine speed signal does not use a subcarrier channel but directly modulates the transmitter during engine operation. The remaining 48 measurements are monitored on the two commutated subcarrier channels. These channels are commutated at 5 revolutions per second with 60 segments on each channel.

The airborne tracking subsystem includes a C-band radar transponder, a radiofrequency switch, and an antenna. The transponder receives coded signals from the tracking radar on a carrier frequency of 5630 megahertz and transmits coded responses on a carrier frequency of 5555 megahertz at a minimum pulsed-power output of 200 watts at the input terminals of the antenna. The coded responses are at pulse rates (pulse repetition frequency) from 0 to 1600 pulses per second. The pulse rate is dependent on the rates transmitted from the ground tracking stations and the number of stations simultaneously interrogating the transponder. The radiofrequency switch connects the output of the transponder to either the umbilical for ground checkout or the antenna for flight.

The Agena flight termination subsystem (located on the booster adapter) provides a range safety flight termination capability for the Agena from lift-off until Thorad-Agena separation. This subsystem is composed of two batteries, interconnecting wiring assemblies, two separation switches, a destruct initiator with two detonators, and a destruct charge. Flight termination can be initiated by a signal from either of the Thorad command receivers prior to Thorad-Agena separation, or automatically if Thorad-Agena separation occurs before Thorad main engine cutoff (i. e., premature). The automatic portion of the system is disabled at Thorad main engine cutoff to permit a normal Thorad-Agena separation.

A time delay circuit in the Thorad safe/arm mechanisms insures destruction of both stages by delaying Thorad destruct initiation until 0.1 second after Agena destruct initiation. Agena destruct is effected by ignition of a shaped mounted on the booster adapter which ruptures the propellant tanks causing mixing of the hypergolic propellants.

Performance

The telemetry subsystem performance was satisfactory throughout the flight. Signal strength data from all participating ground telemetry stations indicated an adequate and continuous signal level from the vehicle telemetry transmitters from lift-off through the completion of the Agena second retrothrust. Analysis of the telemetry data indicated that the performance of the voltage controlled oscillators, switch and calibrate unit, dc-dc converters, and the commutator were satisfactory. Usable data were obtained from all Agena telemetered instrumentation. Appendix C (fig. C-2) presents the coverage provided by the supporting telemetry stations.

The tracking subsystem performance was satisfactory throughout the flight. The C-band transponder transmitted a continuous response to received interrogation during all periods of radar tracking. Analysis of ground radar signal strength records indicated that received signal levels were lower than expected during the first orbital pass over radar stations at Vandenberg Air Force Base and Hawaii. These low signal levels were caused by the Agena C-band antenna being pointed in a direction which lowered the effective antenna gain as viewed by the ground tracking stations. The incorrect pointing direction of the C-band antenna resulted from the Agena being in an improper attitude during the first orbital pass over the radar stations at Vandenberg Air Force Base and Hawaii (see Agena GUIDANCE AND FLIGHT CONTROL (section VI) for a discussion on the Agena attitude anomaly). Appendix C (fig. C-3) presents the coverage provided by the supporting radar tracking station.

The Agena flight termination subsystem was not monitored during flight. However, because of the system redundancy, it is assumed that the system was capable of destructing the Agena throughout the Thorad powered phase