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A COMPENDIUM OF AEROBEE SOUNDING ROCKET LAUNCHINGS FROM 1959 THROUGH 1963

by Jon R. Busse and Merrill T. Leffler

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Greenbelt, Md.

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ABSTRACT 14910

A total of 95 Aerobee sounding rocket vehicles have been launched between September 11, 1959 through the calendar year 1963. This report summarizes actual vehicle performance data compiled for Aerobee vehicle launchings during this period.* Additionally, specific information pertaining to problem areas encountered during flights, which were due to malfunction or other difficulties, is included. Other information is provided concerning general Aerobee vehicle configuration, ancilliary hardware, and performance statistics. Data is presented as reference material for reviewing vehicle performance on past experiments, and for use by all scientists interested in obtaining expected performance characteristics with Aerobee vehicles on future scientific space probes.

Author

*See Appendix A (a cross reference index) which summarizes all rocket launchings.

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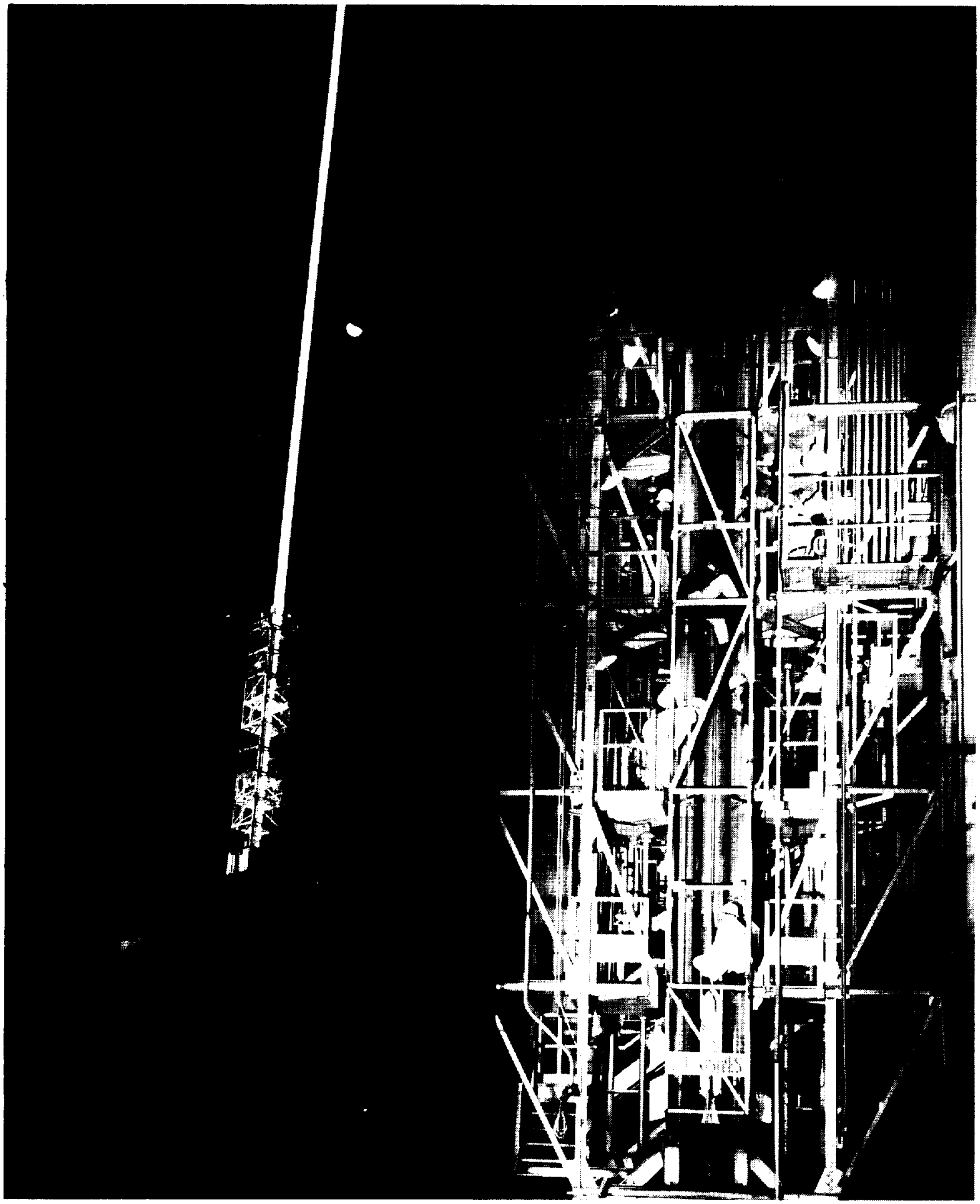

Night launch of Flight 4.54 UG from Wallops Island following final preflight checkout.

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INTRODUCTION

During the past several years the tempo of the Aerobee sounding rocket program has increased considerably. Scientists of the National Aeronautics and Space Administration (NASA) and other government agencies, and experimenters from universities and industry all over the world, have become more and more dependent upon the Aerobee as an effective vehicle for space probes. A variety of payloads carried by Aerobee vehicles have accomplished airglow, aurora and solar x-ray detection, have measured solar ultra-violet radiation and have even collected micrometeoroids. These experiments are but a few of those performed by scientists doing upper atmosphere research.

This report does not discuss the success of the scientific data collected through Aerobee sounding rocket experimentation. Rather, the information presented is intended to provide users with statistics on the performance of past sounding rocket firings, from which Aerobee vehicle capabilities can be evaluated.

Aerobee is the name given to a family of sounding rockets which have gained a reputation as the work horse of the NASA sounding rocket program. This is because the Aerobee, with its relative simplicity and low cost, provides a soft ride vehicle capable of delivering sizable payloads into space with a high degree of performance reliability. Also, the Aerobee provides the support versatility necessary for a variety of upper atmosphere research programs.

Although fourteen Aerobee 100 rockets were fired from 1959 to 1963, the sounding rockets used most extensively today are the Aerobee 150, Aerobee 150A, Aerobee 300, and Aerobee 300A. There are many similarities between Aerobees, and this report will discuss both the similarities and the differences. Since the Aerobee 150A has been the most used member of the Aerobee family, with a total of 52 firings during the period covered by this report this configuration will be considered as the prime vehicle. A typical firing is shown in Figure 1.

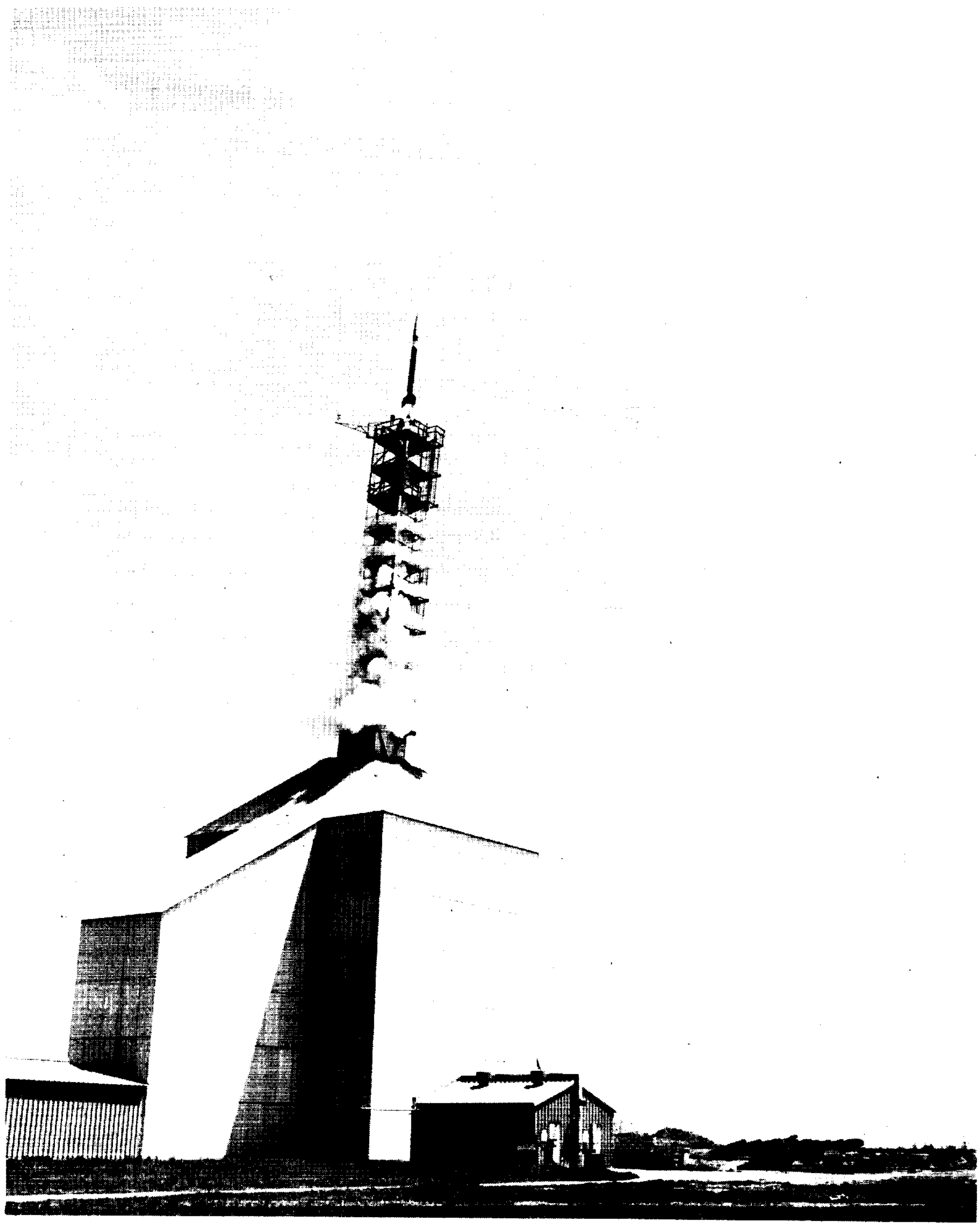


Figure 1—Aerobee 150A sounding rocket launched from Wallops Island.

DESCRIPTION OF AEROBEE 150A

The Aerobee 150A (Figure 2a) is a four-fin sounding rocket approximately 30 feet long and 15 inches in diameter. The manufacturer, the Space-General Corporation of El Monte, California (then the Aerojet General Corporation), assisted in the first successful flight in February 1960. The rocket is capable of transporting from 100 to more than 300 pounds to altitudes of from 180 to 100 miles while maintaining a stable, near-vertical trajectory. Additionally the Aerobee 150A is a free-flight fin-stabilized tower-launched vehicle using a liquid propellant sustainer and boosted from the tower by a solid propellant booster. During flight the rocket is rolled to reduce dispersion due to thrust and structural misalignments.

Sustainer

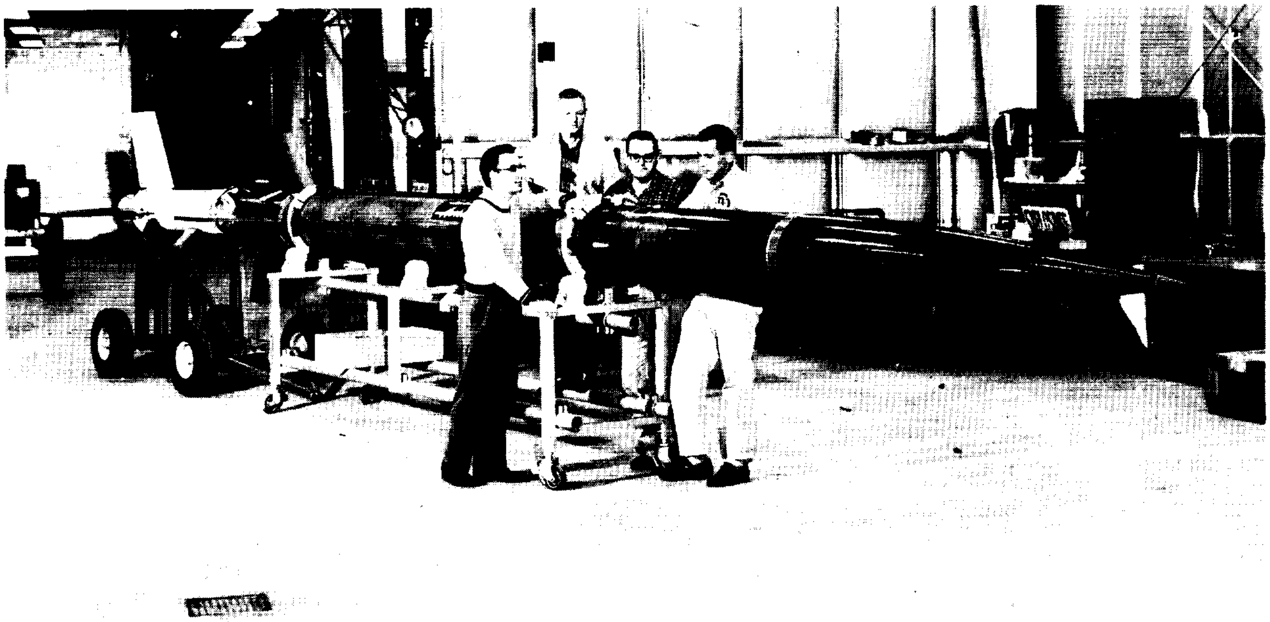
The sustainer portion of the rocket is illustrated in Figure 2b. Basically, the sustainer consists of a nose cone and extensions which house the payload, a forward skirt housing the pressurization system; integral pressurization and propellant tanks which form the main body of the rocket, and an aft structure which houses the thrust chamber and supports the fins. Four shrouds are mounted between the forward skirt and aft structure for propellant tank pressurization lines, instrumentation lines, and antenna cabling. Equidistant between the shrouds, fore and aft, are two sets of riding lugs which support the rocket between the rails in the launch tower. The four-fin configuration of the 150A is the most obvious difference between it and the Aerobee 150.

Nose Cone

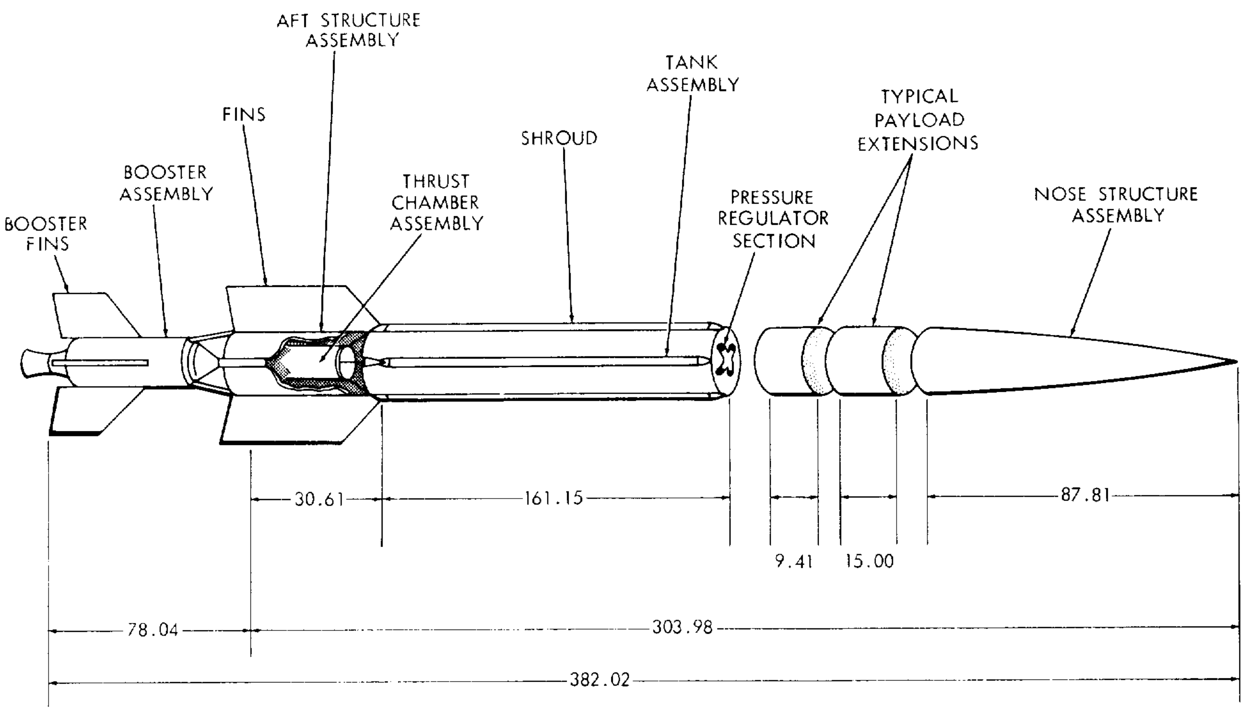
The nose cone (Figure 3a) is a 31-caliber aluminum ogive, circular in cross section, formed by spinning. A typical instrumentation payload is shown in Figure 3b. The total assembly is 87.8 inches in length and has a volume of 4.75 cubic feet. The cone is attached to the rocket, or payload extension if used, by 16 screws. Whenever called for by greater volume requirements, a two piece cone-cylinder nose cone is available for use on all Aerobees. The forward section of this two piece assembly is a cone 42.7 inches long with a 20° vertex. The aft section consists of a 44 inch aluminum cylinder 15 inches in diameter.

Payload Extensions and Forward Skirt

Payload extensions (Figure 3c, 3d) are rolled and welded magnesium sheets .063 inches thick. They are available for use in cylindrical lengths from 6 to 45 inches. Extensions are attached to the rocket, or preceding section, in the same manner as the nose cone. The forward skirt, also a magnesium cylinder, contains the pressure regulator valve, overboard bleed port, external pull-away plugs, and internal instrumentation plugs needed to provide access to the shrouds. Figure 4a provides a top view of the forward skirt, which is riveted to the forward end of the tank assembly and includes an access door. On the forward end of the skirt are tapped holes which are used to attach the nose cone, or extension if used, by means of 16 screws. The sustainer contains 4 stud bolts for attachment of the payload assembly when required. One of these can be viewed in Figure 4a.

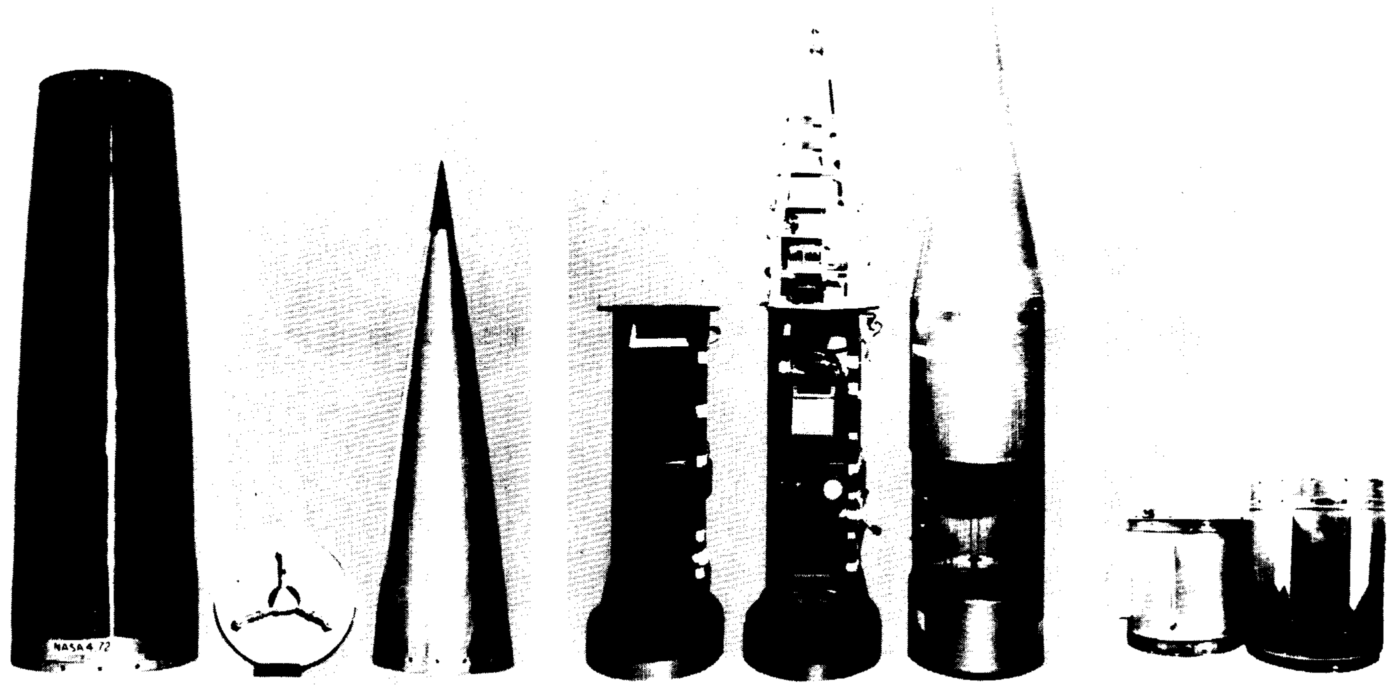


(a) Photo of assembled rocket, payload, and booster motor.



(b) Outline drawing.

Figure 2—Aerobee 150A sounding rocket.



(a) Ogive nose cone and ejection mechanism showing aft side of release cam bulkhead.

(b) Typical instrumentation package with cone cylinder nose cone.

(c) Side view of payload extensions with quadraloop antennas mounted on outside surface.

Figure 3—Aerobee rocket payloads.

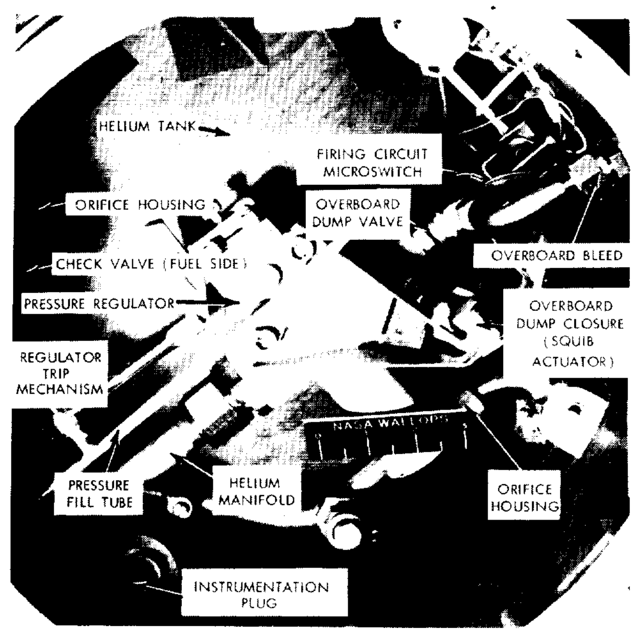
Tank Assembly

The tank assembly is a cylinder 161.5 inches long and 15 inches in outside diameter. It is made of three welded tanks for helium, fuel, and oxidizer, arranged fore and aft with the tank walls forming the external skin of the rocket. The aft helium bulkhead and forward fuel bulkhead are common, as are the aft fuel bulkhead and forward oxidizer bulkhead. The assembly is fabricated from type 410 stainless steel and is heat treated to a minimum tensile strength of 142,000 psi. The helium tank is normally pressurized to 3,450 (±50) psia of gas initially. Gas feed lines emerge through the forward skirt, go down the shrouds and terminate in the ullage portion of the propellant tanks. The fuel feed line extends from the center of the aft fuel bulkhead through the oxidizer tank and out the oxidizer tank head. Baffles at the outlet of each tank stabilize the propellant flow into the feed lines.

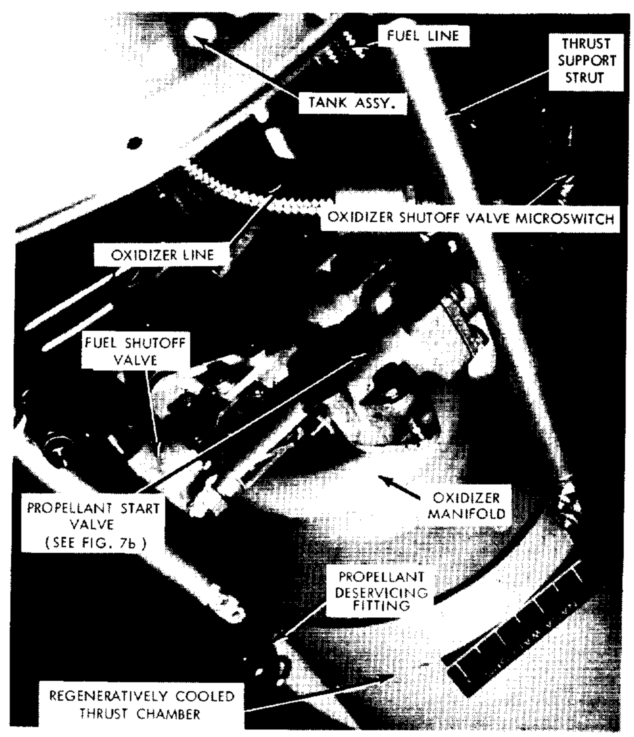
Aft Structure and Shut-off Valves

The aft structure contains the thrust support structure, the modified Nike propellant start valve, the fuel and oxidizer shutoff valves, propellant flex lines, and the regeneratively cooled thrust chamber (Figure 4b).

The shutoff valves are poppet-type, normally open, squib actuated valves. They may be closed by ground command to terminate thrust whenever necessary. Frequently they are closed after rocket burnout to conserve the helium for attitude control or despin functions, or to prevent contamination of the experiment by the exhausting gas. Microswitches are presently used to monitor the positions of the valves. The thrust chamber is a welded assembly consisting of four major areas: the fuel coolant jacket; the fuel and oxidizer



(a) Forward skirt.



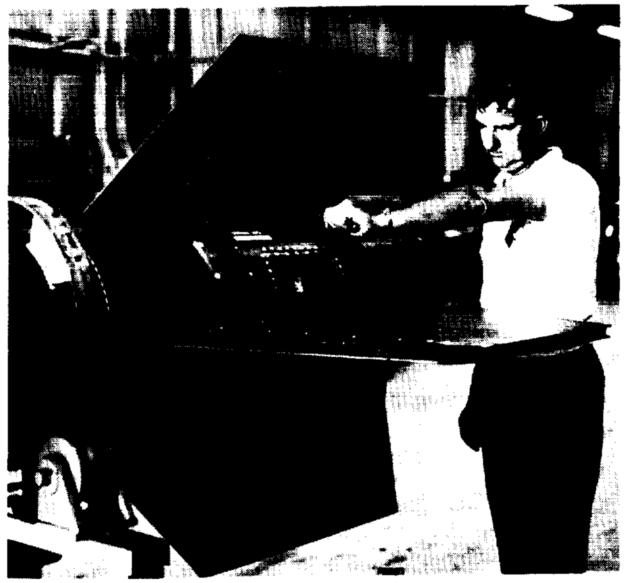
(b) Tail assembly.

Figure 4—Sustainer components.

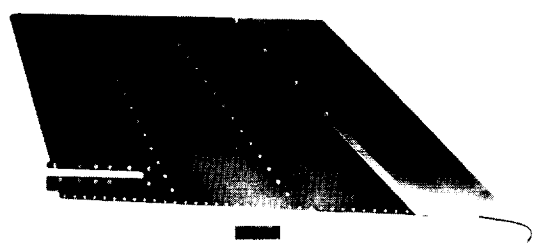
manifolds; the injector; and the combustion chamber and DeLaval nozzle. The aft skirt is a rolled and welded magnesium cylinder 30.3 inches in length, attached to the tank assembly with 16 screws.

Fins

Figure 5 illustrates an Aerobee 150A sustainer fin. Each is a modified single wedge of magnesium skin and spars, an aluminum box structure attachment base, and a stainless steel leading edge cuff .010 inch thick. Each fin has a total fin area of 14.88 sq. ft., weighs 7 pounds, and is attached to the aft skirt by means of two half-inch bolts. The fins can be canted up to 20' to induce rolling motion to the rocket.



(a) Overall view.



(b) Side view.

Figure 5—Aerobee 150A sustainer tail fin.

Propellants

The Aerobee 150A uses a fuel comprised of a mixture of 65 percent aniline and 35 percent furfuryl alcohol (ANFA) and an oxidizer of inhibited red fuming nitric acid (IRFNA). The fuel and oxidizer are hypergolic.

IRFNA is a corrosive, toxic, non-flammable liquid mixture of nitric acid (HNO_3), water, and dissolved nitrogen dioxide (NO_2). The liquid is light orange to orange in color. A small percentage of hydrofluoric acid (HF) is added to inhibit corrosion in the oxidizer tank.

The significant characteristics of IRFNA are:

(1) Water	less than 2%
(2) NO_2	6-8%
(3) HF	0.6%
(4) HNO_3	Residual (90% +)
(5) Odor	Acrid
(6) Hygroscopic	Yes
(7) Specific gravity	1.54 (68°F)

(8)	Freezing point	-49°F
(9)	Normal boiling point	+152°F
(10)	Approximate maximum decomposition pressure at 80°F and 10% ullage	150 psia

Aniline ($\overline{CH\ (CH)_4\ C} - NH_2$) is a flammable, non-corrosive, toxic, oily liquid which varies in color from colorless to brown. It has an amine odor, is low in volatility, and is hypergolic with nitric acid. Its significant characteristics are:

(1)	Odor	Amine
(2)	Boiling point	364°F
(3)	Freezing point	22°F
(4)	Flash point (closed cup)	168°F
(5)	Ignition temperature	1418°F
(6)	Specific gravity	1.002 (68°F)

Furfuryl alcohol, also called 2-furancarbinol ($\overline{OCH:\ CH\ CH:\ C}-CH_2\ OH$), is a flammable, non-corrosive, non-toxic liquid which varies in color from straw yellow to dark amber. It has a brine-like odor and is hypergolic with nitric acid. The significant characteristics of furfuryl alcohol are:

(1)	Specific gravity	1.136 (60°F)
(2)	Hygroscopic	Slightly
(3)	Boiling point	332.6°F-343.4°F
(4)	Flash point	167°F

Booster

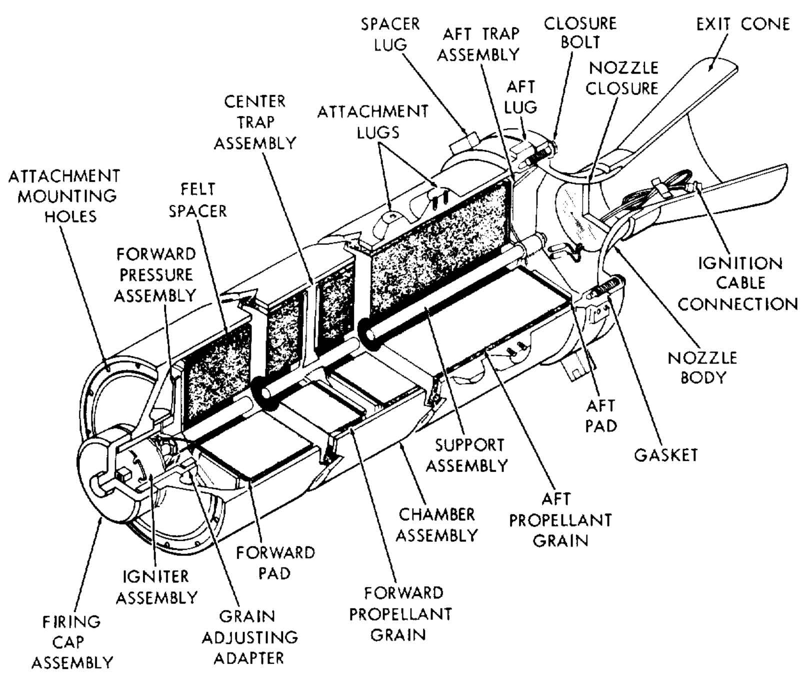
The booster is an Aerojet General type 2.5KS-18,000 motor with a 2.5 sec burning time and high thrust. The motor, which is occasionally used in sled testing, was designed and first used between 1946 and 1948, and reflects the state of the art of that period. Over 850 of these motors have been fired since 1947. The thrust structure consists of three legs and a thrust ring which transmits the booster thrust to the aft structure of the sustainer. The thrust structure is of cast and welded construction and is attached to the booster by 12 screws. It mates with the aft skirt by a shoulder-keyed joint. A flight cone is attached above the igniter firing cap and diverts the sustainer rocket flame away from the booster.

The chamber barrel is rolled and welded from 0.190-in. thick AISI-4130 sheet steel stock. An aft ring and a forward closure are welded to the barrel section, the forward closure containing a boss for installing an adjusting adapter and igniter assembly. The external surface on the forward closure is machined for attaching a thrust skirt assembly. The aft ring is drilled and tapped for attaching the nozzle assembly. Centering clips are spot welded to the inside of the barrel section for centering the charge assembly. Fin attachment pads and guide lugs are welded to the outside of the chamber. The chamber, heat treated to 150,000 psia minimum ultimate tensile strength, is hydrostatically tested to 2400 psig after fabrication.

The nozzle assembly is primarily composed of an AISI-4130 steel closure and exit cone. The forward ring of the closure is drilled for attaching the assembly to the chamber; the aft end of the closure is threaded for attaching the exit cone. The closure is heat treated to 150,000 minimum ultimate tensile strength and is hydrostatically tested to 2400 psig. A 0.50-in. thick plastic closure is cemented to the entrance section of the nozzle closure to maintain adequate pressure for aiding propellant ignition and bursts between 800 and 1200 psig. The entire nozzle assembly is attached to the chamber with twenty-four 1/2-inch diameter bolts.

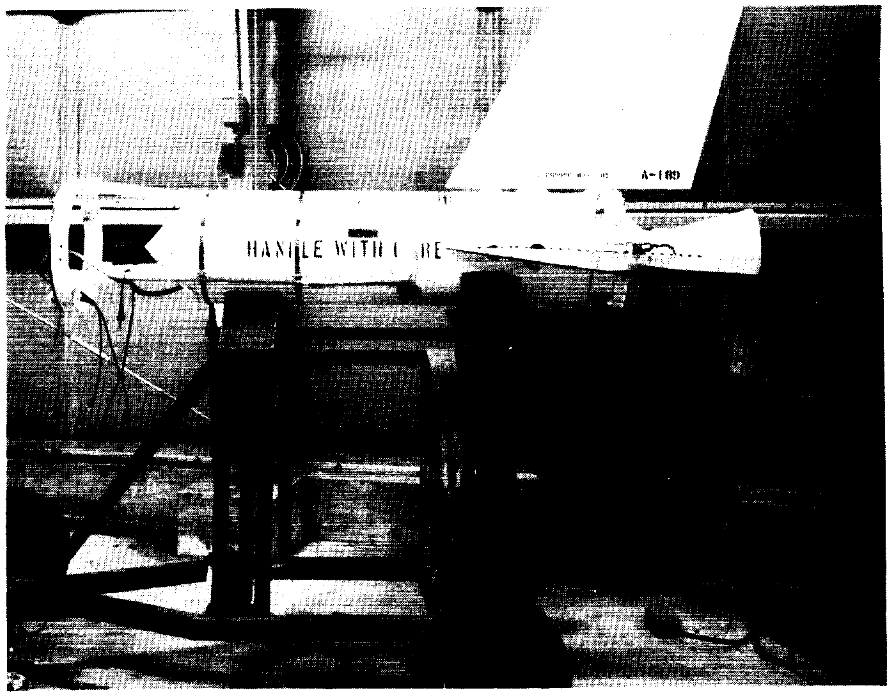
The booster fins are similar to the 150A fins in shape and construction. Each fin is attached to three pads on the booster chamber by means of bolts. The holes are so machined to provide a pre-set fin cant of 2.5°. The fin cant is not adjustable. Figure 6 shows outline dimensions and a cutaway drawing of the booster assembly.

The charge assembly is composed of two internal-external burning grains, a center trap assembly, forward and aft traps, and adjusting adapter, and igniter guide post with lead wires. The grain assemblies consists of two 130-lb. cylindrical AK-14-Mod I propellant grains, both ends of which are inhibited with glass laminates. An asbestos sheet is cemented to the glass laminates to

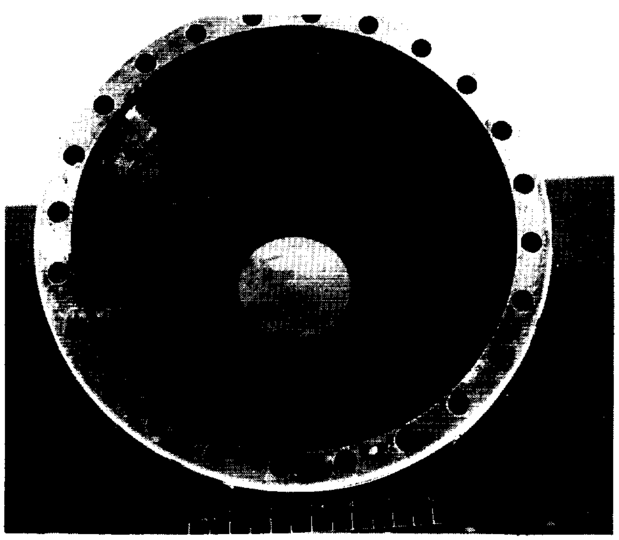


(a) Cutaway view showing major components.

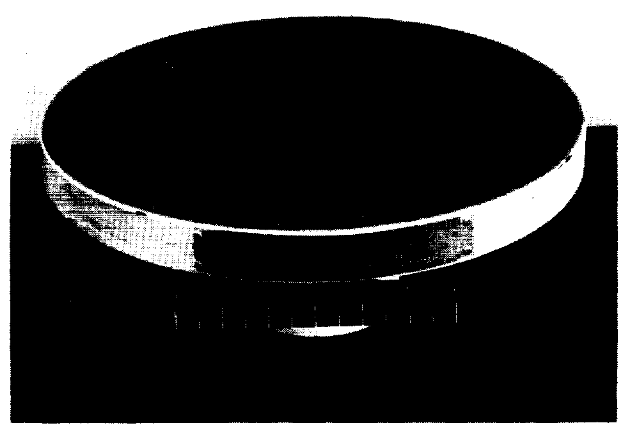
Figure 6—Aerobee booster motor, type 2.5KS-18000.



(b) Side view.



(c) Inside view of nozzle closure.



(d) Side view of nozzle closure.

Figure 6—Aerobee booster motor, type 2.5KS-18000.

preclude radiant ignition, and discs are cemented to the asbestos sheet to allow for compression during assembly. The grain assemblies are torqued to the center trap assembly, using the forward and aft traps as compression plates. The total impulse delivered by the 2 grains is between 44,375 and 50,000 lb.-sec.

The igniter is designed to produce sufficient pressure and heat to ignite the propellant grain. The main charge, consisting of 180 gm. of sodium nitrate black powder, is contained in a circular frangible plastic container. Two squibs, filled with potassium nitrate black powder, ignite the main charge. A 5 ampere current is used for reliable ignition.

Firing Sequence

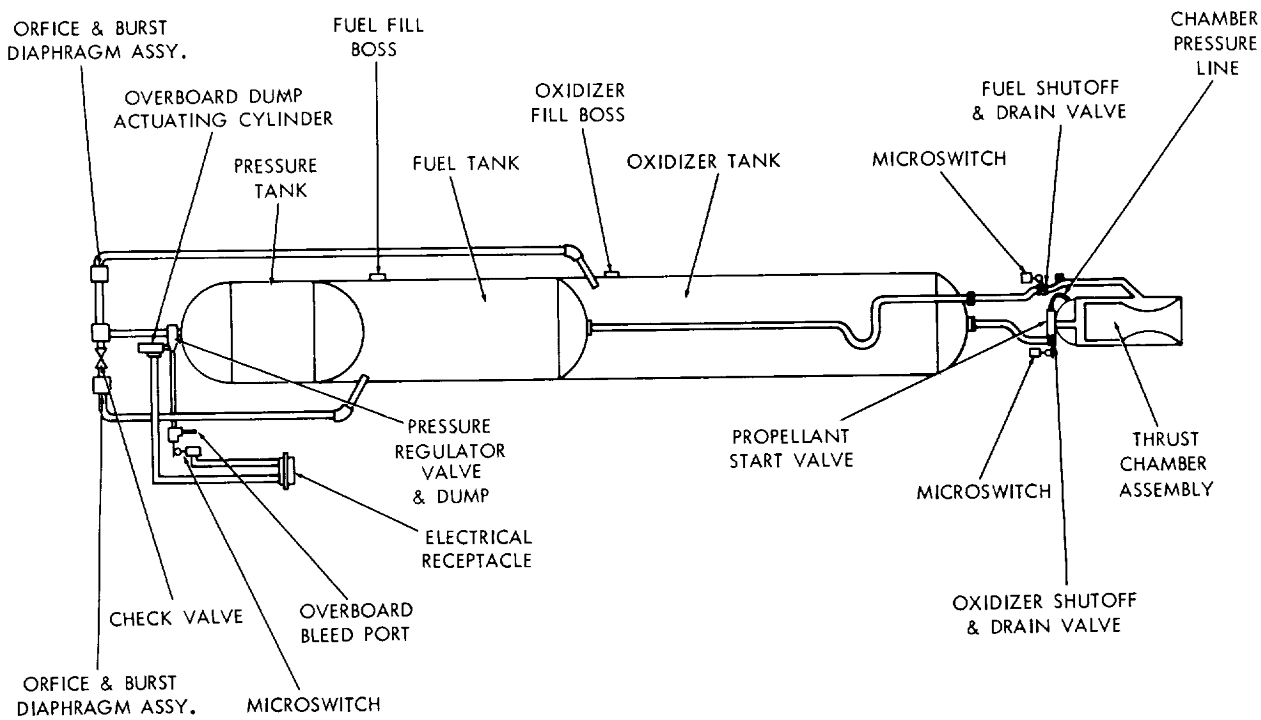
The firing of an Aerobee 150A is accomplished by remote control. Figure 7a illustrates the schematic diagram of the propulsion system. The firing sequence is as follows:

(1) The helium overboard dump is closed by actuation of a squib-operated mechanism.

(2) After a 200 millisecond delay, the booster igniter is fired.

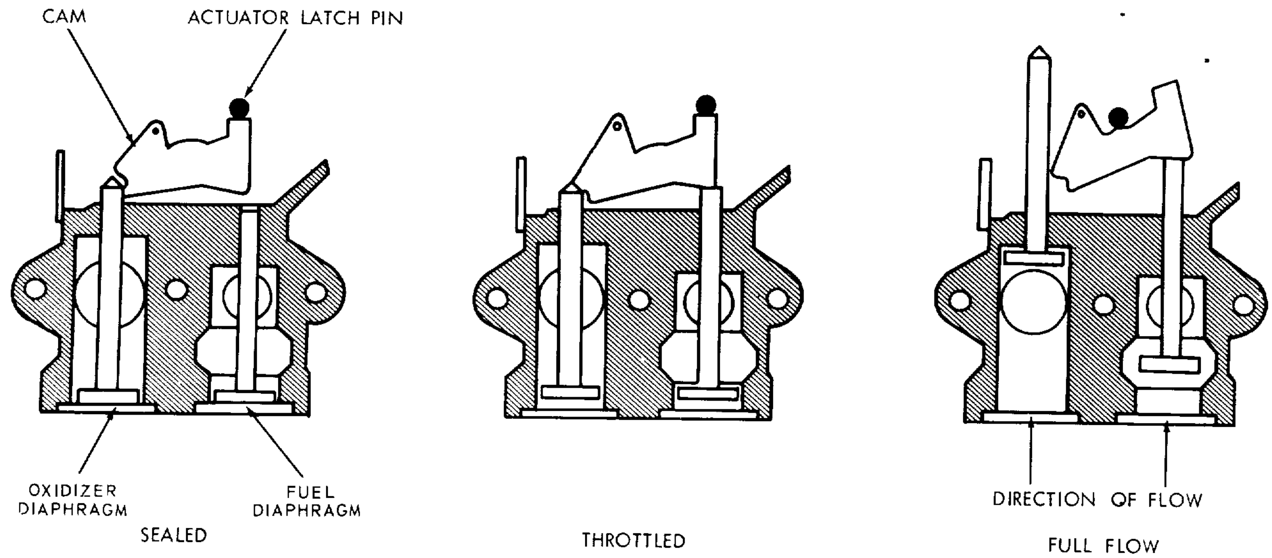
(3) As the rocket moves vertically, the regulator is actuated by pulling a trip wire.

(4) This action opens the pressure regulator valve (Figure 7a) and feeds helium into the propellant tanks (the regulator reduces the gas from 3450 (±50) psia to approximately 500 psia).



(a) Schematic diagram.

Figure 7—Propulsion system.



(b) Positions of propellant start valve.

Figure 7—Propulsion system.

(5) At 160 psig the oxidizer diaphragm in the propellant start valve breaks (Figure 7b).

(6) At 325 psig the fuel diaphragm breaks. The rate of tank pressurization is controlled, by orifices downstream of the regulator. (The fuel tank is pressurized at a rate faster than oxidizer tank pressurization to prevent implosion of the common bulkhead.)

(7) The Nike valve cam holds the pintles in a throttled position to meter the flow of the propellants in the combustion chamber.

(8) When the chamber pressure reaches 100 psig, the propellant start valve actuator releases the cam and pintles and the propellants are in a full flow condition (this is approximately 0.6 second after first booster motion).

(9) At approximately 2.5 seconds the booster burns out and separates from the sustainer.

Nominal Performance Characteristics

Nominal performance characteristics of the Aerobee 150A are as follows:

Liquid-Propulsion System:

Pressurizing Gas	Helium-Grade A
Oxidizer to fuel ratio	2.56 to 1
Thrust chamber pressure	324.0 psia
Sea level thrust	4100 lb.
Powered duration	51.5 sec.
Propellant flow rate	20.71 lb./sec.
Nozzle expansion ratio	4.6

Specific impulse	198 lb-sec/lb
Total impulse at sea level	208,690 lb./sec.

Solid-Propulsion System:

Sea level thrust	18,600 lb.
Powered duration	2.5 sec.
Chamber pressure	1340 psia avg.
Area throat	8.50 in.^{2}
Expansion ratio	7.9
Weight flow rate	104 lb./sec.
Surface-to-Port ratio	74
Specific impulse	178 lb-sec/lb
Flame temperature	2960°F

*Rocket Performance Characteristics.**

Peak altitude	179	statute miles with 100 pound payload
	101.7	statute miles with 300 pound payload
Burnout Velocity	7,094	ft./sec. with 100 lb. payload
	5,260	ft./sec. with 300 lb. payload
Burnout Altitude	138,584	ft. with 100 lb. payload
	111,688	ft. with 300 lb. payload
Burnout Acceleration	349.44	ft./sec.^{2} with 100 lb. payload
	218.24	ft./sec.^{2} with 300 lb. payload

Dispersion Factors (150-lb. Payload):

Tower Tilt Factor	94.0 statute miles for 4° tower tilt
Ballistic Factor	5.2 miles/mph ballistic wind

Weights (In Pounds):

Payload	100 to 300
Vehicle Gross Weight (with payload)	2097.5
Rocket (empty)	279.1

*Performance characteristics are obtained using an ogive nose cone. The cone-cylinder results in an approximate loss of 4% in altitude (launched at sea level).

Booster (loaded)	520.0
Booster (expended)	260.0
Fins (4)	28.0

Volumes (In Cubic Feet):

Pressure Tank	2.57
Fuel Tank	4.46
Oxidizer Tank	7.88
Ullage Space	0.14

Propellant Weights (In Pounds):

Oxidizer	758.2
Fuel	303.3
Helium	5.15

Launch Facility

The Aerobee 150A is only launched from NASA Wallops Station, Wallops Island, Virginia, because at present Wallops has the only tower that can accommodate a four-finned vehicle. The launch tower and preparation facilities (Figure 8) include a launcher 160 feet high which can be adjusted in elevation and in azimuth. The coordinates of Wallops Island are 37° 50' north, 75° 29' west.

AEROBEE 150

The Aerobee 150, being launched from the White Sands Missile Range (WSMR) in Figure 9a, is similar in many ways to the 150A described in the previous section. Obvious physical differences that can be noted are that the Aerobee 150 has a three-fin sustainer and booster. Likewise, the Aerobee 150 has only three shrouds and three riding lugs whereas the 150A configuration has four of each. Also the location of the common oxidizer and fuel bulkhead, the propellant start slug, and the orientation of the pressurization system in the aft structure differ slightly in the Aerobee 150 configuration.

The Aerobee 150 is launched from a three-rail tower such as the tower installation at WSMR (shown in Figure 9b). Fins for the 150 are biconvex and are attached with eight bolts. A comparison between the fin configuration for the Aerobee 150 and the Aerobee 150A is provided in Figure 10. Sustainer fins may be canted to induce roll, and as in the 150A the 150 booster fins are preset at an angle of 2.5° to induce roll.

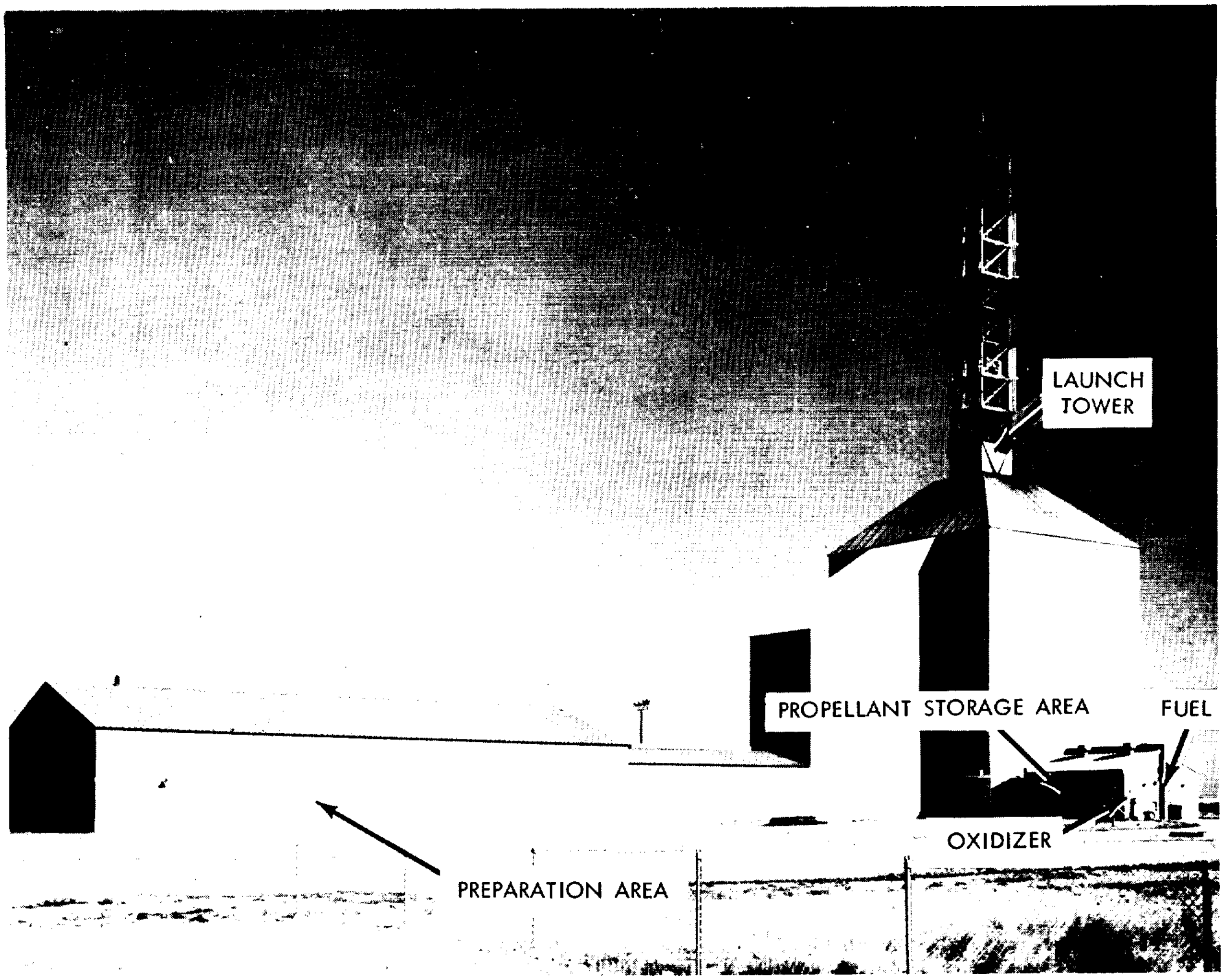
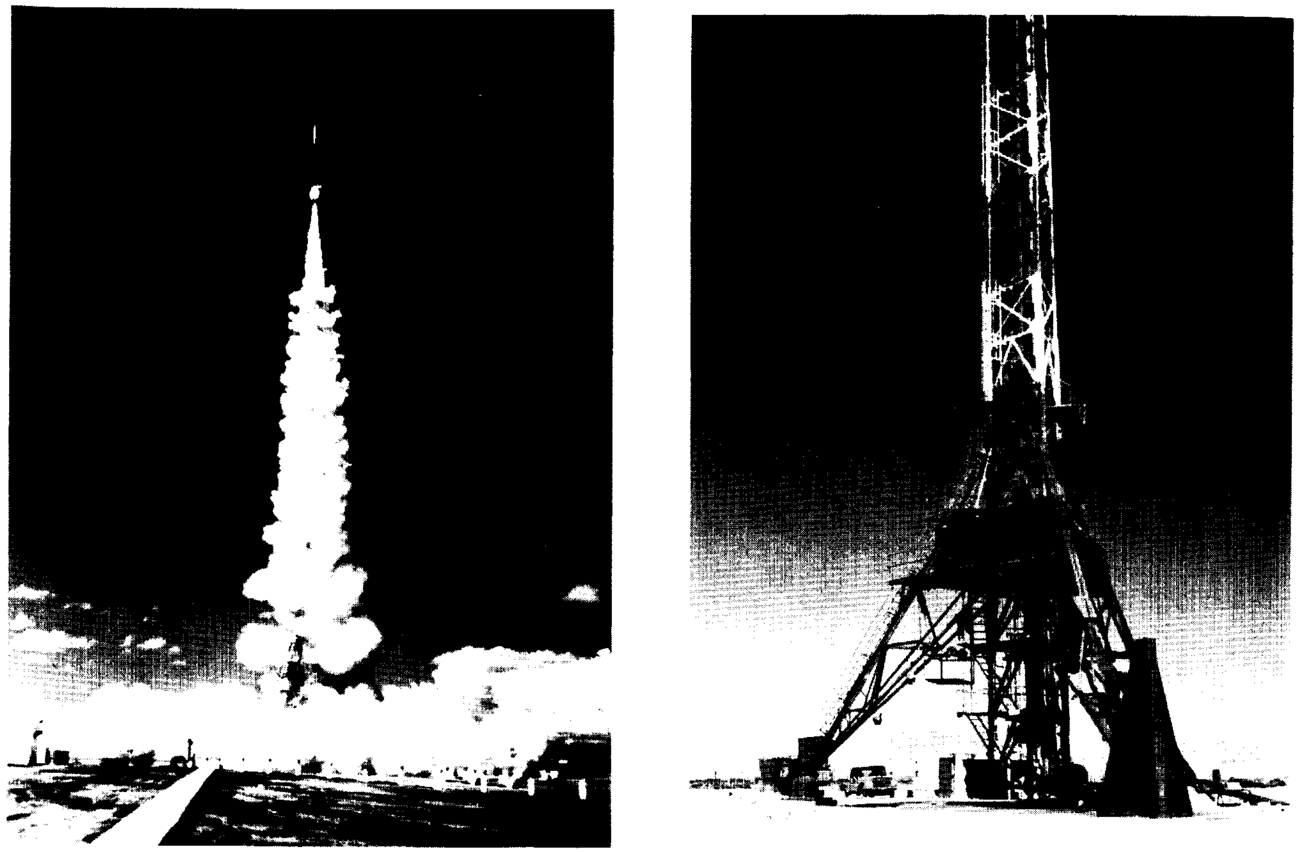


Figure 8—Aerobee launch facility at Wallops Island.

The 150 sustainer uses a 7 lb. start slug of 70% furfuryl alcohol and 30% aniline by weight, which provides slightly improved ignition characteristics over the 65% aniline, 35% furfuryl alcohol mixture used in the 150A. The oxidizer tanks on the 150 are located forward of the fuel tanks. The Figure 11 outline drawing shows the location of the oxidizer fill boss, relative to the fuel fill boss. This propellant positioning requires a change in regulated feed pressures, however; thus the system hydraulic pressure drops and in-flight acceleration heads differ from those of the 150A.

Since the Aerobee 150 has only three shrouds and is launched from a three-rail tower, a rearrangement of the pressurization system in the forward skirt is evident. Figure 12 provides a top view of this revised arrangement. The components of the pressurization system are the same, but fewer instrumentation plugs are available in the 150: Only one plug is shown in Figure 12, whereas two are shown in the forward skirt illustration, (Figure 4a) for the Aerobee 150A.



(a) Typical sounding rocket launch.

(b) Aerobee launch tower installation.

Figure 9—Aerobee launch facility at White Sands Missile Range.

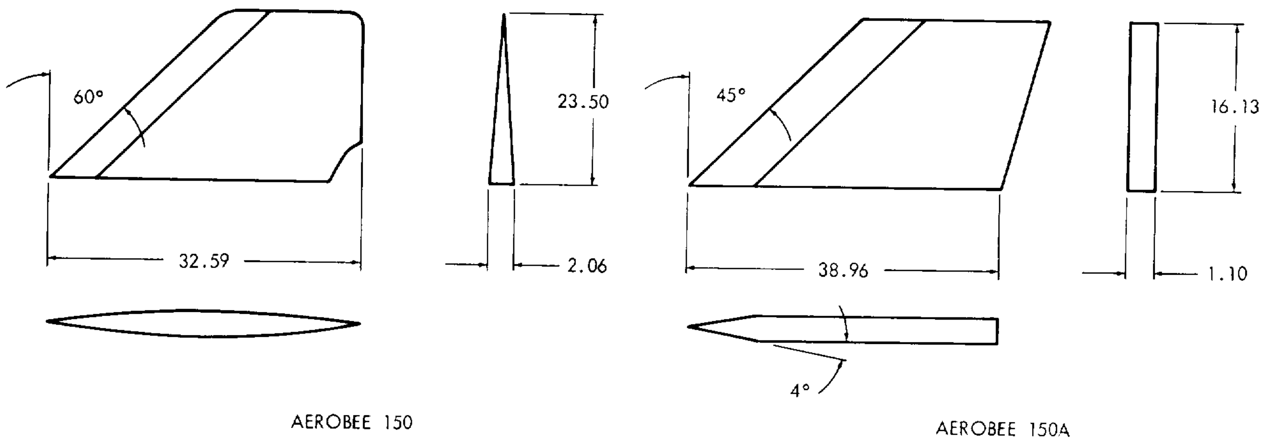


Figure 10—Aerobee tail fin configuration.

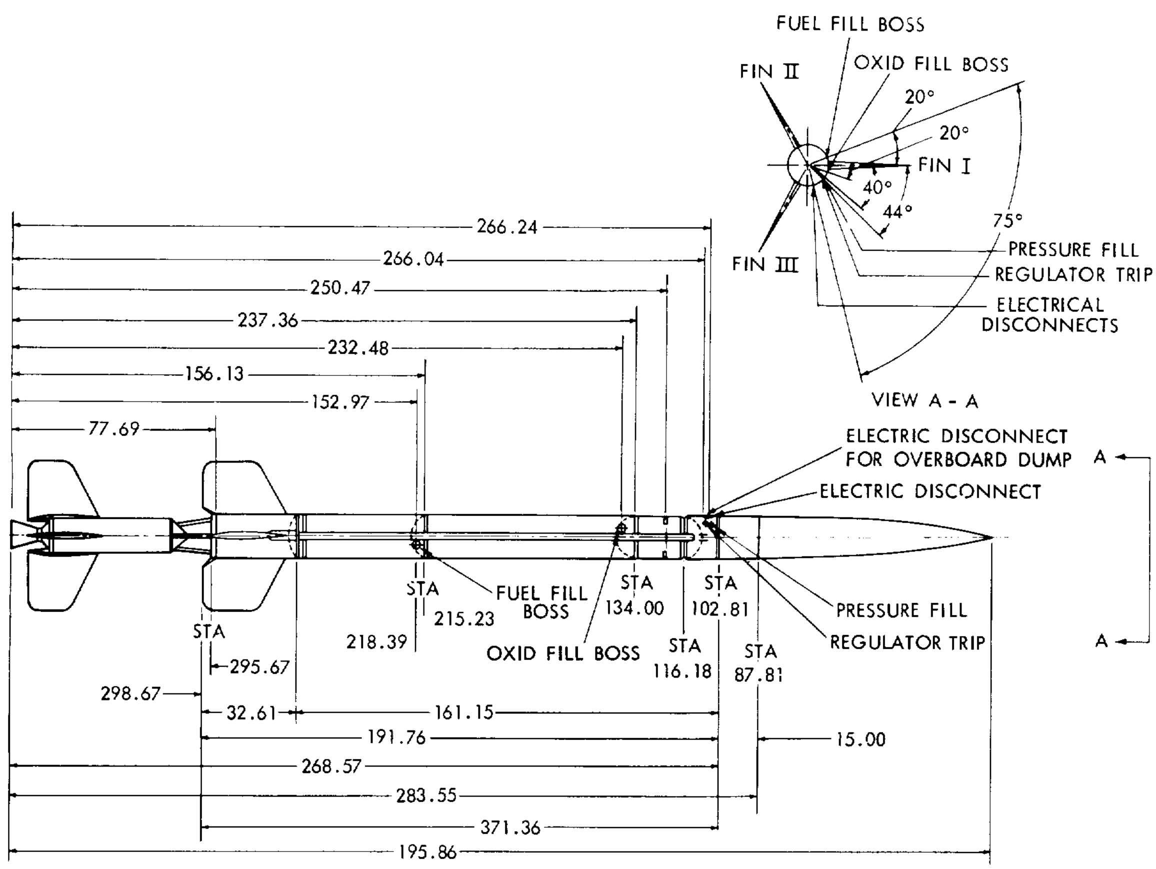


Figure 11—Aerobee 150 outline drawing, showing dimensions and all umbilical connections.

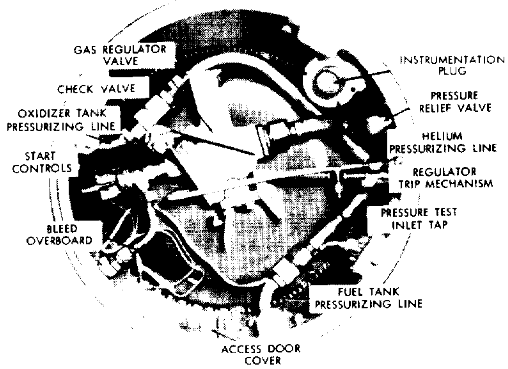


Figure 12—Aerobee 150 forward skirt, showing locations of pressurizing system components.

There are some other minor differences. Figure 13 shows an Aerobee 150 tail assembly. Note the use of hard lines, flare fittings and the arrangement of some of the hardware which differs from that in the 150A. Also, low pressure burst diaphragms (50 ± 10 psi) provide the initial throttling capability which is afforded by the Nike valve in the 150A configuration. There are no differences in the booster case or grain arrangement.

Some typical performance characteristics of the Aerobee 150 (launched at sea level), with a 150 lb. payload and ogive nose cone are:

Peak altitude	158 statute miles
Burnout altitude	132,000 ft.
Burnout velocity	6580 fps
Thrust at sea level	4100 lbs.
Duration of thrust	51.8 sec.

Aerobee 150 rockets are launched from White Sands, New Mexico (WSMR) and Fort Churchill Research Range, Manitoba, Canada (FC). Figure 9b illustrates the tower installation at WSMR; Figure 14a provides an aerial view of the Fort Churchill launch facility; and Figure 14b shows a

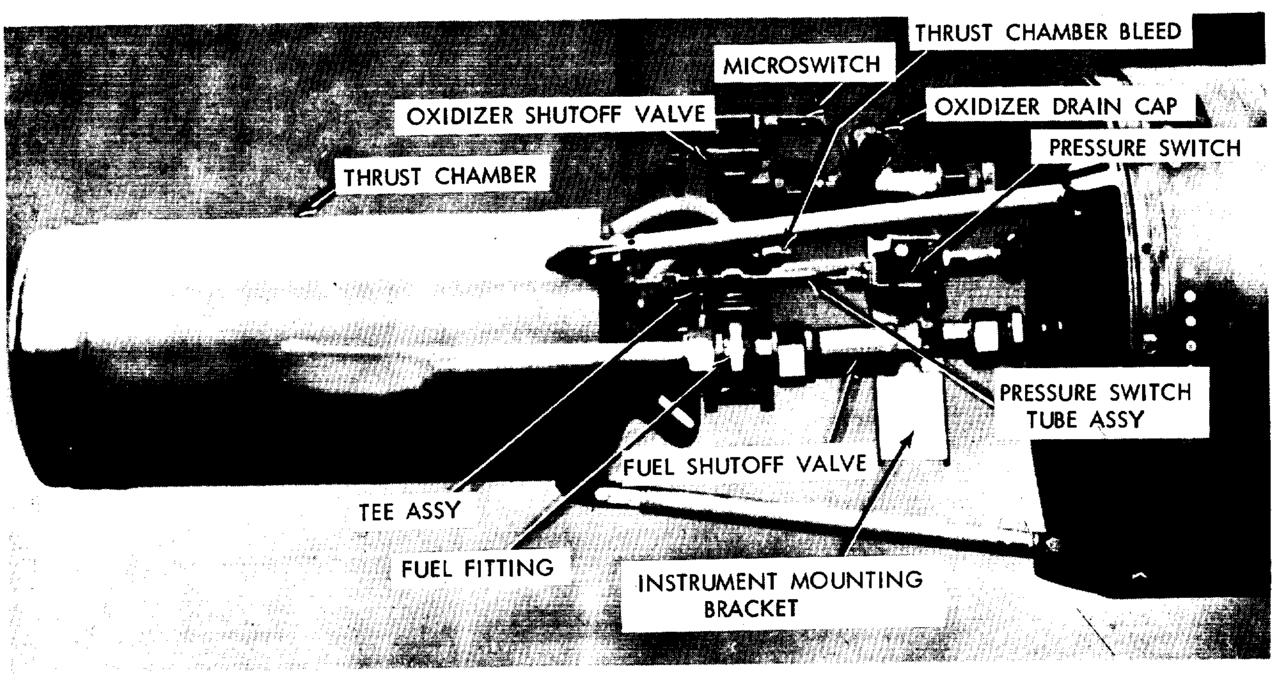
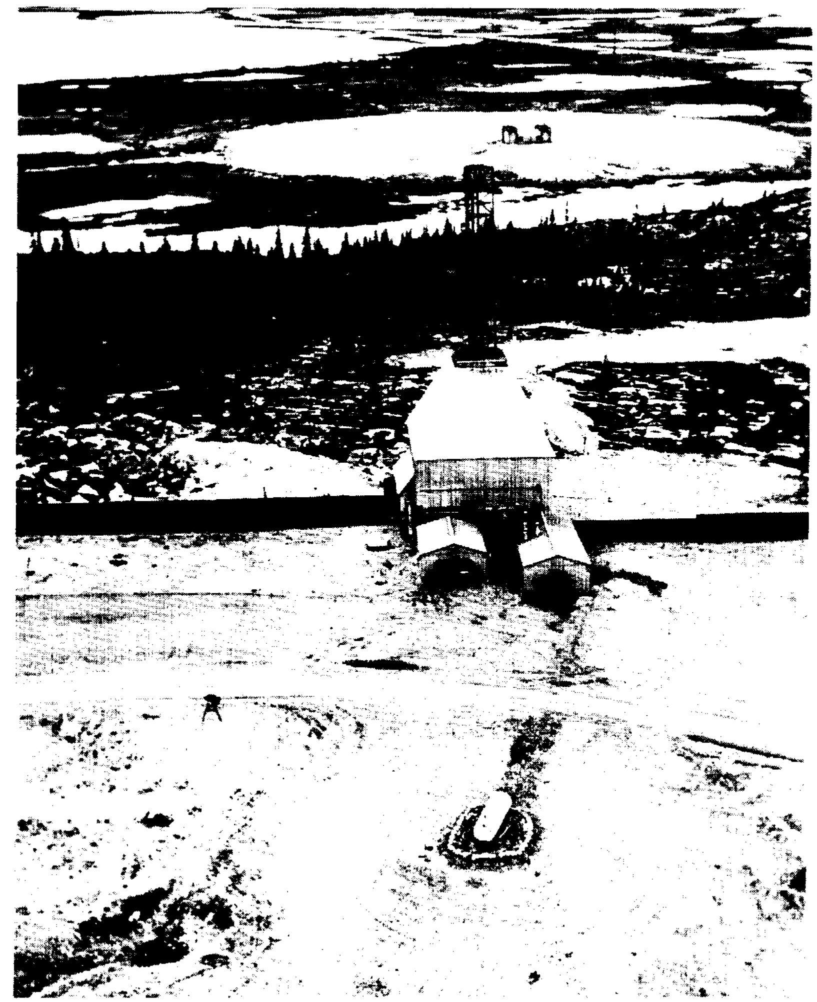


Figure 13—Aerobee 150 tail assembly, showing locations of propellant control fittings.

(a) Overall view.



(b) Closeup view.

Figure 14—Aerial view of Fort Churchill launch facility.

close up of the same facility. Coordinates for the FC launch facility are 58° 44' North, 93° 49' West, on the shore of the Hudson Bay. Coordinates of the WSMR facility are 32° 24' North, 106° 20' 30'' West, approximately 40 miles north of El Paso, Texas. At WSMR, Aerobee 150's are launched from the Naval Ordnance Missile Test Facility with range services provided by the U. S. Army.

AEROBEE 300A

The Aerobee 300A is an Aerobee 150A with a third stage motor added. All Aerobee 150A volumes, weights, and characteristics, except those pertaining to the payload, are applicable to the 300A. Therefore, discussion regarding the Aerobee 300A will be limited to the third stage and its effects on increasing rocket performance.

The third stage shown in Figure 15 is composed of a 1.8KS-7800 solid propellant motor, a high expansion ratio nozzle, a separation subsystem, and the nose cone. The nose cone has a maximum diameter of 8 inches, limited by the diameter of the solid motor. The motor provides a nominal thrust of 7800 pounds for 1.8 seconds. It has the following nominal propulsion system ratings.

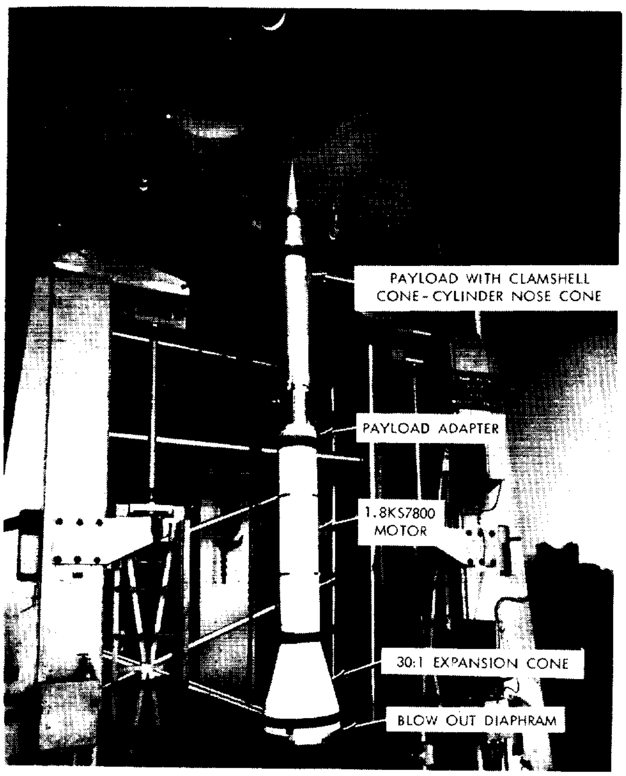


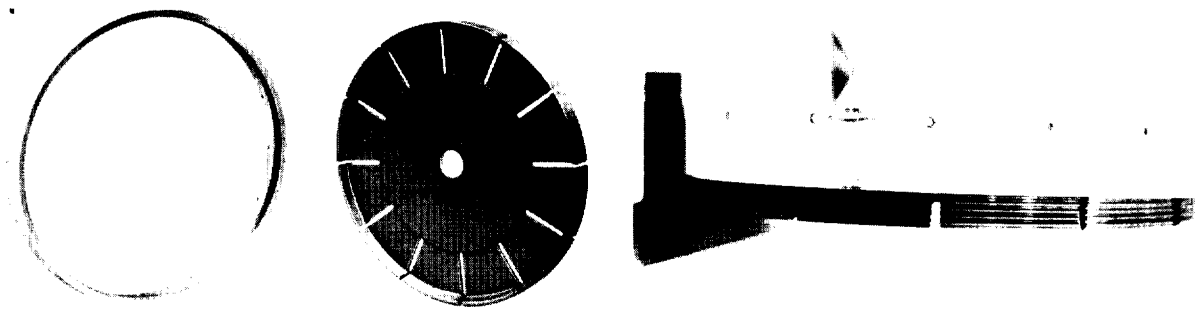
Figure 15—Third stage of Aerobee 300A in dynamic balance facility.

Duration	1.8 sec.
Propellant flow rate	32.09 lb./sec.
Chamber pressure	1000 psia
Throat area	4.43 in.^{2}
Area ratio	30
Diameter	8 in.
Thrust coefficient*	1.73
Thrust*	7664 lb.
Total impulse*	16,478 lb./sec.
Specific impulse*	238.8 lb-sec/lb

The high expansion ratio nozzle is used because the motor operates only at high altitudes; thus optimum expansion is closely approached. Aerodynamic stability during third stage burning is provided by the 14.5 degree half-angle conical transition section housing the 1.8KS-7800 nozzle.

The blowout diaphragm (Figure 16) is used to attach the third stage to the sustainer.

*In vacuum.



(a) End view. (b) Side view.

Figure 16—Aerobee 300A blowout diaphragm.

Upon sustainer thrust termination, a signal ignites the third stage. When this happens, the energy of the motor exhaust causes the diaphragm to deflect, releasing the mating thread engagement between the sustainer and the third stage, and third stage "fly-away" occurs. Payload volume is nominally 0.9 cu. ft. The following total rocket system performance characteristics are expected when the rocket is carrying a 60 lb. payload:

Peak altitude	265 statute miles
Peak time	350 sec.
Burnout velocity	8770 fps
Burnout altitude	144,000 ft.

The Aerobee 300A, like the 150A, can only be fired from a four-rail tower. Thus all Aerobee 300A launchings must at present take place from Wallops Island, Va. (WI).

AEROBEE 300

The Aerobee 300 is similar to the Aerobee 300A, with minor physical differences, in the same way that the Aerobee 150 is similar to the 150A. One of the most obvious distinguishing factors differentiating the 150A from the 150 was that the 150A had four fins, while the 150 had only three. This difference is carried into the 300 series, the 300A having four fins and the 300 three. This has been an important factor in determining the point of launch of the rocket. Three-finned rockets must be launched from a three-rail tower, presently available only at Fort Churchill and at White Sands. So far, however, range boundary limitations at WSMR have restricted the launching of Aerobee 300's there. Prior to Dec. 30th, 1963, only two Aerobee 300 rockets had been fired—both from Fort Churchill.

The Aerobee 300 configuration employs an 1.8KS-7800 motor and an Aerobee 150 rocket. The main performance advantages to be gained by using the Aerobee 300 are for experiments requiring the delivery of smaller payloads of 100 lbs. or less to altitudes about 30 to 50 miles higher than can be expected from the Aerobee 150. Therefore the 300's available payload weight is about one third that of the Aerobee 150. However, the altitude is increased to provide an apogee of 200 or more statute miles.

AEROBEE 100 (JUNIOR)

The Aerobee 100 sounding rocket was a free flight, fin-stabilized, expendable liquid propellant sounding rocket designed for upper atmosphere research, and is no longer used in the NASA sounding rocket program. Consequently the description presented here is mainly of historical interest, since the last of an Aerojet-General production run of 20 Aerobee 100's has been launched.

The Aerobee 100 was designed as a relatively "simple" rocket, of modular construction and is easily stored because of its non-hypergolic fuel. One of the Aerobee 100's best features was its very high degree of reliability, although for some unexplained reason the vehicle continually failed by several miles to attain predicted peak altitude. At the time of the original Aerobee 100 production run, the NASA sounding rocket program had no other rocket in the series which provided these characteristics, in addition to the "off-the-shelf" availability provided by the Aerobee 100. Today, however, the Nike-Cajun, Nike-Apache, etc. have eliminated the need for this rocket.

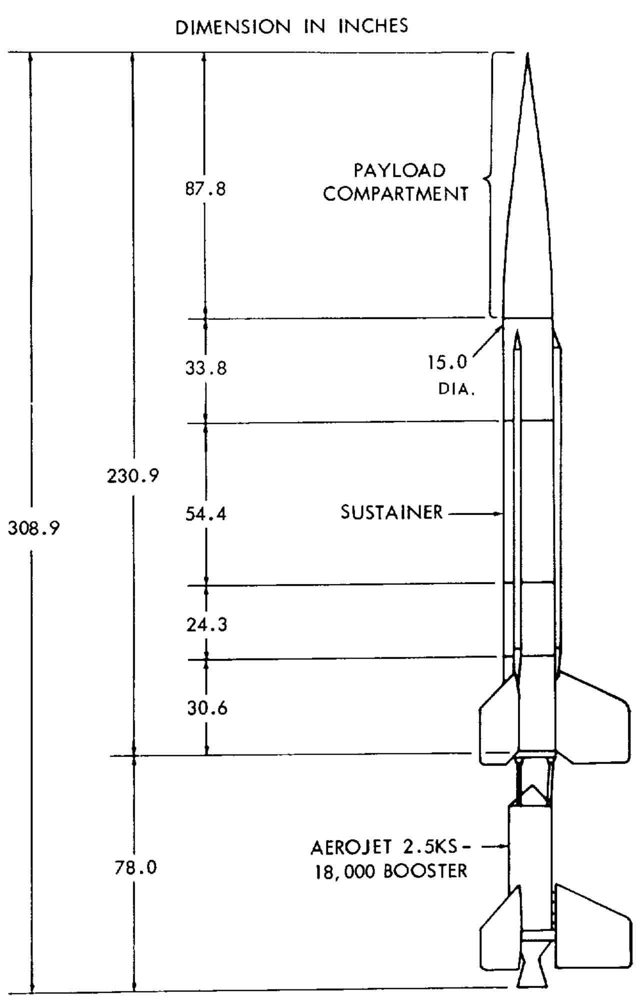


Figure 17—Aerobee 100 outline drawing.

The Aerobee 100 (Figure 17) was a cylindrically-shaped vehicle approximately 15 inches in diameter and about 308 inches in over-all length including the 87.8 inch nose cone. The forebody, a 31-caliber ogival nose section, was also the payload compartment. Three fixed fins, spaced 120° apart and located at the aft end, furnished aerodynamic stability. The engine consisted of a pressurizing tank, thrust chamber assembly, pressure regulator valve, and associated valves and interconnecting plumbing. It started from the hypergolic reaction between inhibited red fuming nitric acid (IRFNA) and a starting slug of unsymmetrical dimethyl hydrazine (UDMH), and operated on IRFNA and JP-4 propellants. It produced a nominal thrust of 2600 pounds for a duration of 40 seconds. The engine, the same as that used in the Nike-Ajax sustainer in combination with a booster, powered the sounding rocket to a zenith altitude of approximately 92 miles with a 40-pound payload when launched from a 4000-foot elevation. The rocket was designed to be launched from a tower in an essentially vertical attitude with initial guidance from fixed rails, and with auxiliary thrust from a 2.5KS-18,000 solid propellant booster rocket (the same booster as that used with the Aerobee 150).

Typical performance parameters of the rocket were as follows (with a 40 pound payload):

Characteristic	Nominal Rated Value at Launching Elevation: Sea Level	Nominal Rated Value at Launching Elevation: 4000 ft.
Altitude (zenith altitude based on vehicle gross weight of 1447 lb.)-miles	79	92
Velocity (at end of boost period)-ft/sec.	1100	1100
Velocity (maximum at cessation of sustaining power in normal flight)-ft/sec.	4660	5000
Time (to trajectory summit)-sec.	187	200
Acceleration (maximum during boost 2-1/2 sec. period)-g	15.2	15.3
Acceleration (maximum during sustaining period)-g	7.7	7.9
Total Impulse, I_t (at ground level)-lb./sec.	104,000	104,000
Thrust, F (at ground level)-lb.	2600	2600
Instantaneous mixture ratio (steady state static test)	4.35	4.35

The weight breakdown of the Aerobee Junior sustainer is:

Item	Nominal Weight (pounds)	
Sounding rocket total dry weight (including nose assembly)	260	260
Oxidizer at 68°F (Sp. Gr. of 1.560)	426	
Fuel at 68°F (Sp. Gr. of 0.785)	96	
Pressurizing gas (air or nitrogen)	24	
Total propellant and gas weight		546
Total net weight		806

The working pressures of the sustainer are:

Pressure tank	3000 ± 50 psig
Propellant tank	440 ± 10 psig
Fuel circuit	430 ± 10 psig
Oxidizer circuit	430 ± 10 psig

FLIGHT IDENTIFICATION SYSTEM

The NASA flight identification normally consists of five alpha-numeric characters, such as 4.21 GA.

a) The first character, followed by a decimal, denotes the type of Aerobee rocket, thus:

1. = Aerobee 100
4. = Aerobee 150, 150A
6. = Aerobee 300, 300A

b) Immediately following the decimal, an identifying two digit number is assigned. This number is peculiar to only one flight.

c) The last two characters in the flight number are the identifying letters. These letters identify, first the instrumenting agency, and second the type-experiment. The listing below provides the coding used.

AGENCY	EXPERIMENT
G - Goddard	A - Aeronomy
N - Other NASA Centers	E - Energetic Particles and Fields
U - College or University	I - Ionospheric Physics
D - DOD	S - Solar Physics
A - Other Government Agency	G - Galactic Astronomy
C - Industrial Corporations	R - Radio Astronomy
I - International	B - Biological
	P - Special Projects
	T - Test and Support

SOUNDING ROCKET PARAMETERS AND CHARACTERISTICS

Tables 1, 2, and 3 describe the various parameters and characteristics of the Aerobee sounding rockets utilized in the various NASA experiment programs. Included are data on performance and physical characteristics of each vehicle type.

Table 1

Sounding Rocket Performance Parameters.

PARAMETER & UNIT OF MEASURE	BOOSTER 2.5KS-18,000	AEROBEE				
		100	150	150A	300**	300A**
Nominal thrust (lb.)*	18,600	2600	4100	4100	7664 (vac.)	7664 (vac.)
Thrust duration (sec.)	2.5	40	51.3	50.9	1.73	1.73
I_{sp} (lb-sec/lb)*	178.8	200	198	198	238.8	238.8
Total impulse (lb./sec.)	46,500	104,000	210,330	208,690	16,478	16,478
Thrust coefficient*	1.58	1.342	1.37	1.37	1.73	1.73
Thrust chamber pressure (psia)	1340	330	324	324	1000	1000
Exhaust velocity (ft./sec.)	-	4800	4650	4650	-	-
Total propellant flow rate, avg. (lb./sec.)	104	13.0	20.71	20.71	32.09	32.09
Fuel flow rate, avg. (lb./sec.)	-	2.36	5.82	5.82	-	-
Oxidizer flow rate, avg. (lb./sec.)	-	10.64	14.89	14.89	-	-
Instantaneous mixture ratio (avg.)	-	4.35	2.56	2.56	-	-
Acceleration max. (g)	15.4	7.9	10.3	10.3	33.0†	33.0†
Sustainer ignition time after launch (sec.)	-	1.0	0.5	0.6	-	-
Ignition time (sec.)	-	-	-	-	51.8	51.5
Flame temperature (°F)	2960°					

*At sea level unless otherwise specified.

†90 lb. payload.

**3rd stage only.

Table 2

Sounding Rocket Propulsion System Characteristics.

PARAMETER & UNIT OF MEASURE	BOOSTER 2.5KS-18,000	AEROBEE				
		100	150	150A	300**	300A**
THRUST CHAMBER						
Nozzle throat area (in.^{2})	8.50	5.87	9.24	9.24	4.43	4.43
Nozzle exit area (in.^{2})	67.2	30.0	42.75	42.75	(133)	(133)
Nozzle exit dia. (in.)	9.24	6.2	7.378	7.378	8	8
Nozzle area ratio	7.9	5.1	4.6	4.6	30	30
Chamber-throat area ratio	-	4.5	3.88	3.88	-	-
PRESSURE TANK						
Volume (ft.^{3})	-	1.72	2.57	2.57	-	-
Max. work press. (psig)	-	3000	3650	3650	-	-
Proof pressure (psig)	-	4000	4000	4000	-	-
OXIDIZER TANK						
Volume, incl. ullage (ft.^{3})	-	4.67	8.02	8.02	-	-
Max. work press. (psig)	-	440	500	500	-	-
Proof pressure (psig)	-	550	550	550	-	-
FUEL TANK						
Volume, incl. ullage (ft.^{3})	-	2.08	4.60	4.60	-	-
Max. work press. (psig)	-	440	500	500	-	-
Proof pressure (psig)	-	550	550	550	-	-
TANK ASSEMBLY						
Total length (in.)	-	-	160.14	161.5	-	-
Diameter (in.)			15	15		

**3rd stage only.

Table 3

Sounding Rocket Dimension and Weights.

PARAMETER & UNIT OF MEASURE	BOOSTER 2.5KS-18,000	AEROBEE				
		100	150	150A	300**	300A**
SUSTAINER						
Weight (lb.)						
Sustainer	-	246.0	256.0	262.7	60	60
Nose cone	-	15.5	15.5	15.5	7	7
Oxidizer	-	426.0	764.4	758.2	-	-
Fuel	-	99.0	304.4	303.3	69	69
Helium	-	2.9	5.1	5.15	-	-
Total net weight	-	789.4	1345.4	1344.8	136	136
BOOSTER						
Booster motor inerts, w/igniter	246	246	246	246	-	-
Booster fin assy	-	27(3)	27(3)	30(4)	-	-
Booster thrust structure	62	62	62	62	-	-
Booster dry weight		333	333	338		
Propellant	260	260	260	260	-	-
Launch weight	-	600	600	600	-	-
DIMENSIONS						
Body length (in.)	78.1	143.0	190.9	191.8	57.6**	57.6**
Body diameter (in.)	13	15	15	15	8.0**	8.0**
Dia. thru riding lugs (in.)		15.75	15.75	15.75		
Fin diameter (in.)		62	62	47.2		
Length o. a. (excl. payload) (in.)		221.1 (18.4ft)	268 (22.38ft)	270.8 (22.47ft)		
Fin cant (min.)	2.5°		0-20'	0-20'		

*3rd stage motor.

**3rd stage only, loaded.

ANCILLARY HARDWARE

Attitude Control Systems

The inertial attitude control system (IACS) used in the Aerobee rocket is a ground oriented inertial controlled system built by the Space-General Corporation of El Monte, California (formerly the Aerojet-General Corporation). The IACS controls the vehicle about its roll, pitch and yaw axes during the free-flight portion of the trajectory. Two gyros are used to establish the inertial reference for vehicle alignment, each containing two degrees of freedom. One gyro is used for pitch and roll, the other for yaw. Programmed maneuvers are accomplished during flight by changing the inertial attitude of the free gyros. The system senses this change as an error and activates the appropriate jet or jets to correct the error. The vehicle is directed about its axes by eight cold-gas jets; and these jets utilize the residual helium in the propellant pressurization system. Two of the roll jets are used to despin the vehicle, after thrust termination.

Components in the IACS

The following components are used in the IACS:

(1) Power Supply: The battery power supply consists of 20 Yardney HR-1 silver cells. The HR-1 silver cell is a silver-zinc alkaline high-rate discharge battery. The cells, connected in series, supply 28 volts to the ACS unit when the ACS is on internal power.

(2) Static Inverter: The static inverter supplies a 26-volt, 400-cps, 2-phase square wave. The frequency is regulated to ±0.1 percent and phase angles to 90° ± 5 percent. The inverter supplies power for the free gyros, the rate gyros, the control unit, and the synchronous timer motor.

(3) Programmer: The programmer controls the sequential mode of operation by connecting precision voltages, through associated relays, to the ACS components at a predetermined time. The time increment for each sequence of operation is determined by a motor-driven timer and its multi-lobe cam and micro-switches. The programmer functions through a 24-position multi-wafered stepping switch.

(4) Control Unit: The control unit is a solid-state, phase- and amplitude-sensitive device that accepts error and position data for each channel and provides correction signals in the proper sequence of roll, pitch, and yaw.

(5) Free Gyros: The two gyros used are miniature two-axis non-floating free gyros with synchro and torquer on each gimbal axis. The torquers precess the gyro gimbals to the desired inertial attitude. The synchros supply gimbal position information. The outer gimbal has an unrestricted movement range of 360 degrees, and the inner gimbal has a useful movement range of ±80 to 85 degrees. The torquers, with 26 volts rms applied, are capable of precessing their respective gimbals at a rate of 9 degrees per second.

(6) Rate Gyros: Three rate gyros are used in the ACS to determine angular velocity. These gyros are mounted in the roll, pitch, and yaw axes. Their output signals are combined with the respective free gyro position signals (in the programmer) to provide damping.

(7) Remote Adjust Unit: The remote adjust unit consists of three motor-driven variable transformers remotely controlled from the ACS console. Each gimbal torquer in the roll, pitch, and yaw axes has its own signal transformer. The local-vertical correction signal, an input to the transformer prior to launch and at a given time in the program, is supplied to the gyro torquers.

(8) Control Valves and Jets: The ACS has a total of seven control valves and eight cold-gas jets. The aft structure contains the pitch and yaw control valves and jets, and the insert contains the roll control valves and jets. The insert also contains the despin control valve which controls one set of roll jets. At operating altitude the pitch and yaw jets produce five pounds of thrust each, and the roll jets produce one pound each. The despin jets produce 20 pounds of thrust per pair.

Another model of the ACS incorporates a roll-stabilized platform, used to limit the pitch and yaw gyro drift which results from the rocket roll environment during sustainer burning. The current ACS system orients the rocket to within 1° of a pre-selected target. Currently under development is a Fine Attitude Control System (FACS) that will provide greater pointing accuracies than are capable with any of the present systems.

Despin Systems

A gas despin system designed by Goddard Space Flight Center personnel has been successfully employed on many flights requiring a zero or low roll rate during the data collection period. This attitude control system, mounted for an Aerobee 150 rocket, is pictured in Figure 18a-e.

Operational Sequence of the Gas Despin System

The operational sequence of the gas despin system is as follows:

(1) (Liftoff minus one to three minutes)—The gyro rate switch motor is started on 28 VDC. The rate switch motor should be running on internal power at rocket liftoff.

(2) The "G" reduction timer begins timing as vehicle acceleration of greater than 4.0 g releases a mechanical latch on the timer arm.

(3) (Liftoff +2.5 seconds)—The booster drops away from the sustainer rocket and thereby allows the booster tail switch (in the sustainer rocket) to arm the rocket shutdown circuit.

(4) (Liftoff + approximately 25 seconds)—The sustainer rocket reaches an altitude of approximately thirty thousand feet where the altitude switch energizes the automatic rocket shutdown and despin initiation circuits.

(5) (Liftoff + approximately 30 seconds)—The "G" reduction timer weight moves to a latching or arming position. This is induced by approximately 4.0 g of vehicle acceleration.

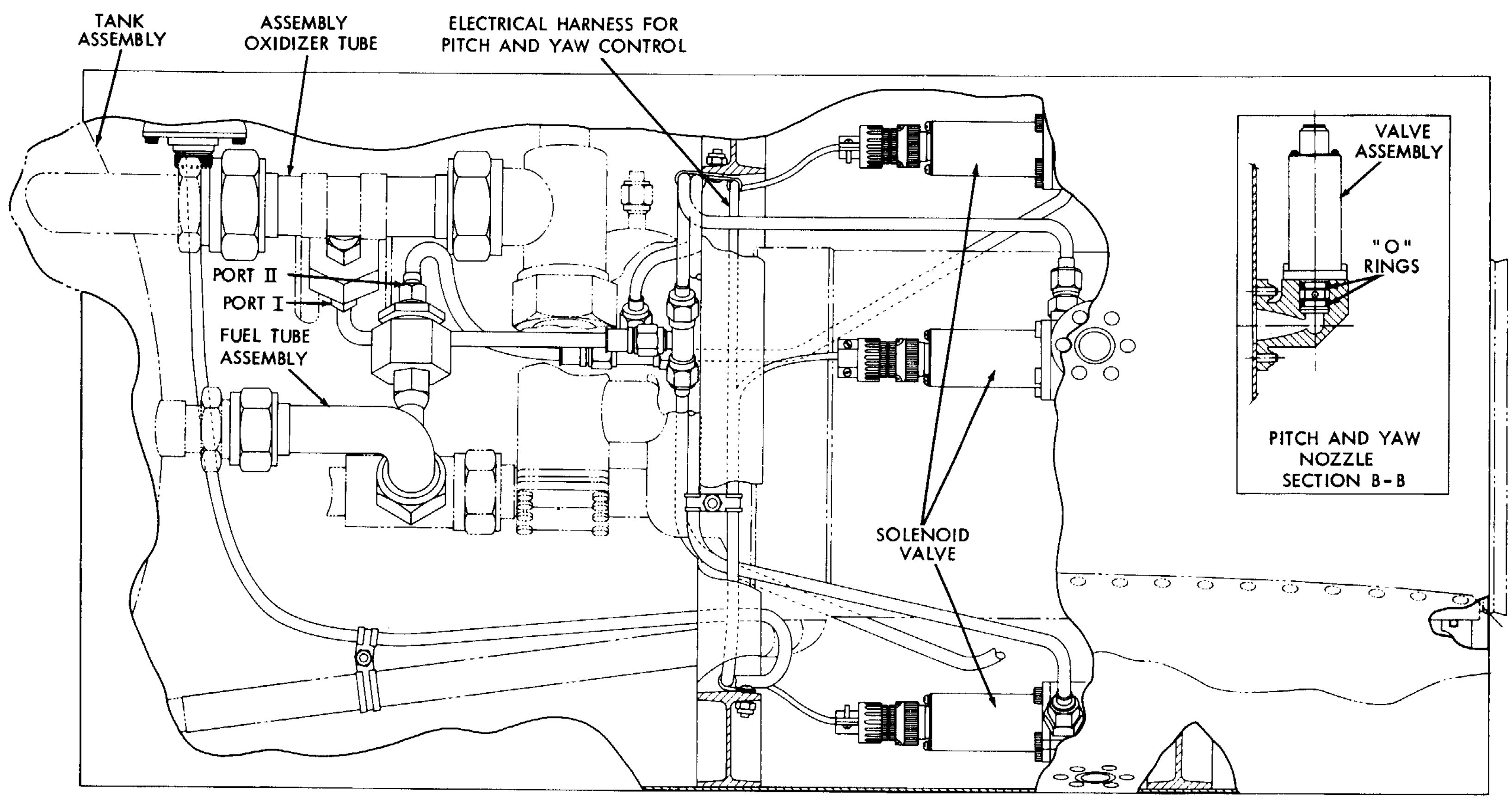
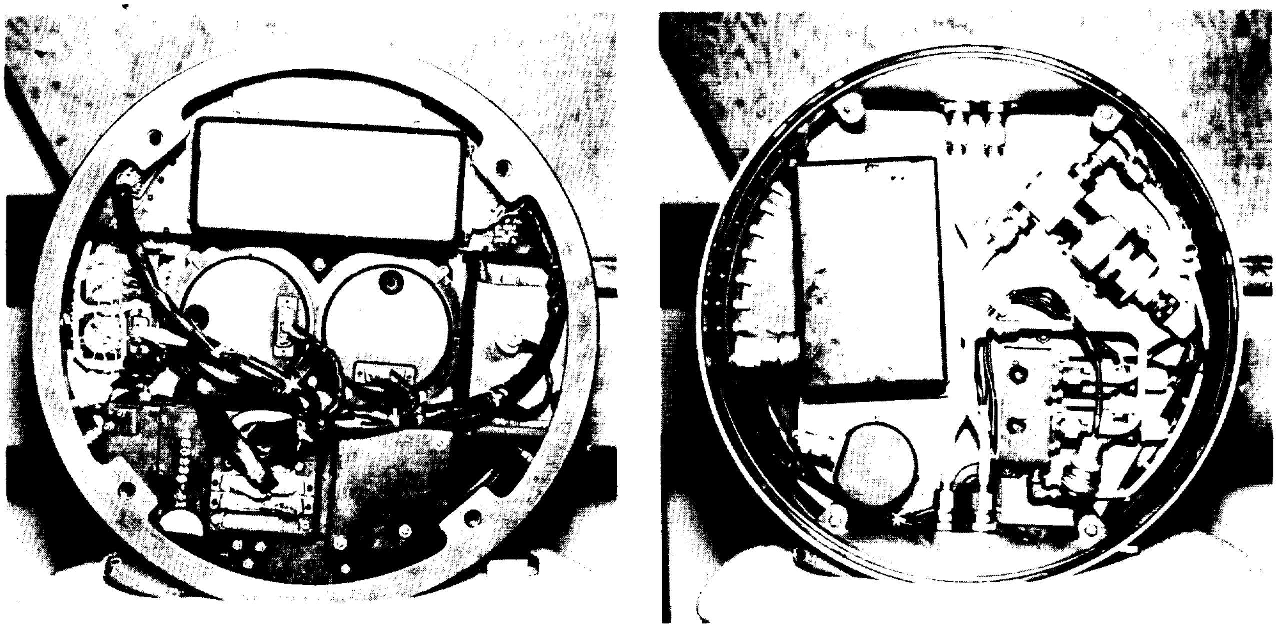


Figure 18—Attitude control system for the Aerobee 150 sounding rocket. (a) Cutaway drawing showing electrical and mechanical installation of ACS pitch and yaw jets in the tail can. (b) Side view of pitch-yaw nozzle.



(c) Top view showing location of parts, routing of plumbing, and orientation between ACS and forward skirt.

(d) Orientation of pitch and yaw nozzles, and plumbing connections, looking aft in the tail can.

Figure 18—Attitude control system for the Aerobee 150 sounding rocket.

(6) (Liftoff + 48 seconds)—The "G" reduction timer arm "times out" and jumps to the armed or latched position where it is stopped by the latching weight mentioned in step 5.

(7) (Vehicle burnout—approximately 52 seconds after liftoff)—The "G" reduction timer latching weight returns to rest position, when the actuating vehicle acceleration is removed, and allows the timer arm to seat and to actuate switches. Power is thereby sent to the pyrotechnic shutoff valves in the sustainer rocket propellant lines to shutdown the vehicle and trap residual pressurization gas (Helium) in the rocket tanks. Normal Aerobee shutdown may be commanded via the Aerobee cutoff receiver after liftoff as a backup.

(8) Despin is initiated about 68 seconds after liftoff when a timer switch applies power to the normally closed despin valve (Conax Model SEV-16-4-A). The gas is then allowed to flow from the rocket tanks to the control nozzles on the skin of the rocket, which will exert an average despin torque of approximately 4.9 ft.-lb. on the vehicle. Despin is generally delayed until the vehicle is essentially free of aerodynamic forces.

(9) Despin Completion—The time required for the vehicle to despin to the desired roll rate will depend on the initial and final roll rates and the roll inertia of the rocket. Generally, the despin time is between 15 and 25 seconds. When the rocket roll rate reaches the rate switch setting, the rate switch applies electrical power to the normally open despin valve, cutting gas flow to the control nozzles. The rocket should then remain at nearly the rotational rate at which the control torque was removed. The rate switch (Humphrey, Model RSO1-0313-1) is generally used to allow switching rates to be set between 10 and 60 degrees per second. On this particular model, switching

accuracy is within ±1 degree per second of the set rate. Although this accuracy is normally desired, other rate switches of similar design have been used successfully.

In addition to the gas despin system, single-wrap and three-wrap yo-yo type despin systems (Figure 18g) are available. These systems despin the rocket much faster than the gas system, but have less accurate control over the final roll rate.

Solar Pointing Controls

Many experiments required accurate orientation of the payload toward the sun. To fulfill such a requirement, the University of Colorado (U. Colo.) and the Ball Brothers Research Corporation (BBRC), have built solar pointing controls.

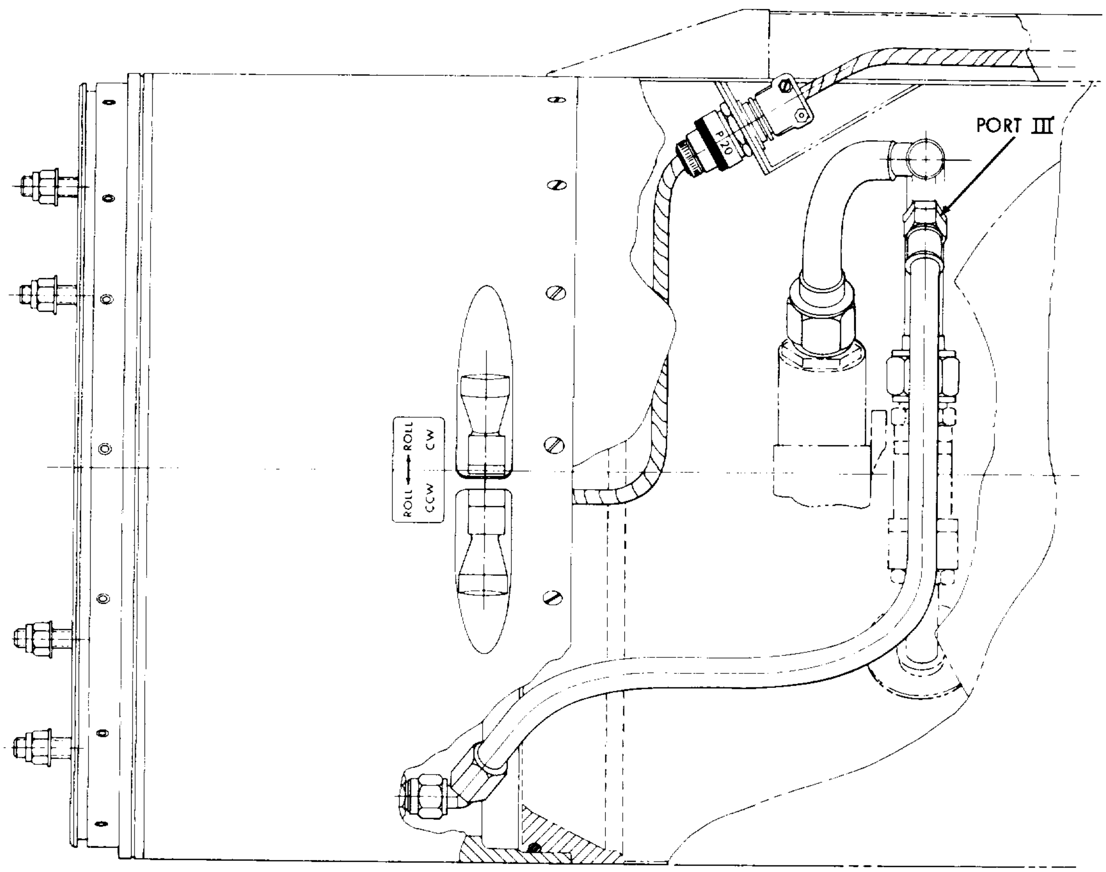
For purposes of illustration, only one solar pointing control (BBRC model SPC-300) will be discussed here. While there is considerable variation in the BBRC models and the U. Colo. model, the basic objective and theory of operation of the biaxial pointing control (BPC) remains the same.

Solar Pointing Control Theory of Operation

The solar pointing control provides high accuracy, biaxial orientation of instruments toward the sun from Aerobee sounding rockets. The basic configuration is adaptable for use with a broad range of research instrumentation. Payload orientation is provided by two servo systems operating in the vehicle (azimuth) and transverse (elevation) axes. Error sensing is provided by coarse and fine

(e) View of gas jet nozzles.

Figure 18—Attitude control system for the Aerobee 150 sounding rocket.



(f) Cutaway of ACS and forward skirt, showing the location of roll jets and connections to the helium regulator manifold.

Figure 18—Attitude control system for the Aerobee 150 sounding rocket.

light sensitive detectors in each axis. The fine (high resolution) detectors are attached directly to the pointed instrument and aligned to the desired optical axis.

The solar pointing control utilizes the standard Aerobee nose cone assembly. The maximum instrument size is determined by the cone diameter between stations 24 and 65 (distance in inches from the cone tip). Approximately half of the ogive between these points is reserved for the instrument, attached on one side normally at station 49.5 and rotating about the elevation axis.

The solar pointing control type SPC-300A is similar but requires a cone-cylinder assembly in order to accommodate larger pointed instruments. Instrument space available in this configuration is half of a cylinder approximately 40 inches long with a radius of 6.5 inches.

On either configuration, the skin assembly is unlatched at altitudes greater than 350,000 feet, and raised sufficiently to allow the instrument to rotate about the elevation axis. If recovery is

(g) Ground test of three-wrap yo-yo despin system.

Figure 18—Yo-yo design system for the Aerobee 150 sounding rocket.

desired, the instrument is allowed to point until at approximately 350,000 feet on the down leg of the trajectory; the instrument is then locked into the stow position, the skin assembly is retracted and locked into position for atmospheric re-entry.

Specifications for the solar pointing control are as follows:

Pointing error (from solar center)	±10 minutes of arc
Minimum operating altitude	350,000 feet
Maximum vehicle spin rate	3 rps
Length*	87.5 inches
Maximum diameter	15 inches
Weight*	133 pounds
Maximum pointed instrument weight*	40 pounds
Typical zenith altitude†	140 miles
Typical pointing duration†	320 seconds

Recovery Systems

Land Recovery

When recovery of vehicle and payload is desired, one basic recovery system is often used on Aerobee vehicles. A land recovery system, manufactured by the Space-General Corporation (Figure 19) consists of 24-foot-diameter main parachute, a 57-inch diameter pilot chute, and a severance system initiated by an electrical actuation system. The parachute is contained in a 10-inch-diameter canister mounted within a 15-inch-diameter magnesium rocket extension. The total length of the recovery system is 14.75 inches.

Water Recovery

A water recovery system can also be used which, in addition to the hardware mentioned above, includes a flotation system. This system is 20 inches in length. Still other means of recovering sustainers and portions of payloads have been employed in the past but these are not described here.

General Recovery Sequence

The following general sequence of events occurs when the recovery system is flown:

a. Both forward and aft initiators are armed by a lanyard trip upon initial vehicle motion.

*Typical configuration

†Average Aerobee 150 performance with typical pointing control payloads.

b. The actuation box is armed on the upward leg of the trajectory.

c. Payload and sustainer severance is signalled by the range safety receiver or by a timer at approximately 300,000 feet altitude on the down leg of the trajectory.

d. The aft initiator is fired, initiating the aft primacord.

e. The primacord cuts all electrical wiring and plumbing and separates the payload from the sustainer.

f. The payload tumbles in an approximately flat spin attitude, reducing its velocity to approximately 250 feet per second.

g. At approximately 18,000 feet altitude, the actuation box fires the forward initiator and primacord.

h. The primacord severs the electrical wiring and plumbing routed through the cover and cuts off the cover.

i. The cover is pulled away from the payload by aerodynamic drag, and extracts the pilot chute deployment bag and bridle. Initial movement of the bag initiates the main parachute reefing line cutter timers.

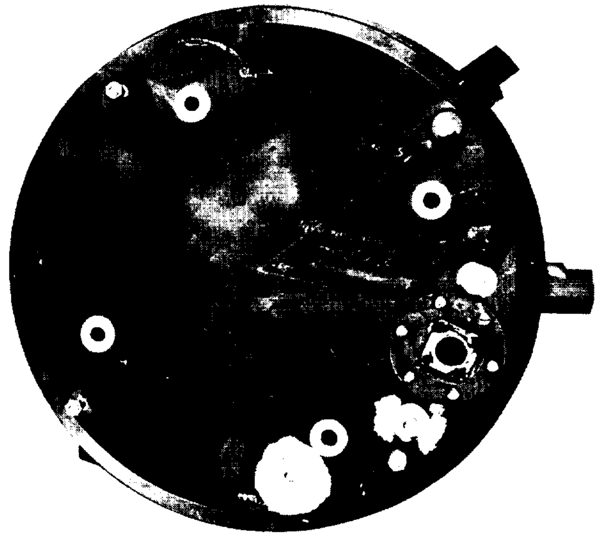
j. The pilot chute is filled and stops the payload tumbling during the next 12 seconds.

k. The reefing line cutters open the main deployment bag and the pilot chute carries it away.

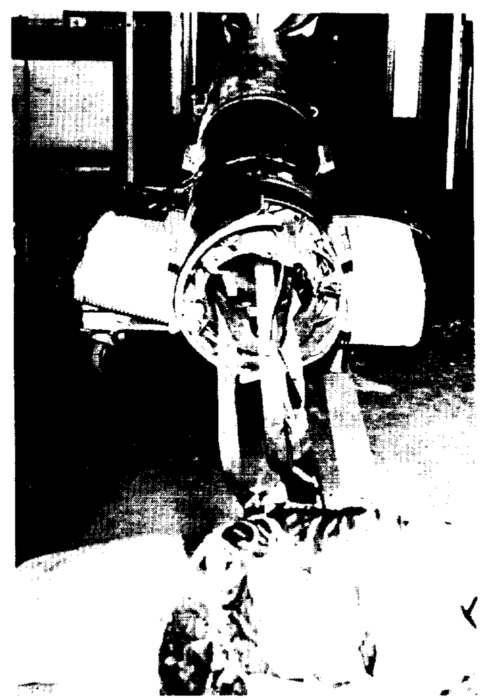
l. The main chute is deployed by the drag chute and decelerates the payload to a mean descent velocity of 25 feet per second until impact occurs.

CHRONOLOGY

Of the 95 total NASA Aerobee launchings from September 11, 1959 to the end of calendar



(a) Top view of parachute extension bulkhead.



(b) Payload after recovery showing parachute attachments.

Figure 19—Aerobee payload recovery system.

(c) Camera (packaged inside nose tip) and recovery package showing deployment of parachute and flotation gear.

Figure 19—Aerobee payload recovery system.

year (CY) 1963, 14 launches were Aerobee 100's, 20 were Aerobee 150's, 52 were Aerobee 150A's, 2 were Aerobee 300's and 7 were Aerobee 300A's. In the following paragraphs, each flight is summarized and listed separately in chronological order by CY except where grouped to facilitate analysis (i.e., when several flights carried similar payloads although fired at different times of the year). Each discussion will only report the facts as they were received from actual flight reports. Assumptions are necessarily made in some cases due to the lack of concrete information; however, such are only offered where deduced from the evidence presented. In any event, only the performance of the vehicle will be discussed and not the success of the scientific experiment, except where unavoidable. In such instances comments are not to be considered as final data but only as information requiring concurrence by the project scientist cognizant of that flight.

For maximum utilization of this information, the Summary of Rocket Launchings (Appendix A) should be used with the detailed discussion in this section. Line drawings and some characteristics of the rocket and its flight are included in the description for each rocket flown.

FIRINGS FOR CY 1959

Only four Aerobee rockets were flown in 1959. All were Aerobee 150's, launched in September from Fort Churchill. Very little vehicle data was retained at that time and recovery of the payloads after launching was not required. Three of the four launchings performed satisfactorily. The fourth failed to transmit telemetry data. The following launchings were accomplished:

Flight Number	Launched from	Date of Launch
4.08 GI	FC	9-11-59
4.07 GI	FC	9-14-59
4.02 II	FC	9-17-59
4.03 II	FC	9-20-59

Flights 4.07 GI and 4.08 GI

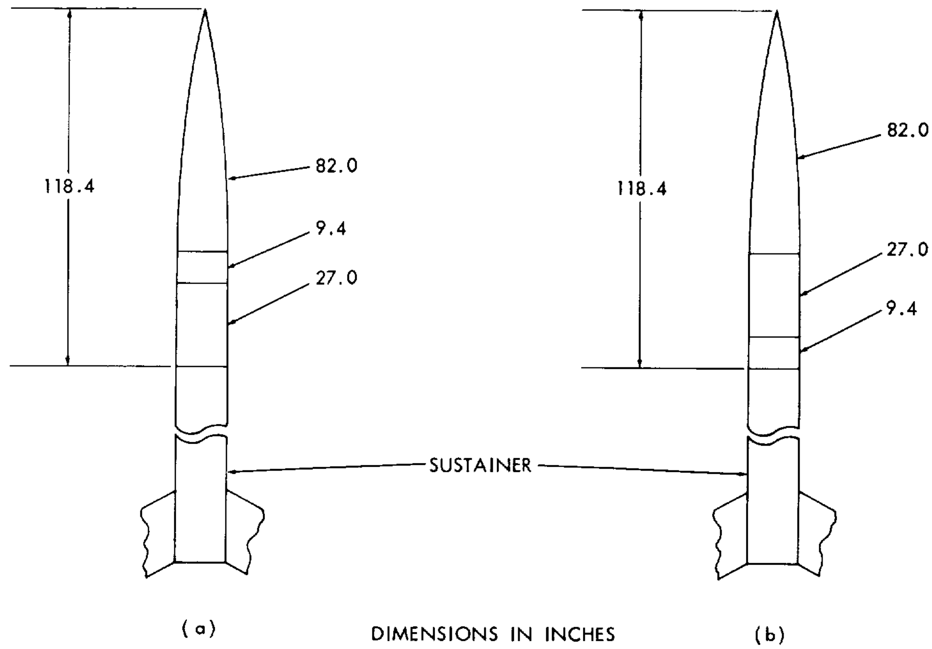
Flights 4.07 GI and 4.08 GI were the first NASA Aerobees to be launched. Both rocket payloads were identical and were flown primarily to measure ion and electron concentrations and ambient temperatures in the ionosphere. According to available records, both vehicles performed as expected with no malfunctions following launch. The only difficulties reported involved Flight 4.07 GI. Although intended to be first, Flight 4.07 GI was cancelled and removed from the tower two days prior to the original launch date. After fuel servicing was completed and oxidizer servicing commenced, the "Y" nozzle, used for servicing the oxidizer tank, was found to be inadvertently installed upside-down. The return line was thus positioned below the oxidizer fill, allowing a large amount of overflow to run back into the lines as oxidizer servicing was completed, prior to pump shutoff. A vacuum was created in the oxidizer tank when both lines were allowed to drain, thus causing the tank to buckle in two places. The tank wall was returned to normal when the vacuum was relieved by starting the pump. After Flight 4.07 GI underwent a 550 psi hydrostatic test on the oxidizer tank, it was rescheduled, rechecked for general pressurization; and fired on September 14.

One of the more significant results of this flight was that large holes in the nose cone, away from scientific data sensors, easily and significantly reduced the effects of gaseous contaminants.

Figure 20 gives payload dimensions and characteristics of these rockets and their flights.

Flights 4.02 II and 4.03 II

Flights 4.02 II and 4.03 II were flown by the Goddard Space Flight Center (GSFC) for the Defense Research Telecommunications Establishment (DRTE) at Fort Churchill. The primary purpose of these two payloads was to determine some physical parameters of the ionosphere, such as electron density and absorption of radio waves. Flight 4.02 II performed as predicted. Flight 4.03 II, however, exhibited an unexplained phenomenon: at T +25 seconds the velocity increased to 200 fps above that predicted, and the roll rate increased from 1 rps to 2.8 rps within 3.4 seconds. At 28.4 seconds, all telemetry transmissions abruptly ceased. It has been assumed that a structural failure occurred in either the helium tank section or the nose cone. A detailed investigation of the failure was not made at that time; and therefore, no significant conclusions can be stated about this flight. Although Flight 4.03 II did not successfully transmit the quantity of data required in the



FLIGHT	4.08 GI
FIRING DATE	11 SEPT. 1959
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	191.00
APOGEE (ST. MI.)	141.00
TIME TO APOGEE (SEC.)	255 ± 2
CENTER OF GRAVITY (CAL.)	10.50
CENTER OF PRESSURE (CAL.)	13.30
STATIC MARGIN (CAL.)	2.80
RESTORING MOMENT (PER DEGREE)	-0.286
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	1.62
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

FLIGHT	4.07 GI
FIRING DATE	14 SEPT. 1959
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	192.25
APOGEE (ST. MI.)	141.00 (radar)
TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	10.73
CENTER OF PRESSURE (CAL.)	13.25
STATIC MARGIN (CAL.)	2.52
RESTORING MOMENT (PER DEGREE)	-0.255
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	2.00
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

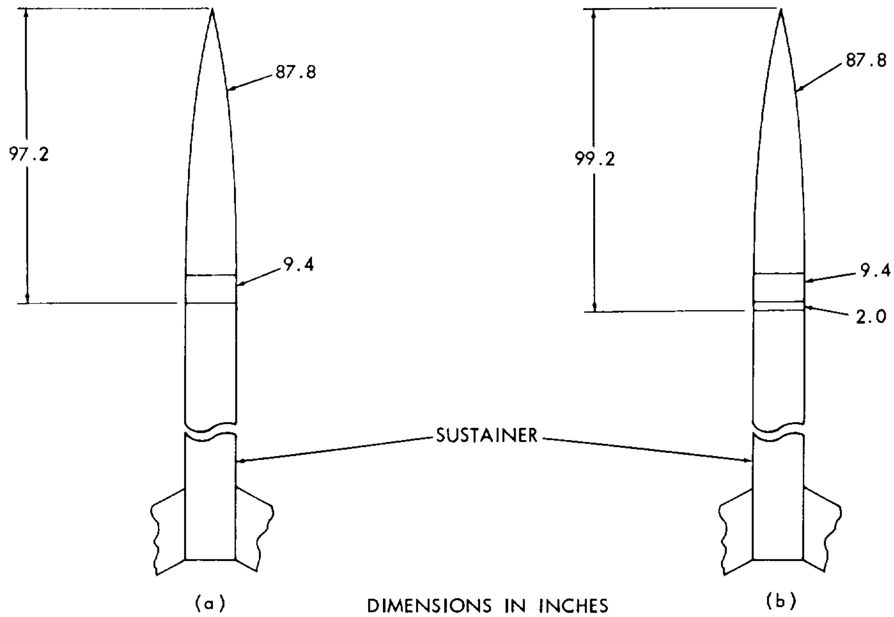
Figure 20—Flights 4.07 GI and 4.08 GI - payload dimensions and flight characteristics.

experiment, data received from flight 4.02 II did supply enough information to accomplish the scientific objectives of the experiment series. Recovery of the vehicle and payload, after flight, was not required. Each landed in the Hudson Bay.

Figure 21 gives payload dimensions and characteristics of these rockets and their flights.

FIRINGS FOR CY 1960

A total of eighteen (18) firings were made in 1960. Of these ten (10) Aerobee 150A's and one (1) Spaerobee (Aerobee 300A) were launched from Wallops Island, Va. Four (4) Aerobee 100's, one (1) Aerobee 150 and two (2) Spaerobee 300's were fired from Fort Churchill. Of these firings only one, Flight 4.01 GT (the first flight for the year), was considered a failure. This rocket, one of the first to be fired from Wallops Island, was to evaluate the new Aerobee 150A rocket and four-rail



FLIGHT	4.02 II	FLIGHT	4.03 II
FIRING DATE	17 SEPT. 1959	FIRING DATE	20 SEPT. 1959
LAUNCH SITE	FC	LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	156.75	PAYLOAD WT. (LBS.)	159.00
APOGEE (ST. MI.)	159.00 (radar)	APOGEE (ST. MI.)	
TIME TO APOGEE (SEC.)	270.00	TIME TO APOGEE (SEC.)	
CENTER OF GRAVITY (CAL.)	10.20	CENTER OF GRAVITY (CAL.)	
CENTER OF PRESSURE (CAL.)	12.41	CENTER OF PRESSURE (CAL.)	
STATIC MARGIN (CAL.)	2.21	STATIC MARGIN (CAL.)	
RESTORING MOMENT (PER DEGREE)	-0.221	RESTORING MOMENT (PER DEGREE)	
SUSTAINER BURNOUT TIME (SEC.)	54.00	SUSTAINER BURNOUT TIME (SEC.)	
ROLL RATE AT BURNOUT (RPS)	unknown *	ROLL RATE AT BURNOUT (RPS)	*
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	
NO. OF JOINTS	2.00	NO. OF JOINTS	3.00

* Set for 2.0 revolutions per second

* Set for 2.0 revolutions per second

Figure 21—Flights 4.02 II and 4.03 II - payload dimensions and flight characteristics.

tower configuration, and led to improvements which were incorporated into later, more successful, firings of the Aerobee 150A. Generally, Aerobee performance for the year was good with the remaining 17 tests listed in the satisfactory-to-completely-successful category. In some cases, vehicles considered to have performed only satisfactorily, were studied. Although early flight analyses were not as detailed as analyses of later flights, the results have provided change data which resulted in hardware improvements. Thus, performance improved as the year progressed. During the year only four attempts were made to recover the vehicle and payload. Of these, two (Flights 1.03 GP and 4.43 GP) were completely successful. Another (Flight 1.05 GP) was partially successful; and the last (Flight 4.10 GT) was unsuccessful. The following vehicles were launched in 1960:

Flight Number	Launch Site	Date of Launch
4.01 GT	WI	2-16-60
4.12 GT	WI	3-25-60*
4.10 GT	WI	4-23-60*
6.01 UI	FC	3-16-60
6.02 UI	FC	6-15-60*
4.04 GG	WI	4-27-60
4.05 GG	WI	5-27-60*
4.06 GG	WI	6-24-60*
4.09 GA	WI	4-29-60
6.03 UI	WI	8-3-60
4.16 UE	WI	8-23-60
1.03 GP	FC	9-15-60
1.05 GP	FC	9-24-60
4.43 GP	FC	10-5-60
4.14 GA	WI	11-15-60
4.11 GG	WI	11-22-60
1.01 GI	FC	11-23-60
1.02 GI	FC	11-27-60

Flights 4.01 GT, 4.12 GT, and 4.10 GT

Three Aerobee 150A rockets were launched from Wallops Island in 1960 for the purpose of closely monitoring the operation of the oxidizer and fuel tanks, the four modified single wedge fins, and the Nike start valve. These were design changes from the Aerobee 150 which were incorporated into the new Aerobee 150A rocket configuration. These tests were intended to accomplish two major objectives:

(1) evaluate the new Aerobee 150A configuration, and
(2) evaluate the new four-rail launch facility.

Flight 4.01 GT

The first launch (Flight 4.01 GT) occurred on February 16. A thrust chamber failure occurred during the start transient, which was apparently due to a very low fuel-oxidizer mixture ratio. The

*The summary of this rocket firing is not in chronological order, but follows the description of a similar payload fired earlier in the year.

vehicle exploded in flight approximately 1 second after launch. The estimated mixture ratio (oxidizer to fuel) during the step operation (based on flight instrumentation) was 2.0; during full thrust the mixture ratio was at the proper level of 2.56. Later analysis of this and similar post-flight static firings indicated that a low mixture ratio results in excessive high frequency pressure variation in the thrust chamber. It is believed that this low frequency instability, coupled with flight conditions, resulted in the initiation of high frequency instability during the start transient.

The high frequency instability lasted for one second, causing mechanical erosion of the thrust chamber liner and its subsequent destruction. The fuel continued to flow, venting through the jacket and out of the chamber, and burned in the atmosphere directly aft of the rocket. When venting of the fuel tank was complete, reverse flow conditions occurred in the pressurization system. This caused mixing of the hypergolic propellants in the tank and the resultant explosion. The common bulkhead between the fuel and oxidizer tank was destroyed, thereby causing the pressurization bottle to be severed from the remainder of the propulsion system. It is believed that this explosion was the one visually observed at approximately 45 seconds after launch.

Figure 22 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.12 GT

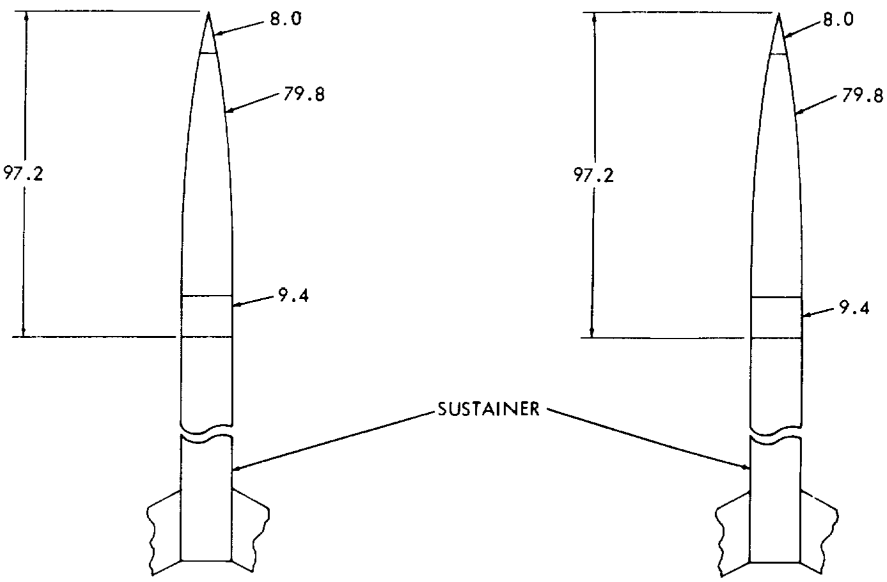
Flight 4.12 GT was launched on 25 March 1960. It incorporated a number of Nike flight valve modifications which resulted from the Flight 4.01 GT failure analysis and from a propulsion system test program which had been established by the Space-General Corporation following the failure. The 70 - 30 percent-by-weight furfuryl alcohol - aniline starting mixture was replaced by the 65 - 35 percent-by-weight furfuryl alcohol - aniline running mixture. Vehicle performance was successful although the peak altitude was twenty percent lower than the 165 statute miles predicted. Loss of altitude is attributed to pitch-roll coupling of the rocket during burning, and telemetered data on angle of attack and roll rate supports this hypothesis. Propulsion system details of Flights 4.01 GT and 4.12 GT, and the propulsion system tests, are the subject of a manufacturer's report (Reference 1). Complete reduced performance data from Flight 4.12 GT is contained in a New Mexico State University report (Reference 2). Data received included pressures in the oxidizer tank, fuel tank, helium tank and thrust chamber; rocket aspect, roll rate, temperature, and acceleration data.

In addition to Flight 4.12 GT underperformance, the booster fins were sheared along the outer edges while riding up the tower rails. Because wind-loading is near maximum at tower exit, the booster's sheared fins can largely account for the observed 52° azimuth shift in predicted sustainer impact. As a result of the sheared fins the following action was taken:

(1) booster riding lugs were widened to 1.8 inches overall, and

(2) the booster guide lug slot depth was increased from 0.5 to 0.75 inches.

Figure 22 gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.01 GT
FIRING DATE	16 FEB. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	150.00
APOGEE (ST. MI.)	2.00 (approx.)
TIME TO APOGEE (SEC.)	3.00 (approx.)
CENTER OF GRAVITY (CAL.)	10.60
CENTER OF PRESSURE (CAL.)	na
STATIC MARGIN (CAL.)	na
RESTORING MOMENT (PER DEGREE)	na
SUSTAINER BURNOUT TIME (SEC.)	1+
ROLL RATE AT BURNOUT (RPS)	na
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

Sustainer failed. No flight data.

FLIGHT	4.12 GT
FIRING DATE	25 MAR. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	152.00
APOGEE (ST. MI.)	132.00*
TIME TO APOGEE (SEC.)	244.00
CENTER OF GRAVITY (CAL.)	10.22
CENTER OF PRESSURE (CAL.)	13.63
STATIC MARGIN (CAL.)	3.41
RESTORING MOMENT (PER DEGREE)	0.443
SUSTAINER BURNOUT TIME (SEC.)	52.10
ROLL RATE AT BURNOUT (RPS)	0.45
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

* Payload weight was 2lbs. greater than predicted. Apogee 21 miles less than predicted.

Figure 22—Flights 4.01 GT and 4.12 GT - payload dimensions and flight characteristics.

Flight 4.10 GT

The third test (Flight 4.10 GT) was delayed until the above changes were incorporated, and was successfully launched on 23 April 1960. Although the flight was considered satisfactory; there was approximately a twelve percent underperformance. An attempt was made at retrieving the sustainer and although radar indicated parachute deployment, the vehicle impacted in the ocean and sank before recovery could be effected.

Figure 23 gives payload dimensions and characteristics of this rocket and its flight.

Flight 6.01 UI and 6.02 UI

Flights 6.01 UI and 6.02 UI were successfully launched from Fort Churchill on 16 March and 15 June respectively. Each measured electron temperatures and ion densities using a University of Michigan payload. Peak altitude for Flight 6.01 UI was approximately 15% lower than predicted values for Flight 6.02 UI. Postflight analyses of these flights also indicate that rocket instrumentation performance was excellent and excellent data was received.

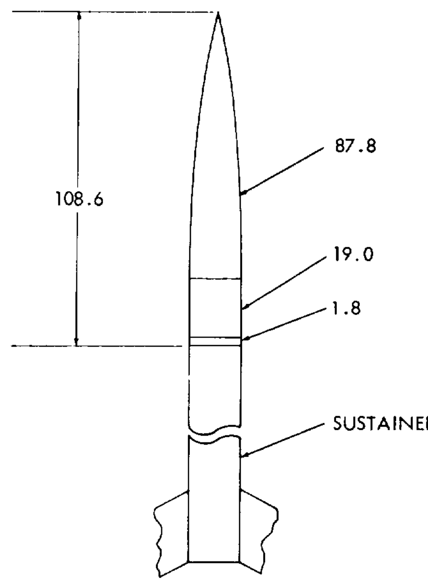
Figure 24 gives payload dimensions and characteristics of these rockets and their flights.

Flights 4.04 GG, 4.05 GG and 4.06 GG

Flights 4.04 GG, 4.05 GG, and 4.06 GG were successfully launched on 26 April, 27 May and 24 June from Wallops Island. The primary objectives of these launchings were to measure stellar and nebular fluxes in specific ultraviolet bands. The performance of the 150A's was successful, although a particular squib failure in the early flights, later corrected, hampered total system performance.

Flight 4.04 GG

Flight 4.04 GG reached an altitude of ten miles below that predicted; and telemetry data showed that at T +40 seconds, the rocket experienced pitch-roll resonance. This induced an angle of attack of approximately 20° and precession about the roll axis with a half-angle of 89° 32'. The presence of pitch-roll resonance, reducing the roll rate to a significantly low value, obscured the failure of the despin mechanism, and this failure was not discovered until after the firing of Flight 4.05 GG.



DIMENSIONS IN INCHES

FLIGHT	4.10 GT
FIRING DATE	23 APR. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	127.80
APOGEE (ST. MI.)	153.00
TIME TO APOGEE (SEC.)	260.00
CENTER OF GRAVITY (CAL.)	10.42
CENTER OF PRESSURE (CAL.)	13.40
STATIC MARGIN (CAL.)	2.98
RESTORING MOMENT (PER DEGREE)	-0.387
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	0.58*
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

Fin cant: I, 9.0 min; II, 9.2 min; III, 9.3 min; and IV, 8.95 min.
*Pitch-roll coupling occurred at approximately 41 seconds.

Figure 23—Flight 4.10 GT - payload dimensions and flight characteristics.

A subsequent analysis showed that due to a change in the firing current requirement which was not communicated to the instrumentation group, the propellant squibs which actuated the shutoff valves failed to fire. The result was that all of the residual helium blew down through the thrust chamber; and the gas despin system, which is wholly dependent upon residual helium, failed to operate.

Figure 25 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.05 GG and 4.06 GG

Flights 4.05 GG and 4.06 GG were both launched successfully. The gas despin system on the former did not function and an investigation showed that this was due to a squib firing failure.

	6.01 UI	6.02 UI
FLIGHT	6.01 UI	6.02 UI
FIRING DATE	16 MAR. 1960	15 JUN. 1960
LAUNCH SITE	FC	FC
PAYLOAD WEIGHT, 2ND STAGE (lbs)	245.00	244.50
PAYLOAD WEIGHT, 3RD STAGE (lbs)	65.50	64.75
APOGEE (statute miles)	205.00	195.00
TIME TO APOGEE (seconds)	UNKNOWN	307.00
CENTER OF GRAVITY, SUSTAINER BURNOUT (calculated)	10.733	11.11
CENTER OF PRESSURE, SUSTAINER BURNOUT (calculated)	13.77	13.40
STATIC MARGIN, SUSTAINER BURNOUT (calculated)	3.04	2.29
RESTORING MOMENT, SUSTAINER BURNOUT (per degree)	- 0.341	- 0.252
CENTER OF GRAVITY, 3RD STAGE IGNITION (calculated)	9.20	9.28
CENTER OF PRESSURE, 3RD STAGE IGNITION (calculated)	10.70	10.85
STATIC MARGIN, 3RD STAGE IGNITION (calculated)	1.50	0.97
RESTORING MOMENT, 3RD STAGE IGNITION (per degree)	- 0.0540	-0.0350
SUSTAINER BURNOUT (seconds)	50.70	54.20
THIRD STAGE BURNOUT (seconds)	54.00 (est.)	56.80
ROLL RATE AT BURNOUT, SUSTAINER (rps)	1.40*	1.00*
ROLL RATE AT BURNOUT, 3RD STAGE (rps)	unknown	unknown
PROBE EJECT (seconds)	80.00	75.00
NUMBER OF JOINTS	7.00	7.00
THIRD STAGE LENGTH (in.)	120.00	120.00
PAYLOAD HOUSING LENGTH X (in.)	68.88	69.88

*AT 50 seconds

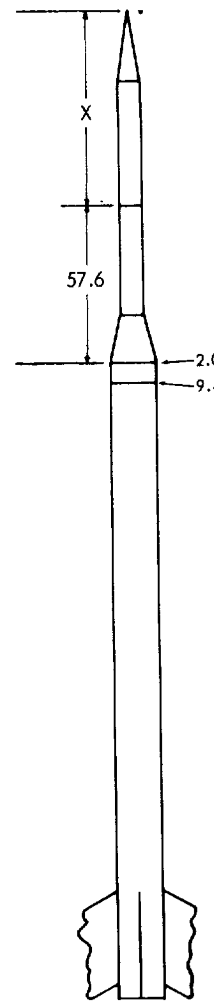


Figure 24—Flights 6.01 UI and 6.02 UI - payload dimensions and flight characteristics.

This appears to be the reason for the failure of the gas despin system on Flight 4.04 GG. Because of the high (2.2 rps) roll rate at burnout, good quality data were obtained only for the airglow experiment. The second flight was a complete success and as predicted. The gas despin system performed well, giving the vehicle a post-burnout roll period of 17.5 seconds, allowing the collection of excellent data on ultraviolet fluxes.

Figure 26 gives payload dimensions and characteristics of these rockets and their flights.

Flight 4.09 GA

Flight 4.09 GA was successfully launched from Wallops Island on 29 April. The rocket went six miles above the predicted altitude, to 154 statute miles. The vehicle carried instrumentation to determine the composition and pressure of the atmosphere between attitudes of 100 and 150 kilometers. Rocket performance telemetry data was received from the New Mexico State University

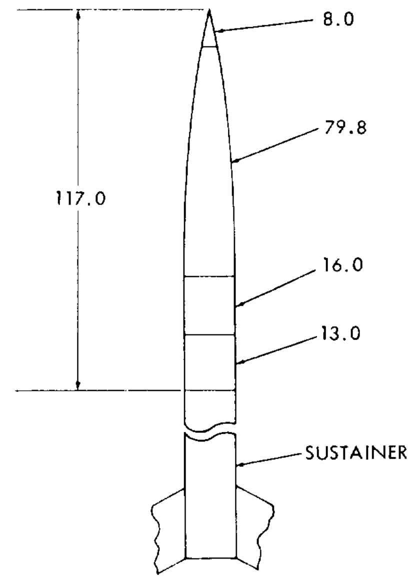
(Reference 3). This flight also produced adequate data for plotting pitch frequency and roll versus time, chamber pressure and longitudinal acceleration, and accomplished the expected experimental objectives.

Figure 27 gives payload dimensions and characteristics of this rocket and its flight.

Flight 6.03 UI

Flight 6.03 UI was launched successfully from Wallops Island on 3 August. The purpose of this experiment (nearly identical to Flights 6.01 UI and 6.02 UI) was to carry the "Dumbbell" form of an electrostatic probe for measurement of ionosphere ion density and electron temperature. A major objective was to obtain these measurements at altitudes lower than those attained by Flights 6.01 UI and 6.02 UI, in a quiet ionosphere. Excellent data were obtained and the rocket achieved the predicted altitude of 250 miles.

Figure 28 gives payload dimensions and characteristics of this rocket and its flight.



DIMENSIONS IN INCHES

FLIGHT	4.04 GG
FIRING DATE	27 APR. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	202.00
APOGEE (ST. MI.)	130.00
TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	10.93
CENTER OF PRESSURE (CAL.)	14.15
STATIC MARGIN (CAL.)	3.27
RESTORING MOMENT (PER DEGREE)	-0.457
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	0.60
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 25—Flight 4.04 GG - payload dimensions and flight characteristics.

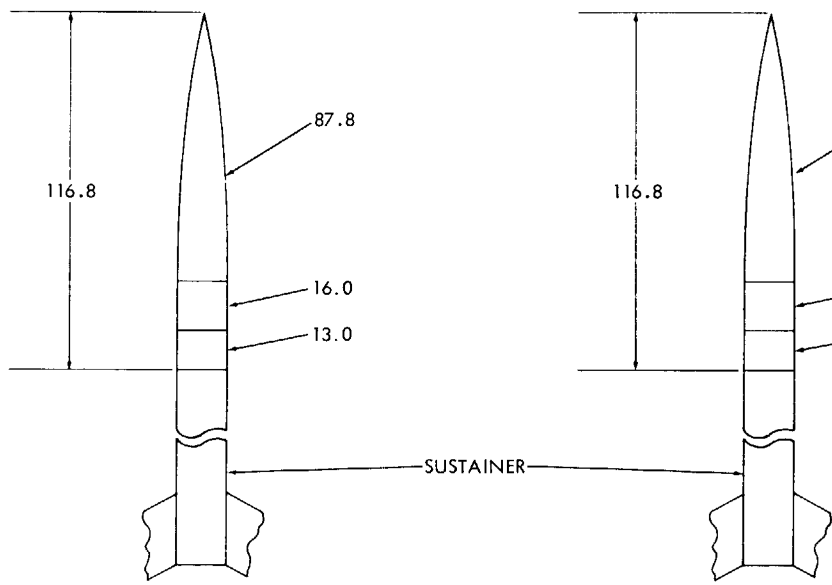
Flight 4.16 UE

Flight 4.16 UE was successfully launched on 23 August. The experiment employed neutron counters to measure slow-neutron intensity. The vehicle performed well, although a lower-than-expected roll rate was realized. The fins were canted to induce a roll rate at burnout of 2.2 rps. Although the actual roll rate was 1.6 rps, the experiment was in no way compromised. Later analysis of the flight data have led to the assumption that the lower roll rate was probably due to warped fins.

Figure 29 gives payload dimensions and characteristics of this rocket and its flight.

Flights 1.03 GP and 1.05 GP

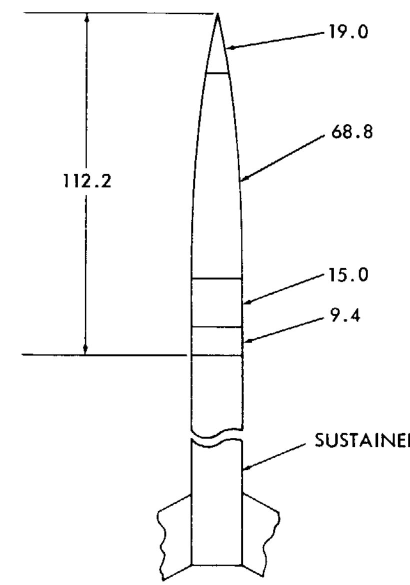
Flight 1.03 GP and 1.05 GP were successfully flown from Fort Churchill on 15 September and 24 September respectively. Both rockets carried photographic payloads.



FLIGHT	4.05 GG
FIRING DATE	27 MAY, 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	204.00
APOGEE (ST. MI.)	135.00
TIME TO APOGEE (SEC.)	257.00
CENTER OF GRAVITY (CAL.)	11.00
CENTER OF PRESSURE (CAL.)	14.50
STATIC MARGIN (CAL.)	3.50
RESTORING MOMENT (PER DEGREE)	-0.462
SUSTAINER BURNOUT TIME (SEC.)	52.50
ROLL RATE AT BURNOUT (RPS)	2.20
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

FLIGHT	4.06 GG
FIRING DATE	24 JUN. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	191.00
APOGEE (ST. MI.)	131.00
TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	10.93
CENTER OF PRESSURE (CAL.)	14.40
STATIC MARGIN (CAL.)	3.47
RESTORING MOMENT (PER DEGREE)	-0.4476
SUSTAINER BURNOUT TIME (SEC.)	52.90
ROLL RATE AT BURNOUT (RPS)	2.50
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	3.00

Figure 26—Flights 4.05 GG and 4.06 GG - payload dimensions and flight characteristics.



FLIGHT	4.09 GA
FIRING DATE	29 APR. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	167.50
APOGEE (ST. MI.)	154.00
TIME TO APOGEE (SEC.)	258.00
CENTER OF GRAVITY (CAL.)	10.30
CENTER OF PRESSURE (CAL.)	13.90
STATIC MARGIN (CAL.)	3.60
RESTORING MOMENT (PER DEGREE)	-0.4608
SUSTAINER BURNOUT TIME (SEC.)	50.50
ROLL RATE AT BURNOUT (RPS)	2.10
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	4.00

Figure 27—Flight 4.09 GA - payload dimensions and flight characteristics.

FLIGHT	6.03 UI
FIRING DATE	3 AUG. 1960
LAUNCH SITE	WI
PAYLOAD WEIGHT, 2ND STAGE (lbs)	200.30
PAYLOAD WEIGHT, 3RD STAGE (lbs)	55.50
APOGEE (statute miles)	258.00
TIME TO APOGEE (seconds)	370.00
CENTER OF GRAVITY, SUSTAINER BURNOUT (calculated)	10.75
CENTER OF PRESSURE, SUSTAINER BURNOUT (calculated)	14.80
STATIC MARGIN, SUSTAINER BURNOUT (calculated)	4.05
RESTORING MOMENT, SUSTAINER BURNOUT (per degree)	- 0.535
CENTER OF GRAVITY, 3RD STAGE IGNITION (calculated)	8.65
CENTER OF PRESSURE, 3RD STAGE IGNITION (calculated)	10.22
STATIC MARGIN, 3RD STAGE IGNITION (calculated)	1.57
RESTORING MOMENT, 3RD STAGE IGNITION (per degree)	- 0.0565
SUSTAINER BURNOUT (seconds)	53.00
THIRD STAGE BURNOUT (seconds)	55.00
ROLL RATE AT BURNOUT, SUSTAINER (rps)	2.20
ROLL RATE AT BURNOUT, 3RD STAGE (rps)	1.75
PROBE EJECT (seconds)	75.00
NUMBER OF JOINTS	7.00
THIRD STAGE LENGTH (in.)	118.1
PAYLOAD HOUSING LENGTH X (in.)	60.5

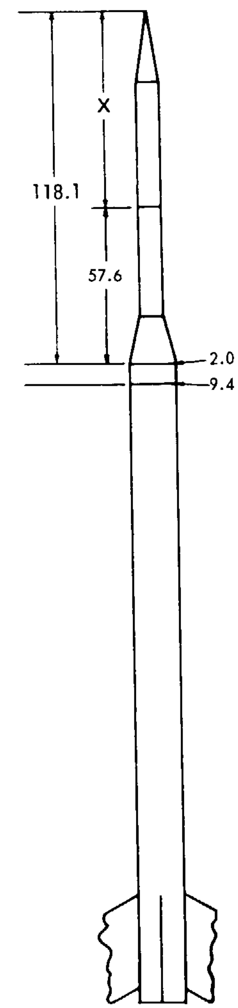
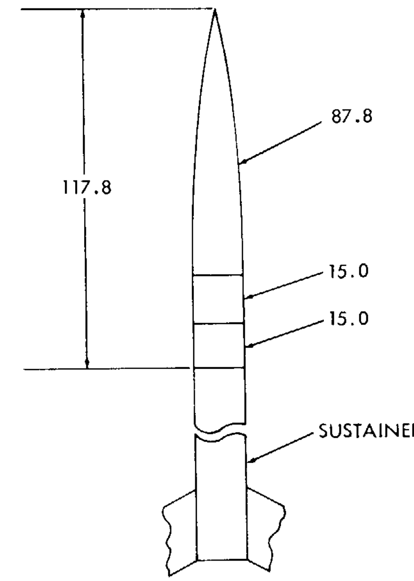


Figure 28—Flight 6.03 UI - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.16 UE
FIRING DATE	23 AUG. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	318.80
APOGEE (ST. MI.)	118.00
TIME TO APOGEE (SEC.)	230.00
CENTER OF GRAVITY (CAL.)	10.40
CENTER OF PRESSURE (CAL.)	14.35
STATIC MARGIN (CAL.)	3.95
RESTORING MOMENT (PER DEGREE)	-0.553
SUSTAINER BURNOUT TIME (SEC.)	50.00
ROLL RATE AT BURNOUT (RPS)	1.70
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

Figure 29—Flight 4.16 UE - payload dimensions and flight characteristics.

Flight 1.03 GP

Flight 1.03 GP experienced satisfactory rocket performance. Good data were obtained and the photographic payload was recovered undamaged.

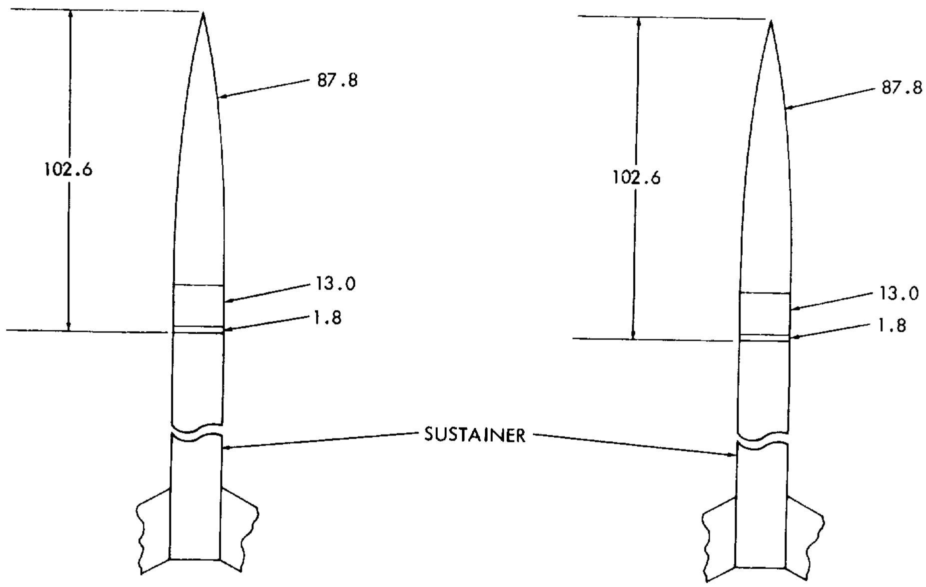
Flight 1.05 GP

Flight 1.05 GP performed satisfactorily. However, the payload recovery package did not function properly. Consequently, only 40 frames of fair quality black and white film were recovered.

Figure 30 gives payload dimensions and characteristics of these rockets and their flights.

Flight 4.43 GP

Flight 4.43 GP was launched from Fort Churchill on 5 October. This vehicle, the only Aerobee 150 launched from Fort Churchill for the year, was the third in a series of firings to photograph



DIMENSIONS IN INCHES

FLIGHT	1.03 GP
FIRING DATE	15 SEPT. 1960
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	144.75
APOGEE (ST. MI.)	47.30
TIME TO APOGEE (SEC.)	148.00
CENTER OF GRAVITY (CAL.)	9.813
CENTER OF PRESSURE (CAL.)	12.20 (approx.)
STATIC MARGIN (CAL.)	2.39 (approx.)
RESTORING MOMENT (PER DEGREE)	-0.30 (approx.)
SUSTAINER BURNOUT TIME (SEC.)	41.50
ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	3.00

* Set for 0.0 revolutions per second.

FLIGHT	1.05 GP
FIRING DATE	24 SEPT. 1960
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	145.00
APOGEE (ST. MI.)	47.20
TIME TO APOGEE (SEC.)	149.20
CENTER OF GRAVITY (CAL.)	9.173
CENTER OF PRESSURE (CAL.)	12.20 (approx.)
STATIC MARGIN (CAL.)	3.03 (approx.)
RESTORING MOMENT (PER DEGREE)	-0.30
SUSTAINER BURNOUT TIME (SEC.)	39.70
ROLL RATE AT BURNOUT (RPS)	-0.054
TIP EJECT (SEC.)	443.00 (approx.)
NO. OF JOINTS	3.00

Figure 30—Flights 1.03 GP and 1.05 GP - payload dimensions and flight characteristics.

a vigorous synoptic weather situation. The two previous firings in the program were with Aerobee 100's (Aerobee Junior). Although the vehicle achieved a peak altitude of 15 miles under the predicted value, the experimental objectives were not compromised. The fins were purposely set to an average cant angle of 1.4 minutes to produce a low roll rate. Figure 31 indicates the roll history and shows a sharp decrease at burnout; the vehicle went into a flat spin and although the experiment was not compromised the flat spin is the most probable cause of the loss in altitude. The large precessional angles after burnout are expected and have been observed in low-roll Aerobees; it is primarily a result of pitch-roll coupling. Figure 31 also illustrates the cross-over and the subsequent lock-in of the pitch and roll frequencies.

Figure 32 shows a representation of the vehicle on its trajectory and the angle between vehicle centerline and the zenith. At about +90 seconds the vehicle enters into a flat spin. Magnetometer data is reduced and presented in Figure 33, which shows rocket attitude with respect to the earth horizontal. At +78 seconds the pitch angle increases significantly, and by +90 seconds the rocket goes into a flat spin. Figure 34 shows two pictures of the earth's surface taken from experimental cameras carried in the experimental package, which was recovered intact.

Post-launch data indicated that all instrumentation except the parachute cable cutter release mechanism functioned properly. The film in both cameras ran through the magazines, aspect data were recorded, the payload separation was clean, and the parachute functioned properly. Telemetry data received indicated that accelerometers functioned properly and recovered components survived the flight without damage.

Figure 35 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.14 GA

Flight 4.14 GA was launched successfully from Wallops Island on 15 November. The primary objective was to determine the composition and pressure of the upper atmosphere in the 100 to 250 kilometer altitude range. Although the predicted impact of 65 nautical miles at 110 degrees true azimuth was not achieved; the launch, flight, and experiment were considered highly successful. Actual impact was 39.7 nautical miles at a true

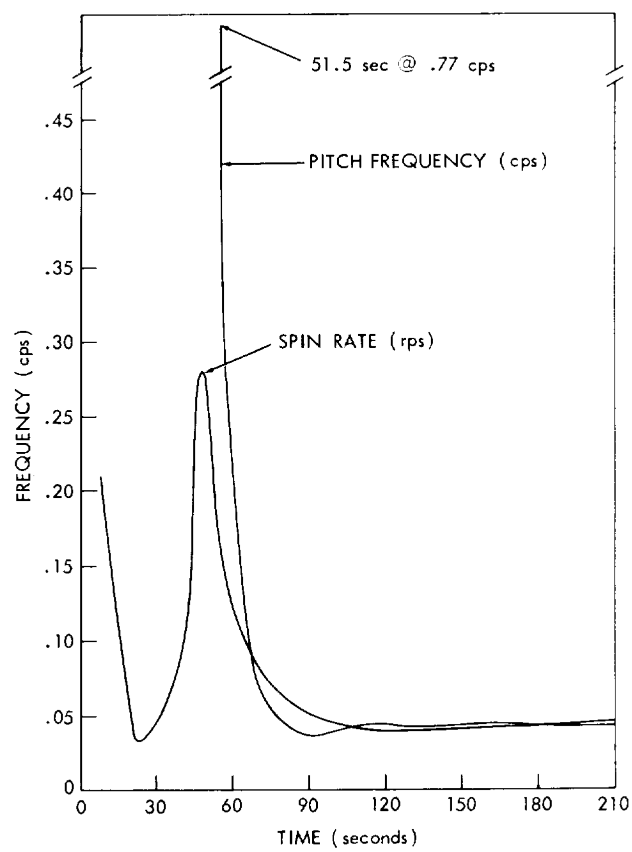


Figure 31—Pitch frequency vs. spin rate (exploded view) - Flight 4.43 GP.

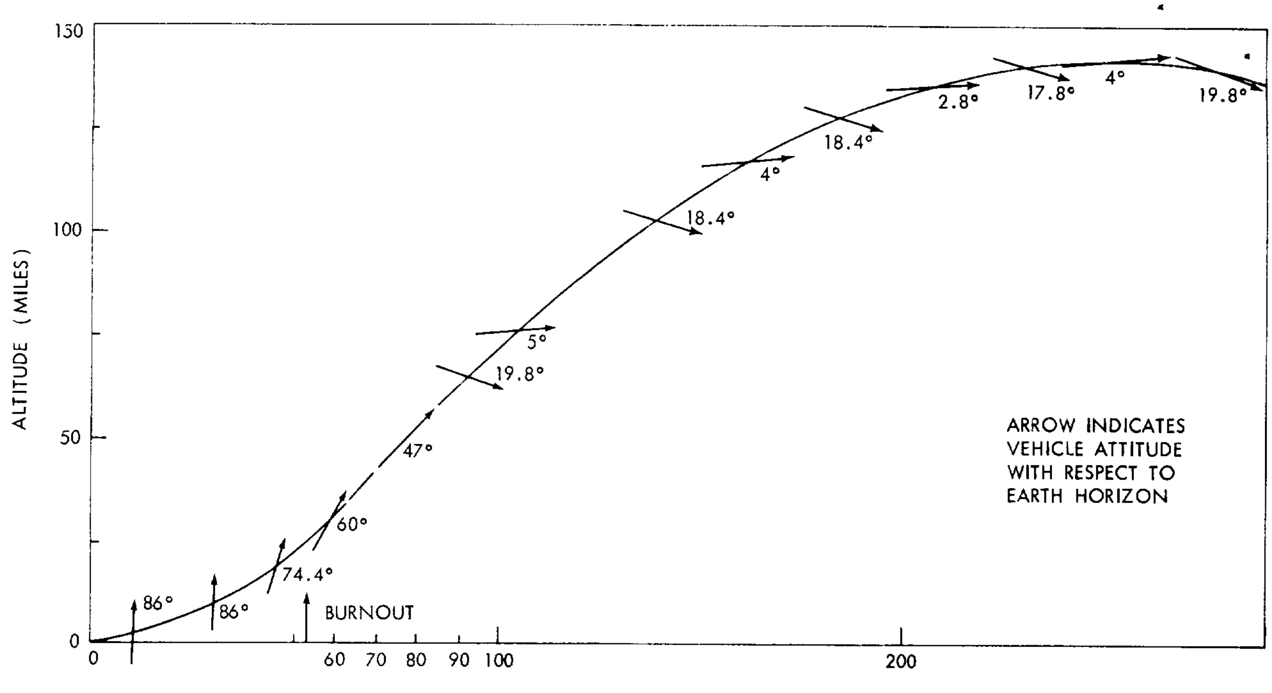


Figure 32—Rocket trajectory, Flight 4.43 GP.

azimuth of 148 degrees 50 minutes. Burnout roll rate was .5 rps greater than expected although no other anomalies were observed. A zenith altitude of 145 statute miles was obtained with a 162.5 lb. payload. Wind impact data and telemetry data reports were received from the New Mexico State University following the flight.

Figure 36 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.11 GG

Flight 4.11 GG was successfully launched from Wallops Island on November 22, and obtained spectra with 50 angstrom resolution from a number of stars of varying spectral types. All payload equipment functioned properly and rocket performance was satisfactory although it attained a peak altitude of approximately ten miles below that predicted. Prior to flight, the tail can was strengthened and flown unpressurized (Reference 4). This was the first flight to use the strengthened and unpressurized tail can, later incorporated as a standard configuration for Aerobees. The gas despin system was activated at T +70 seconds, and vehicle roll rate was reduced from 3.1 rps at burnout to 19.3 degrees per second, 27 seconds after burnout. Before despin the precession cone half-angle was less than 1/2 degree. After despin, the precession cone had increased to a half-angle of 73° with a precession period of 800 seconds. Telemetry data was received for 415 seconds.

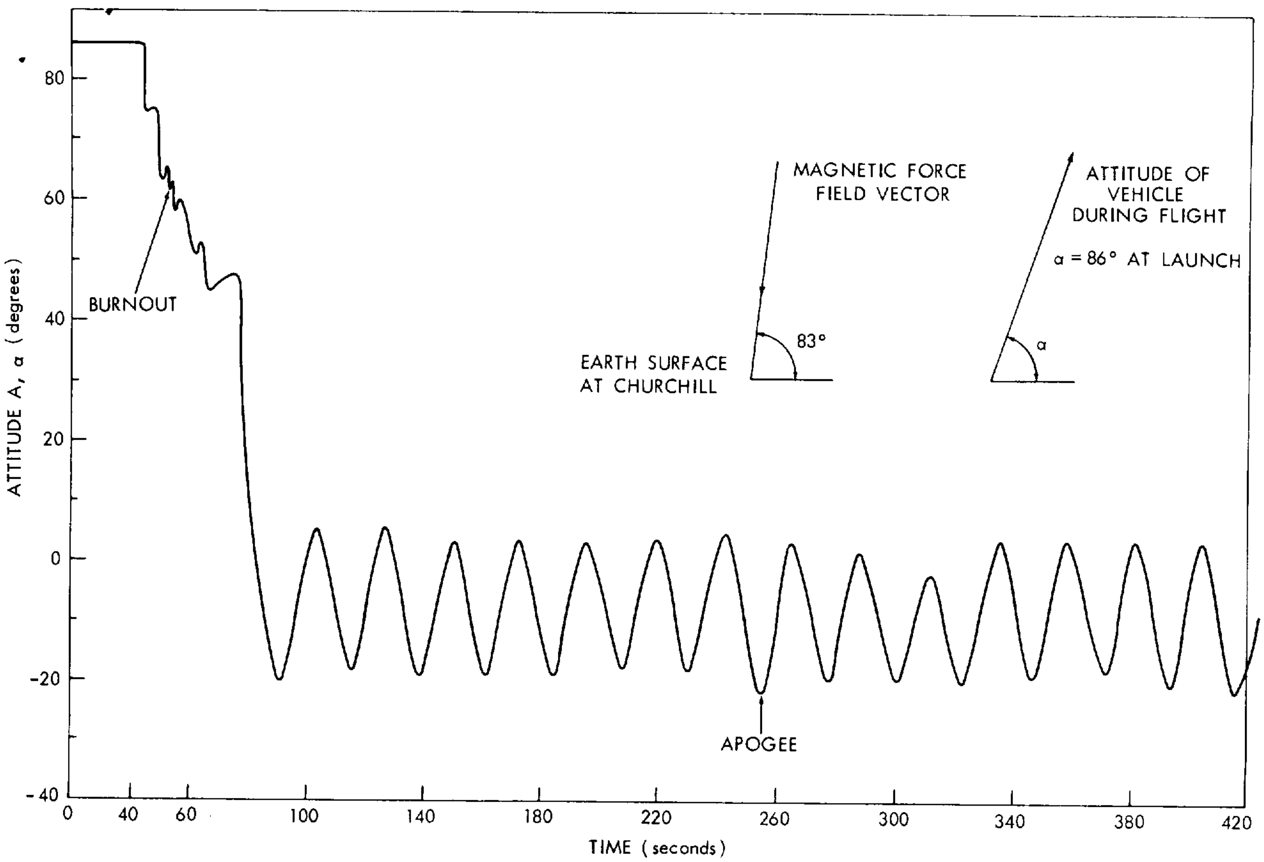


Figure 33—Attitude angle vs. flight time, Flight 4.43 GP pitch frequency spin rate.

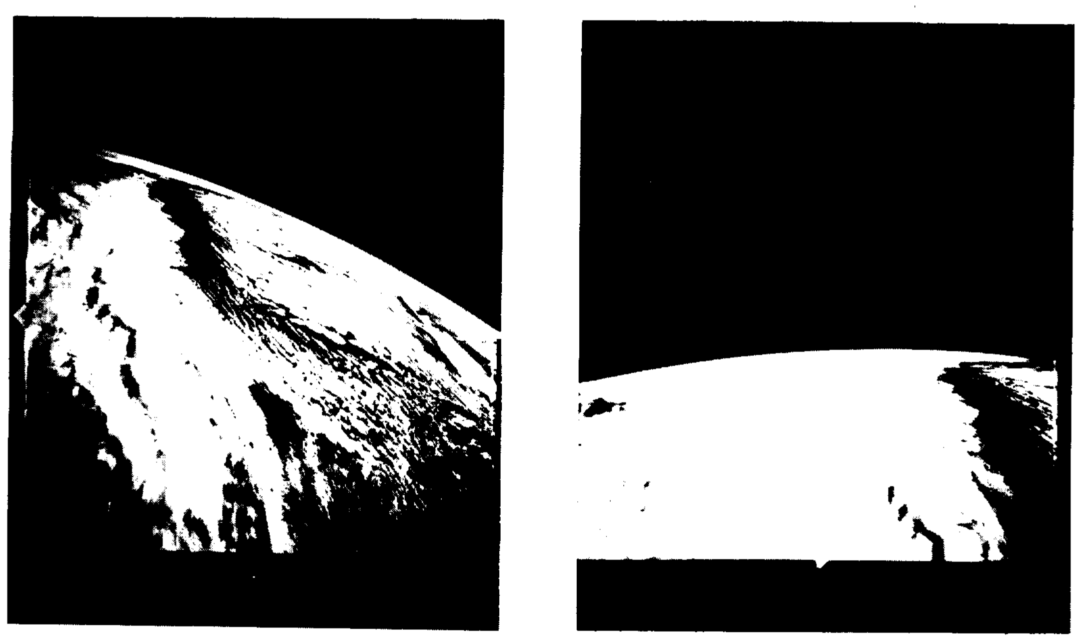
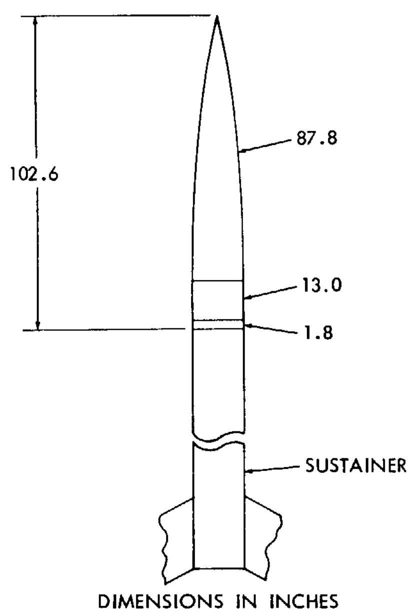


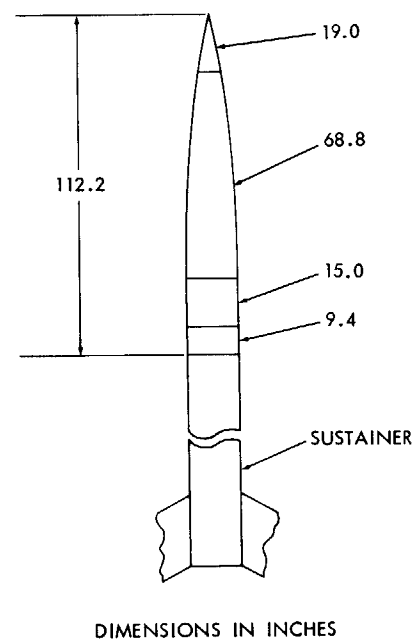
Figure 34—Photos of the earth's surface from Flight 4.43 GP.



FLIGHT	4.43 GP
FIRING DATE	5 OCT. 1960
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	137.50
APOGEE (ST. MI.)	140.10
TIME TO APOGEE (SEC.)	253.60
CENTER OF GRAVITY (CAL.)	9.03
CENTER OF PRESSURE (CAL.)	12.60
STATIC MARGIN (CAL.)	3.56
RESTORING MOMENT (PER DEGREE)	-0.360
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	0.18
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

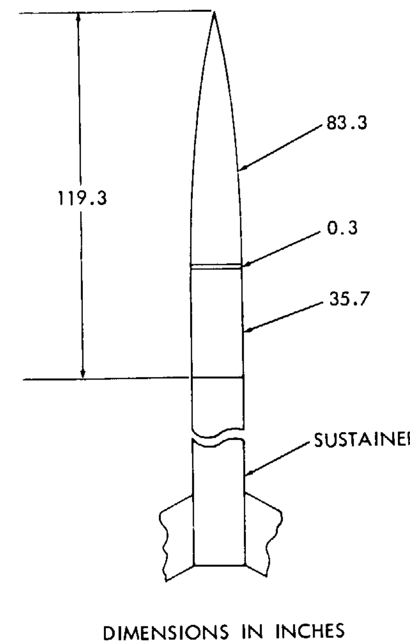
* Fin cant: I, 1.45 min; II, 0.8 min; and III, 1.9 min.

Figure 35—Flight 4.43 GP - payload dimensions and flight characteristics.



FLIGHT	4.14 GA
FIRING DATE	15 NOV. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	162.50
APOGEE (ST. MI.)	143.00
TIME TO APOGEE (SEC.)	260.00
CENTER OF GRAVITY (CAL.)	10.50
CENTER OF PRESSURE (CAL.)	14.00
STATIC MARGIN (CAL.)	3.50
RESTORING MOMENT (PER DEGREE)	-0.445
SUSTAINER BURNOUT TIME (SEC.)	50.70
ROLL RATE AT BURNOUT (RPS)	2.70
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	4.00

Figure 36—Flight 4.14 GA - payload dimensions and flight characteristics.



FLIGHT	4.11 GG
FIRING DATE	22 NOV. 1960
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	200.00
APOGEE (ST. MI.)	105.00
TIME TO APOGEE (SEC.)	148.00
CENTER OF GRAVITY (CAL.)	10.42
CENTER OF PRESSURE (CAL.)	14.23
STATIC MARGIN (CAL.)	3.81
RESTORING MOMENT (PER DEGREE)	-0.51
SUSTAINER BURNOUT TIME (SEC.)	51.90
ROLL RATE AT BURNOUT (RPS)	3.10
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

Figure 37—Flight 4.11 GG - payload dimensions and flight characteristics.

Figure 37 gives payload dimensions and characteristics of this rocket and its flight.

Flights 1.01 GI and 1.02 GI

Flights 1.01 GI and 1.02 GI, two Aerobee 100's (Aerobee Juniors), were successfully flown from Fort Churchill on 23 November and 27 November. The payloads made measurements of daytime and nighttime ion density and electrical conductivity of the atmosphere in the range between 20 and 90 kilometers. Cylindrical chambers, to measure ionic conductivity, were mounted on the nose tip as shown in Figure 38. The aerodynamic, structural and heating effects of these chambers are the subject of an Aerojet report (Reference 5).

Rocket performance on both flights was satisfactory although an early burnout time was observed on Flight 1.02 GI. Figure 39 gives payload dimensions and characteristics of these rockets and their flights.

FIRINGS FOR CY 1961

A total of eighteen (18) Aerobee firings were achieved in CY 1961. Of these, eight (8) were Aerobee 150A's and two (2) Spaerobee 300A's launched from Wallops Island, Va. A total of eight (8) Aerobee 100's (Aerobee Juniors) were launched from Fort Churchill, Canada. Of the eighteen (18) launchings achieved, only one (Flight 4.34 GG) was considered to have been a failure. Recovery

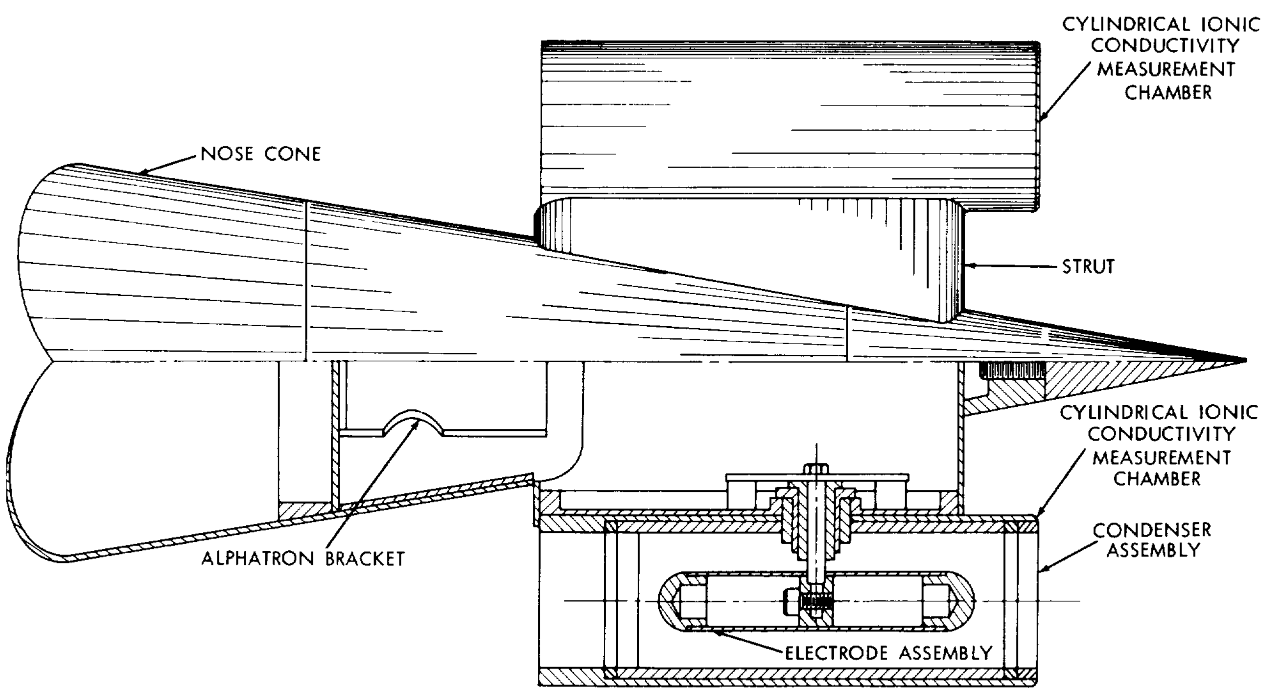
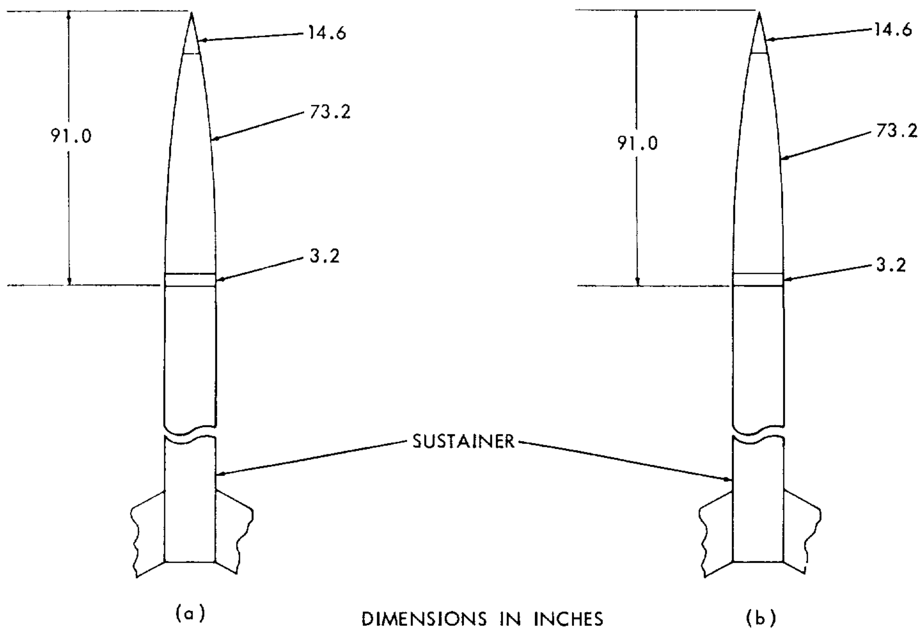


Figure 38—Aerobee 100 nose modifications for NASA ionic conductivity experiment.



	(a)		(b)
FLIGHT	1.01 GI	FLIGHT	1.02 GI
FIRING DATE	23 NOV. 1960	FIRING DATE	27 NOV. 1960
LAUNCH SITE	FC	LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	109.50	PAYLOAD WT. (LBS.)	109.70
APOGEE (ST. MI.)	56.70	APOGEE (ST. MI.)	52.70
TIME TO APOGEE (SEC.)	159.40	TIME TO APOGEE (SEC.)	155.00
CENTER OF GRAVITY (CAL.)	8.82	CENTER OF GRAVITY (CAL.)	8.82
CENTER OF PRESSURE (CAL.)	unknown	CENTER OF PRESSURE (CAL.)	unknown
STATIC MARGIN (CAL.)	unknown	STATIC MARGIN (CAL.)	unknown
RESTORING MOMENT (PER DEGREE)	unknown	RESTORING MOMENT (PER DEGREE)	unknown
SUSTAINER BURNOUT TIME (SEC.)	40.20 (approx.)	SUSTAINER BURNOUT TIME (SEC.)	38.50
ROLL RATE AT BURNOUT (RPS)	unknown*	ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00	NO. OF JOINTS	3.00

* Set for 2.5 revolutions per second radar data unusuable

* Set for 2.5 revolutions per second radar data inadequate to provide rocket performance evalvation.

Figure 39—Flights 1.01 GI and 1.02 GI - payload dimensions and flight characteristics.

was attempted on all but five flights, with a high degree of success. Thirteen (13) recovery packages operated successfully. Of these, one recovery was not effected (Flight 4.38 NP) due to the inavailability of a suitable recovery vessel, and one recovery (Flight 1.04 GP) was only partially effected due to the payload separating from the parachute before impact. All other recoveries were accomplished successfully. The following vehicles were launched in 1961:

Flight Number	Launch Site	Date of Launch
4.38 NP	WI	2-5-61
4.39 NP	WI	4-21-61*

*The summary of this rocket firing is not in chronological order; it is grouped with a similar payload fired later in the year. Refer to the description of the flight for further information.

Flight Number	Launch Site	Date of Launch
4.40 NP	WI	10-18-61*
4.42 NP	WI	8-12-61*
6.04 UI	WI	3-26-61
6.05 UI	WI	12-22-61*
4.34 GG	WI	3-31-61
4.19 GT	WI	4-14-61
4.20 GT	WI	6-26-61*
1.04 GP	FC	5-17-61
1.06 GP	FC	5-19-61
1.08 GA	FC	9-23-61
1.10 GA	FC	10-15-61*
1.07 GA	FC	10-17-61*
1.11 GA	FC	11-2-61*
1.12 GA	FC	11-5-61*
1.09 GA	FC	9-30-61
4.25 GS	WI	9-30-61

Flights 4.38 NP, 4.39 NP, 4.40 NP and 4.42 NP

Flights 4.38 NP, 4.39 NP, 4.40 NP and 4.42 NP were all launched successfully from Wallops Island on 5 February, 21 April, 18 October and 12 August respectively. All carried experimental payloads designed to measure temperatures, pressures, accelerations and positions of liquid hydrogen under zero gravity (with calibrated heat input into the liquid H_2) for the NASA Lewis Research Center, Cleveland, Ohio.

All rockets included a special recovery package in the forward 36 inches of the nose cone. Each package contained a camera (which observed the liquid hydrogen under zero gravity), a parachute, a flotation bag, radar chaff, a Sarah beacon, and a dye marker. The recovery packages worked on all four flights; however, recovery was not effected on Flight 4.38 NP because no recovery ship was available. A gas despin system and a turntable on which the liquid hydrogen dewar was mounted, were used to remove spin from the payload. A significant fact realized from these experiments was that atmospheric drag on the vehicle after burnout was of sufficient magnitude to have caused hydrogen to accelerate from the bottom to the top of the dewar, thereby imparting a motion to the liquid that would not dump out during the flight. As a result, on later "zero-G"

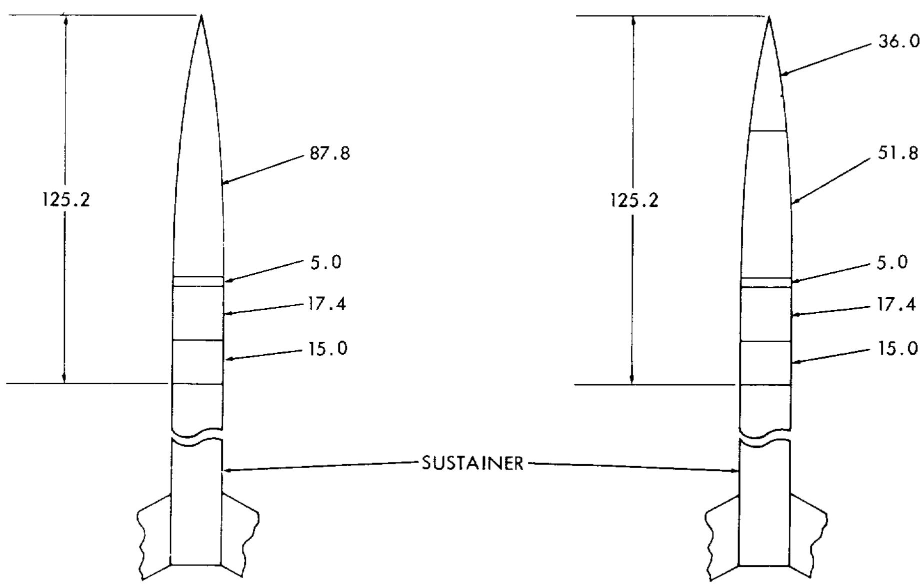
*The summary of this rocket firing is not in chronological order; it is grouped with a similar payload fired later in the year. Refer to the description of the flight for further information.

experiments, post-burnout thrust systems operated by residual helium pressure were installed to give an initial 110 pounds thrust after burnout. These systems produce the effect of thrust decaying to zero in 20 seconds.

Flight 4.38 NP

Flight 4.38 NP performed satisfactorily although impact was farther than anticipated. Instrumentation performed satisfactorily, providing good telemetry data, and the post-burnout thrust system performed well in maintaining positive acceleration. Chamber and helium pressure data and thrust vector data were also received.

Figure 40a gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.38 NP	FLIGHT	4.39 NP
FIRING DATE	5 FEB. 1961	FIRING DATE	21 APR. 1961
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	303.25	PAYLOAD WT. (LBS.)	301.00
APOGEE (ST. MI.)	93.90	APOGEE (ST. MI.)	96.00
TIME TO APOGEE (SEC.)	215.00	TIME TO APOGEE (SEC.)	212.00
CENTER OF GRAVITY (CAL.)	10.10	CENTER OF GRAVITY (CAL.)	10.10
CENTER OF PRESSURE (CAL.)	14.65	CENTER OF PRESSURE (CAL.)	15.25
STATIC MARGIN (CAL.)	4.55	STATIC MARGIN (CAL.)	5.15
RESTORING MOMENT (PER DEGREE)	-0.720	RESTORING MOMENT (PER DEGREE)	-0.664
SUSTAINER BURNOUT TIME (SEC.)	53.00	SUSTAINER BURNOUT TIME (SEC.)	52.50
ROLL RATE AT BURNOUT (RPS)	2.20	ROLL RATE AT BURNOUT (RPS)	2.50
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	351.00
NO. OF JOINTS	4.00	NO. OF JOINTS	5.00

Figure 40—Flights 4.38 NP and 4.39 NP - payload dimensions and flight characteristics.

Flight 4.39 NP

Flight 4.39 NP performed satisfactorily, within predicted parameters, reaching a peak altitude of 96 statute miles in 212 seconds. The rocket's attitude and stability were within experimental requirements and the despin system reduced the casing spin rate to substantially zero. No significant conical motion resulted from the despinning operation. Telemetry data received was excellent and tracking by radar was extremely effective. Desired experimental conditions were obtained for a period of approximately 60 seconds. Results of this test indicate that the Aerobee sounding rocket, with a spin table and a gas despin system, can be an excellent "zero-G" facility.

Figure 40b gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.40 NP

Flight 4.40 NP reached an altitude of 10 miles below that predicted, although it agreed closely with three other Lewis "zero-G" flights. Rocket roll rate at sustainer burnout was 2.8 rps, higher than the 2.4 rps predicted. As a result, more time was required to despin the vehicle. A total of 176 seconds of good "zero-G" time was obtained from completion-of-despin until the termination of data collection. Neither the lower maximum altitude nor the higher spin rate adversely affected the results of the experiment. Vehicle performance, flight course and impact point were within predicted limits. Additionally, the experiment was successful, both as to the amount of telemetered data received, and as to the quality of photographic material recovered.

Figure 41a gives payload dimensions and characteristics of this rocket and its flight.

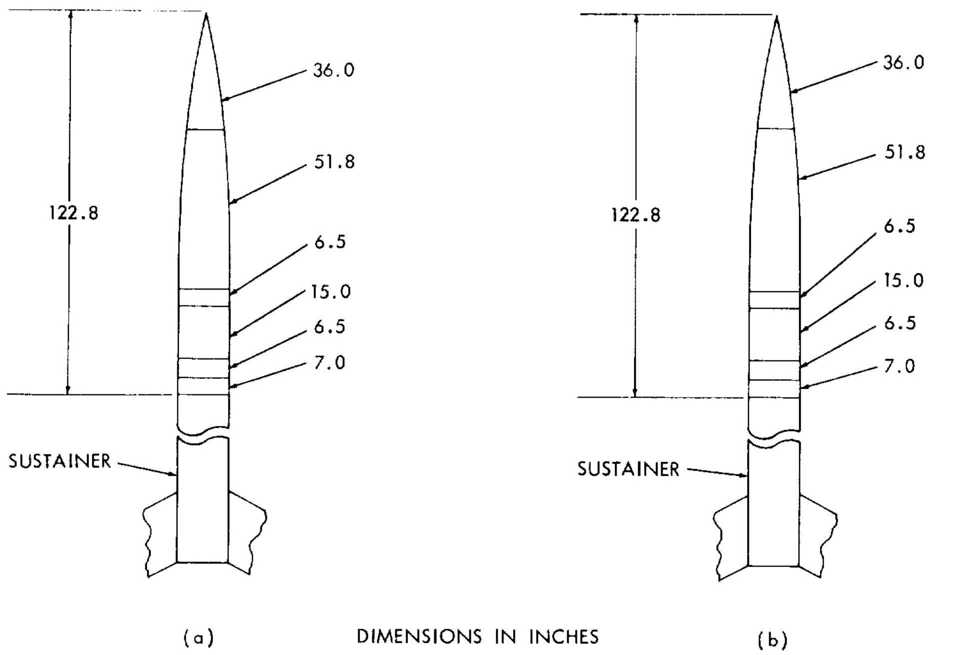
Flight 4.42 NP

Flight 4.42 NP was launched successfully, carrying a payload of 283 pounds to a zenith altitude of 95.5 statute miles, as predicted. One significant difficulty that did occur concerning this flight, however, was a power failure at T +1 second. As a result, all data on rocket performance, accelerometers and rocket pressure was lost. Telemetry signals became noisy at 213 seconds and got progressively worse during the remainder of the flight. Radar tracking was excellent, pinpointing the recovery package for pickup 22 minutes after launch.

Figure 41b gives payload dimensions and characteristics of this rocket and its flight.

Flights 6.04 UI and 6.05 UI

Flights 6.04 UI and 6.05 UI were two Spaerobee 300's successfully launched from Wallops Island on 26 March and 22 December respectively. Both rockets carried the "Dumbbell" form of elastrostatic probe to measure electron temperatures and ion densities in the ionosphere. In this respect, the flights were similar to Flights 6.01 UI and 6.02 UI, fired successfully in 1960 at Fort Churchill, and to Flight 6.03 UI, also launched successfully at Wallops Island in 1960. No recovery attempt was necessary or required for Flights 6.04 UI and 6.05 UI.



FLIGHT	4.40 NP	FLIGHT	4.42 NP
FIRING DATE	18 OCT. 1961	FIRING DATE	12 AUG. 1961
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	277.50	PAYLOAD WT. (LBS.)	283.00
APOGEE (ST. MI.)	95.00	APOGEE (ST. MI.)	95.50
TIME TO APOGEE (SEC.)	213.00	TIME TO APOGEE (SEC.)	210.00
CENTER OF GRAVITY (CAL.)	9.97	CENTER OF GRAVITY (CAL.)	10.10
CENTER OF PRESSURE (CAL.)	13.80	CENTER OF PRESSURE (CAL.)	13.97
STATIC MARGIN (CAL.)	3.83	STATIC MARGIN (CAL.)	3.87
RESTORING MOMENT (PER DEGREE)	-0.545	RESTORING MOMENT (PER DEGREE)	-0.4089
SUSTAINER BURNOUT TIME (SEC.)	53.00	SUSTAINER BURNOUT TIME (SEC.)	52.00
ROLL RATE AT BURNOUT (RPS)	2.80	ROLL RATE AT BURNOUT (RPS)	2.31
TIP EJECT (SEC.)	unknown	TIP EJECT (SEC.)	unkown
NO. OF JOINTS	6.00	NO. OF JOINTS	6.00

Figure 41—Flights 4.40 NP and 4.42 NP - payload dimensions and flight characteristics.

Flight 6.04 UI

Flight 6.04 UI was a highly successful flight. In addition to the above objectives, it extended these measurements to include a larger percentage of electrons, with an independent unequal area bipolar probe system. A third major objective, sponsored by the Ballistics Research Laboratory of Aberdeen Proving Ground, Md., was to obtain measurements of the ionosphere electron density by means of the two-frequency beacon, for comparison with the probe results. A relatively small payload of 64 pounds was carried to a zenith altitude of 252 statute miles. The "Dumbbell" ejected properly from the nose cone at T +70 seconds. Complete data recovery and tracking was realized and upper air instrumentation functioned properly.

Figure 42 gives payload dimensions and characteristics of this rocket and its flight.

Flight 6.05 UI

Flight 6.05 UI, similar to Flight 6.04 UI, was highly successful; although the peak altitude attained was only 227 statute miles (compared to the predicted altitude of 260 statute miles). In

FLIGHT	6.04 UI	6.05 UI
FIRING DATE	26 MAR. 1961	22 DEC. 1961
LAUNCH SITE	WI	WI
PAYLOAD WEIGHT, 2ND STAGE (lbs)	216.30	205.80
PAYLOAD WEIGHT, 3RD STAGE (lbs)	64.00	60.00
APOGEE (statute miles)	252.00	227.00
TIME TO APOGEE (seconds)	339.00	323.00
CENTER OF GRAVITY, SUSTAINER BURNOUT (calculated)	10.76	10.81
CENTER OF PRESSURE, SUSTAINER BURNOUT (calculated)	14.90	14.91
STATIC MARGIN, SUSTAINER BURNOUT (calculated)	4.14	4.10
RESTORING MOMENT, SUSTAINER BURNOUT (per degree)	-0.459	-0.545
CENTER OF GRAVITY, 3RD STAGE IGNITION (calculated)	8.54	8.41
CENTER OF PRESSURE, 3RD STAGE IGNITION (calculated)	10.23	10.38
STATIC MARGIN, 3RD STAGE IGNITION (calculated)	1.55	1.84
RESTORING MOMENT, 3RD STAGE IGNITION (per degree)	-0.0558	-0.6620
SUSTAINER BURNOUT (seconds)	51.70	52.50
THIRD STAGE BURNOUT (seconds)	54.00	56.30
ROLL RATE AT BURNOUT, SUSTAINER (rps)	2.70	2.00
ROLL RATE AT BURNOUT, 3RD STAGE (rps)	2.20	unknown
PROBE EJECT (seconds)	70.00	70.00
NUMBER OF JOINTS	7.00	7.00
THIRD STAGE LENGTH (in.)	122.85	122.85
PAYLOAD HOUSING LENGTH X (in.)	65.25	65.25

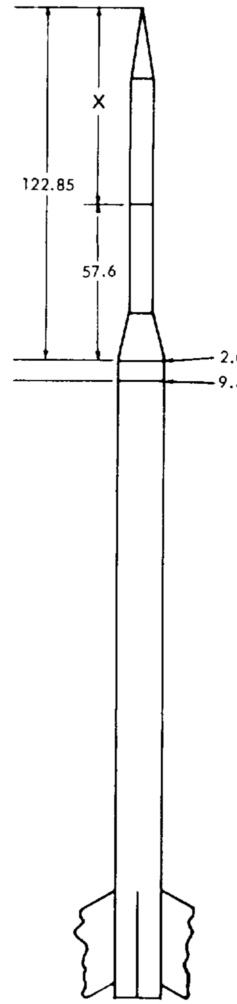


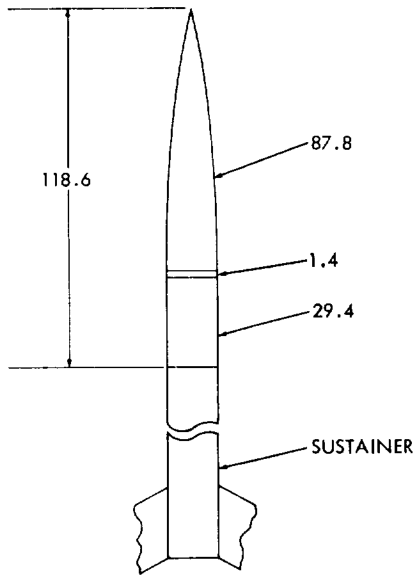
Figure 42—Flights 6.04 UI and 6.05 UI - payload dimensions and flight characteristics.

addition to the objectives of Flight 6.04 UI, Flight 6.05 UI carried a secondary experiment to evaluate the feasibility of a non-ejectable probe system. By using the rocket body as one electrode of the probe pair, this experiment obtained similar measurements to compare with the dumbbell probe. Good data was received from the dumbbell, although very little useful data was attained from the Sparrow extension, (secondary experiment) after Sparrow ignition, due to a weak telemetry signal. Good accelerometer data was attained during Aerobee burning, however, and all radars tracked to their design limits.

Figure 42 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.34 GG

Flight 4.34 GG was an Aerobee 150A launched from Wallops Island, on March 31. The purpose of this flight was to receive and measure ultraviolet stellar and nebula fluxes. Rocket performance



DIMENSIONS IN INCHES

FLIGHT	4.34 GG
FIRING DATE	31 MAR. 1961
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	182.50
APOGEE (ST. MI.)	44.50*
TIME TO APOGEE (SEC.)	142.00
CENTER OF GRAVITY (CAL.)	10.68
CENTER OF PRESSURE (CAL.)	
STATIC MARGIN (CAL.)	
RESTORING MOMENT (PER DEGREE)	
SUSTAINER BURNOUT TIME (SEC.)	41.50
ROLL RATE AT BURNOUT (RPS)	
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

* Payload doors ejected in the tower and the 'G' reduction timer shut down the engine prematurely.

Figure 43—Flight 4.34 GG - payload dimensions and flight characteristics.

appeared to be normal until approximately T +7 seconds when an unexpected ejection of 5 of the 6 payload door assemblies occurred. Thereafter the missile continued at a near-zero angle of yaw to an early shutdown at 41.5 seconds. Performance of the rocket until thrust termination, resulting from drag and possibly a low thrust program, was considerably less than predicted. Without the doors, it was difficult to accurately determine the amount of discrepancy due to possible errors in drag estimates.

A later investigation of the problem has determined that the increased drag on the vehicle, and associated reduced vehicle acceleration, resulted in a premature actuation of the propellant shutdown valve by the "g" reduction timer—thus premature thrust termination. The "g" reduction timer is normally used to close propellant valves immediately after burnout and conserve the helium gas for the despin system.

Although performance was indicated on radar plots to be considerably lower than predicted for a normal trajectory, and telemetry data indicated an abrupt break in acceleration, there was no evidence to indicate a blowdown or malfunction such as a hole in the chamber. A pitch/yaw gage flown on the vehicle indicated angles of attack during burning of less than one degree—so small that there was no reason for concern. Since the peak altitude was only 72 kilometers, the vehicle did not provide the capability to collect the scientific data required by its mission. Therefore, the flight was unsuccessful. A successful recovery followed the flight.

Figure 43 gives payload dimensions and characteristics of this rocket and its flight.

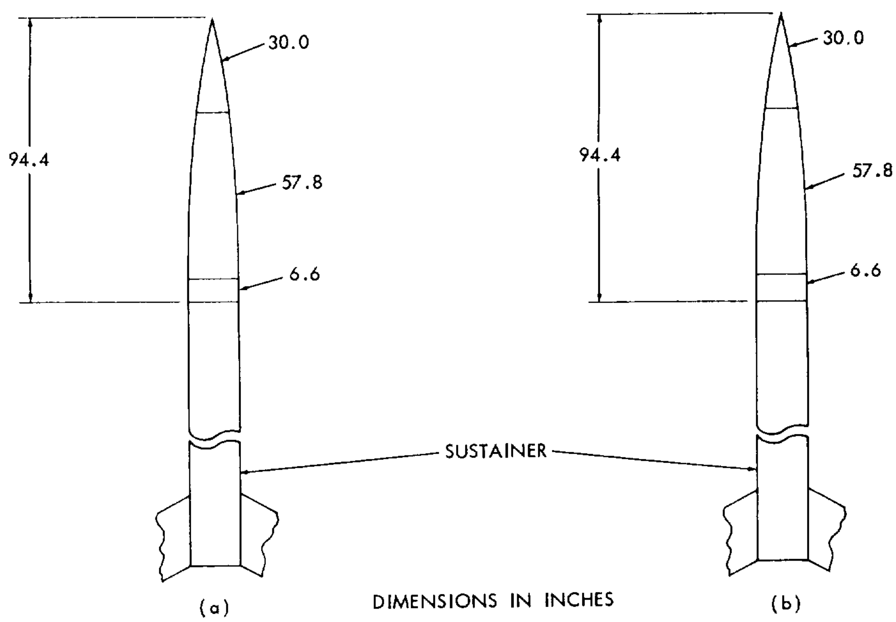
Flights 4.19 GT and 4.20 GT

Flights 4.19 GT and 4.20 GT were two Aerobee 150A's launched from Wallops Island, and were the first two tests of the Aerobee attitude control system. The launchings occurred on 14 April and 26 June respectively. The primary objectives were to flight test the maneuverability, holding, and acquisition accuracy of the control system. The payload on each included an aspect sensing system, a gamma-ray background experiment, a solar flux experiment, a longitudinal acceleration and combustion chamber pressure sensor, and longitudinal and lateral vibration pickups.

Flight 4.19 GT

Flight 4.19 GT reached a zenith altitude of 128 statute miles with a payload of 206 pounds as predicted. Although only a small quantity of data was received on the experiments due to a malfunction of the rocket despin system, the launch and flight of the vehicle were successful. It was later deduced that a wiring failure, about 20 seconds after despin initiation, caused the loss of the 28 volts needed to despin the rocket. Thus the vehicle was never able to stabilize and maneuver.

Figure 44a gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.19 GT
FIRING DATE	14 APR. 1961
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	206.00
APOGEE (ST. MI.)	128.00
TIME TO APOGEE (SEC.)	240.00
CENTER OF GRAVITY (CAL.)	9.50
CENTER OF PRESSURE (CAL.)	13.10
STATIC MARGIN (CAL.)	3.60
RESTORING MOMENT (PER DEGREE)	-0.464
SUSTAINER BURNOUT TIME (SEC.)	52.70
ROLL RATE AT BURNOUT (RPS)	2.80
TIP EJECT (SEC.)	75.00
NO. OF JOINTS	3.00

FLIGHT	4.20 GT
FIRING DATE	26 JUN. 1961
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	214.00
APOGEE (ST. MI.)	116.00
TIME TO APOGEE (SEC.)	235.00
CENTER OF GRAVITY (CAL.)	9.46
CENTER OF PRESSURE (CAL.)	13.80
STATIC MARGIN (CAL.)	4.34
RESTORING MOMENT (PER DEGREE)	-0.5859
SUSTAINER BURNOUT TIME (SEC.)	52.00
ROLL RATE AT BURNOUT (RPS)	3.00
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	3.00

Booster blew up approximately 2.5 seconds

Figure 44—Flights 4.19 GT and 4.20 GT - payload dimensions and flight characteristics.

Flight 4.20 GT

Flight 4.20 GT carried a payload of 214 pounds to a zenith altitude of 116 statute miles, approximately 10 miles under the predicted value. The launch and flight of the vehicle was reasonably successful even though a booster failure occurred during the boost phase, causing a booster case rupture. The booster exploded at approximately 2.5 seconds. However, this did not affect the sustainer flight. The roll rate was determined to be 3.0 rps, almost 1.0 rps greater than expected for the flight. The 28-volt instrumentation line was lost, possibly as a result of the booster explosion, and no experiment data was received as the ACS didn't get a start command. Longitudinal and lateral vibration instrumentation were installed in the payload, and good telemetry data were received from this instrumentation. A report on the vibration levels was published (Reference 6).

Figure 44b gives payload dimensions and characteristics of this rocket and its flight.

Flights 1.04 GP and 1.06 GP

Flights 1.04 GP and 1.06 GP were successfully launched from Fort Churchill on 17 May and 19 May. Each was an Aerobee 100, carrying photographic payloads as follow-up for GSFC arctic meteorological photo probes (similar to those launched in 1960 on Flights 1.03 GP and 1.05 GP). Photographs were desired to assist in distinguishing between clouds, ice, and snow in the subsequent launching of the sophisticated Nimbus weather satellite. Nuclear emulsion packs, each weighing approximately one pound, were also flown to measure radiation of solar beam particles.

Flight 1.04 GP

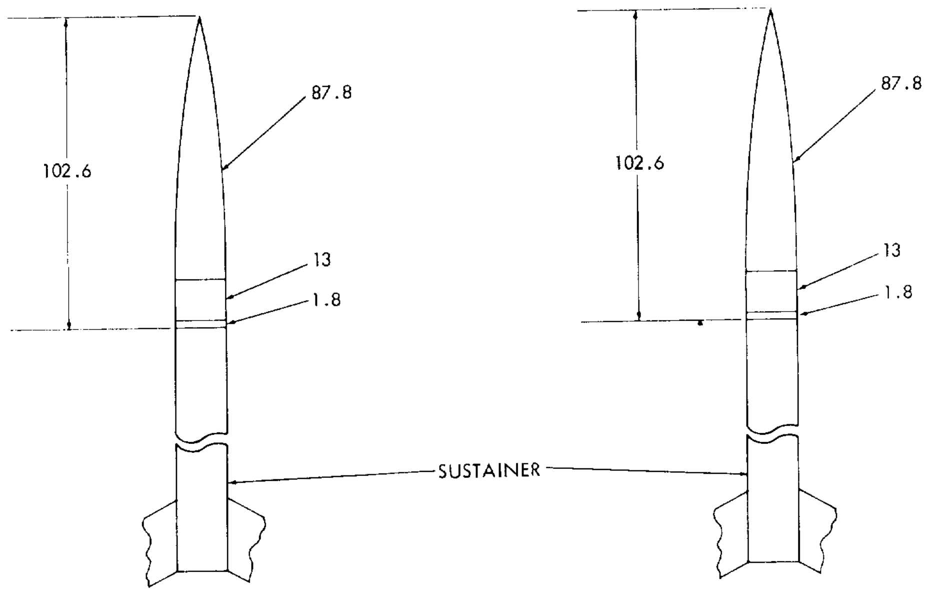
Flight 1.04 GP apparently had satisfactory rocket performance. There is an amount of speculation concerning this flight, however, since radar tracking was lost at T +40 seconds and range safety required a termination of the flight. It was later determined that flight safety personnel had misunderstood the plus count and attempted the termination after sustainer burnout. The radars were unable to track because of continuous wave jamming from an unknown source.

Although parachute deployment was prevented because the payload sustainer separation did not occur, the payload and rocket were both recovered in a hard ground area. It was evident that the vehicle had impacted at an extremely high velocity, and that detonation of the separation detonator block and primacord did not occur until impact. The nuclear emulsions and radiation dosimeters were destroyed, but the two film packs were recovered. Unfortunately, some damage had occurred to the camera case, overexposing most of the film, and only a few pictures were saved.

Figure 45a gives payload dimensions and characteristics of this rocket and its flight.

Flight 1.06 GP

Flight 1.06 GP reached predicted altitude; however, the payload suffered some structural damage when the parachute and payload were separated prematurely an unknown distance above



FLIGHT	1.04 GP
FIRING DATE	17 MAY, 1961
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	143.00
APOGEE (ST. MI.)	47.50
TIME TO APOGEE (SEC.)	unknown
CENTER OF GRAVITY (CAL.)	9.233
CENTER OF PRESSURE (CAL.)	12.7 (approx.)
STATIC MARGIN (CAL.)	3.47 (approx.)
RESTORING MOMENT (PER DEGREE)	-0.3
SUSTAINER BURNOUT TIME (SEC.)	unknown
ROLL RATE AT BURNOUT (RPS)	0.16 (approx.)
TIP EJECT (SEC.)	at impact
NO. OF JOINTS	3.00

FLIGHT	1.06 GP
FIRING DATE	19 MAY, 1961
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	139.70
APOGEE (ST. MI.)	45.40
TIME TO APOGEE (SEC.)	151.00
CENTER OF GRAVITY (CAL.)	9.133
CENTER OF PRESSURE (CAL.)	12.20 (approx.)
STATIC MARGIN (CAL.)	3.03 (approx.)
RESTORING MOMENT (PER DEGREE)	-0.3
SUSTAINER BURNOUT TIME (SEC.)	unknown
ROLL RATE AT BURNOUT (RPS)	0.33
TIP EJECT (SEC.)	200.00
NO. OF JOINTS	3.00

Figure 45—Flights 1.04 GP and 1.06 GP - payload dimensions and flight characteristics.

the ground. The nose cone experienced a soft impact in eighteen inches of snow and a recovery was later made by a helicopter. The camera and nuclear emulsion packages were not damaged and high quality pictures were obtained.

Figure 45b gives payload dimensions and characteristics of this rocket and its flight.

Flights 1.07 GA through 1.12 GA

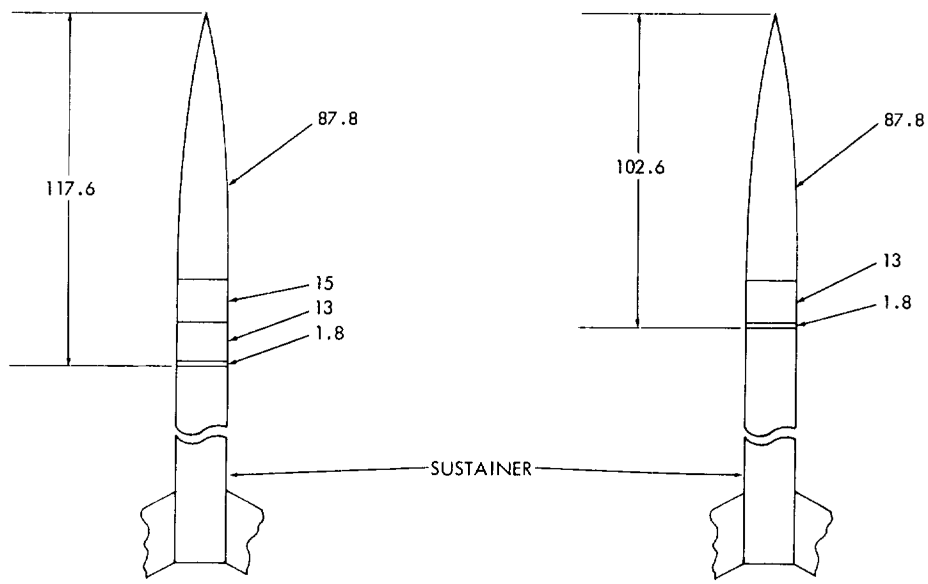
Flights 1.07 GA, 1.08 GA, 1.09 GA, 1.10 GA, 1.11 GA, and 1.12 GA (all Aerobee 100's) were successfully flown from Fort Churchill on 17 October, 23 September, 30 September, 15 October, 2 November, and 5 November, respectively. The objective of all flights was to launch and recover a payload consisting of a Vac-Sorb pump (a vacuum pump built by Varian Associates) and two nuclear emulsion packs. Each payload was designed to examine the upper atmosphere from 40 to 50 miles altitude in the near arctic region.

Performance of all rockets and recovery packages was successful and extremely close to predicted. No telemetry was used on these flights and the range requirement for a flight termination system was waived. No major vehicle performance difficulties occurred during this series of launchings.

Figures 46, 47,and 48 give payload dimensions and characteristics of these rockets and their flights.

Flight 4.25 GS

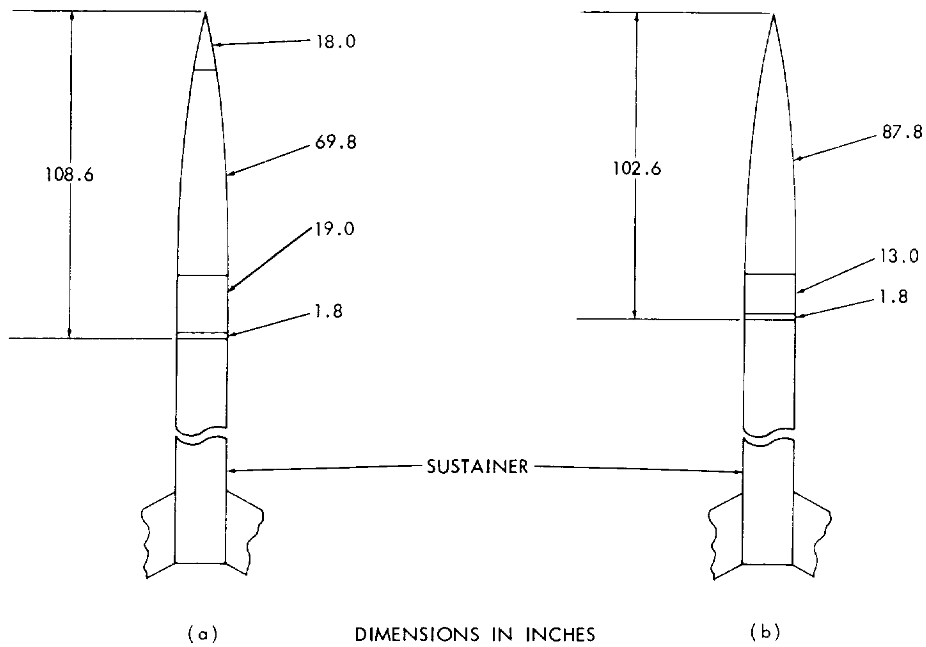
Flight 4.25 GS (an Aerobee 150A vehicle) was successfully launched from Wallops Island on September 30. The payload section included the solar pointing control system (Ball Brothers) to orient the payload toward the sun so that solar flux could be measured in the 2200 and 2600 angstrom regions. Other objectives of the test were to flight test a solar x-ray spectrophotometer, a



DIMENSIONS IN INCHES

FLIGHT	1.07 GA	FLIGHT	1.08 GA
FIRING DATE	17 OCT. 1961	FIRING DATE	23 SEPT. 1961
LAUNCH SITE	FC	LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	202.00	PAYLOAD WT. (LBS.)	148.50
APOGEE (ST. MI.)	40.70	APOGEE (ST. MI.)	48.50
TIME TO APOGEE (SEC.)	140.00	TIME TO APOGEE (SEC.)	145.00
CENTER OF GRAVITY (CAL.)	9.353	CENTER OF GRAVITY (CAL.)	9.30
CENTER OF PRESSURE (CAL.)	13.10	CENTER OF PRESSURE (CAL.)	12.133
STATIC MARGIN (CAL.)	3.70	STATIC MARGIN (CAL.)	2.80
RESTORING MOMENT (PER DEGREE)	-0.503	RESTORING MOMENT (PER DEGREE)	-0.378
SUSTAINER BURNOUT TIME (SEC.)	40.00 (approx.)	SUSTAINER BURNOUT TIME (SEC.)	40.00
ROLL RATE AT BURNOUT (RPS)	na	ROLL RATE AT BURNOUT (RPS)	unknown
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	80.00
NO. OF JOINTS	4.00	NO. OF JOINTS	3.00

Figure 46—Flights 1.07 GA and 1.08 GA - payload dimensions and flight characteristics.



FLIGHT	1.09 GA	FLIGHT	1.10 GA
FIRING DATE	30 SEPT. 1961	FIRING DATE	15 OCT. 1961
LAUNCH SITE	FC	LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	161.00	PAYLOAD WT. (LBS.)	171.50
APOGEE (ST. MI.)	45.30	APOGEE (ST. MI.)	46.60
TIME TO APOGEE (SEC.)	145.00	TIME TO APOGEE (SEC.)	145.00
CENTER OF GRAVITY (CAL.)	9.073	CENTER OF GRAVITY (CAL.)	8.913
CENTER OF PRESSURE (CAL.)	12.773	CENTER OF PRESSURE (CAL.)	13.05
STATIC MARGIN (CAL.)	3.70	STATIC MARGIN (CAL.)	4.14
RESTORING MOMENT (PER DEGREE)	-0.380	RESTORING MOMENT (PER DEGREE	-0.505
SUSTAINER BURNOUT TIME (SEC.)	41.00	SUSTAINER BURNOUT TIME (SEC.)	40.00 (approx.)
ROLL RATE AT BURNOUT (RPS)	0.20 (approx.)	ROLL RATE AT BURNOUT (RPS)	unknown
TIP EJECT (SEC.)	80.00	TIP EJECT (SEC.)	unknown
NO. OF JOINTS	4.00	NO. OF JOINTS	3.00

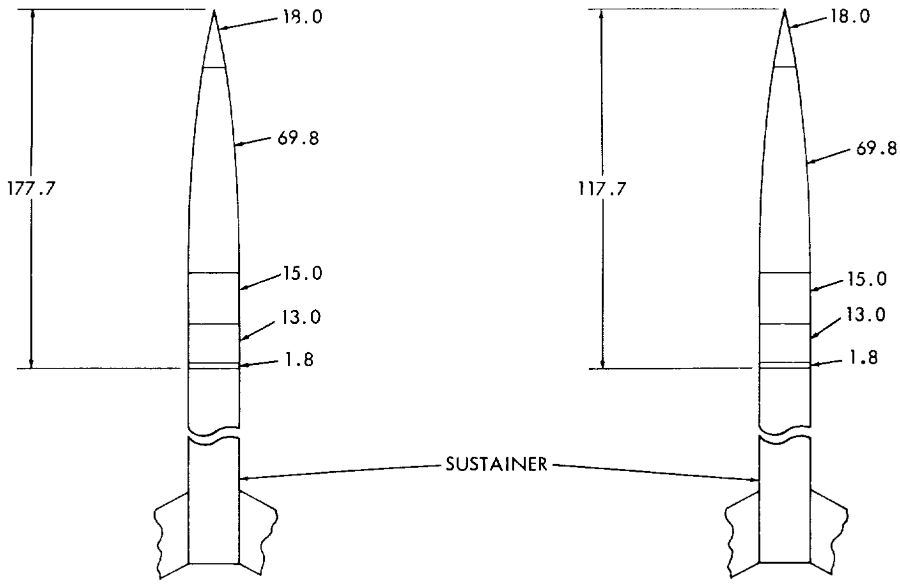
Figure 47—Flights 1.09 GA and 1.10 GA - payload dimensions and flight characteristics.

special diode experiment, and solar aspect eyes designed for the S-16 satellite (Orbiting Solar Observatory). A payload of 182.5 pounds was carried to 139 statute miles as predicted. The solar pointing control aimed the experiments at the sun for 328 seconds and all experiments operated properly producing data until breakup on reentry. Telemetry data was received for 470 seconds.

Figure 49 gives payload dimensions and characteristics of this rocket and its flight.

FIRINGS FOR CY 1962

Twenty-three (23) Aerobee vehicles were launched in 1962. Seventeen (17) Aerobee 150A's and one (1) Spaerobee 300A were launched from Wallops Island, Va., and three (3) Aerobee 150's and two (2) Aerobee 100's (Aerobee Juniors) were launched from the White Sands Missile Range. Only eight of the vehicles fired were equipped with recovery packs. Six of these recoveries were



(a) DIMENSIONS IN INCHES (b)

FLIGHT	1.11 GA	FLIGHT	1.12 GA
FIRING DATE	2 NOV. 1961	FIRING DATE	5 NOV. 1961
LAUNCH SITE	FC	LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	200.00	PAYLOAD WT. (LBS.)	183.00
APOGEE (ST. MI.)	42.60	APOGEE (ST. MI.)	43.00
TIME TO APOGEE (SEC.)	140.00	TIME TO APOGEE (SEC.)	130.00
CENTER OF GRAVITY (CAL.)	9.42	CENTER OF GRAVITY (CAL.)	9.66
CENTER OF PRESSURE (CAL.)	12.86	CENTER OF PRESSURE (CAL.)	13.06
STATIC MARGIN (CAL.)	3.44	STATIC MARGIN (CAL.)	3.40
RESTORING MOMENT (PER DEGREE)	-0.449	RESTORING MOMENT (PER DEGREE)	-0.415
SUSTAINER BURNOUT TIME (SEC.)	40.00	SUSTAINER BURNOUT TIME (SEC.)	40.00
ROLL RATE AT BURNOUT (RPS)	unknown *	ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	unknown	TIP EJECT (SEC.)	80.00
NO. OF JOINTS	5.00	NO. OF JOINTS	5.00

* Set for 0.2 revolutions per second

* Set for 0.2 revolutions per second

Figure 48—Flights 1.11 GA and 1.12 GA - payload dimensions and flight characteristics.

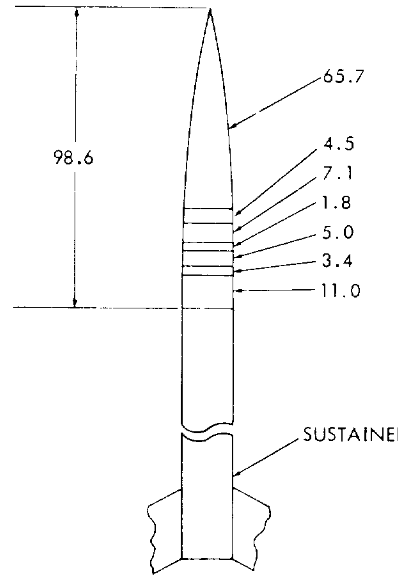
completely successful. Of the other two, one was completely lost due to confusion in the recovery operation (Flight 4.60 GT); and the other payload was severely damaged (Flight 4.21 US), as a premature deployment of the parachute caused the chute to be torn away from the payload. In the latter case, however, recovery of the payload was not essential to the experiment. Another rocket failed (Flight 4.74 UA) when the booster exploded upon ignition and all vehicle hardware impacted in the tower.

Out of the twenty three vehicle firings achieved for the year, sixteen (16) were listed as successful, one (1) was partially successful (Flight 4.60 GT), and six (6) were under performance requirements (Flights 4.35 GG, 4.18 GA, 4.79 II, 1.14 NA, 4.80 II, and 4.74 UA). The following Aerobee vehicles were launched in 1962:

Flight Number	Launch Site	Date of Launch
4.68 GT	WI	1-13-62
4.60 GT	WI	8-8-62*

*The summary of this rocket firing is not in chronological order, but follows the description of a similar payload fired earlier in the year.

Flight Number	Launch Site	Date of Launch
4.35 GG	WI	2-7-62
4.36 GG	WI	9-22-62*
4.41 NP	WI	2-17-62
4.26 NP	WI	6-20-62*
4.27 NP	WI	11-18-62*
4.18 GA	WI	3-19-62
4.46 NP	WSMR	5-8-62
4.47 NP	WSMR	7-10-62*
4.48 GT	WI	5-25-62
4.71 UP	WI	6-20-62
4.72 UP	WI	6-29-62
4.74 UA	WI	12-13-62*
4.23 US	WI	7-24-62
1.13 NP	WSMR	9-6-62
1.14 NA	WSMR	11-20-62*
4.69 CG	WI	9-30-62
4.54 UG	WI	10-30-62
4.79 II	WI	11-16-62
4.80 II	WI	12-11-62*
6.06 GA	WI	11-20-62
4.21 US	WI	11-27-62



DIMENSIONS IN INCHES

FLIGHT	4.25 GS
FIRING DATE	30 SEPT. 1961
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	180.00
APOGEE (ST. MI.)	140.00
TIME TO APOGEE (SEC.)	252.00
CENTER OF GRAVITY (CAL.)	9.70
CENTER OF PRESSURE (CAL.)	13.75
STATIC MARGIN (CAL.)	4.05
RESTORING MOMENT (PER DEGREE)	-0.5356
SUSTAINER BURNOUT TIME (SEC.)	51.50
ROLL RATE AT BURNOUT (RPS)	1.90
TIP EJECT (SEC.)	na
NO. OF JOINTS	7.00

Figure 49—Flight 4.25 GS - payload dimensions and flight characteristics.

Flights 4.68 GT and 4.60 GT

Flights 4.68 GT and 4.60 GT were the third and fourth test flights of the attitude control system. Rocket instrumentation included solar tracking and magnetic aspect sensing systems. Other experiments included in the payload were measurement instruments for gamma ray detection and solar flux experiments, and a rocket vibration experiment.

Flight 4.68 GT

Flight 4.68 GT performed as predicted, reaching a peak altitude of 130 statute miles (128 statute miles predicted) in 246 seconds. The nose cone was successfully ejected via a pyrotechnic

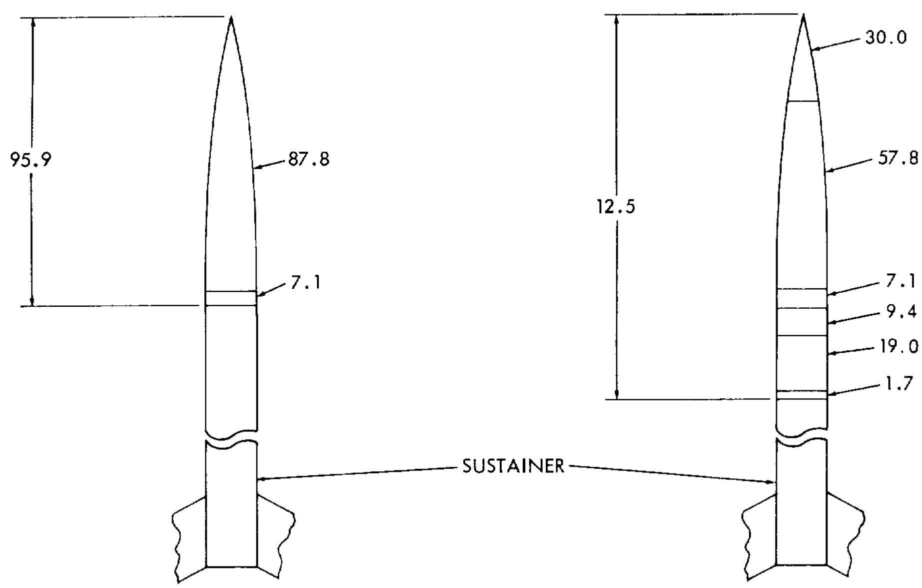
*The summary of this rocket firing is not in chronological order, but follows the description of a similar payload fired earlier in the year.

bolt cutter and springs at approximately 74 seconds after liftoff. Complete data recovery was achieved and tracking was good. The attitude control system met the stabilization, limit cycling, and maneuver requirements expected; and maneuvered the vehicle to three programmed targets. Due to electrical problems encountered in the first maneuver sequence, the pointing accuracy was less than expected. However, the electrical problems were obvious ones which could easily be remedied in later flights. Reference 6 contains vibration data collected on this flight.

Figure 50a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.60 GT

The performance of Flight 4.60 GT is considered to have been only a partial success. The vehicle carried a net payload of 260 pounds, including a pointing control test and four scientific experiments, to a peak altitude of 93 statute miles—18 miles below that predicted. Due to the low



FLIGHT	4.68 GT	FLIGHT	4.60 GT
FIRING DATE	13 JAN. 1962	FIRING DATE	8 AUG. 1962
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	212.00	PAYLOAD WT. (LBS.)	260.00
APOGEE (ST. MI.)	130.00	APOGEE (ST. MI.)	93.00
TIME TO APOGEE (SEC.)	246.00	TIME TO APOGEE (SEC.)	211.20
CENTER OF GRAVITY (CAL.)	10.40	CENTER OF GRAVITY (CAL.)	10.60
CENTER OF PRESSURE (CAL.)	14.73	CENTER OF PRESSURE (CAL.)	14.80
STATIC MARGIN (CAL.)	4.33	STATIC MARGIN (CAL.)	4.20
RESTORING MOMENT (PER DEGREE)	-0.583	RESTORING MOMENT (PER DEGREE)	-0.570
SUSTAINER BURNOUT TIME (SEC.)	53.10	SUSTAINER BURNOUT TIME (SEC.)	51.50
ROLL RATE AT BURNOUT (RPS)	1.52	ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	74.00	TIP EJECT (SEC.)	unknown
NO. OF JOINTS	2.00	NO. OF JOINTS	6.00

* Set for 2.2 revolutions per second

Figure 50—Flights 4.68 GT and 4.60 GT - payload dimensions and flight characteristics.

burnout altitude the ACS took much longer than expected to despin and stabilize the vehicle. Rocket control was not good after maneuvers were begun due to relatively poor control in roll which intermittently "locked-out" pitch and yaw circuits. The parachute recovery system failed to operate as expected due to an incomplete initial severance. Later confusion in the recovery operation precluded the recovery of any of the rocket hardware after impact.

Although no definite conclusions could be made explaining the cause of Flight 4.60 GT underperformance, the following were determined to be important facts observed:

1. Radar data transmitted during the flight were examined. It was noted that although a predicted launch angle of 3 degrees from vertical was anticipated, the final effective launch angle was 5 degrees from vertical. However, calculations made with the adjusted launch angle of 5 degrees indicated that this would have only dropped the peak altitude estimate by 2 statute miles.

2. Attempts to analyze fuel and oxidizer flow rates were made; however, it was impossible to interpret these without drawing upon extremely presumptuous conditions. These attempts were made by imposing actual flight results onto the vehicle propulsion system performance values of required residual propellant and required off-loading propellant weights.

Although Flight 4.60 GT was only partially successful, scientific data were obtained on the solar aspect sensing systems; planetary spectra experiment; atmospheric irradiance experiment; Lyman-alpha albedo experiment; and instrumentation pullaway experiment. Also rocket performance data received during the flight was sufficient to permit the later plotting of chamber pressure, fuel pressure, oxidizer pressure and acceleration curves, which were useful in the post-flight analysis.

Figure 50b gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.35 GG and 4.36 GG

Flights 4.35 GG and 4.36 GG were two Aerobee 150A's, launched from Wallops Island on 7 February and 22 September. Both rockets carried four scanning photoelectric spectrophotometers to measure the absolute intensity of the spectrum of stars with fifty angstrom resolution.

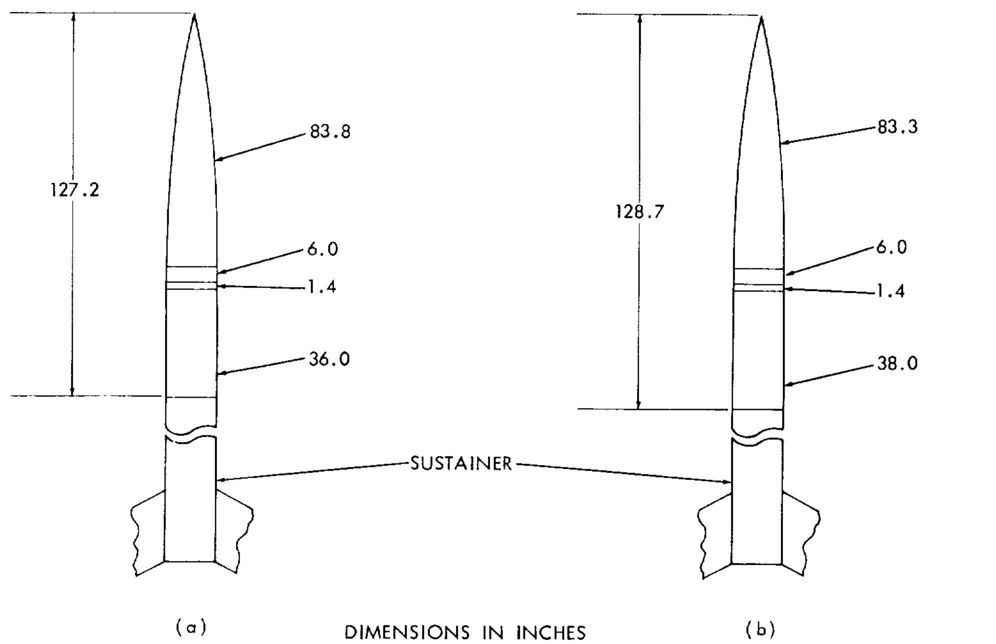
Flight 4.35 GG

Flight 4.35 GG was launched successfully at Wallops Island on 7 February, and performed as expected for 4.9 seconds until the Range Safety Officer inadvertently terminated powered flight. Personnel operating the closed circuit television, which was at a fixed azimuth and moveable elevation, tracked the booster rather than the sustainer. Believing the sustainer had gone off course, the Range Safety Officer initiated cut-down by closing the propellant shutoff valves. Although telemetry functioned properly during the entire flight and all radar functioned within the limits of their capability until the rocket impacted in the ocean, there was insufficient altitude to operate the upper air instrumentation.

Figure 51a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.36 GG

Flight 4.36 GG was satisfactory although not completely successful. The vehicle reached an apogee of 117 statute miles, approximately 8 miles below predicted. The gas despin system failed to function, and the experiment instrumentation failed to operate. Thus experimental objectives were not realized. However, telemetry and support instrumentation did work satisfactorily, providing adequate chamber pressure, helium pressure, and accelerometer data. Later



FLIGHT	4.35 GG
FIRING DATE	7 FEB. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	214.00
APOGEE (ST. MI.)	2.27
TIME TO APOGEE (SEC.)	30.00
CENTER OF GRAVITY (CAL.)	9.30
CENTER OF PRESSURE (CAL.)	na
STATIC MARGIN (CAL.)	na
RESTORING MOMENT (PER DEGREE)	na
SUSTAINER BURNOUT TIME (SEC.)	4.90
ROLL RATE AT BURNOUT (RPS)	na
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Range safety error rocket was shutoff 4.9 seconds after liftoff

FLIGHT	4.36 GG
FIRING DATE	22 SEPT. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	217.00
APOGEE (ST. MI.)	117.00
TIME TO APOGEE (SEC.)	230.00
CENTER OF GRAVITY (CAL.)	11.00
CENTER OF PRESSURE (CAL.)	14.80
STATIC MARGIN (CAL.)	3.80
RESTORING MOMENT (PER DEGREE)	-0.510
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	2.50
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 51—Flights 4.35 GG and 4.36 GG - payload dimensions and flight characteristics.

analysis of the flight narrowed the cause of the failure to three areas for study. The conclusions of these studies resulted in electrical circuitry changes to overcome the problem in future firings.

Figure 51b gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.41 NP, 4.26 NP, and 4.27 NP

Flights 4.41 NP, 4.26 NP, and 4.27 NP were Aerobee 150A rockets launched from Wallops Island as a continuation of the Lewis Research Center's series of "zero-G" experiments. The major objective of the flights were to determine heat transfer coefficients under conditions of a hemispherical radiant heat input and zero gravity (see similar Flights 4.38 NP, 4.39 NP, 4.40 NP, and 4.42 NP). As in the other Lewis experiments, the rockets carried a partially filled liquid hydrogen dewar containing an experimental ullage control system and a special temperature probe.

Flight 4.41 NP

On 17 February, Flight 4.41 NP rocket and instrumentation performed well and an apogee of 97.5 statute miles was attained. Although the despin system failed to despin the rocket as expected, the boundary layer temperature gradient experiment was still successful. The ullage control system functioned properly even under the extremely high lateral acceleration vectors. Recovery was initiated immediately after flight, and the payload including the camera package and good photographs of the liquid hydrogen were retrieved only nineteen (19) minutes after launch.

Figure 52a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.26 NP

Flight 4.26 NP was launched successfully on 20 June and reached a peak altitude of 97.5 statute miles. Although the rocket performed slightly below predicted estimates and the gas despin unit again failed to function, the experiment was still successful and satisfactory data was collected.

Figure 52b gives payload dimensions and characteristics of this rocket and its flight.

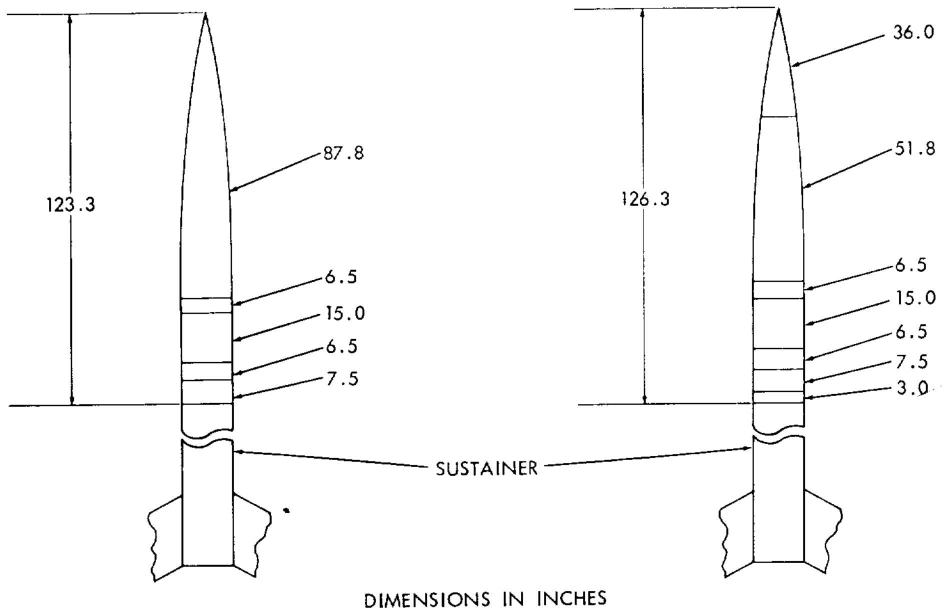
Flight 4.27 NP

Flight 4.27 NP was launched successfully on 18 November to a peak altitude of 129 statute miles. Telemetry signals were received until +450 seconds. The despin system functioned properly; the dewar flask heaters functioned properly, and data was obtained as planned. The only difficulty experienced on the flight involved a minor malfunction in the on-board telemetry commutator.

Figure 53 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.18 GA

Flight 4.18 GA, an Aerobee 150A, was launched from Wallops Island on 19 March. The purpose of this flight was to measure temperature, density, and pressure of neutral particles above



(a)

FLIGHT	4.41 NP
FIRING DATE	17 FEB. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	280.00
APOGEE (ST. MI.)	97.50
TIME TO APOGEE (SEC.)	213.00
CENTER OF GRAVITY (CAL.)	10.15
CENTER OF PRESSURE (CAL.)	13.86
STATIC MARGIN (CAL.)	3.71
RESTORING MOMENT (PER DEGREE)	-0.5236
SUSTAINER BURNOUT TIME (SEC.)	53.80
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

* Set for 2.2 revolutions per second

(b)

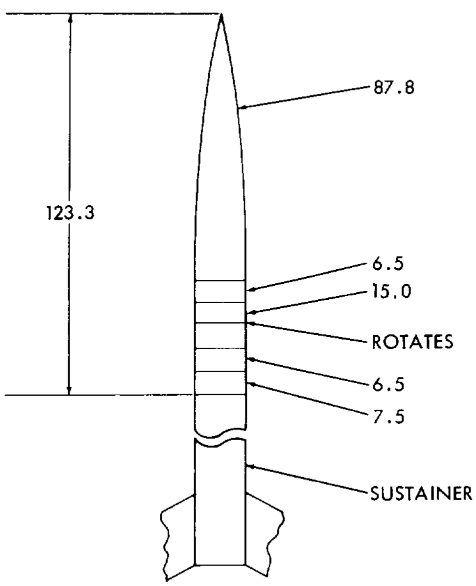
FLIGHT	4.26 NP
FIRING DATE	20 JUN. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	300.00
APOGEE (ST. MI.)	97.50
TIME TO APOGEE (SEC.)	217.00
CENTER OF GRAVITY (CAL.)	10.26
CENTER OF PRESSURE (CAL.)	14.52
STATIC MARGIN (CAL.)	4.26
RESTORING MOMENT (PER DEGREE)	-0.588
SUSTAINER BURNOUT TIME (SEC.)	54.10
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	na
NO. OF JOINTS	7.00

* Set for 2.2 revolutions per second

Figure 52—Flights 4.41 NP and 4.26 NP - payload dimensions and flight characteristics.

100 km by ejecting an instrumented 13 inch diameter sphere. All experimental instrumentation functioned properly but the experiment was not a success because the rocket was prematurely shutdown at 44.1 seconds. A peak altitude of only 48.9 statute miles was achieved. The propellant shutoff valves, which were designed to conserve residual helium for despinning the vehicle, malfunctioned and were prematurely closed at 44.1 seconds after liftoff by the G-reduction timer prior to normal burnout. The low apogee observed thus resulted due to the timer operating out of its specified tolerance range. Sufficient telemetry data was received and complete tracking was effected. A later failure analysis led to a decision to modify future G-reduction characteristics. Subsequent G-reduction times were established at a minimum arming time of 48 seconds and at most , a 4 G actuation level.

Figure 54 gives payload dimensions and characteristics of this rocket and its flight.

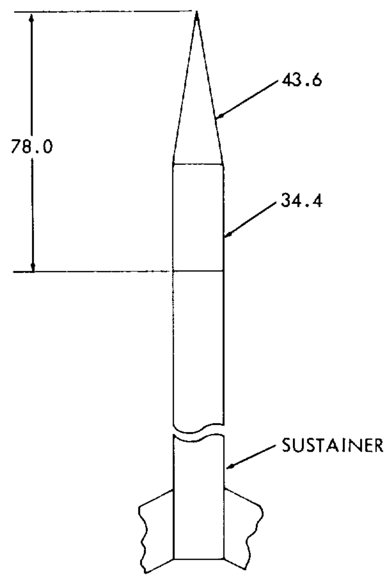


DIMENSIONS IN INCHES

FLIGHT	4.27 NP
FIRING DATE	18 NOV. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	194.00
APOGEE (ST. MI.)	129.00
TIME TO APOGEE (SEC.)	245.10
CENTER OF GRAVITY (CAL.)	11.10
CENTER OF PRESSURE (CAL.)	14.50
STATIC MARGIN (CAL.)	3.40
RESTORING MOMENT (PER DEGREE)	-0.45
SUSTAINER BURNOUT TIME (SEC.)	53.60
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	na
NO. OF JOINTS	6.00

* Set for 2.2 revolutions per second

Figure 53—Flight 4.27 NP - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.18 GA
FIRING DATE	19 MAR. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	224.00
APOGEE (ST. MI.)	48.90
TIME TO APOGEE (SEC.)	153.00
CENTER OF GRAVITY (CAL.)	8.20
CENTER OF PRESSURE (CAL.)	13.85
STATIC MARGIN (CAL.)	5.65
RESTORING MOMENT (PER DEGREE)	na
SUSTAINER BURNOUT TIME (SEC.)	44.10
ROLL RATE AT BURNOUT (RPS)	na
TIP EJECT (SEC.)	na
NO. OF JOINTS	2.00

* Premature shutoff due to malfunction of 'G' reduction timer

Figure 54—Flight 4.18 GA - payload dimensions and flight characteristics.

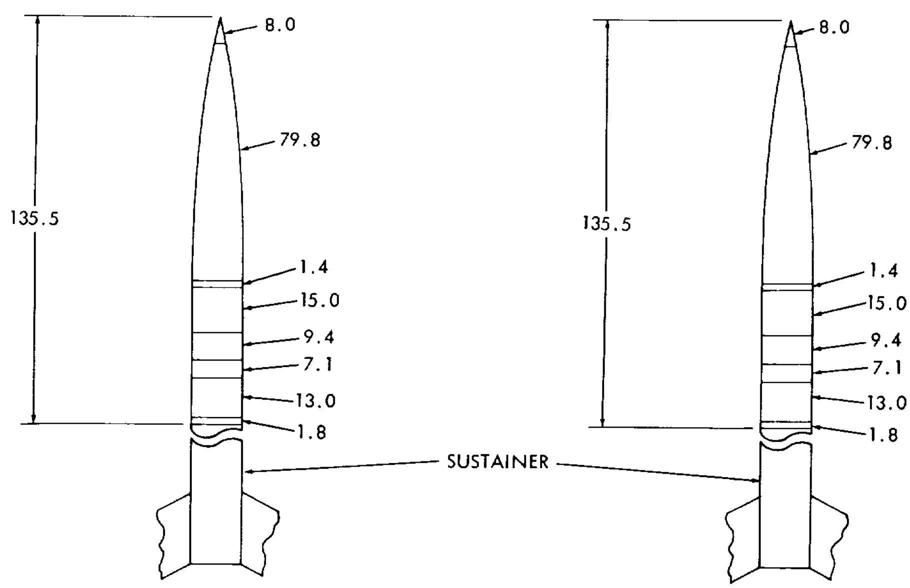
Flights 4.46 NP and 4.47 NP

Flights 4.46 NP and 4.47 NP were firings with radar payloads, from the Jet Propulsion Laboratory (JPL), to measure radar return from a high altitude over a surface with known characteristics. The flights were launched from White Sands on 8 May and 10 July respectively. The end objectives in each case, were to correlate and calibrate measurements from the known surface of the earth with radar measurements to be made of other planetary surfaces in the future. Both vehicles were launched successfully to predicted altitude, and both payloads were successfully recovered. The ACS appears not to have functioned properly on Flight 4.46 NP as evidenced by recovered photographs that indicate the nose cone was pointing at the sky rather than the earth. On Flight 4.47 NP, the ACS functioned as planned, although off target by approximately 15°. Although successful experimental radar transmissions were not made on either flight, rocket instrumentation performance was satisfactory on Flight 4.46 NP, and excellent on Flight 4.47 NP. Tracking was successful in both cases and recovery was effectively accomplished as a result. The land recovery system designed by the Space-General Corporation was used. Additional radar payload flights are planned for JPL in 1965.

Figure 55 gives payload dimensions and characteristics of these rockets and their flights.

Flight 4.48 GT

The primary purpose of Flight 4.48 GT, launched on 25 May, was to test the performance of a new water parachute recovery system built by the Space-General Corporation. The payload consisted of "off-the-shelf" GSFC experiments which gathered cosmic ray data, electron density data, meteoritic cratering evidence, and evaluation of transistorized PPM telemetry. The vehicle performed as expected, reaching a peak altitude of 124.3 statute miles in 244.5 seconds. The predicted



	(a)		(b)
FLIGHT	4.46 NP	FLIGHT	4.47 NP
FIRING DATE	8 MAY, 1962	FIRING DATE	10 JUL. 1962
LAUNCH SITE	WSMR	LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	268.10	PAYLOAD WT. (LBS.)	255.47
APOGEE (ST. MI.)	122.00	APOGEE (ST. MI.)	124.00
TIME TO APOGEE (SEC.)	240.00	TIME TO APOGEE (SEC.)	240.00
CENTER OF GRAVITY (CAL.)	11.06	CENTER OF GRAVITY (CAL.)	11.00
CENTER OF PRESSURE (CAL.)	14.30	CENTER OF PRESSURE (CAL.)	14.30
STATIC MARGIN (CAL.)	3.24	STATIC MARGIN (CAL.)	3.30
RESTORING MOMENT (PER DEGREE)	-0.339	RESTORING MOMENT (PER DEGREE)	-0.339
SUSTAINER BURNOUT TIME (SEC.)	52.00	SUSTAINER BURNOUT TIME (SEC.)	52.30
ROLL RATE AT BURNOUT (RPS)	1.6 (approx.)	ROLL RATE AT BURNOUT (RPS)	2.15
TIP EJECT (SEC.)	*	TIP EJECT (SEC.)	*
NO. OF JOINTS	8.00	NO. OF JOINTS	8.00

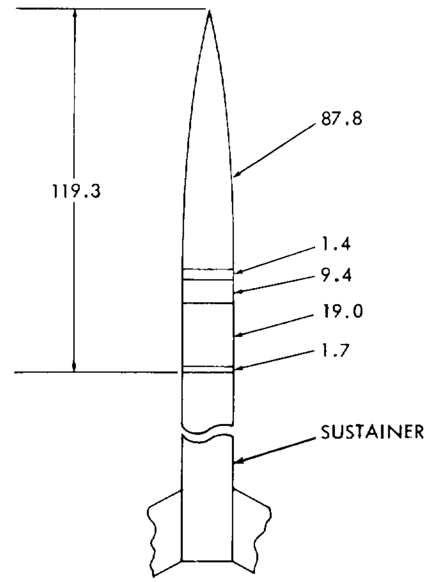
* Tip ejected at 200,000 + feet

* Tip ejected at 200,000 + feet

Figure 55—Flights 4.46 NP and 4.47 NP - payload dimensions and flight characteristics.

altitude had been 124 miles in 238 seconds. Both rocket performance instrumentation and experiment instrumentation provided complete and excellent data during flight. Complete tracking of the flight was effected, providing a successful recovery 27 minutes after launch. Slight damage occurred within the payload when a shroud line, trapped by one of the probes during the retraction phase, prevented complete sealing of the unit. A small quantity of water entered this extension. The sustainer stage was also recovered.

Figure 56 gives payload dimensions and characteristics of this rocket and its flight.



DIMENSIONS IN INCHES

FLIGHT	4.48 GT
FIRING DATE	25 MAY, 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	213.00
APOGEE (ST. MI.)	124.30
TIME TO APOGEE (SEC.)	244.50
CENTER OF GRAVITY (CAL.)	10.68
CENTER OF PRESSURE (CAL.)	13.58
STATIC MARGIN (CAL.)	2.90
RESTORING MOMENT (PER DEGREE)	-0.3915
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	1.50
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

Figure 56—Flight 4.48 GT - payload dimensions and flight characteristics.

Flights 4.71 UP, 4.72 UP, and 4.74 UA

Flights 4.71 UP, 4.72 UP, and 4.74 UA were a series of Aerobee 150A vehicle flights for the Johns Hopkins University to measure spectral features of the far ultraviolet region in the day and night airglow. The payloads consisted of spectrophotometric instrumentation including a far ultraviolet scanning grating spectrophotometer and three filtered photometers. Aspect was measured with two magnetometers and an optical aspect sensor. Observations were made in the zenith direction after nose tip ejection. Two of the three firings were successful (Flights 4.71 UP and 4.72 UP), and were the first two Aerobees to be launched from the same facility on the same day.

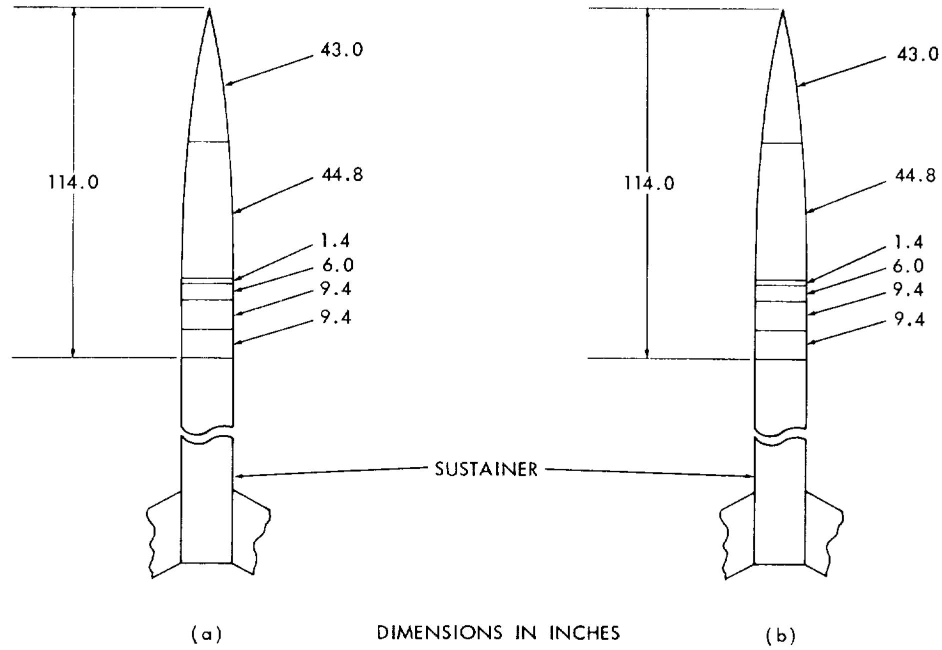
Flight 4.71 UP

Flight 4.71 UP, flown from Wallops Island, had good instrumentation and vehicle performance. The nose tip was ejected at 72 seconds as programmed and the vehicle reached a peak altitude of 130 statute miles in 246 seconds (as compared to predicted objectives of 128 statute miles in 242 seconds). Complete data recovery was achieved and tracking and upper air instrumentation operated as planned.

Figure 57a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.72 UP

As experienced for Flight 4.71 UP, Flight 4.72 UP performed slightly beyond predicted parameters. All instrumentation operated successfully and complete data recovery and tracking were



FLIGHT	4.71 UP	FLIGHT	4.72 UP
FIRING DATE	29 JUN. 1962	FIRING DATE	29 JUN. 1962
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	185.00	PAYLOAD WT. (LBS.)	189.00
APOGEE (ST. MI.)	130.00	APOGEE (ST. MI.)	130.50
TIME TO APOGEE (SEC.)	246.00	TIME TO APOGEE (SEC.)	248.00
CENTER OF GRAVITY (CAL.)	10.88	CENTER OF GRAVITY (CAL.)	11.15
CENTER OF PRESSURE (CAL.)	14.30	CENTER OF PRESSURE (CAL.)	14.32
STATIC MARGIN (CAL.)	3.42	STATIC MARGIN (CAL.)	3.17
RESTORING MOMENT (PER DEGREE)	-0.4317	RESTORING MOMENT (PER DEGREE)	-0.4073
SUSTAINER BURNOUT TIME (SEC.)	52.80	SUSTAINER BURNOUT TIME (SEC.)	52.60
ROLL RATE AT BURNOUT (RPS)	2.00	ROLL RATE AT BURNOUT (RPS)	2.20
TIP EJECT (SEC.)	72.00	TIP EJECT (SEC.)	unknown
NO. OF JOINTS	6.00	NO. OF JOINTS	6.00

Figure 57—Flights 4.71 UP and 4.72 UP - payload dimensions and flight characteristics.

achieved. Magnetometer data received indicated that the rocket remained oriented near zenith, allowing the scanning spectrophotometer to work well. The peak altitude achieved was 130.5 statute miles in 248 seconds (the predicted values had been 125 miles in 238 seconds).

Figure 57b gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.74 UA

The rocket performance of Flight 4.74 UA was unsatisfactory. The solid propellant booster exploded less than one second after ignition, and this in turn collapsed the sustainer tail can and oxidizer tank, causing a fire in the tower. The impulse delivered by the booster was not sufficient to get the sustainer out of the tower. As a result, all of the rocket hardware impacted in the tower causing extensive damage to the tower rails, wiring, plumbing, and enclosure. The payload, an Ebert-Fastie spectrophotometer, was recovered with only a slight amount of smoke damage and was subsequently flown successfully on Flight 4.98 UA. Reference 7 contains information on the booster investigation which followed this failure.

Figure 58 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.23 US

Flight 4.23 US was an Aerobee 150A launched from Wallops Island on 24 July. It carried a solar experiment designed to monitor the Lyman-ultraviolet radiation emitted from the sun by studying the wavelength profile as a function of altitude. The purpose of the flight was to obtain preliminary data to be used in calibrating similar instruments on future satellite flights and to provide an instrument checkout prior to the satellite flight. A biaxial solar pointing control (U. Colo.) was used to orient the payload toward the sun during flight. A single-wrap yo-yo despin system was to be used after burnout to reduce the vehicle roll rate to approximately 0.7 rps; however, the yo-yo system actuated prematurely (at approximately 50 seconds) and the rocket spun to near its original value of roll rate immediately after the despin weights were released. Consequently, the desired reduction in roll rate was not obtained. This did not adversely affect the experiment or rocket performance. The rocket reached a peak altitude of 128.5 statute miles in 244 seconds and performed close to the predicted characteristics in all other respects. The telemetry instrumentation and pointing control system performed satisfactorily. Data was obtained from +100 seconds to +412 seconds. The electronics on the spectrophotometer worked perfectly.

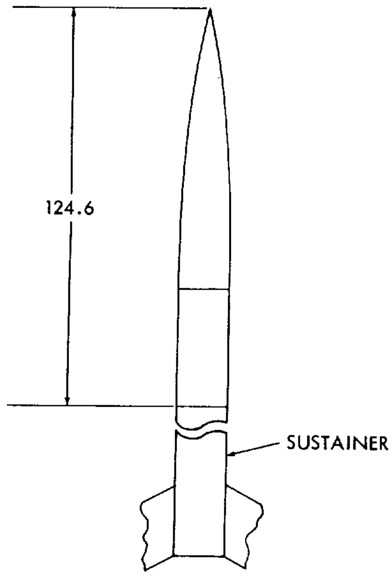
Figure 59 gives payload dimensions and characteristics of this rocket and its flight.

Flights 1.13 NP and 1.14 NA

Flights 1.13 NP and 1.14 NA were the last two Aerobee 100's (Aerobee Juniors) in the NASA inventory, and there are no plans to reactivate the production which made the original stock of Aerobee 100 an "off-the-shelf", item. Both flights carried an ultraviolet scanning grating spectrophotometer and two ultraviolet photometers to measure the ultraviolet day airglow spectrum at 50 and 120 kilometer altitudes.

Flight 1.13 NP

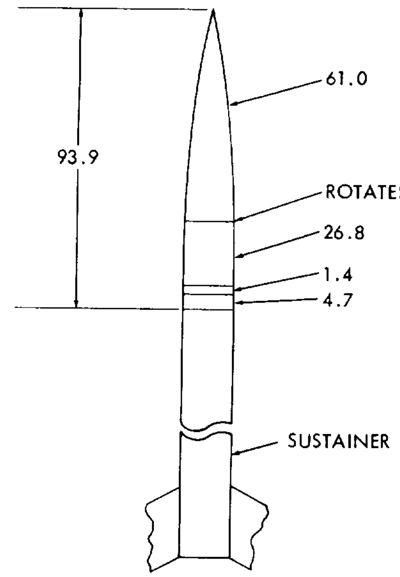
Flight 1.13 NP was successfully launched from White Sands on 6 September. Although the peak altitude achieved was only 74 kilometers (46 statute miles), the ultraviolet spectrophotometer and the two photometers recorded ultraviolet spectra in the altitude range between 40 and 74 kilometers. Ultraviolet spectra were also measured during the re-entry phase of the trajectory when the rocket was pointed down at the atmosphere. The rocket began to yaw at 165 seconds, at a 68 kilometer altitude. The amplitude of yaw decreased with descending altitude and reached a minimum at 250 seconds (18 kilometers). Satisfactory telemetry was received from 0 to 247 seconds, and partial data received until 299 seconds. Complete tracking of the rocket was achieved.



FLIGHT	4.74 UA
FIRING DATE	13 DEC. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	
APOGEE (ST. MI.)	
TIME TO APOGEE (SEC.)	
CENTER OF GRAVITY (CAL.)	
CENTER OF PRESSURE (CAL.)	
STATIC MARGIN (CAL.)	
RESTORING MOMENT (PER DEGREE)	
SUSTAINER BURNOUT TIME (SEC.)	
ROLL RATE AT BURNOUT (RPS)	
TIP EJECT (SEC.)	
NO. OF JOINTS	

Booster blew in tower

Figure 58—Flight 4.74 UA - Payload dimensions and flight characteristics.



FLIGHT	4.23 US
FIRING DATE	24 JUL. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	190.50
APOGEE (ST. MI.)	128.50
TIME TO APOGEE (SEC.)	244.00
CENTER OF GRAVITY (CAL.)	9.34
CENTER OF PRESSURE (CAL.)	13.05
STATIC MARGIN (CAL.)	3.71
RESTORING MOMENT (PER DEGREE)	-0.4767
SUSTAINER BURNOUT TIME (SEC.)	52.00+
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

* Set for 2.2 revolutions per second

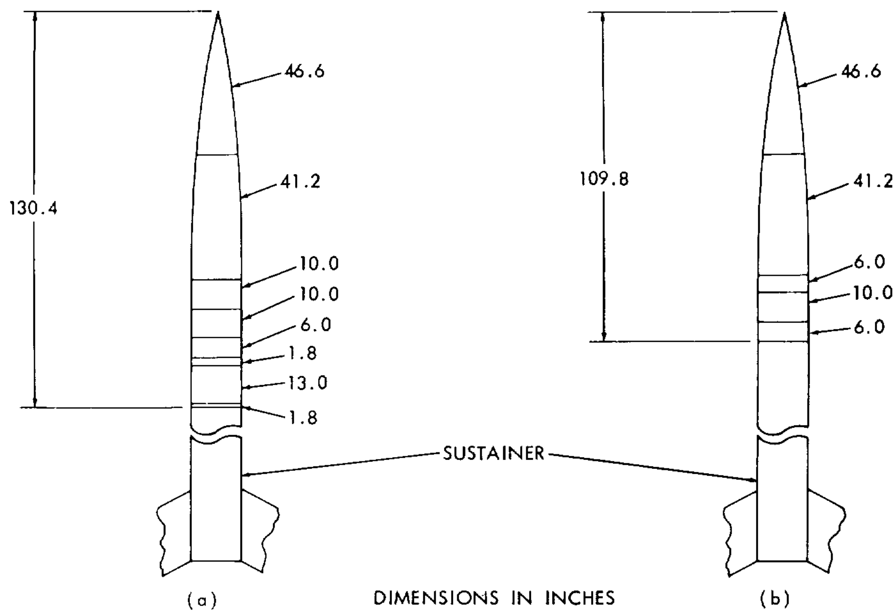
Figure 59—Flight 4.23 US - payload dimensions and flight characteristics.

Figure 60a gives payload dimensions and characteristics of this rocket and its flight.

Flight 1.14 NA

Flight 1.14 NA was flown from White Sands on 20 November. A malfunction in the sustainer propulsion system (apparently an obstruction, a leak, or a rupture in one of the propellant lines) caused the rocket to perform unsatisfactorily. A peak altitude of only 67,000 feet was attained; thus limited experimental data was obtained because the rocket did not arrive in the region of high intensity day airglow. Although the rocket performance was unsatisfactory, instrumentation performance was adequate. Flight 1.14 NA, the last Aerobee 100 to be launched, was the only one of its type to have failed out of fourteen launched by NASA personnel.

Figure 60b gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	1.13 NP	FLIGHT	1.14 NA
FIRING DATE	6 SEPT. 1962	FIRING DATE	20 NOV. 1962
LAUNCH SITE	WSMR	LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	158.10	PAYLOAD WT. (LBS.)	138.40
APOGEE (ST. MI.)	46.00	APOGEE (ST. MI.)	12.13
TIME TO APOGEE (SEC.)	140.40	TIME TO APOGEE (SEC.)	75.00
CENTER OF GRAVITY (CAL.)	10.00	CENTER OF GRAVITY (CAL.)	9.95
CENTER OF PRESSURE (CAL.)	12.40	CENTER OF PRESSURE (CAL.)	12.30
STATIC MARGIN (CAL.)	2.40	STATIC MARGIN (CAL.)	2.35
RESTORING MOMENT (PER DEGREE)	-0.29	RESTORING MOMENT (PER DEGREE)	-0.245
SUSTAINER BURNOUT TIME (SEC.)	37.40	SUSTAINER BURNOUT TIME (SEC.)	41.00
ROLL RATE AT BURNOUT (RPS)	1.78	ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	unknown	TIP EJECT (SEC.)	53.00
NO. OF JOINTS	8.00	NO. OF JOINTS	5.00

* Set for 2.0 revolutions per second
Propellant line broke

Figure 60—Flights 1.13 NP and 1.14 NA - payload dimensions and flight characteristics.

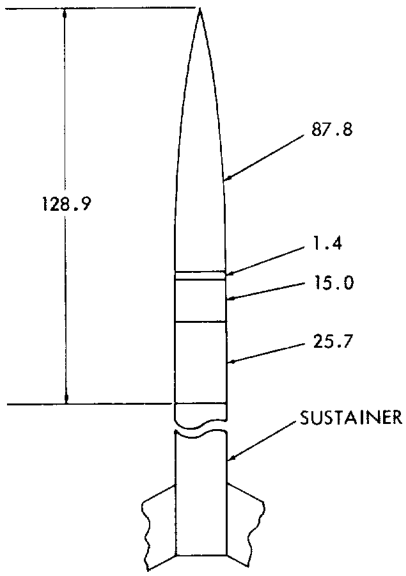
Flight 4.69 CG

Flight 4.69 CG was successfully launched to a peak altitude of 107 statute miles, approximately 10 miles below predicted. The primary objective of the experiment was to map the night sky in the soft x-ray region. A secondary objective was to flight-test the performance of a gas flow counter. Instrumentation performed satisfactorily and the helium despin system functioned properly after burnout, to despin the vehicle to a roll rate of 16.4 degrees per second. The rocket then had an 85 degree precessional cone half-angle with a precessional rate of 0.72 degrees per second.

Figure 61 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.54 UG

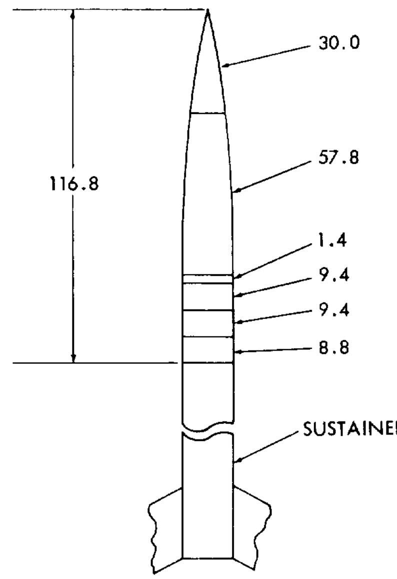
Flight 4.54 UG was launched with the primary objectives of measuring energy distribution of early-type stars in the 3200-2100 Å spectral region. A secondary objective was a performance



DIMENSIONS IN INCHES

FLIGHT	4.69 CG
FIRING DATE	30 SEPT. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	242.00
APOGEE (ST. MI.)	107.00
TIME TO APOGEE (SEC.)	224.08
CENTER OF GRAVITY (CAL.)	11.10
CENTER OF PRESSURE (CAL.)	15.00
STATIC MARGIN (CAL.)	3.90
RESTORING MOMENT (PER DEGREE)	-0.527
SUSTAINER BURNOUT TIME (SEC.)	52.80
ROLL RATE AT BURNOUT (RPS)	2.04
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 61—Flight 4.69 CG - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.54 UG
FIRING DATE	30 OCT. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	214.50
APOGEE (ST. MI.)	117.00
TIME TO APOGEE (SEC.)	240.00
CENTER OF GRAVITY (CAL.)	10.53
CENTER OF PRESSURE (CAL.)	14.25
STATIC MARGIN (CAL.)	3.72
RESTORING MOMENT (PER DEGREE)	-0.500
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	2.80
TIP EJECT (SEC.)	unknown
NO. OF JOINTS	6.00

Figure 62—Flight 4.54 UG - payload dimensions and flight characteristics:

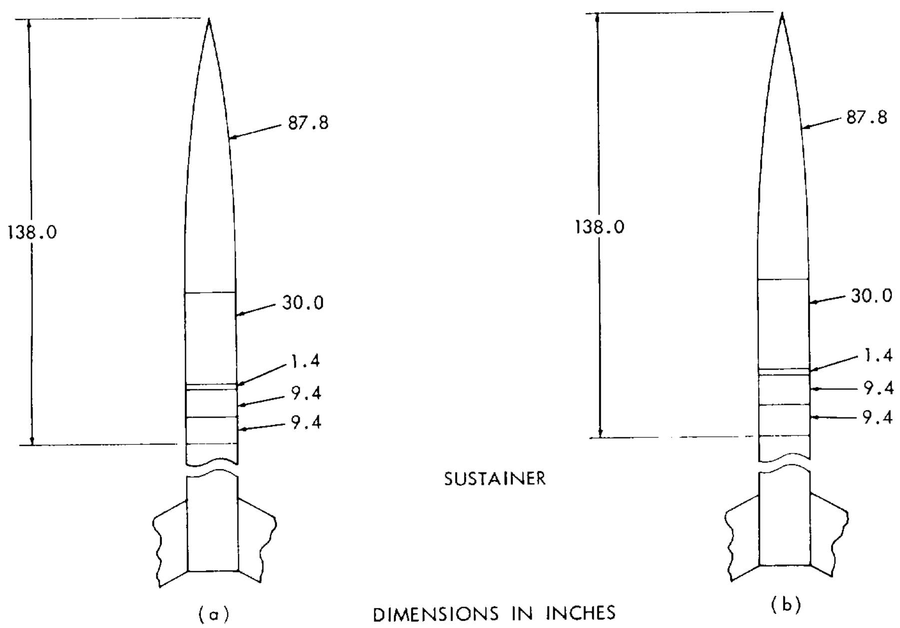
test of various components to be used in the University of Wisconsin experiment for the Orbiting Astronomical Observatory (OAO). The instrumentation included three small telescopes, photomultipliers, amplifiers and control circuitry. The photometry cycling sequence was initiated by a spurious pulse before ACS stabilization and transmitted start pulse. The vehicle performance was satisfactory, although the peak altitude of 188 kilometers (117 statute miles) was approximately 9 miles under the predicted altitude. All systems operated, although some malfunctions occurred and the ACS pointing accuracy was less than predicted. Both analog and digital data were obtained, but the digital time base was lost.

Figure 62 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.79 II and 4.80 II

Flights 4.79 II and 4.80 II were Aerobee 150A vehicles, fired in a cooperative effort between NASA and the Australian National Committee for Space Research (ANCSR). The primary objectives of the flights were to obtain intensity spectrum data on quasi-VLF noise above the E-region of the ionosphere under undisturbed conditions. Flight 4.79 II was flown on 16 November and Flight 4.80 II on 11 December 1962, both from Wallops Island, Va. Both rockets were unsuccessful and broke up during burning. Flight 4.79 II reached a peak altitude of 29.8 kilometers after breaking up at +37 seconds and Flight 4.80 II reached a peak altitude of 53 kilometers after breaking up +42 seconds. The cause of failure in both cases was a combination of minimum stability and extreme aeroelastic effects. The aeroelastic effects resulted from the use of a fiberglass nose cone and 30 inch fiberglass extension on each rocket. Flight 4.79 II used a larger and lighter nose cone than ever used previously on an Aerobee 150A. Although Flight 4.80 II incorporated stiffeners in the fiberglass extension, was ballasted to improve stability, and both rocket and payload were balanced, the flight results indicated that the improvements were not sufficient to overcome aeroelastic effects. A detailed flight investigation is the subject of a space general report (Reference 8).

Figure 63 gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.79 II
FIRING DATE	16 NOV. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	130.00
APOGEE (ST. MI.)	18.50
TIME TO APOGEE (SEC.)	na *
CENTER OF GRAVITY (CAL.)	13.00
CENTER OF PRESSURE (CAL.)	15.25
STATIC MARGIN (CAL.)	2.25
RESTORING MOMENT (PER DEGREE)	− 0.288
SUSTAINER BURNOUT TIME (SEC.)	37.20
ROLL RATE AT BURNOUT (RPS)	na
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

* Rocket broke up at approximately 37 seconds

FLIGHT	4.80 II
FIRING DATE	11 DEC. 1962
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	170.20
APOGEE (ST. MI.)	32.40 *
TIME TO APOGEE (SEC.)	118.40
CENTER OF GRAVITY (CAL.)	12.00
CENTER OF PRESSURE (CAL.)	15.00
STATIC MARGIN (CAL.)	3.00
RESTORING MOMENT (PER DEGREE)	− 0.40
SUSTAINER BURNOUT TIME (SEC.)	54.40
ROLL RATE AT BURNOUT (RPS)	na
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

* Rocket broke up at approximately 42 seconds

Figure 63—Flights 4.79 II and 4.80 II - payload dimensions and flight characteristics.

Flight 6.06 GA

Flight 6.06 GA, the only Spaerobee launched in 1962, was successfully flown from Wallops Island on 20 November. The primary objective of the flight was the simultaneous measurement of electron and neutral particles in the 120-360 kilometers altitude region. Secondary and tertiary objectives were the measurement of ion and neutral particle density in the same altitude interval, and the flight testing of a newly-designed thermosphere probe system. The rocket performed satisfactorily, reaching a peak altitude (based on plot board data) of 344 kilometers (213.6 statute miles). Telemetry signals were received until T +590 seconds and overall payload instrumentation operated well during flight, providing excellent data from all parts of the experiment. Roll and tumble rates were also satisfactory.

Figure 64 gives payload dimensions and characteristics of this rocket and its flight.

FLIGHT	6.06 GA
FIRING DATE	20 NOV. 1962
LAUNCH SITE	WI
PAYLOAD WEIGHT, 2ND STAGE (lbs)	222.50
PAYLOAD WEIGHT, 3RD STAGE (lbs)	89.50
APOGEE (statute miles)	213.60
TIME TO APOGEE (seconds)	320.00
CENTER OF GRAVITY, SUSTAINER BURNOUT (calculated)	10.70
CENTER OF PRESSURE, SUSTAINER BURNOUT (calculated)	15.15
STATIC MARGIN, SUSTAINER BURNOUT (calculated)	4.45
RESTORING MOMENT, SUSTAINER BURNOUT (per degree)	-0.614
CENTER OF GRAVITY, 3RD STAGE IGNITION (calculated)	unknown
CENTER OF PRESSURE, 3RD STAGE IGNITION (calculated)	10.62
STATIC MARGIN, 3RD STAGE IGNITION (calculated)	2.21
RESTORING MOMENT, 3RD STAGE IGNITION (per degree)	-0.0795
SUSTAINER BURNOUT (seconds)	53.30
THIRD STAGE BURNOUT (seconds)	55.70
ROLL RATE AT BURNOUT, SUSTAINER (rps)	unknown
ROLL RATE AT BURNOUT, 3RD STAGE (rps)	unknown
PROBE EJECT (seconds)	unknown
NUMBER OF JOINTS	7.00
THIRD STAGE LENGTH (in.)	123.8
PAYLOAD HOUSING LENGTH X (in.)	66.2

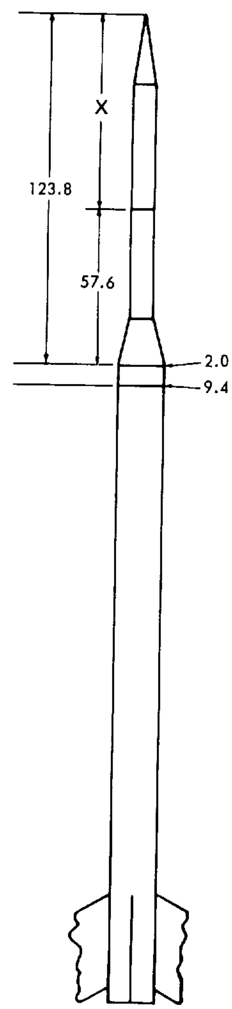


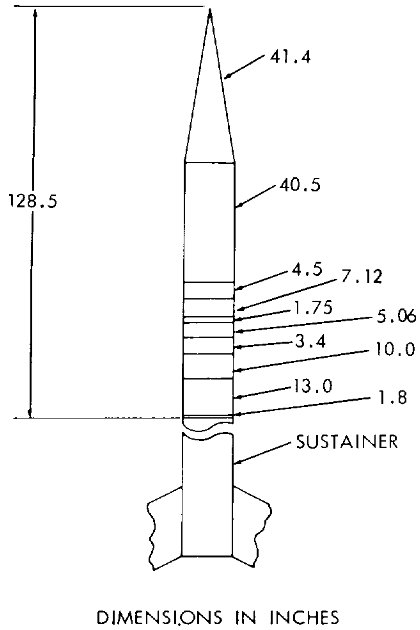
Figure 64—Flight 6.06 GA - payload dimensions and flight characteristics.

Flight 4.21 US

Flight 4.21 US, an Aerobee 150, was successfully launched from White Sands on 27 November with a Harvard College Observatory (HCO) payload which was intended to gather ultraviolet radiation data from the sun. A peak altitude of 202 kilometers was reached in +238 seconds (203 kilometers in +237 seconds predicted). Likewise, other performance characteristics occurred as predicted. Unfortunately, high voltage arcing in the payload instrumentation prohibited collection of adequate experimental data. However, good meteorological data was received. The solar pointing control (Ball Brothers) worked successfully, providing a high degree of pointing accuracy. Also, the performance of the telemetry system was excellent and the HCO spectrometer obtained good data.

The main parachute deployed prematurely at an altitude in excess of 50,000 feet. As a result, the high air loads tore the parachute from the payload, and severe damage was done to payload on impact. The recovery, however, was not essential to scientific data collection.

Figure 65 gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.21 US
FIRING DATE	27 NOV. 1962
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	245.00
APOGEE (ST. MI.)	126.00
TIME TO APOGEE (SEC.)	238.00
CENTER OF GRAVITY (CAL.)	10.58
CENTER OF PRESSURE (CAL.)	13.75
STATIC MARGIN (CAL.)	2.17
RESTORING MOMENT (PER DEGREE)	-0.33
SUSTAINER BURNOUT TIME (SEC.)	52.80
ROLL RATE AT BURNOUT (RPS)	2.00
TIP EJECT (SEC.)	na
NO. OF JOINTS	10.00

Figure 65—Flight 4.21 US - payload dimensions and flight characteristics.

FIRINGS FOR CY 1963

Thirty-two (32) Aerobee vehicles were launched in 1963; twenty (20) were launched from Wallops Island, Va., including eighteen (18) Aerobee 150A's and two (2) Spaerobee 300A's. Of the twelve remaining, ten (10) were Aerobee 150's launched from the White Sands Missile Range, and two (2) were Aerobee 150's launched from Fort Churchill. Twenty-nine of the thirty-two vehicles were considered to have performed satisfactorily-to-completely successful. Three vehicles (Flights 4.31 GG, 4.73 UA, and 4.75 UA) performed unsatisfactorily. Nine (9) vehicles contained recovery systems. Of these nine attempted recoveries, five were completely successful; three systems worked properly but recovery was not totally effected (Flights 4.66 NP, 4.61 AS, 4.78 GS), and one system was not effected due to a rocket explosion (Flight 4.31 GG). Another recovery, not included above, was effected for 4.30 GG. Recovery of this Flight was effected by the severance of the tail can assembly. Although no parachute was used, the soft impact resulting from the induced tumbling motion enabled the payload and vehicle to be recovered. The following Aerobee vehicles were launched in 1963:

Flight Number	Launch Site	Date of Launch
4.73 UA	WI	1-29-63
4.98 UA	WI	5-07-63*
4.76 UA	WI	11-12-63*
4.70 CG	WI	3-16-63
4.30 GG	WSMR	3-28-63
4.31 GG	WSMR	10-10-63*
4.58 UF	WI	4-03-63
4.59 UI	WI	7-10-63*
4.96 II	WI	4-12-63
4.97 II	WI	5-09-63*
6.07 GA	WI	4-18-63
6.08 GA	WI	7-20-63*
4.44 GI	WI	4-23-63
4.66 NP	WSMR	5-14-63
4.87 GT	WSMR	6-17-63
4.28 NP	WI	6-19-63
4.32 NP	WI	9-11-63*
4.61 AS	WSMR	6-20-63
4.62 AS	WSMR	6-28-63
4.37 GG	WI	7-19-63
4.29 GG	WI	7-23-63*
4.77 GS	WSMR	7-20-63
4.78 GS	WSMR	10-01-63*
4.75 UA	FC	7-20-63
4.76 UA	WI	11-12-63*
4.91 GE	FC	9-04-63
4.22 US	WSMR	9-06-63
4.65 GI	WI	9-25-63
4.64 GI	WI	9-28-63

*The summary of this rocket firing is not in chronological order, but follows the description of a similar payload fired earlier in the year.

Flight Number	Launch Site	Date of Launch
4.33 GS	WSMR	10-15-63
4.93 II	WI	10-17-63
4.94 II	WI	10-31-63
4.85 NA	WI	11-18-63

Flights 4.73 UA, 4.98 UA, and 4.76 UA

Flights 4.73 UA, 4.98 UA, and 4.76 UA were launched from Wallops Island on 29 January, 7 May, and 12 November respectively. Each rocket payload carried spectrophotometric instrumentation to measure the absolute intensity of certain spectral features in the far ultraviolet region of the night airglow above 80 kilometers. The objective of each flight was to observe in the zenith direction only, thus requiring a high rate of spin to maintain the approximate zenith orientation throughout the flight.

Flight 4.73 UA

Flight 4.73 UA encountered a sustainer malfunction prior to tower exit; as a result, none of the experimental objectives were realized. The peak altitude attained by the sustainer was 13,000 feet. The sustainer malfunction was attributed to either a structural failure of a portion of the propulsion system in the tail cylinder, or a "hard" start which triggered high frequency combustion instability. The high frequency instability would have caused erosion through the combustion chamber in a fraction of a second. The inability to recover any of the aft propulsion system hardware due to detonation of the remaining fuel in the sustainer upon impact, made a positive diagnosis of the cause of failure impossible. Telemetry transmission ceased prior to tower exit and thus could not be used in determining the failure causes. The sustainer failure was characterized by a long fuel-rich sustainer flame, with flame combustion taking place in the atmosphere behind the rocket. The burning time of 13 seconds was followed by blowdown of the helium and residual propellant (most likely oxidizer) in the form of a whitish vapor.

The specific items possibly causing the hard start on Flight 4.73 UA were limited to the following:

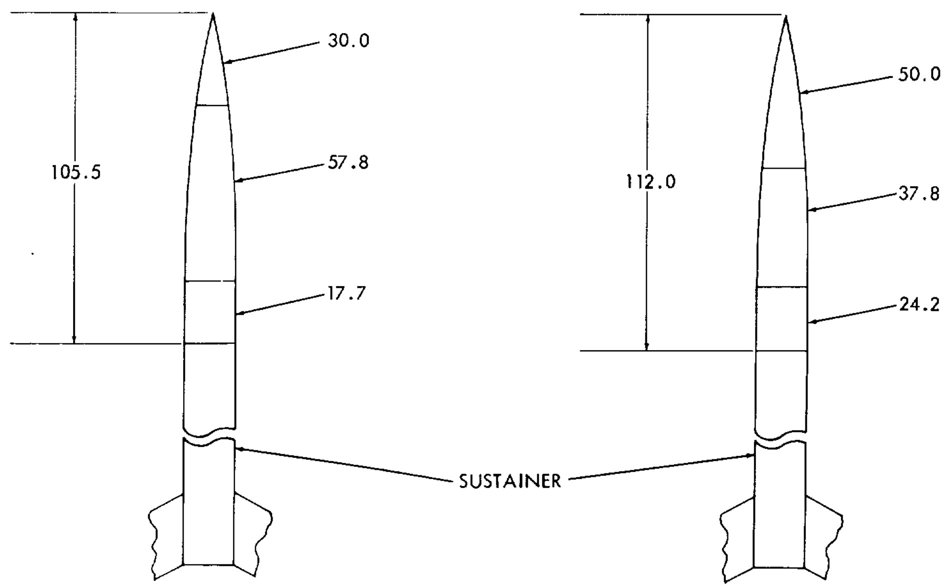
(1) The fuel diaphragm had a burst pressure lower than that of the burst pressure of the diaphragms used for the oxidizer system. This could have resulted in a fuel leak which in turn could have caused a "hard" start and high frequency instability.

(2) An obstruction in one of the propellant lines could have caused off-mixture ratio operation and the resulting failure. The possibility of an obstruction was considered since manufacturing irregularities were later found in other Aerobee 150A's at Wallops Island.

(3) The relatively low temperature of the propellants (41°F) could have compounded situations (1) and (2) due to increased ignition delay at this temperature. However, the low propellant temperature would not be a primary cause since other rockets have flown successfully with propellants at equally low temperatures.

Following the failure of Flight 4.73 UA, all Aerobee 150A flights were suspended indefinitely until a proper investigation could be made. This was because Flight 4.73 UA was the fourth 150A failure in a period of ten weeks. The other failures, in the later part of CY 1962, were Flights 4.79 II, 4.80 II, and 4.74 UA. The failures of Flights 4.79 II and 4.80 II were determined to have resulted from the structural failure of the fiberglass nose cone and extension payloads, each of light weight, during sustainer burning. It was determined that the failure of Flight 4.74 UA occurred as a result of a booster blow-up immediately after ignition. The investigation of these flights and of Flight 4.73 UA revealed that incorrect burst diaphragms were used for these rockets and that a number of additional sustainer checks, to be performed prior to flight, were necessary. A great amount of detail involving the vehicle sustainers and boosters was explored during the investigation, however, these are not pertinent to this presentation.

Figure 66a gives payload dimensions and characteristics of this rocket and its flight.



	(a)		(b)
FLIGHT	4.73 UA	FLIGHT	4.98 UA
FIRING DATE	29 JAN. 1963	FIRING DATE	7 MAY, 1963
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	129.25	PAYLOAD WT. (LBS.)	136.30
APOGEE (ST. MI.)	2.46 *	APOGEE (ST. MI.)	138.60
TIME TO APOGEE (SEC.)	*	TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	10.33	CENTER OF GRAVITY (CAL.)	10.87
CENTER OF PRESSURE (CAL.)	13.60	CENTER OF PRESSURE (CAL.)	13.90
STATIC MARGIN (CAL.)	3.27	STATIC MARGIN (CAL.)	3.03
RESTORING MOMENT (PER DEGREE)	-0.418	RESTORING MOMENT (PER DEGREE)	-0.393
SUSTAINER BURNOUT TIME (SEC.)	*	SUSTAINER BURNOUT TIME (SEC.)	51.4
ROLL RATE AT BURNOUT (RPS)	*	ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	*	TIP EJECT (SEC.)	65
NO. OF JOINTS	3.00	NO. OF JOINTS	3.00

*Sustainer failed in the tower.

* Set for 2.2 revolutions per second

Figure 66—Flights 4.73 UA and 4.98 UA - payload dimensions and flight characteristics.

Flight 4.98 UA

Flight 4.98 UA was successfully launched to a peak altitude of 138.6 statute miles. Although the peak altitude reached was 15 statute miles below the predicted value, all instrumentation performance was excellent with tip ejection occurring at 65 seconds. Good radar and plot board data was received. The lower peak altitude attained has been attributed to the fact that the rocket burned for 51.4 seconds as compared to the expected burning of 53.0 seconds. Flight 4.98 UA was originally scheduled for flight on 12 April but high surface winds and a delay in firing time necessary to allow the sun's position to be sufficiently remote from the instrumentation viewing axis, caused cancellation of the shot. Had the shot not been cancelled, it would have marked the first time that two Aerobee 150A rockets had been launched from Wallops Island within a 13 hour period (Flight 4.96 II was launched prior to the attempt to launch Flight 4.98 UA). Following the cancellation, Flight 4.98 UA was deserviced, the propellants were drained, and the vehicle removed from the tower, to allow installation of Flight 6.07 GA (which had a critical firing window). Flight 4.98 UA was finally launched on 7 May and provided adequate scientific data as expected.

Figure 66b gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.76 UA

Flight 4.76 UA was successfully flown to a peak altitude of 136 statute miles with all instrumentation performing very well. The forward 47 inch portion of the ogive nose cone was ejected to allow the spectrophotometric instrumentation to view the day airglow by using a special mechanism designed by GSFC personnel.

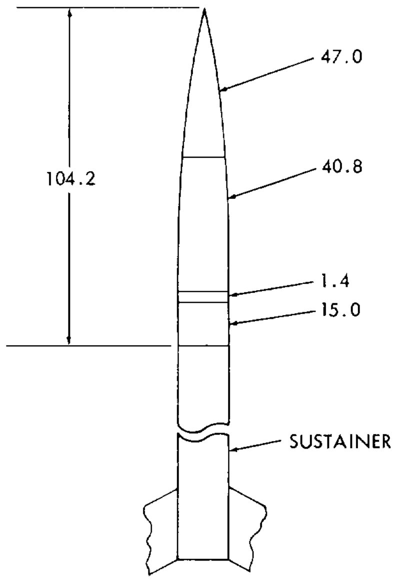
The rocket took an unexplained azimuth shift at approximately 20 seconds. Predicted impact was 81.7 statute miles at 112 degrees—actual impact was 78 statute miles at 141 degrees. Comparison of pre- and post-firing wind runs did not provide any reason for the azimuth shift. This shift allowed sunlight to enter one of the experiment's photometer tubes; thus no useful scientific information was gathered from this channel. It was, however, a minor part of the experiment.

Large holes were cut in the side of the nose cone and shrouds were mounted over the forward end of the holes so that a pumping action or evacuation of the cone could be accomplished during the flight.

Figure 67 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.70 CG

Flight 4.70 CG was the first Aerobee 150A to be launched following the complete investigation of four prior Aerobee 150A consecutive failures (Flight 4.73 UA of 1-29-63 and Flights 4.79 II, 4.80 II, and 4.74 II in 1962). Flight 4.70 CG was successfully launched to a peak altitude of 122.8 statute miles, carrying a payload intended to map night sky sources which emit photons in the 0.1 to 20 kev range. The experiment, consisting of a special extension prepared by the Lockheed

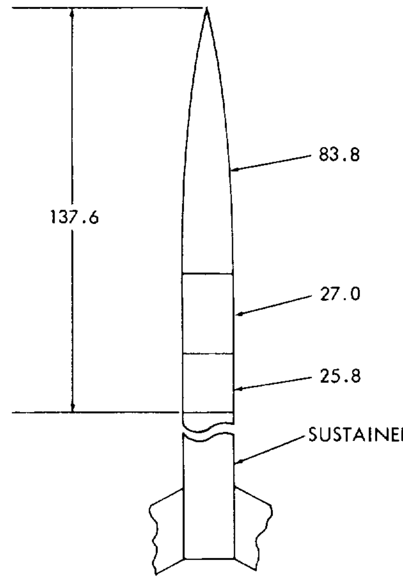


DIMENSIONS IN INCHES

FLIGHT	4.76 UA
FIRING DATE	12 NOV. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	135.00
APOGEE (ST. MI.)	136.00
TIME TO APOGEE (SEC.)	248.00
CENTER OF GRAVITY (CAL.)	10.13
CENTER OF PRESSURE (CAL.)	13.30
STATIC MARGIN (CAL.)	3.17
RESTORING MOMENT (PER DEGREE)	-0.41
SUSTAINER BURNOUT TIME (SEC.)	51.40
ROLL RATE AT BURNOUT (RPS)	unknown
TIP EJECT (SEC.)	unknown *
NO. OF JOINTS	4.00

* Set for 2.2 revolutions per second

Figure 67—Flight 4.76 UA - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.70 GG
FIRING DATE	16 MAR. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	231.00
APOGEE (ST. MI.)	122.80
TIME TO APOGEE (SEC.)	243.00
CENTER OF GRAVITY (CAL.)	11.25
CENTER OF PRESSURE (CAL.)	15.15
STATIC MARGIN (CAL.)	3.90
RESTORING MOMENT (PER DEGREE)	-0.521
SUSTAINER BURNOUT TIME (SEC.)	53.90
ROLL RATE AT BURNOUT (RPS)	2.50
TIP EJECT (SEC.)	na
NO. OF JOINTS	3.00

Figure 68—Flight 4.70 GG - payload dimensions and flight characteristics.

Missiles and Space Company (LMSC) performed successfully. The successfulness of the experimental equipment functioning was marred only by the failure of one 3 mil beryllium window of one of the four anticoincidence sealed counters. However both starlight photometers, both magnetometers, and the remaining three of the four anticoincidence systems operated as intended and excellent data was obtained. The gas despin was employed after sustainer burnout. Roll rate was reduced from 2.5 rps to 15 degrees per second. After despin, the rocket precessed around a cone of 50° half-angle at a rate of 0.18° per second.

Figure 68 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.30 GG and 4.31 GG

Flight 4.30 GG

Flight 4.30 GG was fired at White Sands on 28 March. The experiment contained ten ion chambers for measuring intensity and spatial distribution of resonantly-scattered hydrogen

Lyman-alpha at 1216 Å. The 126-pound payload was considerably lighter than recent Aerobee experiments, and the resultant apogee still remains the highest ever recorded by the Aerobee 150. Although the standard parachute system was not used, an attempt was made at recovery by initiating severance of the tail can (including fins) at 300,000 feet during re-entry. Loss of the fins induced instability and caused the vehicle to tumble end over end, thereby decelerating enough to effect a relatively "soft" impact. On re-entry the payload broke apart from the sustainer; nevertheless the payload was recovered in relatively good condition. Figure 69 compares the expected and actual trajectories; they are almost coincident, the achieved altitude being 3% greater than the predicted altitude. All instrumentation performed as expected and the gas despin system worked well despinning the vehicle as desired.

Figure 70a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.31 GG

Flight 4.31 GG (Figure 70b) was launched from White Sands on 10 October and resulted in the first NASA Aerobee 150 vehicle failure at White Sands. Sustainer ignition was never realized, and the vehicle impacted approximately one-quarter mile away from the tower after normal booster burning. In addition to the accelerometer and chamber pressure gage required on every Aerobee

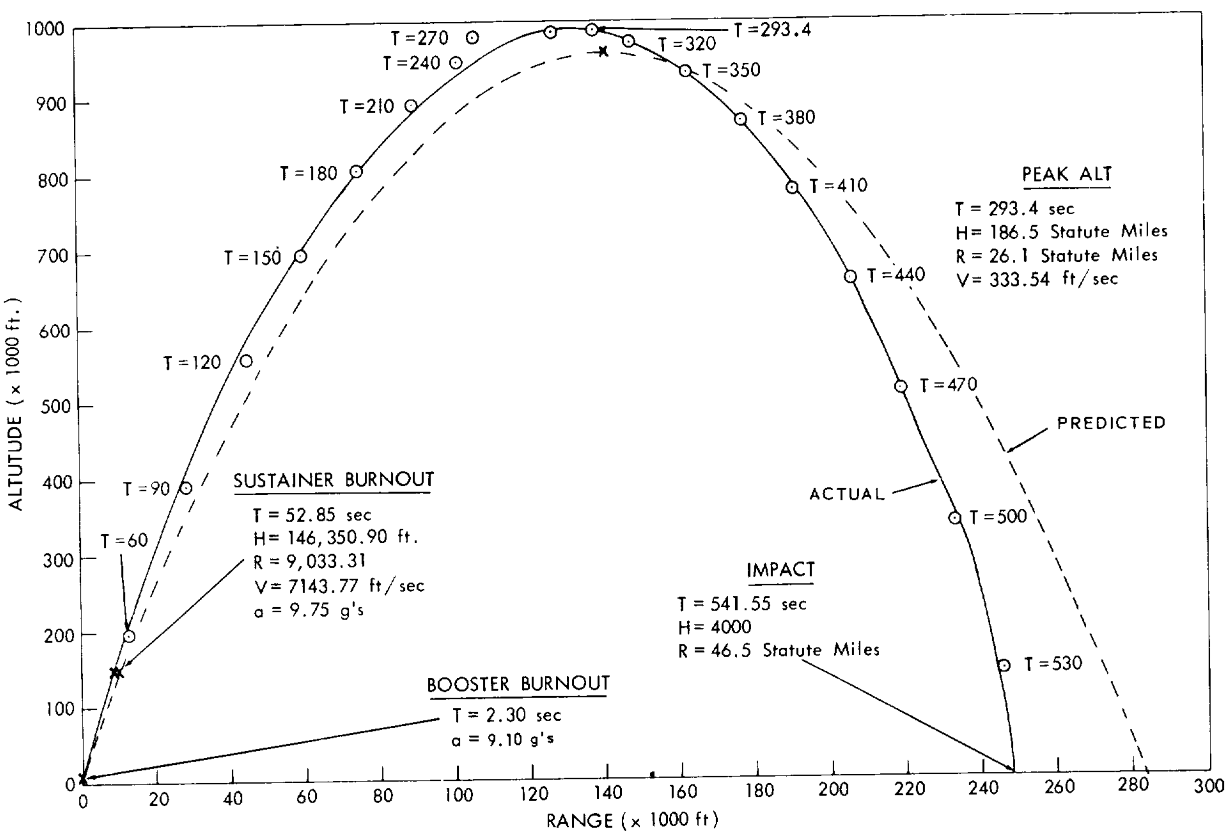
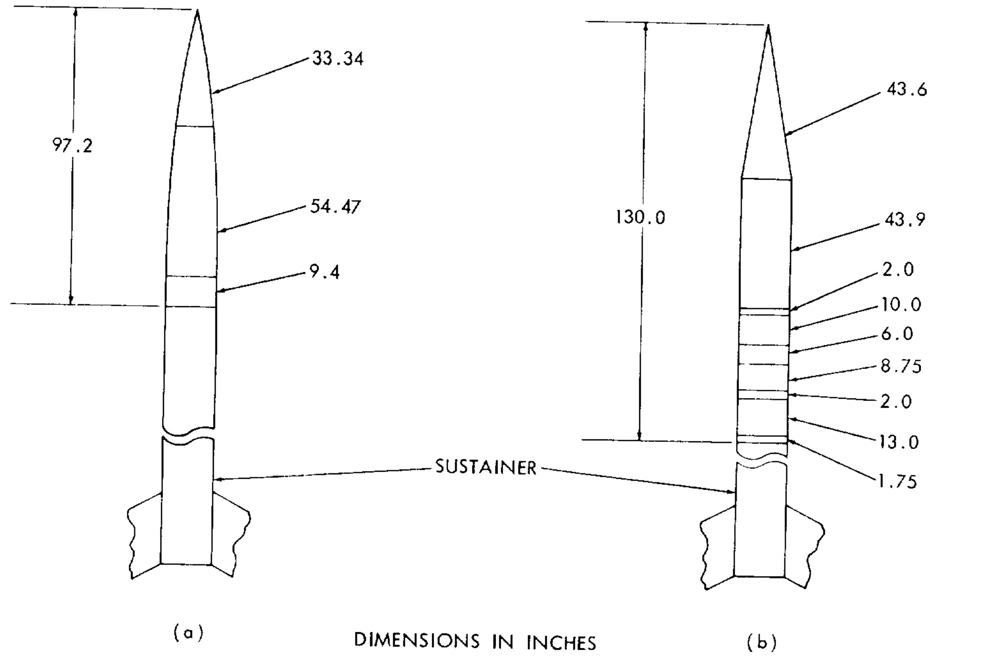


Figure 69—Flight 4.30 GG - altitude vs. range.



FLIGHT	4.30 GG
FIRING DATE	28 MARCH, 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	126.20
APOGEE (ST. MI.)	186.30
TIME TO APOGEE (SEC.)	255.00
CENTER OF GRAVITY (CAL.)	10.45
CENTER OF PRESSURE (CAL.)	12.25
STATIC MARGIN (CAL.)	1.80
RESTORING MOMENT (PER DEGREE)	0.174
SUSTAINER BURNOUT TIME (SEC.)	53.80
ROLL RATE AT BURNOUT (RPS)	1.40
TIP EJECT (SEC.)	*
NO. OF JOINTS	3.00

* Tip ejected at 200,000 + feet

FLIGHT	4.31 GG
FIRING DATE	10 OCT. 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	
APOGEE (ST. MI.)	*
TIME TO APOGEE (SEC.)	
CENTER OF GRAVITY (CAL.)	
CENTER OF PRESSURE (CAL.)	
STATIC MARGIN (CAL.)	
RESTORING MOMENT (PER DEGREE)	
SUSTAINER BURNOUT TIME (SEC.)	
ROLL RATE AT BURNOUT (RPS)	
TIP EJECT (SEC.)	
NO. OF JOINTS	9.00

* Sustainer failed to ignite. No flight history

Figure 70—Flights 4.30 GG and 4.31 GG - payload dimensions and flight characteristics.

flight, transducers were installed to monitor regulated helium pressures and oxidizer pressures for use primarily during the attitude control system (ACS) target maneuvering. The helium gage was mounted in the regulator section on a tap on the fuel pressurization line. The fuel pressure, before entering the thrust chamber, was approximately 15-20 psi less than the monitored pressure as a result of pressure drops through the fuel lines. The oxidizer transducer was located in the tail skirt to provide an accurate indication of pressure before entering the thrust chamber. There were no indications from either the helium or oxidizer gages of any regulated pressure at lift-off.

No quantitative evidence was available as the sustainer blew up upon impact, however, two explanations for the failure have been advanced: (1) helium was not pumped into the sustainer helium tank and therefore helium was never available to pressurize the rocket, and (2) helium was vented through the overboard dump rather than regulated to the propellant tanks.

In each case, the explanation is dependent upon assumptions that are not necessarily known to be valid. At T -3 days a 3,000 psi pressure leak check was made on the sustainer's helium tank. Leaks were noted at the Wiggins disconnect and in the ground service line during these checks; the connection at the Wiggins was reseated and the leak eliminated, although the small leak in the ground service line was not repaired until after the flight. After the test, the helium was bled out with 400 psi left in the sustainer tank; Space General Corporation engineers surmised that "the residual pressure in the vehicle was completely vented through the line leak." It has been assumed that the helium tank was not pressurized because the Wiggins disconnect was dislodged from the vehicle accidentally while working on the tower. There is no factual evidence to support the theory that this valve was dislodged. It has been further assumed that with the observed abnormally fast pressurization rate, 1800 psi in one and a half minutes, the ground service line was pressurized and the tanks possibly were not.

Another possibility for failure lies with the overboard dump. Normally, at T -3 seconds, the firing panel operator pushes the "Flare" switch. This fires a squib which closes the overboard bleed valve. The microswitch senses this closing and is used as the first energizer in the firing circuit. At T -0, the booster "fire" switch is actuated, thereby energizing the circuit and firing the vehicle. However, in running tests on another sustainer the following day, it was noted that if the overboard dump was not completely closed when the regulator wire was tripped. Gas bled out through the valve and no pressure remained. This may explain the fact that the remaining 400 psi from pressure checks in the sustainer was never observed on the fuel or pressure transducers; it would have been expended through the overboard bleed valve. The microswitch senses closing the overboard dump after the pintle has traveled 2/3 of the distance to its closed position. Supposing that if both switches, "Flare" and "Booster Fire," were actuated simultaneously; the possibility exists that the microswitch sensed the overboard dump valve closing before the seat was completed. The booster fire switch was then actuated, thereby firing the booster, and sequentially tripping the helium regulator as the vehicle moved up the tower, allowing pressurization of the helium tanks. Since the overboard dump valve was not completely closed, it was jammed back open and allowed the depressurization of the helium tank. This theory supposes that in addition, although no evidence was indicated, both switches were actuated simultaneously and that the time delay for the overboard dump to close was sufficiently long enough to allow booster ignition.

As a result of this failure and the possible causes for failure the following actions were instituted immediately:

(1) All subsequent NASA Aerobee vehicles were to utilize a pressure switch to monitor helium in the sustainer as it was being pressurized during the countdown. The primary purpose was to indicate that there was pressure in the helium tank and that line pressure was not being monitored.

(2) A delay of 5 seconds was to be required between the "Flare" and "Booster Fire" actuation. This was to allow more than enough time for the overboard dump to close.

Flights 4.58 UI and 4.59 UI

Flights 4.58 UI and 4.59 UI were two Aerobee 150A vehicles successfully flown on 3 April and 10 July respectively from Wallops Island. Each rocket carried experiments to accomplish the following objectives:

(1) Make an electromagnetic noise survey, (2) flight test an Eccentric Orbiting Geophysical Observatory (EOGO) experiment, (3) measure VLF transmission through the ionosphere, and (4) make electric antenna impedance measurements in the ionosphere.

Both rockets used fiberglass ogive nose cones that obtained additional bending resistance by engaging the payload rack through neoprene rubber "snubbers" such as illustrated in Figure 71a. Figure 71b illustrates the specially modified nose tip for Flight 4.59 UI which incorporated an experiment antenna.

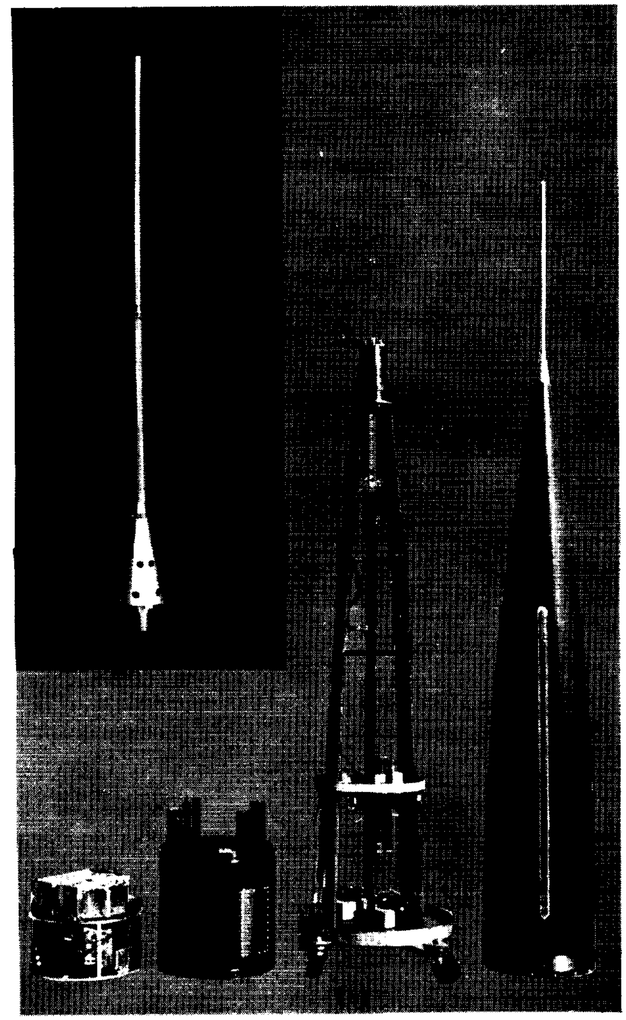


Figure 71—Flight 4.59 UI (a) Fiberglass ogive nose cone and specially modified nose tip. (b) Closeup of specially modified nose tip.

Flight 4.58 UI

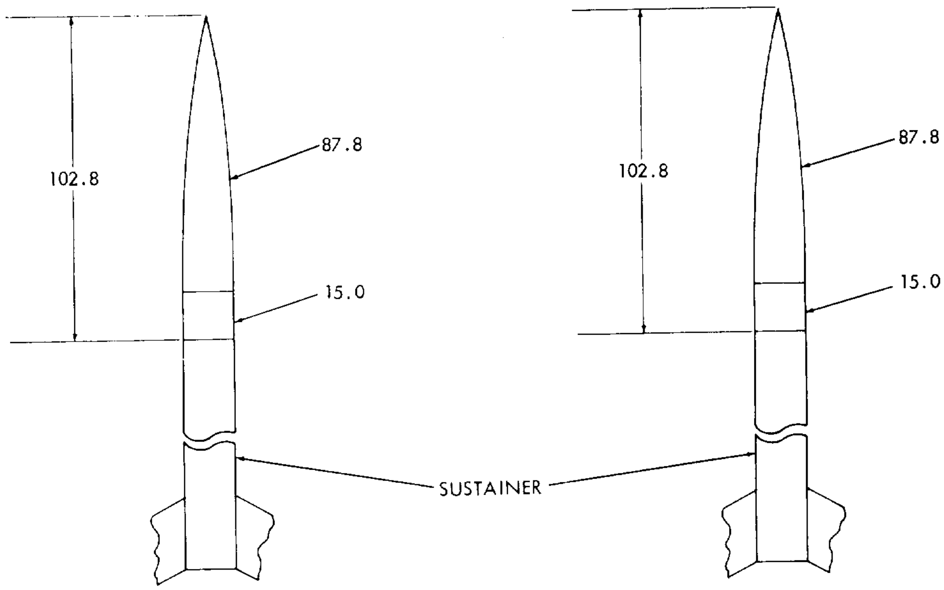
Flight 4.58 UI inadvertently fired at T -9 seconds; however, all stations were prepared and the vehicle went as predicted. Telemetry data and tracking instrumentation was good, and good noise spectra and signal strengths of VLF stations were obtained at all altitudes. The peak altitude attained was 147 statute miles in 259 seconds, four miles above the predicted peak altitude for that time.

Figure 72a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.59 UI

Flight 4.59 UI performed satisfactorily and produced sufficient data although the peak altitude attained was only 126.9 statute miles (15 miles below predicted). Telemetry data received was good and the FPS-16 radar followed the vehicle for 429 seconds.

Figure 72b gives payload dimensions and characteristics of this rocket and its flight.



DIMENSIONS IN INCHES

(a)		(b)	
FLIGHT	4.58 UI	FLIGHT	4.59 UI
FIRING DATE	3 APR. 1963	FIRING DATE	10 JUL. 1963
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	159.00	PAYLOAD WT. (LBS.)	161.50
APOGEE (ST. MI.)	147.00	APOGEE (ST. MI.)	126.90
TIME TO APOGEE (SEC.)	259.00	TIME TO APOGEE (SEC.)	224.00
CENTER OF GRAVITY (CAL.)	10.00	CENTER OF GRAVITY (CAL.)	9.94
CENTER OF PRESSURE (CAL.)	13.45	CENTER OF PRESSURE (CAL.)	13.50
STATIC MARGIN (CAL.)	3.45	STATIC MARGIN (CAL.)	3.56
RESTORING MOMENT (PER DEGREE)	-0.445	RESTORING MOMENT (PER DEGREE)	-0.445
SUSTAINER BURNOUT TIME (SEC.)	54.70	SUSTAINER BURNOUT TIME (SEC.)	51.50
ROLL RATE AT BURNOUT (RPS)	unknown*	ROLL RATE AT BURNOUT (RPS)	2.90
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	2.00	NO. OF JOINTS	2.00

* Set for 2.0 revolutions per second

Figure 72—Flights 4.58 UI and 4.59 UI - payload dimensions and flight characteristics.

Flights 4.96 II and 4.97 II

Flights 4.96 II and 4.97 II carried experiments similar to those that were previously unsuccessful on Flights 4.79 II and 4.80 II (in November which experienced structural failure during sustainer thrusting). Both Flights 4.96 II and 4.97 II were successful, however, and were flown to peak altitudes of 124.6 statute miles and 125.8 statute miles, respectively. Satisfactory data was gathered relating to VLF noise above the region of the ionosphere, measurements of the amplitude of spherics, and measurements of electron densities to 70 km, on both shots.

A mechanism designed by GSFC personnel was used to eject the complete aluminum ogive nose cone at 200,00 feet altitude. Ejection of the complete nose cone in flight eliminated the need for an electromagnetically invisible fiberglass nose cone. This was considered desirable at the time because of the previous experiences with Flights 4.79 II and 4.80 II. Analysis made subsequent to Flights 4.79 II and 4.80 II, and structural improvements in the fiberglass nose cone, have now made the fiberglass cone a safe piece of flight hardware. An additional advantage of ejecting the entire nose cone was the fact that antennas, packaged inside the nose cone, could be erected to a greatly increased size after cone ejection.

Figure 73a shows the nose cone being ejected from the antenna payload in the GSFC test and evaluation facility. Figure 73b shows a closeup of the antenna payload assembly. Figure 74 gives payload dimensions and characteristics for those rockets and their flights.

Flights 6.07 GA and 6.08 GA

Flights 6.07 GA and 6.08 GA were two Spaerobee 300A's successfully flown from Wallops Island in 1963. The payloads made electron and neutral particle temperature and density measurements.

Flight 6.07 GA

Flight 6.07 GA was launched on 18 April to coincide with the passage of the S-6 satellite, thus imposing a launch window of less than 1 minute. The closest point of approach to the satellite with the payload was estimated to be 25 statute miles. Rocket performance was satisfactory and as predicted. All instrumentation performed excellently and the planned ejection of the thermosphere probe occurred on schedule. Complete data was received from the experiments. The peak altitude attained by Flight 6.07 GA was 212.5 statute miles.

Figure 75 gives payload dimensions and characteristics of this rocket and its flight.

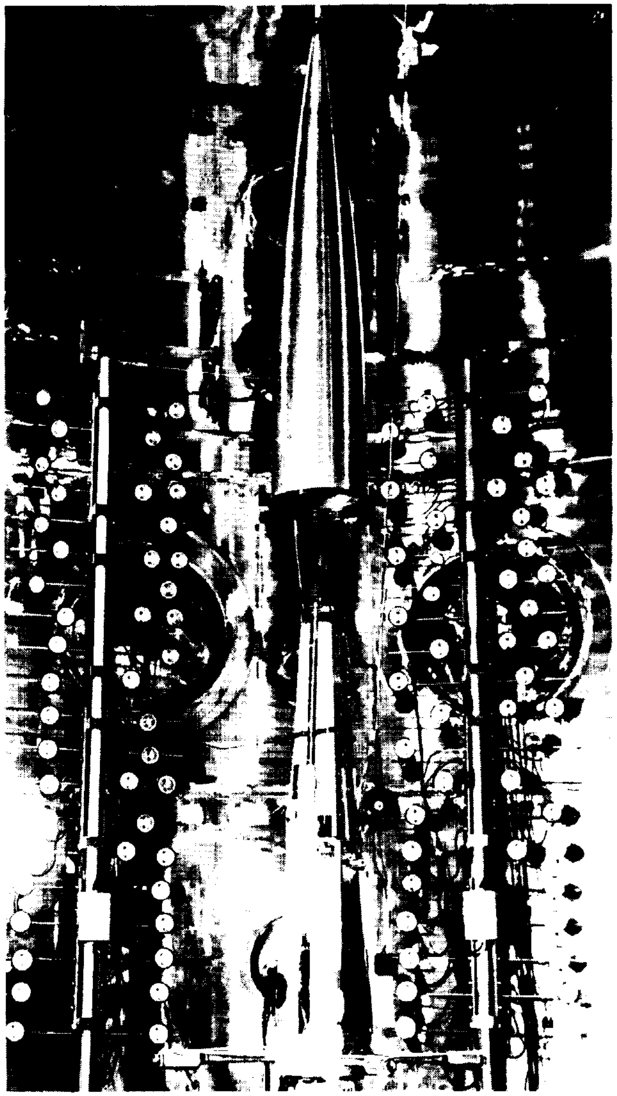
Flight 6.08 GA

Flight 6.08 GA was launched to a peak altitude of 210 statute miles in 319.3 seconds on 20 July. The flight had been planned to occur during a solar eclipse. The vehicle performed close to predicted expectations. Telemetry data was received for 9 minutes and 34 seconds. The ejectable thermosphere probe payload was ejected at +97 seconds, three minutes after the eclipse maximum (well within the launch window), with a tumble period of 1.9 seconds. Figure 76 shows the vehicle in flight during the solar eclipse. Spin modulated pressure of helium and nitrogen were measured and telemetered throughout the flight, and the FPS-16 radar tracked to peak. Spandar radar tracked to break-up at approximately 120,000 feet.

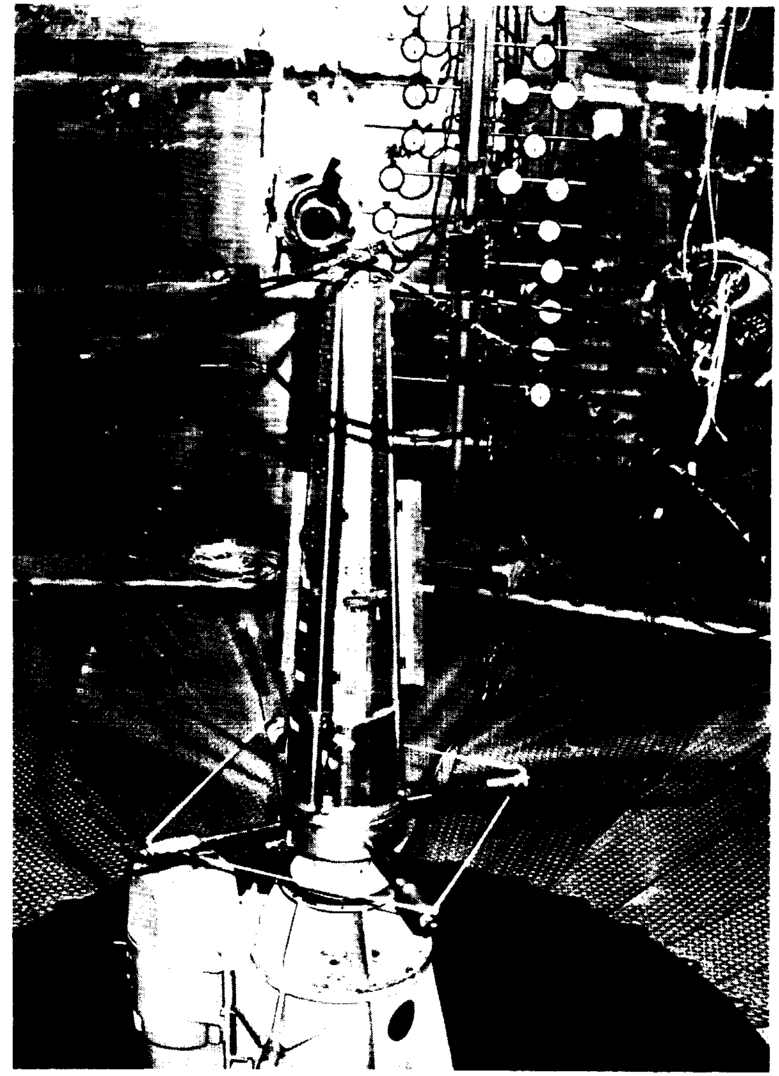
Figure 75 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.44 GI

Flight 4.44 GI was successfully launched to a peak altitude of 125 statute miles on 23 April. Payload instrumentation designed to measure electron densities in the ionosphere, by several different methods, performed satisfactorily. Figure 77 shows Flight 4.44 GI during rocket assembly at Wallops Island.

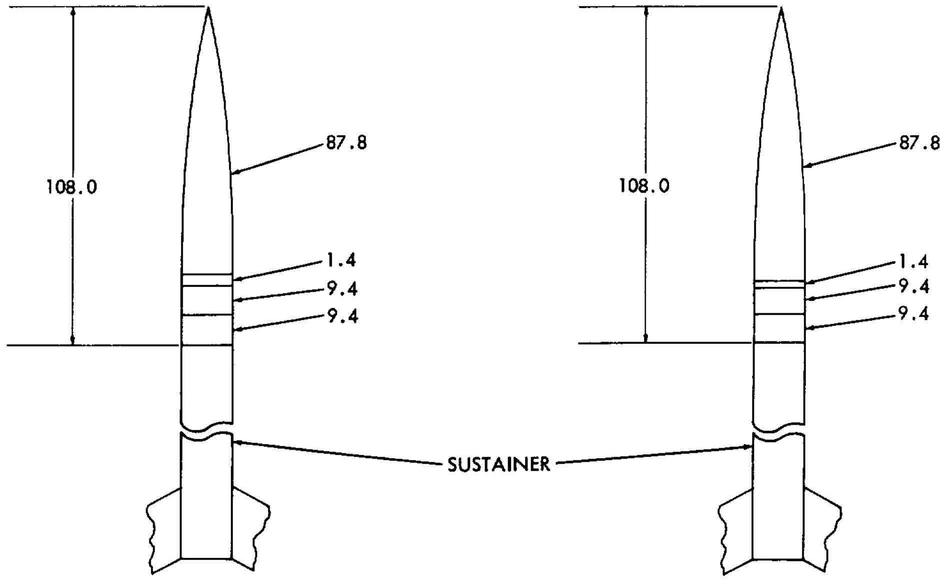


(a) Nose cone eject mechanism, separated from the antenna payload during testing.



(b) Closeup of antenna payload assembly.

Figure 73—Flight 4.79 II.



DIMENSIONS IN INCHES

(a)

FLIGHT	4.96 II
FIRING DATE	12 APR. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	193.00
APOGEE (ST. MI.)	124.60
TIME TO APOGEE (SEC.)	242.00
CENTER OF GRAVITY (CAL.)	10.30
CENTER OF PRESSURE (CAL.)	13.80
STATIC MARGIN (CAL.)	3.50
RESTORING MOMENT (PER DEGREE)	−0.463
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	unknown*
NO. OF JOINTS	4.00

* Set for 2.2 revolutions per second

(b)

FLIGHT	4.97 II
FIRING DATE	9 MAY, 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	191.50
APOGEE (ST. MI.)	125.80
TIME TO APOGEE (SEC.)	242.00
CENTER OF GRAVITY (CAL.)	10.30
CENTER OF PRESSURE (CAL.)	13.80
STATIC MARGIN (CAL.)	3.50
RESTORING MOMENT (PER DEGREE)	− 0.455
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	2.60
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 74—Flights 4.96 II and 4.97 II - payload dimensions and flight characteristics.

The firing was accomplished after a four hour hold, due to variable wind and low ceiling conditions. The rocket took an unpredicted azimuth shift during burning, and impacted at 168° azimuth 34 statute miles down range instead of a predicted 110° azimuth at 63 statute miles down range. None of the experimental objectives were sacrificed by this azimuth shift; however, the rocket came dangerously close to the range safety boundary. Had the rocket crossed the boundary during thrusting, range safety would have shut off the sustainer motor. No specific cause of the azimuth over-shift has been found, but the most probable cause was a wind shift just prior to launch.

Figure 78 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.66 NP

Flight 4.66 NP was successfully launched from the White Sands Missile Range on 14 May. The objectives of this flight were to: (1) obtain meteoroid frequency impact and penetration depth data,

FLIGHT	6.07 GA	6.08 GA
FIRING DATE	18 APR. 1963	20 JUL. 1963
LAUNCH SITE	WI	WI
PAYLOAD WEIGHT, 2ND STAGE (lbs)	252.70	237.00
PAYLOAD WEIGHT, 3RD STAGE (lbs)	86.50	81.00
APOGEE (statute miles)	212.50	210.00
TIME TO APOGEE (seconds)	315.00	319.30
CENTER OF GRAVITY, SUSTAINER BURNOUT (calculated)	10.82	10.77
CENTER OF PRESSURE, SUSTAINER BURNOUT (calculated)	15.12	14.80
STATIC MARGIN, SUSTAINER BURNOUT (calculated)	4.30	4.03
RESTORING MOMENT, SUSTAINER BURNOUT (per degree)	-0.577	-0.5199
CENTER OF GRAVITY, 3RD STAGE IGNITION (calculated)	8.74	7.59
CENTER OF PRESSURE, 3RD STAGE IGNITION (calculated)	10.60	10.65
STATIC MARGIN, 3RD STAGE IGNITION (calculated)	1.86	3.06
RESTORING MOMENT, 3RD STAGE IGNITION (per degree)	-0.062	-0.11
SUSTAINER BURNOUT (seconds)	53.95	52.50
THIRD STAGE BURNOUT (seconds)	56.75	55.20
ROLL RATE AT BURNOUT, SUSTAINER (rps)	2.50	unknown
ROLL RATE AT BURNOUT, 3RD STAGE (rps)	unknown	unknown
PROBE EJECT (seconds)	unknown	97.00
NUMBER OF JOINTS	7.00	7.00
THIRD STAGE LENGTH (in.)	125.80	126.00
PAYLOAD HOUSING LENGTH X (in.)		

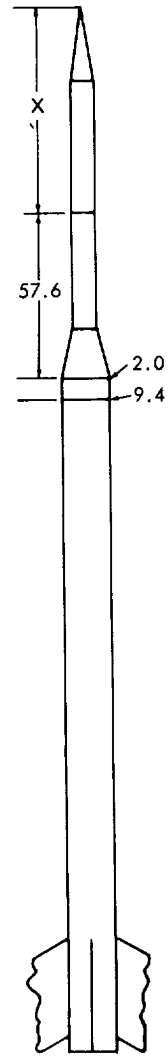


Figure 75—Flights 6.07 GA and 6.08 GA - payload dimensions and flight characteristics.

(2) analyze meteoroid craters in a paraglider for design purposes, and collect meteoroid material for laboratory analysis, and (3) determine the ability of an inflated paraglider to survive re-entry.

The rocket performance was excellent. The vehicle reached the predicted peak altitude of 114.7 statute in 230.7 seconds carrying a payload measuring 145.8 inches in length—the longest payload ever flown on an Aerobee sounding rocket to that time. Unfortunately the inflatable paraglider (with capacitor penetration sensors) failed to deploy from the packing cannister at the correct time, and as a result, none of the payload objectives were realized. The deployment failure resulted either from a structural failure of the packing cannister or from a failure of the separation retrorockets. Telemetry instrumentation performed as expected (until 332.5 seconds when it was lost), except for the calibration unit, which failed to function at all. Radar picked up four targets after re-entry. All targets were tracked to apparent impact close to each other, but only the 15 inch extension and the nose cone were recovered. The sustainer and the main portion of the paraglider package were not found.

Figure 79 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.87 GT

The primary purpose of Flight 4.87 GT, launched on 17 June, was to flight test the capabilities of the inertial attitude control system (IACS). The IACS is programmed to inertially point the vehicle at desired stellar targets, using six sets of cold gas reaction jets.

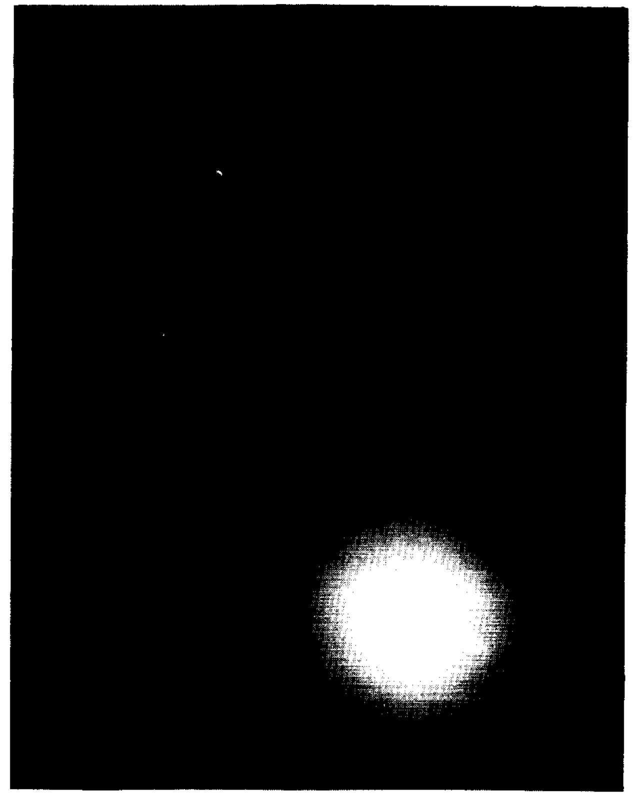


Figure 76—Flight 6.08 GA, launched during 1963 solar eclipse.

Although there was an 8% underperformance, compared to predictions, the vehicle otherwise performed normally. As no abnormalities were detected by the rocket instrumentation, no solution has been advanced to account for the underperformance. Although not substantiated, however, a higher-than-normal propellant temperature could have had some effect on reducing performance effectiveness. A roll rate of 1.82 rps was observed with an average fin setting of 15.96°. This roll rate was exceptionally close to the 1.8 rps roll rate prediction determined prior to the vehicle's launching. A total of four different aspect systems were flown to monitor the IACS performance. These were: (1) A solar aspect sensing system (Ball Brothers), using a servo-driven platform to measure the angle between the vehicle's longitudinal axis and the solar vector, (2) two solar aspect sensors (Adcole), which measure the rocket's pitch and yaw deviations from the solar vector and measured by a digital wide angle sensor, (3) a spin-stabilized gyro aspect system, and (4) a camera aspect system.

The latter used two 70 mm cameras pointing down 147° from the nose. The cameras were pulsed during critical portions of the stabilization (about three times per second), and during on-target or holding sequences (about once every three seconds). Knowing the location of pictured ground landmarks and the vehicle altitude (from radar), it was possible to determine rocket aspect.

Figures 80 and 81 are pictures taken at 46 and 108 miles above ground level. Due to the objectives of the flight it was essential that cloud cover be no greater than a maximum of 25%, otherwise camera aspect would be of little or no value. This requirement was responsible for the 1 day delay in launching Flight 4.87 GT.

Figure 82 gives payload dimensions and characteristics of this rocket and its flight.

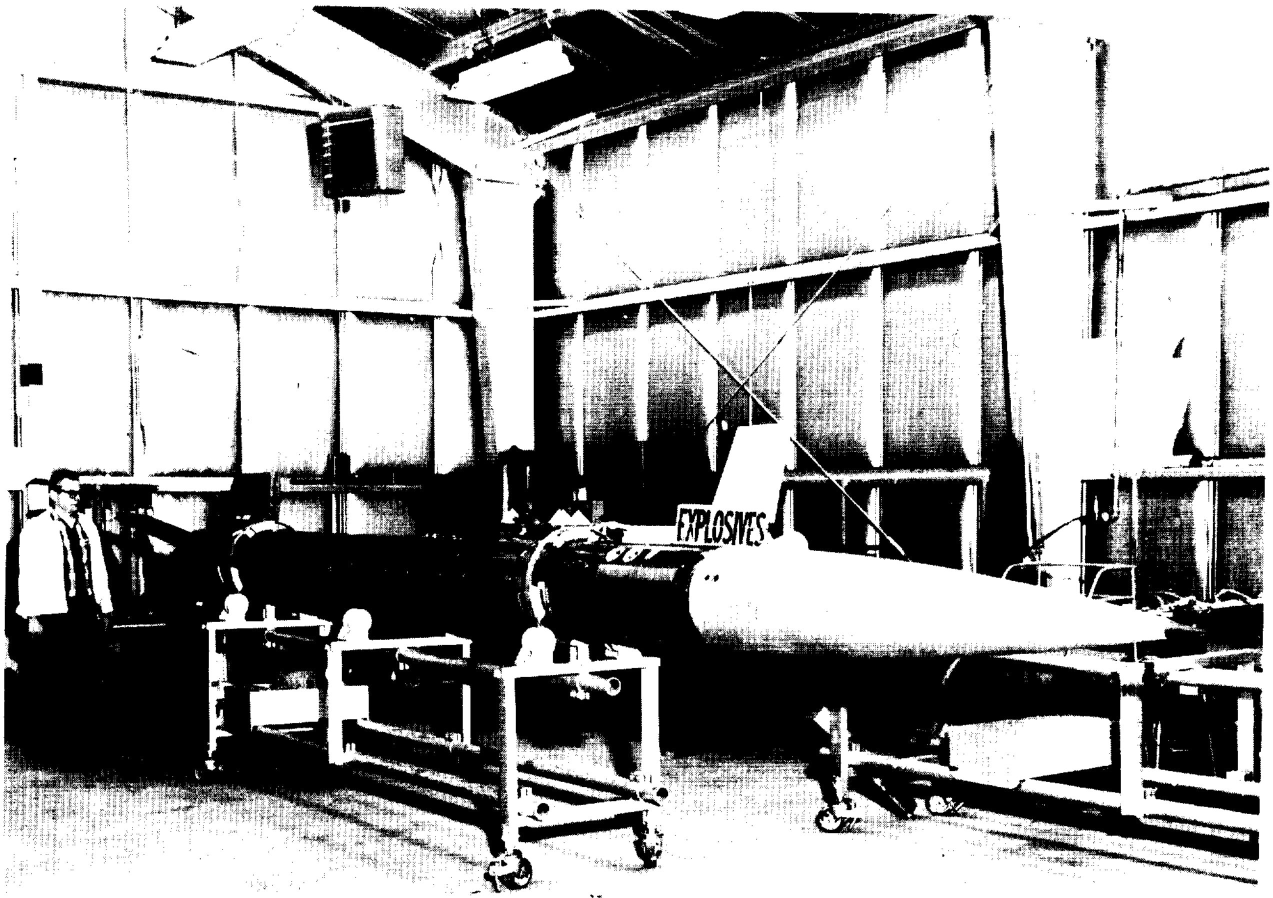


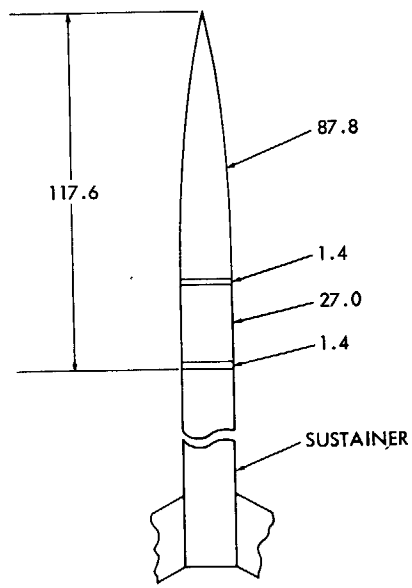
Figure 77—Flight 4.44 GI rocket assembly at Wallops Island launch facility.

Flights 4.28 NP and 4.32 NP

Flights 4.28 NP and 4.32 NP were the final launches in the Lewis Research Center, zero-G, liquid hydrogen experiments (refer to Flights 4.38 NP in 1961, and 4.41 NP in 1962). In addition to this experiment, another purpose of the flight was to measure the lateral acceleration of launcher rails. Both launches were successful. Each vehicle carried a spin stabilized platform (Ball Brothers) to despin the payload - a necessary requirement for the Lewis experiment. Neither vehicle was equipped with recovery packages.

Flight 4.28 NP

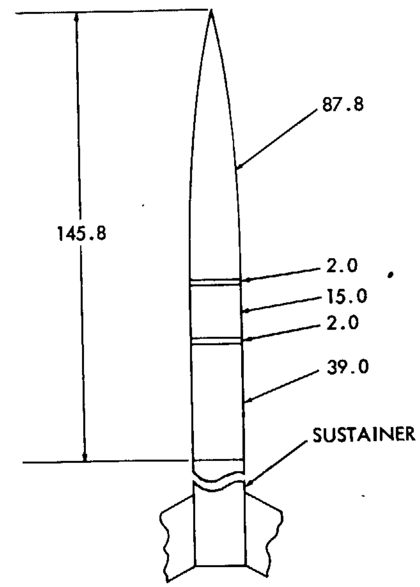
Unfortunately the despin system failed to operate on Flight 4.28 NP when it was launched from Wallops Island on 19 June. Therefore, the primary objectives of the Lewis experiment could not be



DIMENSIONS IN INCHES

FLIGHT	4.44 GI
FIRING DATE	23 APRIL 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	179.80
APOGEE (ST. MI.)	125.00
TIME TO APOGEE (SEC.)	239.04
CENTER OF GRAVITY (CAL.)	10.90
CENTER OF PRESSURE (CAL.)	14.25
STATIC MARGIN (CAL.)	3.35
RESTORING MOMENT (PER DEGREE)	-0.425
SUSTAINER BURNOUT TIME (SEC.)	52.20
ROLL RATE AT BURNOUT (RPS)	2.50
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 78—Flight 4.44 GI - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.66 NP
FIRING DATE	14 MAY, 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	294.50
APOGEE (ST. MI.)	114.70
TIME TO APOGEE (SEC.)	230.70
CENTER OF GRAVITY (CAL.)	11.50
CENTER OF PRESSURE (CAL.)	14.65
STATIC MARGIN (CAL.)	3.15
RESTORING MOMENT (PER DEGREE)	-0.337
SUSTAINER BURNOUT TIME (SEC.)	52.50
ROLL RATE AT BURNOUT (RPS)	1.5 (approx.)
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

Figure 79—Flight 4.66 NP - payload dimensions and flight characteristics.

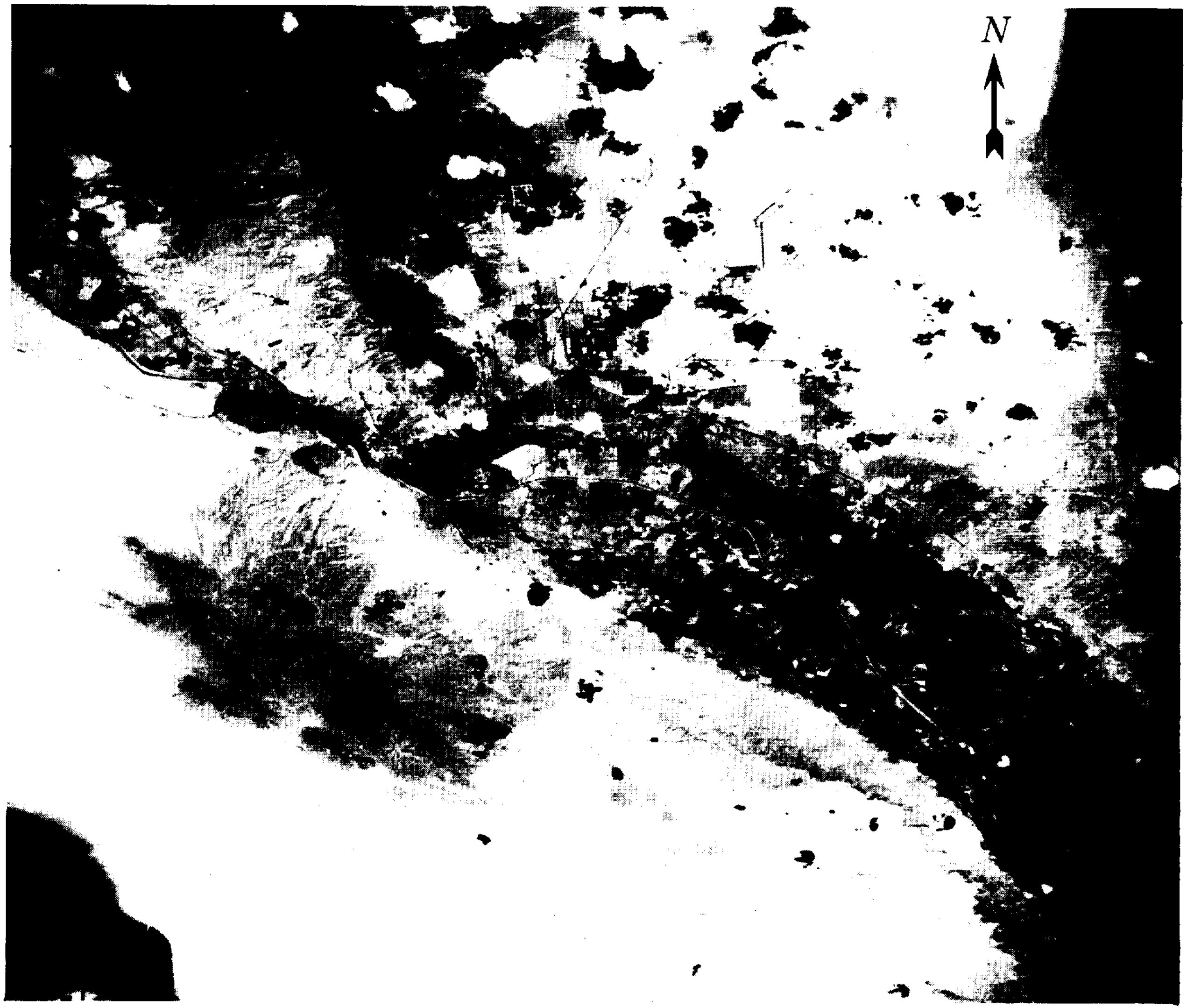


Figure 80—Photograph of El Paso from an altitude of 46 miles (Flight 4.87 GT).

realized. However, the vehicle did perform as predicted and did provide data pertaining to lateral acceleration. Good telemetry data was received for 436 seconds.

Figure 83a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.32 NP

Flight 4.32 NP was launched from Wallops Island successfully on 11 September, to a peak altitude of 102.2 statute miles. Although the rocket performed slightly below expected predictions, the despin system performed satisfactorily. Telemetry and instrumentation performance were good, and experimental data was successfully obtained. The payload remained stationary during flight after the rocket despun 8.8 seconds after burnout (at 73.1 seconds). The resulting roll rate

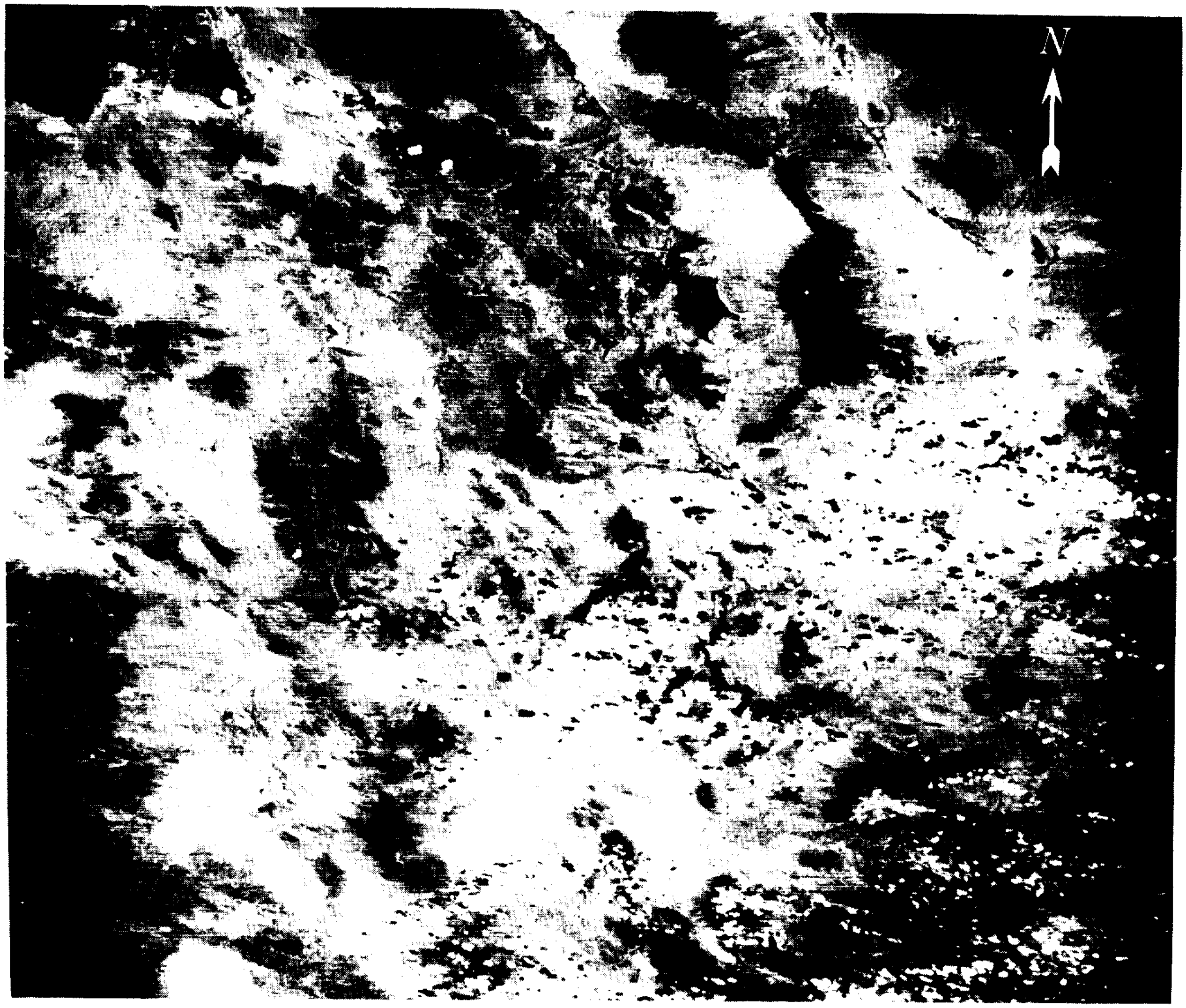


Figure 81—An oblique view south, of Mexico, from an altitude of 108 miles (Flight 4.87 GT).

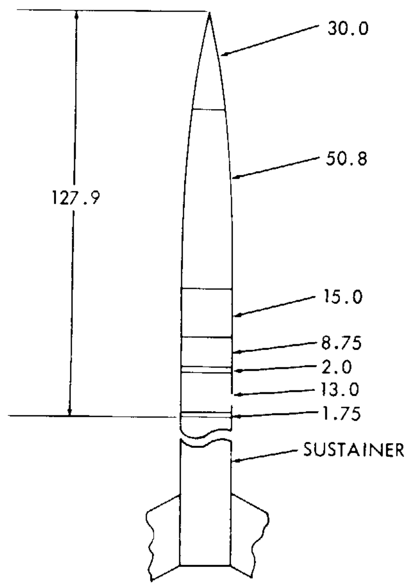
was too low to measure. Four minutes of good "zero-G" time was experienced during the flight. Some slight disturbances were observed from pitch and yaw accelerometers, and the thrust accelerometer. Spandar indicated break-up at 420 seconds.

Figure 83b gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.61 AS and 4.62 AS

Flights 4.61 AS and 4.62 AS were two Aerobee 150's successfully flown with NRL* solar instrumentation duplicating that to be flown on the S-17 satellite. Scientific data was collected on

*Naval Research Laboratory, Washington, D.C.

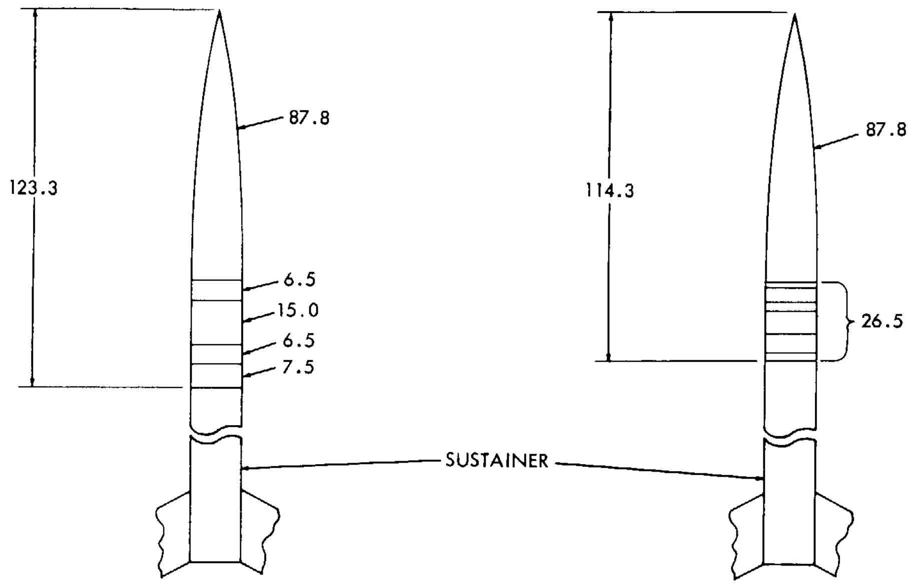


DIMENSIONS IN INCHES

FLIGHT	4.87 GT
FIRING DATE	17 JUN. 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	266.00
APOGEE (ST. MI.)	113.00
TIME TO APOGEE (SEC.)	235.00
CENTER OF GRAVITY (CAL.)	10.22
CENTER OF PRESSURE (CAL.)	13.75
STATIC MARGIN (CAL.)	3.53
RESTORING MOMENT (PER DEGREE)	-0.34
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	1.82
TIP EJECT (SEC.)	*
NO. OF JOINTS	7.00

* Tip ejected at 200,000 + feet

Figure 82—Flight 4.87 GT - payload dimensions and flight characteristics.



DIMENSIONS IN INCHES

FLIGHT	4.28 NP
FIRING DATE	19 JUN. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	200.00
APOGEE (ST. MI.)	119.30
TIME TO APOGEE (SEC.)	237.00
CENTER OF GRAVITY (CAL.)	11.15
CENTER OF PRESSURE (CAL.)	14.20
STATIC MARGIN (CAL.)	3.05
RESTORING MOMENT (PER DEGREE)	-0.396
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	na
NO. OF JOINTS	5.00

* Set for 2.2 revolutions per second

FLIGHT	4.32 NP
FIRING DATE	11 SEPT. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	231.00
APOGEE (ST. MI.)	102.20
TIME TO APOGEE (SEC.)	221.50
CENTER OF GRAVITY (CAL.)	11.36
CENTER OF PRESSURE (CAL.)	15.05
STATIC MARGIN (CAL.)	3.69
RESTORING MOMENT (PER DEGREE)	-0.594
SUSTAINER BURNOUT TIME (SEC.)	54.25
ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	na
NO. OF JOINTS	7.00

* Set for 2.2 revolutions per second

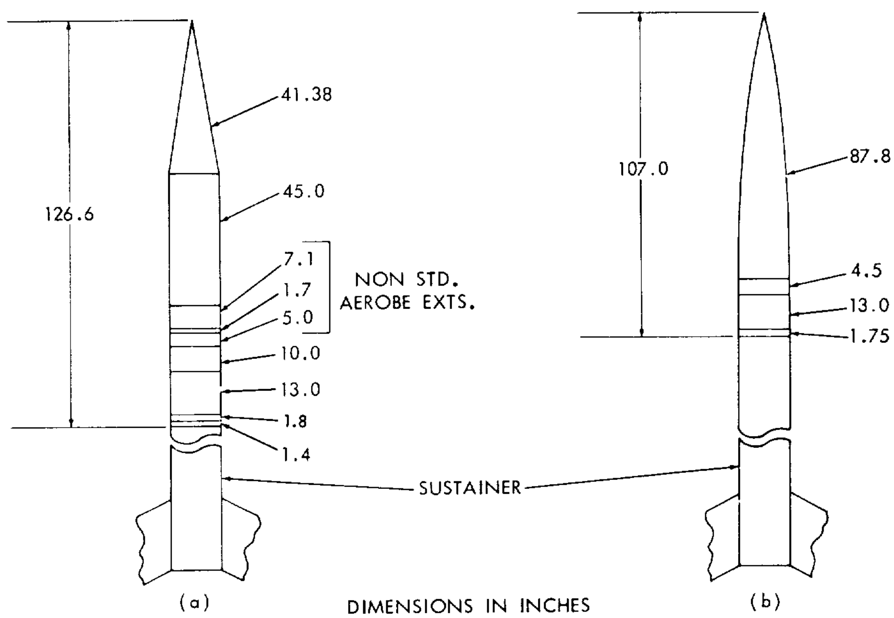
Figure 83—Flights 4.28 NP and 4.32 NP - payload dimensions and flight characteristics.

both flights and the solar pointing controls, one from Ball Brothers Research Corporation (Flight 4.61 AS), and one from the University of Colorado (Flight 4.62 AS), provided accurate target pointing.

Flight 4.61 AS

Flight 4.61 AS was launched successfully from White Sands on 20 June. The vehicle attained a peak altitude of 119.2 statute miles and performed satisfactorily. Rocket performance instrumentation worked properly and experimental instrumentation was functioning. Although Flight 4.61 AS was equipped with a recovery pack and radar noted the parachute deployment, the payload impacted in the mountains and was never found.

Figure 84a gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.61 AS	FLIGHT	4.62 AS
FIRING DATE	20 JUN. 1963	FIRING DATE	28 JUN. 1963
LAUNCH SITE	WSMR	LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	266.10	PAYLOAD WT. (LBS.)	266.35
APOGEE (ST. MI.)	119.20	APOGEE (ST. MI.)	126.00
TIME TO APOGEE (SEC.)	230.00+	TIME TO APOGEE (SEC.)	228.00
CENTER OF GRAVITY (CAL.)	10.23	CENTER OF GRAVITY (CAL.)	9.52
CENTER OF PRESSURE (CAL.)	14.10	CENTER OF PRESSURE (CAL.)	13.12
STATIC MARGIN (CAL.)	3.87	STATIC MARGIN (CAL.)	3.60
RESTORING MOMENT (PER DEGREE)	-0.406	RESTORING MOMENT (PER DEGREE)	- 0.367
SUSTAINER BURNOUT TIME (SEC.)	53.50	SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	unknown*	ROLL RATE AT BURNOUT (RPS)	1.0
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	9.00	NO. OF JOINTS	4.00

* Set for 1.8 revolutions per second

* Set for 1.8 revolutions per second

Figure 84—Flights 4.61 AS and 4.62 AS - payload dimensions and flight characteristics.

Flight 4.62 AS

Flight 4.62 AS experienced a successful launch at White Sands on 28 June. The vehicle performed well, attaining a peak altitude of 126 statute miles. The instrumentation performed well and the pointing control system operated successfully with a 45° yaw. A roll rate of only one rps was achieved, however, although a rate of two rps was desired. During the recovery operation, the payload separated at the pointing control turntable during main chute deployment. The scientific data film, in the part of the payload not attached to the parachute, was only partially recovered.

Figure 84b gives payload dimensions and characteristics of this rocket and its flight.

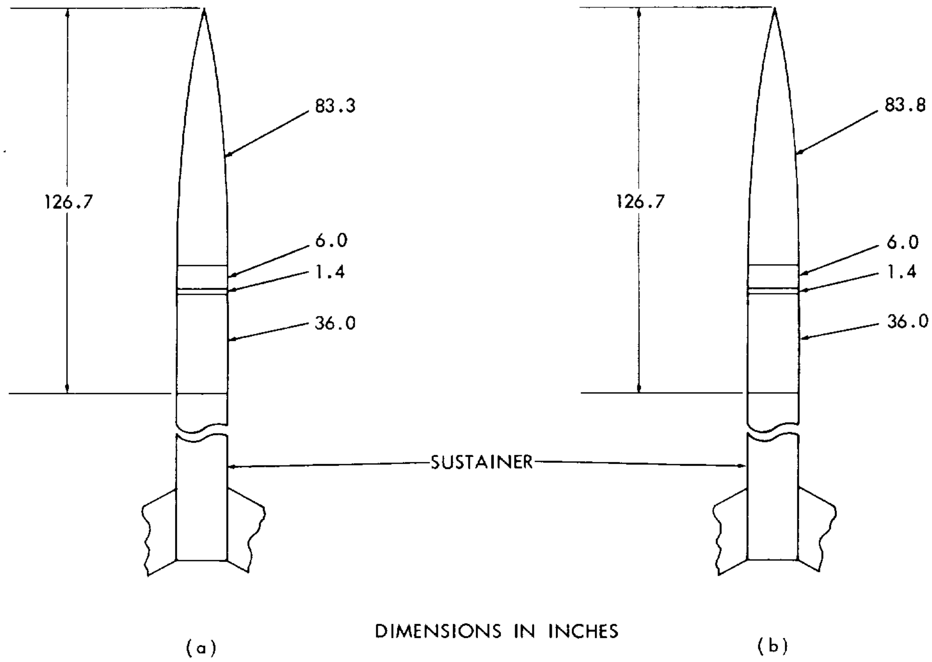
Flights 4.29 GG and 4.37 GG

Flights 4.29 GG and 4.37 GG were successfully launched from Wallops Island on 23 July and 19 July respectively, and collected data on stellar spectra. Gas despin systems were successfully used on each firing, providing nominal despin and precession rates—the half-angle of the precession cone after despin being between 40 and 50 degrees for both shots. The final roll period was approximately 22 seconds; the peak altitude attained was as predicted; and telemetry data was received, in both cases, for approximately 7 minutes. Sufficient radar data was received and the astronomical and geophysical conditions for flight were satisfactorily met.

Figure 85 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.77 GS and 4.78 GS

Flights 4.77 GS and 4.78 GS were launched from White Sands on 20 July and 1 October, respectively. Their primary objectives were to flight-test the performance and calibration of the solar ultraviolet spectrometer optics to be flown on the S-17 satellite. Figure 86 is a comparison plot of vehicle spin rate. Fins were canted to give both vehicles a spin rate of 1.8 rps at burnout; Flight 4.77 GS was spinning at 2.33 rps at burnout and Flight 4.78 GS was spinning at 1.58 rps. The difference between expected and actual rates can be partly attributed to inaccuracies in fin setting, misalignments incurred as a result of fin warpage, and predicted burnout velocities for determining fin cant. The latter appears to be the largest error contributor. If flight burnout velocities are used with the actual fin cant (assuming no misalignments), vehicle roll rate would have been 1.73 rps for Flight 4.77 GS and 1.77 rps for Flight 4.78 GS. Normally, spin rates increase for each vehicle at 90 seconds during flight as a result of induced vehicle momentum imparted to the vehicle from despinning the deployed solar pointing control. Figure 87 pictures the pointing control in its deployed configuration. Further, all unguided Aerobee vehicles experience a precessional motion about the longitudinal axis after burnout. Predicting precessional angles and periods with any degree of confidence is difficult because of its dependence upon forcing functions inherent in the vehicle during burning (such as deploying the solar pointing control, thrust misalignments, fin misalignments, mass unbalance, wind gusts, yaw-roll resonance). An abnormally large precessional angle (42°) occurred on Flight 4.77 GS. For this reason Flight 4.78 GS was instrumented by GSFC with an "albus cell" to give a continuous record of the precessional angle, and period. Figure 88



FLIGHT	4.29 GG	FLIGHT	4.37 GG
FIRING DATE	23 JUL. 1963	FIRING DATE	19 JUL. 1963
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	221.00	PAYLOAD WT. (LBS.)	212.20
APOGEE (ST. MI.)	111.00	APOGEE (ST. MI.)	115.00
TIME TO APOGEE (SEC.)	225.00	TIME TO APOGEE (SEC.)	232.00
CENTER OF GRAVITY (CAL.)	10.50	CENTER OF GRAVITY (CAL.)	10.90
CENTER OF PRESSURE (CAL.)	14.60	CENTER OF PRESSURE (CAL.)	14.70
STATIC MARGIN (CAL.)	4.10	STATIC MARGIN (CAL.)	3.60
RESTORING MOMENT (PER DEGREE)	-0.541	RESTORING MOMENT (PER DEGREE)	-0.505
SUSTAINER BURNOUT TIME (SEC.)	53.23	SUSTAINER BURNOUT TIME (SEC.)	53.80
ROLL RATE AT BURNOUT (RPS)	2.86	ROLL RATE AT BURNOUT (RPS)	2.10
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00	NO. OF JOINTS	4.00

Figure 85—Flights 4.29 GG and 4.37 GG - payload dimensions and flight characteristics.

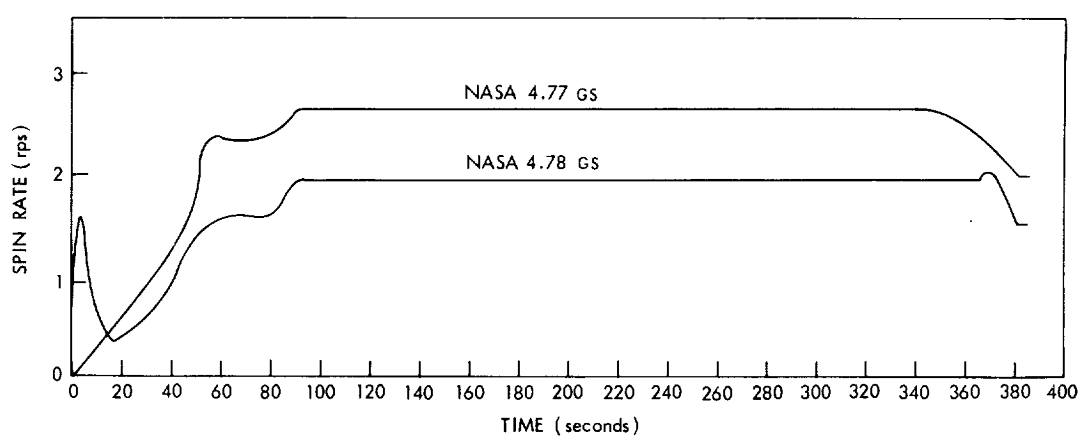


Figure 86—Plot of vehicle spin rate from Flights 4.77 GS and 4.78 GS.

is a plot of the angle between the sun and vehicle's longitudinal axis. Figure 89 is the total precessional angle and is derived from Figure 88 by taking a peak to peak variation with time. The precession for Flight 4.77 GS was at an angle of 42° with a period of 56 seconds, and for Flight 4.78 GS was at an angle of 15° with a period of 80 seconds. Figure 90 plots the theoretical pitch frequency against the actual vehicle roll rates. Pitch-roll resonance occurred at 36 and 39 seconds for Flights 4.77 GS and 4.78 GS respectively.

Figure 91 gives payload dimensions and characteristics of these rockets and their flights.

Flights 4.75 UA and 4.76 UA

Plans were made in late 1962 for a series of two 1963 Aerobee launchings from Fort Churchill by the Johns Hopkins University. The experiment was another in a series of Johns Hopkins tests designed to measure spectral features of the upper atmosphere. Ultraviolet measurements were to be taken at a time coincident with a solar eclipse, thus providing clues

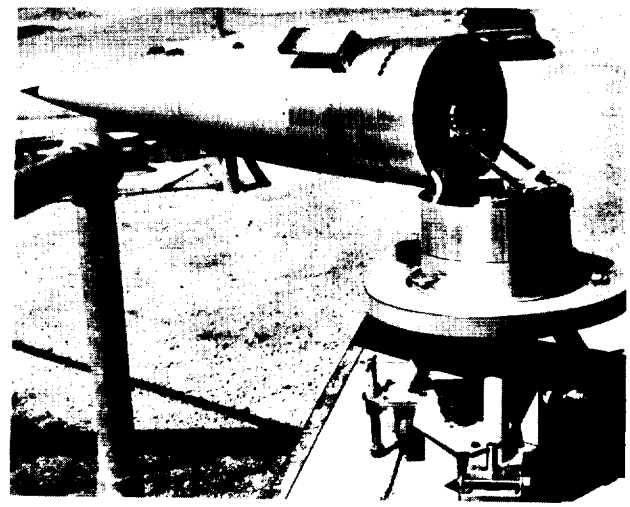


Figure 87—Solar pointing control (deployed configuration).

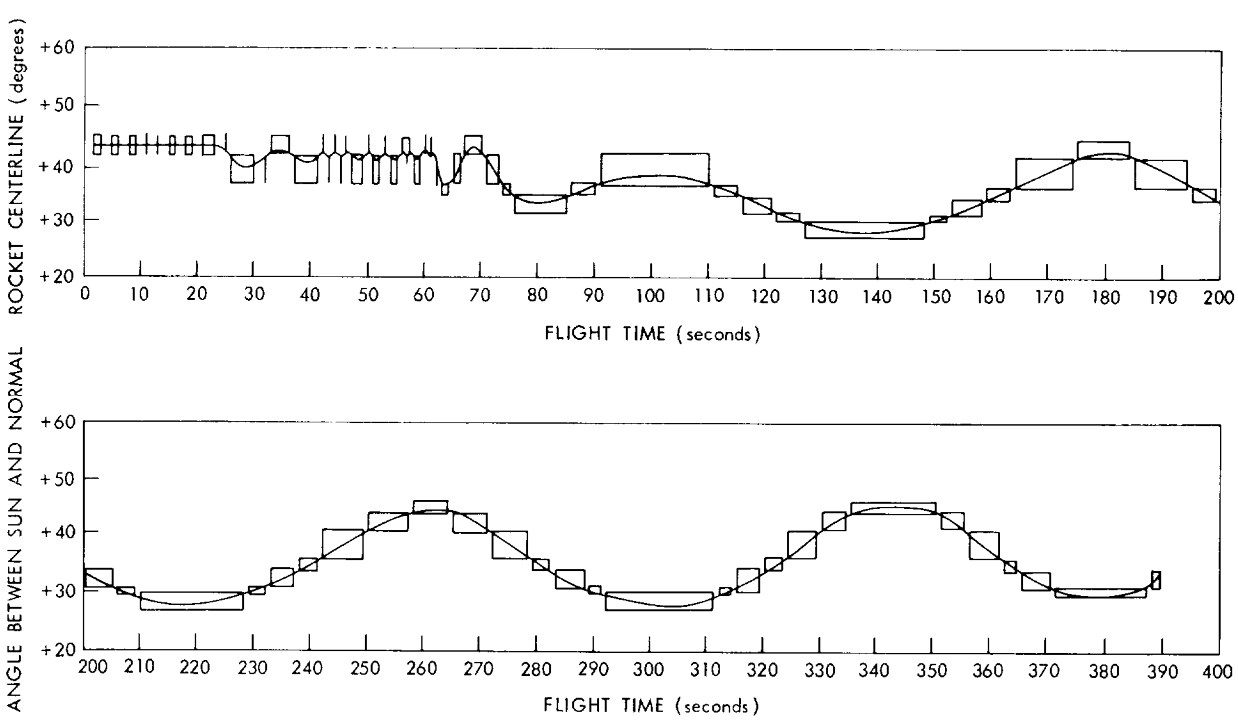


Figure 88—Angle between sun and normal rocket centerline, Flight 4.78 GS.

to the origin of spectral intensities with respect to their vertical distribution. Preliminary plans included the launch of Flight 4.75 UA at the peak of the solar eclipse, and Flight 4.76 UA several days later. Prior to the launch, however, it was necessary to perform a general overhaul of the inactive Ft. Churchill Aerobee launch facility.

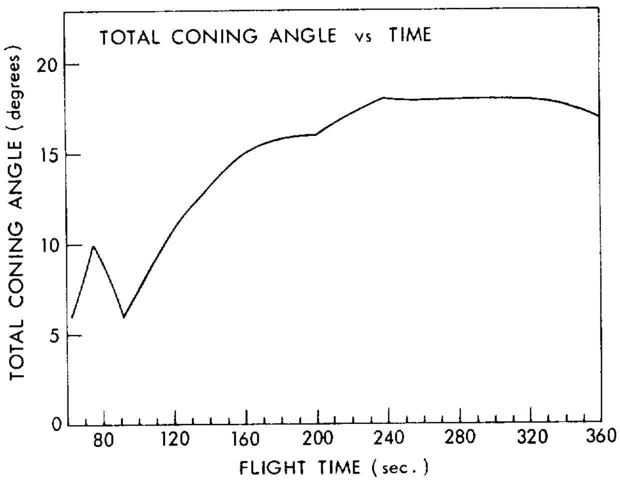


Figure 89—Total coning angle vs. time, Flight 4.78 GS.

Flight 4.75 UA

Flight 4.75 UA was launched from Fort Churchill on 20 July. Unfortunately, this flight was unsuccessful due to a booster explosion that occurred at 2.5 seconds (booster burnout time). Although burning just before booster burnout appeared to be normal, a maximum "g-loading" of 12-g's was observed. Normally, at booster thrust termination, the booster falls away as the overriding sustainer thrust continues for another 50 seconds. In this case, however, the booster ruptured as separation

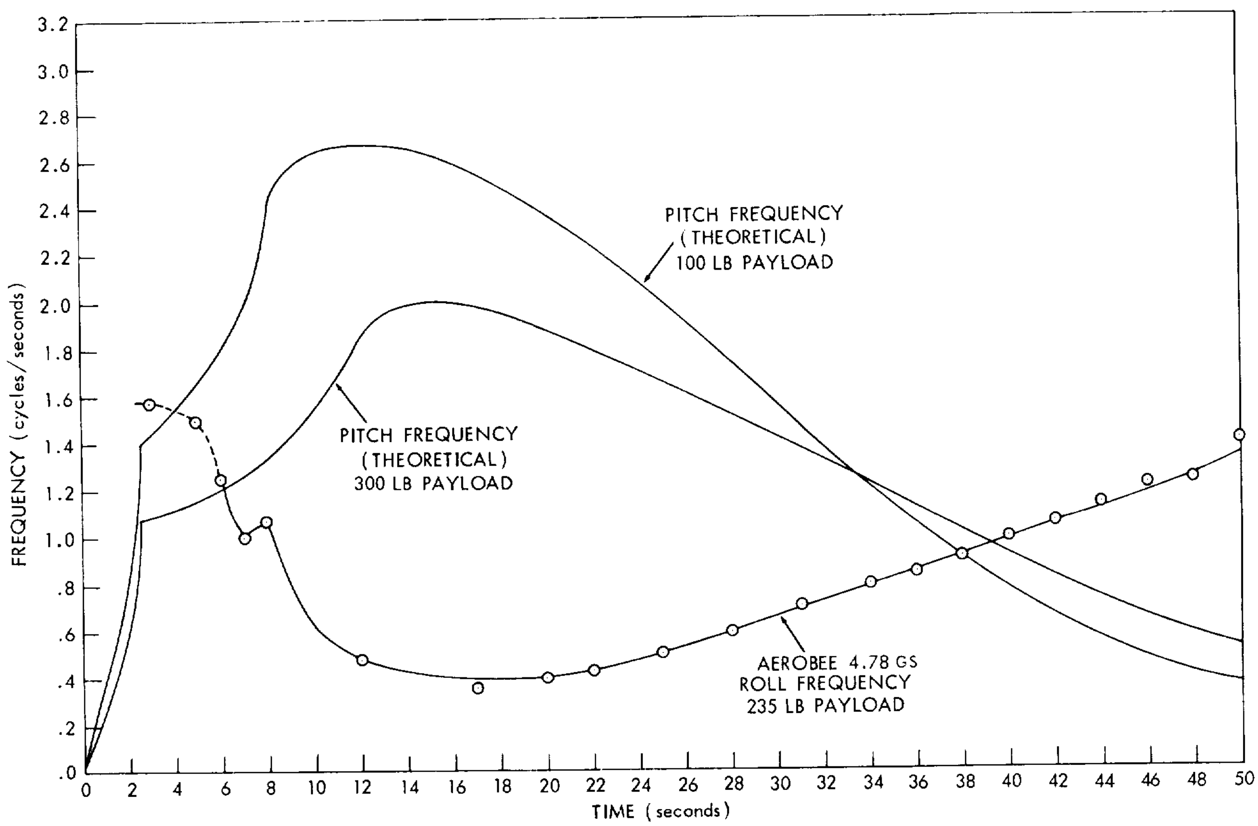
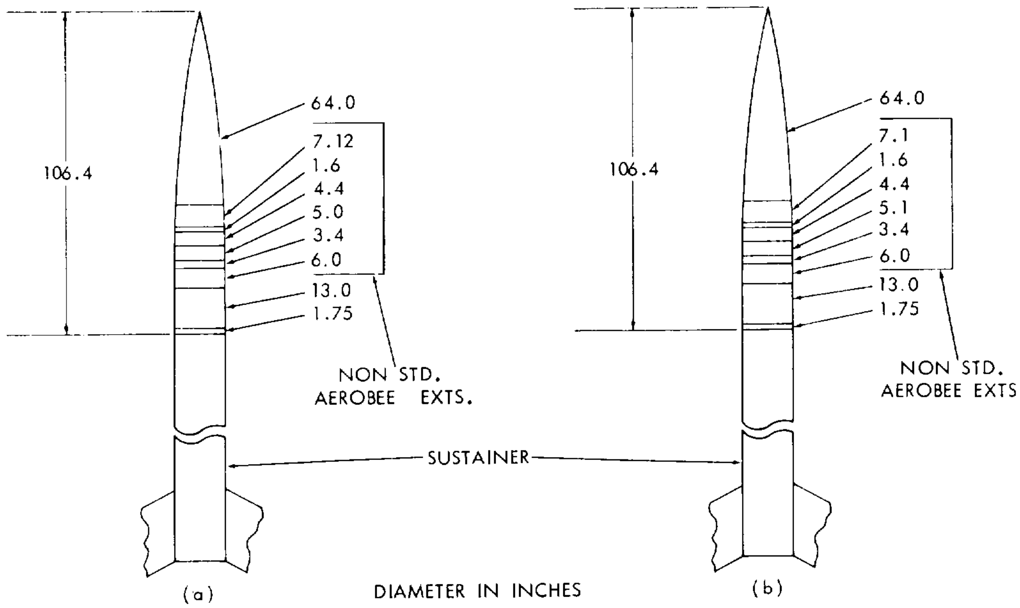


Figure 90—Theoretical pitch and roll frequencies vs. time, Flight 4.78 GS.



FLIGHT	4.77 GS	FLIGHT	4.78 GS
FIRING DATE	20 JUL. 1963	FIRING DATE	1 OCT. 1963
LAUNCH SITE	WSMR	LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	240.40	PAYLOAD WT. (LBS.)	240.40
APOGEE (ST. MI.)	130.80	APOGEE (ST. MI.)	135.90
TIME TO APOGEE (SEC.)	245.00	TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	9.68	CENTER OF GRAVITY (CAL.)	10.00
CENTER OF PRESSURE (CAL.)	12.95	CENTER OF PRESSURE (CAL.)	13.05
STATIC MARGIN (CAL.)	3.27	STATIC MARGIN (CAL.)	3.05
RESTORING MOMENT (PER DEGREE)	-0.337	RESTORING MOMENT (PER DEGREE)	-0.317
SUSTAINER BURNOUT TIME (SEC.)	54.00	SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	1.50	ROLL RATE AT BURNOUT (RPS)	1.60
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	9.00	NO. OF JOINTS	9.00

Figure 91—Flights 4.77 GS and 4.78 GS - payload dimensions and flight characteristics.

was occurring and imparted abnormal torque to the sustainer. As a result of the explosion the vehicle roll frequency was affected, thus causing the vehicle to spin more slowly.

Following the recovery of pieces of the booster an intensive investigation was begun to determine the cause of the booster failure. Preliminary analysis of the failure indicated that the most probable causes were a combination of high temperatures and pressures, and discrepancies in manufacturing tolerances. Corrosion about the booster clip area had definitely weakened the booster casing, finally resulting in the explosion. Several figures have been included to illustrate Flight 4.75 UA vehicle performance. Figures 92 and 93 show Flight 4.75 UA sustainer acceleration history. Figure 94 provides the chamber pressure trace for this flight. These figures indicate g-levels which were expected up to 47 seconds, at which time telemetry was lost. This loss made further monitoring of burnout or tip ejection impossible. Most likely, erratic vehicle maneuvers during pitch-roll coupling caused the telemetry failure.

Several possibilities were considered to have led to the low burning performance of the vehicle. Some were: defective helium pressurization, premature cut-off, propellant specific gravity, and

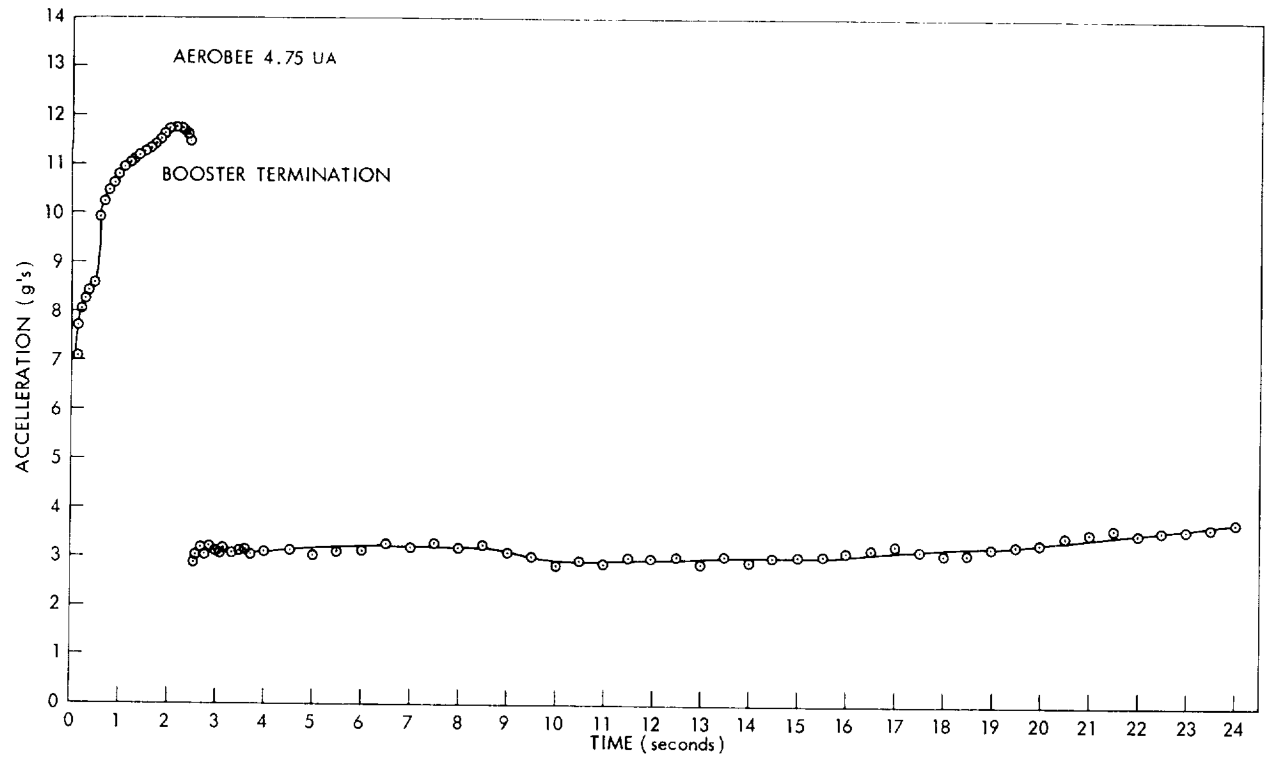


Figure 92—Acceleration vs. time, Flight 4.75 UA (0-24 sec.).

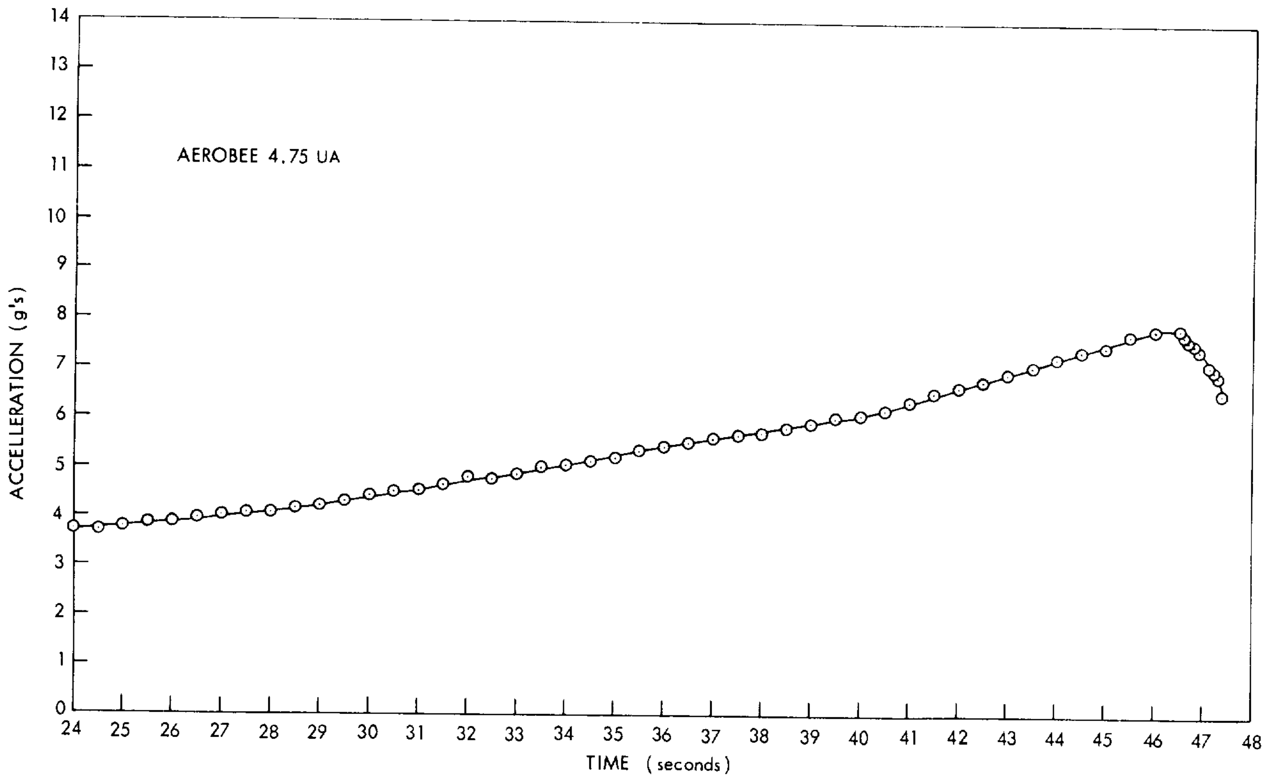


Figure 93—Acceleration vs. time, Flight 4.75 UA (24-48 sec.).

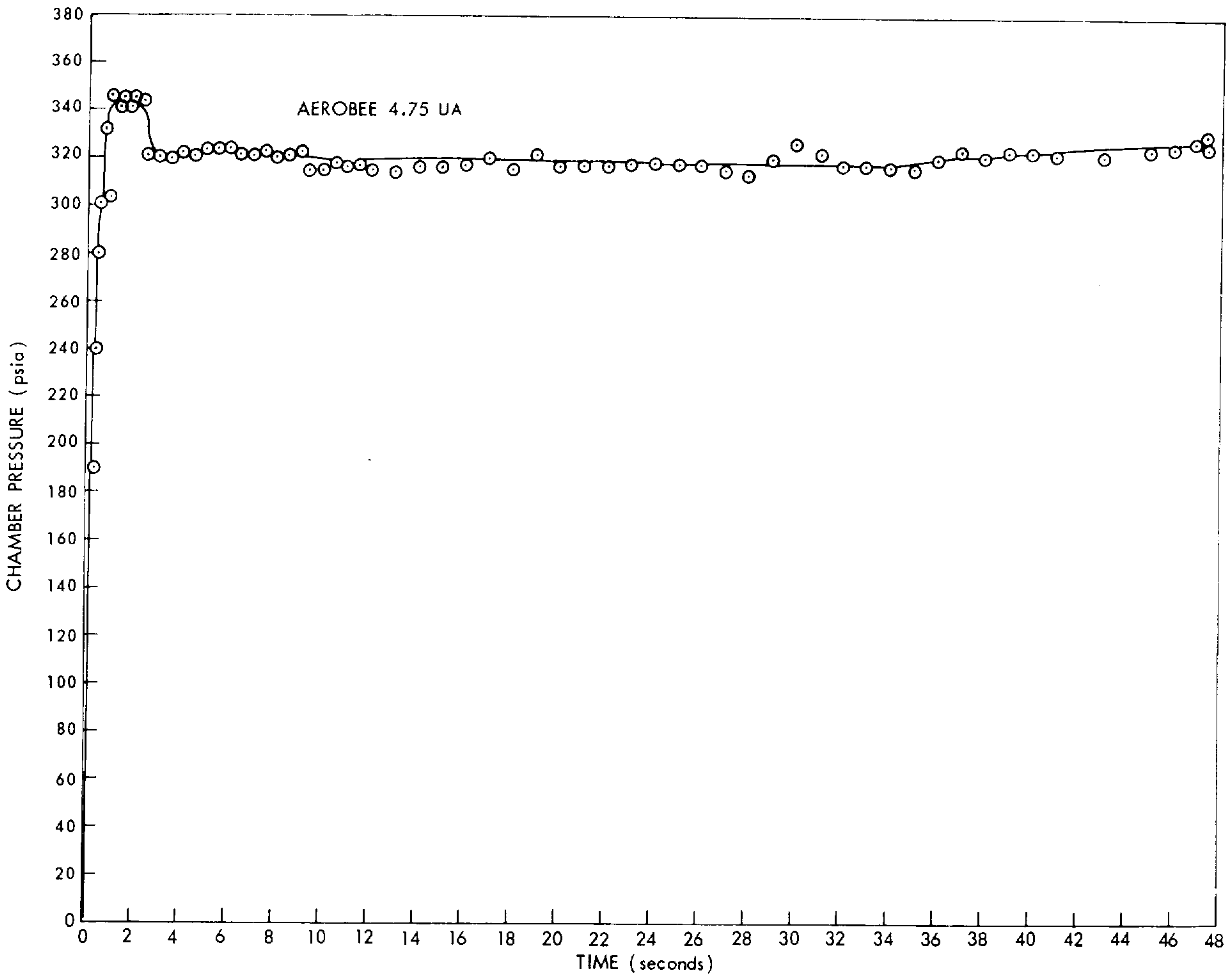


Figure 94—Thrust chamber pressure vs. time, Flight 4.75 UA.

temperature deviation. Of these, however, there were no indications of helium leaks in the system, nor were there any indications from available telemetry records that thrusting was terminated by premature propellant cutoff. Later analyses of the red fuming nitric acid and the aniline-furfuryl alcohol fuel mixture (shown in Table 4), indicated specific gravities within model specifications. These compared favorably with observed data from several similar NRL and AFCRL* flights.

Not enough data was attained to positively identify vehicle lock-in as the cause of the failure, and to establish the reason for the loss of telemetry. However, it was observed that coupling occurred at 37.5 seconds, followed by vehicle lock-in approximately 6 seconds later; then telemetry was lost. Figure 95 shows a theoretical pitch and flight roll frequency for a normal flight. What actually caused Flight 4.75 UA to decrease in roll rate is unknown; although not probable, a gust of wind at 37.5 seconds may have magnified the angle of attack to a point beyond damping, or the booster explosion may have damaged a fin making its performance marginal. As the vehicle was

*U. S. Air Force Cambridge Research Laboratory, Hanscom Field, Bedford, Mass.

Table 4

Propellant Analysis.

Data	Value
Date of Oxidizer Analysis	7/14/63
Color	Orange
Clarity	Clear
Sediment	None
Specific Gravity	1.546
Temperature of Sample	62°F
Total acid as $HNO/_3$	91.66%
Oxides of Nitrogen as NO_2	6.99%
HF Content	0.6%
Solids as Metal Nitrates	0.03%
Water by Difference	0.74%
Sample Source	Drums (when filled)
Fuel	65% aniline 35% furfuryl alcohol
Date of Fuel Analysis	7.19.63
Specific Gravity	1.064
Temperature of Sample	63°F
Water by Weight	Unmeasured
Non-volatile Matter	Unmeasured
Sample Source	Leading tank

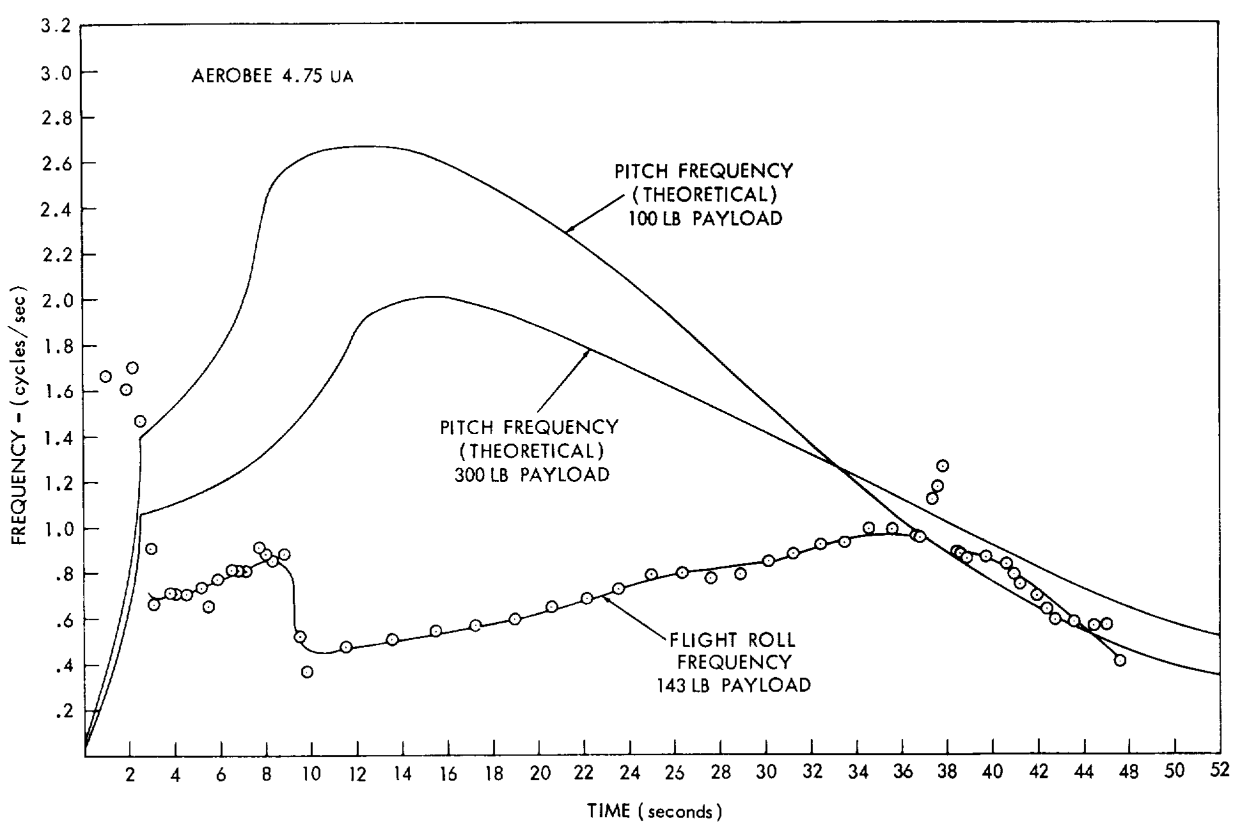


Figure 95—Pitch frequency (theoretical) and roll frequency vs. time, Flight 4.75 UA.

coupling, the magnified angle of attack may have severely loaded the fins, consequently inducing a reduced roll rate and making it more susceptible to lock-in.

Figure 96 indicates the predicted trajectory and the observed radar trajectory for the flight. During the initial powered flight, the predicted and actual altitudes were in good coincidence. At approximately 45 seconds, when coupling lock-in occurred, the flight path angle started decreasing, and the vehicle followed a ballistic trajectory to an altitude well below predicted and a peak time of 100 seconds less than expected. Unsuccessful attempts were made to recover the vehicle to determine the amount of vehicle damage incurred.

Figure 97 gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.76 UA

As a result of the failure of Flight 4.75 UA, Flight 4.76 UA was cancelled; and it later successfully launched from Wallops Island on 12 November. Refer to the flight summary for Flights 4.73 UA, 4.98 US, and 4.76 UA (1963).

Flight 4.91 GE

Flight 4.91 GE was successfully fired from Fort Churchill on 4 September. The vehicle reached a peak altitude of 150 statute miles (8 miles above predicted), and was considered to have performed well. All instrumentation performed properly and the vehicle was successfully tracked and recovered. The payload, containing large sheets of nuclear emulsions for studying very low energy cosmic ray heavy nuclei, was successfully recovered undamaged from an inland lake 7-1/2 hours after launch. Figures 98a through 98d illustrate the recovery

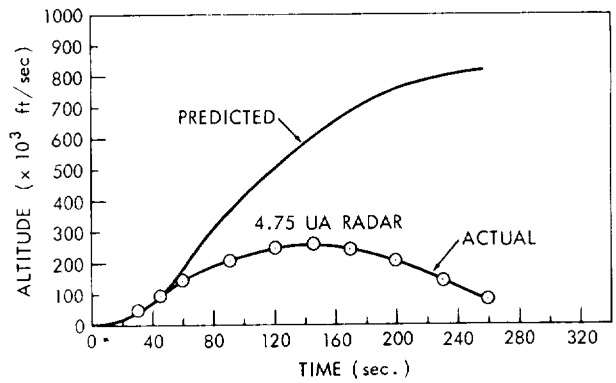
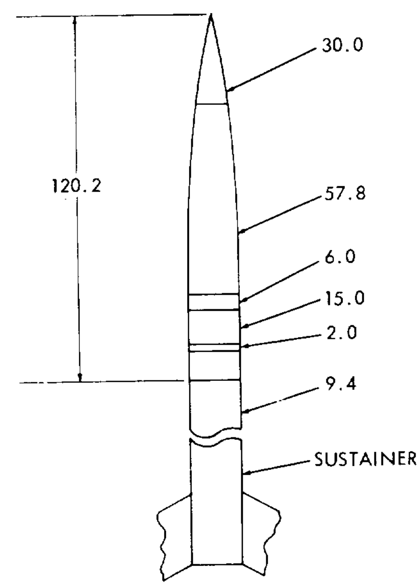


Figure 96—Predicted vs. observed trajectory Flight 4.75 UA.

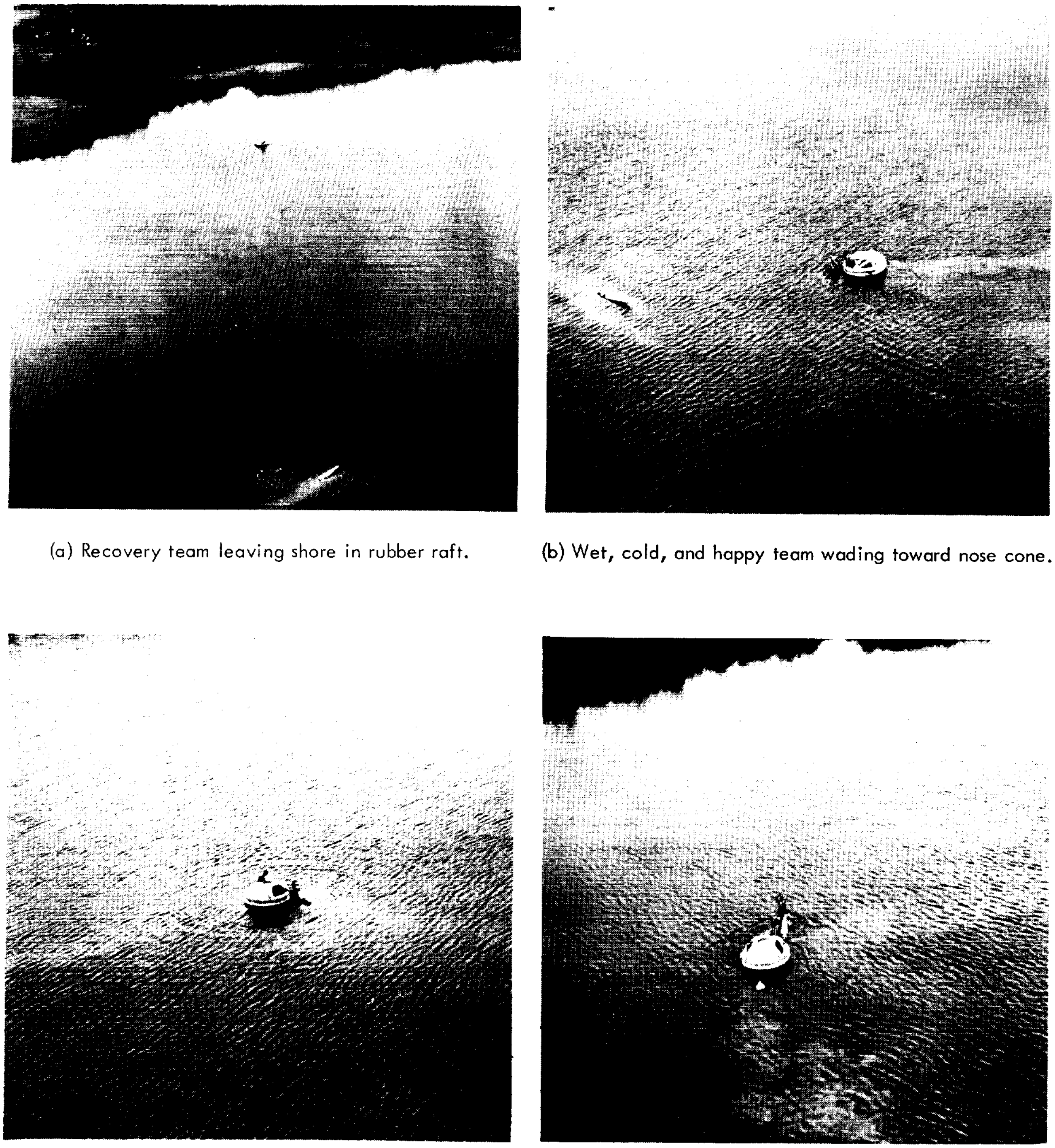


DIMENSIONS IN INCHES

FLIGHT	4.75 UA
FIRING DATE	20 JULY, 1963
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	142.50
APOGEE (ST. MI.)	48.50
TIME TO APOGEE (SEC.)	47.00
CENTER OF GRAVITY (CAL.)	11.30
CENTER OF PRESSURE (CAL.)	11.37
STATIC MARGIN (CAL.)	2.07
RESTORING MOMENT (PER DEGREE)	-0.23
SUSTAINER BURNOUT TIME (SEC.)	47.00
ROLL RATE AT BURNOUT (RPS)	0.04
TIP EJECT (SEC.)	unknown*
NO. OF JOINTS	6.00

*T/M lost at 47 sec.

Figure 97—Flight 4.75 UA - payload dimensions and flight characteristics.



(a) Recovery team leaving shore in rubber raft.

(b) Wet, cold, and happy team wading toward nose cone.

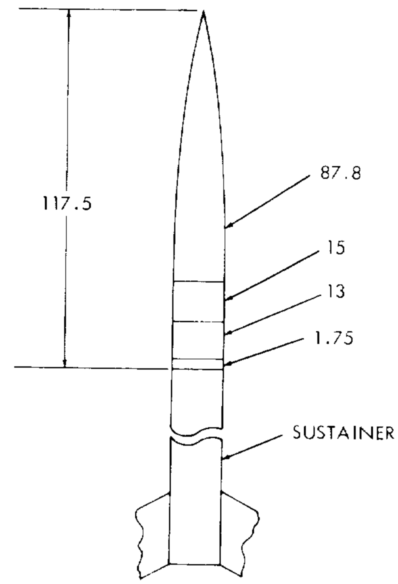
(c) Attaching recovery line to nose cone.

(d) Dragging the nose cone back to shore.

Figure 98—Recovery sequence for Flight 4.91 GE, September 1963 at Fort Churchill.

sequence in which an RCAF* search and rescue team located the payload after obtaining a SARAH beacon fix while still 70 miles from the impact site. The impact occurred approximately 62 miles west of the predicted location in a remote area due to erroneous wind weightings and tower settings, no personal or property damage occurred.

Figure 99 gives payload dimensions and characteristics of this rocket and its flight.



DIMENSIONS IN INCHES

FLIGHT	4.91 GE
FIRING DATE	4 SEPT. 1963
LAUNCH SITE	FC
PAYLOAD WT. (LBS.)	171.50
APOGEE (ST. MI.)	150.00
TIME TO APOGEE (SEC.)	253.00
CENTER OF GRAVITY (CAL.)	10.67
CENTER OF PRESSURE (CAL.)	13.30
STATIC MARGIN (CAL.)	2.64
RESTORING MOMENT (PER DEGREE)	-0.269
SUSTAINER BURNOUT TIME (SEC.)	53.00 (approx.)
ROLL RATE AT BURNOUT (RPS)	1.6 (approx.)
TIP EJECT (SEC.)	na
NO. OF JOINTS	4.00

Figure 99—Flight 4.91 GE - payload dimensions and flight characteristics.

Flight 4.22 US

Flight 4.22 US was the second of two experiments by the Harvard College Observatory for flight-testing the performance of a solar ultraviolet experiment designed to fly on the S-17 (Orbiting Solar Observatory) satellite. The vehicle was launched on 6 September and performed as expected, reaching an apogee of 138 statute miles. All instrumentation performed as expected, including the solar pointing control, which enabled the spectrometer to make two and one-half scans of the sun's ultraviolet spectrum.

Fins were canted to induce a roll rate at burnout of 1.8 rps. Figure 100 shows the vehicle roll history for this flight, indicating a vehicle roll rate of 1.78 rps at burnout. At 79 seconds the pointing control despun the payload to a zero roll rate, thus the energy transferred to the vehicle resulted in the increased roll period from 79 to 81 seconds. The vehicle precessed with a total cone angle of 18° and a period of 65 seconds.

Figure 101 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.65 GI and 4.64 GI

Flights 4.65 GI and 4.64 GI were successfully flown on 25 September and 28 September from Wallops Island in support of a joint (GSFC—Radio Research Laboratory, Tokyo, Japan) scientific effort. Both flights successfully used clamshell-type nose cones and successfully collected data on electron temperatures and charge densities, (as a function of altitude in the ionosphere), along with other ionospheric data.

*Royal Canadian Air Force.

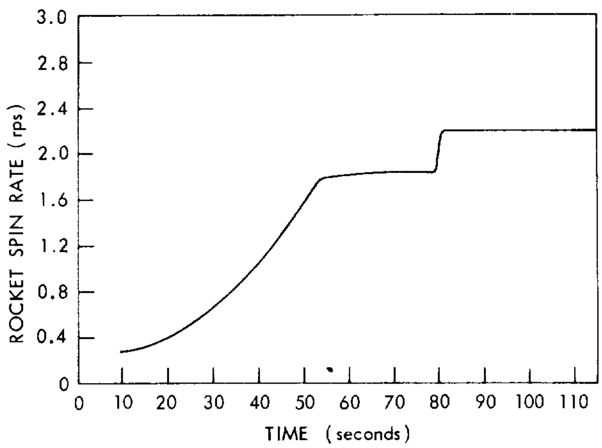
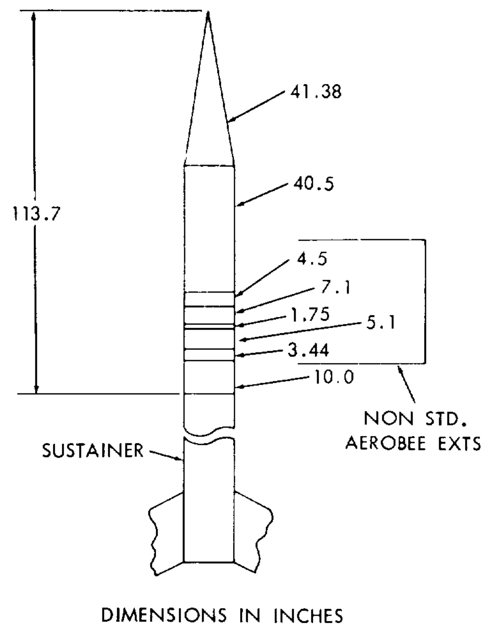


Figure 100—Flight 4.22 US - rocket spin rate vs. time.

Flight 4.65 GI

Flight 4.65 GI rocket performance was excellent. The vehicle reached a peak altitude of 139.5 statute miles as predicted. All experimental and rocket instrumentation performance was very good, and data was received until 474 seconds. The clam shell nose cone was ejected at 65.9 seconds with no difficulties and did not have any effect on rocket performance. The FPS-16 tracking radar followed the flight to breakup at 42,000 feet.

Figure 102a gives payload dimensions and characteristics of this rocket and its flight.



FLIGHT	4.22 US
FIRING DATE	6 SEP. 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	218.00
APOGEE (ST. MI.)	138.00
TIME TO APOGEE (SEC.)	250.00
CENTER OF GRAVITY (CAL.)	10.33
CENTER OF PRESSURE (CAL.)	12.85
STATIC MARGIN (CAL.)	2.52
RESTORING MOMENT (PER DEGREE)	-0.262
SUSTAINER BURNOUT TIME (SEC.)	52.20
ROLL RATE AT BURNOUT (RPS)	1.98
TIP EJECT (SEC.)	na
NO. OF JOINTS	8.00

Figure 101—Flight 4.22 US - payload dimensions and flight characteristics.

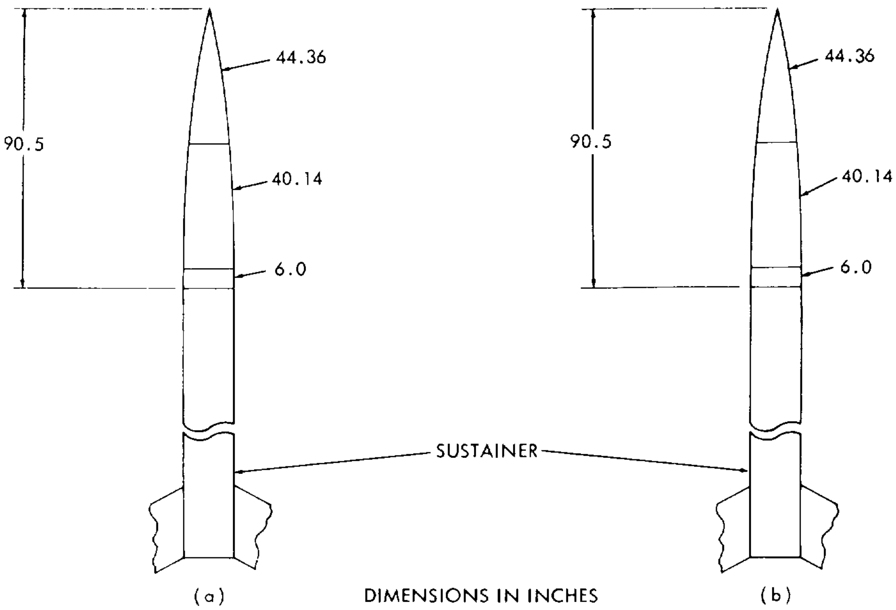
Flight 4.64 GI

Flight 4.64 GI attained a peak altitude of 140.7 statute miles, less than three miles under the prediction for the flight. All rocket and experimental instrumentation performed as expected. Good data was received for 473 seconds and the FPS-16 tracking radar followed the flight to breakup at 42,000 feet.

Figure 102b gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.33 GS

Flight 4.33 GS was successfully fired on 15 October from the White Sands Missile Range. The primary objective of this flight was to obtain solar x-ray spectroheliograms in the 8-20 and 44-60 angstrom regions. The solar pointing control, Model SPC-300B (Ball Brothers) was used to point x-ray telescopes at the sun. The rocket performed as predicted, reaching a peak altitude of



FLIGHT	4.65 GI
FIRING DATE	25 SEPT. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	177.50
APOGEE (ST. MI.)	139.50
TIME TO APOGEE (SEC.)	256.00
CENTER OF GRAVITY (CAL.)	9.55
CENTER OF PRESSURE (CAL.)	13.13
STATIC MARGIN (CAL.)	3.46
RESTORING MOMENT (PER DEGREE)	-0.442
SUSTAINER BURNOUT TIME (SEC.)	54.6
ROLL RATE AT BURNOUT (RPS)	unknown*
TIP EJECT (SEC.)	65.90 **
NO. OF JOINTS	3.00

* Set for 2.2 revolutions per second

** Clam shell nose cone used

FLIGHT	4.64 GI
FIRING DATE	28 SEPT. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	165.50
APOGEE (ST. MI.)	140.70
TIME TO APOGEE (SEC.)	255.00
CENTER OF GRAVITY (CAL.)	9.64
CENTER OF PRESSURE (CAL.)	13.10
STATIC MARGIN (CAL.)	3.46
RESTORING MOMENT (PER DEGREE)	-0.442
SUSTAINER BURNOUT TIME (SEC.)	53.00
ROLL RATE AT BURNOUT (RPS)	unknown *
TIP EJECT (SEC.)	67.00 **
NO. OF JOINTS	3.00

* Set for 2.2 revolutions per second

** Clam shell nose cone used

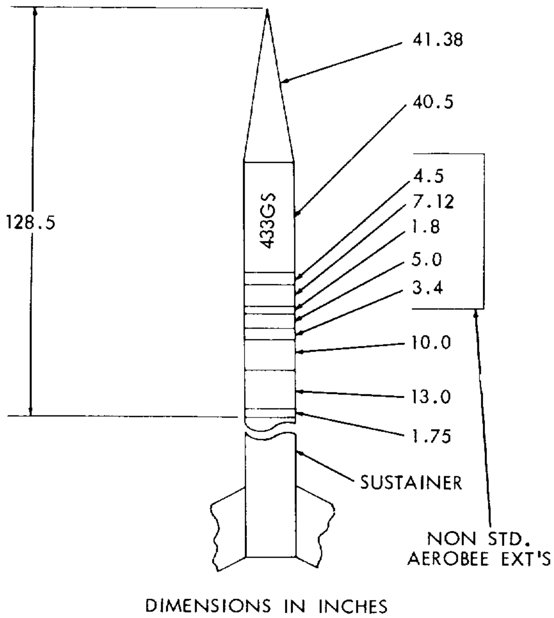
Figure 102—Flights 4.65 GI and 4.64 GI - payload dimensions and flight characteristics.

123.5 statute miles. Successful recovery of the payload took place soon after impact. The fins were canted at an angle of 15.5 minutes to obtain a roll rate at burnout of 1.6 rps. The observed vehicle roll rate at burnout was 1.1 rps. A precessional cone total angle of 42.5° was observed with a period of 145 seconds. The instrumentation performed as planned; and the experiment functioned satisfactorily, providing good data.

Figure 103 gives payload dimensions and characteristics of this rocket and its flight.

Flights 4.93 II and 4.94 II

Flights 4.93 II and 4.94 II, two Aerobee 150A's, were successfully flown from Wallops Island for the Centre National d'Etudes Telecommunications (CNET), Paris, France. VLF measurements were successfully made on both flights. Both vehicles used a cone-cylinder nose cone. These were



FLIGHT	4.33 GS
FIRING DATE	15 OCT. 1963
LAUNCH SITE	WSMR
PAYLOAD WT. (LBS.)	259.00
APOGEE (ST. MI.)	123.50
TIME TO APOGEE (SEC.)	233.00
CENTER OF GRAVITY (CAL.)	10.18
CENTER OF PRESSURE (CAL.)	14.20
STATIC MARGIN (CAL.)	3.84
RESTORING MOMENT (PER DEGREE)	-0.422
SUSTAINER BURNOUT TIME (SEC.)	54.00
ROLL RATE AT BURNOUT (RPS)	1.1
TIP EJECT (SEC.)	na
NO. OF JOINTS	10.00

Figure 103—Flight 4.33 GS - payload dimensions and flight characteristics.

the first cone-cylinder nose cones to have ever been flown on the Aerobee 150A. Each cone was 43.4 inches long, subtending an angle of 19.6°, and made of phenolic fiberglass. The cylinder portion of the nose was 78.5 inches long.

Flight 4.93 II

A first attempt to launch Flight 4.93 II resulted in a booster non-ignition. Later another booster was placed under the vehicle and on 17 October Flight 4.93 II successfully attained a peak altitude of 116.4 statute miles. Figure 104 illustrates Flight 4.93 II booster non-ignition. Rocket performance was considered marginal since the booster case ruptured (see Figure 105). Peak altitude was 16 miles lower than predicted, and 4 miles lower than the desired minimum. All instrumentation performed exceptionally well. Telemetry was received for 427 seconds on all channels, and the data obtained was in the range of expectation and of outstanding quality. Even though the rocket underperformed, the experimental results are considered to be excellent.

Figure 106a gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.94 II

Flight 4.94 II was launched successfully on 31 October. Although the peak altitude was 16 statute miles lower than predicted, the rocket performed well in every other respect and instrumentation performance was exceptionally good. Telemetry was received for 420 seconds on all channels. Despite the lower than predicted peak altitude, the data obtained was in the range of expectation, and of even better quality than that received on Flight 4.93 II.

Figure 106b gives payload dimensions and characteristics of this rocket and its flight.

Flight 4.85 NA

Flight 4.85 NA was an Aerobee 150A successfully flown from Wallops Island, with a Jet Propulsion Laboratory ultraviolet airglow payload intended to measure the ultraviolet light in the 60-220 km region. The peak altitude attained was 114.6 statute miles (15 miles below predicted). The ACS (which was to maneuver the rocket during the scientific data collection period to a first

Figure 104—Flight 4.93 II booster non-ignition.

Figure 105—Flight 4.93 II terminal failure.

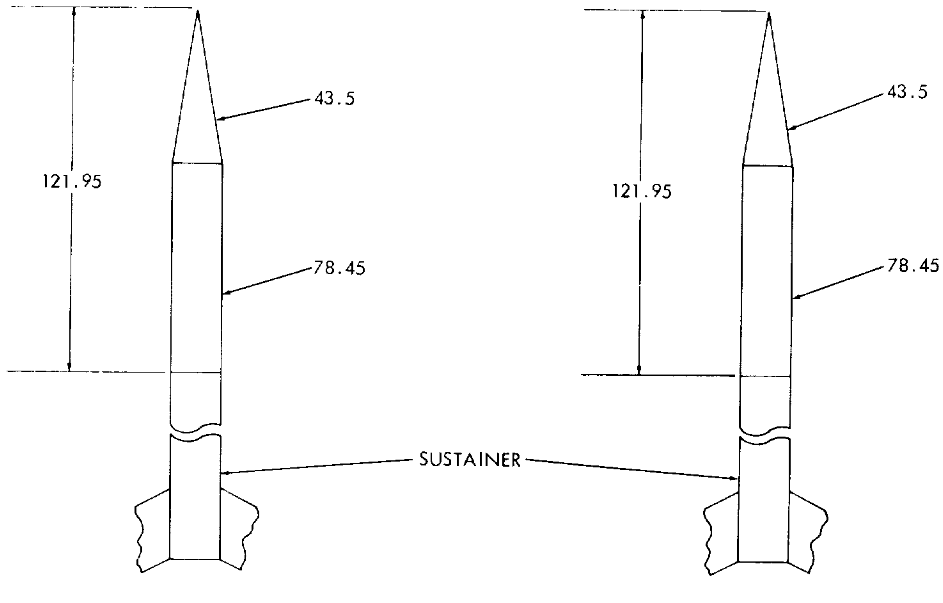
position looking up at the atmosphere, then down, then up again) despun and erected the vehicle, and then lost control. This resulted in the vehicle slowly turning to look down, but not recovering to look up again. The experiment was considered a success even with this malfunction, since the quality of experimental data received was excellent. Telemetry data was received for 520 seconds, and the nose cone (modified to eject the forward 47 inches at an altitude of 180,000 feet) ejected at 179,400 feet at T +63.2 seconds.

Figure 107 gives payload dimensions and characteristics of this rocket and its flight.

PHOTOGRAPHS

The following pages contain additional photographs of various phases of the sounding rocket program of the Goddard Space Flight Center. The topics covered are listed below, along with the number of the figures.

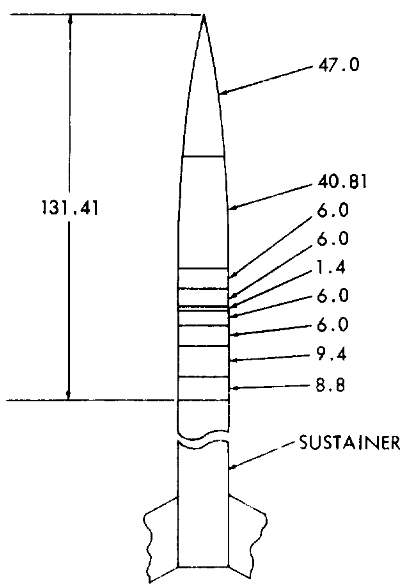
Topic	Figure Number
Payload extension package	108
Vacuum chamber instrumentation	109



	(a)		(b)
FLIGHT	4.93 II	FLIGHT	4.94 II
FIRING DATE	17 OCT. 63	FIRING DATE	31 OCT. 63
LAUNCH SITE	WI	LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	190.25	PAYLOAD WT. (LBS.)	192.00
APOGEE (ST. MI.)	116.40	APOGEE (ST. MI.)	114.70
TIME TO APOGEE (SEC.)	233.20	TIME TO APOGEE (SEC.)	231.15
CENTER OF GRAVITY (CAL.)	10.78	CENTER OF GRAVITY (CAL.)	10.78
CENTER OF PRESSURE (CAL.)	14.45	CENTER OF PRESSURE (CAL.)	14.50
STATIC MARGIN (CAL.)	3.67	STATIC MARGIN (CAL.)	3.72
RESTORING MOMENT (PER DEGREE)	-0.477	RESTORING MOMENT (PER DEGREE)	-0.485
SUSTAINER BURNOUT TIME (SEC.)	51.3	SUSTAINER BURNOUT TIME (SEC.)	51.5
ROLL RATE AT BURNOUT (RPS)	2.94	ROLL RATE AT BURNOUT (RPS)	2.25
TIP EJECT (SEC.)	na	TIP EJECT (SEC.)	na
NO. OF JOINTS	2.00	NO. OF JOINTS	2.00

Figure 106—Flights 4.93 II and 4.94 II - payload dimensions and flight characteristics.

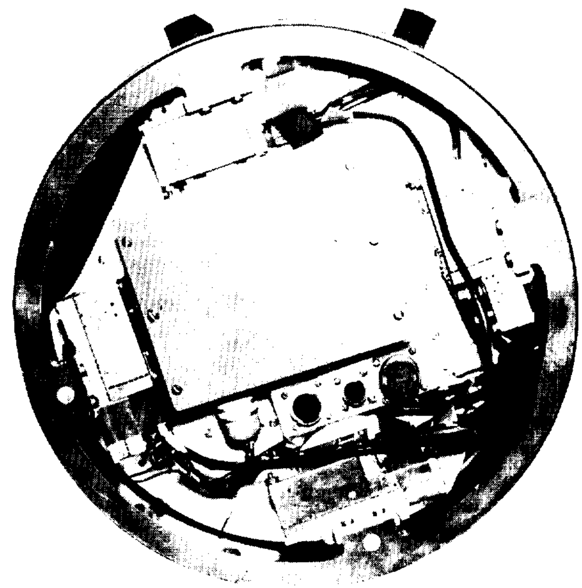
Topic	Figure Number
Typical instrumentation packages	110
Nose cone ejection mechanism	111, 112
Solar pointing control mechanisms	113
Aerobee 100 (Junior)	114
Aerobee 300A (Spaerobee)	115
Aerobee 150 launch operations	116
Aerobee 150A launch operations	117
Nose cone recovery at Fort Churchill	118
Nose cone recovery at Wallops Island	119



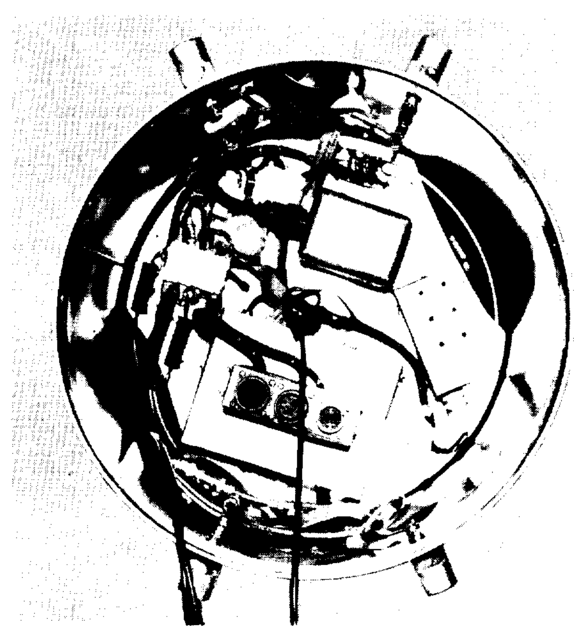
DIMENSIONS IN INCHES

FLIGHT	4.85 NA
FIRING DATE	18 NOV. 1963
LAUNCH SITE	WI
PAYLOAD WT. (LBS.)	203.80
APOGEE (ST. MI.)	114.60
TIME TO APOGEE (SEC.)	230.10
CENTER OF GRAVITY (CAL.)	11.58
CENTER OF PRESSURE (CAL.)	14.87
STATIC MARGIN (CAL.)	3.29
RESTORING MOMENT (PER DEGREE)	-0.427
SUSTAINER BURNOUT TIME (SEC.)	52.40
ROLL RATE AT BURNOUT (RPS)	2.38
TIP EJECT (SEC.)	63.20
NO. OF JOINTS	9.00

Figure 107—Flight 4.85 NA - payload dimensions and flight characteristics.



(a) Forward end view.



(b) Aft end view.

Figure 108—Payload extension package.

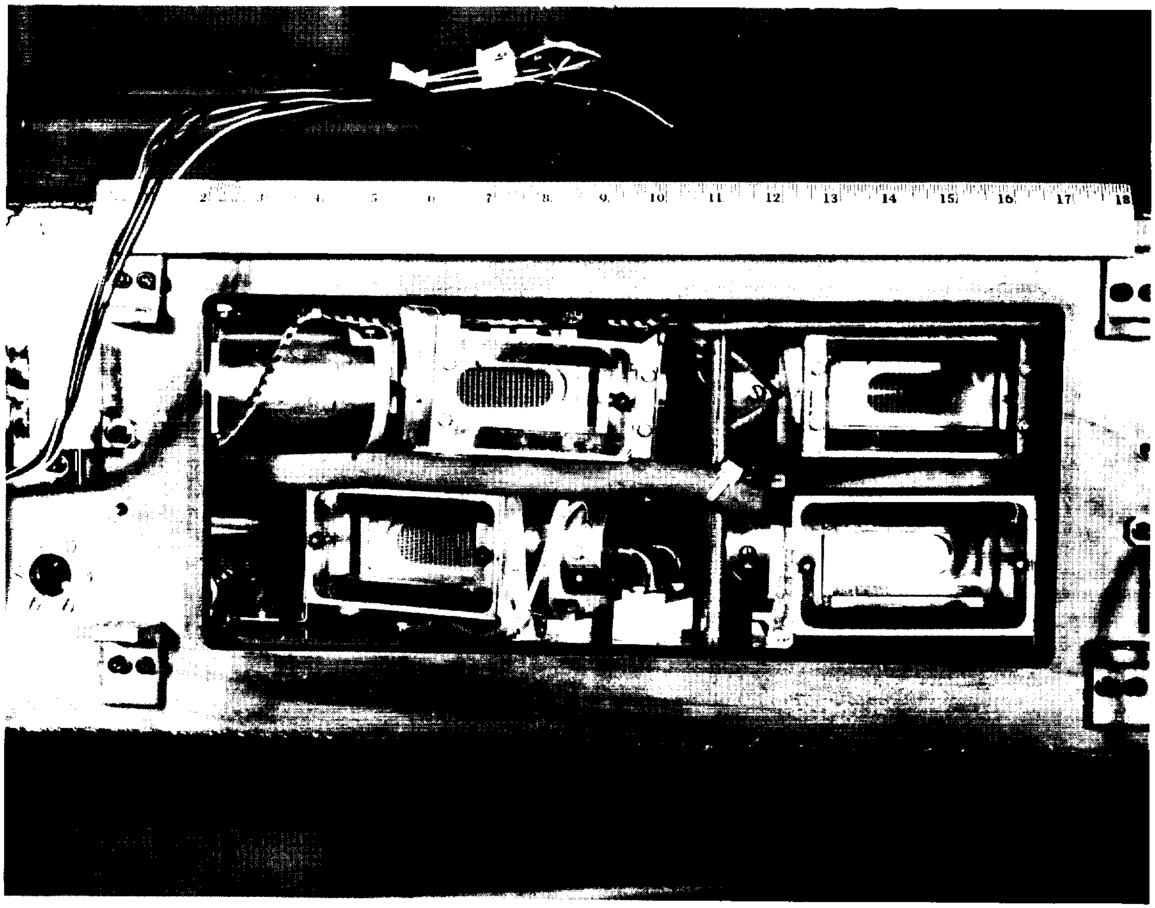
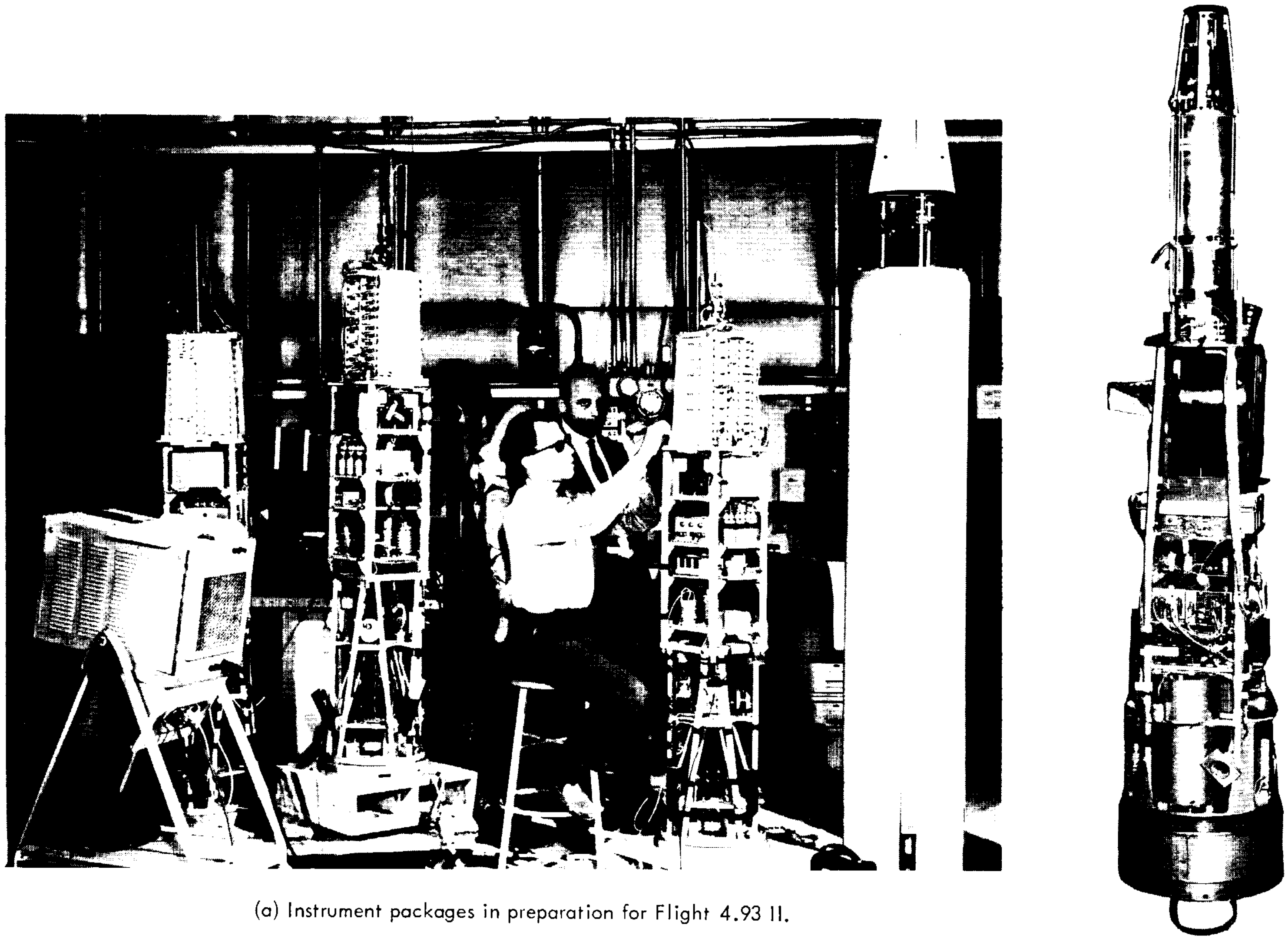


Figure 109—Vacuum chamber instrumentation flown on Aerobee rocket 4.69 CG.

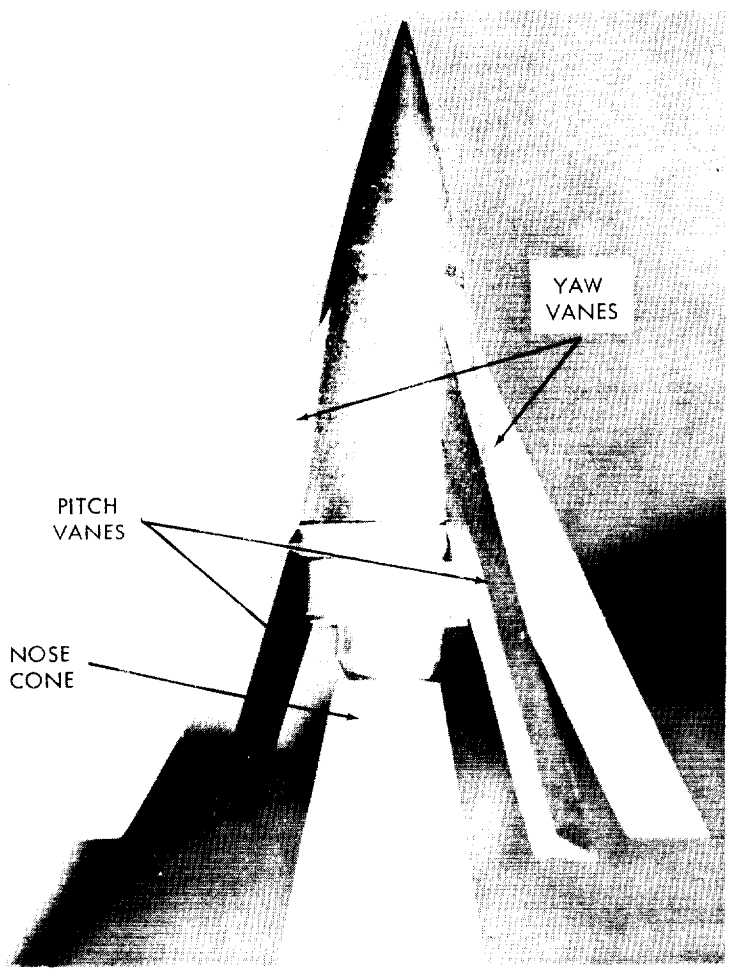


(a) Instrument packages in preparation for Flight 4.93 II.

(b) Assembled instrument package (Flight 4.64 GI).

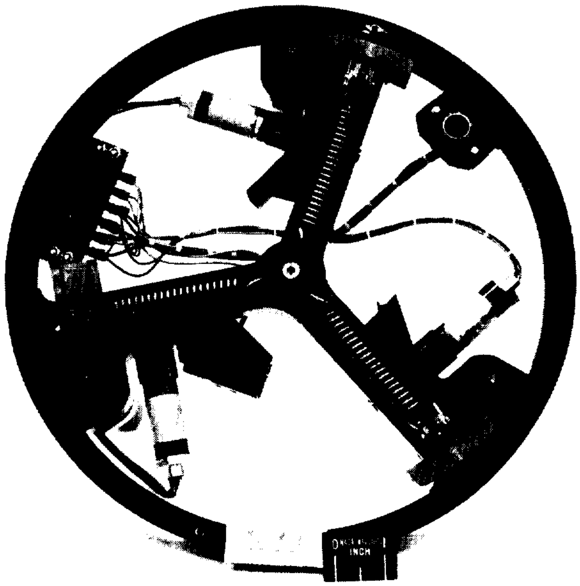
Figure 110—Aerobee instrument packages.

(c) Instrumentation section (to be inserted in nose cone).

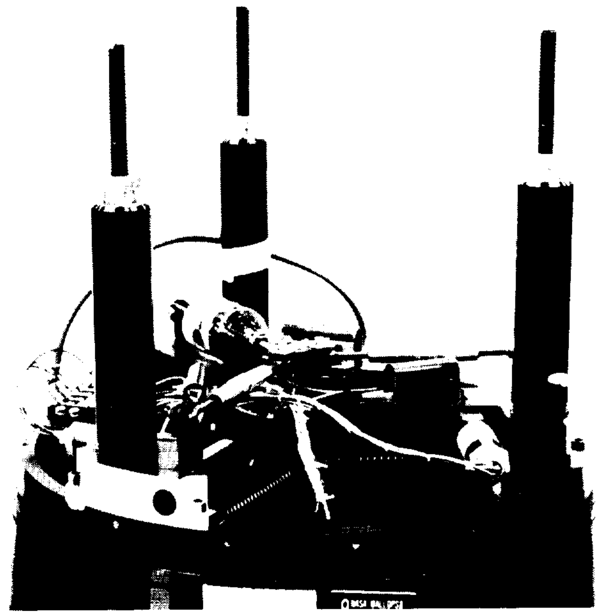


(d) Sounding rocket attitude (pitch-yaw) transducer.

Figure 110—Aerobee instrument packages.



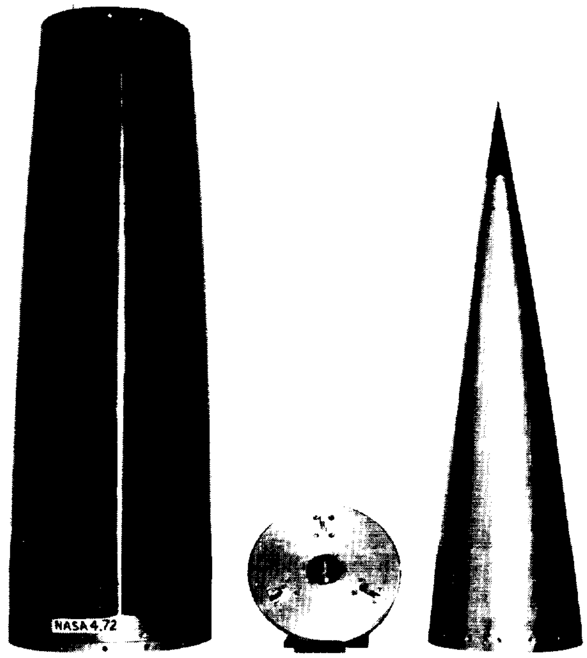
(a)



(b)

(c)

Figure 111—Nose cone ejection mechanism components.

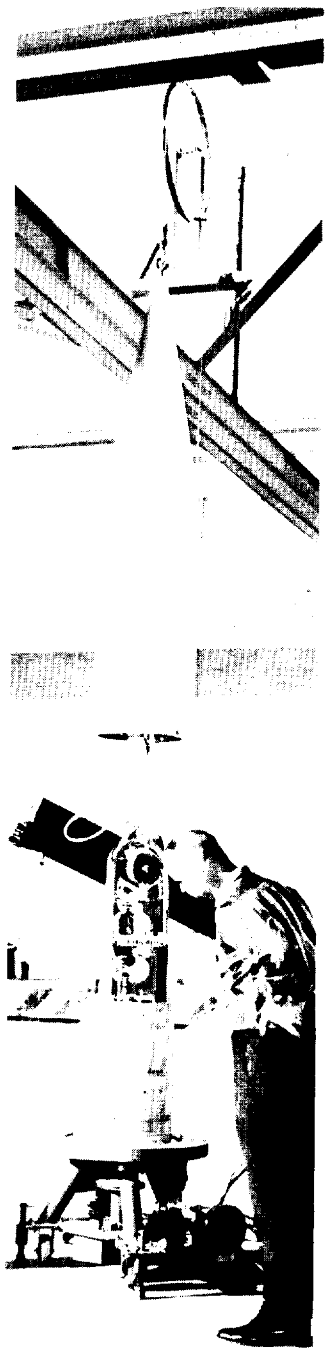


(a) Separated nose cone and forward side of release cam bulkhead.

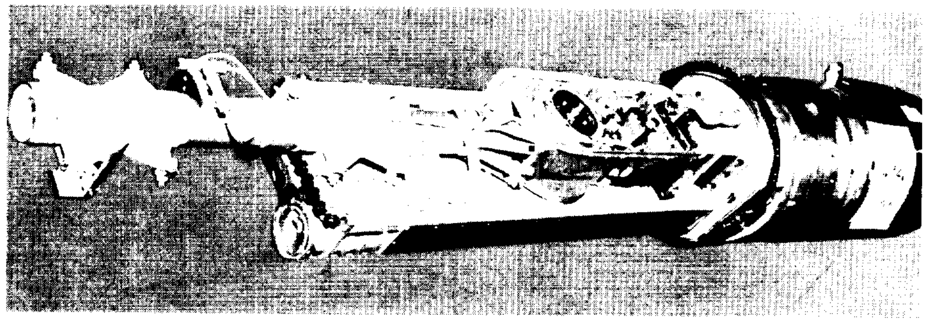
(b) Closeup of aft side of bulkhead.

(c) Closeup of forward side of bulkhead.

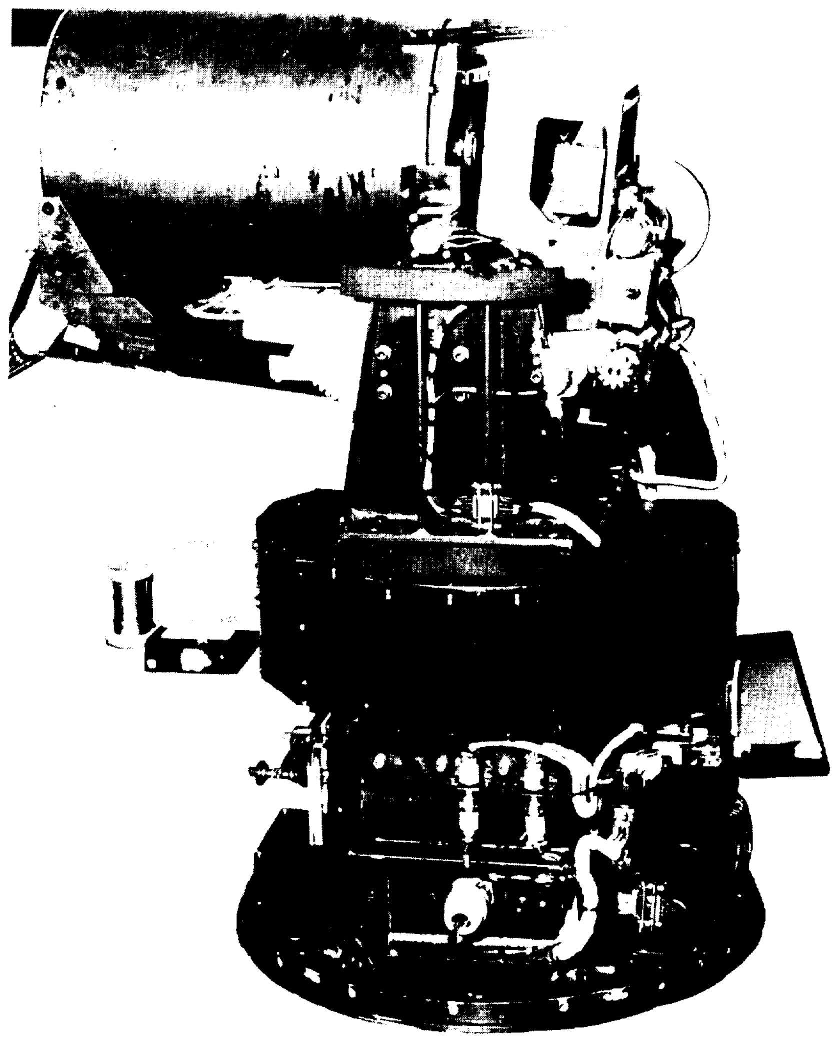
Figure 112—Release cam bulkhead of nose cone ejection mechanism.



(a) Test of the SPC (Ball Bros.) prior to final rocket assembly.

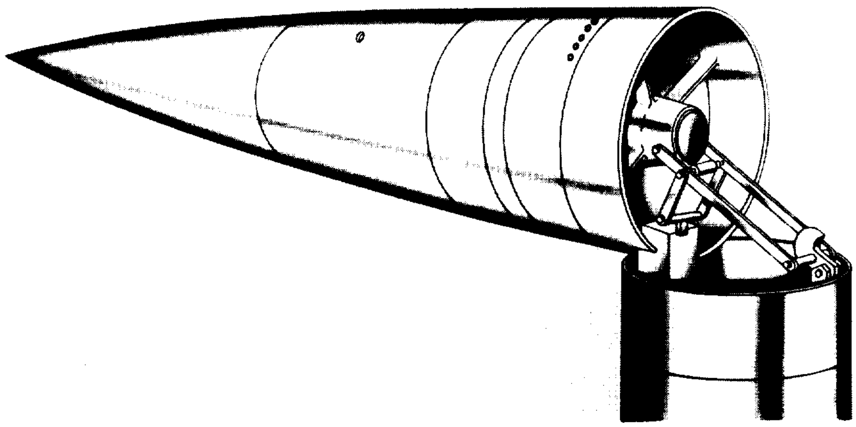


(b) Closeup view of the Model SPC-400 mechanism (Ball Bros.).



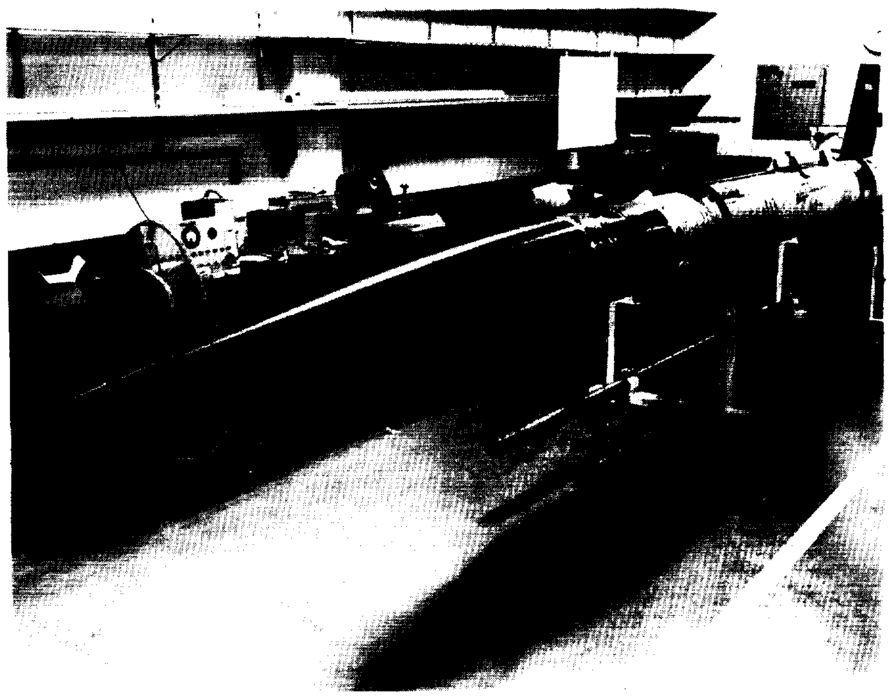
(c) Closeup of an early model of the Ball Bros. device.

Figure 113—Solar pointing control mechanisms.



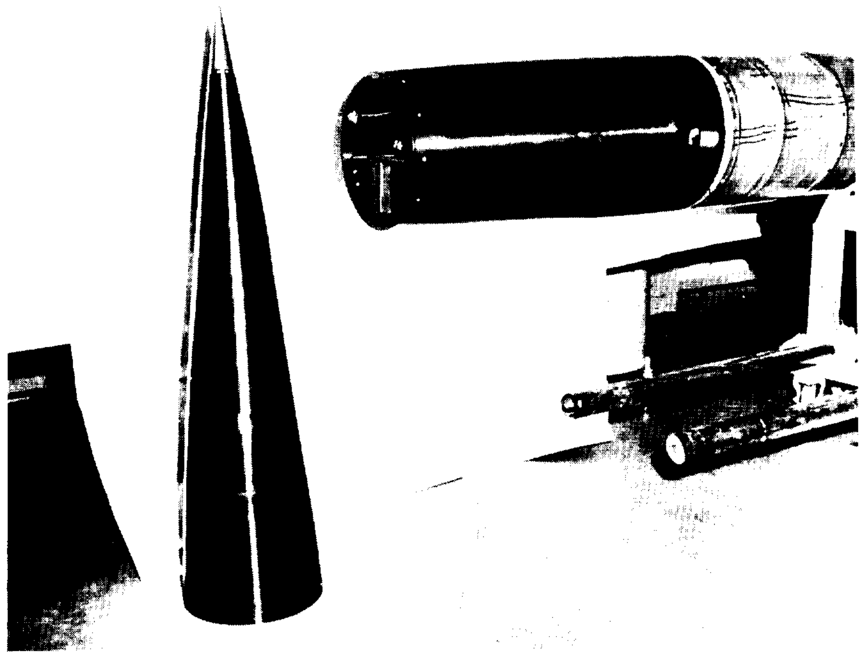
(d) Control linkages.

Figure 113—Solar pointing control mechanisms.



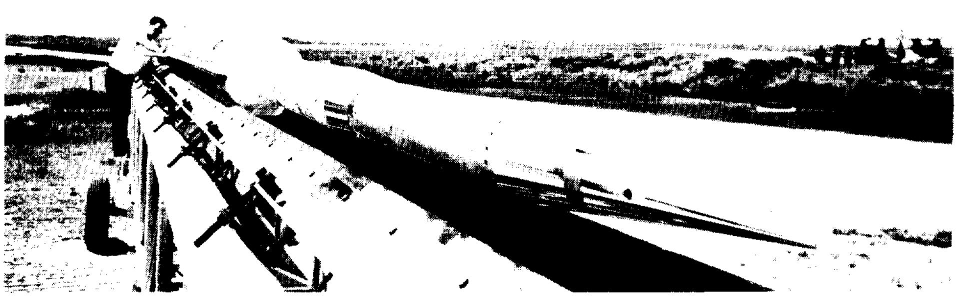
(a) Rocket on assembly dolly.

Figure 114—Aerobee 100 (Junior).



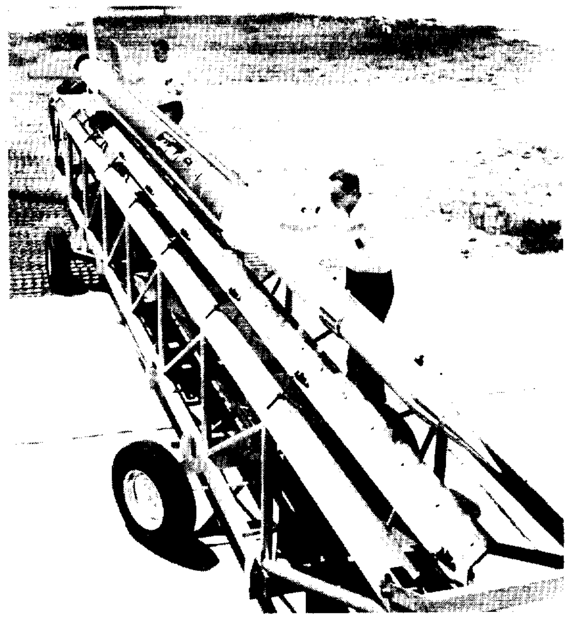
(b) Nose cone eject prior to final assembly.

Figure 114—Aerobee 100 (Junior).

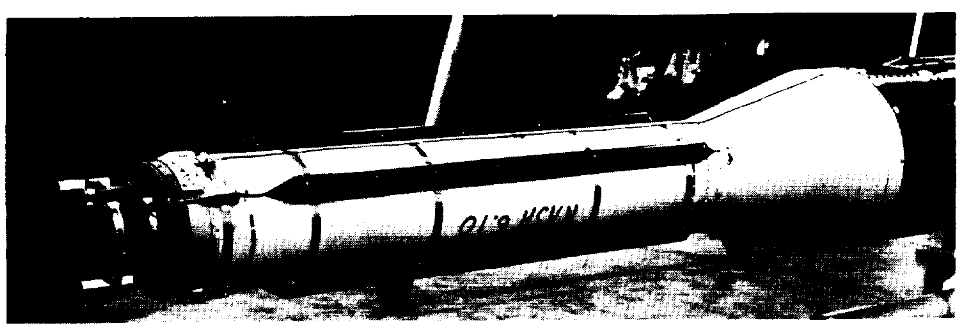


(a) Side view.

Figure 115—Aerobee 300A.

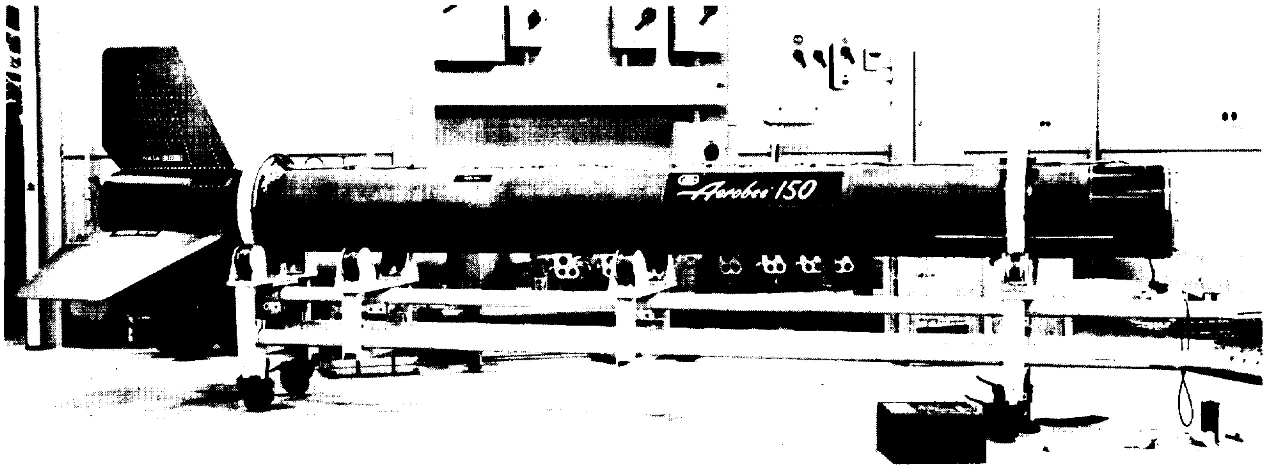


(b) Top view.

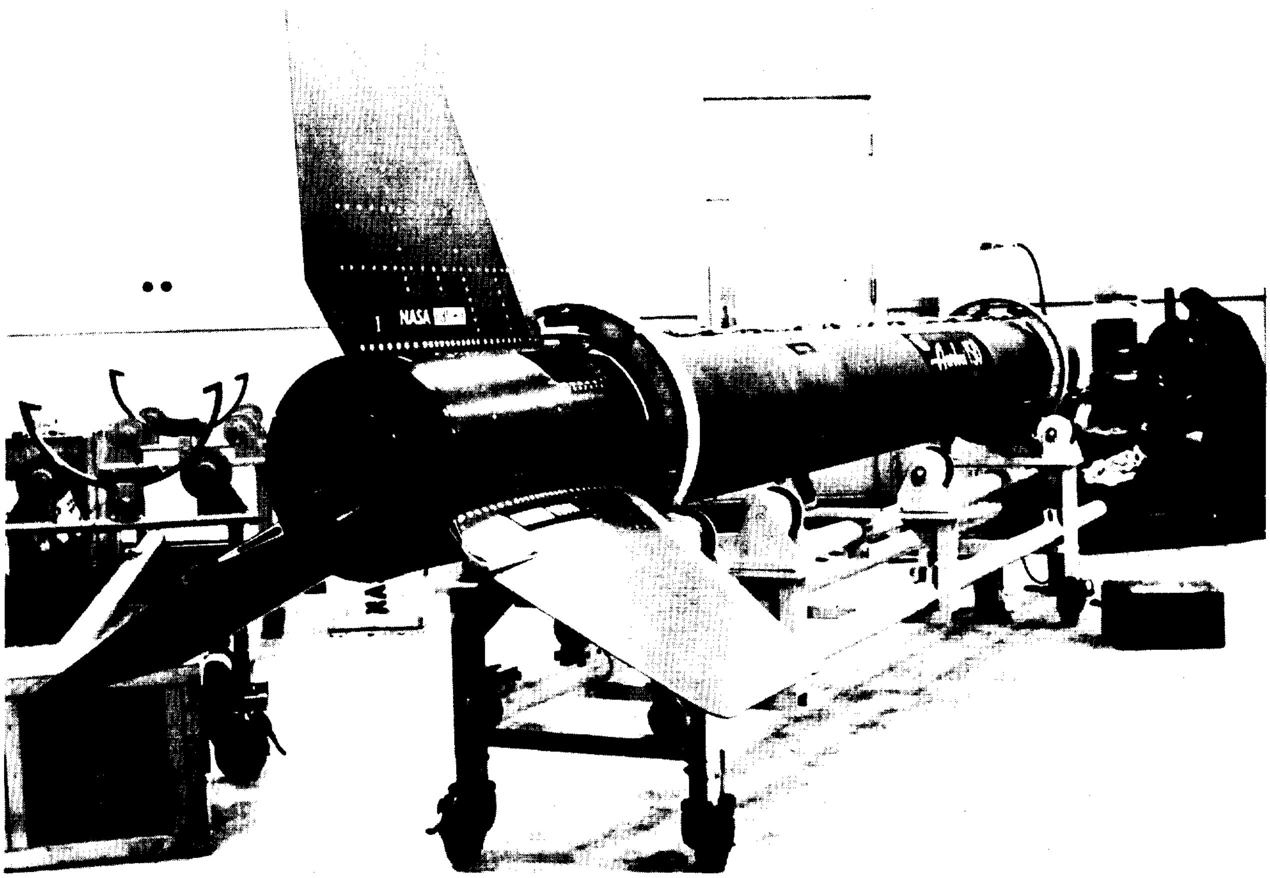


(c) Third stage motor with DOVAP transducers and antennas.

Figure 115—Aerobee 300A.

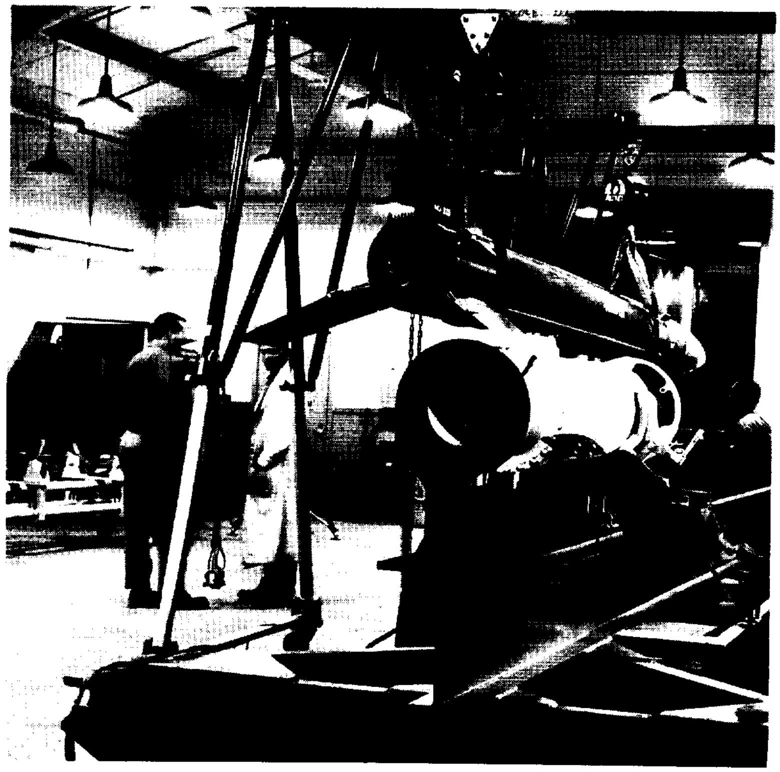


(a) Sustainer motor, side view.

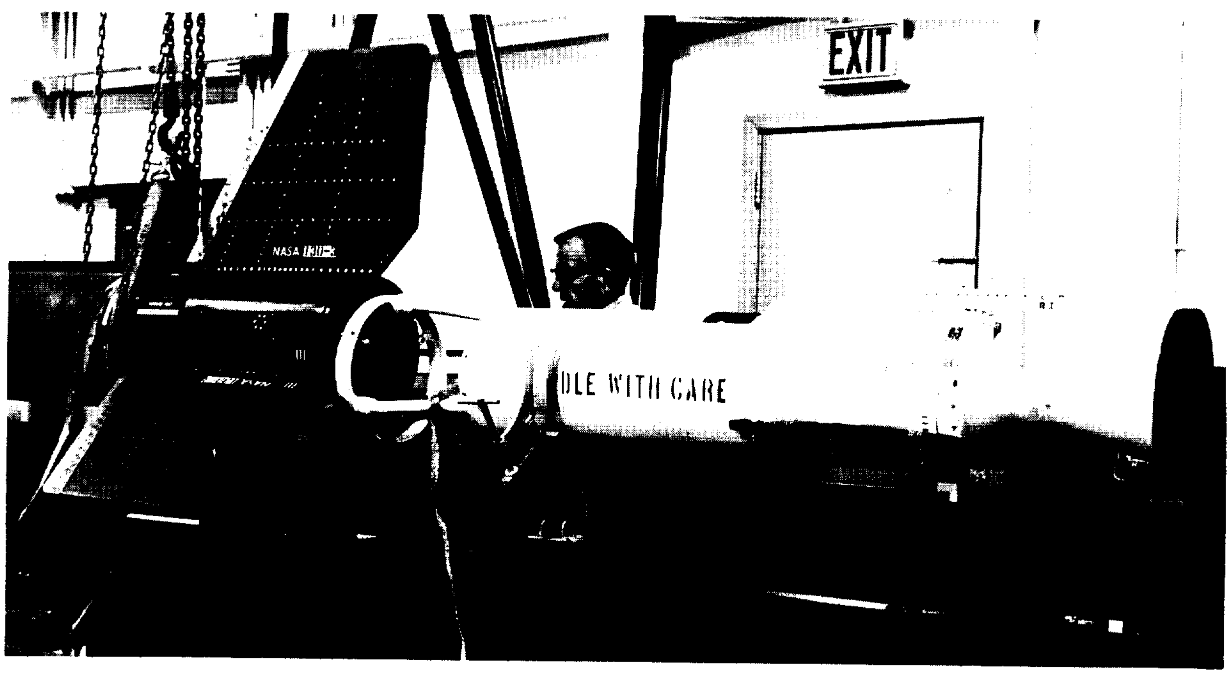


(b) Sustainer motor, end view.

Figure 116—Aerobee 150 launch operations (Ft. Churchill).

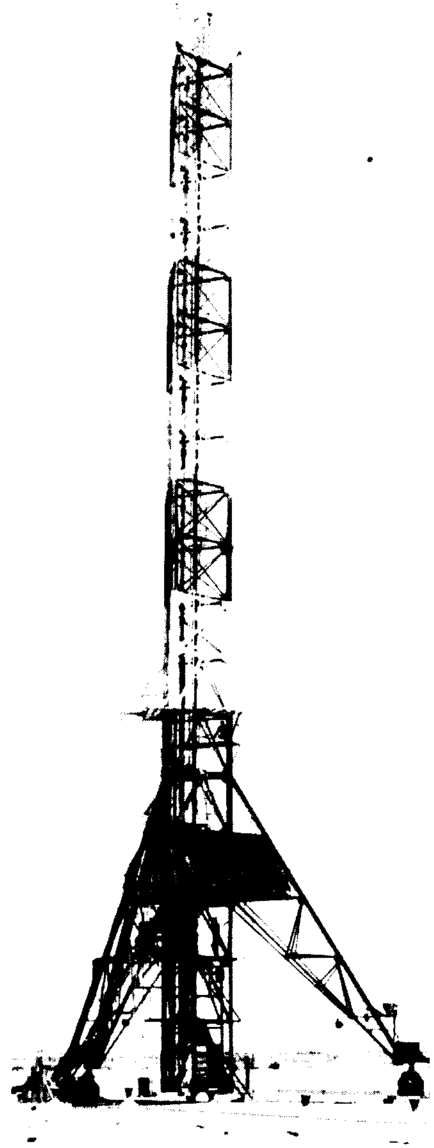


(c) Transfer of rocket from assembly dolly to launch rail dolly.

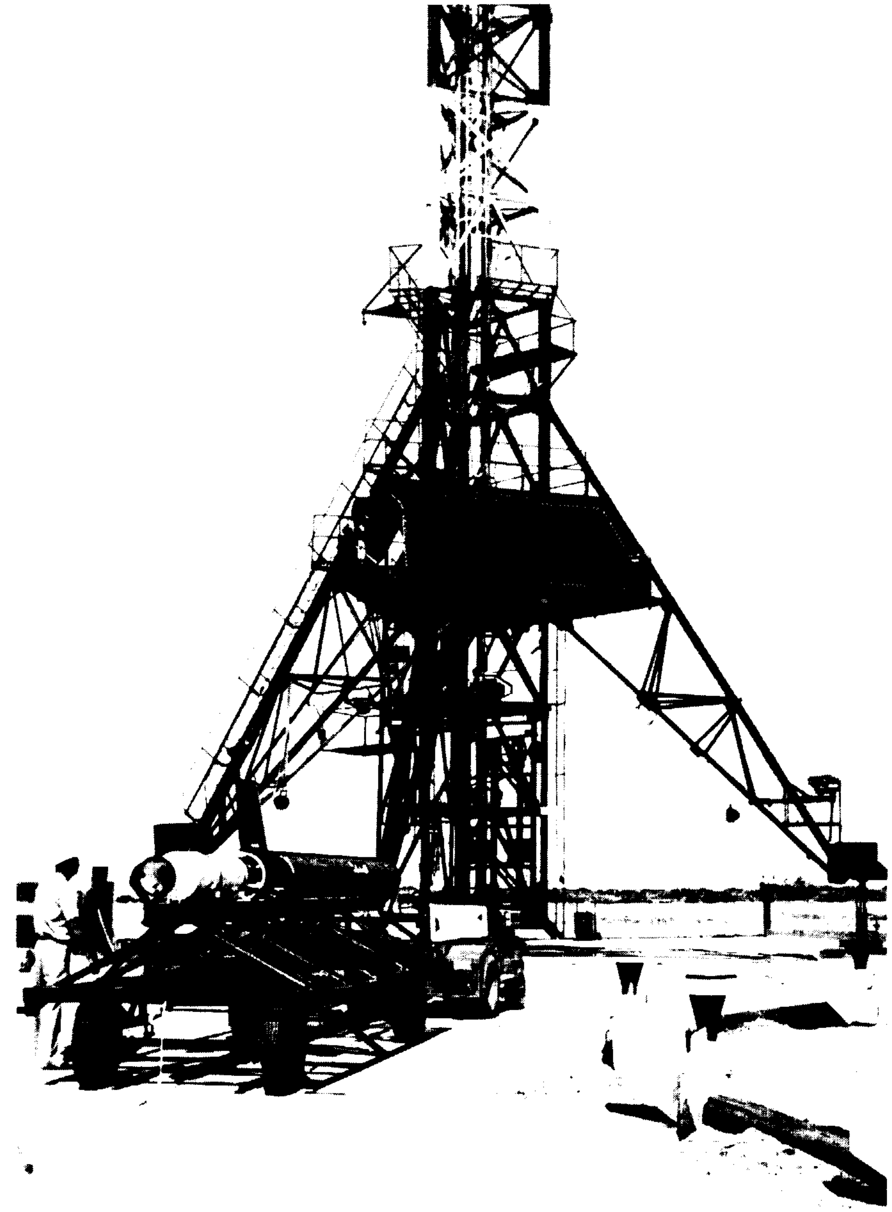


(d) Mating with booster motor.

Figure 116—Aerobee 150 launch operations (Ft. Churchill).

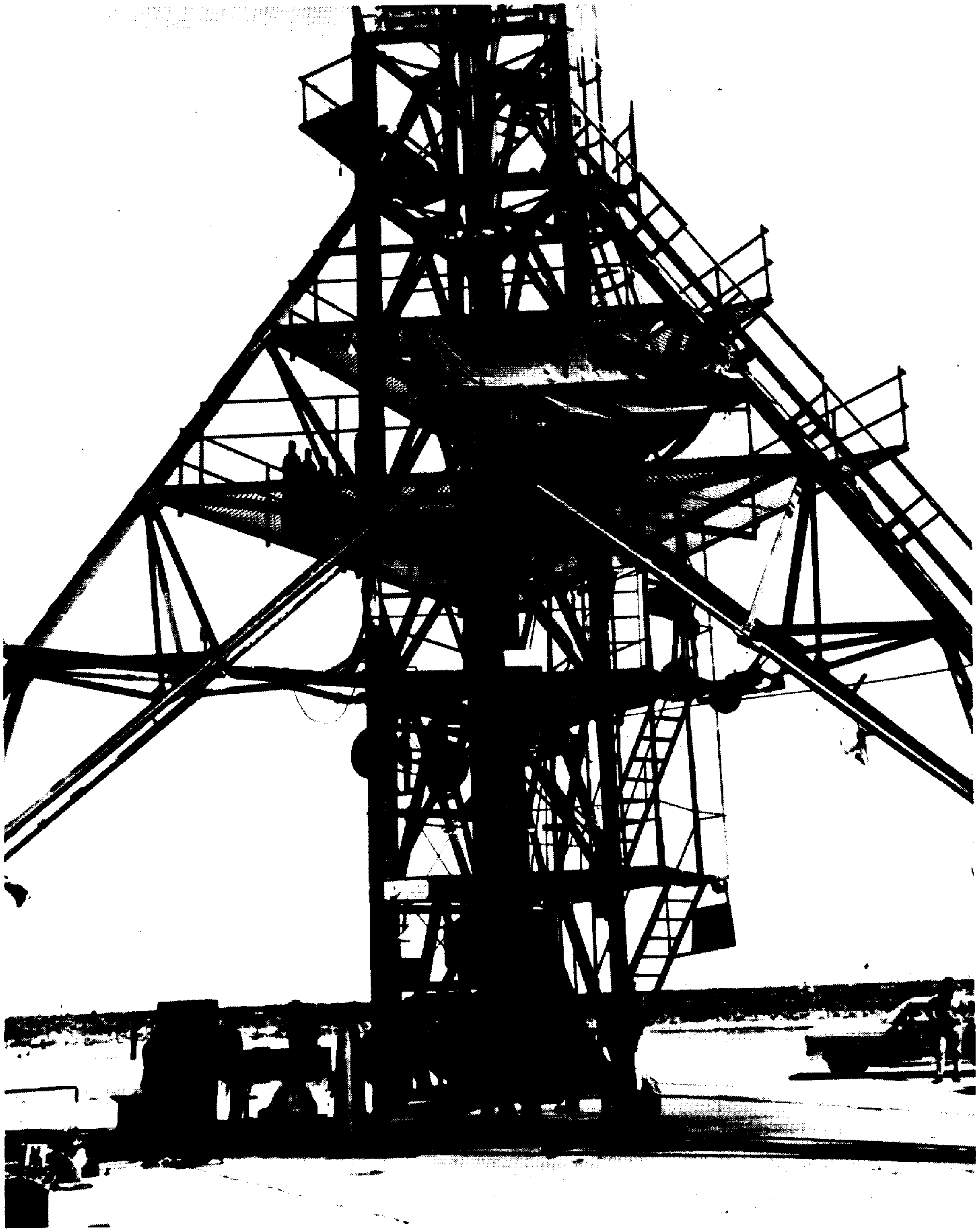


(e) Overall view of launch tower.



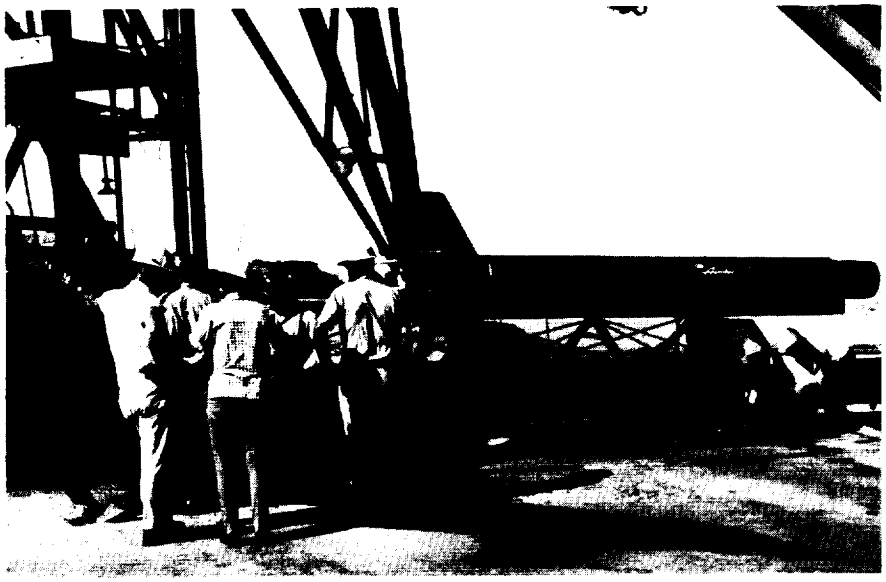
(f) Launch tower with sounding rocket ready for installation.

Figure 116–Aerobee 150 launch operations (WSMR).

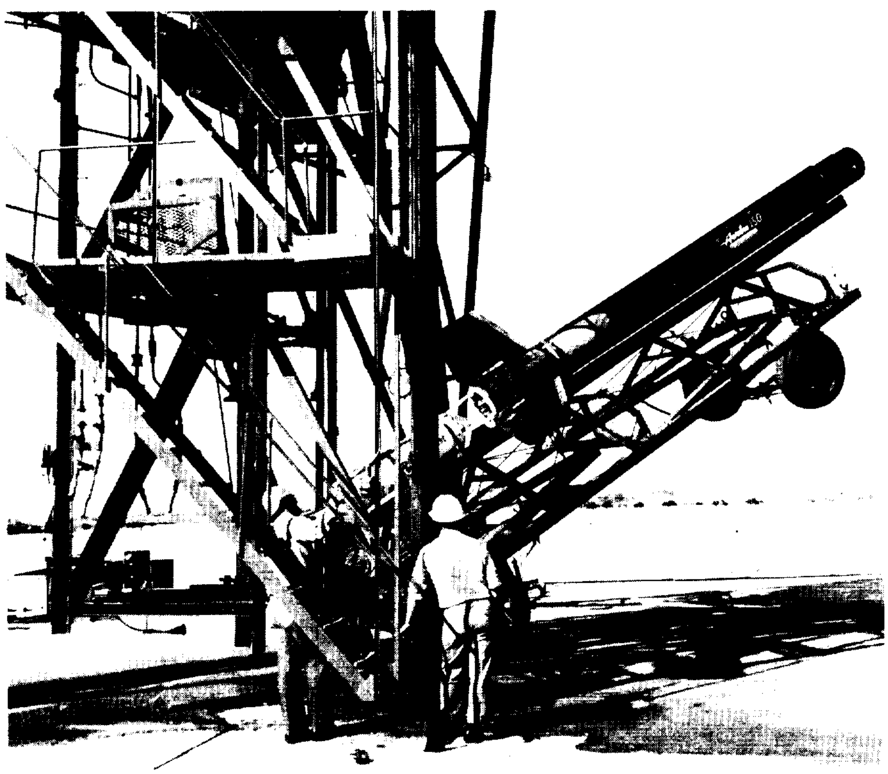


(g) Closeup view of base of launch tower (WSMR).

Figure 116—Aerobee 150 launch operations.

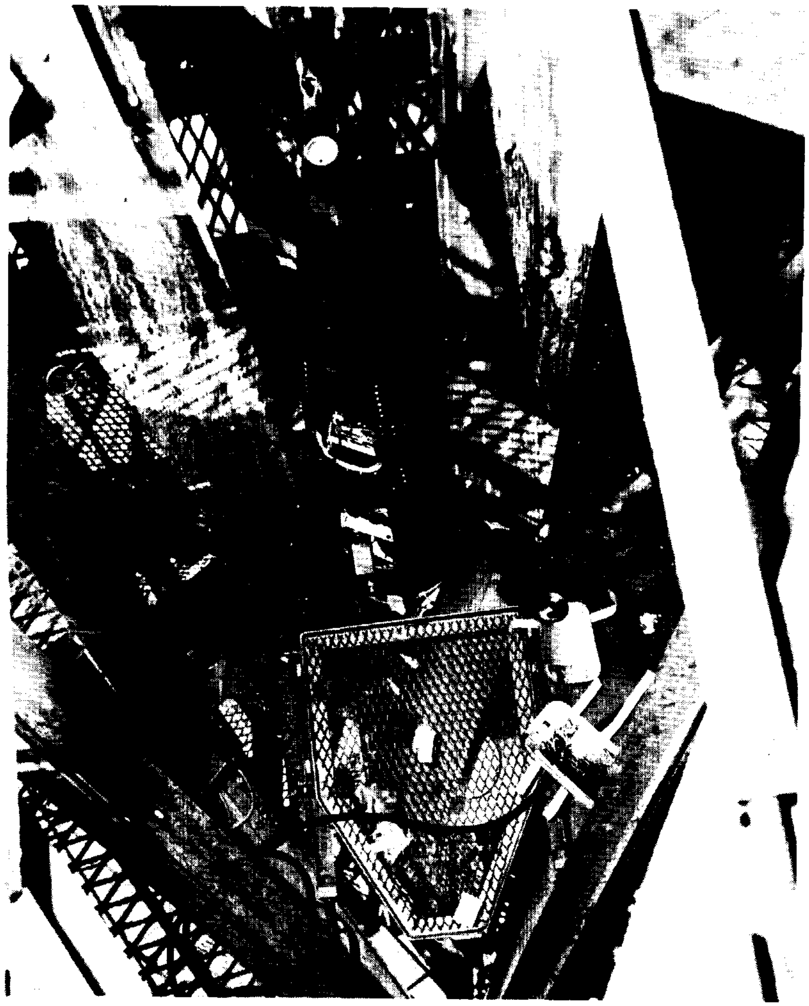


(h) Launch rail dolly backed up to base of launch tower (WSMR).

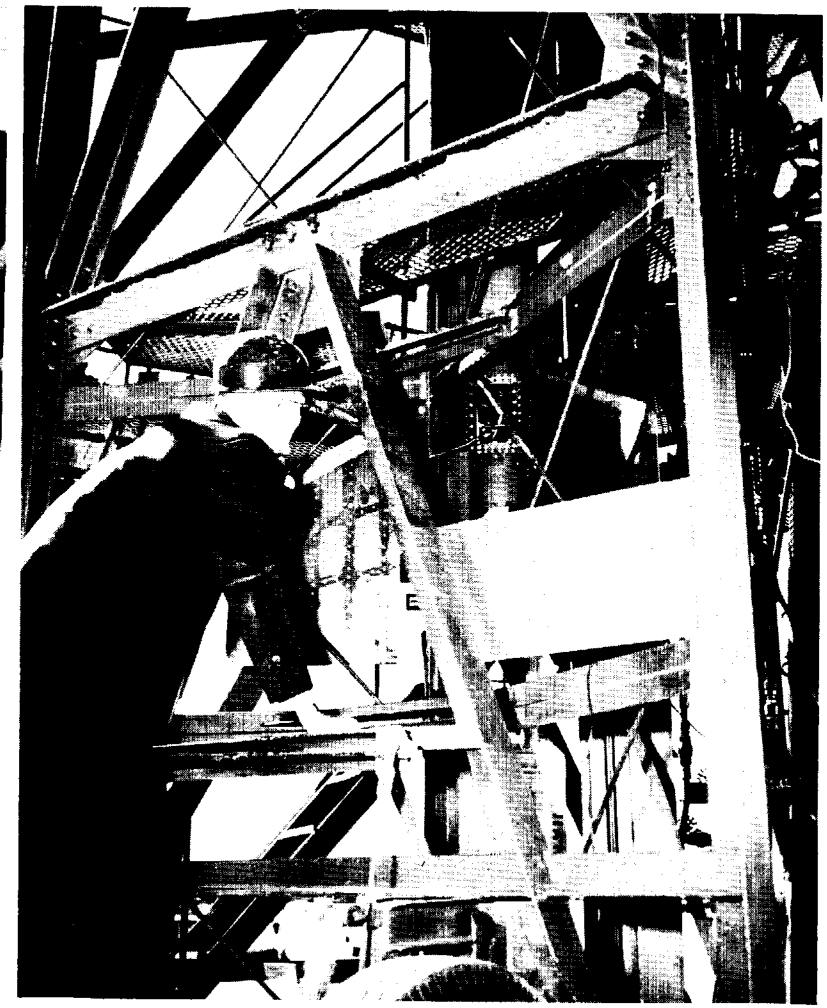


(i) Sounding rocket being lifted into launch tower (WSMR).

Figure 116—Aerobee 150 launch operations.

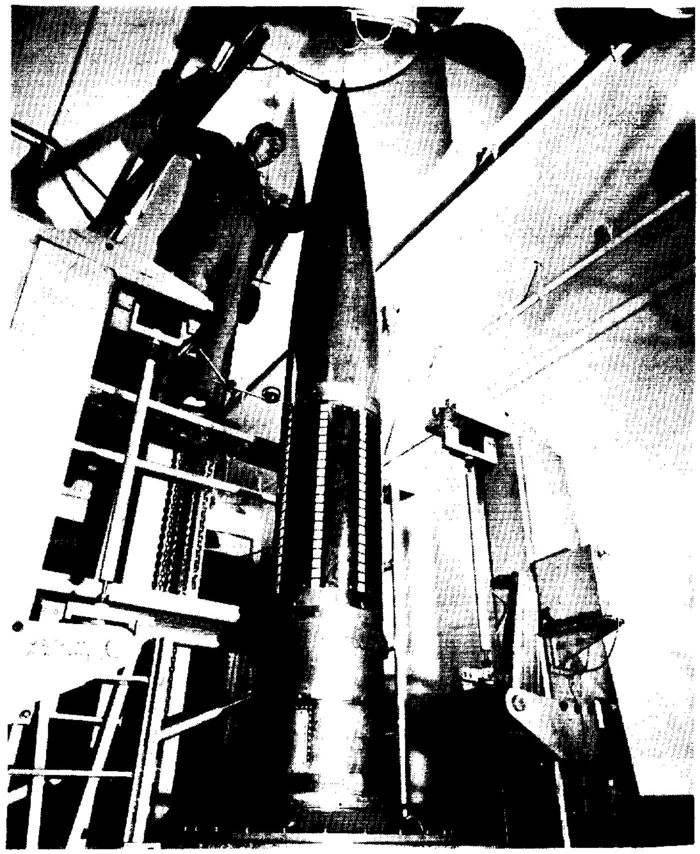


(j) Payload in the tower.

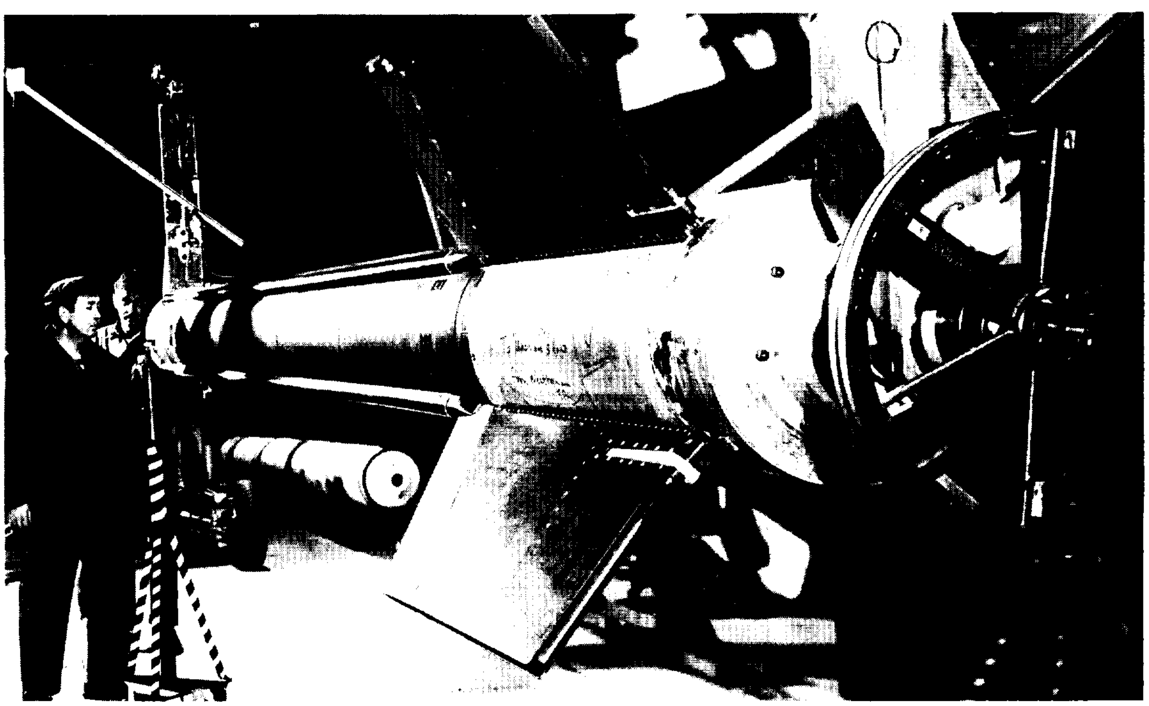


(k) Tail circuit check by range safety.

Figure 116—Aerobee 150 launch operations (WSMR).



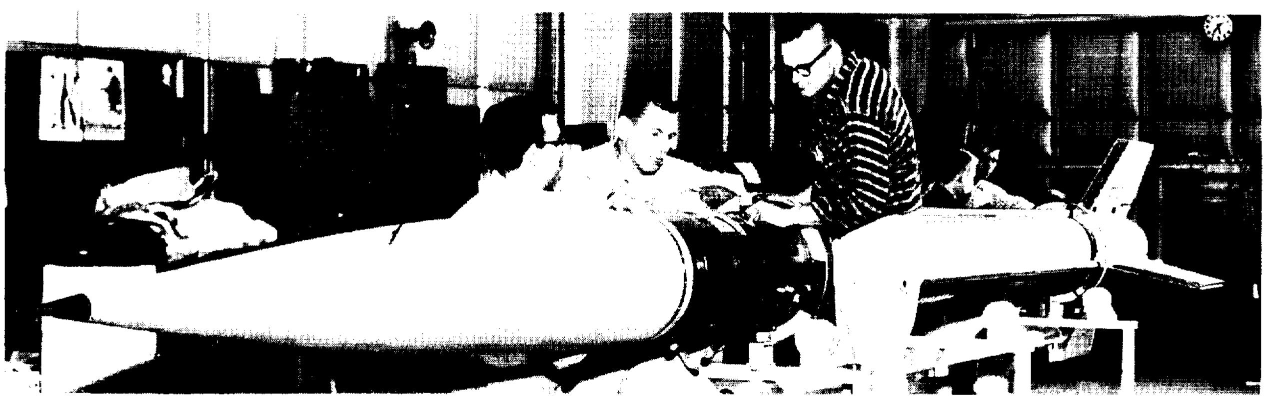
(a) Payload extension and nose cone on vertical spin table (WI).



(b) Sustainer motor on horizontal spin unit.

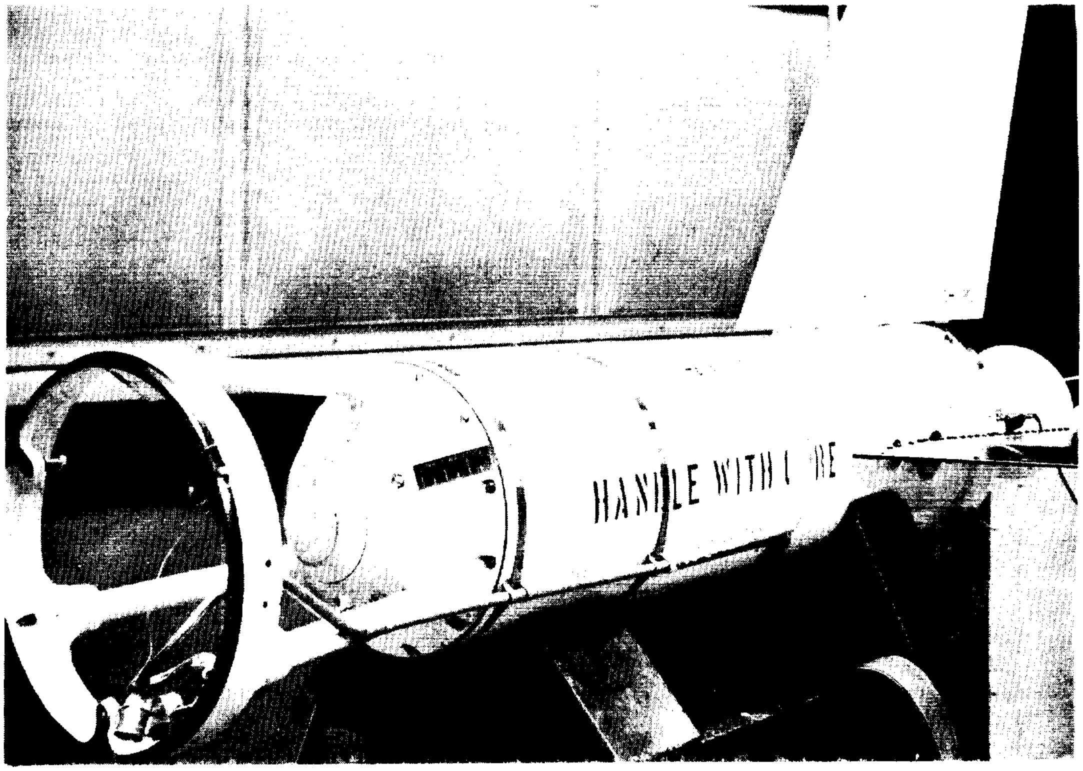
Figure 117—Aerobee 150A launch operations (WI).

(c) Fin alignment Aerobee 150A.

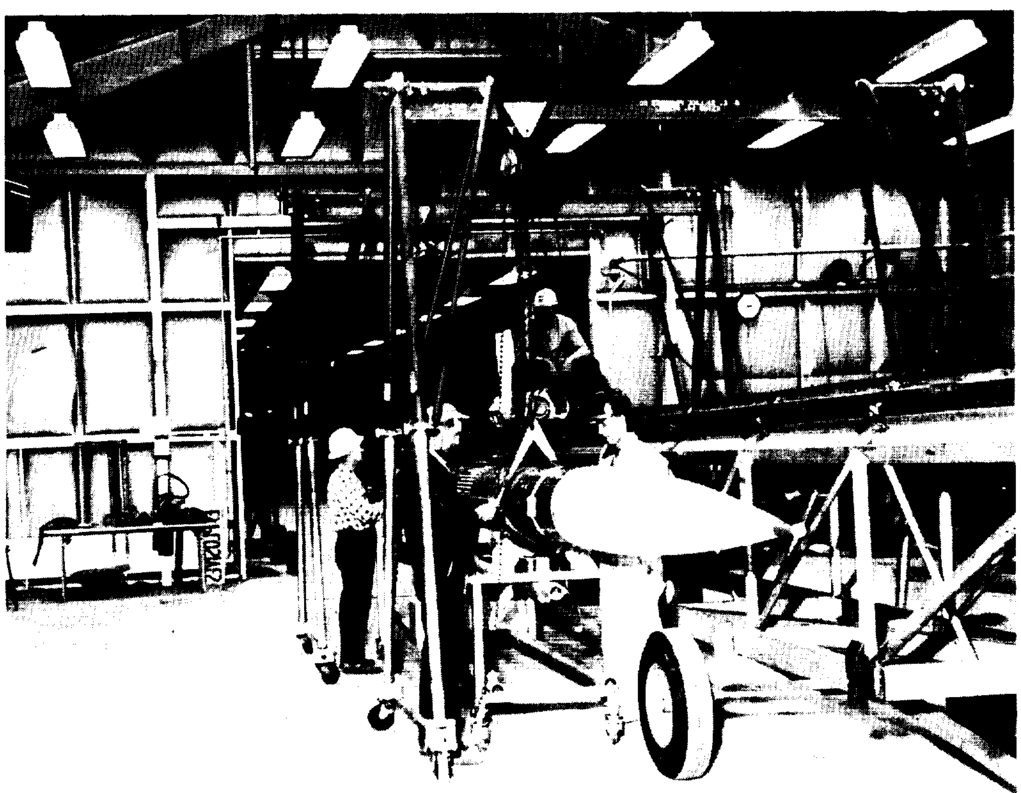


(d) Rocket in checkout room prior to transfer to launch rail dolly.

Figure 117—Aerobee 150A launch operations.

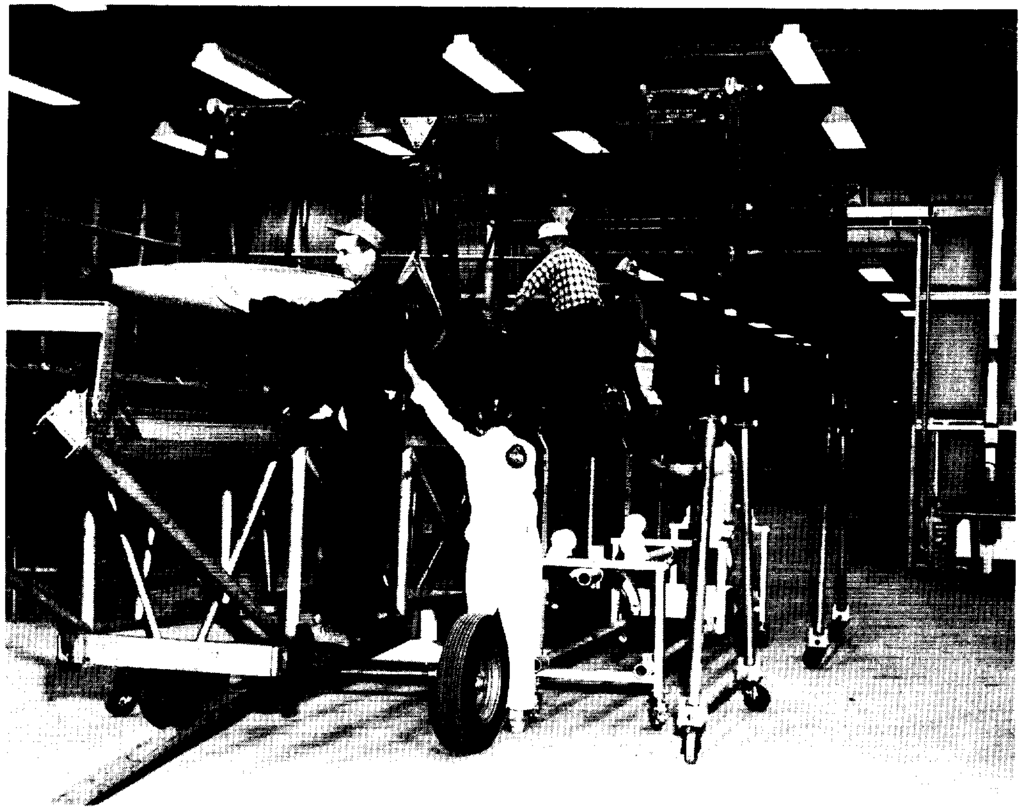


(e) Booster motor.

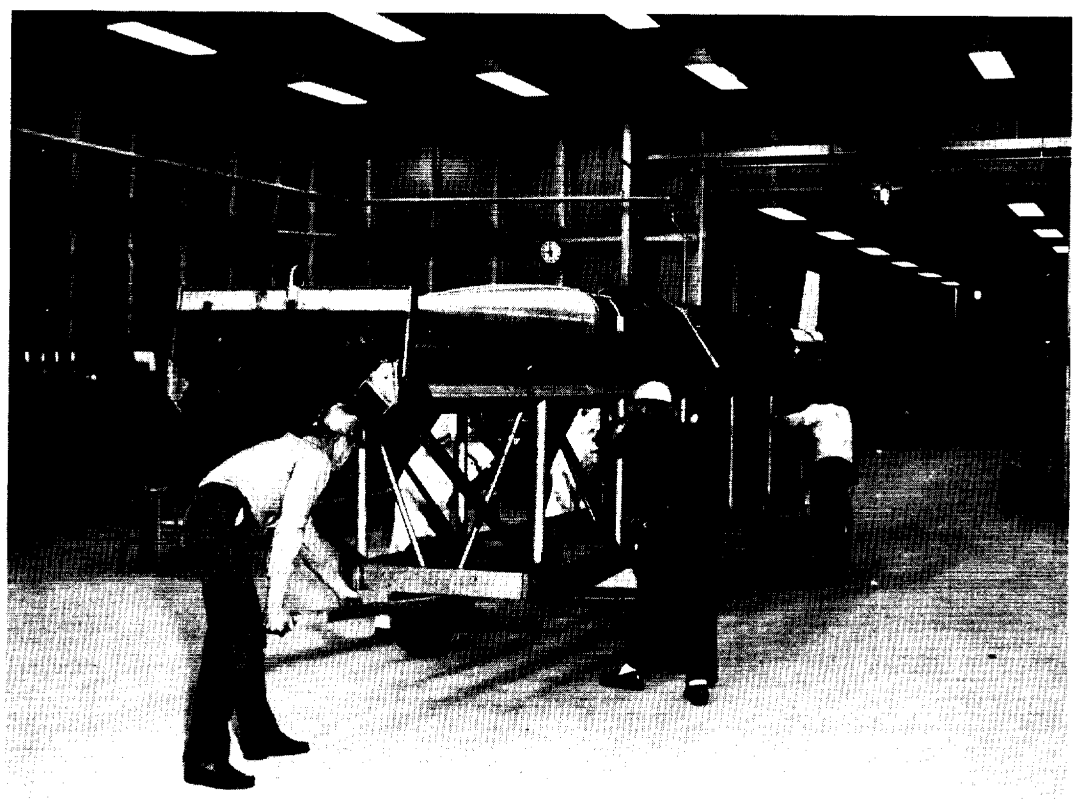


(f) Transfer of sounding rocket from assembly dolly to launch rail dolly, Step I.

Figure 117—Aerobee 150A launch operations.

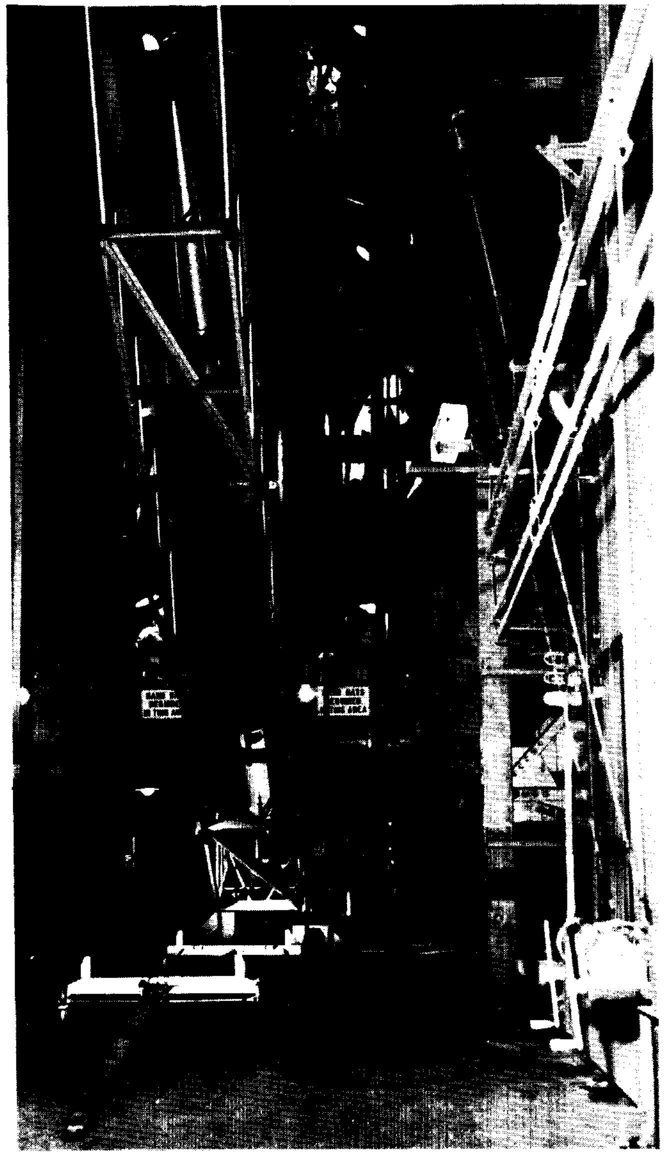


(g) Transfer of sounding rocket from assembly dolly to launch rail dolly, Step II.

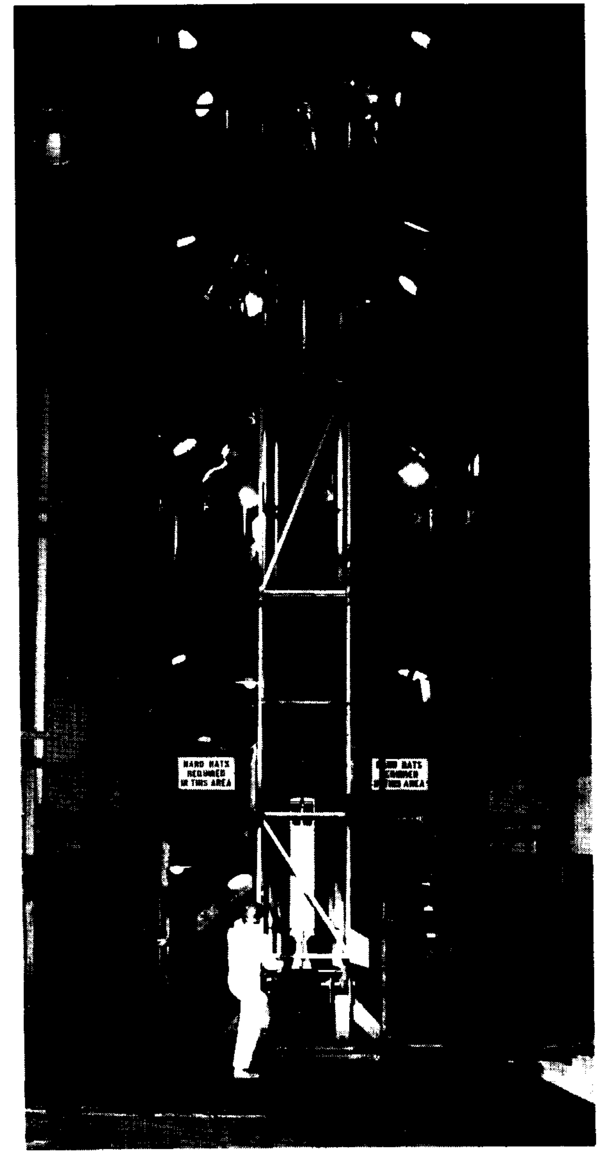


(h) Step III.

Figure 117—Aerobee 150A launch operations.

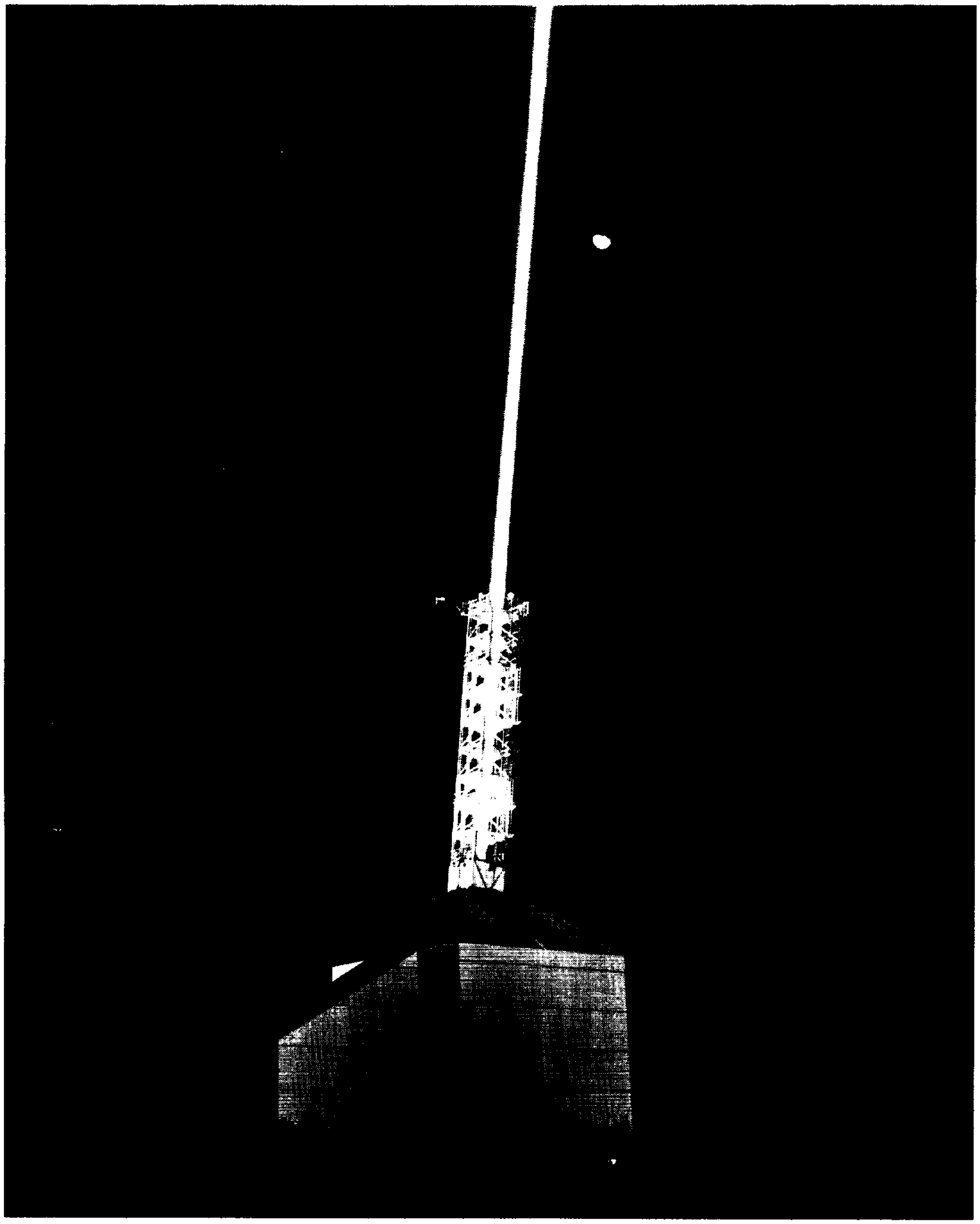


(i) Lifting of launch rail dolly and sounding rocket into launch tower.



(j) Final checkout of rocket.

Figure 117—Aerobee 150A launch operations.



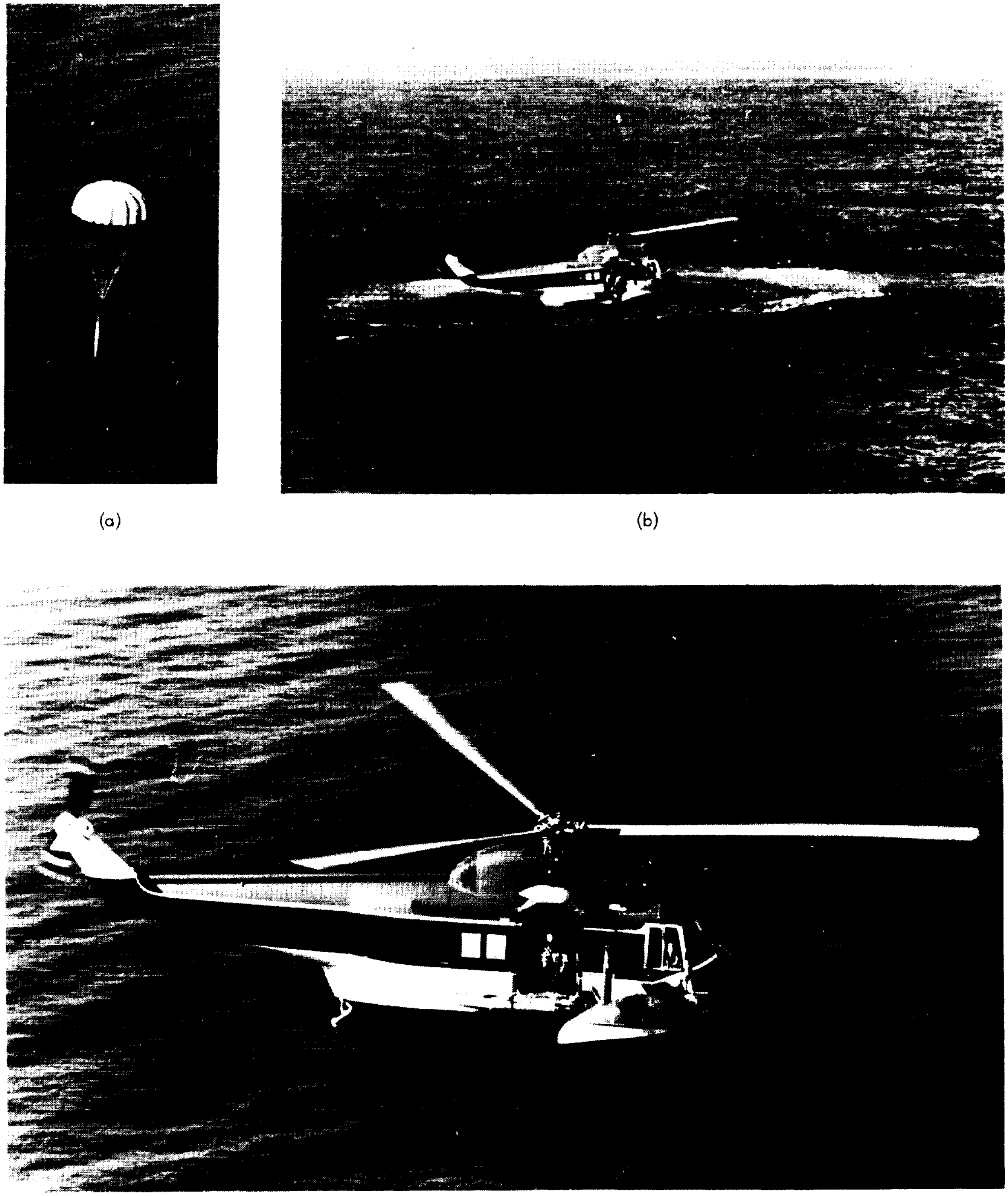
(k) Night firing of rocket (WI).

Figure 117—Aerobee 150A launch operations.

(a)

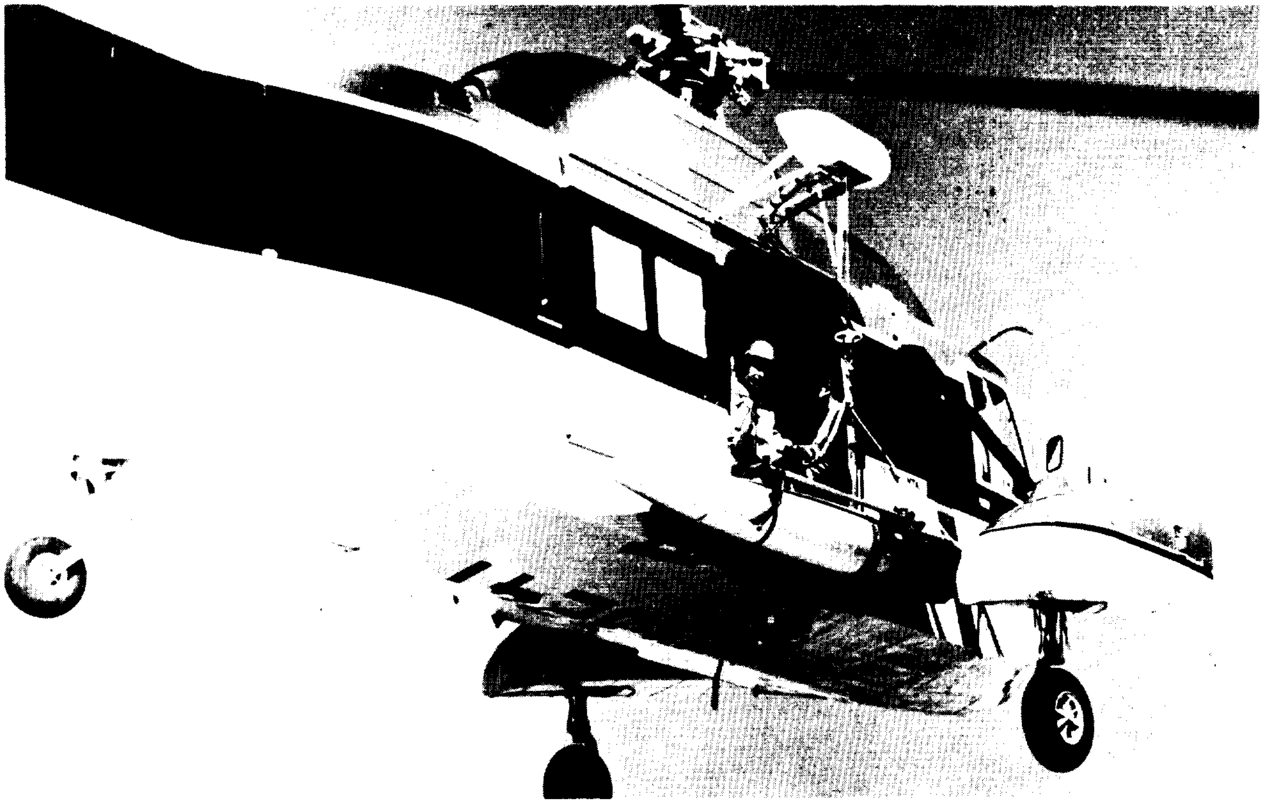
(b)

Figure 118—Recovery of nose cone fired at Fort Churchill.



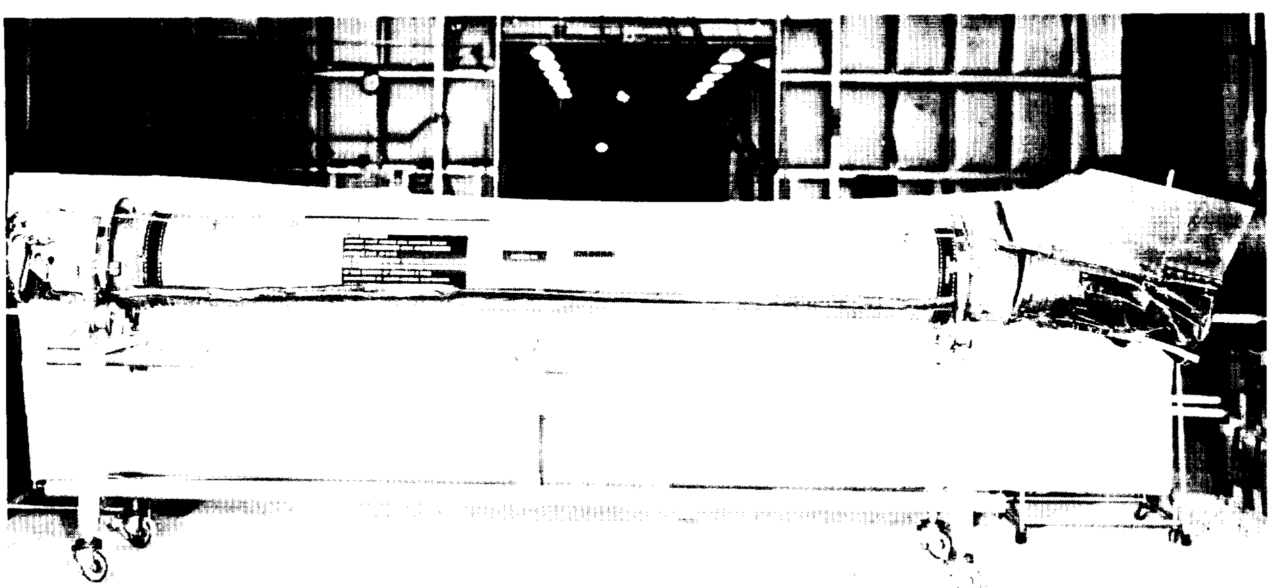
(a) (b) (c)

Figure 119—Recovery of nose cone fired at Wallops Island (Flight 4.48 GT).



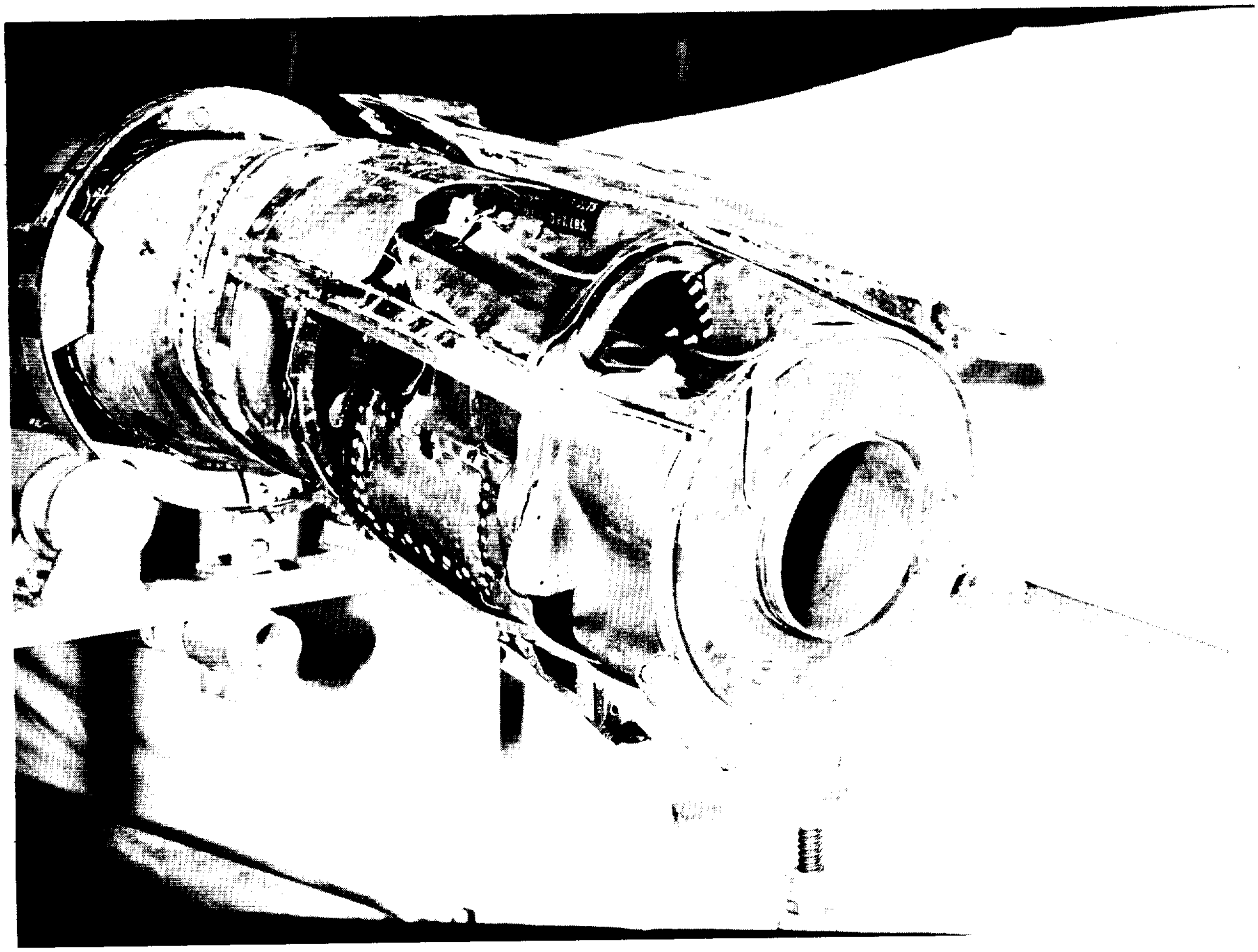
(d)

Figure 119—Recovery of nose cone fired at Wallops Island (Flight 4.48 GT).



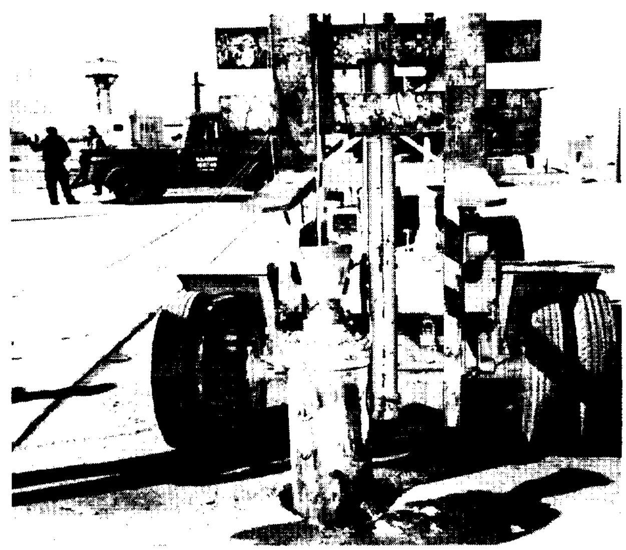
(a)

Figure 120—Recovered sustainer motor (Flight 4.48 GT). Damage resulted from impact.



(b)
Figure 120—Recovered sustainer motor (Flight 4.48 GT).
Damage resulted from Impact.

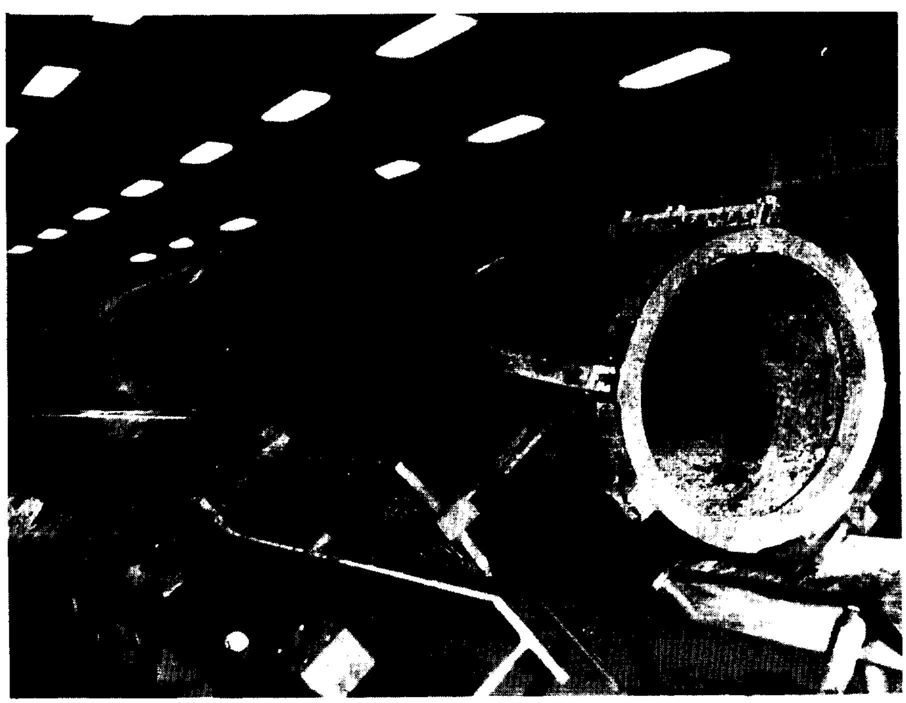
(a)



(b)

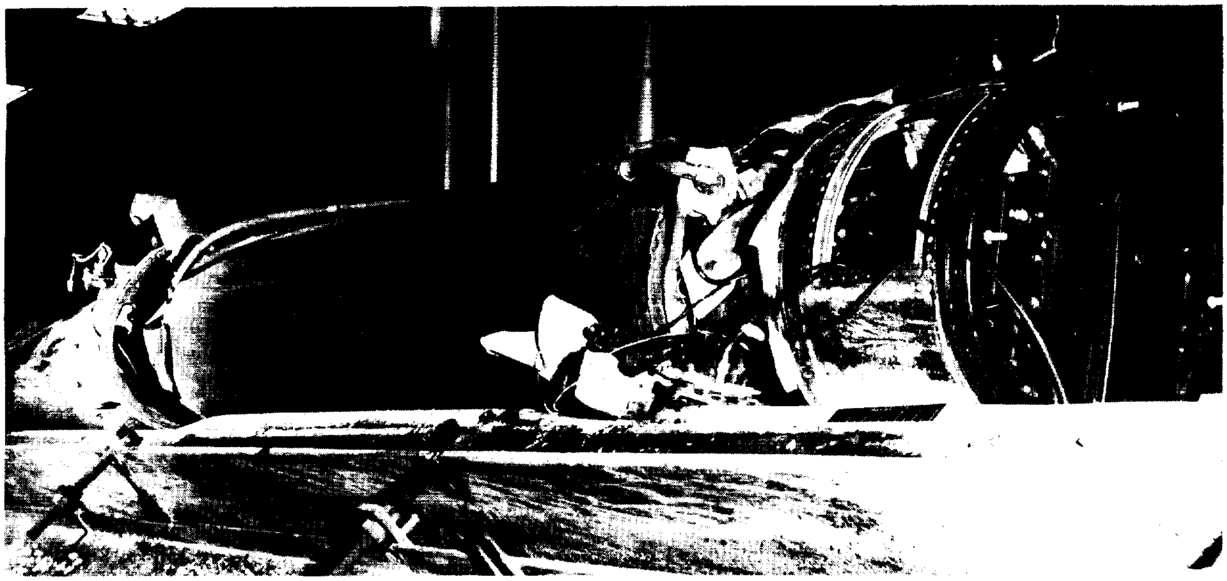
Figure 121—Booster motor which impacted on concrete launch pad behind tower (NASA 1.14).

Figure 122—Crater resulting from impact and detonation of unfired sustainer (Flight 4.31 GG) 1/4-mile from tower.

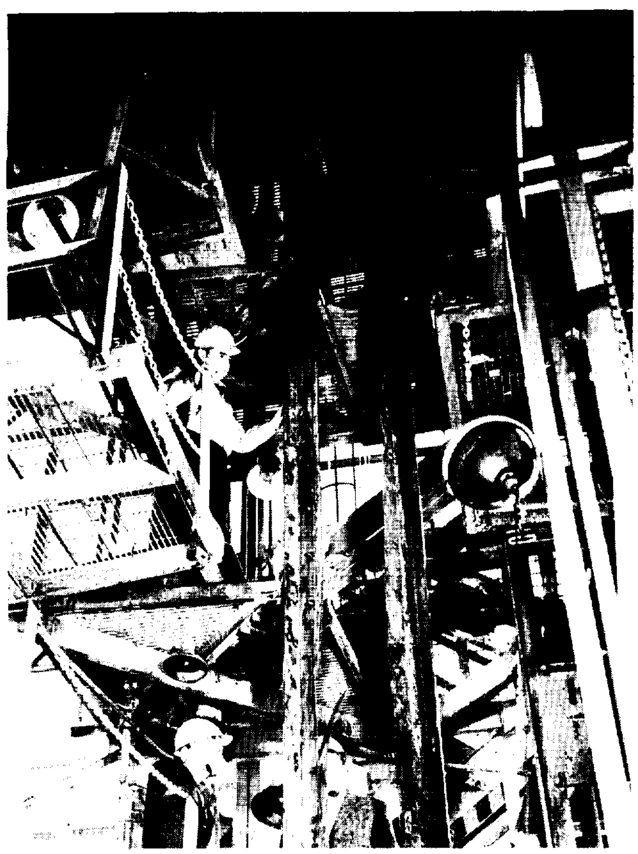


(a) Aft view of booster and sustainer, looking forward.

Figure 123—Aerobee 4.73UA which exploded in launch tower (WI).



(b) Forward view of sustainer and booster, looking aft.



(c) View of damage to launch tower and rails.

Figure 123—Aerobee 4.74UA which exploded in launch tower (WI).

(a) Damage to sustainer thrust structure (4.73 UA).

(b) Damage to aft closure (4.74 UA).

Figure 124—Aerobee which exploded in launch tower (WI).

(c) Damage to booster nozzle.

Figure 124—Aerobee 4.74 UA which exploded in launch tower (WI).

CONCLUSIONS

This report summarizes all Aerobee sounding rocket launchings by the NASA Goddard Space Flight Center conducted during the period from September 1959 through December 1963 inclusive. Further technical information concerning the types of sounding rockets used may be found in the bibliography.

ACKNOWLEDGEMENTS

This work could not have been accomplished without the complete cooperation and support of W. G. Moon, who helped to prepare this manuscript. The authors also wish to acknowledge the use of U. S. Army official photographs (White Sands) and U. S. Air Force official photographs (Fort Churchill) taken at each range.

(Manuscript received February 1, 1965)

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Appendix A

Summary of Rocket Launchings

Sounding rocket launchings for CY 1959 through CY 1963 are listed on pages 36 through 83, in sequence by flight number. For each flight, the launch site and date, the rocket type and performance, the experiment scientist and sponsoring institute, and the rocket auxiliary systems are given.

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Summary of Rocke

Flight	Launch Site	Launch Date	Rocket Type	Rocket Performance	Scientist
1.01 GI	FC	23 Nov 60	100	S	Whipple/GSFC*
1.02 GI	FC	27 Nov 60	100	S	Hamilton
1.03 GP	FC	15 Sep 60	100	S	Baumann
1.04 GP	FC	15 Sep 60	100	S	Baumann
1.05 GP	FC	24 Sep 60	100	S	Baumann
1.06 GP	FC	19 May 61	100	S	Baumann
1.07 GA	FC	17 Oct 61	100	S	Martin/Varian
1.08 GA	FC	23 Sep 61	100	S	Martin/Varian
1.09 GA	FC	30 Sep 61	100	S	Martin/Varian
1.10 GA	FC	15 Oct 61	100	S	Martin/Varian
1.11 GA	FC	2 Nov 61	100	S	Martin/Varian
1.12 GA	FC	5 Nov 61	100	S	Martin/Varian
1.13 NP	WSMR	6 Sep 62	100	S	Barth/JPL*
1.14 NA	WSMR	20 Nov 62	100	U	Barth/JPL
4.01 GT	WI	16 Feb 60	150A	U	Medrow/GSFC
4.02 II	FC	17 Sep 59	150	S	Jackson/DRTE*
4.03 II	FC	20 Sep 59	150	U	Jackson/DRTE
4.04 GG	WI	26 Apr 60	150A	S	Kupperian
4.05 GG	WI	27 May 60	150A	S	Boggess/GSFC
4.06 GG	WI	24 Jun 60	150A	S	Boggess/GSFC
4.07 GI	FC	14 Sep 59	150	S	Jackson/DRTE
4.08 GI	FC	11 Sep 59	150	S	Jackson/DRTE
4.09 GA	WI	29 Apr 60	150A	S	Horowitz
4.10 GT	WI	23 Apr 60	150A	S	Medrow/GSFC
4.11 GG	WI	22 Nov 60	150A	S	Stecher/GSFC
4.12 GT	WI	25 Mar 60	150A	S	Medrow/GSFC
4.14 GA	WI	15 Nov 60	150A	S	Taylor
4.16 UE	WI	23 Aug 60	150A	S	Meredith/NYU*
4.18 GA	WI	19 Mar 62	150A	U	Spencer/U Mich*
4.19 GT	WI	14 Apr 61	150A	S	Russell/GSFC
4.20 GT	WI	26 Jun 61	150A	S	Russell/GSFC
4.21 US	WSMR	27 Nov 62	150	S	Goldberg/HCO*

*Refer to Appendix D

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Attitude Control System	Solar Pointing Control	Recovery System	Despin System	Remarks	Page
No	No	No	No		53
No	No	No	No		53
No	No	Yes	No		45
No	No	Yes	No		62
No	No	Yes	No		45
No	No	Yes	No		62
No	No	Yes	No		63
No	No	Yes	No		63
No	No	Yes	No		63
No	No	Yes	No		63
No	No	Yes	No		63
No	No	Yes	No		63
No	No	No	No		77
No	No	No	No		77
No	No	No	No		40
No	No	No	No		37
No	No	No	No		37
No	No	No	Yes	Gas despin system	43
No	No	No	Yes	Gas despin system	43
No	No	No	Yes	Gas despin system	43
No	No	No	No	Gas despin system	37
No	No	No	No		37
No	No	No	No		44
No	No	Yes	No		42
No	No	No	Yes	Gas despin system	50
No	No	No	No		41
No	No	No	No		49
No	No	No	No		45
No	No	No	Yes	Gas despin system Rocket shutdown premature	71
Yes	No	No	No		60
Yes	No	No	No	Terminal booster failure	60
No	BBRC	Yes	No	Recovery system malfunction	83

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Summary of Rocl
(continue

Flight	Launch Site	Launch Date	Rocket Type	Rocket Performance	Scientist
4.22 US	WSMR	6 Sep 63	150	S	Goldberg/HCO
4.23 US	WI	24 Jul 62	150A	S	U Colo*
4.25 GS	WI	30 Sep 61	150A	S	Behring
4.26 NP	WI	20 Jun 62	150A	S	Flagge
4.27 NP	WI	17 Nov 62	150A	S	Corpas/Lewis Res.
4.28 NP	WI	19 Jun 62	150A	S	Corpas/Lewis Res.
4.29 GG	WI	23 Jul 63	150A	S	Stecher/GSFC
4.30 GG	WSMR	28 Mar 63	150	S	Bogges/GSFC
4.31 GG	WSMR	10 Oct 63	150	U	Bogges/GSFC
4.32 NP	WI	11 Sep 63	150A	S	Corpas/Lewis Res.
4.33 GS	WSMR	15 Oct 63	150	S	Muney/GSFC
4.34 GG	WI	30 Mar 61	150A	U	Boggess/GSFC
4.35 GG	WI	7 Feb 62	150A	U	Stecher/GSFC
4.36 GG	WI	22 Sep 62	150A	S	Stecher/GSFC
4.37 GG	WI	19 Jul 63	150A	S	Stecher/GSFC
4.38 NP	WI	5 Feb 61	150A	S	Gold/Lewis Res.
4.39 NP	WI	21 Apr 61	150A	S	Gold/Lewis Res.
4.40 NP	WI	18 Oct 61	150A	S	Regetz
4.41 NP	WI	17 Feb 61	150A	S	Dillon
4.42 NP	WI	12 Aug 61	150A	S	Plohr
4.43 GP	FC	5 Oct 60	150	S	Baumann/NRL*
4.44 GI	WI	23 Apr 63	150A	S	Bauer
4.46 NP	WSMR	8 May 62	150	S	Brown/JPL
4.47 NP	WSMR	10 Jul 62	150	S	Brown/JPL
4.48 GT	WI	25 May 62	150A	S	Pressly/GSFC
4.54 UG	WI	29 Oct 62	150A	S	Code/U Wisc*
4.58 UI	WI	3 Apr 63	150A	S	Rorden/SRI*
4.59 UI	WI	10 Jul 63	150A	S	Rorden/SRI
4.60 GT	WI	8 Aug 62	150	P	Russell/GSFC
4.61 AS	WSMR	20 Jun 63	150	S	Packer/NRL
4.62 AS	WSMR	28 Jun 63	150	S	Packer/NRL
4.64 GI	WI	28 Sep 63	150A	S	Serbu/GSFC

*Refer to Appendix D

X A

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Attitude Control System	Solar Pointing Control	Recovery System	Despin System	Remarks	Page
No	BBRC	No	No		115
No	U Colo	No	No		77
No	BBRC	No	No		64
No	No	Yes	Yes	Gas despin system	71
No	No	No	Yes	Gas despin system	71
No	No	No	Yes	Gas despin system	99
No	No	No	Yes	Gas despin system	105
No	No	No	Yes	Gas despin system	88
Yes	No	Yes	No	Sustainer did not ignite	88
No	No	No	Yes	Gas despin system	99
No	Yes	Yes	No		116
No	No	Yes	Yes	Premature sustainer shutdown	59
No	No	No	Yes	Range safety shutdown error	69
No	No	No	Yes	Gas despin system malfunction	69
No	No	No	Yes	Gas despin system	105
No	No	Yes	Yes	Gas despin system	55
No	No	Yes	Yes	Gas despin system	55
No	No	Yes	Yes	Gas despin system	55
No	No	Yes	Yes	Gas despin system	71
No	No	Yes	Yes	Gas despin system	55
No	No	Yes	No	Set for low roll rate	48
No	No	No	No		94
Yes	No	Yes	No		73
Yes	No	Yes	No		73
No	No	Yes	No	Water recovery system	74
Yes	No	No	No		79
No	No	No	No	Fiberglass nose cone	92
No	No	No	No		92
No	No	No	No	Water recovery system	67
No	BBRC	Yes	No		102
No	U Colo	Yes	No		102
No	No	No	No	Clamshell nose cone	115

APPENDIX

Summary of Rocke
(continue

Flight	Launch Site	Launch Date	Rocket Type	Rocket Performance	Scientist
4.65 GI	WI	25 Sep 63	150A	S	Serbu/GSFC
4.66 NP	WSMR	14 May 63	150	S	Kinard/Langley
4.68 GT	WI	13 Jan 62	150A	S	Russell/GSFC
4.69 CG	WI	30 Sep 62	150A	S	Fisher /LMSC*
4.70 GG	WI	16 Mar 63	150A	S	Fisher/LMSC
4.71 UA	WI	29 Jun 62	150A	S	Fastie/JHU
4.72 UA	WI	29 Jun 62	150A	S	Fastie/JHU
4.73 UA	WI	29 Jan 63	150A	U	Fastie/JHU
4.74 UA	WI	13 Dec 62	150A	U	Fastie/JHU
4.75 UA	FC	20 Jul 63	150	U	Fastie/JHU
4.76 UA	WI	12 Nov 63	150A	S	Fastie/JHU
4.77 GS	WSMR	20 Jul 63	150	S	Hallam/GSFC
4.78 GS	WSMR	1 Oct 63	150	S	Hallam /GSFC
4.79 II	WI	15 Nov 62	150A	U	Cartwright
4.80 II	WI	11 Dec 62	150A	U	Cartwright
4.85 NA	WI	18 Nov 63	150A	S	Barth/JPL*
4.87 GT	WSMR	17 Jun 63	150	S	Russell/GSFC
4.91 GE	FC	4 Sep 63	150	S	Fichtel/GSFC
4.93 II	WI	17 Oct 63	150A	S	Schmerling
4.94 II	WI	31 Oct 63	150A	S	Schmerling
4.96 II	WI	12 Apr 63	150A	S	Cartwright
4.97 II	WI	9 May 63	150A	S	Cartwright
4.98 US	WI	7 May 63	150A	S	Fastie/JHU
6.01 UI	FC	16 Mar 60	300	S	Bourdeau/U Mich
6.02 UI	FC	15 Jun 60	300	S	Bourdeau/U Mich
6.03 UI	WI	3 Aug 60	300A	S	Spencer/U Mich
6.04 UI	WI	26 Mar 61	300A	S	Bourdeau/U Mich
6.05 UI	WI	22 Dec 61	300A	S	Wright/U Mich
6.06 GA	WI	20 Nov 62	300A	S	Brace/GSFC
6.07 GA	WI	18 Apr 63	300A	S	Brace /GSFC
6.08 GA	WI	20 Jul 63	300A	S	Brace/GSFC

*Refer to Appendix D

2

A

t Launching
d)

Attitude Control System	Solar Pointing Control	Recovery System	Despin System	Remarks	Page
No	No	No		Clamshell nose cone	115
No	No	Yes	Yes	Gas despin system	96
				Paraglide recovery	
Yes	No	Yes	No		67
No	No	No	Yes		79
No	No	No	Yes		87
No	No	No	No		75
No	No	No	No		75
No	No	No	No	Sustainer malfunction	85
No	No	No	No	Booster exploded	75
No	No	No	No	Booster terminal failure	107
No	No	No	No		85
No	BBRC	Yes	No		105
No	BBRC	Yes	No		105
No	BBRC	No	No	Rocket structural failure	80
No	BBRC	No	No	Rocket structural failure	80
Yes	BBRC	No	No		118
Yes	BBRC	Yes	No		98
No	BBRC	Yes	No		113
No	BBRC	No	No	Booster terminal failure	117
No	BBRC	No	No		117
No	BBRC	No	No		93
No	BBRC	No	No		93
No	BBRC	No	No		85
No	No	No	No		42
No	No	No	No		42
No	No	No	No		45
No	No	No	No		57
No	No	No	No		57
No	No	No	No		82
No	No	No	No		94
No	No	No	No		94

Appendix B

Performance Characteristics Charts

Performance characteristics charts for the Aerobee 150 and 150A are contained on pages 158 through 160. They include the following:

1. Peak altitude vs. net payload for ogival nose cones.
2. Peak altitude vs. net payload for conical nose cones.
3. Altitude and velocity vs. time for various payloads (ogive nose cones).
4. Summit time vs. net payload for ogival nose cones.
5. Acceleration vs. time for typical flights.

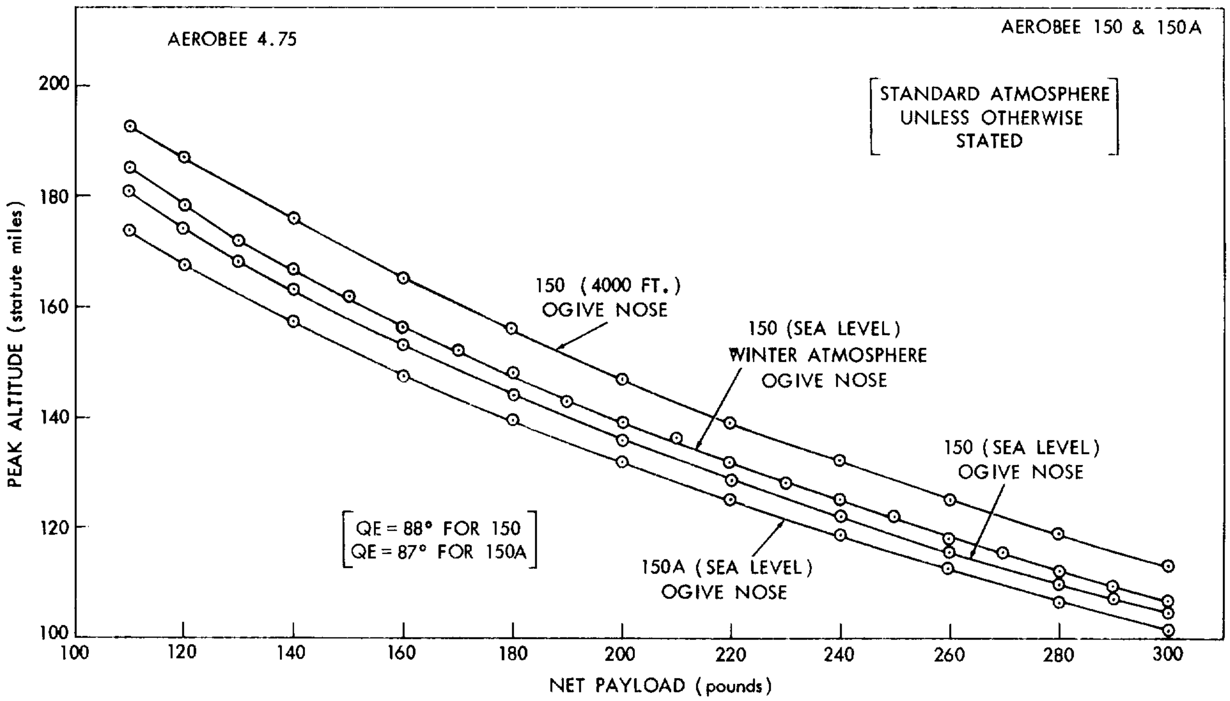

Figure B1—Peak altitude vs. net payload for ogival nose cones.

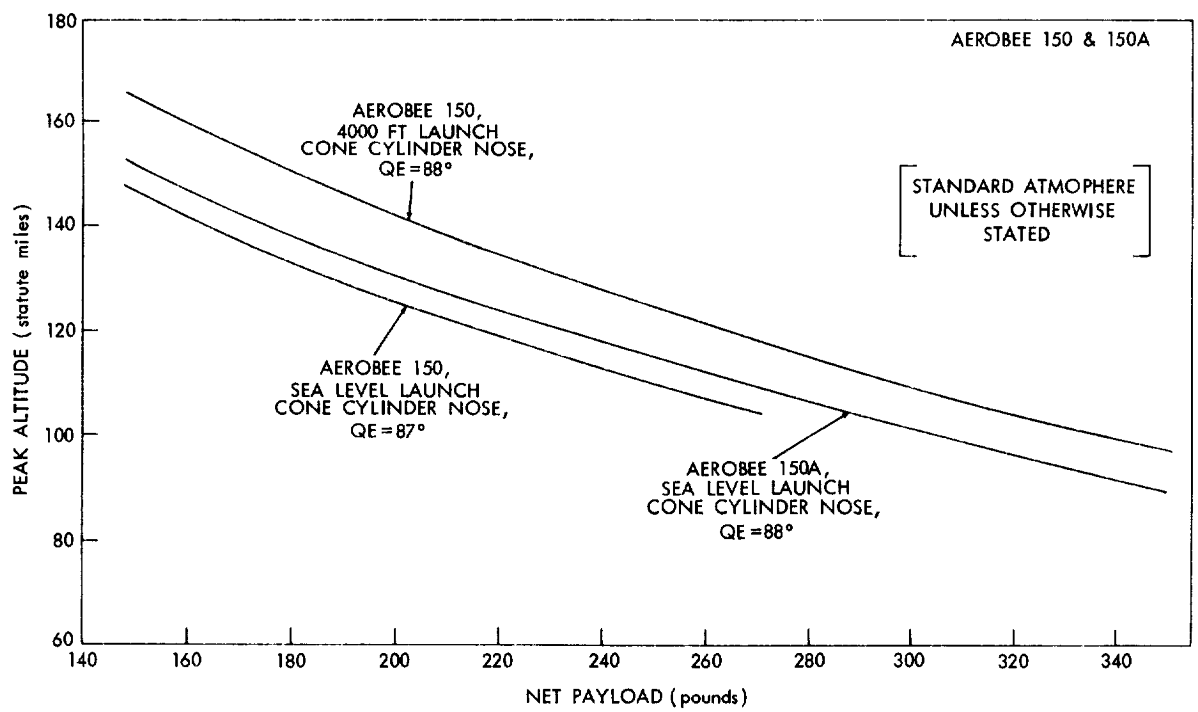

Figure B2—Peak altitude vs. net payload for cone-cylinder nose cones.

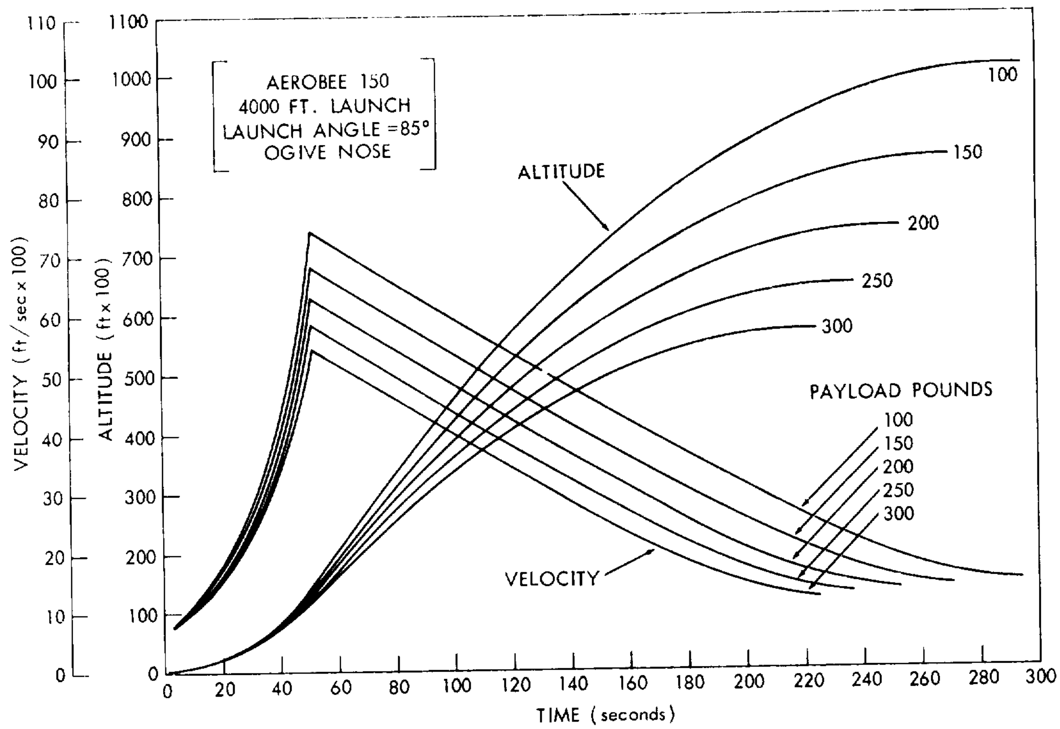

Figure B3—Aerobee 150 velocity and altitude vs. time for various payloads.

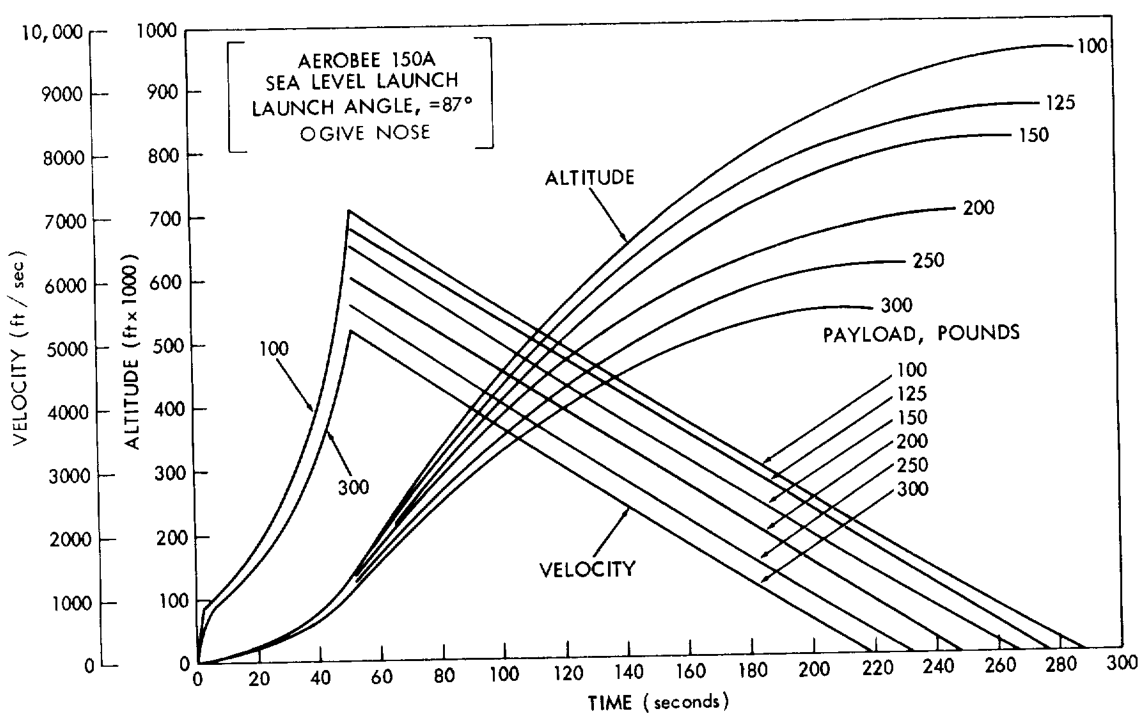

Figure B4—Aerobee 150A velocity and altitude vs. time for various payloads.

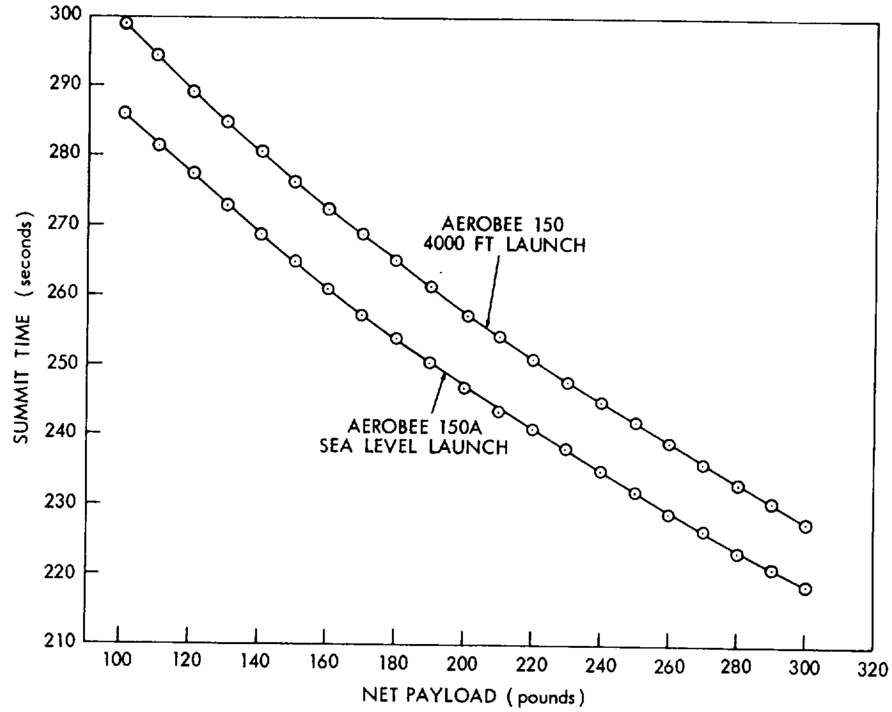

Figure B5—Summit time vs. net payload for Aerobee 150 and 150A sounding rockets with ogival nose cones and a QE = 87°.

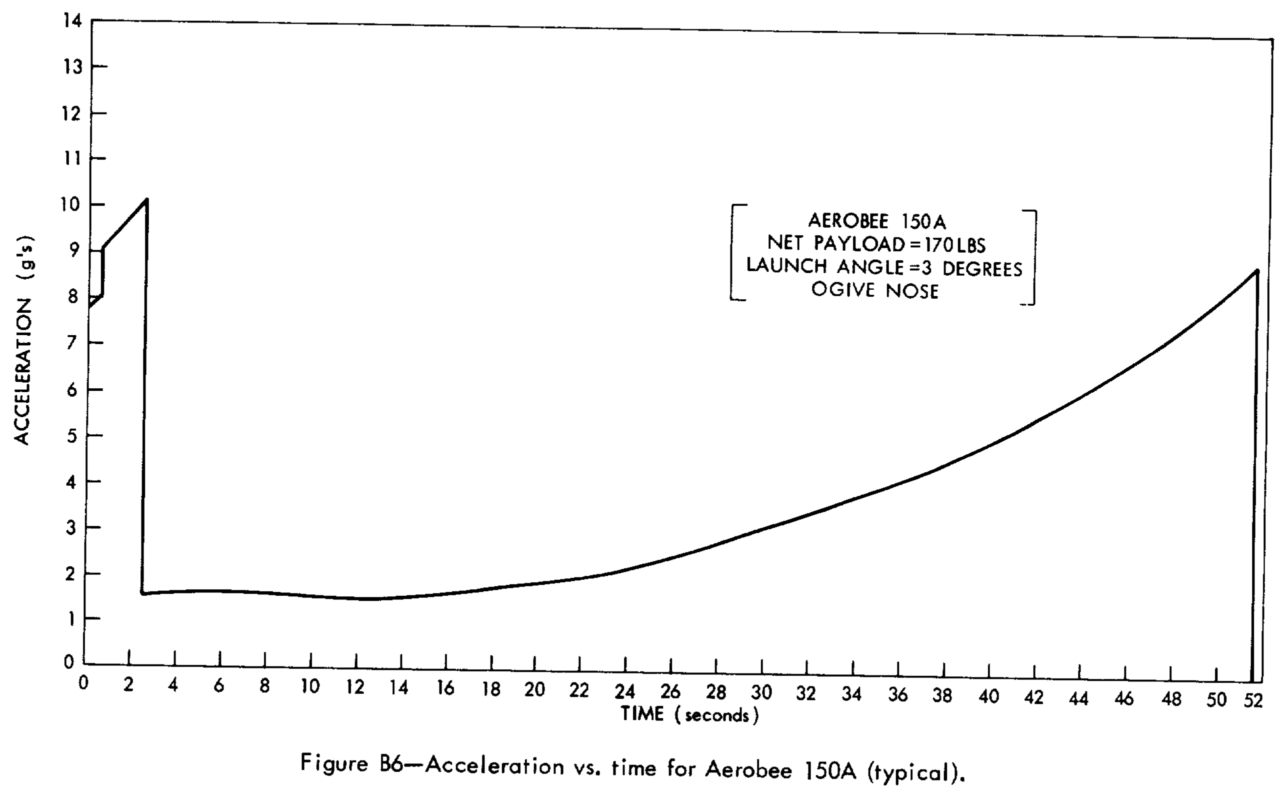

Figure B6—Acceleration vs. time for Aerobee 150A (typical).

Appendix C

Representative Flight Temperatures for Ogival Nose Cones

Flight temperature data is plotted on pages 162 and 163.

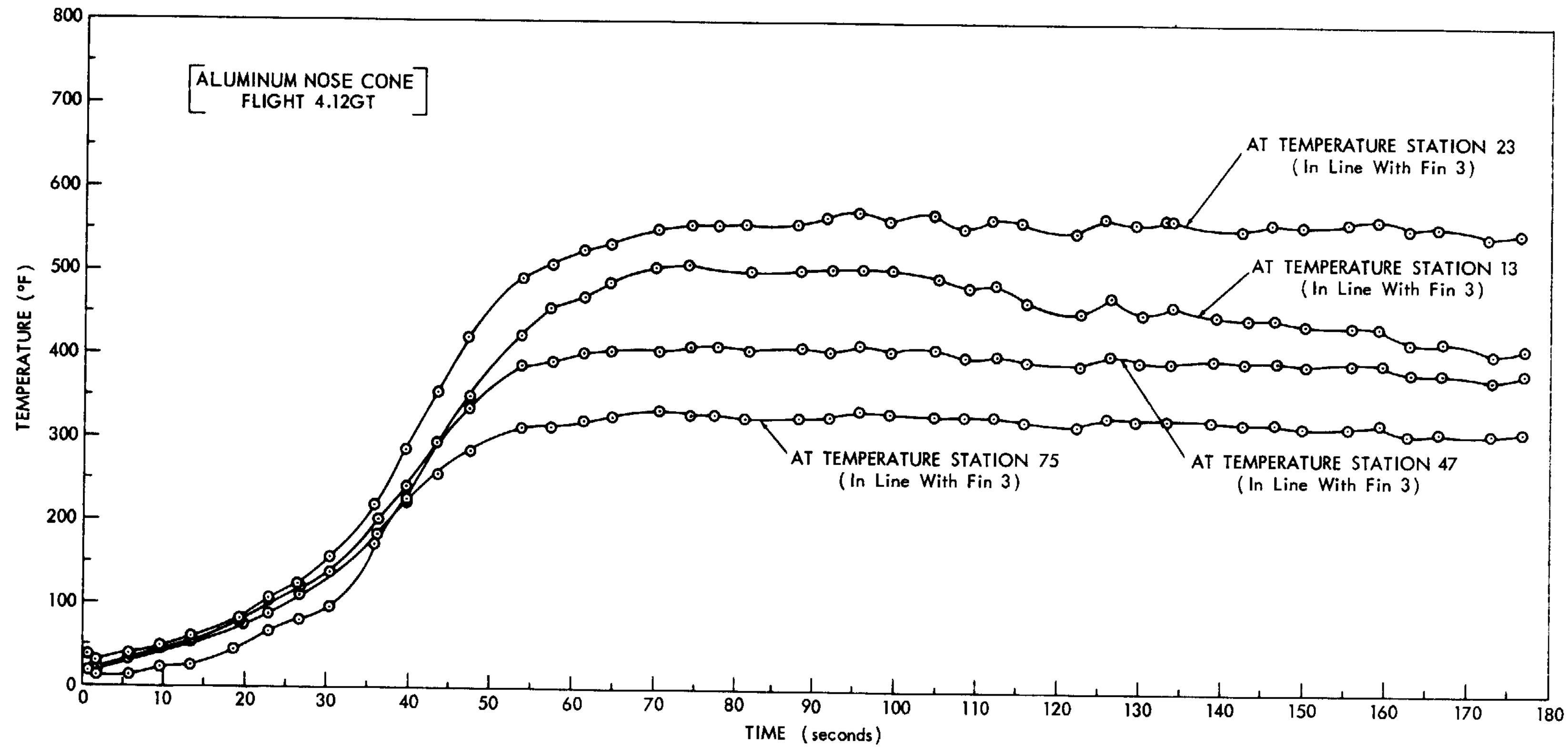

Figure C1—Representative flight temperatures for ogival nose cones.

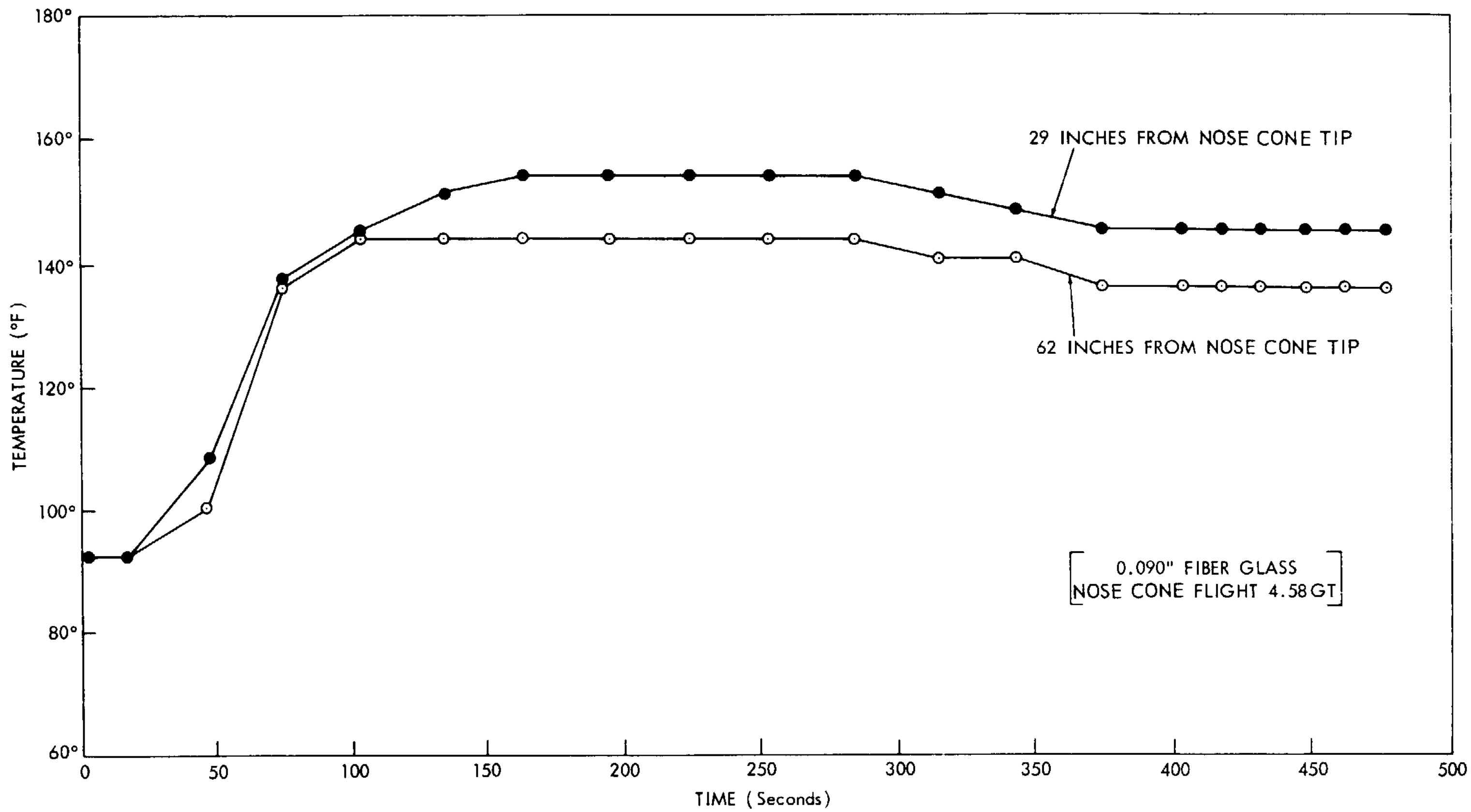

Figure C2—Representative flight temperatures for ogival nose cones.

Appendix D

Abbreviations and Definitions

ACS	Attitude control system
AFCRL	U.S.A.F. Cambridge Research Laboratory, Bedford, Mass.
AGC	Aerojet General Corp., Azusa, Cal.
ANCSR	Australian National Committee for Space Research
BBRC	Ball Bros. Research Corp., Boulder, Colo.
BPC	Biaxial pointing control
BRL	Ballistics Research Laboratory, Aberdeen Proving Ground, Maryland
CNET	Centre National d'Etudes Telecommunications, Paris
DRTE	Defence Research Telecommunications Establishment, Canada
EOGO	Eccentric Orbiting Geophysical Observatory
FACS	Fine attitude control system
FC	Fort Churchill Launch Facility, Ft. Churchill, Manitoba, Canada
FPS-16	A C-band, high precision monopulse missile tracking radar with a 16-foot parabolic reflector and a 1000 mile beacon tracking range (150 miles passive), providing real-time present-position analog data for range safety.
GSFC	Goddard Space Flight Center, NASA, Greenbelt, Md.
HCO	Harvard College Observatory
IACS	Inertial attitude control system
JHU	Johns Hopkins University, Baltimore, Md.
JPL	Jet Propulsion Laboratory, California Institute of Technology
Lewis	Lewis Research Center, NASA, Cleveland, Ohio
LMSC	Lockheed Missile & Space Corp.

NMSU	New Mexico State University
NRL	Naval Research Laboratory, Washington, D.C.
NYU	New York University, New York, N.Y.
OAO	Orbiting Astronomical Observatory
P	Partially successful sounding rocket launch
PPM	Pulse position modulation
RCAF	Royal Canadian Air Force
S	Successful sounding rocket launch
SGC	Space General Corp., El Monte, Cal.
SPANDAR	A high-power (5 MW pulse) S-band conical scan missile tracking radar with a 60-foot parabolic reflector and a 5000 mile beacon tracking range (600 miles passive) providing digital data, with a parametric amplifier in the receiver circuit
Sarah	A beacon transmitter (C or S-band) flown in a sounding rocket
SPC	Solar pointing control
SRI	Stanford Research Institute
U	Unsuccessful sounding rocket launch
U Colo	University of Colorado, Boulder, Colo.
U Mich	University of Michigan, Ann Arbor, Mich.
U Wisc	University of Wisconsin, Madison, Wisc.
WI	Wallops Island Launch Facility, Wallops Island, Va.
WSMR	White Sands Missile Range, White Sands, N. Mex.

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