20p

(TMX-54520)

FLAT-SPIN RECOVERY SYSTEM

~~By~~ John C. McFall, Jr. [1964] 20p refs

1608751

NASA Langley Reserach Center
Langley Station, ~~Hampton~~, Va.

Presented at the Symposium on Parachute Technology and Evaluation

El Centro, California
April 7-9, 1964

Unc.

[redacted]

FLAT-SPIN RECOVERY SYSTEM

By John C. McFall, Jr.

ABSTRACT

35207/A

Some application techniques for parachutes used in low-altitude recovery missions have been developed by the NASA Langley Research Center. One of these techniques is illustrated in use with two recovery systems developed to recover a camera pod ejected from the second stage of an NASA Scout booster in a space environment and ablation materials nose cones used on an NASA Langley developed four-stage boost system. In both these systems the recoverable is decelerated by unaugmented drag in a flat spin prior to parachute deployment. The deployment of the parachute is aided by the centrifugal force of the flat spinning recoverable and a spring forcing the canopy from its container.

AUTHOR

[redacted]

FLAT-SPIN RECOVERY SYSTEM

By John C. McFall, Jr.*

NASA Langley Research Center

INTRODUCTION

Reliability of retardation devices during the terminal portion of flight is a primary requirement in most recovery systems. Since most ballistic configurations cannot provide sufficient terminal deceleration for recovery without drag augmentation, typical reentry bodies requiring recovery have used a staged parachute system. The systems generally include a small drogue parachute or a reefed main parachute to decelerate the body to speeds that allow full deployment of a landing parachute. Reliability of such systems is sometimes compromised by a large number of required sequences. The sequences may include cover plate ejection, deployment of a drogue parachute, and subsequent deployment of a reefed main parachute which must finally be fully deployed to allow a safe landing. The attractive feature of the staged parachute system is that it generally requires the least weight and volume. Greater reliability can be attained, however, when weight and volume restrictions allow the use of only a single parachute suitable for terminal descent.

The purpose of this paper is to present an application technique for single nonreefed parachutes in simple low-altitude recovery systems. In this technique a payload assembly of cylindrical configuration is separated from its booster and allowed to decelerate in a flat spin until conditions are suitable for full deployment of a landing parachute. The use of this technique is illustrated in recovery systems developed by the NASA Langley Research Center for the recovery of nose cones used in ablation materials tests and for a piggy-back camera pod on a Scout booster.

SYSTEM CONCEPT

The normal deceleration sequence for current ballistic configurations requiring recovery is shown in figure 1. As previously noted, it is desired that the nose section of the configuration enter a spin in a high-drag attitude in order that the speed be reduced sufficiently to allow the deployment of a single parachute for landing. One configuration which inherently has the desired characteristics is a cylinder. Figure 2 shows some aerodynamic characteristics of such a cylinder. There are two trim points for the cylinder and the feature of high drag at the statically stable 90° trim condition indicates its capability of being used as a decelerator.

---

*Aerospace Engineer.

L-3933

A vivid demonstration of the behavior of cylinders in free-fall was observed a number of times in the early days of rocket firings at the NASA Wallops Station. In these flights, booster motors were seen descending in a flat spin with a propellerlike rotation after shedding their fins. Somewhat more tangible data on cylinder stability and drag may be found in references 1 through 4.

When the NASA Langley Research Center had a requirement for the recovery of several small research payloads having essentially cylindrical shapes, it was decided to examine the flat-spin recovery concept. The sequence of this concept is illustrated in figure 3. Here the cylinder has trimmed in a position normal to the relative wind and has a propellerlike rotation. In this condition one end of the cylinder is released with subsequent deployment of the single parachute. Because of uncertainties in timed events (such as rocket motor firings in unguided systems) barometric switches were selected to initiate the recovery sequence. Parallel electrical circuits were included for all pyrotechnic sequences.

Water impact requirements dictated reasonable terminal descent velocity and a buoyant body. For the payloads under consideration 60 feet/second impact velocity gave reasonable loads on the structure and internal components. The bodies were made inherently buoyant to give the highest reliability of flotation.

Selection of location aids was based on possibilities of overshoot in cases of unguided multistage booster vehicles fired over extended ranges (over 100 nautical miles). For coarse location, radar chaff packed with the parachute (also radar reflective) was considered useful. A radio beacon was included to give precise location of the floating payload. In this application a leaf-spring antenna for the beacon was held folded in a protective bracket until water impact, when it was released by the wetting of water soluble tape. Holding the antenna folded in this manner obviated the flutter problem of extended antennas (and possibly structural failure) during descent. For final visual location, dye blocks attached to the payload base in perforated cans were considered suitable.

DEVELOPMENT AND TESTING

Component Qualification

Commercially available recovery-system components were selected and subjected to at least flight level environmental qualification tests. These tests included shock, vibration, and steady-state loads. Structural tests were conducted on the parachute attachment fittings and separation mechanisms. Ground firings of pyrotechnic circuits confirmed their circuit designs.

Parachute selection was based on calculation methods given in reference 5 and involved compromises among weight, volume, safety factor, opening reliability, cost, and availability. The parachute selected was a 20° conical ribbon parachute having approximately 30 percent porosity. This parachute had been extensively qualified as a drogue in the Mercury program (ref. 6).

Parachute Deployment Tests

One of the advantages of a low-altitude subsonic parachute application is the possibility of duplicating the deployment environment in drop tests. Three drop tests of the flat-spin recovery-system assembly confirmed the propeller-like rotation of cylindrical payloads in a flat spin. Parachute deployment appeared orderly in the drop tests. An explosive bolt was used to release the parachute container, which included a spring pushplate for positive ejection of the canopy.

Location Aids Tests

In setout tests of the radio beacons, ranging runs were made with a fixed-wing aircraft. The results of these runs indicated that reliable homing signals could be received at ranges greater than 30 nautical miles with the search aircraft flying at an altitude between 6,000 and 10,000 feet and with the payload in still water or in seas with wave heights up to 8 feet. In the rougher sea conditions the homing signal was somewhat intermittent, as the nose cone bobbed below the surface as much as 25 percent of the time.

The setout tests showed that the dye blocks attached to the payload base in perforated cans were effective in producing a slick visible to search aircraft at ranges from 3 to 4 nautical miles.

Systems Test

Operation of the complete flat-spin recovery system was tested in two firings of single-stage rocket-boosted payloads at the NASA Wallops Island Range. Successful results from these tests indicated that the system was suitable for operational use.

FLIGHT TESTS

Ablation Material Nose Cones

The nose cone assembly developed for the ablation material tests is shown in figure 4. The flat spinning cylinder in this case included the portion of the assembly forward of the diaphragm joint in the separation section.

A four-stage boost vehicle was used to propel the nose cone to the test environment. Figure 5 shows the booster and one payload assembly on a launcher at the NASA Wallops Island Range. The first two stages carried the payload to an apogee of approximately 80,000 feet, after which the two remaining stages were fired in quick succession on a downward trajectory. Figure 6 shows the dynamic pressures and the trajectory profile (altitude and horizontal range) with significant events noted along the flight path. In these tests tracking radar indicated that the parachute had deployed and that the impact point was near nominal. A very short time later the green dye marker could be sighted from the fixed-wing aircraft and the pickup made by helicopter. Figures 7, 8, and 9 show before-and-after photographs of the three materials-test nose cones recovered in the three attempts using the flat-spin recovery system. Reference 6 reports the data obtained in flight tests of Ablation Materials Tests 2 and 3.

Camera Pod

The pod developed for recovering a camera flown onboard the second stage of an NASA Scout booster vehicle is shown in figure 10. The design, which made use of previous recovery-system experience, had a low frontal area and included a mirror in the camera end of the pod in order to extend the camera field of view. The purpose of the camera was to photograph the rocket exhaust plume of the Scout second stage. The pod is shown on its piggy-back cradle in figure 11. After burnout of the Scout second stage the camera pod assembly was spring-ejected from its cradle and followed a ballistic trajectory. Figure 12 shows the trajectory profile and the dynamic pressures during the terminal portion of the flight.

Since the camera pod cylinder reentered the atmosphere at a velocity in excess of 9,000 feet per second, considerable aerodynamic heating was experienced. In a flat spin the cylinder presented a large blunt surface to dissipate the heat energy. The weight penalty due to the heat-protection material was small since the cylinder was constructed of an ablating plastic. Figure 13 shows preflight and postflight photographs of the pod. Reference 7 reports the data obtained from the film recovered with the camera pod flown on the Scout vehicle.

CONCLUDING REMARKS

An application technique for single nonreefed parachutes in low-altitude recovery systems has been presented. When weight and volume restrictions allow the use of only a single parachute for terminal descent this technique should have high reliability. Four flight tests using the flat-spin recovery system by the NASA Langley Research Center have resulted in the recovery of three ablation materials nose cones from four-stage rocket-boosted vehicles and a camera pod from an NASA Scout vehicle.

REFERENCES

1. Penland, Jim A.: Aerodynamic Characteristics of a Circular Cylinder at Mach Number 6.86 and Angles of Attack up to 90°. NACA TN 3861, 1957. (Supersedes NACA RM L54A14.)

2. Long, J. E.: Supersonic Drag Coefficients of Circular Cylinders up to Mach Number 8. Navord Rep. 4382, U.S. Naval Ord. Lab. (White Oak, Md.), Oct. 26, 1956.

3. Crogan, Leonard E.: Drag and Stability Data Obtained From Free-Flight Range Firings Within the Mach Number Range of 0.4 to 3.0 for Several Cylindrical Configurations. U.S. Naval Ord. Lab. (White Oak, Md.), Navord Rep. 6731, Oct. 3, 1960.

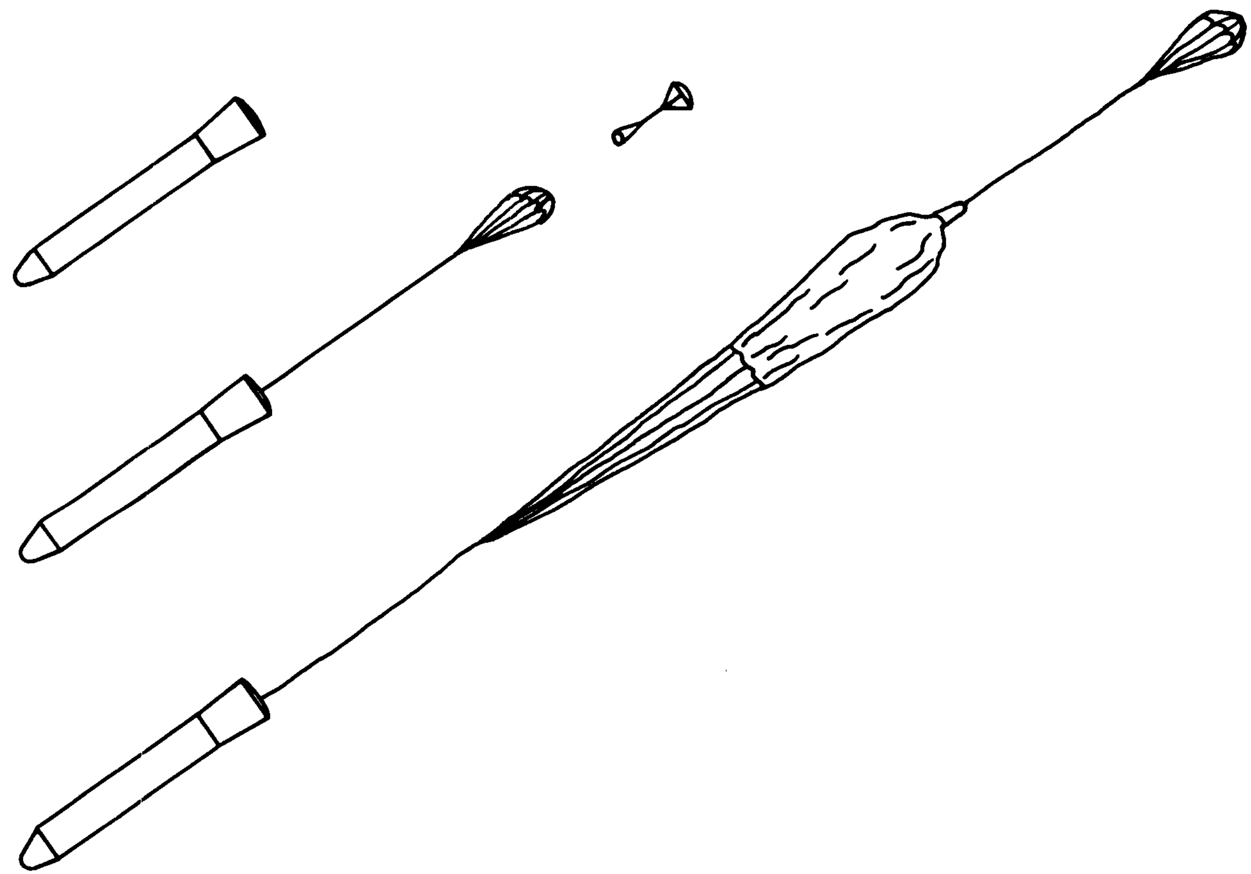
4. Raymond, J. L., and Garber, T. B.: On the Stability of a Circular Cylinder at Hypersonic Speeds. RAND Corp. Rep. P-723, Jan. 1956.

5. Anon.: United States Air Force Parachute Handbook. WADC Tech. Rep. 55-265, ASTIA Doc. No. AD 118036, U.S. Air Force, Dec. 1956.

6. Johnson, Clinton T.: Investigation of the Characteristics of 6-Foot Drogue-Stabilization Ribbon Parachutes at High Altitudes and Low Supersonic Speeds. NASA TM X-448, 1960.

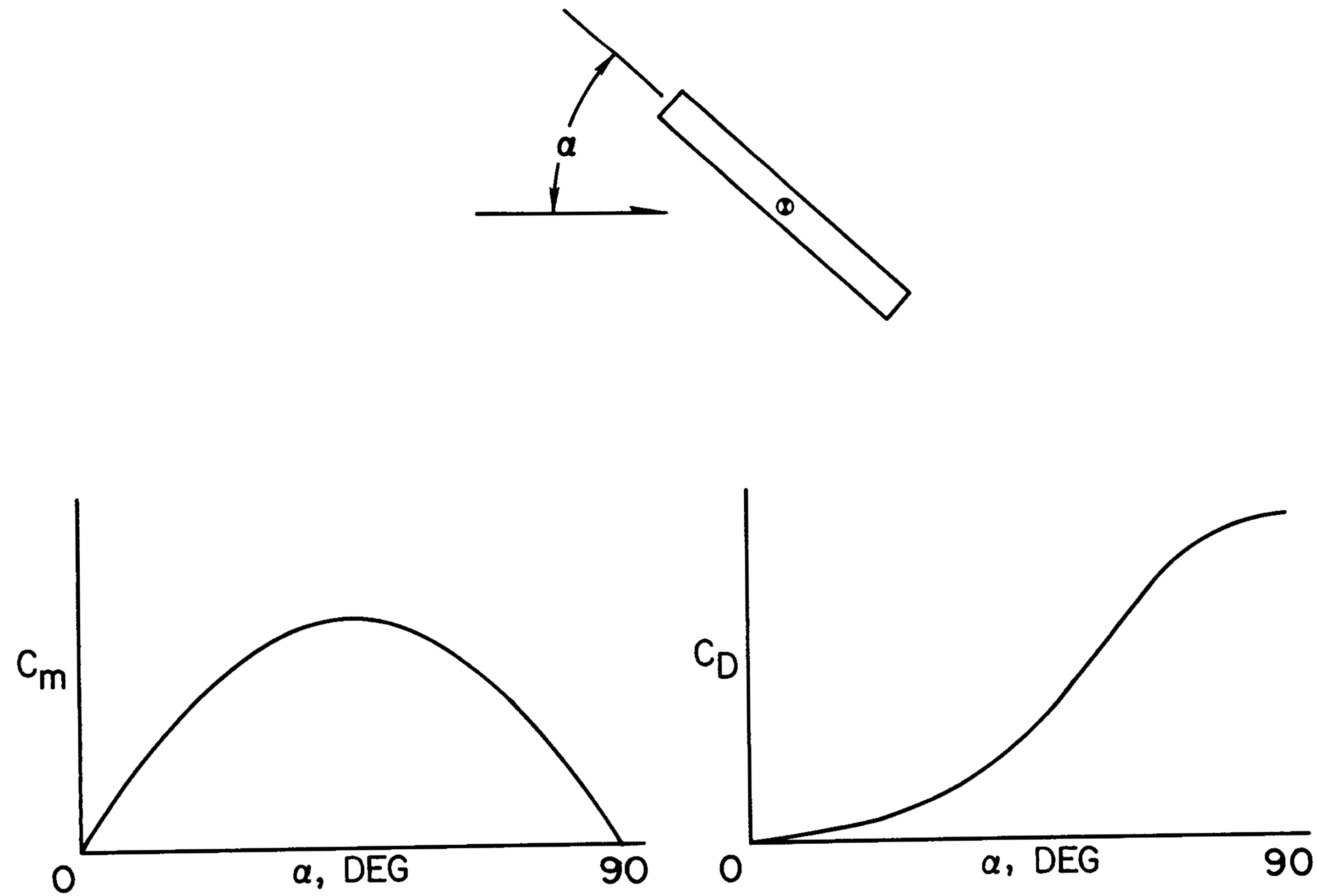
7. Lawrence, George F., Whitlock, Charles H., and Walton, Thomas E., Jr.: Aerothermal Measurements of Damaged Reentry Bodies Obtained in Free Flight at Mach Numbers From 11.0 to 2.0. (Proposed NASA TM.)

8. McIver, Duncan E., Jr.: Study of the Effects of a Rocket Exhaust on Radio Frequency Signal Attenuation by the Use of a Recoverable Camera on the NASA Scout Vehicle. NASA TM X-888, 1963.



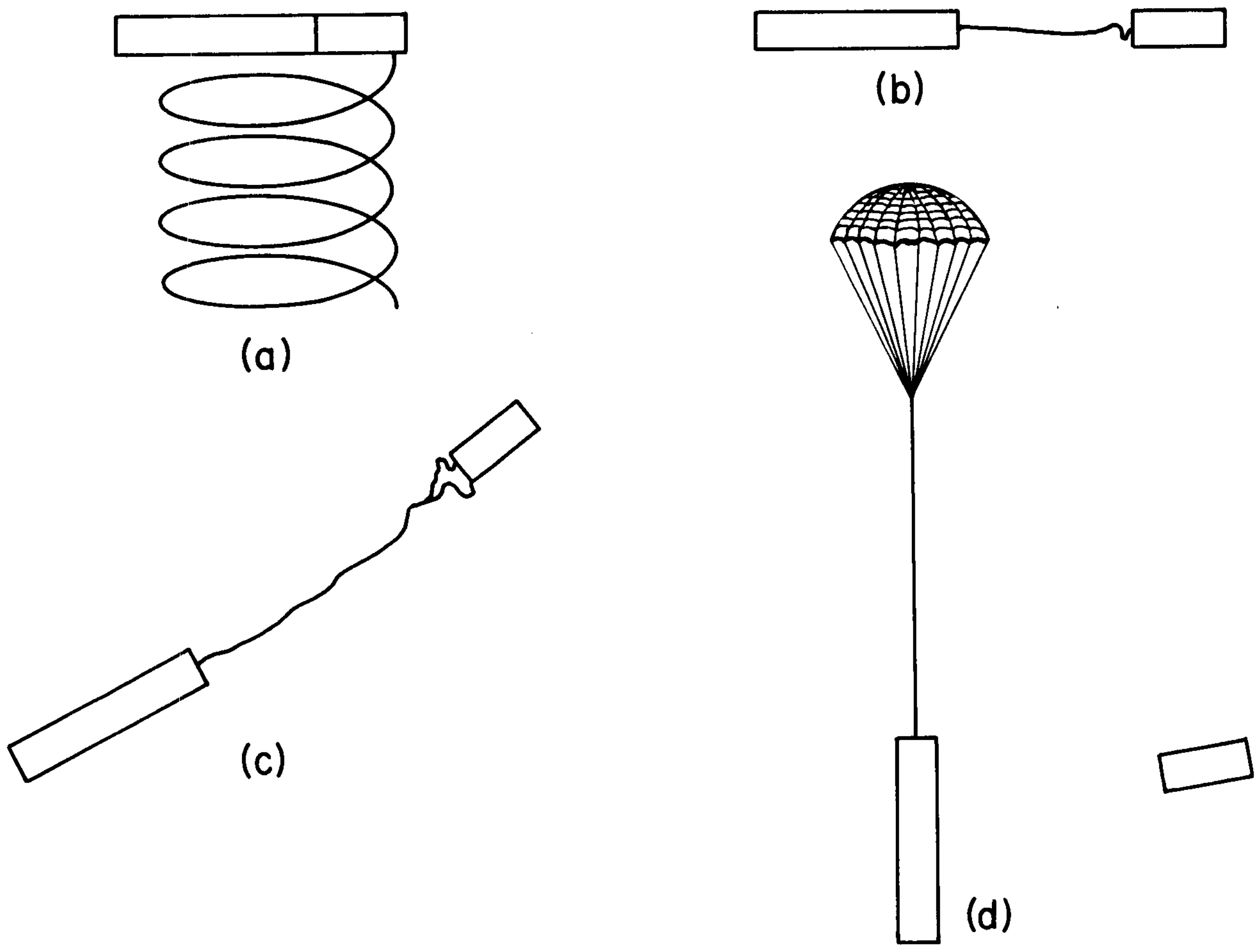
NASA

Figure 1.- Normal deceleration sequence for a staged parachute recovery system.



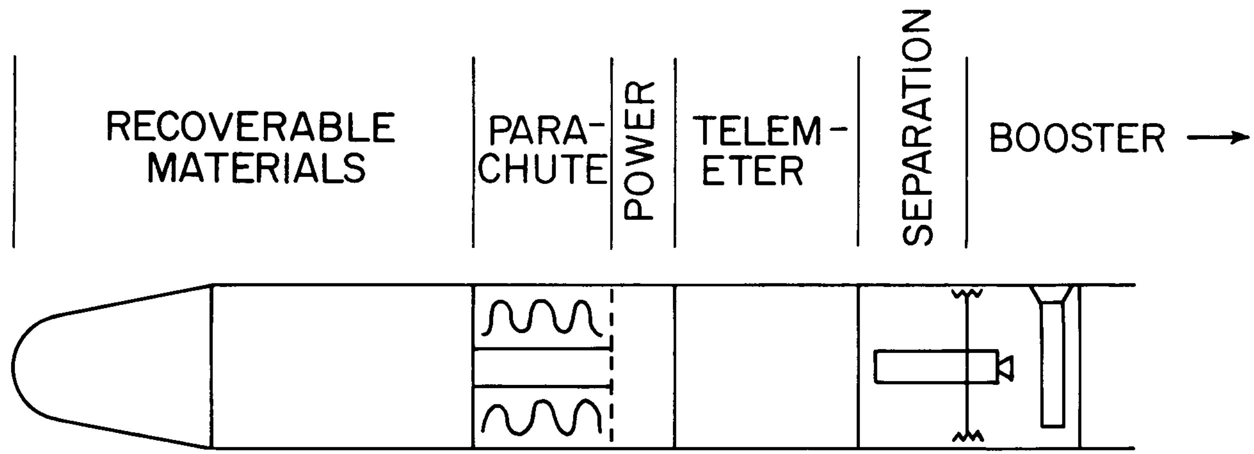
NASA

Figure 2.- Aerodynamic characteristics of a flat circular cylinder.



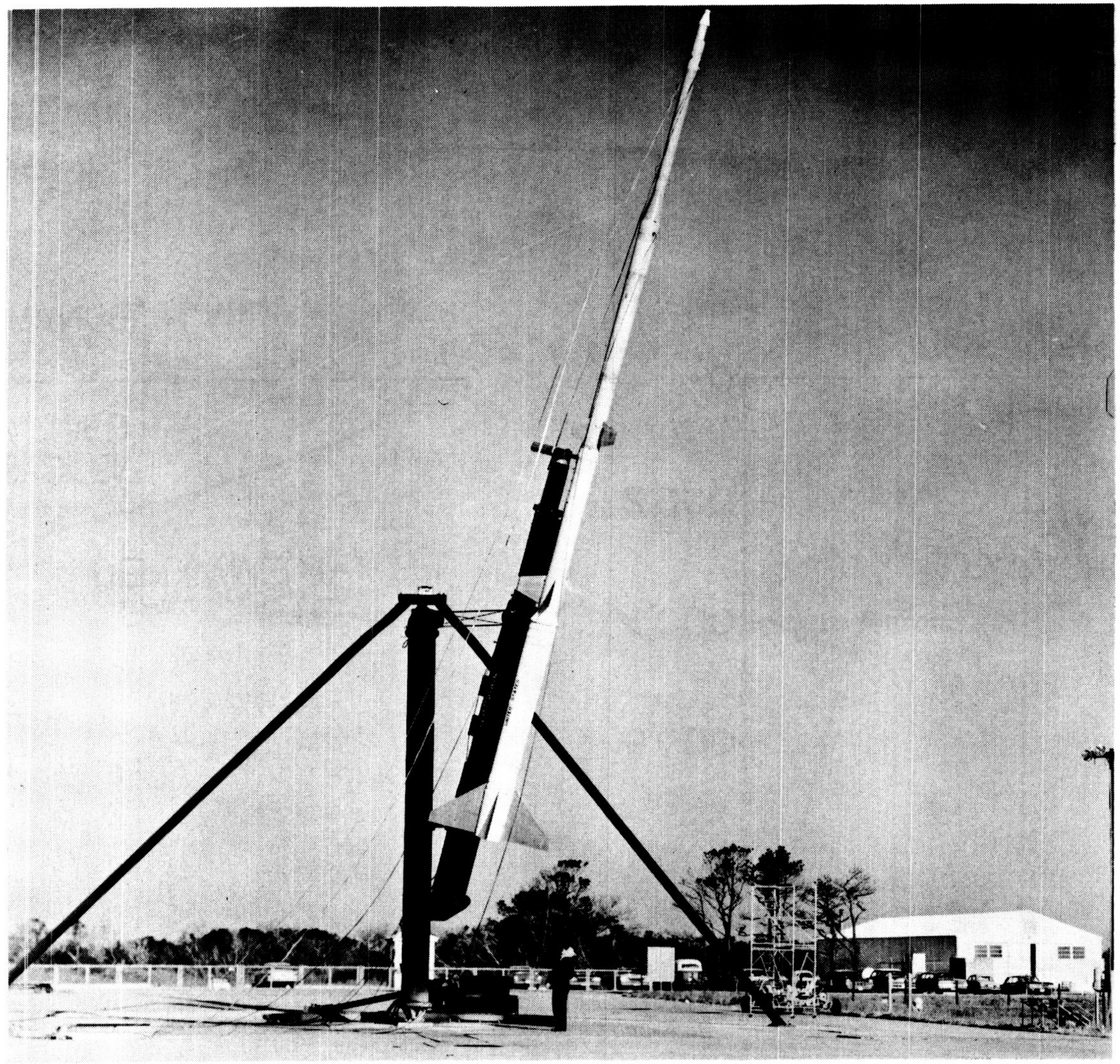
NASA

Figure 3.- Typical deployment sequence for flat spin recovery system.



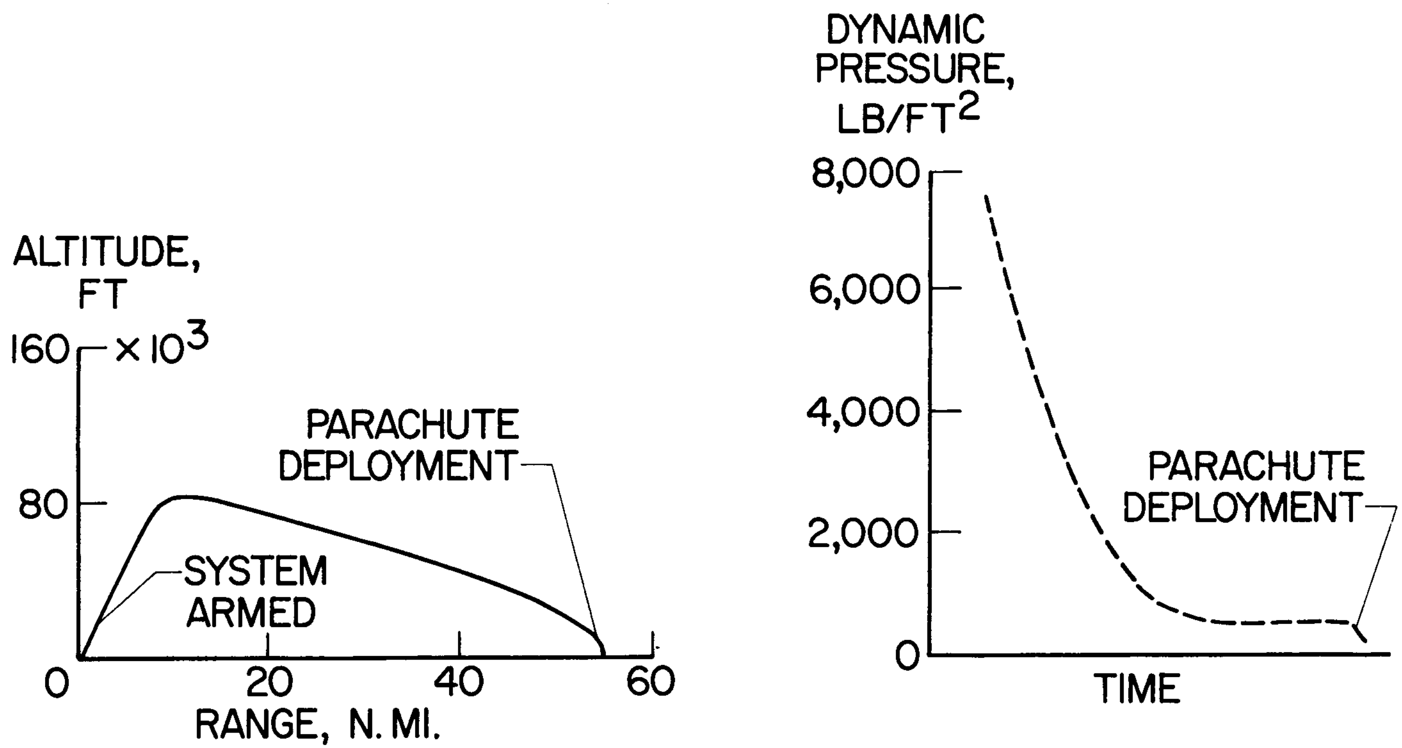
NASA

Figure 4.- Sketch of ablation materials nose cone assembly.



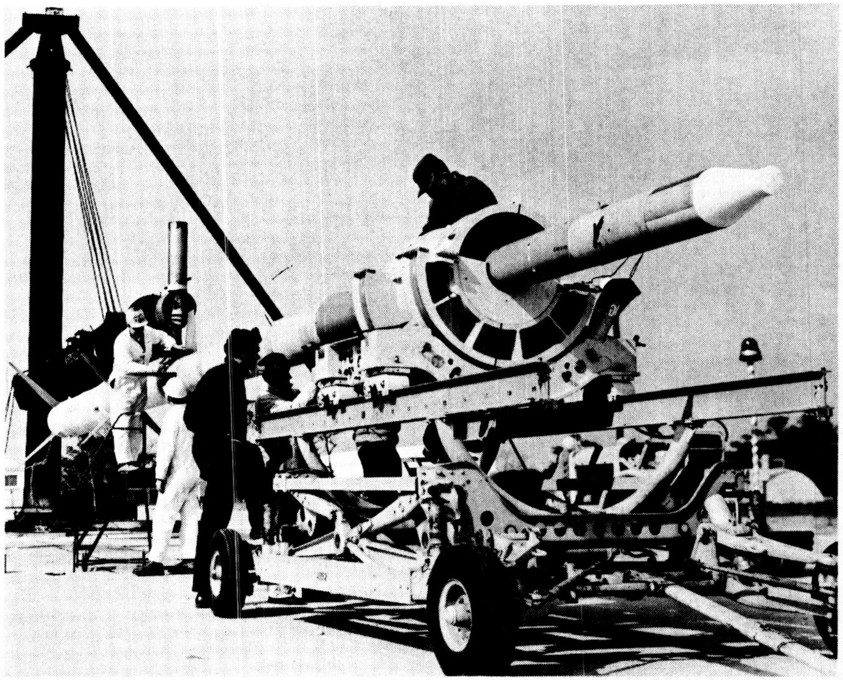
NASA

Figure 5.- Ablation materials vehicle on launcher.

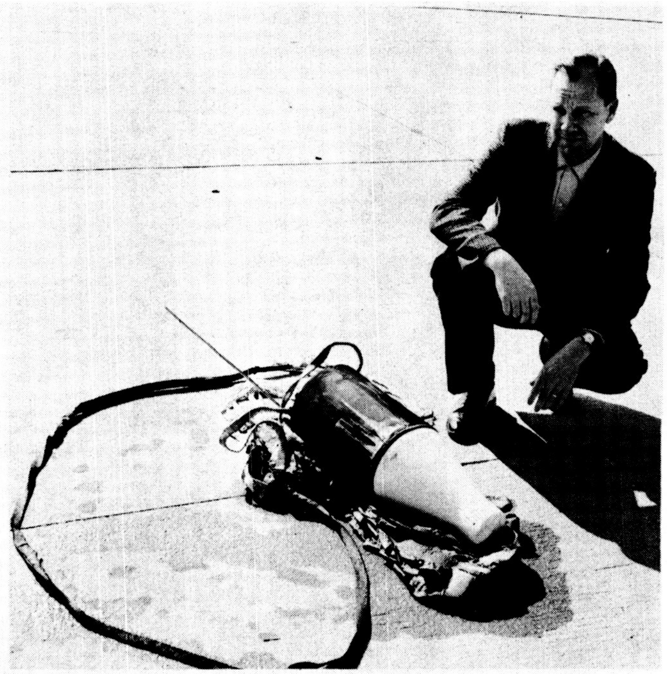


NASA

Figure 6.- Trajectory conditions for the ablation material tests.



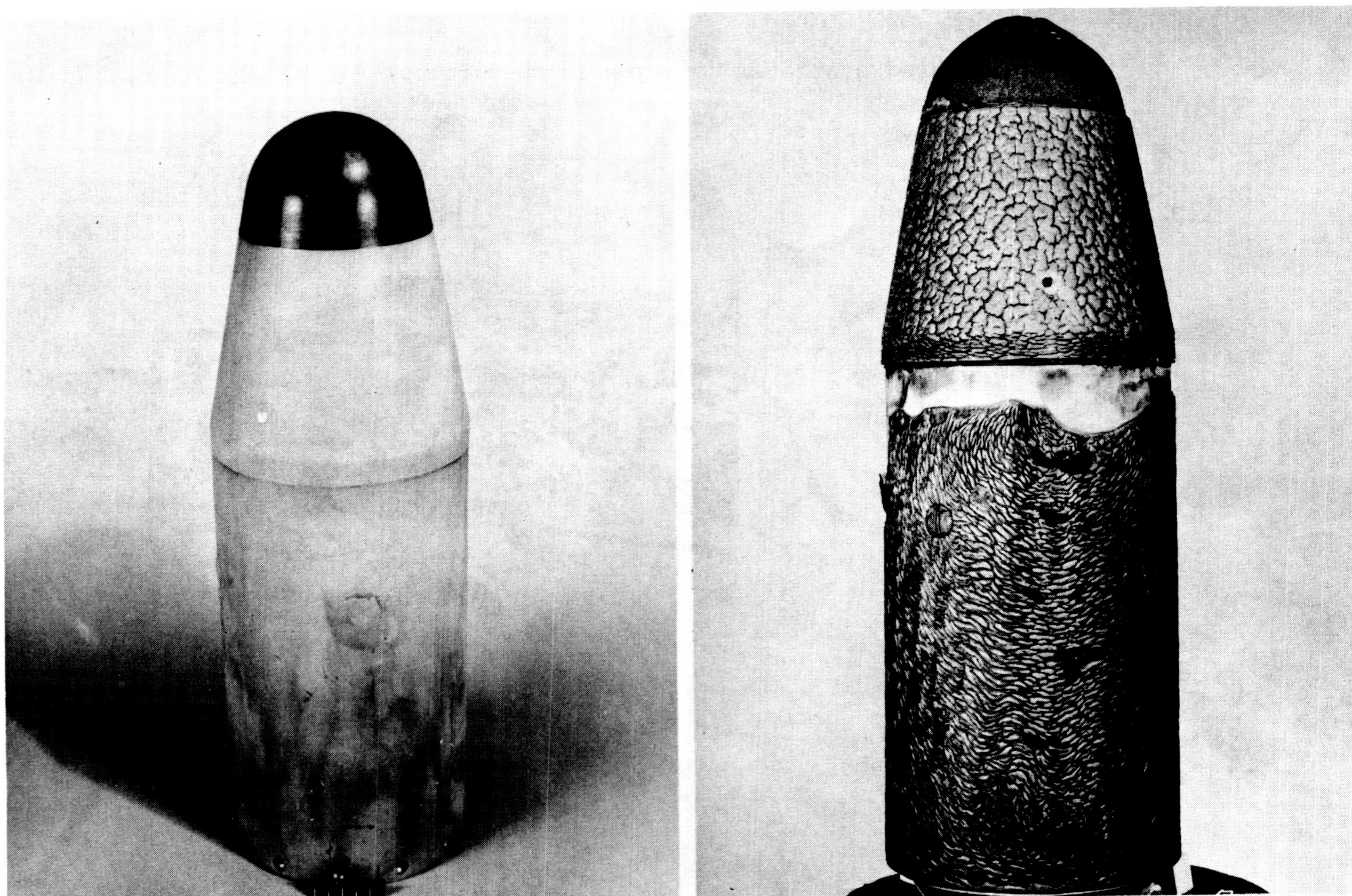
(a) PREFLIGHT



(b) POSTFLIGHT

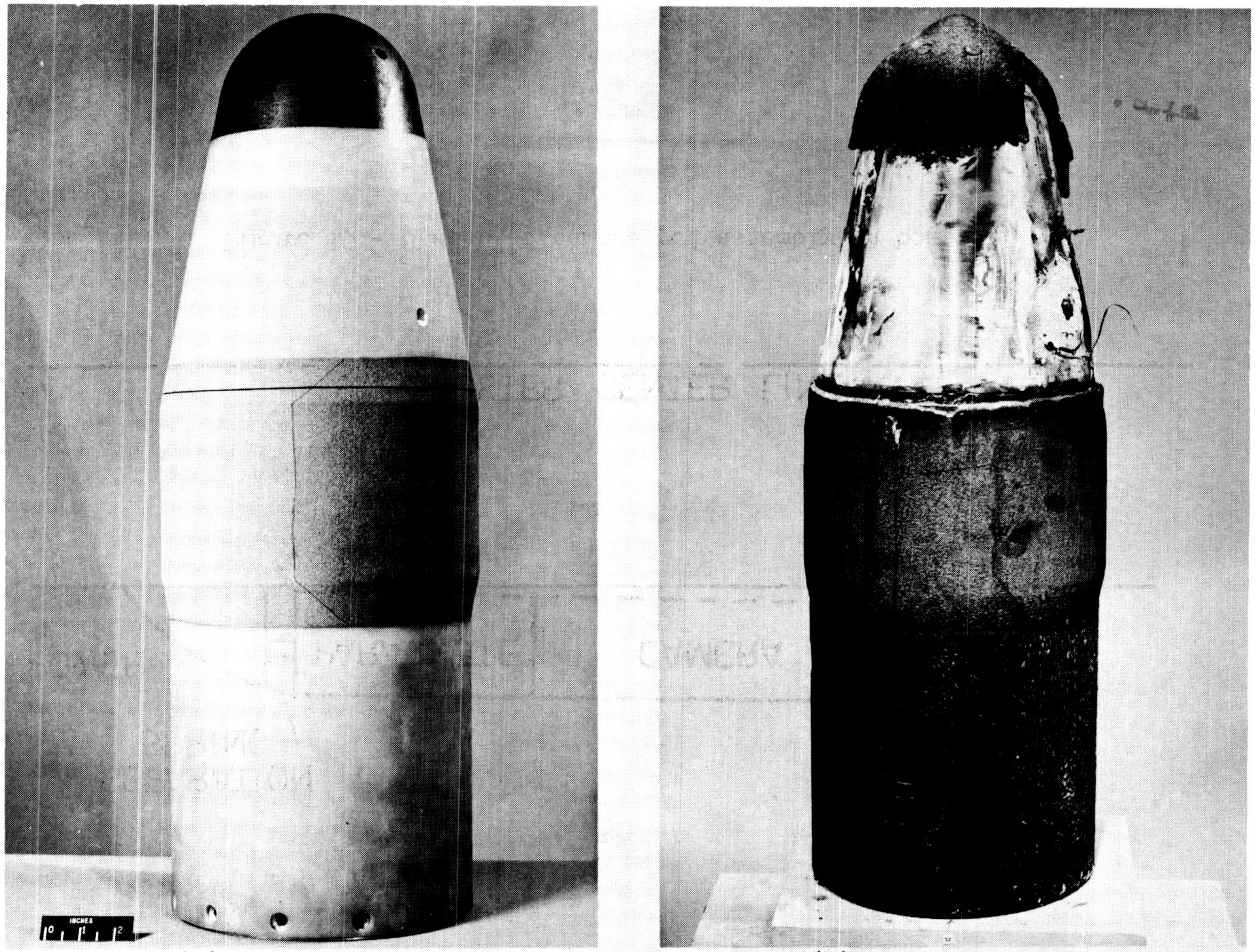
NASA

Figure 7.- Photographs of ablation materials test 1 nose cone.



(a) PREFLIGHT (b) POSTFLIGHT

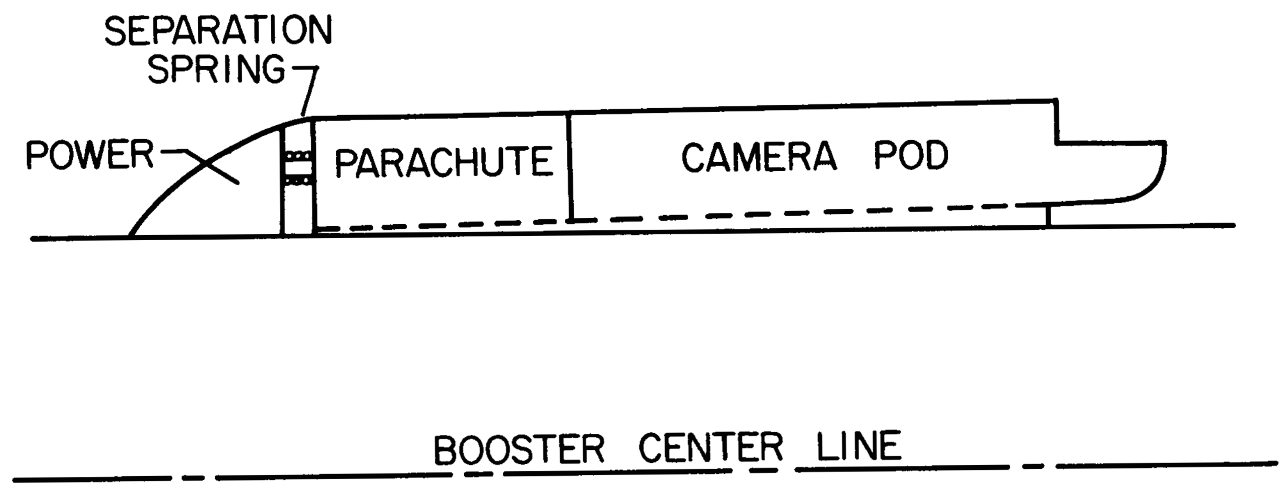
Figure 8.- Photographs of ablation materials test 2 nose cone.



(a) PREFLIGHT (b) POSTFLIGHT

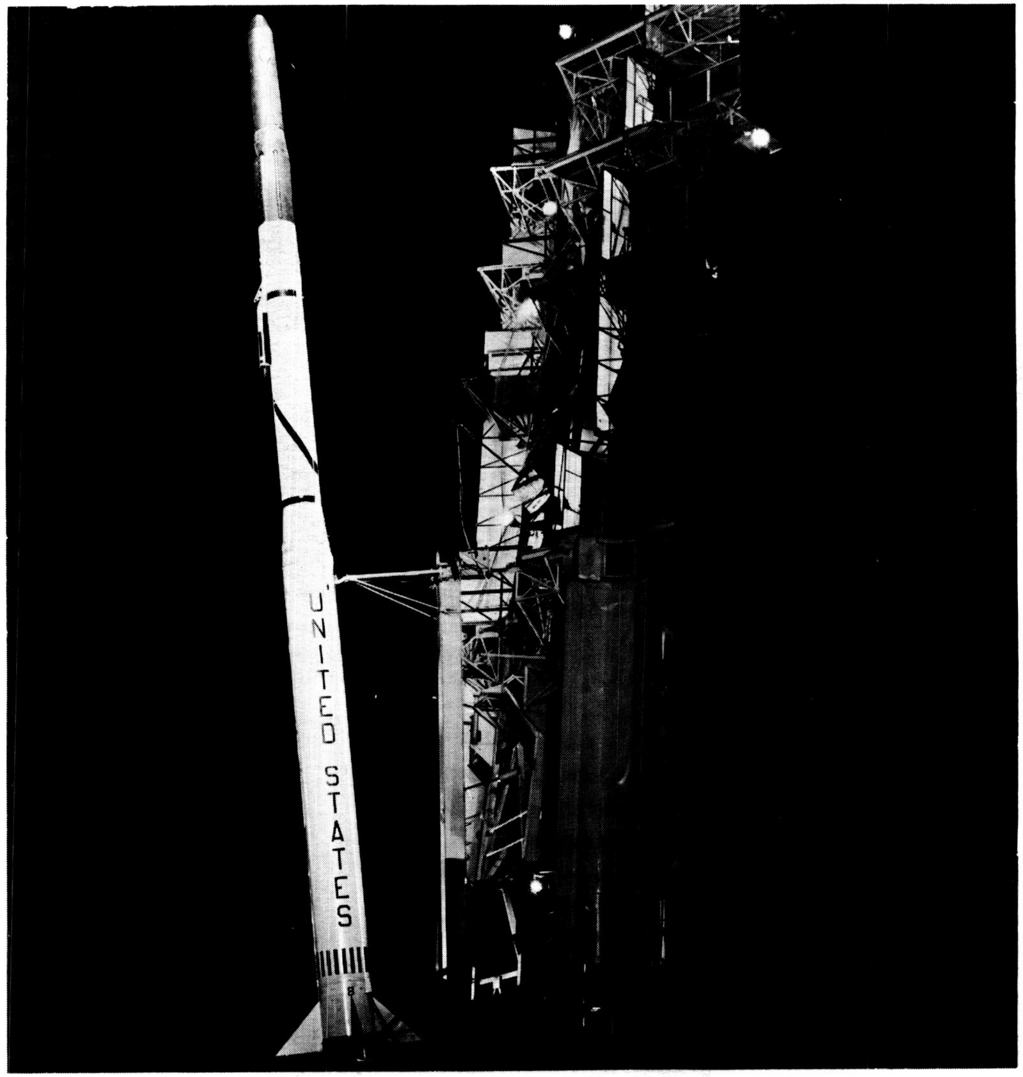
NASA

Figure 9.- Photographs of ablation materials test 3 nose cone.



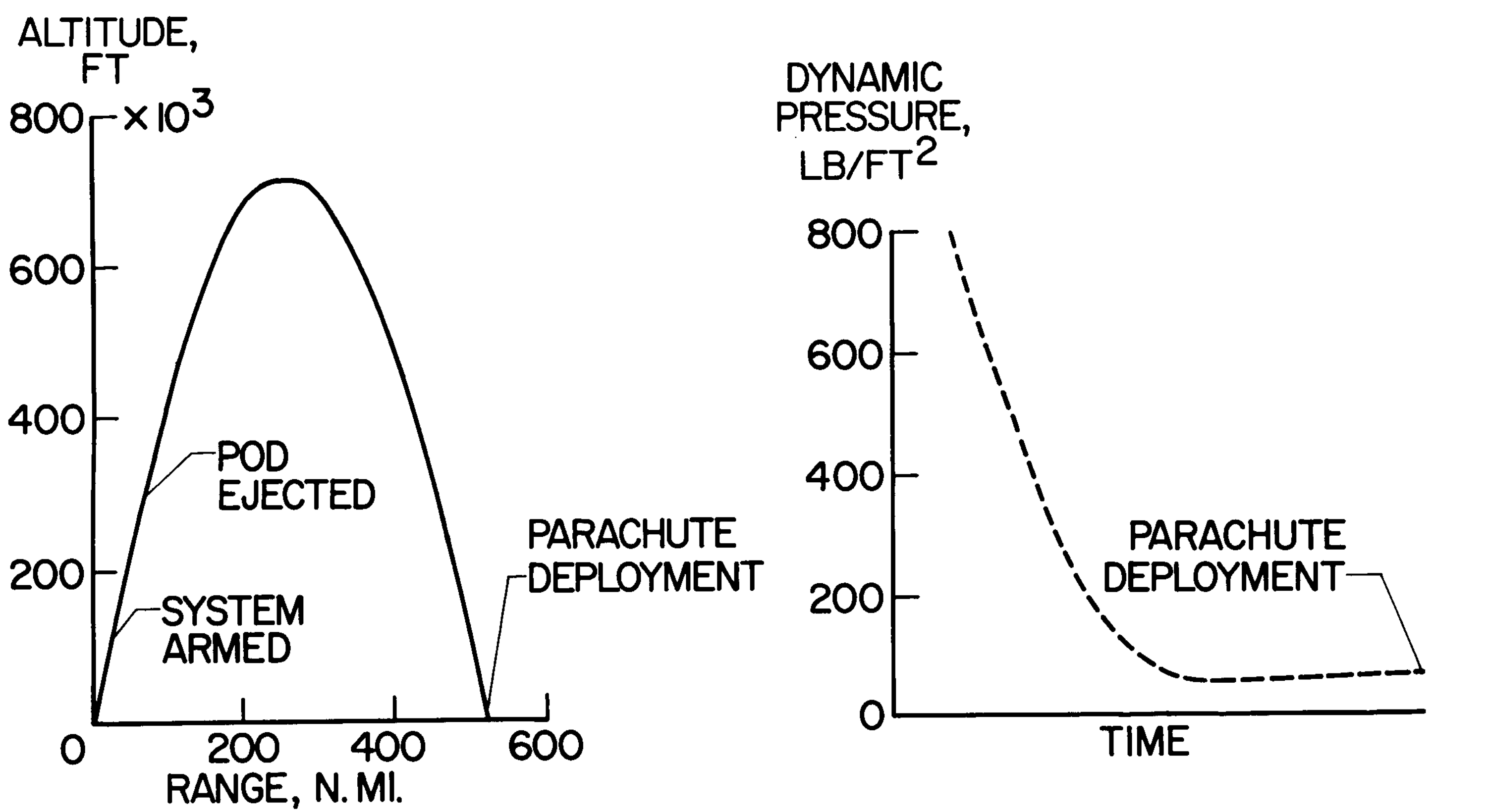
NASA

Figure 10.- Sketch of camera pod assembly on booster.



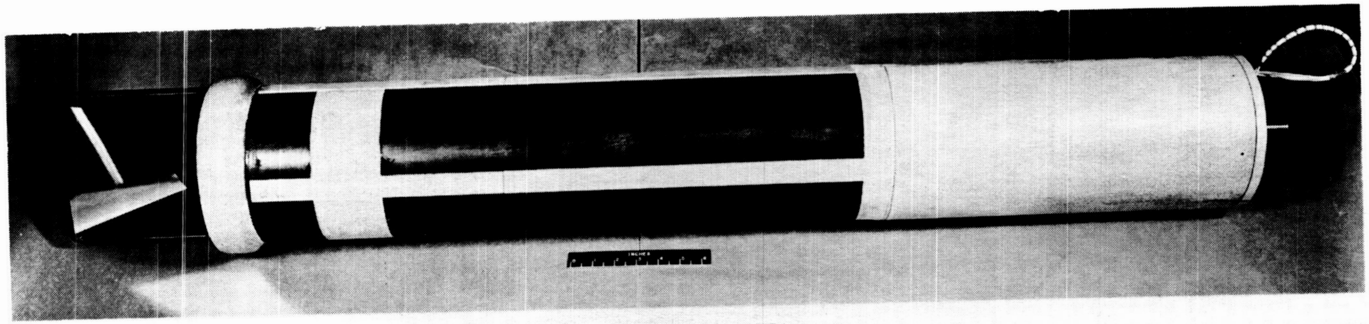
NASA

Figure 11.- Camera pod attached to Scout second stage on launcher.

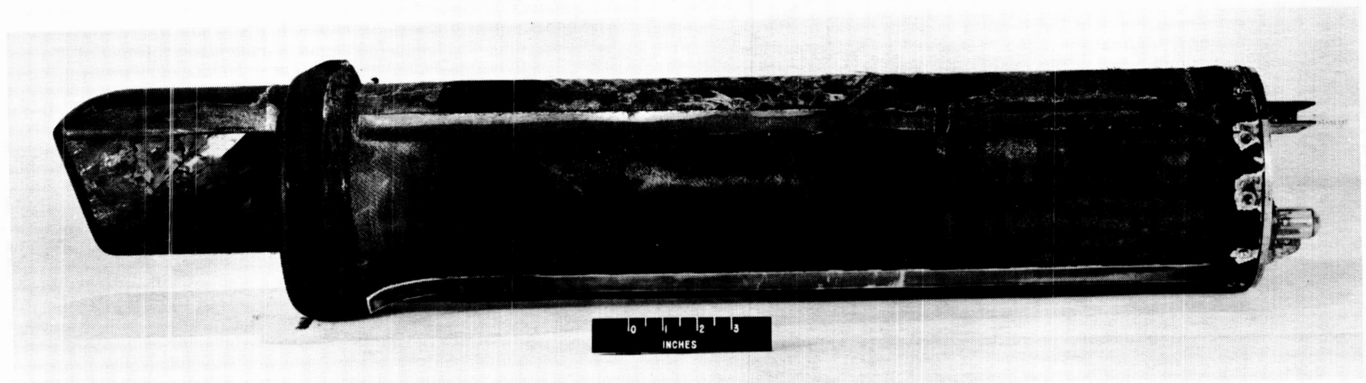


NASA

Figure 12.- Trajectory conditions for the Scout camera pod.



(a) PREFLIGHT



(b) POSTFLIGHT

NASA

Figure 13.- Photographs of camera pod for Scout.

NASA-Langley, 1964