FOREWORD

Track tests of the Canopy Escape Capsule were conducted at the Hurricane Supersonic Research Site, Utah, between 17 June 1959 and 2 September 1960 by the Coleman Engineering Company, Incorporated, Torrance, California, under Contract AF33(616)-3261. Principal test engineer for Coleman Engineering was Mr. David L. Buoy. The information contained in Coleman reports (SMART Technical Memoranda 167, 188, 189, 194, 198 and Interim Data Report 245) was assembled for use in this report.

The research described in this report is part of a continuing effort to provide escape capability for flight vehicles as part of the Air Force Systems Command's Applied Research Program 750A, the Mechanics of Flight. Air Force representatives at the track test site were Mr. Richard J. Dobbek (program monitor) and Mr. Robert A. Doutaz. These tests were performed under Project 1362, ''Crew Escape for Flight Vehicles,'' Task 136203, ''Crew Escape Techniques Research,'' for the Flight Dynamics Laboratory, Directorate of Aeromechanics, Deputy for Technology, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

ABSTRACT

This report presents the results of all of the track tests for the Air Force Canopy Escape Capsule. The purposes of these tests were to evaluate the ejection and recovery of the capsule and to obtain aerodynamic, structural, component functioning, and physiological information. Descriptions of the capsule model, test equipment, and test procedure are included in the report.

Feasibility of the canopy-type capsule method of escape was not fully demonstrated because the track tests were terminated prior to completing the design range of test velocities and because the test results indicated a need for an evaluation of the stability and impact problems of the capsule for these velocities.

The tests showed that unguided separation of the capsule was successful, that proper functioning of the recovery system was demonstrated for the 150-knot run, and that low-level ejection capability of the escape capsule was indicated.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

William C. Nielsen

WILLIAM C. NIELSEN
Colonel, USAF
Chief, Flight Dynamics Laboratory

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

INTRODUCTION

The increasing performance capability of United States aircraft led to the consideration of encapsulated escape devices in the post-World War II period. In 1952, the Air Force awarded a study contract to the Stanley Aviation Corporation to evolve a generalized escape capsule configuration and to adapt it specifically to the cockpit of the Convair F-102 Interceptor. The canopy-type capsule was chosen for further investigation and a full-scale mockup was constructed. In 1957, the Air Force made plans to purchase track test models of the capsule; track testing was commenced in June of 1959.

The Air Force directive for the track test requested an extensive program of ten tests; one was to cover a static ejection and the subsequent runs were to be conducted in the range of 150 through 700 knots. Such an extensive program was permitted because of the economic factors of the Hurricane Supersonic Research Site--its unique recovery capability and its use of a liquid-propellant pusher sled. The track test program, however, was terminated in 1960 after the loss of available capsule models.

The primary objective of the track tests was to evaluate full-scale subsonic, transsonic, and supersonic ejection and recovery of the Canopy Escape Capsule. Additional objectives were to obtain aerodynamic, structural, physiological, and component functioning information as follows:

1. Aerodynamic Information: Dynamic behavior of capsule, attitude and space trajectory of capsule, and aerodynamic pressure data.

2. Structural Information: Tail-boom loads and recovery-system loads.

3. Physiological Information: Accelerations and forces on the test subject throughout the trajectory and at ground-impact.

4. Functional Information: Ejection and separation event sequencing and recovery-system deployment and sequencing.

TEST SPECIMEN

TRACK-TEST MODEL OF CAPSULE

Figures 1 and 2 show views of a mockup of the prototype of the Canopy Escape Capsule. For the track tests, full-scale models of the capsule were fabricated to simulate the prototype. All windows were eliminated in the track-test models, and the seat retraction sequence was replaced with a fixed structure to duplicate the ejection position (see Figure 3).

Manuscript released by author on 11 April 1962 for publication as an ASD Technical Documentary Report.

TRIM TABS

Normal sequence for the capsule involved positioning of the tail-boom trim tabs by a thruster activated upon separation. For the track tests, a mockup deployment gun and metal brackets were used to firmly position the tabs to particular settings for each run. Figure 4 shows the trim tabs in the deployed position.

RELEASE MECHANISM OF CAPSULE

Figure 5 shows the capsule in position on the track-test cab. Attachment points of the capsule are located along the sill line of the canopy, and release of the capsule is accomplished by four double-ignition explosive bolts. Shear pins, located at approximately the same station as the rocket motor, were installed to take acceleration loads in the longitudinal direction. For firing sequence of the track tests, screen boxes were located along the track to fire the explosive bolts immediately after rocket-motor ignition.

EJECTION ROCKET

All tests of the capsule used the 0.24 KS 9900 rocket-assist takeoff unit that is rated nominally at 9200 pounds of thrust for 0.25 second of burning time. This unit was installed on the bottom of the capsule to thrust at an angle of approximately 25 degrees forward of the vertical. The center-of-gravity location of the capsule is approximately (plus or minus) 1 inch along the thrust line. Ignition of the rocket motor was by screen box located on the track.

RECOVERY SYSTEM

The recovery system of the capsule consisted of a first-stage drogue parachute for stabilization and deceleration and a 48-foot solid-flat, extended-skirt main parachute. Descent rate at sea level for such a parachute is about 25 to 30 feet per second.

As the capsule leaves the sled, a static lanyard fires the T-32 drogue gun. The line of the drogue gun pays out, and an attached lanyard opens the container of the drogue parachute, which permits deployment.

The suspension lines of the drogue parachute were connected to a steel cable, which was attached to the capsule through a release unit. The release unit was designed to operate by gas from standard pyrotechnic devices (series connected) whose firing times were controlled by delay cartridges. The system was initiated by a static lanyard as the capsule left the sled.

The steel cable was also attached to the deployment bag of the recovery parachute. When the drogue release device was actuated, the retention straps of the recovery-parachute deployment bag were freed. The drogue parachute then forcibly deployed the main recovery parachute whose risers were connected to the capsule. The parachute was deployed in a reefed condition. Type M2A1 2.0-second-delay reefing cutters were initiated during deployment.

Various configurations of the recovery system were used. These are shown in Table I.

TABLE I

CONFIGURATION OF RECOVERY SYSTEM

Run No.	Type Test	Drogue Parachute			48-Foot Diameter Recovery Parachute
		Diameter	Type	Drogue Release (seconds)	
1	Static	8 Feet	Flat Circular	1	Unreefed
2A	150 KEAS* Uninstrumented	5 Feet	Guide Surface No Slots; No Spoilers	1	Unreefed
3	150 KEAS Instrumented	5 Feet	Guide Surface No Slots; No Spoilers	2	Unreefed
4	300 KEAS Instrumented	30 Inches	Guide Surface No Slots; 15% Spoilers	6	2-sec. Reefing
5	400 KEAS Uninstrumented	4 Feet	Guide Surface Slots; No Spoilers	5	2-sec. Reefing

*Knots equivalent airspeed.

TEST SUBJECT

Loads on the occupant of the capsule and his restraint system were simulated with the use of an instrumented dummy as the test subject. The dummy was of the standard type except that the torso was modified to include an instrumentation box.

The torso and the instrumentation boxes are shown in Figure 6. Figure 7 shows the modified dummy. Personal equipment used on the dummy for these tests consisted of the modified MB-1A shoulder harness and a lap belt with manual-release MA-3 buckle. These are shown in the installed position in Figure 8. Figure 9 shows the installation of the capsule.

TEST APPARATUS

SLED

The sled cab consisted of the fuselage structure of a YF-102 aircraft that was modified to accommodate the Canopy Escape Capsule and to meet track requirements. Track slippers were installed and the structure was fabricated to mate the cab and the pusher vehicle. Figure 10 shows the cab and its undercarriage trusswork.

PUSHER VEHICLE

Use was made of one of the liquid-propellant pusher sleds that were specially designed for escape-system testing at the Hurricane Supersonic Research track site.

The entire sled vehicle is shown in Figure 11. Installation of the capsule, attachment of the cab and the pusher sled, and installation of the track slippers are shown in this figure.

On-track recovery of the sled vehicle was accomplished by means of the water brake and the mechanical arresting gear, which lay immediately behind the track muzzle. The water-brake scoop was located near the aft section of the pusher vehicle. During the high-speed runs, braking occurred almost immediately after ejection of the capsule.

TRACK FACILITY

The facility used for these track tests was the Hurricane Supersonic Research Site (HSRS). This facility is specifically designed for escape system testing; it is located on the top of Hurricane Mesa, a 3-1/2-mile long mesa in southwestern Utah (see Figure 12). The track is 12,000 feet long and terminates about 45 feet short of the mesa cliff.

TEST INSTRUMENTATION

Photographic Instrumentation

The cameras available at HSRS for escape system tests were located as shown in Figure 13. Additional sites were used as indicated in the test results.

Electronic Instrumentation

Nineteen channels for data transmission were contained in the torso package of the dummy. Table II gives the summary of the telemetering instrumentation used.

TABLE II
SUMMARY OF ELECTRONIC INSTRUMENTATION

All Tests Except Static Test

Parameter	Location	Parameter Range		
		150 Knots	300 Knots	400 Knots
1. Longitudinal Accel. Pusher Sled	Aft Sled	± 15 G's	± 25/-80 G's	± 50 G's
2. Space Time Data	Aft Sled			

150-Knot and 300-Knot Instrumented Runs

Parameter	Location	Range	Remarks
1. R. H. Shoulder Harness Load	Dummy	0/1000 lbs	
2. L. H. Shoulder Harness Load	Dummy	0/1000 lbs	
3. Capsule Pressure	Dummy	0/25 PSIA	
4. Lap Belt Load	Dummy	0/1000 lbs	
5. Spinal Acceleration (Head)	Dummy	± 50 G's	
6. Transverse Acceleration (Head)	Dummy	± 50 G's	Figs. 27 and 34
7. Lateral Acceleration (Head)	Dummy	± 30 G's	Fig. 35
8. Roll Rate (C.G.)	Capsule	± 1000 deg/sec	Figs. 29 and 36
9. Yaw Rate (C.G.)	Capsule	± 600 deg/sec	Figs. 29 and 36
10. Pitch Rate (C.G.)	Capsule	± 600 deg/sec	Figs. 29 and 36
11. Normal Accel. (Capsule Sta. 215)	Capsule	± 75 G's	Figs. 27 and 34
12. Lateral Accel. (Capsule Sta. 215)	Capsule	± 50 G's	Fig. 35
13. Center Tail Flap Load	Capsule	0/1200 lbs	
14. Drogue Parachute Load	Capsule	0/18000 lbs	
15. Longitudinal Acceleration (C.G.)	Capsule	± 50 G's	
16. Normal Acceleration (C.G.)	Capsule	± 50 G's	Figs. 27 and 34
17. Lateral Acceleration (C.G.)	Capsule	± 30 G's	Fig. 35
18. Recovery Parachute Load	Capsule	0/18000 lbs	

TEST PROCEDURES AND DISCUSSION OF RESULTS OF TESTS

Data on the various tests, test conditions, and the capsule are given in Table III.

TABLE III

TEST CONDITIONS AND CAPSULE CONFIGURATION

Run No.	Date	Type Test	Test Condition at Ejection	Temp (°F)	Bar Press. (In Hg.)	Wind	Capsule Model	Ejected Weight (pounds)	Trim Tabs
1	17 Jun 59	Static	Static	89	25.08	Calm	1-1	1267	Closed (0 degrees)
2	28 Aug 59	150 KEAS* Uninstrumented	36 KEAS	84	25.00	Light	1-9	0	Full Open (40 degrees)
2A	1 Sep 59	Re-Run of 2	148 KEAS -1.5 G's	80	25.10	Light	1-9	1292	Full Open (40 degrees)
3	8 Oct 59	150 KEAS Instrumented	154 KEAS -0.5 G's	63	25.04	Light	1-8	1282	Full Open (40 degrees)
4	5 Nov 59	300 KEAS Instrumented	305 KEAS -0.5 G's	49	25.42	Calm	1-8	1310	Open at (16 degrees)
5	2 Sep 60	400 KEAS Uninstrumented	408 KEAS -0.5 G's	75	25.18	Calm	1-9	1310	Closed (0 degrees)

*Knots equivalent airspeed

RUN NUMBER 1

Test No. 1 was conducted to evaluate the effect of rocket blast, disconnect system of the capsule, initiation and firing of the rocket, and deployment of the parachute recovery system.

The static firing was made at the muzzle end of the track to provide additional altitude for the recovery system sequence (refer to Tables I and III for capsule and recovery system configuration). Full recovery of the capsule was not expected in this distance, however. The capsule was considered expendable for this test.

For the purpose of this test, the ejection initiation and recovery system were operated in the following manner:

1. The JATO unit, explosive bolts, and a flash bulb were fired simultaneously.

2. The pin of the drogue gun was pulled by the M1A1 exactor, which was fired by gas pressure from the M-12 initiator. The pin of the M-12 initiator was pulled by a lanyard that was attached to the vehicle. A flash bulb and pressure switch were incorporated in this system as a functional check point during coverage by the camera.

3. The stabilization trim tabs were held in the closed position by the mockup deployment gun.

4. The container of the drogue parachute was firmly tied to the under side of the tail boom of the capsule. The cover of the container was held in place by four-pound, No. 24 type 1 BZ, cotton thread that was double-laced.

5. The riser of the drogue parachute was attached to the deployment bag of the recovery parachute. An additional tie was made between the risers and the apex of the recovery parachute by one loop of 500-pound line.

6. The steel cable, normally used to connect the drogue chute to its release unit, was used between the risers of the recovery parachute and the capsule.

Data for this test were acquired by photographic coverage. No electronic instrumentation was provided except for timing signals for the cameras. The dummy was fitted with a mockup instrumentation package.

Results of the test were as follows:

1. The JATO unit and explosive bolts functioned properly.

2. The lacing of the drogue-chute container failed prematurely from JATO blast. The drogue chute deployed as the capsule cleared the vehicle and withdrew the slug from the drogue gun prior to initiation of the drogue gun.

3. The initiation system of the drogue gun functioned properly.

4. The capsule rose from the vehicle in a level attitude and then rotated nose up approximately 90 degrees. The nose then dropped and the capsule descended to the impact area.

5. The drogue chute withdrew the deployment bag of the recovery chute properly.

6. The deployment of the recovery chute was normal; however, full development did not occur before impact of the capsule. The loop of 500-pound line between the risers of the drogue chute and the apex of the recovery chute did not break.

7. The nose cone was buried in the ground at impact; the remainder of the capsule sheared free of the cone.

8. The structure of the capsule forward of the canopy was crushed at impact.

9. The tail-boom structure was undamaged except for the left-hand fairing of the stabilizing fin, which caught in the risers after impact and was torn free.

10. At impact three bracket bolts that were attached to the seat were pulled out of the bracket holes and the fourth bracket weld failed. The seat and dummy slid forward against the forward bulkhead. At this point the five 1/4-inch bolts, which attached the legs of the dummy to its torso, were sheared. The shoulder harness and lap belt were undamaged and held the dummy in the seat.

11. The JATO blast pressure pushed in the skin on the bottom and both sides of the capsule in the area below the support sill.

12. The interior of the forward vehicle was damaged slightly by the blast of the JATO unit. The damage consisted of the following:

a. The skin of the floor of the cockpit area was torn loose.

b. A small bulkhead forward of the well of the JATO bottle was forced forward. One of its mounting angles was pushed through the exterior skin of the vehicle.

c. Portions of the fire-proofing material in the cockpit were blown out. The vehicle was purposely not vented to obtain an appraisal of possible blast effects.

13. The retainer-nut brackets of the forward explosive bolts were bent as a result of the explosions of the bolts.

14. Preliminary measurements indicated that the structure of the vehicle was not deformed in the area where the explosive bolts were located.

Table IV gives the event times for this test. The trajectory as determined by camera coverage is shown in Figure 14. Trajectory data are given in Appendix B.

TABLE IV

EVENT TIMES - RUN NUMBER 1
(in seconds)

Ignition of JATO bottle and explosive bolts (flash bulb)	0
Capsule clear	0.117
First sighting of drogue chute	0.538
Full development of drogue chute	1.039
Firing (flash bulb) of drogue gun	1.092
Start of recovery chute deployment	1.288
Full deployment of recovery parachute	3.472

The effect of rocket blast (JATO unit), as discussed in the test results, is shown in Figure 15 for the interior of the vehicle. The vehicle had not been vented so as to simulate the actual escape situation and to appraise these blast effects. Blast damage to the capsule was not considered extensive enough to impair escape performance. The premature deployment of the drogue parachute as a result of the JATO blast can be easily corrected.

Performance of the disconnect system of the capsule was considered satisfactory. Likewise, the initiation and firing of the JATO unit was considered successful with no problems posed in this test.

Figure 16 shows installation of the recovery system in the capsule. Figures 17 and 18 further describe this system for the static test. The recovery system did not operate as designed when one considers the premature deployment of the drogue parachute. However, this action did not further disturb the recovery sequence. All functions of the sequence were performed by the components of the system, and test results indicated that the system performed properly.

As was noted in Item 4 of the test results, the capsule rose from the vehicle in a level attitude and then rotated nose up approximately 90 degrees. The rotation of the capsule to the 90-degree pitchup position was not expected in this test. Discussion of pitchup is considered in the succeeding test runs.

RUN NUMBER 2

Test No. 2 was programmed at 150 knots equivalent airspeed to furnish a demonstration of the recovery system of the capsule under dynamic test conditions. No provisions were made for electronic instrumentation except for space time*, vehicle acceleration, and timing signals for the cameras. Table III shows the test configuration. The sled was vented for rocket blast.

Ejection initiation and the recovery system were intended to operate in the following manner:

1. The JATO unit, explosive bolts, and a flash bulb were fired independently from separate screen boxes along the track.

2. The pin of the drogue gun and the pin of the M-12 initiator were pulled by separate lanyards upon separation of the capsule from the vehicle.

3. The drogue parachute was stowed in its special container; a metal container was installed just below the main recovery parachute shelf at the left-hand side of the capsule (see Figure 19).

4. The riser and cable of the drogue parachute were attached to the release-unit cap. The cap is also connected to the deployment bag of the recovery chute by a double thickness of 6000-pound nylon strap. An additional tie was made between this strap and the apex of the recovery parachute by two loops of 75-pound line.

5. The sequence of the parachute system was utilized as designed, but without reefing.

Results of the test were as follows:

1. Velocity of the vehicle at the time of JATO ignition was 67 feet per second instead of the programmed 280 feet per second. This condition was caused by an erroneous estimate of slipper friction.

2. The JATO unit and the explosive bolts of the capsule functioned properly; however, because of the low velocity, the JATO unit was burned out prior to release of the bolts. The capsule did not leave the vehicle and was prevented from sliding off during the braking phase of the run by the two alignment pins of the capsule.

Track-side initiation methods had been employed so that the separation rocket would be ignited 0.08 second prior to release of the capsule. Due to the much slower velocity and the initiation methods used, the delay time for release of the capsule became longer than the total burning time of the rocket (0.24 second). When release of the capsule was finally initiated, thrust was not available to effect separation, and the capsule remained aboard the sled throughout the run. Upon inspection, no damage to the capsule or sled was found to have occurred and that preparation for another run could be started without change to the system as installed.

Telemetered space time is plotted in Figure 20. The velocity decay that had been expected for this run is superimposed. The corresponding difference between the actual and expected velocity profiles is readily seen.

---

*Space time refers to track station, time, and velocity of vehicle data.

Maximum values of the telemetered longitudinal acceleration of the sled are 2.8 G's at 6.25 seconds and -1.0 G at 63.21 seconds (time zero at start of run).

RUN NUMBER 2A

Run No. 2A was a rerun of the 28 August test (Run No. 2). The same procedures, configurations, and instrumentation were used. See also Table III.

Test results were as follows:

1. The JATO unit and explosive bolts functioned properly.

2. After clearing the vehicle, the drogue gun fired as designed.

3. The flash bulb signaling release of the main recovery parachute fired as programmed.

4. The drogue parachute system and the main recovery-parachute system functioned properly and "full development" of the recovery system was accomplished above the level of the Mesa.

5. Prior to the firing of the drogue gun, the capsule assumed an attitude of approximately 80 degrees nose up. After development of the drogue parachute, a more normal attitude was observed, and the capsule rolled 90 degrees to the left. Pitch oscillations of lesser magnitude were in evidence.

6. At recovery, the risers of the main parachute were found twisted together. Some small cuts and twist breaks were in evidence. No evidence of JATO flame damage was found on the parachutes or lines (see Figure 21).

7. Damage of the capsule in landing was relatively light. All damage was repairable. The nose cone was undamaged except for a weld split on the left-hand side near the aft end. The right-hand side of the cockpit cover was smoothly dented. The guide channel of the right-hand tail fin was broken. The center and left-hand stabilization tabs were ruined during recovery, which required replacement from a spare capsule.

8. The cover plate of the camera in the capsule did not pull free. The shear pin sheared, but the plate guide was too tight. The lanyard was broken.

9. The forward sled was undamaged by the JATO blast.

Ejection of the capsule occurred at approximately 277 feet per second as shown in the telemetered space-time data, Figure 22, at 36.6 seconds. This time value is recorded with the other event times in Table V. Acceleration values of the sled movement were recorded; maximum longitudinal accelerations are 3 G's at 7.15 seconds and -13 G's at 36.94 seconds.

Figure 23 gives a photographic summary of the capsule separation and recovery sequence. Of special interest are the frames showing operation of the drogue parachute. A review of the film from this test run indicated that the drogue parachute did not act as a stabilizer because of its early release. An enumeration of the recovery-system sequence as outlined in the discussion of Run No. 2 is in order. Figure 24 presents a summary of the recovery sequence of Run No. 2A. This figure shows that for the time delays used, the cable of the drogue parachute would be taut (line stretch of drogue) for less than 0.4 second. It is conceivable also that the drogue chute could be released prior to full development and line stretch of the drogue. According to the event times (Table V), the difference in time between full development of the drogue chute and initiation of the release unit of the drogue chute is about 0.23 second. This would allow about one quarter of a second for an application of the drogue-parachute load to aid in stabilization.

TABLE V

EVENT TIMES - RUN NUMBER 2A
(in seconds)

Ignition (flash bulb) of JATO squib	36.530
JATO ignition (first JATO flame)	36.592
First movement (Station 11,574) of capsule	36.626
Firing of drogue gun	37.245
Full development of drogue chute	37.480
Initiation (flash bulb) of drogue-chute release unit	37.712
Start of recovery-chute deployment (drogue and deployment bag release)	37.888
Line stretch of recovery chute	38.418
End of deployment of recovery chute	38.566
Full development of recovery chute	40.769

In reviewing Table V of this test run, it is interesting to note that about 3 seconds were required to fully open the recovery parachute for this unreefed test configuration. Estimates of opening time were in the order of 10 seconds. The test result, therefore, was totally unexpected.

Data on trajectory of the capsule were provided in this test by the photographic coverage. These data are included in Appendix B and include three directional displacements and velocities. Figure 25 shows the displacement plot. This figure shows that the capsule moved a total of 50 feet to the left and reached a trajectory height of about 60 feet. It also indicates winds, which moved the capsule backward as it descended. Figure 26 gives the coordinate system referred to in this report.

Reference to Table I shows that a 5-foot drogue parachute was used in this test and in the succeeding test. This differed from the high-speed design, which incorporated use of a 30-inch drogue. Since this test run showed proper functioning of the recovery parachute under dynamic conditions, it fulfilled its test objective.

RUN NUMBER 3

Run No. 3 was an instrumented test run that was intended to obtain test-subject loads and recovery-system loads as well as the loads and accelerations of the capsule. Tables I and III give the test configuration.

The sequence of the system, that is, the ejection initiation and recovery system, was intended to operate in the same manner as explained in the discussion of the first 150-knot run (Run No. 2). One exception in this test over that of the previous one was the use of a M-4 (2-second delay) initiator rather than the M-12 (1-second delay) initiator for the delay of the drogue-parachute release (see Figure 24).

Test results were as follows:

1. The JATO unit and the explosive bolts functioned properly.

2. The drogue gun fired as programmed.

3. The flash bulb signaling release of the main recovery parachute fired as programmed.

4. Both the drogue and main recovery-parachute systems functioned properly.

5. Prior to the firing of the drogue gun, the capsule assumed an attitude of approximately 80 degrees nose up. After development of the drogue parachute, the capsule yawed to the right about 45 degrees. It then assumed a normal attitude and oscillated in yaw during the recovery-parachute development. After development of the recovery parachute, the attitude of the capsule was normal.

6. No evidence of JATO flame damage was found on the parachute or lines. The forward sled was undamaged by the JATO blast.

7. Damage to the capsule in landing was light. All damage was repairable.

During the run the tape recorder at the ground station recorded an unusual amount of noise. This noise was superimposed on the telemetered data and in most cases obscured the data. The noise stopped at 53.4 seconds or prior to impact and did not reappear. Event times for this test are shown in Table VI. Table VII gives a summary of the maximum values obtained for each of the telemetered parameters and indicates the data that were obscured.

TABLE VI

EVENT TIMES - RUN NUMBER 3
(in seconds)

Ignition of JATO squib	35.63
JATO ignition (first JATO flame)	35.669
First movement (Station, 11,572) of capsule	35.721
Firing of drogue gun	36.391
Full development of drogue chute	36.668
Initiation (flash bulb) of drogue-chute release unit	37.694
Start of recovery-chute deployment (drogue and deployment bag release)	37.871
Line stretch of recovery chute	38.477
End of deployment of recovery chute	38.700
Full development of recovery chute	41.434
Impact	61.35

TABLE VII

MAXIMUM TELEMETRY VALUES - RUN NUMBER 3

Parameter	Value	Time (seconds)	Remarks
R. H. Shoulder Harness Load	Obscured		
L. H. Shoulder Harness	Obscured		
Capsule Pressure	Obscured		
Lap Belt Load	Obscured		
Spinal Accel. (Head)	+ Obscured -30 G's	 61.35 (Impact)	
Transverse Accel. (Head)	+7.0 G's	35.72 (*)	Fig. 27
Lateral Accel. (Head)	Obscured		
Roll Rate (C.G.)	LT 70 deg/sec RT 175 deg/sec	37.2 40.6	Fig. 29
Yaw Rate (C.G.)	LT 170 deg/sec RT 170 deg/sec	39.23 39.63	Fig. 29
Pitch Rate (C.G.)	Up 160 deg/sec Dn 180 deg/sec	36.21 36.90	Fig. 29
Normal Accel. (Capsule Sta. 215)	+ 10 G's + 17 G's - Obscured	35.73 (*) 61.35 (Impact)	Fig. 27
Lateral Accel. (Capsule Sta. 215)	Obscured		
Center Tail-Flap Load	200 lbs	37.20	
Drogue-Parachute Load	1300 lbs	37.13	
Longitudinal Accel. (C.G.)	+ Obscured - 30 G's	 61.35 (Impact)	
Normal Accel. (C.G.)	+ 9 G's + 18 G's - Obscured	35.73 (*) 61.35 (Impact)	Fig. 27
Lateral Accel. (C.G.)	Obscured		
Longitudinal Accel. of Pusher Sled	2.0 G's - 11.5 G's	5.19 36.0	

*First movement of capsule at 35.72.

Figure 27 gives plots of (condensed from oscillograph traces) transverse acceleration (head), normal acceleration (capsule station 215), and normal acceleration (C.G.). These parameters should show closely similar results because they are a measure of acceleration in approximately the same direction. Some dissimilarities should be expected because of differences in longitudinal location. See Figure 28 on Capsule Instrumentation. The portion of this plot showing the actual trace indicates the superimposed noise on these parameters. As would be expected for the magnitude of normal acceleration (C.G.), the maximum values while in flight occurred during operation of the rocket.

Figure 29 shows plots of roll, yaw, and pitch rates about the center of gravity (approximately) of the capsule. Several trends are noted. At first movement of the capsule, this figure shows a roll to the right, yaw to the left, and pitch in the upward direction. The initial roll portion is not significant; pitchup is the predominant initial movement. A review of the film of this test run reveals trends in pitch and yaw concurrent with the oscillograph plots. Photographic coverage of this test also showed that the drogue parachute aided measurably in achieving pitch and yaw stabilization. At the time of drogue-chute release and the recovery-parachute bag release, the capsule pitched up once more. The capsule also yawed to the right until deployment of the recovery parachute.

Figure 29 also indicates the damping in pitch and yaw achieved by the recovery parachute.

Displacement history of the capsule for this run is shown in Figure 30. These trajectory data are also given in Appendix B and include velocity and acceleration of the capsule. Figure 30 shows an attained trajectory height of about 70 feet, which occurred at the beginning of the recovery-parachute deployment.

Figures 31 and 32 show the capsule after impact and indicate only slight damage to the capsule. Installation of the camera on the underside of the capsule is clearly visible. Impact loads are indicated in Table VII to be -30 G's longitudinal acceleration C.G. and +18 G's normal acceleration C.G. Other impact values are -30 G's spinal acceleration (head) and +17 G's normal acceleration (capsule station 215). These instrumentation pickup locations are shown in Figure 28. Evaluation of these impact values for the human occupant is necessarily incomplete because of the lack of information on the structural dynamics of the instrumentation installation and of the load transfer from the structure of the capsule to the occupant (restraint and seating factors). Comparison of these capsule values with the acceleration limitations shown in Military Specification MIL-C-25969A (USAF), "General Requirements for Capsule Emergency Escape Systems," paragraph 3.3.3.1, shows that the 17 G's are higher than the 15-G transverse limitation and the 30 G's are higher than the 15-G upward limitation. Although these values are not tolerance values but specifications, it appears that additional analysis and testing are required to assure tolerable recovery of the capsule. As was shown in Figure 23, descent and impact of the capsule occur with the nose downward (feet of the occupant of the capsule downward). Consideration of this impact problem by the Aerospace Medical Laboratory (Wright Field) in 1953 resulted in the opinion that the best position of the capsule to absorb shock in landing would be the horizontal position (i.e. back of the occupant towards the ground). This would result in transverse rather than spinal deceleration. The landing attitude used, therefore, was based on factors of design feasibility, e.g., parachute stowage, deployment, and riser connection rather than optimum physiological considerations.

RUN NUMBER 4

Run No. 4 was an instrumented run of the capsule programmed at 300 knots equivalent airspeed. The recovery system included a 30-inch-diameter drogue parachute with a 6-second release delay and the main parachute with 2-second reefing incorporated. Procedures for the test were the same as explained for Run No. 2. Test components were equivalent except as indicated in Tables I and III.

Results of this test were as follows:

1. The JATO unit and explosive bolts functioned properly.

2. After the capsule left the sled, it pitched nose up approximately 60 degrees.

3. The drogue gun fired as programmed. Inspection of the film revealed that the left half of the drogue-parachute cable separated from its stowage clips prior to firing of the drogue gun.

4. Shortly after the drogue parachute deployed, the capsule began very unstable gyrations.

5. The release unit of the drogue system (Number WCLS-1-394) functioned properly.

6. The guide release of the drogue cable did not operate. It is apparent that the drogue parachute supplied insufficient force on this unit. Inspection of the film showed that the drogue-gun slug appeared to affect the performance of the drogue parachute by causing momentary and intermittent squidding (i.e. opening and closing of the parachute). Also, inspection of the unit revealed friction damage caused by binding of the cable. Such binding was due to an eccentric load. Some of this friction damage was evident on the underside of the release dog.

7. The film from the N-9 camera that was mounted in the capsule revealed that during early flight the drogue-parachute cable became wedged in the opening between the right-hand fin and the outboard fairing of the tail boom. The film showed the cable still wedged at the time of camera shut-off, which occurred approximately 5 seconds after first movement of the capsule.

8. The drogue cable moved far enough after release from the release unit to pull the bag-release lanyard of the recovery parachute; however, the bag did not separate from the capsule until impact. Consequently the capsule was expended.

These results show that the performance of the recovery system within the first 5 seconds of capsule ejection ultimately led to the expenditure of the capsule. The 30-inch drogue parachute used in this test was not large enough to produce aerodynamic stabilization as evidenced by the excessive oscillations and tumbling of the capsule. It appeared that the oscillations of the capsule accidently caused the steel cable of the drogue to wedge. This wedging of the cable prevented the drogue parachute from pulling out the main parachute even though the release unit of the drogue system functioned properly.

The separation of the drogue-parachute cable from its stowage clips prior to firing of the drogue gun did not have an effect upon operation of the system. This is a system function the failure of which may or may not cause any further system compromises.

Telemetry traces for this test run were good, and no data were obscured as in the past run. Since excessive oscillation of the capsule began shortly after ejection,however, these traces represent data on an unstable body for the greater portion of its flight. Figure 33 gives an attitude plot of the capsule for the first 2 seconds of its flight. The pitchup noted in the results is shown clearly in this figure. This initial pitch builds up to about 65 degrees at 0.5 to 0.6 second after ejection. Reference is made again to the capsule drawing in Figure 28. If no pitchup was experienced, the principal accelerations to be expected would be a normal acceleration and a forward longitudinal acceleration caused by the rocket unit and a longitudinal acceleration resulting from the aerodynamic drag. The normal acceleration of the rocket would be fairly large in magnitude, say about 7 G's thrust-to-weight ratio (9200 pounds thrust, 1310 pounds weight) and would decay rapidly after the nominal burning time of 0.25 second. The longitudinal drag acceleration would be small, say in the order of 1 to 2 G's for 300 knots, would be counteracted upon by the rocket force, and would decay slowly. The effect of pitchup on these acceleration values, which are well within human tolerance, would be such as to increase the normal acceleration and decrease the longitudinal. Since the maximum pitchup occurs after rocket burn-out, however, the value of the maximum normal acceleration should never exceed that value corresponding to the aerodynamic drag G value at the initial dynamic pressure and at 90 degrees pitchup. For 300 knots, this value would be in the order of 8 G's. When a pitch trim angle of 40 to 50 degrees and the test result of 65-degree pitch are considered, this value would be less than 8 G's, say about 6 G's for the 300-knot case. All of these values are within human tolerance and no problems of translational acceleration are seen because of the large pitchup for the 300-knot case.

Table VIII shows the maximum telemetry values obtained in this run. The normal acceleration values corresponding to first movement of the capsule are essentially those caused by the thrust of the rocket. These are from 7 to 11 G's in magnitude. Thrust of the rocket also causes the forward longitudinal acceleration of 2.5 G's at first movement of the capsule. This shows that the rocket unit more than compensates for the aerodynamic drag deceleration at this speed.

TABLE VIII

MAXIMUM TELEMETRY VALUES - RUN NUMBER 4

Parameter	Value	Time (seconds)	Remarks
R. H. Shoulder Harness Load	107 lbs	32.57	
L. H. Shoulder Harness Load	140 lbs	31.51	
Capsule Pressure	12.75 PSIA	27.04	
Lap-Belt Load	560 lbs	32.57	
Spinal Accel. (Head)	-1.5 G's	27.20	
	7.0 G's	28.48	
Transverse Accel. (Head)	-0.5 G's	26.91	
	10.6 G's	26.70 (*)	Fig. 34
Lateral Accel. (Head)	5.7 G's	27.84	
	-8.2 G's	28.51	Fig. 35
Roll Rate (C.G.)	LT 150 deg/sec	28.40	
	RT 380 deg/sec	32.40	Fig. 36
Yaw Rate (C.G.)	LT 425 deg/sec	30.75	
	RT 465 deg/sec	31.47	Fig. 36
Pitch Rate (C.G.)	Dn 385 deg/sec	31.32	
	Up 315 deg/sec	32.30	Fig. 36
Normal Accel. (Capsule Sta. 215)	6.5 G's	26.84 (*)	
	-7.5 G's	30.34	Fig. 34
Lateral Accel. (Capsule Sta. 215)	6.5 G's	28.12	
	-6.5 G's	28.89	Fig. 35
Center Tail-Flap Load (16 deg. open)	130 lbs	30.30	
Drogue-Parachute Load	1200 lbs	27.49	
Longitudinal Accel. (C.G.)	2.5 G's	26.70 (*)	
	-4.0 G's	31.60	
Normal Accel. (C.G.)	7.0 G's	26.70 (*)	
	-1.5 G's	28.07	Fig. 34
Lateral Accel. (C.G.)	5.0 G's	27.71	
	-5.0 G's	28.54	Fig. 35
Longitudinal Accel. of Pusher Sled	4.0 G's	10.00	
	-29.0 G's	26.99	

*First movement of capsule at 26.67

The effect of capsule pitchup on the normal acceleration is shown in Figure 34. This figure gives transverse acceleration (head), normal acceleration (station 215), and normal acceleration (C.G.). All three traces show the initial acceleration due to thrust of the rocket and a second acceleration of lesser magnitude, which corresponds to the time of maximum pitchup as can be seen by comparison with Figure 33. Event times shown in these figures are listed completely in Table IX.

TABLE IX

EVENT TIMES - RUN NUMBER 4
(in seconds)

Ignition of JATO squib	26.575
JATO ignition (first JATO flame)	26.625
Firing of explosive bolt	26.653
First movement (Station 11,433) of capsule	26.671
Firing of drogue gun	27.357
Full development of drogue chute	27.832
Initiation (flash bulb) of drogue-chute release unit	33.969
Impact	42.34

The importance of achieved flight stability early in the escape sequence can be appreciated by noting the excessive yaw shown in Figure 33 and by comparing it with the lateral accelerations imposed upon the occupant of the capsule. These accelerations are shown in Figure 35 and include lateral acceleration (head), lateral acceleration (capsule station 215), and lateral acceleration (C.G.). At the first yaw angle of 90 degrees-left, which occurs at approximately the full development of the drogue chute, these traces show an acceleration of 3 to 6 G's. At this same time, a roll angle of about 30 degrees right is experienced. These acceleration forces remain right-to-left until the capsule yaws to zero degrees. This occurs at about 28.35 seconds. Yaw of the capsule to the right then is accompanied by acceleration forces left-to-right as shown by the traces in Figure 35.

Roll instability will not materially affect the occupant of the capsule as long as the roll rate is not excessive and yaw is controlled within small angles. Yaw during roll can result in additional accelerations; for example, at about 28.15 seconds (Figure 33), a roll angle of 90 degrees-right occurs at the same time as a yaw angle of about 90 degrees-left and produces a normal acceleration force that is chest-to-back.

Pitch, roll, and yaw rates are shown in Figure 36 and illustrate the instability of the capsule shortly after ejection. The capsule was unstable even after full development of the drogue parachute. Data on human tolerance to angular velocities and accelerations do not appear sufficient to make comments in this area. Some data on simple tumbling are noted in Reference 1.

Figure 37 gives displacement data on the capsule. These data show the trajectory height to be about 180 feet. Lateral displacement amounted to only about 20 feet.

An indication of capsule damage is shown in Figure 38.

RUN NUMBER 5

Run No. 5 was performed to obtain data on aerodynamic stability and on the functioning of the stabilization and recovery-system components for ejection at 400 knots equivalent airspeed. Electronic instrumentation included only space time and longitudinal acceleration of the sled; the dummy was fitted with a mockup instrumentation package.

Experience in the previous test indicated the need for a large drogue parachute. Therefore, a 4-foot diameter parachute was used in this test.

The steel cable that connected the riser of the drogue parachute and the capsule for the previous test was replaced by one continuous nylon riser that was 210 inches in length. The riser was stowed in channel sections that were bolted to the underside of the capsule boom. Ties were woven through holes that were drilled in the sides of the channel to hold the riser in place. The riser is shown in Figure 39.

The release unit of the drogue-parachute riser guide from the previous test was replaced by the WWRMDD-12-1 assembly (see Figure 40). An M-3 initiator was mounted near this assembly and connected to it by 14 inches of flex tubing. A steel lanyard was sewn to the riser and connected to the pin of the initiator as shown in Figure 41. The drag line of the drogue gun was lengthened to 30 inches from the designed length of 16 inches.

The drogue-parachute release unit (WCLS-1-394) used on the previous test was replaced with the WCLSJE-500 unit (see Figure 42).

The tail-boom connection to the capsule was strengthened by the addition of steel angles at the base of the boom on each side. These angles were riveted to the structure of the capsule and to the channel sections at each side of the boom.

The capsule system for this test was intended to operate in the following manner:

1. At first movement of the capsule, three lanyards that are attached to the vehicle will pull the lens plate of the camera box, fire the T-32 drogue gun, and pull the pin from a T-39 initiator equipped with a T-311 3.0-second delay cartridge.

2. Gas from the T-39 initiator will route through 14 inches of flex tubing to a T-38 initiator and ignite its M-46 2.0-second-delay cartridge.

3. Gas from the T-38 initiator will route through 14 inches of flex tubing to the drogue-chute release device (WCLSJE-500) and cause it to release the drogue from the body of the capsule. Gas from this initiator will also be used to operate a pressure switch to fire an event flash bulb.

4. As the drogue separates, two lanyards that are attached to the riser will be pulled. These will pull the pin from the retention strap lock of the recovery-chute deployment bag, and pull the pin from an M-3 initiator that is mounted under the aft fairing of the tail boom. Gas from this initiator will operate a Boeing 6-62493-502 pin-pull unit which, in turn, will extract a locking wedge and release the riser guide (WCLSJE-510) of the drogue chute. A nylon strap, attached between the riser and guide unit, will pull the unit free of the capsule after the unit is released by the pin-pull device.

5. The released drogue chute will pull the recovery-parachute deployment bag from its stowed position by means of a doubled 6,000-pound nylon strap, which connects the bag and the drogue-chute riser. The drogue chute will continue its pull on the deployment bag until the recovery chute is deployed, at which time two loops of 75-pound break cord that connects the bag to the apex of the recovery chute will fail.

6. At recovery-chute deployment, two M2A1 2.0-second-delay reefing cutters will be actuated. The parachute will inflate to the reefed condition, and after the cutters cut the 24.8-foot reefing line, the chute will fully inflate.

At the time of this programmed test run, the liquid-propellant pusher sled was no longer available. Solid-propellant rockets attached to a pusher sled were used. Figure 43 shows this test configuration.

Results of this test were as follows:

1. Ignition of the JATO unit and explosive bolts occurred as programmed.

2. The capsule lifted cleanly from the vehicle with no apparent pitchup until it was approximately 3 feet above the sled.

3. Immediately after the capsule cleared the vehicle, the deployment bag of the recovery parachute was seen in the released condition. The recovery parachute then inflated prematurely and tore free from the capsule.

4. The drogue gun fired as programmed and deployed the drogue chute properly.

5. The riser-guide release unit of the drogue chute operated prematurely.

6. The drogue release unit functioned as designed.

7. After the premature operation of the drogue-chute riser-guide release, the capsule was unstable in pitch, roll, and yaw throughout the remainder of its flight.

8. The capsule was irreparably damaged at impact.

Post run observations included the following:

1. All pullaways in the sled pulled properly. These included T-32 drogue gun, T-39 initiator, camera cover plate, and electrical plugs.

2. Explosive bolts operated.

3. The lower rivets of the retention-strap release device were found pulled from the plate nearest the parachute. This condition released the right-hand strap, thus freeing the deployment bag of the recovery parachute. The force required to cause this failure could have occurred during acceleration of the sled or JATO thrusting of the capsule.

4. As the parachute deployed, the risers contacted the capsule and were cut at a point 30 inches aft of the attach point of the capsule, which allowed the chute to drop free of the capsule.

5. The early deployment of the parachute caused excessive air loading, which resulted in the major damage to the chute.

6. Forty of the 48 gores were torn, and 16 of the 48 suspension lines were broken.

7. One reefing cutter on the recovery chute did not fire.

Event times for this test are shown in Table X.

TABLE X

EVENT TIMES - RUN NUMBER 5
(in seconds)

Ignition (first flame) of JATO	5.045
Release (Station 11,176) of retention bolt	5.059
Start of deployment of recovery parachute	5.297
Failure of recovery-parachute risers	5.619
Firing of drogue gun	5.687
Riser guide release of drogue chute operated	6.091
Full deployment of drogue parachute	6.129
Release (flash bulb) of drogue parachute	10.457

Figure 44 shows the longitudinal acceleration of the sled. Maximum values were +9 G's at 0.085 second and -26 G's at 5.560 seconds (water entry). The high positive acceleration is considered to have freed the recovery parachute prior to capsule lift-off. Table X shows that this parachute started to deploy at 5.297 seconds. The corresponding velocity of the capsule is shown by the trajectory data of the capsule (Appendix B) to be about 770 feet per second. This velocity is about 410 knots equivalent airspeed and exceeds the design speed of the recovery parachute.

The three directional displacements are also included in the trajectory data. Figure 45 gives the displacement data graphically.

Results from this test indicate that further design work is required on the recovery-system installation and timing-sequence initiation.

Total destruction of the capsule upon impact is illustrated by Figure 46.

Figure 47 gives a summary of the indicated tail clearance for straight-and-level flight as derived from the trajectory data on the capsule and on assumed aircraft velocity equal to the velocity at ejection (i.e. neither acceleration nor deceleration of the aircraft after ejection). This figure indicates sufficient clearance for speeds between 150 and 300 knots.

CONCLUSIONS AND RECOMMENDATIONS

Feasibility of the canopy-type capsule method of escape was not fully demonstrated because the track tests were terminated before completion of the design range of test velocities and because the test results indicated a need for an evaluation of the stability and impact problems of the capsule for these velocities. More specifically, the following conclusions were made and divided into two areas: separation and recovery system of the capsule.

SEPARATION

1. The performance of the explosive retention bolts used in these tests and the firing sequence of the JATO unit and explosive bolts were considered satisfactory.

2. The separation rocket, 0.24 KS 9900 jet-assist takeoff (JATO) unit, showed successful firing in all tests: static, 150 knots, 300 knots, and 400 knots. No guide rails were used in this system and thus these tests demonstrated successful unguided escape separation.

3. Blast effect from the JATO unit did not appear to have a detrimental effect on the escape procedure dynamically but may have had some effect on the components of the recovery system.

4. Tail clearance was sufficient for the F-102 type aircraft for straight-and-level flights for speeds of 150 through 300 knots equivalent airspeed.

5. The large pitchup angles that were experienced after separation of the capsule appear to have been caused by a large pitchup trim in combination with low damping in the pitch plane and do not appear to have produced excessive translational accelerations for speeds through 300 knots equivalent airspeed. No conclusions regarding the physiological reaction to angular acceleration and pitch rate have been made.

6. Based on the track tests conducted, a conclusive statement concerning the effectiveness of the capsule trim tabs could not be made.

RECOVERY SYSTEM OF CAPSULE

1. Proper functioning of the recovery system of the capsule was demonstrated for the 150-knot run but not for the 300-knot or the 400-knot runs.

2. The recovery parachute exhibited excellent opening characteristics, and the descent velocity appeared to be satisfactory.

3. Impact loads appeared excessive.

4. Trajectory plots of the 150-knot runs showed full inflation of the recovery parachute within a 50-foot drop of the initial point of ejection. This condition indicated low-level, though not ground level, ejection capability.

RECOMMENDATIONS

Based on the results of these tests, the following recommendations concerning escape systems are made:

1. The blast effect caused by a separation rocket with regard to its effect on recovery system components and installation should be considered.

2. The installation of the escape recovery system should be evaluated with regard to aircraft G loads that may be encountered during escape.

3. Attitude of capsule impact as well as descent velocity must be considered to assure tolerable impact loads.

REFERENCE

1. Weiss, H. S., Edelbury, R., Charland, P. V., and Rosenbaum, J. I., The Physiology of Simple Tumbling, Part 2. Human Studies. WADC Technical Report 53-139, Part 2, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, January 1954

OTHER BIBLIOGRAPHICAL MATERIAL

1. Pernini, H. M., (Unclassified Title) Survey and Compilation of Capsule Escape Systems Data, WADC Technical Report 57-661, Volume II, Wright Air Development Center, Wright-Patterson AFB, Ohio. April 1958. pp 399-452. (SECRET Report)

2. D'Anna, P. W., (Unclassified Title) Preliminary Design Study Report, Seat Capsule; Pilot's Emergency Escape, Stanley Aviation Corporation Document Nr. 184, September 1953. (CONFIDENTIAL Report)

3. Buoy, D. L., WADC Canopy Capsule Test, Hurricane Supersonic Research Site, SMART Technical Memo. 167, 188, 189, 194, 198, and Interim Data Report 245, 17 June 1959 through 23 September 1960.

4. Kearney, A. P., Mills, B. J., Huey, R. S., Emergency Escape Capsule Studies, Phase I: Preliminary Laboratory Flotation Studies, WADC Technical Report 59-247 (I), Wright Air Development Center, Wright-Patterson AFB, Ohio. June 1959.

APPENDIX A

ILLUSTRATIONS

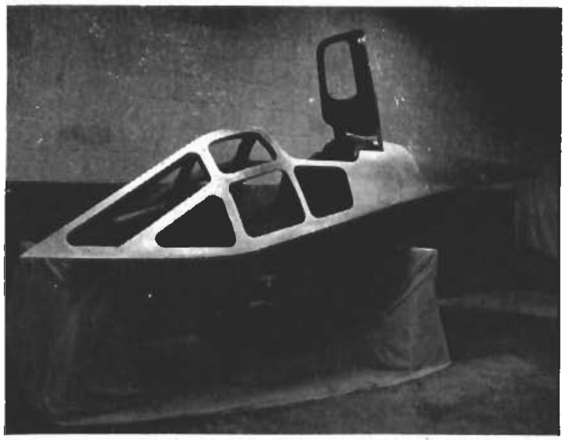


Figure 1. Mockup of Prototype of Canopy Escape Capsule (Hatch Open, Seat Unoccupied, and in Normal Flying Position)

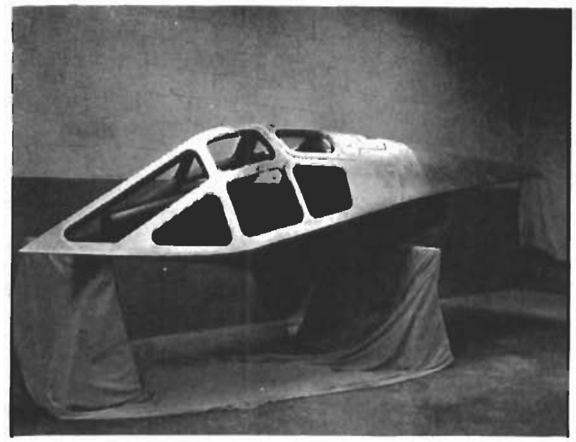


Figure 2. Mockup of Prototype of Canopy Escape Capsule (Seat Retracted; Escape Configuration)

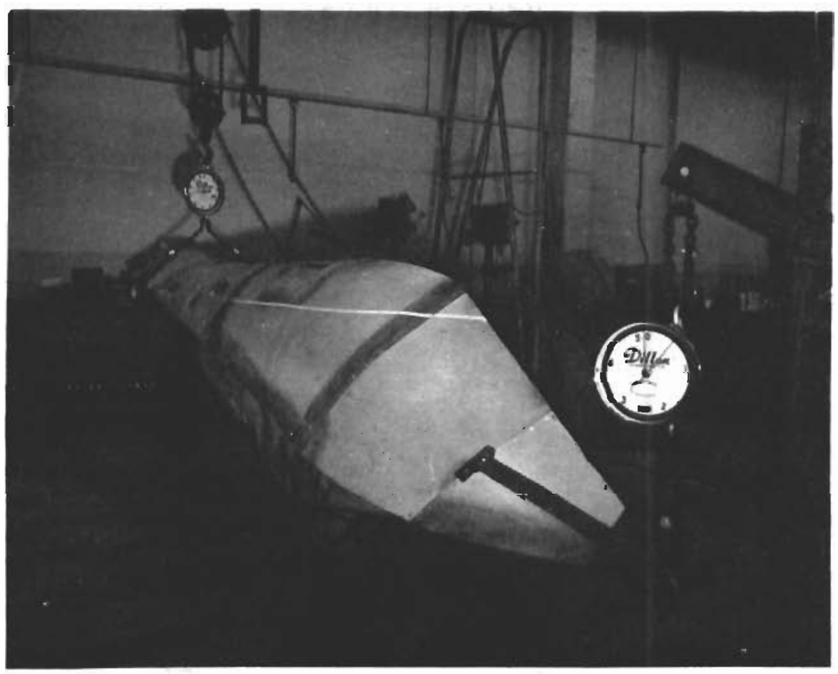


Figure 3. Track-Test Model of Canopy Escape Capsule (Typical C.G. Location Setup)

Figure 4. Capsule with Trim Tabs Deployed

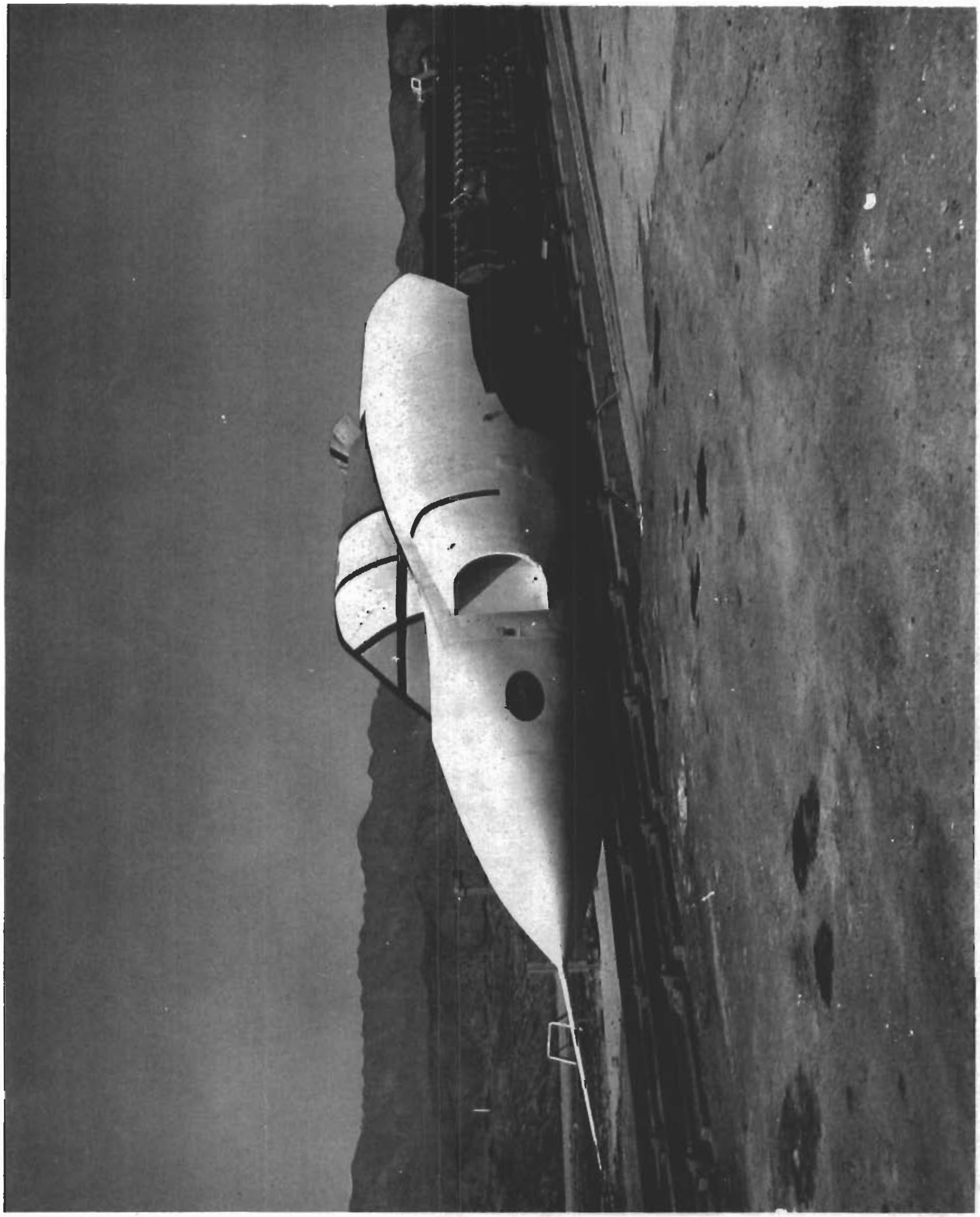


Figure 5. Capsule in Position on Track-Test Cab

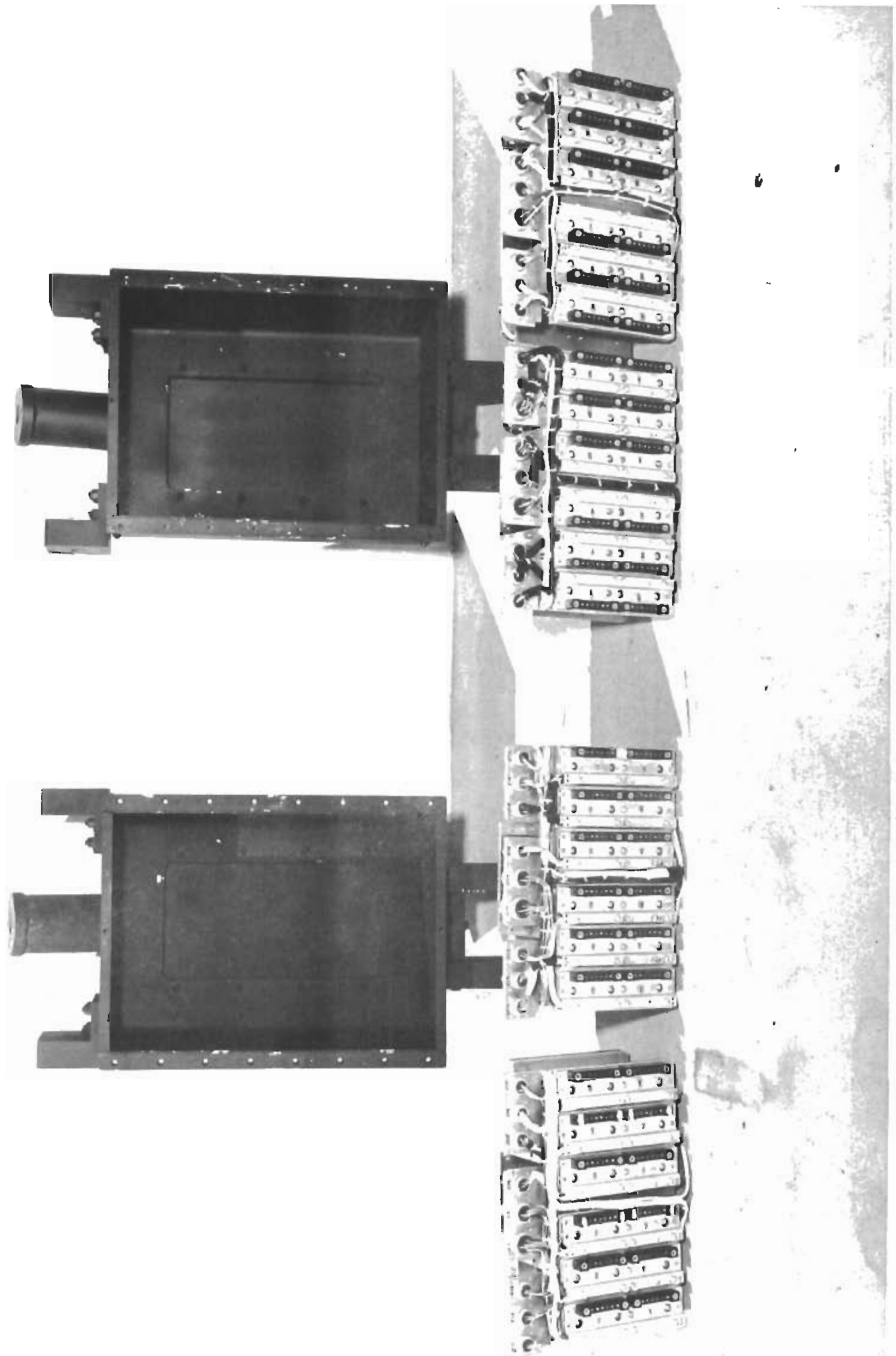


Figure 6. Dummy Torso and Instrumentation Packages

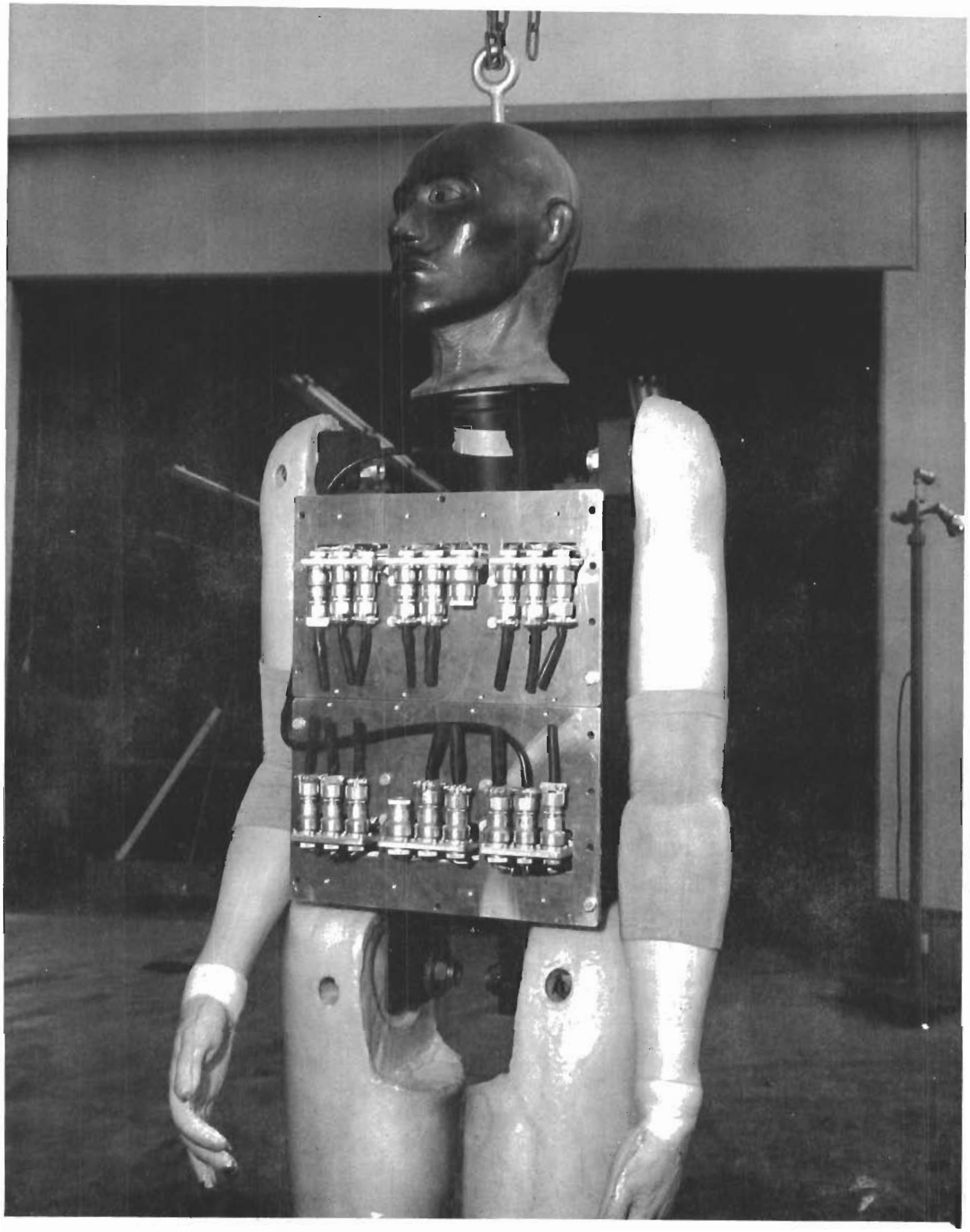


Figure 7. Modified Dummy Showing Instrumentation Packages

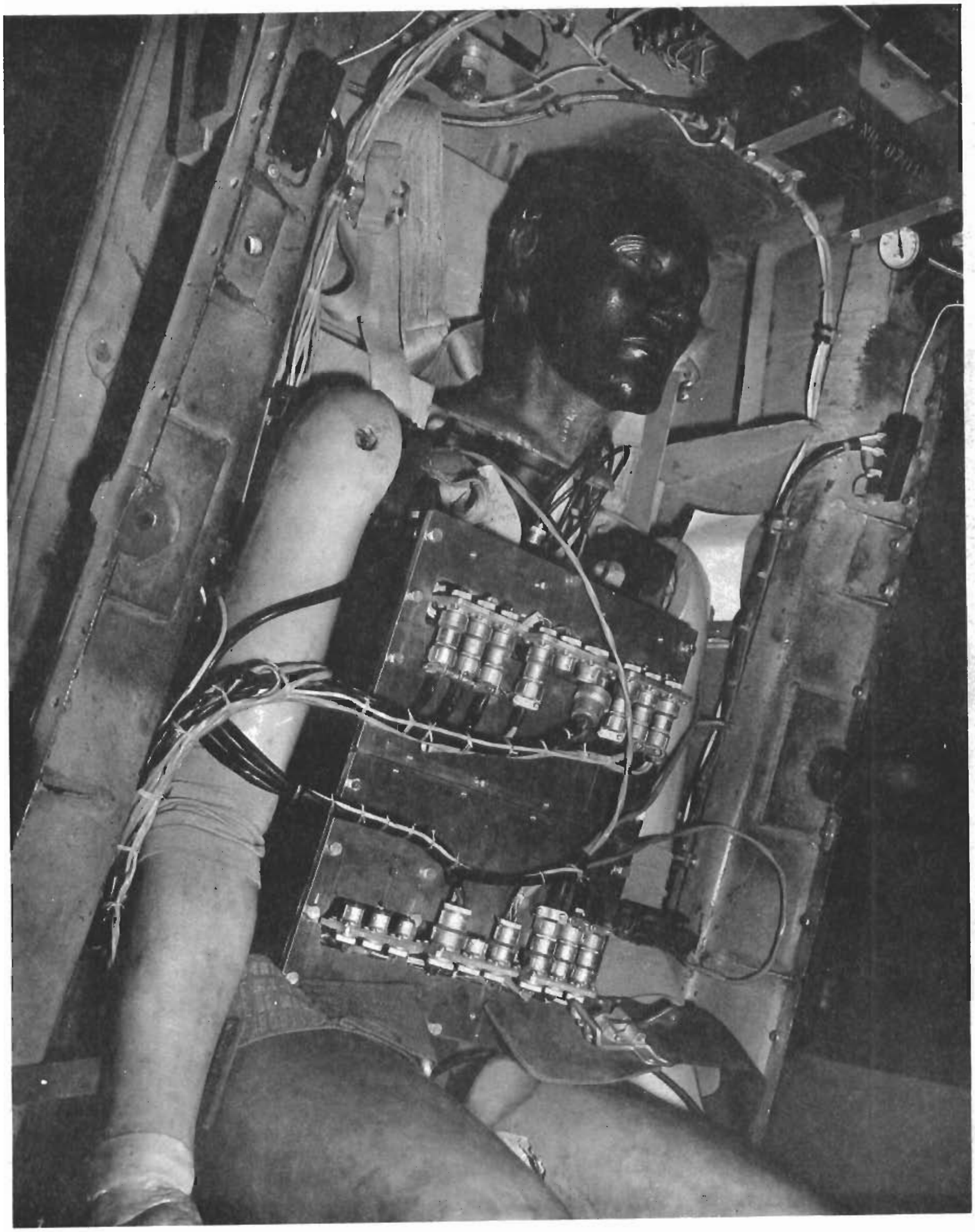


Figure 8. Installed Dummy Prior to Final Instrumentation Hookup

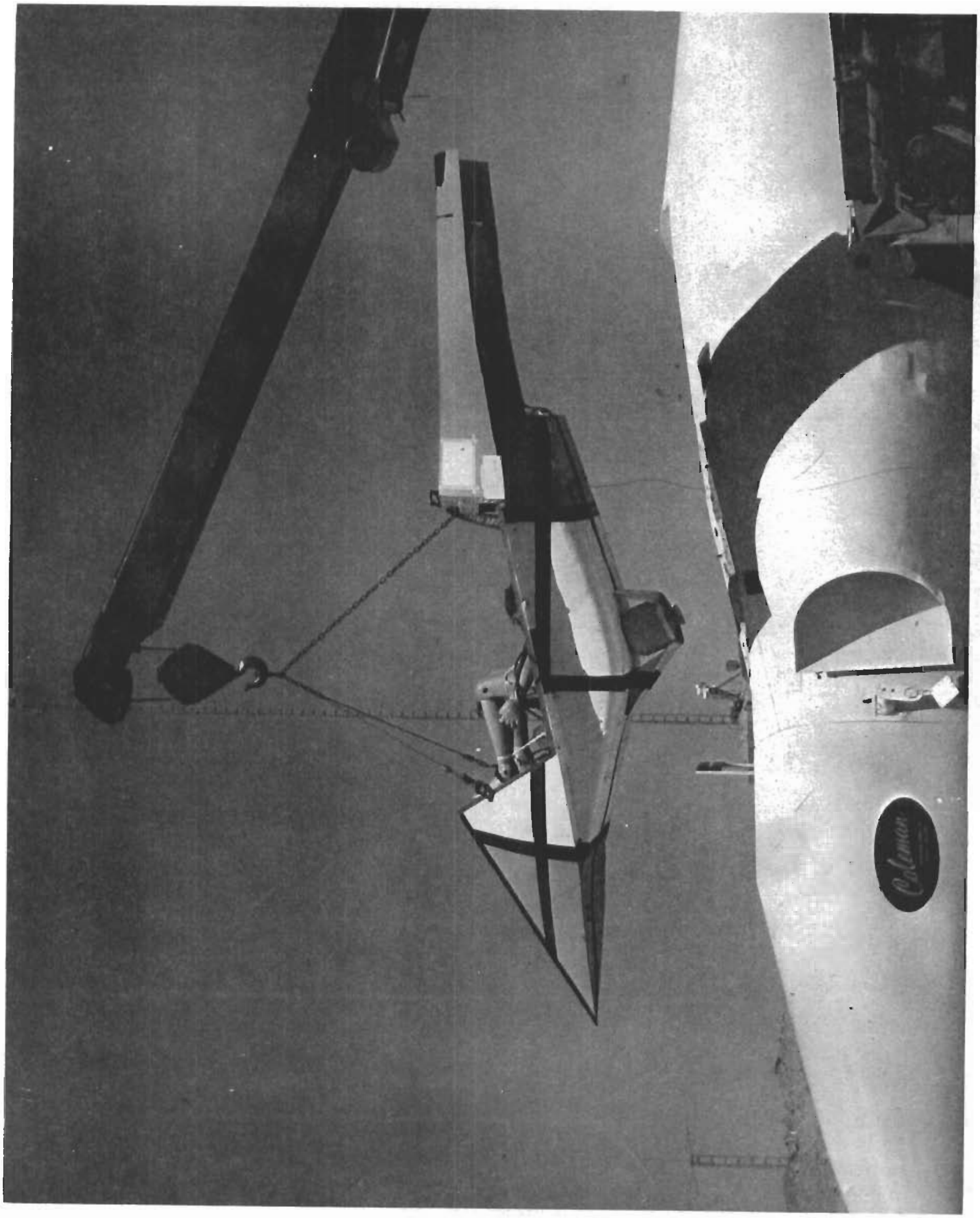


Figure 9. Installation of the Capsule Model on the Test Vehicle (Test Number 1)

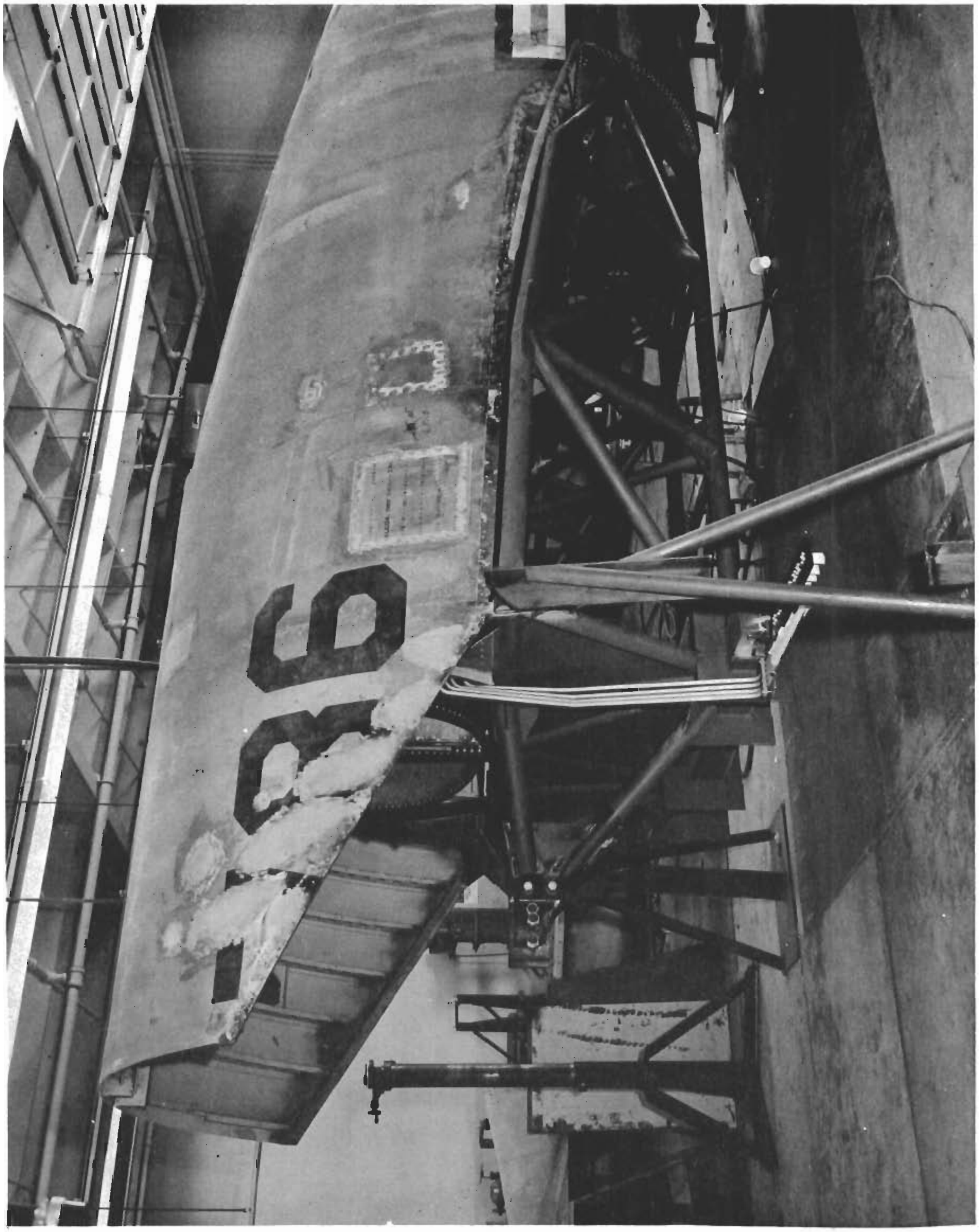


Figure 10. Aircraft-Cab Modification

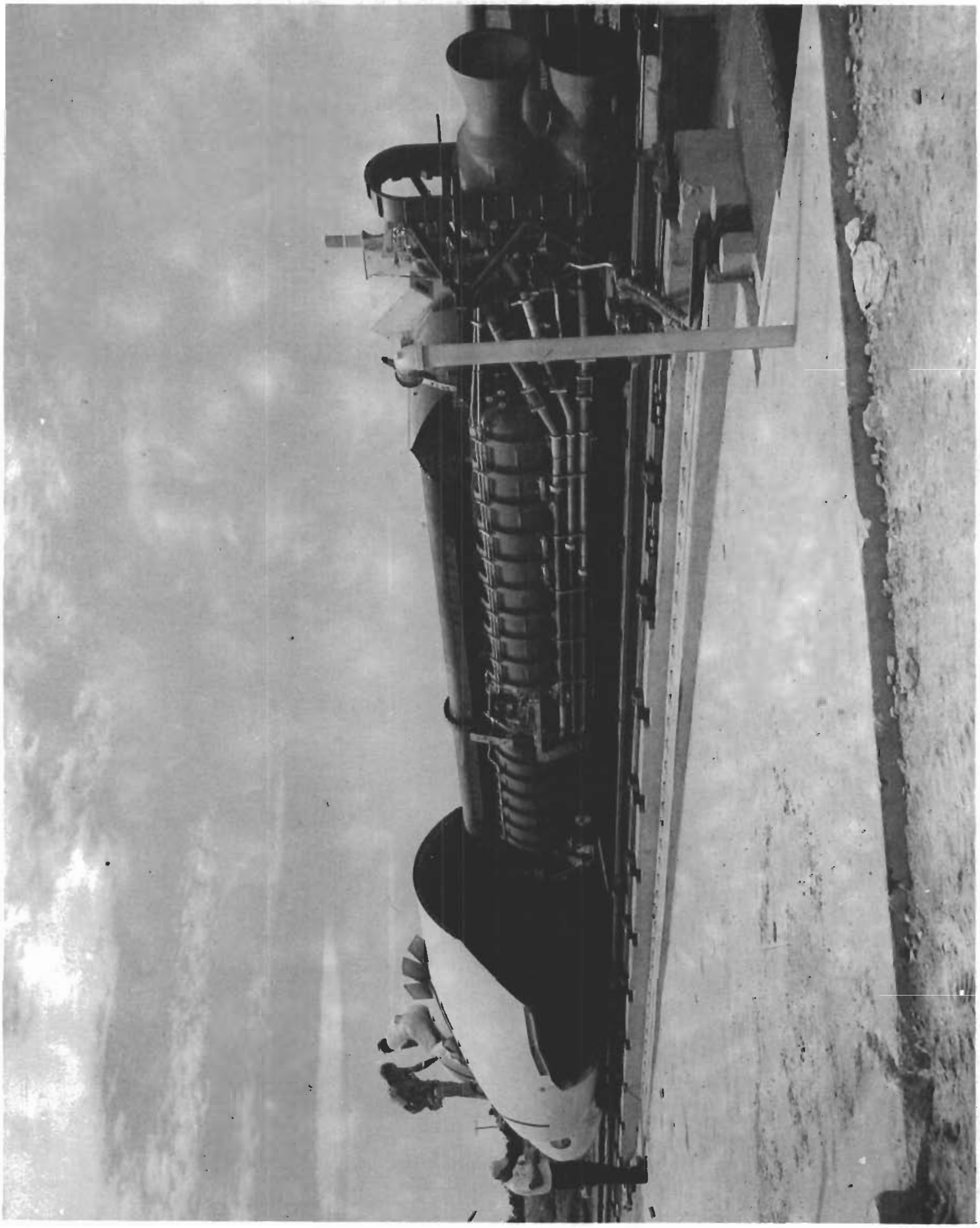


Figure 11. Entire Sled Vehicle Showing Capsule, Sled Cab, and Liquid-Propellant Pusher Sled

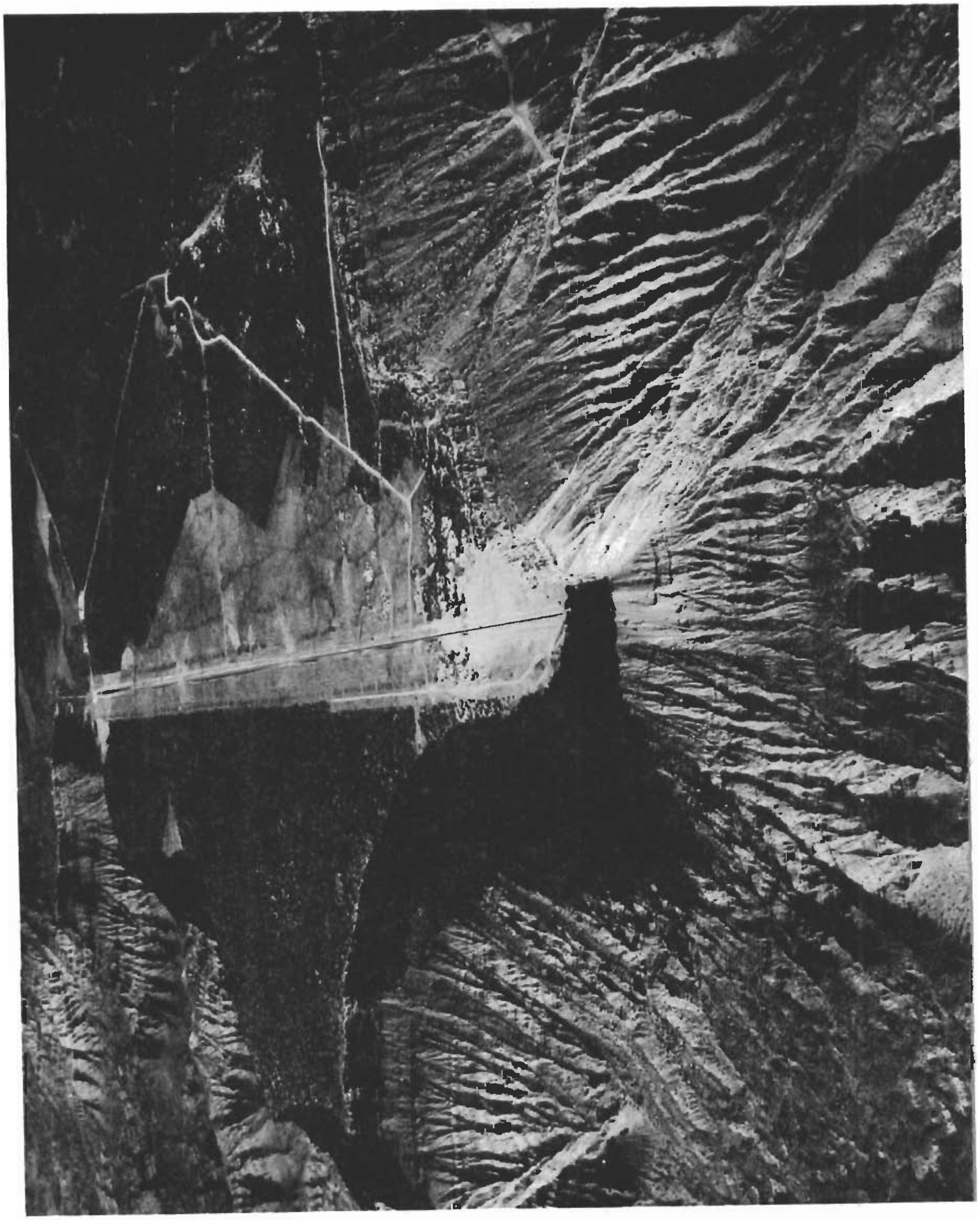


Figure 12. Hurricane Supersonic Research Site, Hurricane Mesa, Utah

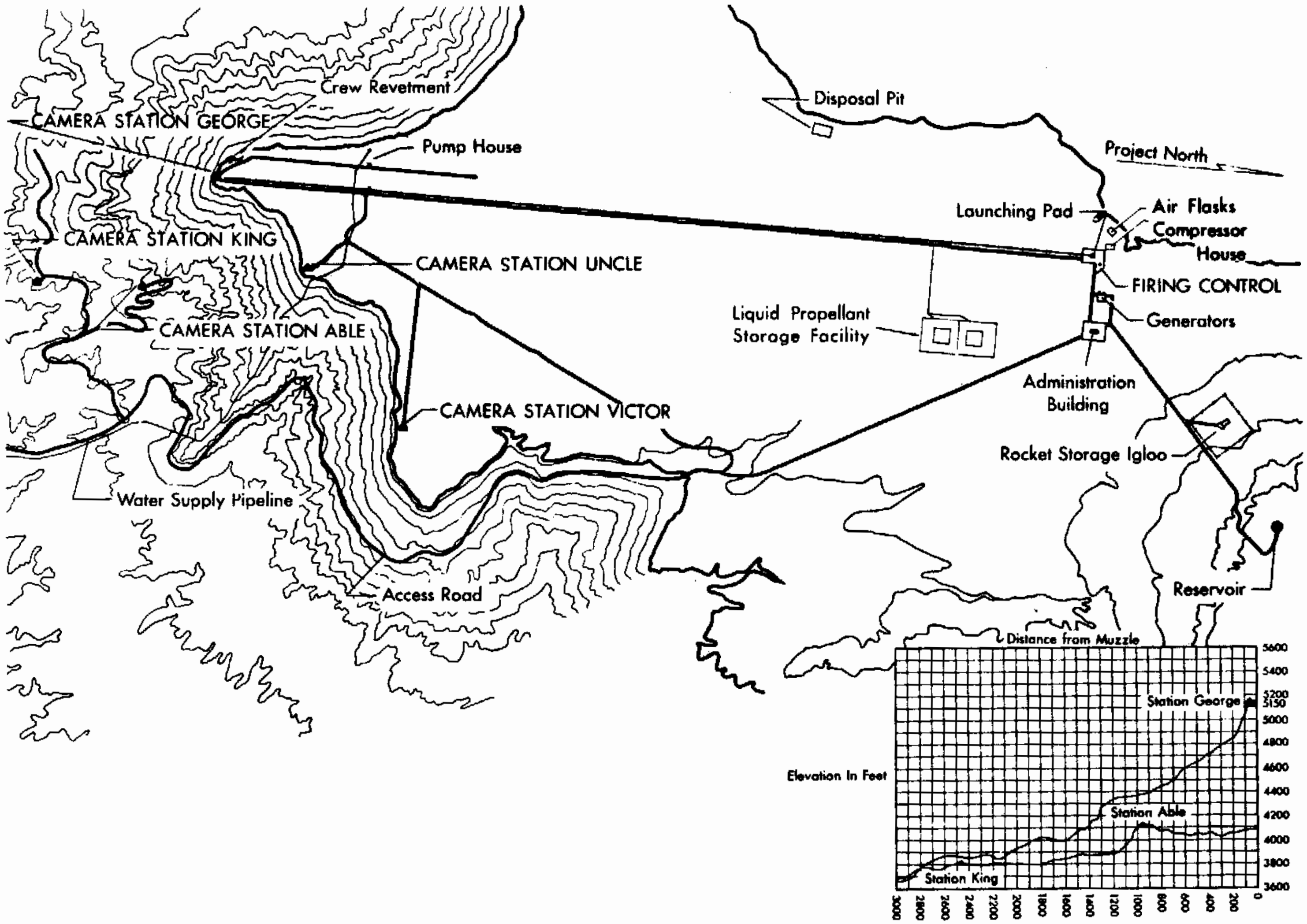


Figure 13. Camera Locations at Hurricane Supersonic Research Site

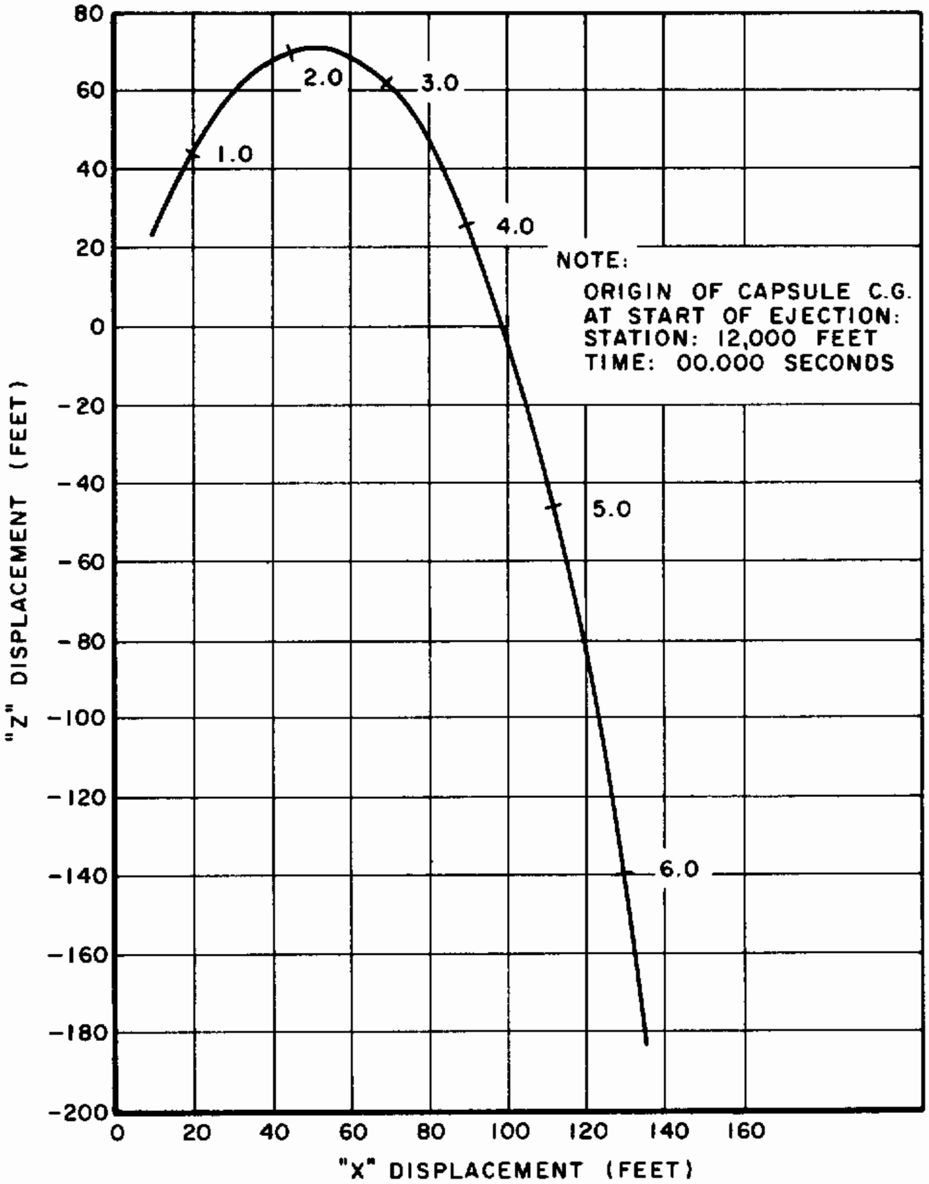


Figure 14. Bowen Trajectory of Capsule - Static Test
(in seconds)

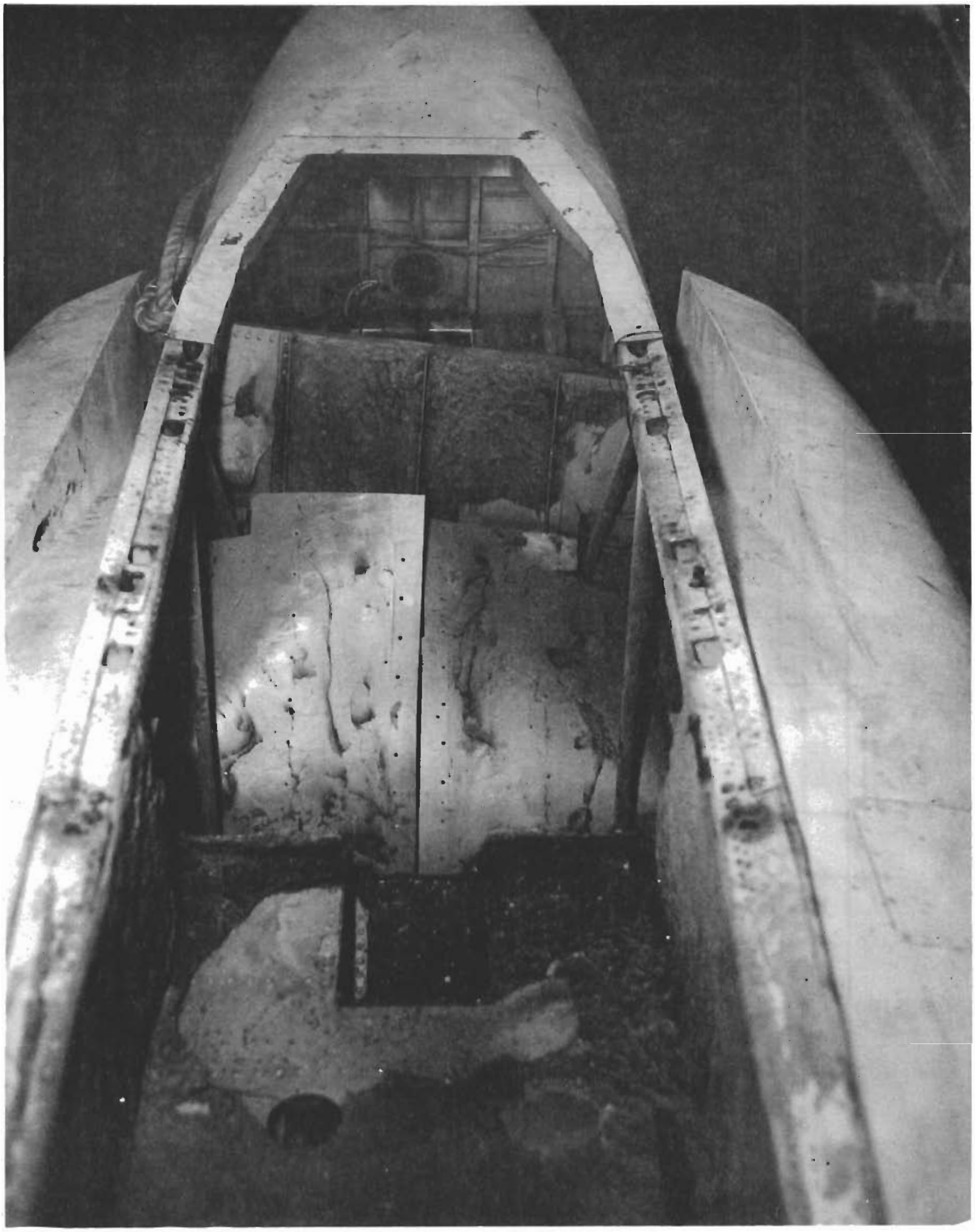


Figure 15. Rocket-Blast Effect on Interior of Vehicle - Static Test

Figure 16. Installation of Recovery System for Static Test

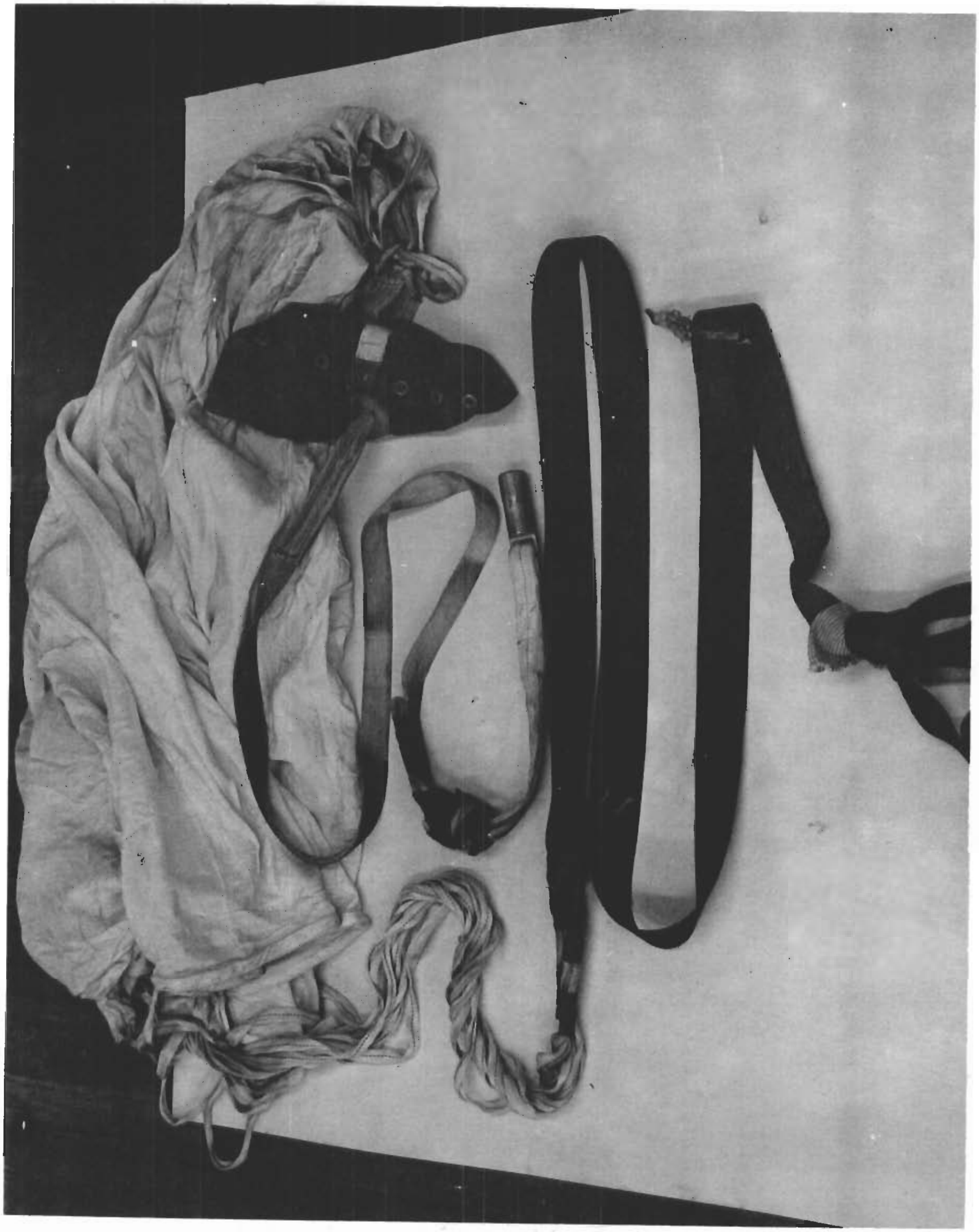


Figure 17. Recovery System Showing Drogue System and Attached Riser for Static Test

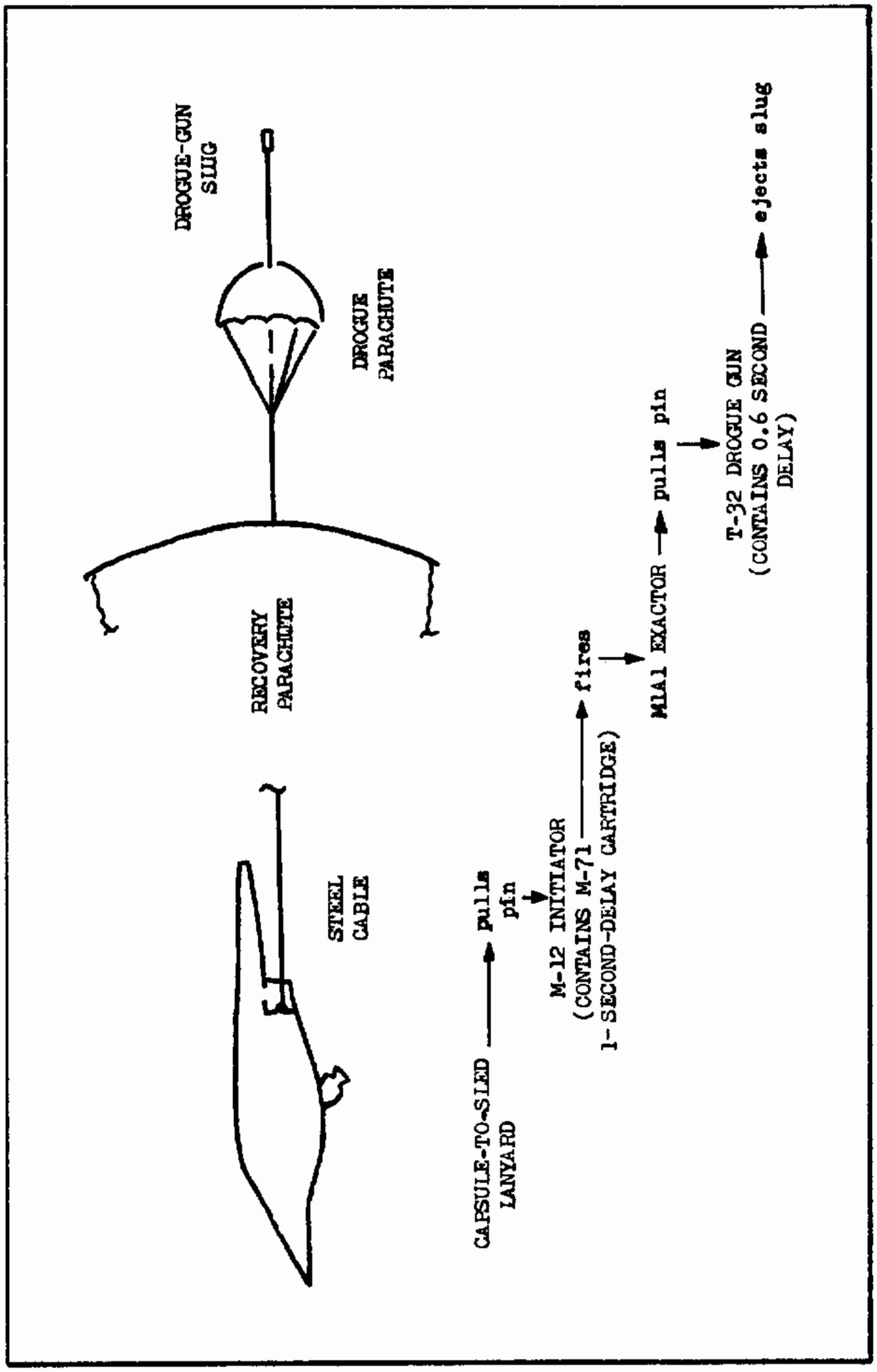


Figure 18. Recovery System for Static Test

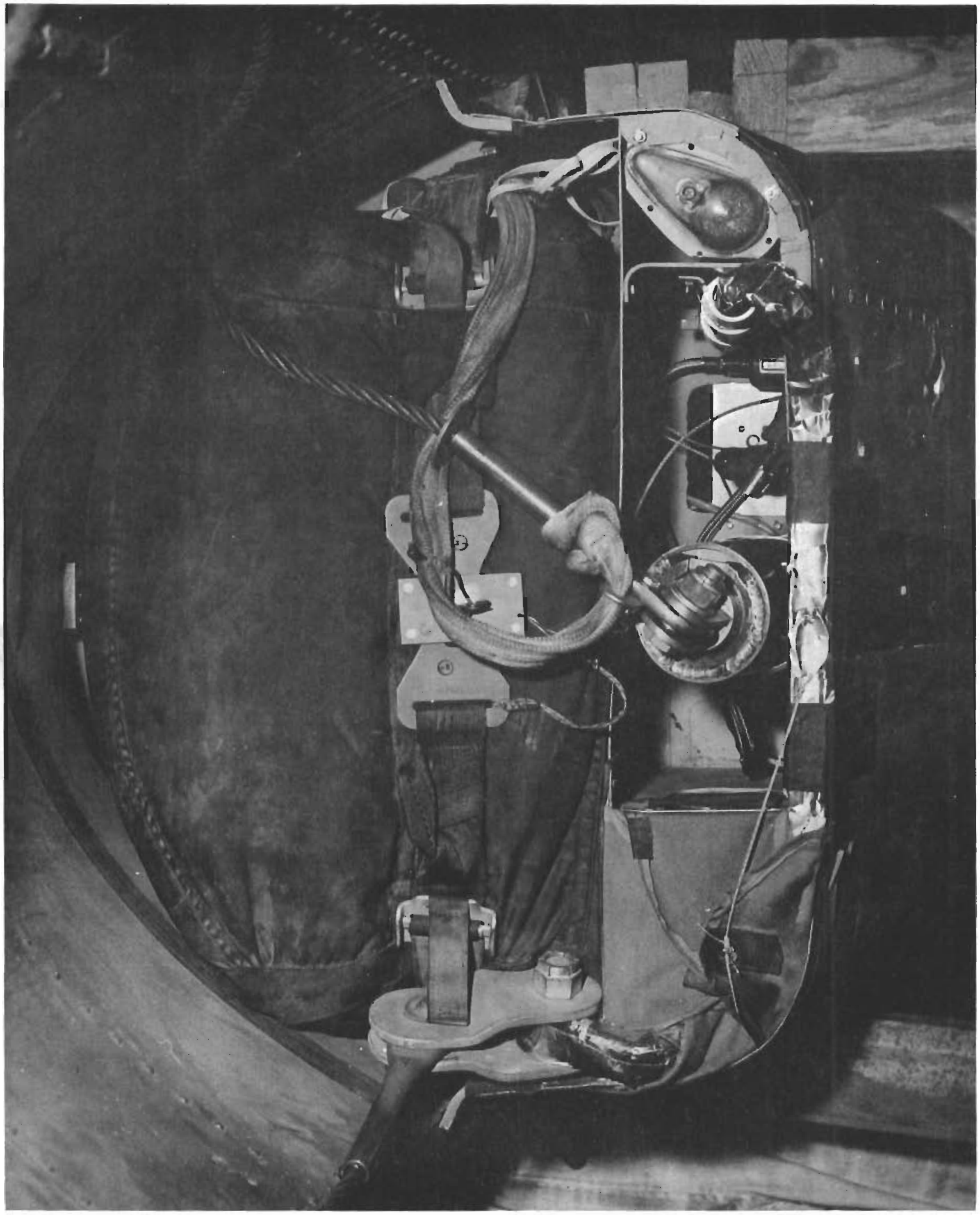


Figure 19. Recovery System Showing Installation of Drogue Parachute on Left-Hand Side of Capsule

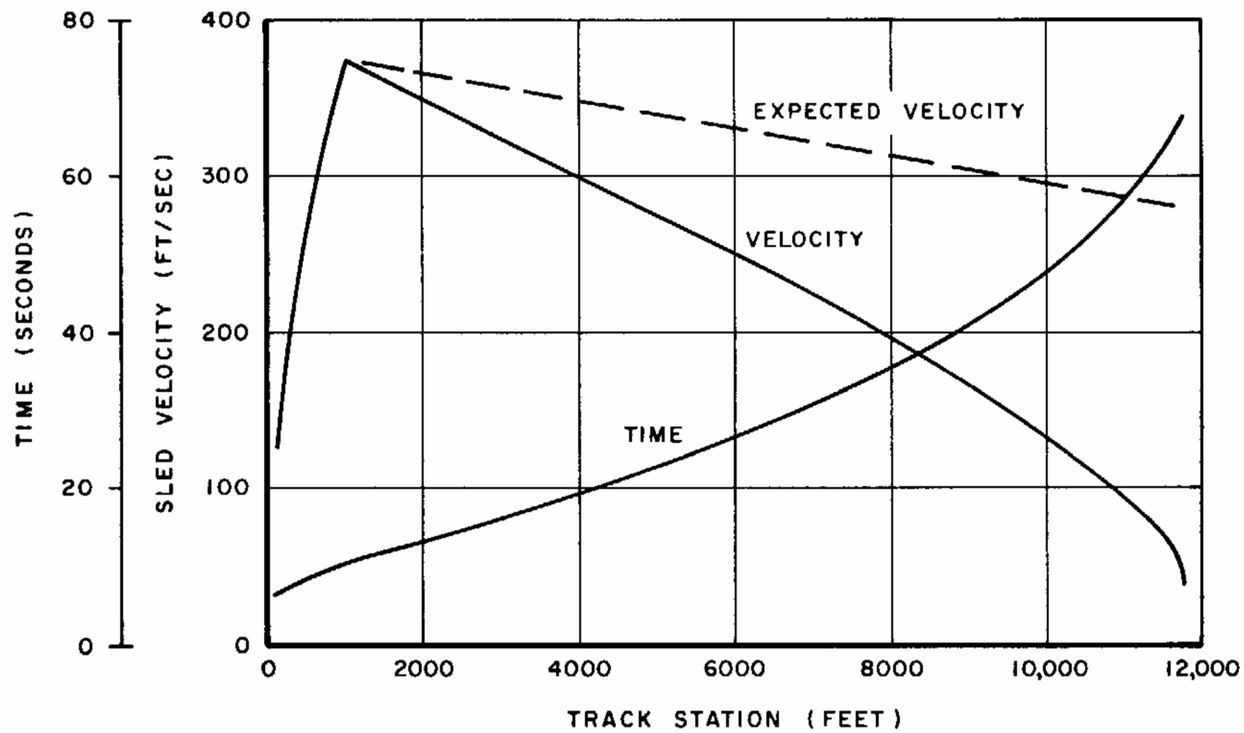


Figure 20. Telemetered Space-Time Data - Run Number 2
(Station-to-Station Average; Ref: Cross on Forward Vehicle)

Figure 21. Capsule after Impact Showing Recovery-Parachute Risers and Suspension Lines (Run Number 2A)

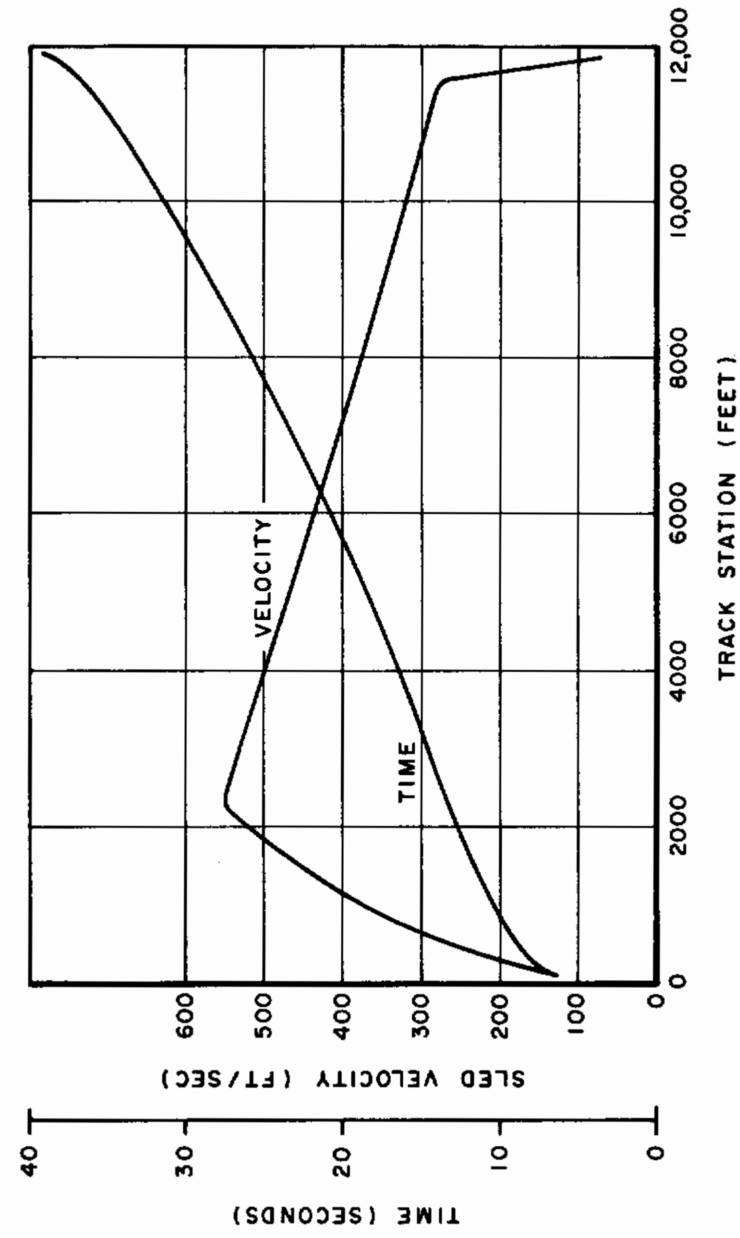
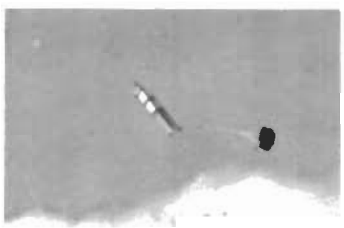


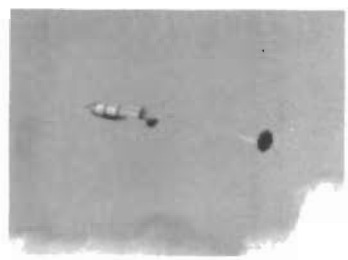
Figure 22. Telemetered Space-Time Data - Run Number 2A (Station-to-Station Average; Ref: Cross on Forward Vehicle)

a. SEPARATION

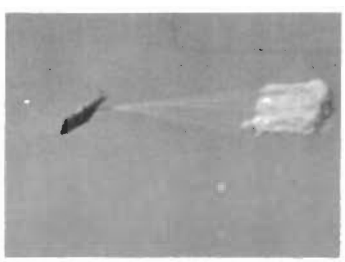
b. START OF DROGUE - PARACHUTE DEPLOYMENT



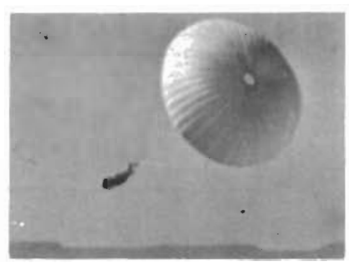
c. INFLATION OF DROGUE PARACHUTE



d. WITHDRAWAL OF RECOVERY - PARACHUTE BAG



e. RECOVERY - PARACHUTE LINE STRETCH



f. INFLATION OF RECOVERY PARACHUTE

Figure 23. Separation and Recovery Sequence - Run Number 2A

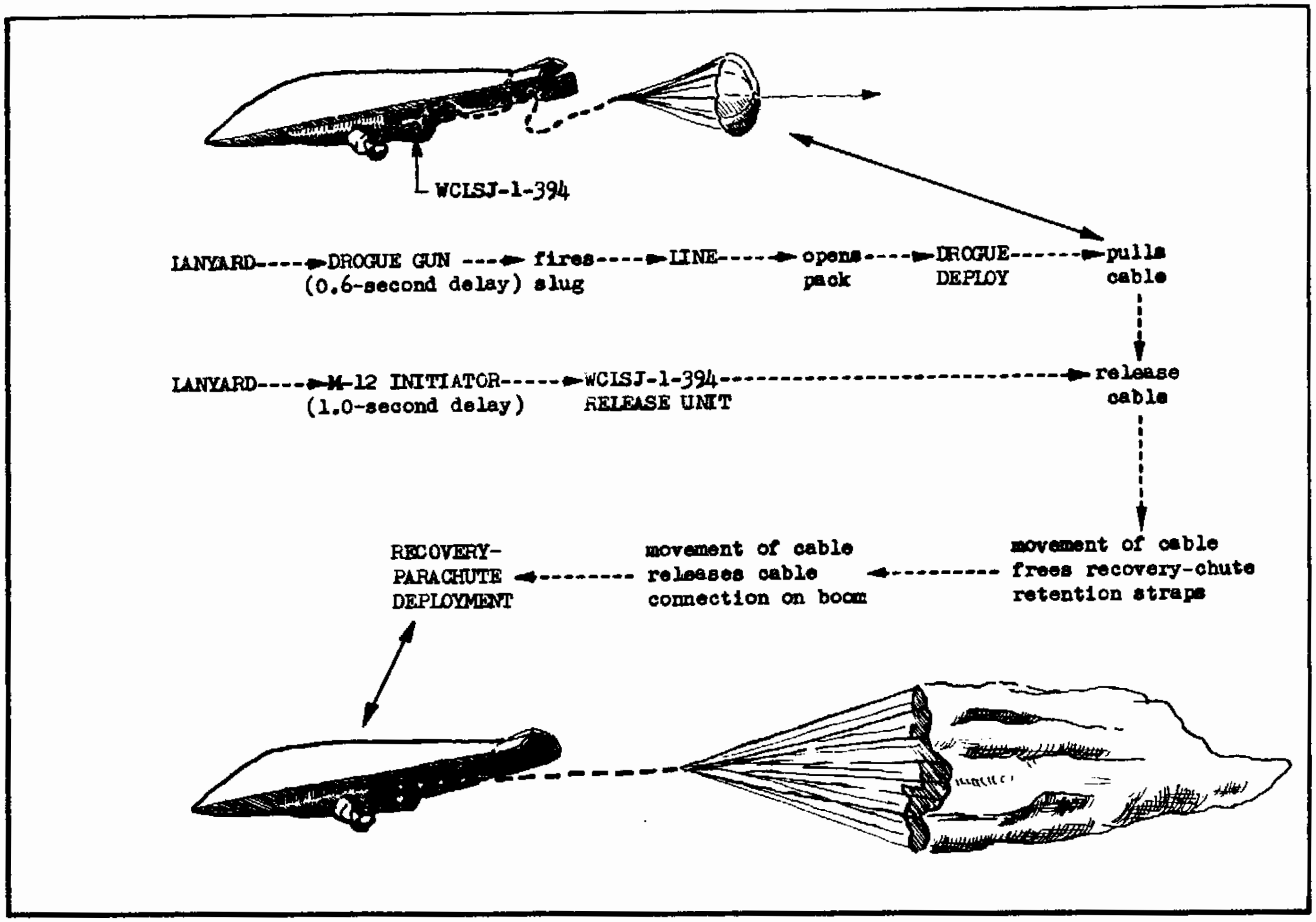


Figure 24. Recovery-System Sequence for Test Run 2A

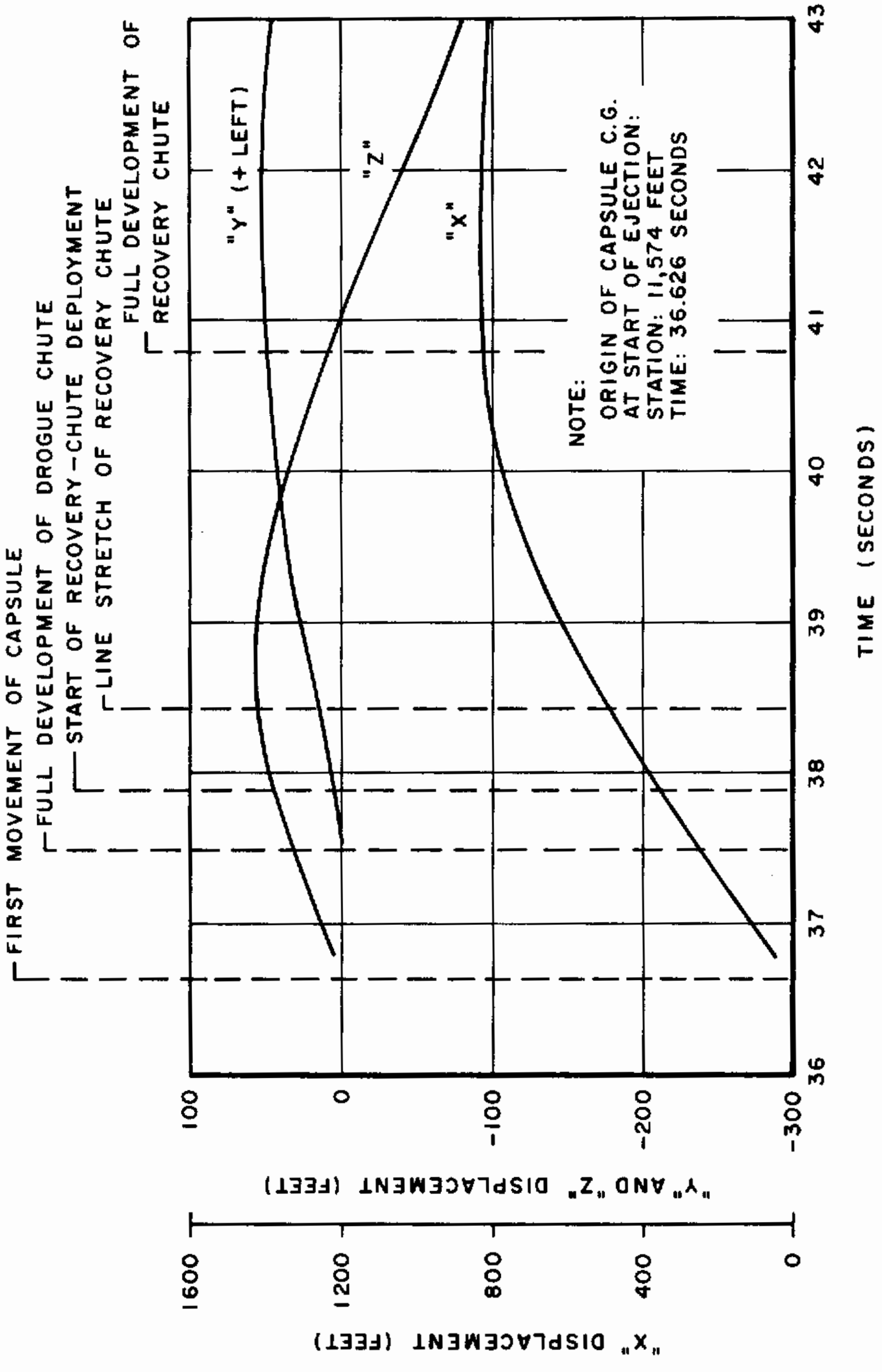


Figure 25. Capsule Displacement Versus Time - Run Number 2A

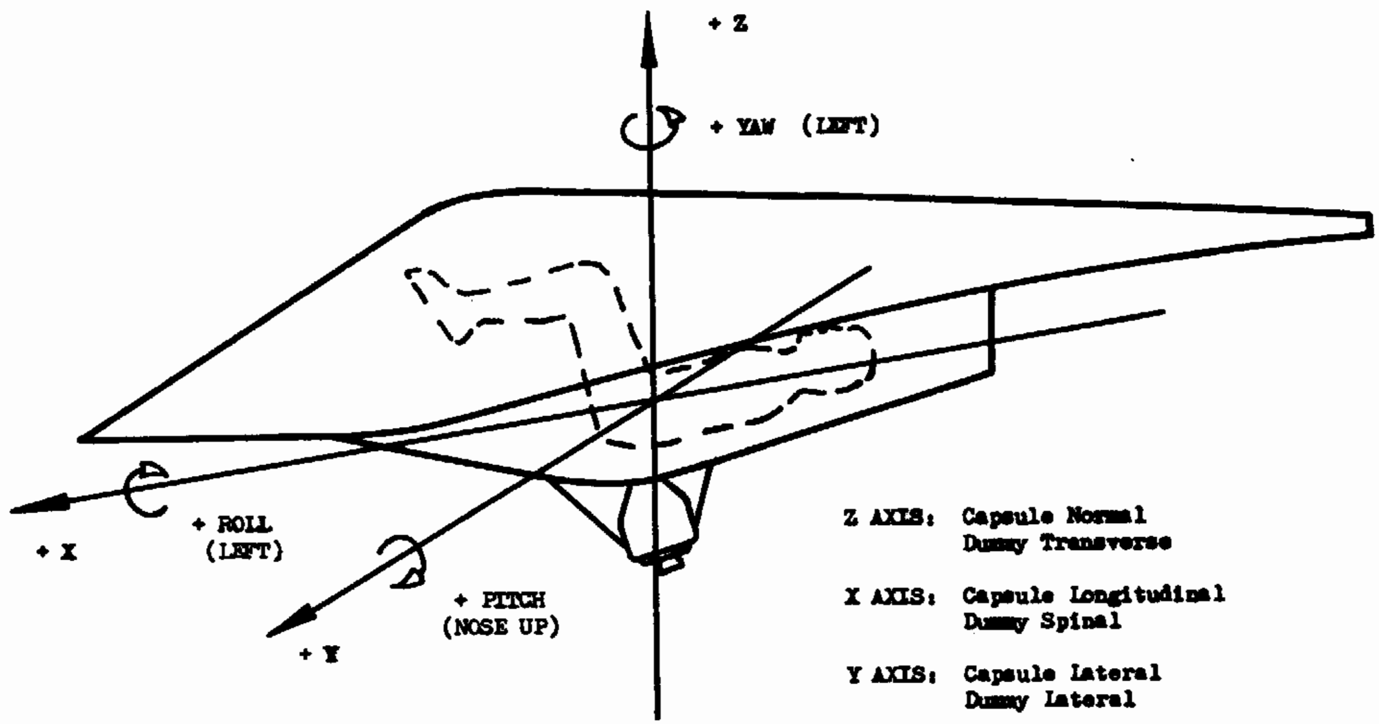


Figure 26. Coordinate Axes of Capsule and Dummy

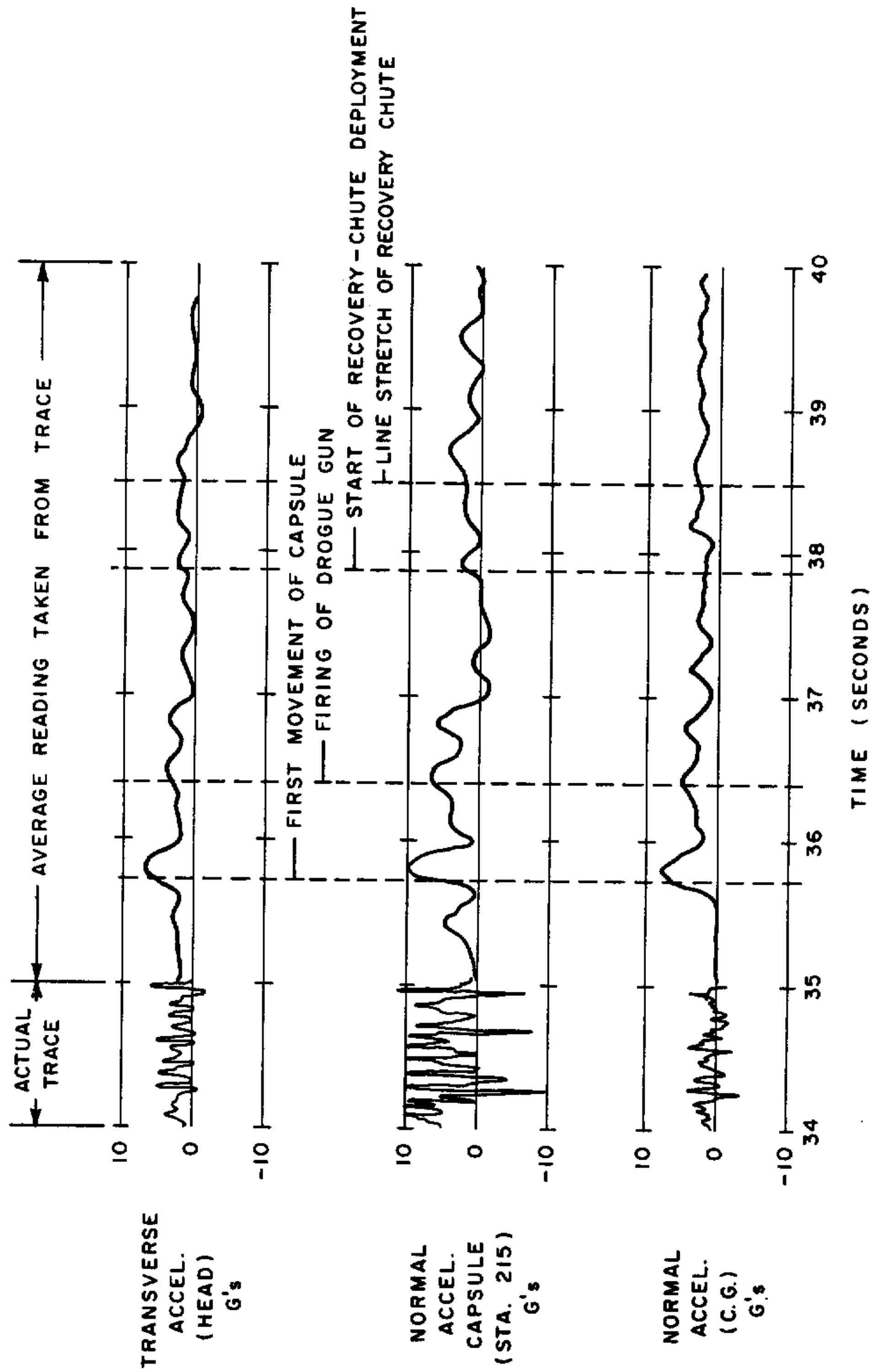


Figure 27. Oscillograph Plot of Normal Acceleration - Run Number 3

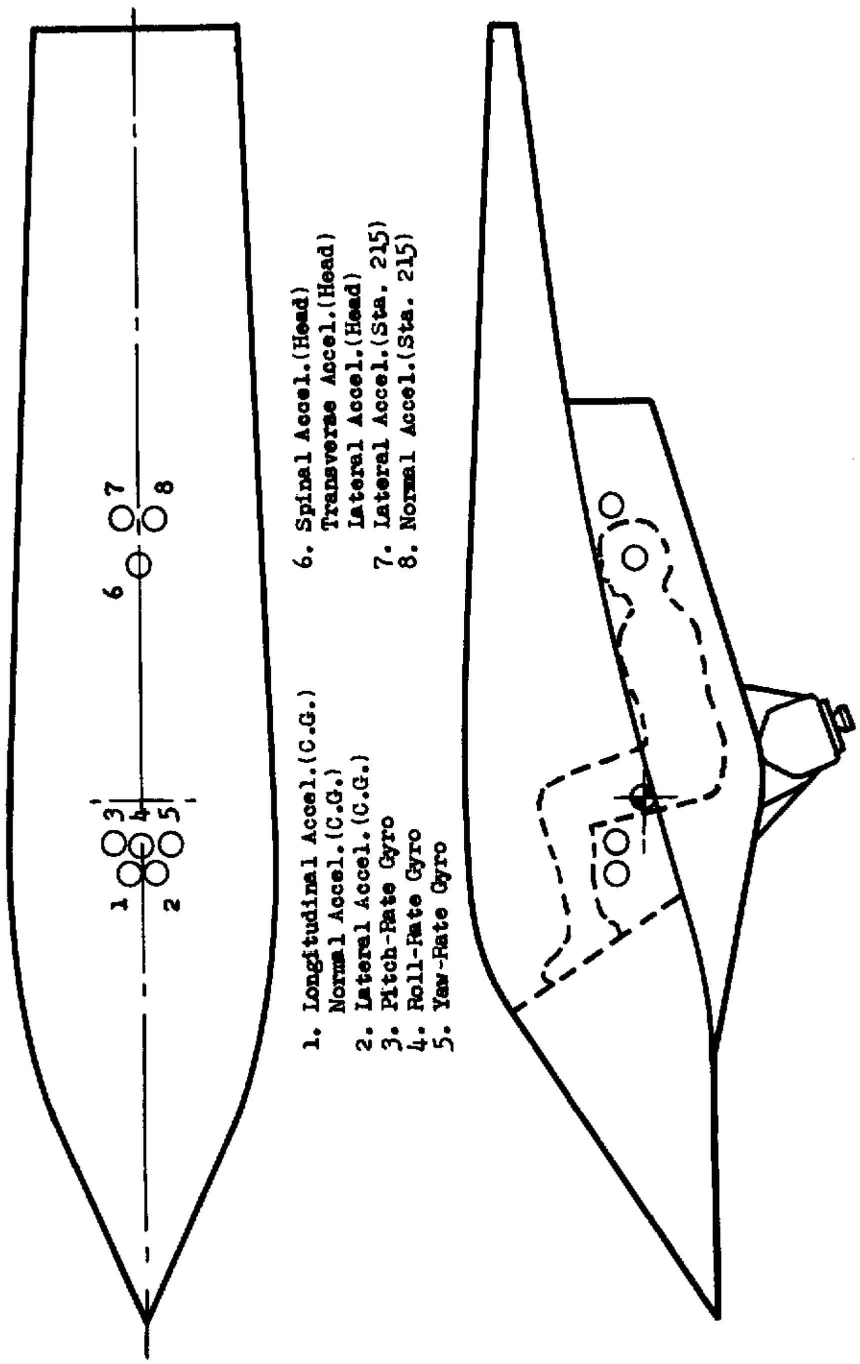


Figure 28. Approximate Location of Instrumentation in Capsule - Run Number 3

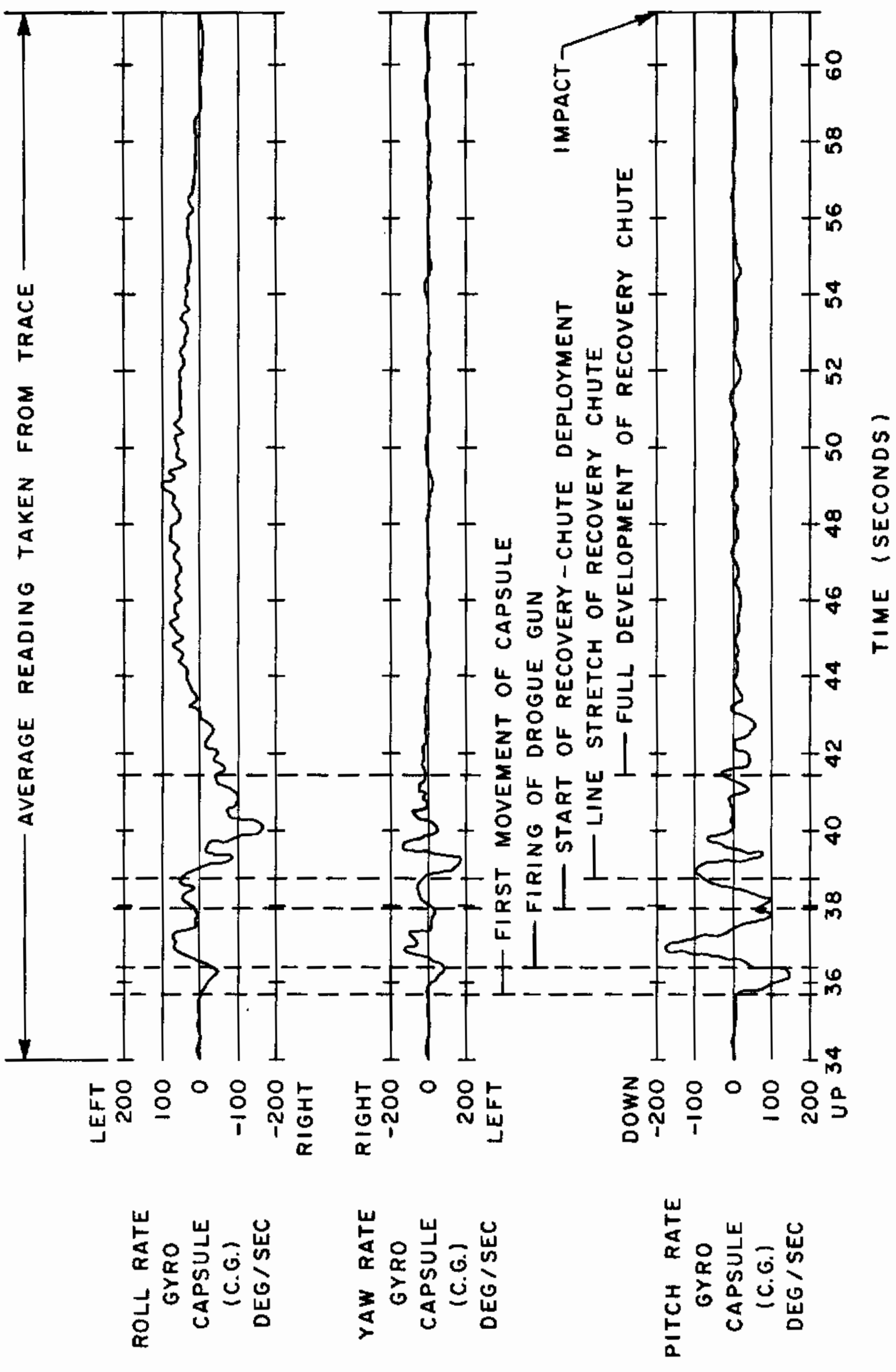


Figure 29. Oscillograph Plot of Roll, Yaw, and Pitch Rates of Capsule - Run Number 3

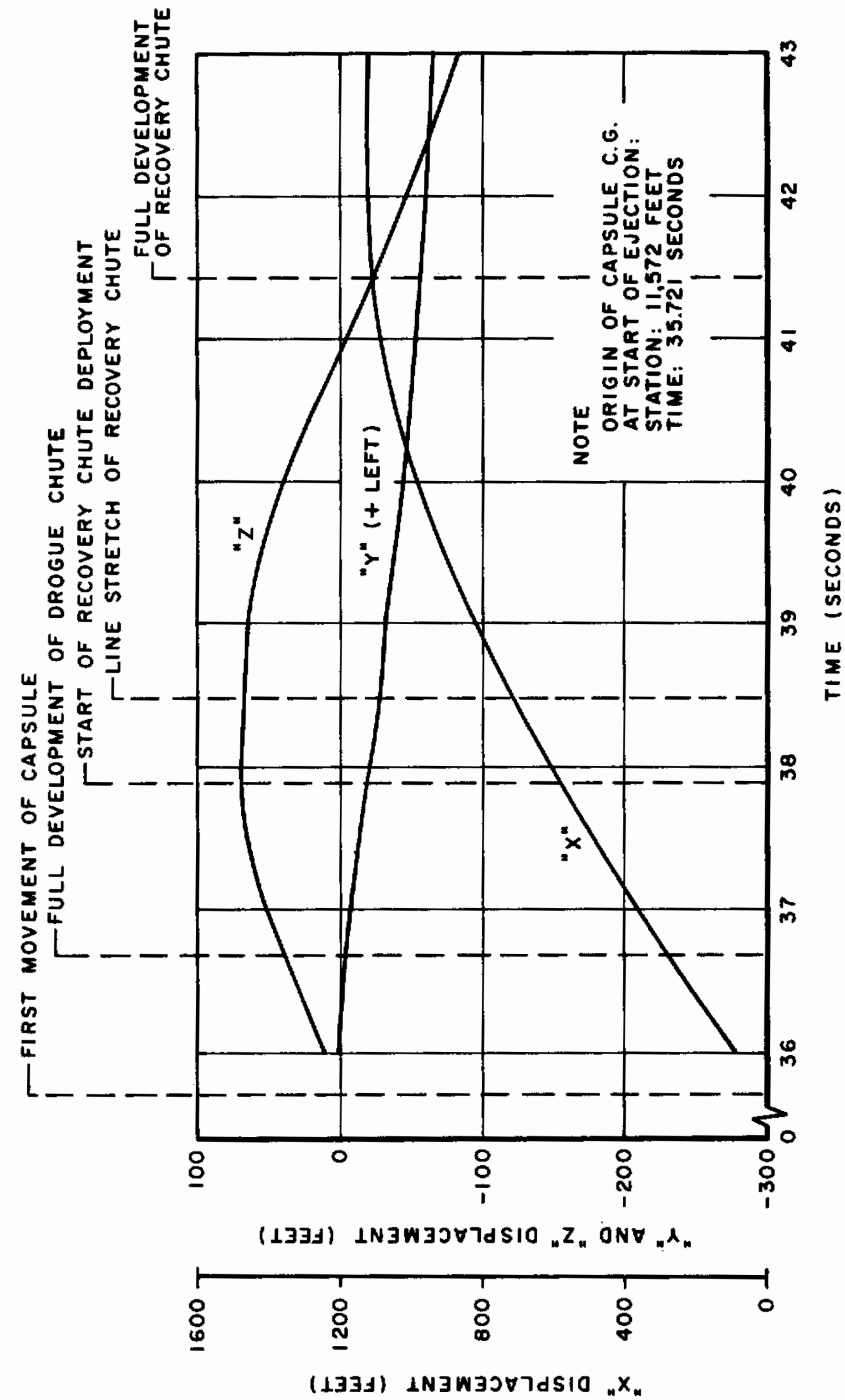


Figure 30. Displacement of Capsule Versus Time - Run Number 3

Figure 31. Side View of Capsule after Impact - Run Number 3

Figure 32. Three-Quarter Rear View of Capsule after Impact - Run Number 3

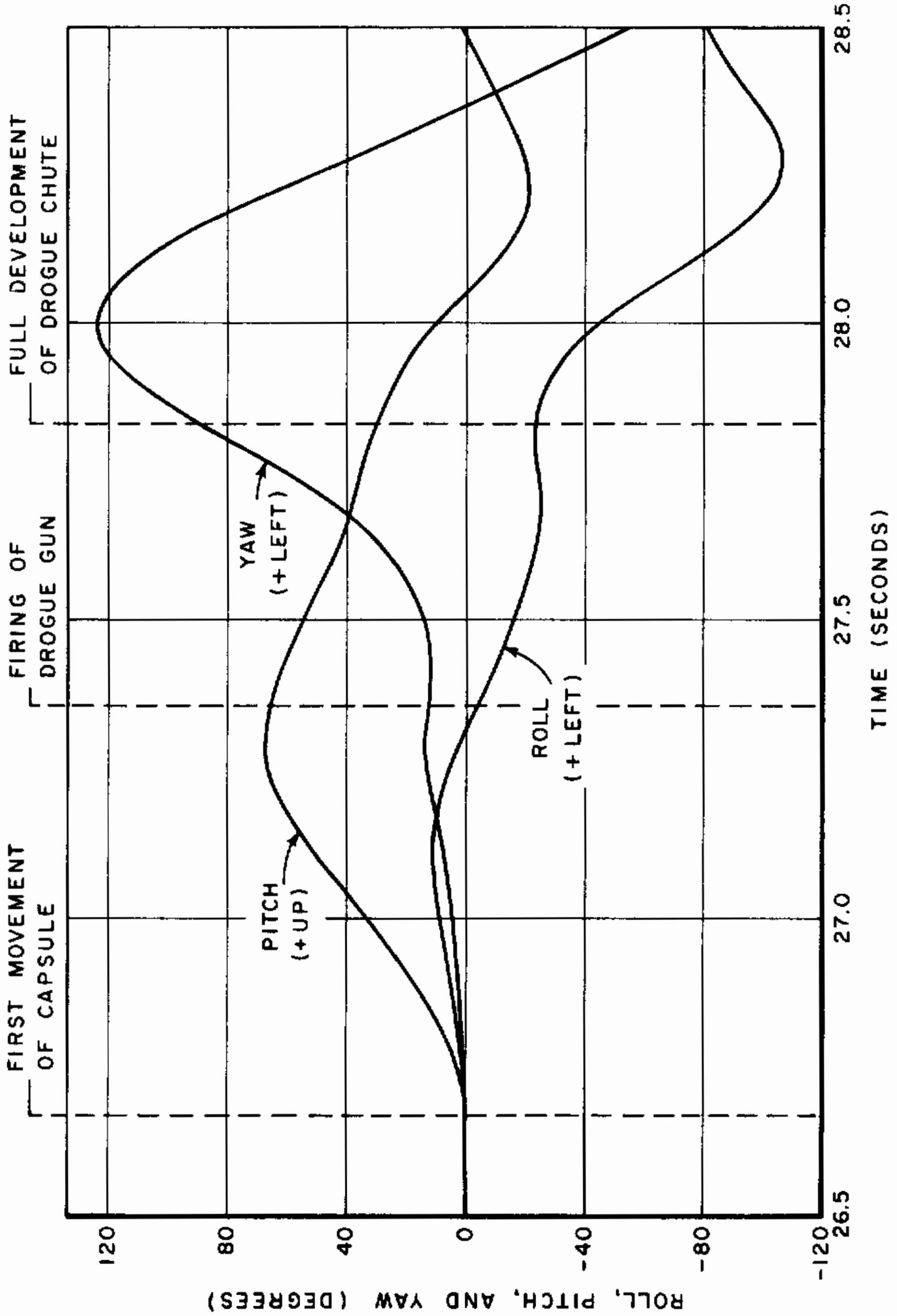


Figure 33. Attitude of Capsule Versus Time - Run Number 4

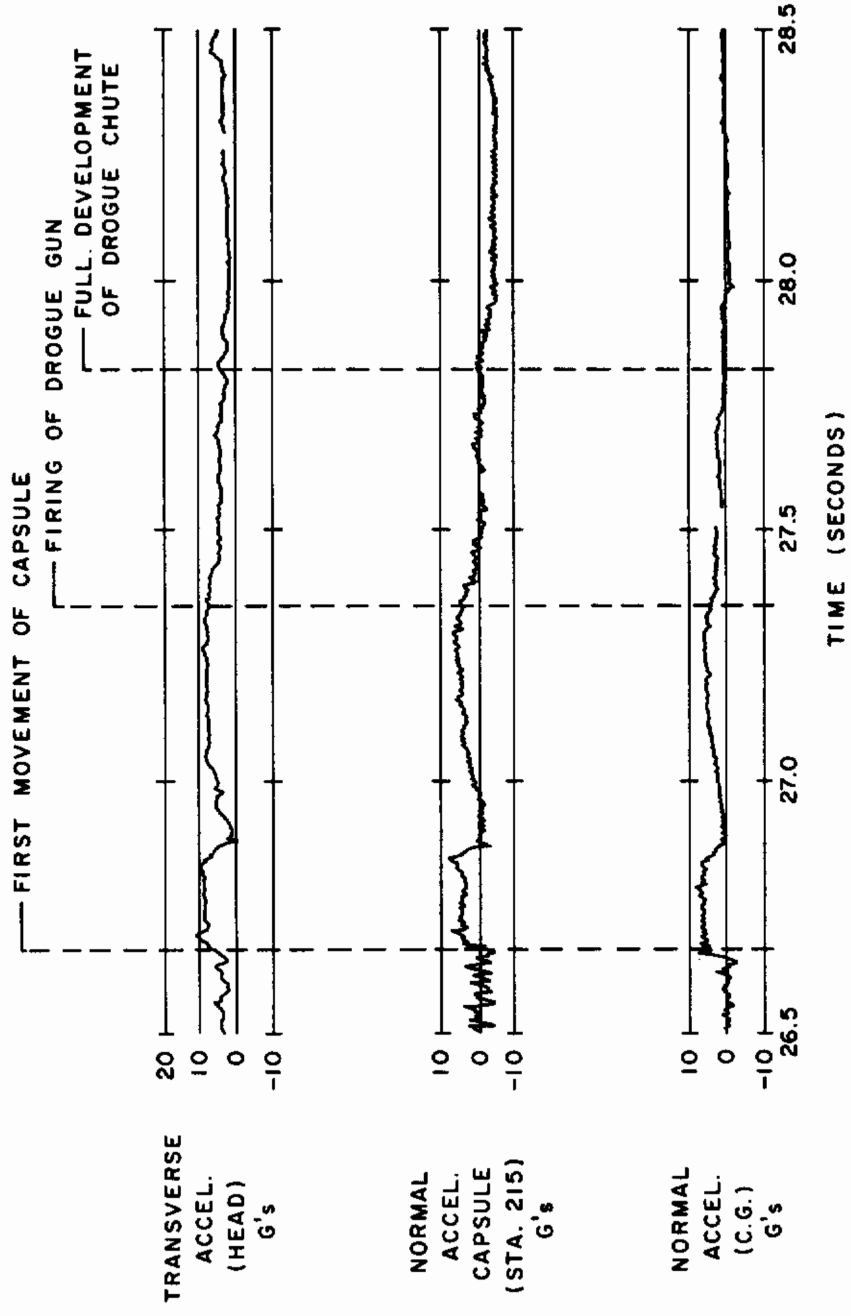


Figure 34. Oscillograph Trace of Normal Acceleration - Run Number 4

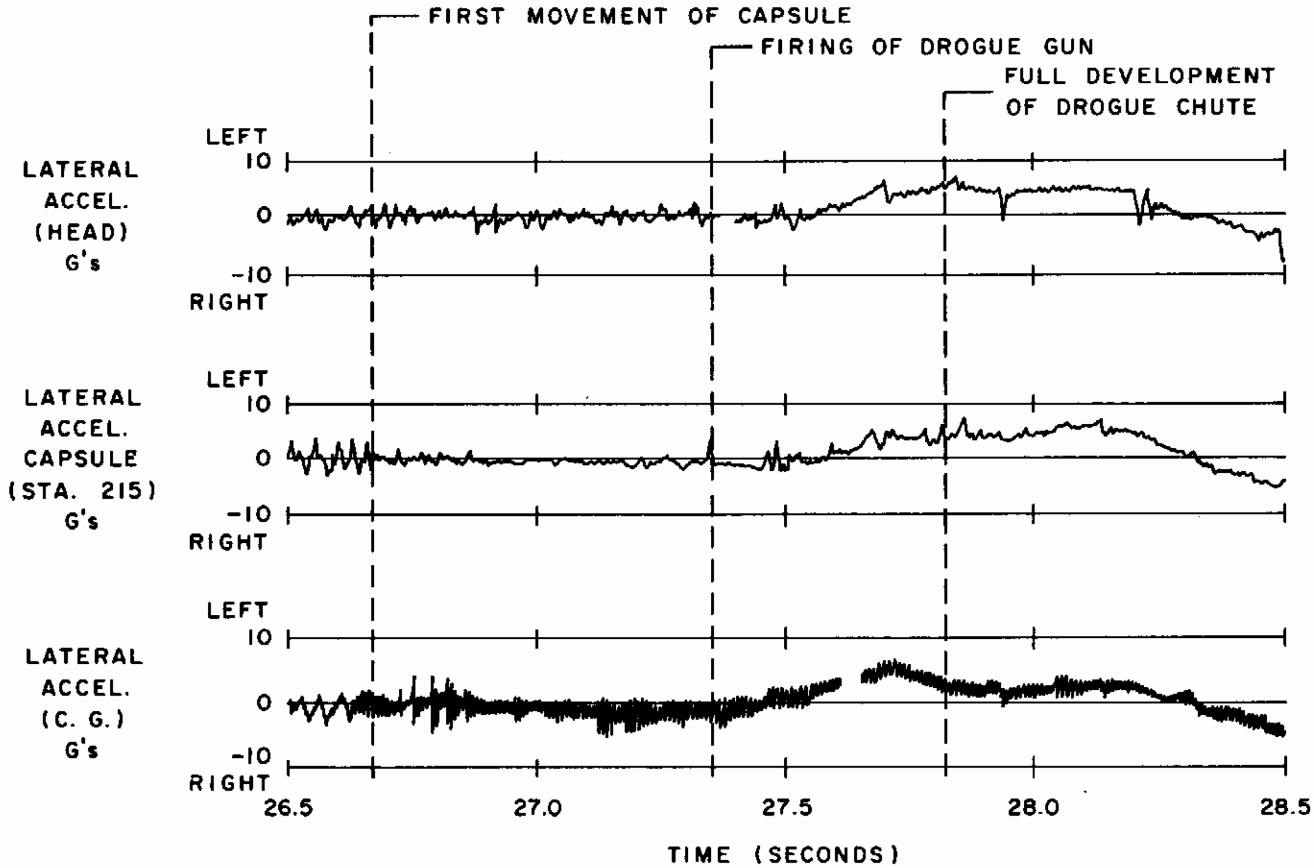


Figure 35. Oscillograph Trace of Lateral Acceleration - Run Number 4

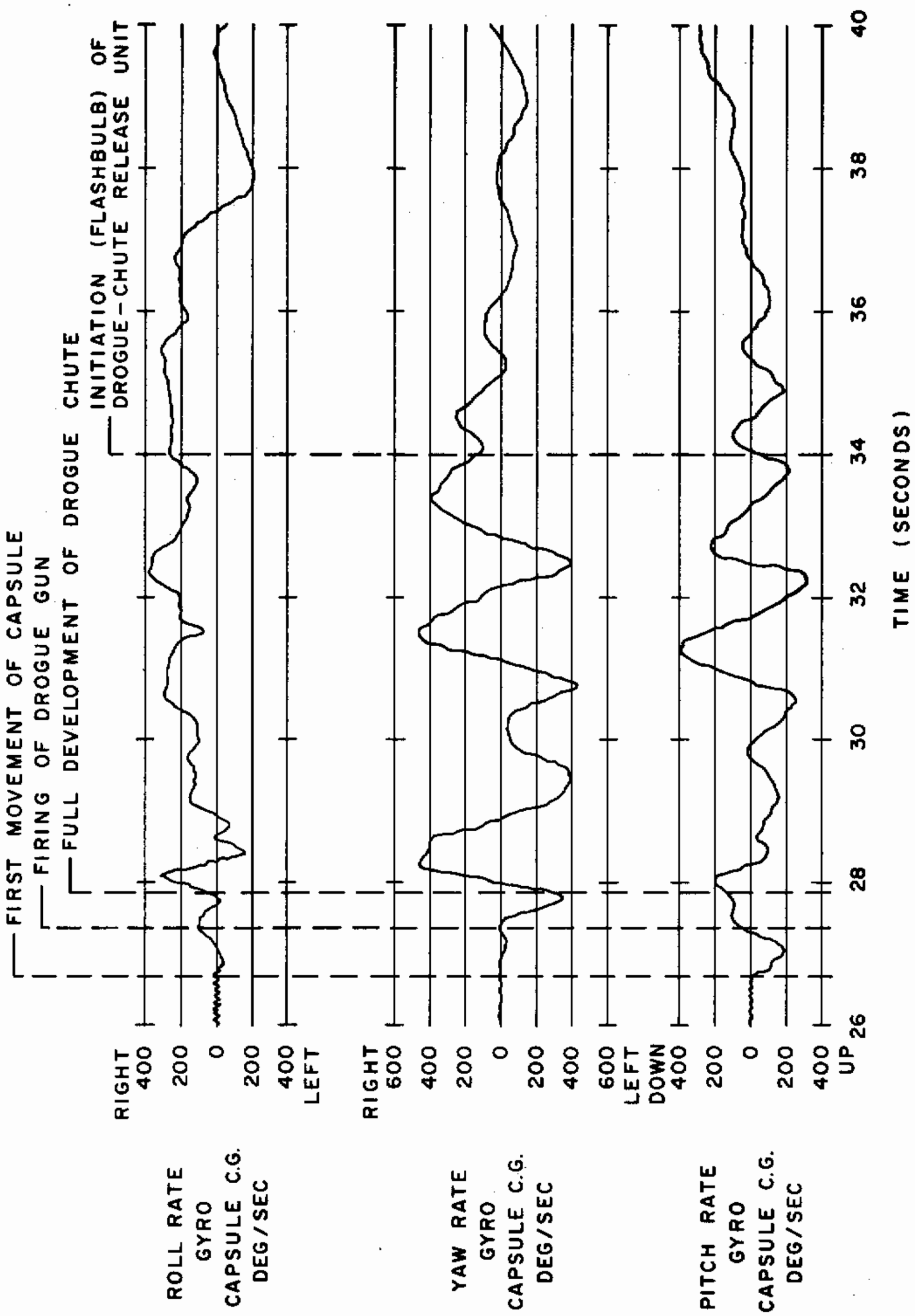


Figure 36. Oscillograph Plot of Roll, Yaw, and Pitch Rates of Capsule - Run Number 4

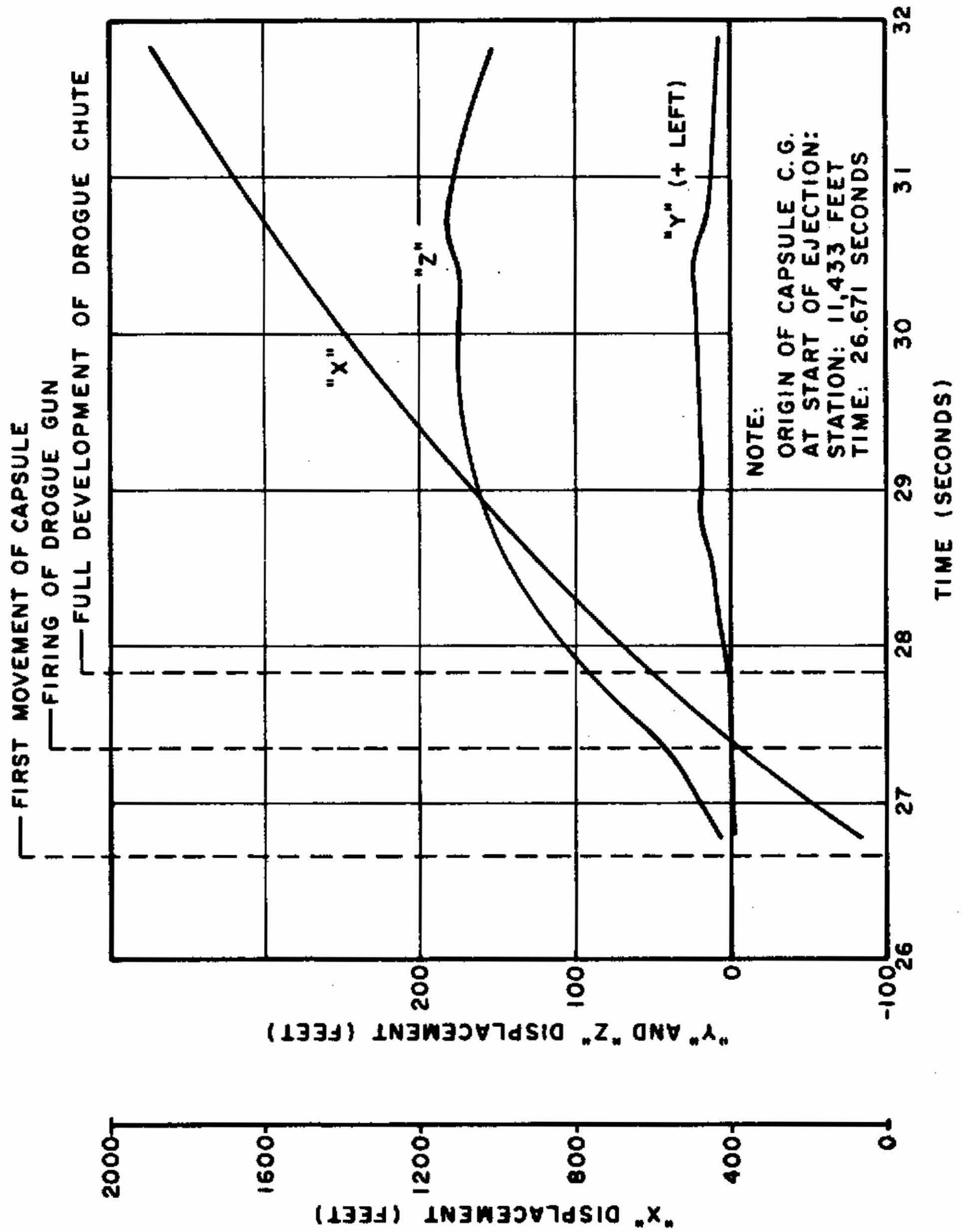


Figure 37. Displacement of Capsule Versus Time - Run Number 4

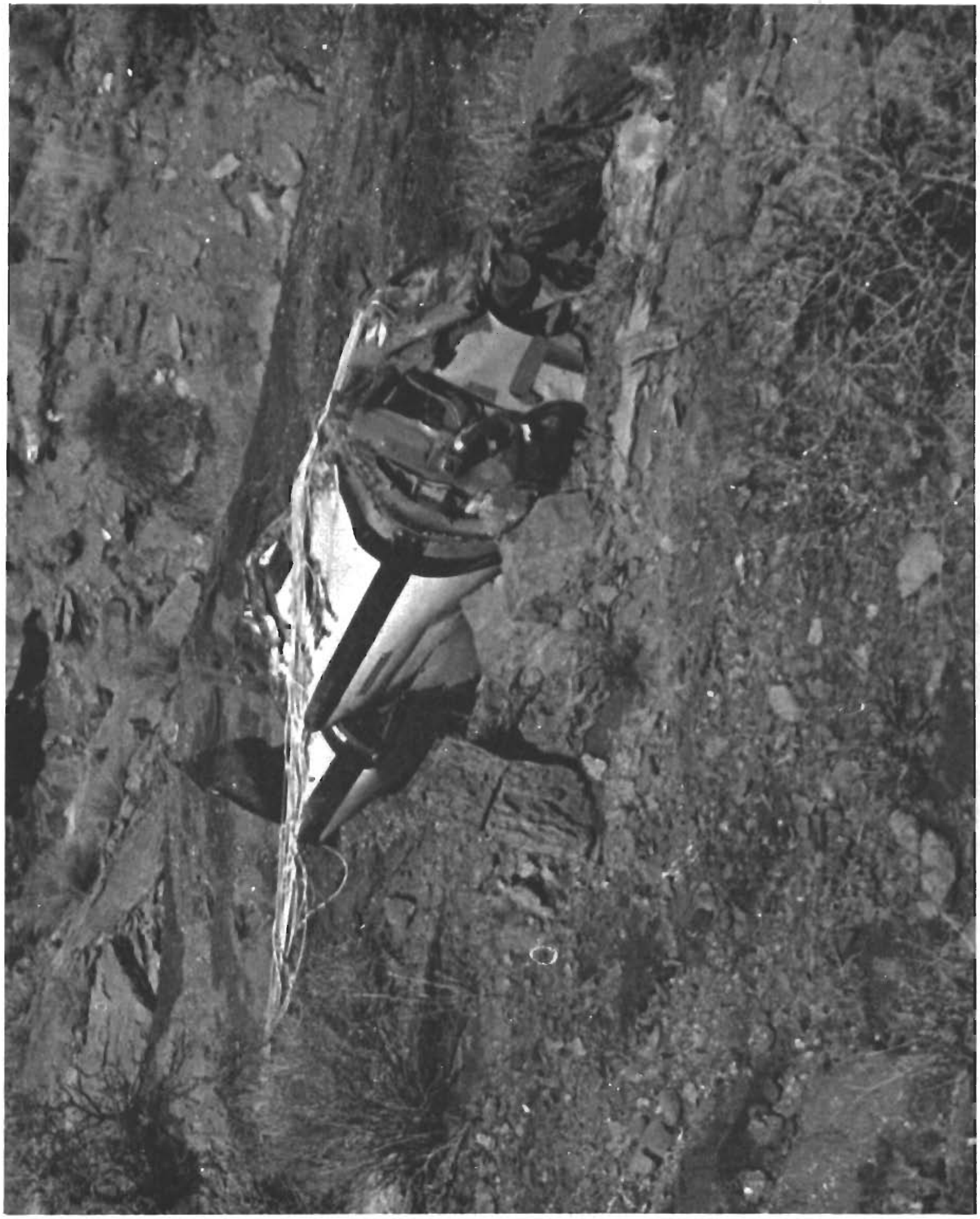


Figure 38. Impact Damage to Capsule - Run Number 4

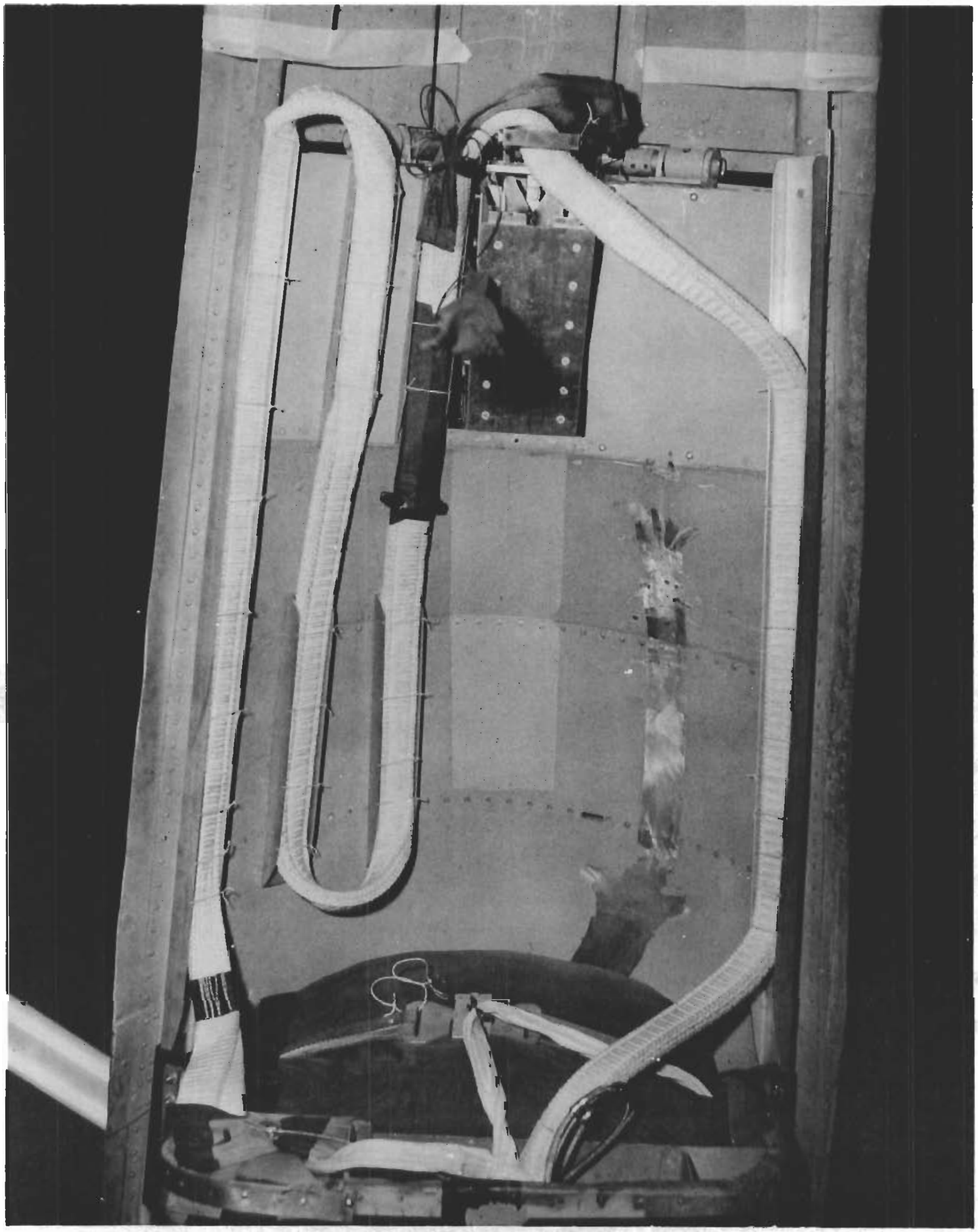


Figure 39. Recovery-System Installation for Run Number 5 - View From Underside of Tail Boom Showing Drogue-Parachute Riser

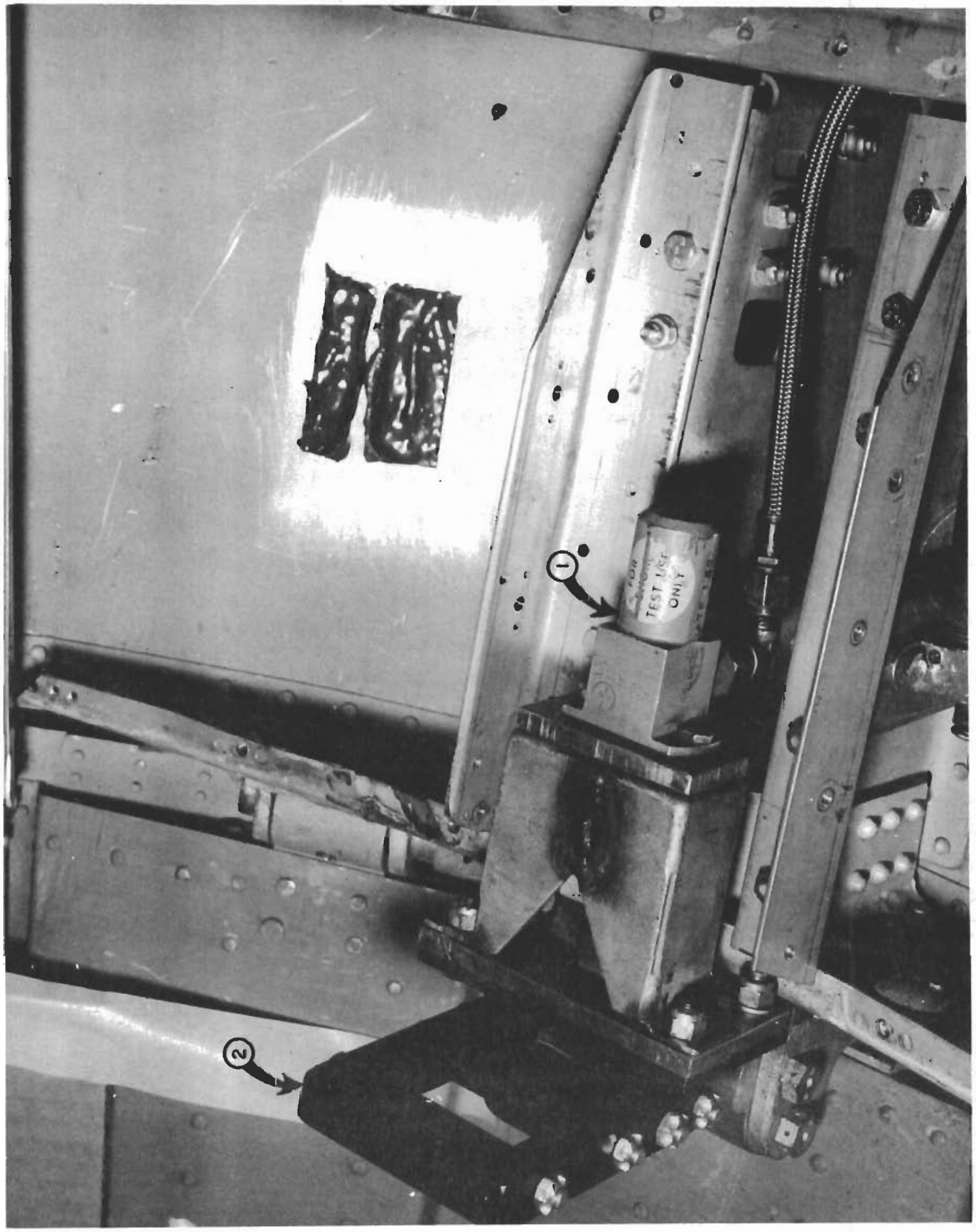


Figure 40. Riser Guide Assembly of Drogue Parachute (WWRMDD-12-1 Assembly) Including (1) Boeing 6-62493-502 Pull Pin and (2) Riser Guide WCLSJE-510

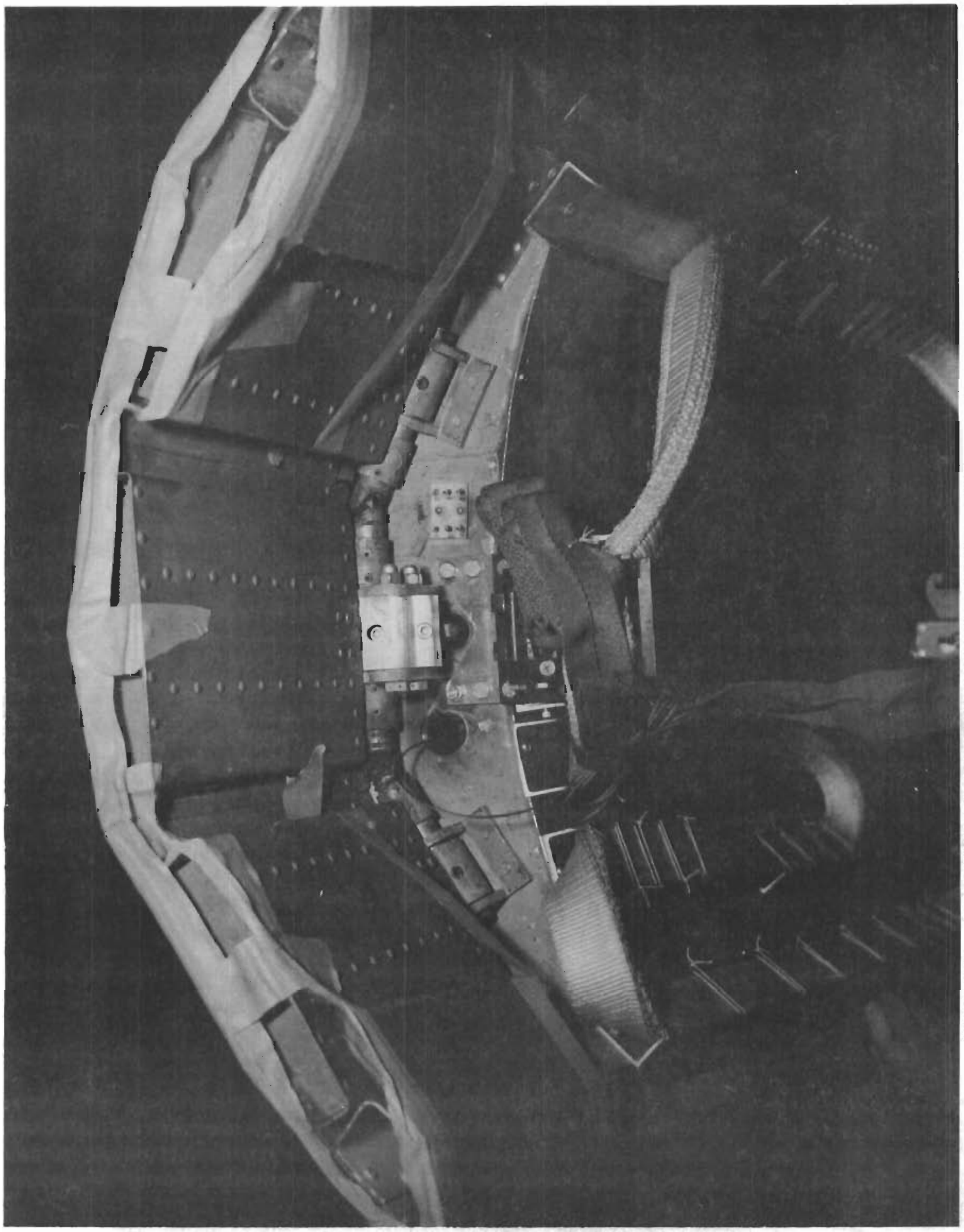


Figure 41. Rear View of Capsule Showing Installation of Drogue-Parachute Riser Guide (Run Number 5)

Figure 42. Release Unit of Drogue Parachute (WCLSJE-500)

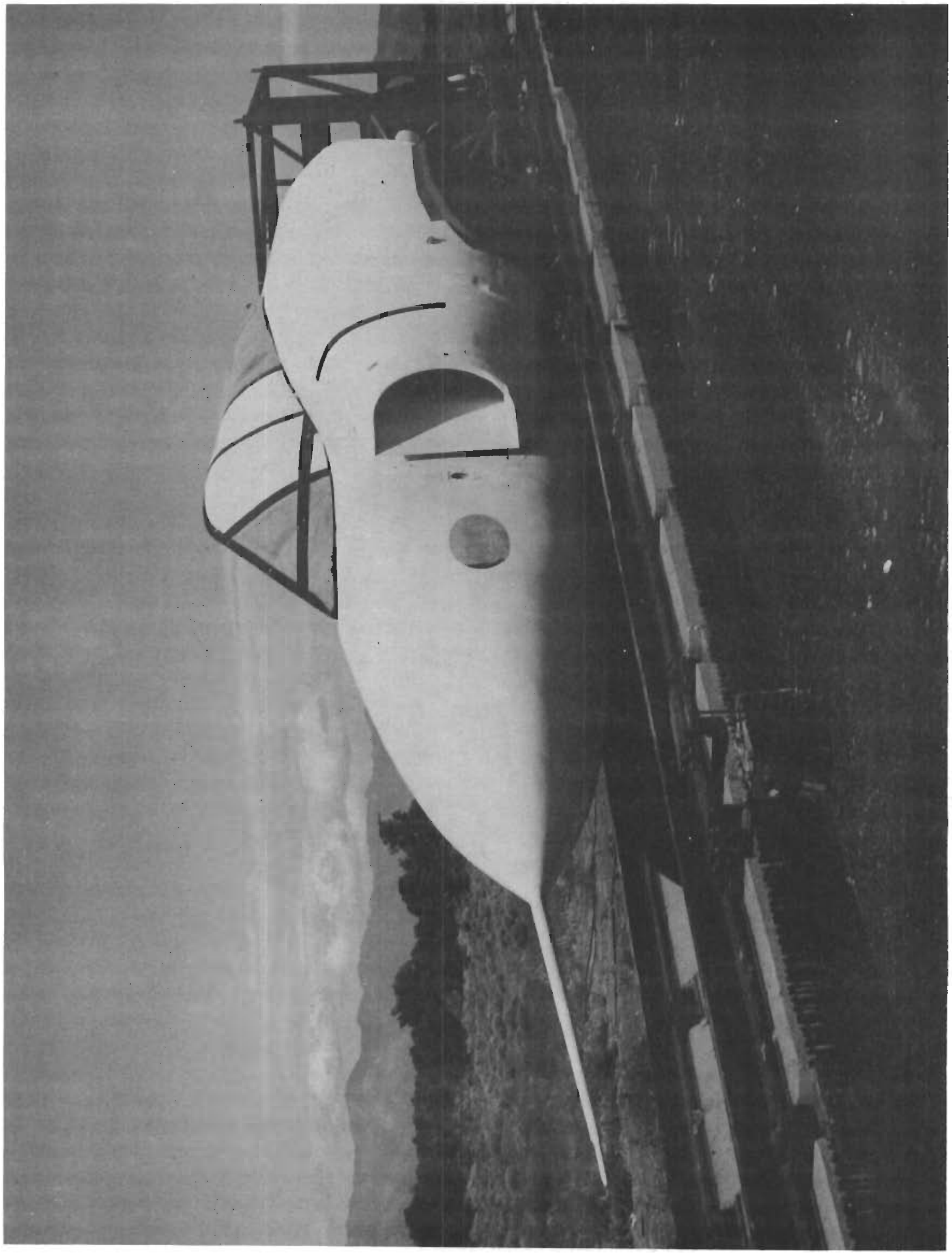


Figure 43. Sled Configuration for Run Number 5 (Solid Propellant Rocket Pusher)

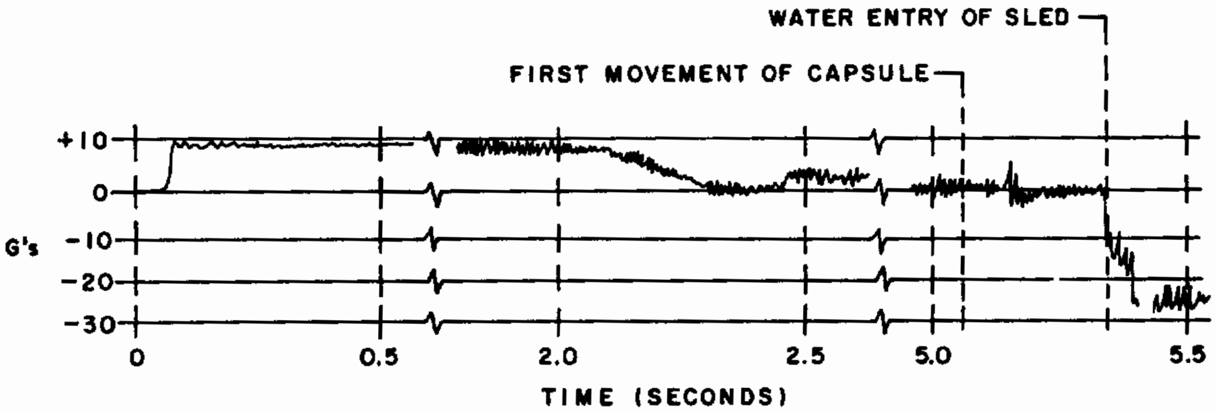


Figure 44. Oscillograph Trace of Longitudinal Acceleration of Sled Run Number 5

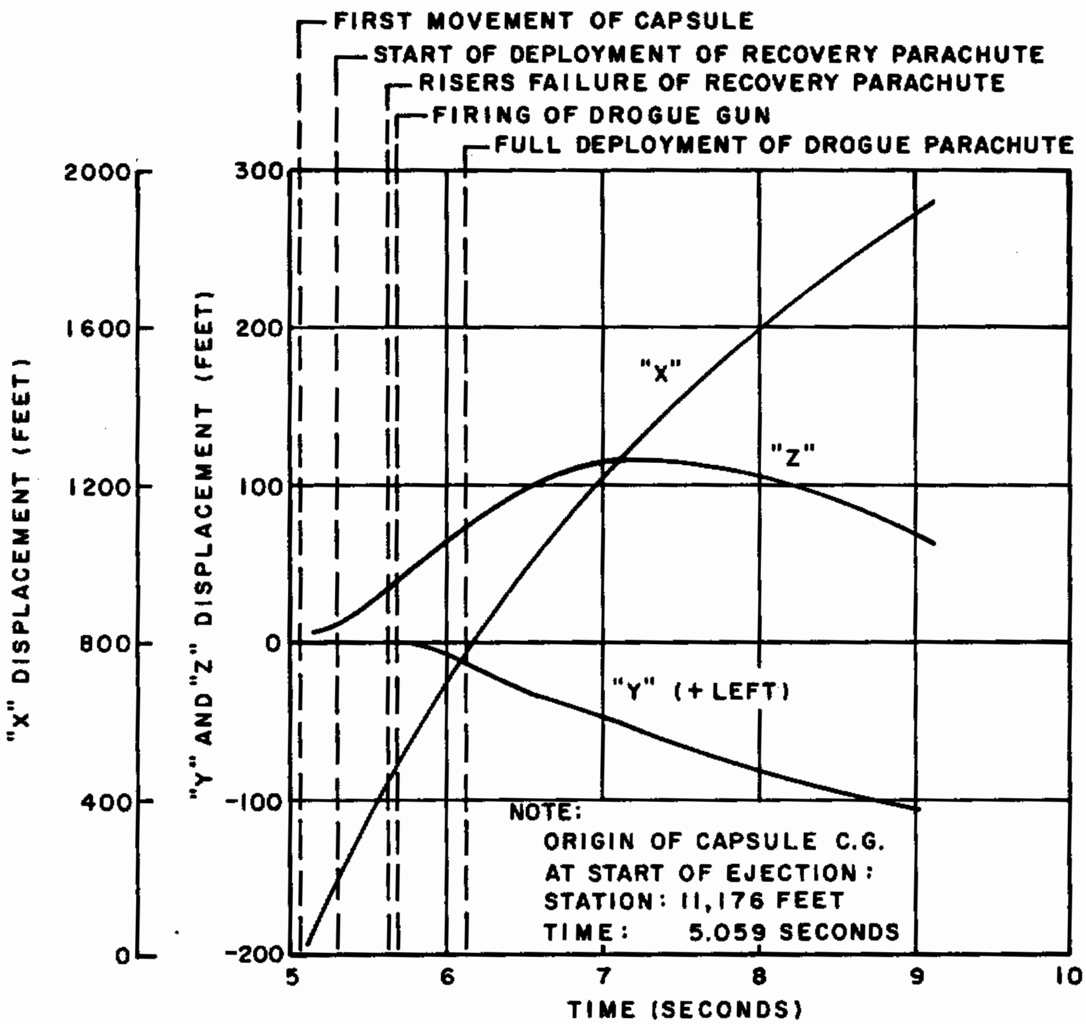


Figure 45. Displacement of Capsule Versus Time - Run Number 5

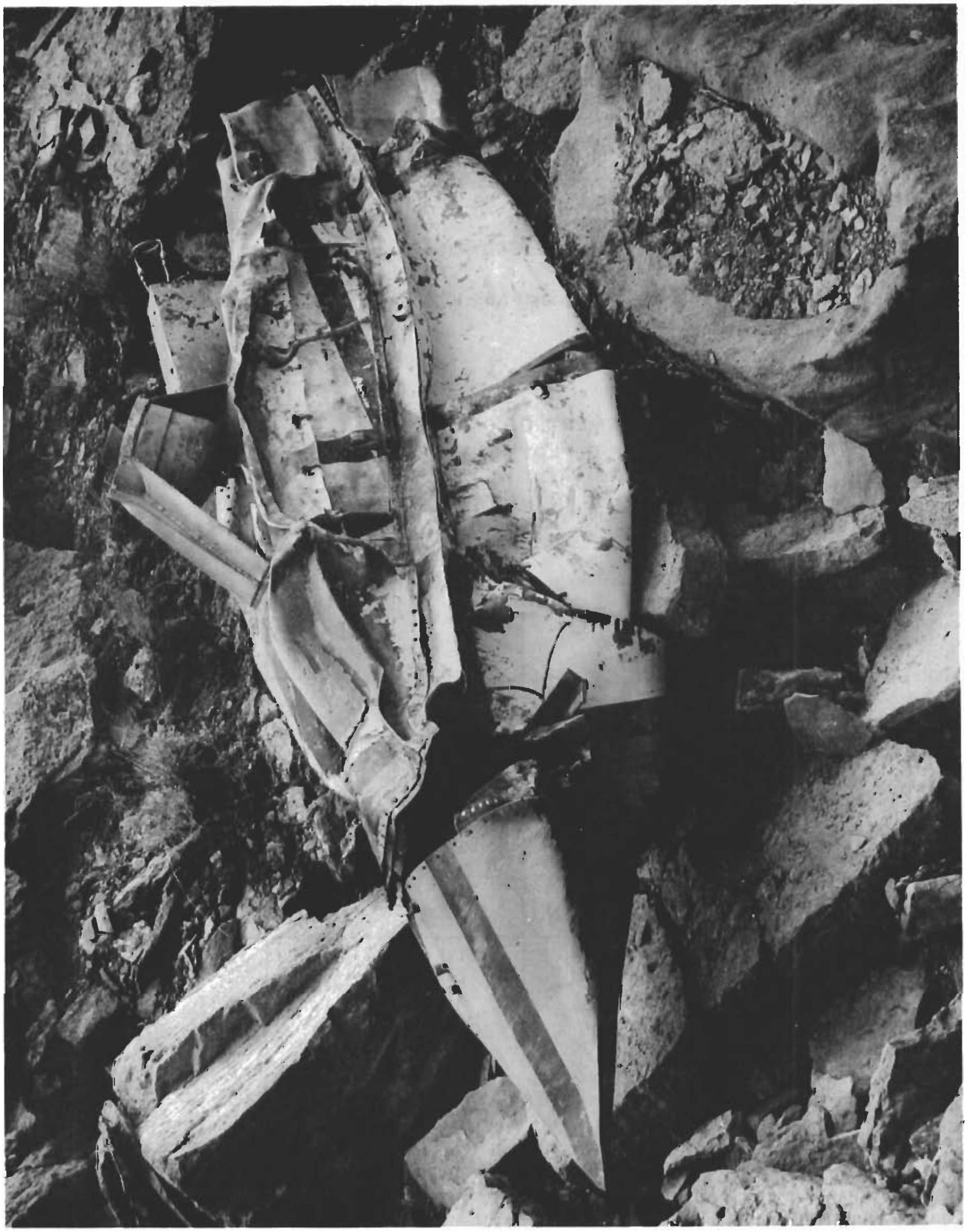
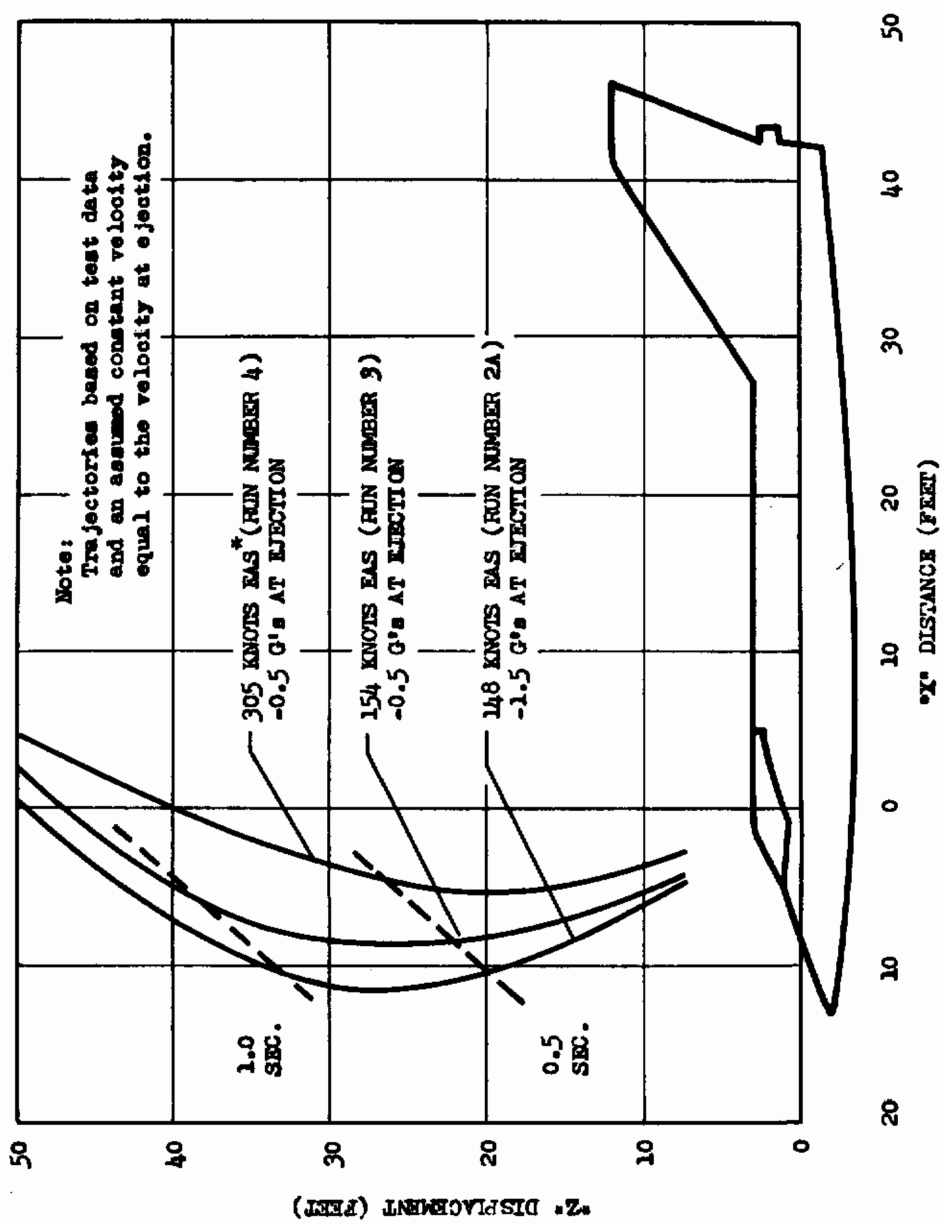


Figure 46. Capsule After Impact - Run Number 5



* - EQUIVALENT AIRSPEED

Figure 47. Tail Clearance Indicated by Test Trajectories for Straight-And-Level Flight

APPENDIX B

RECORDED TEST DATA

RUN NUMBER 1

BOWEN TRAJECTORY

TIME (sec.)	X (ft)	Z (ft)
.438	9	20
.505	9	24
.571	11	28
.638	13	32
.705	14	35
.772	16	38
.839	17	41
.906	19	43
.972	20	46
1.039	22	49
1.173	26	53
1.306	28	57
1.440	31	61
1.574	35	64
1.707	38	67
1.841	41	68
1.975	45	70
2.108	48	71
2.242	50	71
2.376	54	71
2.509	57	70
2.643	60	68
2.777	64	66
2.910	67	64
3.044	70	61
3.177	73	58
3.311	76	54
3.445	79	49
3.578	83	43
3.712	85	37
3.846	87	32
3.979	90	24
4.113	93	17
4.248	96	9
4.381	99	1
4.515	102	-9
4.649	105	-18
4.782	108	-28
4.916	110	-39
5.050	113	-51
5.183	116	-63
5.317	118	-75
5.451	121	-88
5.584	123	-100
5.718	126	-113
5.852	128	-127

RUN NUMBER 1 (Continued)

TIME (sec)	X (ft)	Z (ft)
5.986	130	-140
6.119	131	-153
6.253	133	-168
6.387	136	-182

RUN NUMBER 2A

TRAJECTORY OF CAPSULE

TIME (sec.)	X (ft)	Y (ft)	Z (ft)
36.780	47	0	6
36.847	65	0	9
36.914	85	0	11
36.980	106	0	13
37.047	125	0	16
37.114	145	0	18
37.180	164	0	20
37.247	184	0	22
37.314	203	0	25
37.380	221	0	28
37.447	240	0	31
37.514	257	0	32
37.580	275	1	35
37.647	292	2	38
37.714	309	3	40
37.780	326	4	42
37.847	343	5	45
37.980	378	7	49
38.114	411	9	52
38.247	444	12	54
38.380	480	13	57
38.513	512	15	58
38.647	544	19	59
38.780	574	23	59
38.913	604	26	58
39.047	629	29	57
39.180	656	31	55
39.313	680	34	53
39.447	701	36	51
39.580	722	38	49
39.713	741	40	45
39.847	759	41	41

RUN NUMBER 2A (Continued)

TIME (sec.)	X (ft)	Y (ft)	Z (ft)
39.980	774	43	38
40.113	791	43	34
40.247	801	45	29
40.380	810	46	24
40.513	818	46	20
40.647	825	49	15
40.780	829	50	11
40.913	831	50	6
41.047	834	50	-1
41.180	836	52	-5
41.313	838	53	-10
41.447	839	53	-16
41.580	839	54	-21
41.713	839	54	-27
41.846	838	53	-32
41.980	838	54	-39
42.113	837	55	-45
42.246	835	54	-51
42.380	834	54	-56
42.513	832	53	-60
42.646	830	52	-67
42.780	828	51	-72
42.913	826	50	-77
43.046	824	49	-79
43.180	821	47	-85
43.313	819	45	-90
43.446	817	44	-94
43.580	816	43	-98
43.713	814	41	-100
43.846	812	40	-104
43.980	811	38	-107

RUN NUMBER 2A

TRAJECTORY OF CAPSULE

TIME (sec.)	V_x (ft/sec.)	V_y (ft/sec.)	V_z (ft/sec.)	V_t (ft/sec.)	A_x (ft/sec.^{2})
36.914	292	0	37	293	
37.047	296	0	33	297	
37.180	292	0	33	293	-37
37.314	285	0	41	287	-82
37.447	270	3	37	272	-105
37.580	258	11	33	260	-52
37.714	255	15	37	257	
37.847	258	15	33	260	
37.980	255	15	26	256	-37
38.114	247	18	18	248	7
38.247	258	15	18	259	30
38.380	255	11	15	255	-67
38.513	240	22	7	241	-90
38.647	232	30	3	233	-52
38.780	225	26	3	225	-97
38.913	206	22	7	207	-112
39.047	195	18	11	195	-52
39.180	191	18	15	192	-105
39.313	168	18	15	169	-127
39.447	157	15	15	157	-63
39.580	150	15	22	152	-75
39.713	138	11	30	141	-101
39.847	123	11	26	126	-67
39.980	120	7	26	122	-82
40.113	101	7	33	105	-180
40.247	71	11	37	80	-142
40.380	63	3	33	71	-56
40.513	56	11	33	65	-82
40.647	41	15	33	54	-131
40.780	22	3	33	39	-90
40.913	18	0	37	41	-15
41.047	18	7	41	45	-7
41.180	15	11	41	45	-22
41.313	11	3	41	42	-45
41.447	3	3	41	41	-41
41.580	0	3	41	41	
41.713	3	3	41	41	11
41.846	3	0	45	45	
41.980	3	7	48	48	30
42.113	11	0	45	46	30
42.246	11	3	41	42	
42.380	11	3	33	34	15
42.513	15	7	41	44	15
42.646	15	7	45	47	
42.780	15	7	37	40	

RUN NUMBER 2A (Continued)

TIME (sec.)	V_x (ft/sec.)	V_y (ft/sec.)	V_z (ft/sec.)	V_t (ft/sec.)	A_x (ft/sec.^{2})
42.913	15	7	26	30	7
43.046	18	11	30	36	7
43.180	18	15	41	47	-7
43.313	15	11	33	37	-22
43.446	11	7	30	32	-15
43.580	11	11	22	26	15
43.713	15	11	22	28	
43.846	11	11	26	30	
43.980					

RUN NUMBER 2A

TELEMETERED SPACE TIME

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
8416.2	26.7318	364.1
8516.2	27.0064	361.0
8616.2	27.2834	358.2
8716.2	27.5625	354.9
8816.2	27.8442	352.3
8916.2	28.1280	349.5
9016.2	28.4141	346.5
9116.2	28.7027	343.6
9216.2	28.9937	340.9
9316.2	29.2870	337.9
9416.2	29.5829	335.2
9516.2	29.8812	332.4
9616.2	30.1820	329.4

*Station-to-station average.

RUN NUMBER 2A (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
9716.2	30.4855	
		326.7
9816.2	30.7915	
		324.0
9916.2	31.1001	
		321.4
10016.2	31.4112	
		318.5
10116.2	31.7251	
		315.8
10216.2	32.0417	
		312.0
10416.2	32.6827	
		307.8
10516.2	33.0075	
		305.1
10616.2	33.3352	
		302.4
10716.2	33.6658	
		299.9
10816.2	33.9992	
		297.3
10916.2	34.3355	
		294.4
10966.2	34.5053	
		294.4
11016.2	34.6751	
		292.9
11066.2	34.8458	
		290.8
11116.2	35.0177	
		290.1
11166.2	35.1900	
		288.6
11216.2	35.3632	
		287.3
11266.2	35.5372	
		285.8
11316.2	35.7121	
		285.0
11366.2	35.8875	
		282.8
11416.2	36.0643	
		282.8
11466.2	36.2411	
		280.8

*Station-to-station average.

RUN NUMBER 2A (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
11516.2	36.4191	
		279.9
11566.2	36.5977	
		277.1
11616.2	36.7781	
		267.2
11666.2	36.9652	
		210.5
11716.2	37.2027	
		156.6
11766.2	37.5218	
		116.6
11816.2	37.9503	
		92.2
11866.2	38.4921	
		69.8
11916.2	39.2077	

*Station-to-station average.

RUN NUMBER 3

TRAJECTORY OF CAPSULE

TIME (sec.)	X (ft)	Y (ft)	Z (ft)	V (ft/sec.)	A (ft/sec.^{2})
36.025	93	-1	11		
36.158	133	-1	17	298	
36.291	172	-1	22	287	-56
36.424	209	-1	27	283	-11
36.557	247	-3	33	284	-52
36.691	284	-5	39	269	-97
36.824	318	-6	45	258	-75
36.957	352	-8	50	249	-48
37.090	384	-9	54	245	15
37.223	417	-11	59	253	-15
37.357	451	-13	62	241	-78
37.490	481	-15	65	232	-3
37.623	513	-17	66	240	11
37.756	545	-19	68	235	-48
37.889	576	-21	69	227	-11
38.023	606	-24	69	232	15
38.156	638	-26	69	231	-15
38.289	668	-28	69	228	-22

RUN NUMBER 3 (Continued)

TIME (sec.)	X (ft)	Y (ft)	Z (ft)	V (ft/sec.)	A (ft/sec.^{2})
38.422	699	-30	68	225	-41
38.555	728	-30	67	217	-60
38.689	757	-31	67	209	-56
38.822	784	-32	66	202	3
38.955	811	-33	65	210	-11
39.088	840	-35	63	199	-82
39.221	864	-36	60	188	-60
39.355	890	-38	58	183	-56
39.488	913	-39	55	173	-71
39.621	936	-40	50	164	-75
39.754	956	-42	46	153	-67
39.887	976	-44	42	146	-75
40.021	994	-46	37	133	-71
40.154	1010	-48	32	127	-67
40.287	1026	-48	26	115	-67
40.420	1039	-49	21	109	-26
40.553	1053	-50	15	108	-41
40.687	1065	-52	8	98	-67
40.820	1076	-52	2	90	-63
40.953	1086	-53	-4	81	-60
41.086	1094	-55	-10	74	-56
41.219	1101	-55	-17	66	-67
41.353	1107	-58	-22	56	-67
41.486	1111	-58	-28	48	-56
41.619	1114	-59	-33	41	-45
41.752	1117	-61	-37	36	-15
41.885	1118	-61	-42	37	11
42.019	1119	-62	-47	39	3
42.152	1121	-63	-52	38	-7
42.285	1121	-64	-57	37	11
42.418	1120	-64	-62	41	15
42.551	1121	-66	-68	41	-26
42.685	1120	-65	-73	34	-3
42.818	1119	-68	-77	40	33
42.951	1117	-68	-83	43	-33
43.084	1115	-68	-88	31	-52
43.217	1114	-68	-91	29	22
43.351	1111	-68	-95	37	18
43.484	1109	-68	-100	34	-33
43.617	1107	-70	-103	28	22
43.750	1106	-68	-107	40	33
43.883	1103	-68	-113	37	-26
44.017	1099	-70	-114	33	-22
44.150	1097	-71	-119	31	-18
44.283	1094	-71	-121	28	-30
44.416	1091	-71	-124	23	
44.549	1090	-72	-126		

RUN NUMBER 3

TELEMETERED SPACE TIME

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
7216.2	23.0072	
		407.8
7316.2	23.2524	
		404.5
7416.2	23.4996	
		401.6
7516.2	23.7486	
		398.5
7616.2	23.9995	
		395.7
7716.2	24.2522	
		392.6
7816.2	24.5069	
		389.7
7916.2	24.7635	
		386.8
8016.2	25.0220	
		384.0
8116.2	25.2824	
		380.9
8216.2	25.5449	
		378.0
8316.2	25.8094	
		375.5
8416.2	26.0757	
		372.4
8516.2	26.3442	
		369.2
8616.2	26.6150	
		366.4
8716.2	26.8879	
		363.5
8816.2	27.1630	
		361.1
8916.2	27.4399	
		357.9
9016.2	27.7193	
		355.1
9116.2	28.0009	
		351.8
9216.2	28.2851	
		349.4
9316.2	28.5713	
		346.1

*Station-to-station average.

RUN NUMBER 3 (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
9416.2	28.8602	
		343.2
9516.2	29.1515	
		340.4
9616.2	29.4452	
		337.2
9716.2	29.7417	
		334.6
9816.2	30.0405	
		331.7
9916.2	30.3419	
		328.9
10016.2	30.6459	
		326.3
10116.2	30.9523	
		323.6
10216.2	31.2613	
		320.9
10316.2	31.5729	
		318.3
10416.2	31.8870	
		315.7
10516.2	32.2037	
		313.0
10616.2	32.5231	
		310.0
10716.2	32.8456	
		307.6
10816.2	33.1706	
		305.1
10916.2	33.4983	
		302.2
10966.2	33.6637	
		302.2
11016.2	33.8291	
		300.8
11066.2	33.9953	
		298.8
11116.2	34.1626	
		297.7
11166.2	34.3305	
		296.5
11216.2	34.4991	
		295.5
11266.2	34.6683	
		203.4

*Station-to-station average.

RUN NUMBER 3 (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
11316.2	34.8387	
		292.9
11366.2	35.0094	
		291.0
11416.2	35.1812	
		290.1
11466.2	35.3535	
		288.8
11516.2	35.5266	
		288.3
11566.2	35.7000	
		285.5
11616.2	35.8751	
		275.3
11666.2	36.0567	
		218.2
11716.2	36.2858	
		161.9
11766.2	36.5946	
		119.1
11816.2	37.0141	
		93.6
11866.2	37.5478	
		71.2
11916.2	38.2498	

*Station-to-station average.

RUN NUMBER 3

TAIL-CLEARANCE ATTITUDE

Time (sec.)	Pitch (deg.)	Roll (deg.)	Yaw (deg.)
36.025	30	0	0
36.158	40	7	-5
36.591	60	10	10
36.424	60	14	25
36.557	60	15	30
36.691	55	17	25
36.829	45	20	20
36.957	35	25	0

RUN NUMBER 4

BOWEN TRAJECTORY

TIME (sec.)	X (ft)	Y (ft)	Z (ft)	Velocity (ft/sec.)	Acceleration (ft/sec.^{2})
26.651					
26.785	66	-2	9		
26.918	142	-2	14	564	
27.051	216	-1	22	549	-105
27.185	288		29	536	-108
27.318	358		40	520	-120
27.451	425	1	53	504	-112
27.585	490	1	66	490	-108
27.718	553	1	80	475	-131
27.851	614	4	93	455	-131
27.985	672	6	105	440	-101
28.118	729	8	117	428	-97
28.251	784	9	127	414	-105
28.384	838	10	136	400	-56
28.518	890	11	142	399	-56
28.651	944	16	146	385	-150
28.784	992	18	154	359	-135
28.918	1039	18	160	349	-63
29.051	1085	18	164	342	-71
29.184	1130	19	167	330	-60
29.318	1173	19	170	326	-15
29.451	1217	20	172	326	-30
29.585	1260	21	173	318	-56
29.718	1302	21	174	311	-56
29.852	1343	21	175	303	-45
29.985	1383	22	174	299	-15
30.119	1423	22	175	299	3
30.252	1463	23	174	300	-26
30.385	1503	24	173	292	-33
30.519	1541	20	178	291	-15
30.651	1580	17	182	288	-22
30.784	1618	15	179	285	-56
30.918	1656	15	176	273	-86
31.051	1691	13	174	262	-22
31.184	1726	13	171	267	-18
31.318	1762	11	167	257	-52
31.451	1794	12	162	253	-15
31.584	1829	8	159	253	-41
31.717	1861	9	154	242	
31.851	1893	8	150		

RUN NUMBER 4

TELEMETERED SPACE TIME

Track Station	Time (sec.)	*Velocity (ft/sec.)
7616.2	20.5308	695.8
7716.2	20.6745	690.1
7816.2	20.8194	687.7
7916.2	20.9648	684.0
8016.2	21.1110	679.3
8116.2	21.2582	674.7
8216.2	21.4064	671.5
8316.2	21.5553	668.0
8416.2	21.7050	664.8
8516.2	21.8554	658.7
8616.2	22.0072	657.0
8716.2	22.1594	652.3
8816.2	22.3127	648.5
8916.2	22.4669	644.3
9016.2	22.6221	641.8
9116.2	22.7779	636.9
9216.2	22.9349	632.9
9316.2	23.0929	629.7
9416.2	23.2517	625.7
9516.2	23.4115	621.8
9616.2	23.5723	618.4
9716.2	23.7340	614.3

*Station-to-station average. (Ref to cross on forward vehicle).

RUN NUMBER 4 (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
9816.2	23.8968	
		610.1
9916.2	24.0607	
		607.9
10016.2	24.2252	
		603.5
10116.2	24.3909	
		599.5
10216.2	24.5577	
		596.3
10316.2	24.7254	
		592.4
10416.2	24.8942	
		588.9
10516.2	25.0640	
		585.8
10616.2	25.2347	
		581.3
10716.2	25.4067	
		578.0
10816.2	25.5797	
		574.3
10916.2	25.7538	
		571.4
10966.2	25.8413	
		570.1
11916.2	25.9290	
		568.8
11066.2	26.0169	
		566.2
11116.2	26.1052	
		564.3
11166.2	26.1938	
		563.6
11216.2	26.2825	
		562.4
11266.2	26.3714	
		558.6
11316.2	26.4609	
		557.4
11366.2	26.5506	
		554.9
11416.2	26.6407	
		556.1
11466.2	26.7306	
		551.2

*Station-to-station average. (Ref to cross on forward vehicle).

RUN NUMBER 4 (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
11516.2	26.8213	
		544.6
11566.2	26.9131	
		495.0
11616.2	27.0141	
		392.4
11666.2	27.1415	
		294.4
11716.2	27.3113	
		213.9
11766.2	27.5450	
		165.7
11816.2	27.8466	
		116.8
11866.2	28.2745	
		94.6
11916.2	28.8028	

*Station-to-station average. (Ref to cross on forward vehicle)

RUN NUMBER 5

BOWEN TRAJECTORY

Time (sec.)	X (ft)	Y (ft)	Z (ft)	V (ft/sec.)
5.0920	32.4	.1	6.0	
5.1587	84.6	.1	5.6	780
5.2253	136.4	.1	8.4	776
5.2919	187.9	.1	11.5	776
5.3586	239.6	.1	15.6	771
5.4252	290.6	.1	18.0	
5.6252	439.3	-.5	34.0	
5.6918	486.5	-.8	38.8	711
5.7585	533.5	-1.5	44.1	714
5.8251	581.1	-2.2	48.6	686
5.8918	624.4	-3.8	54.1	664
5.9584	669.0	-6.4	59.1	659
6.0250	711.5	-9.4	64.6	635
6.0917	752.8	-13.2	69.6	627
6.1583	794.2	-17.3	74.7	609
6.2250	833.1	-19.7	79.9	590
6.2916	872.1	-23.4	84.5	568

RUN NUMBER 5 (Continued)

Time (sec.)	X (ft)	Y (ft)	Z (ft)	V (ft/sec.)
6.3583	908.3	-25.7	88.5	562
6.4249	946.2	-30.1	93.7	543
6.4916	980.1	-30.6	96.7	511
6.5582	1014.0	-32.7	99.9	512
6.6248	1048.0	-34.9	102.9	486
6.6915	1078.5	-36.1	105.7	481
6.7581	1111.7	-39.1	108.4	476
6.8248	1141.6	-40.9	111.1	463
6.8914	1173.2	-43.7	113.3	456
6.9581	1202.1	-45.7	115.2	431
7.0247	1230.5	-47.5	115.1	425
7.0914	1258.7	-49.7	116.4	420
7.1580	1286.3	-52.9	117.3	411
7.2247	1313.3	-54.6	117.4	406
7.2913	1340.4	-57.1	117.2	410
7.3579	1367.7	-59.6	116.8	390
7.4246	1392.2	-62.0	117.3	375
7.4912	1417.5	-64.6	116.0	373
7.5579	1441.8	-66.9	114.8	363
7.6245	1465.6	-69.1	113.4	348
7.6912	1488.0	-70.8	112.4	344
7.7578	1511.4	-72.7	111.6	361
7.8245	1536.1	-74.6	110.3	360
7.8911	1559.2	-76.9	109.6	320
7.9577	1578.5	-77.9	107.5	327
8.0244	1602.6	-80.3	106.3	342
8.0910	1623.9	-82.5	105.4	306
8.1577	1643.2	-84.4	103.5	298
8.2243	1663.3	-86.7	101.9	303
8.2910	1683.4	-88.5	100.1	304
8.3576	1703.5	-90.4	98.3	298
8.4243	1722.7	-92.1	95.8	293
8.4909	1742.3	-93.7	94.1	297
8.5576	1761.9	-96.1	91.4	305
8.6242	1782.5	-97.9	88.6	302
8.6908	1801.7	-99.2	85.9	283
8.7575	1819.8	-101.1	83.5	266
8.8241	1836.6	-102.8	80.6	266
8.8908	1854.4	-103.9	76.3	272
8.9574	1872.0	-105.9	73.1	253
9.0241	1887.4	-107.6	70.1	264
9.0907	1906.5	-110.1	66.9	247
9.1574	1919.2	-111.7	62.2	271

RUN NUMBER 5

TELEMETERED SPACE TIME

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
8492.8	.5570	
		221
8592.8	1.0104	
		337
8692.8	1.3075	
		418
8792.8	1.5466	
		486
8892.8	1.7522	
		544
8992.8	1.9360	
		588
9092.8	2.1059	
		605
9192.8	2.2711	
		612
9292.8	2.4344	
		628
9392.8	2.5938	
		643
9492.8	2.7493	
		656
9592.8	2.9017	
		670
9692.8	3.0508	
		681
9792.8	3.1976	
		693
9892.8	3.3419	
		705
9992.8	3.4837	
		716
10092.8	3.6233	
		724
10192.8	3.7613	
		735
10292.8	3.8973	
		746
10392.8	4.0314	
		753
10492.8	4.1643	
		761
10592.8	4.2957	
		762

*Station-to-station average. (Ref to cross on forward vehicle).

RUN NUMBER 5 (Continued)

Track Station (feet)	Time (sec.)	*Velocity (ft/sec.)
10692.8	4.4268	
		765
10792.8	4.5576	
		765
10892.8	4.6883	
		763
10942.8	4.7538	
		767
10992.8	4.8190	
		765
11042.8	4.8844	
		764
11092.8	4.9498	
		765
11142.8	5.0152	
		763
11192.8	5.0808	
		762
11242.8	5.1464	
		760
11292.8	5.2121	
		756
11342.8	5.2783	
		724
11392.8	5.3474	
		670
11442.8	5.4220	
		606
11492.8	5.5046	
		535
11542.8	5.5981	
		458
11592.8	5.7071	
		376
11642.8	5.8402	
		281
11692.8	6.0184	
		207
11742.8	6.2603	
		154
11792.8	6.5851	
		122
11842.8	6.9957	
		91
11892.8	7.5473	

*Station-to-station average. Ref to cross on forward vehicle.