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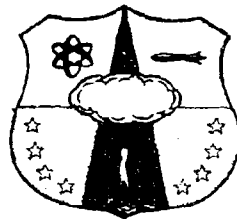
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PREPRODUCTION TESTING OF THE BDU-38/B PRACTICE BOMB

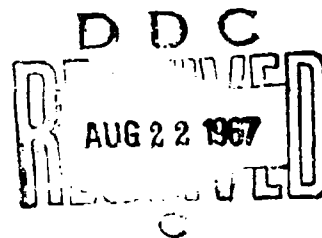
Frank T. Krek

TECHNICAL REPORT NO. AFSWC-TR-67-16



AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

July 1967



AIR FORCE SPECIAL WEAPONS CENTER
Air Force Systems Command
Kirtland Air Force Base
New Mexico

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PREPRODUCTION TESTING OF THE
BDU-38/B PRACTICE BOMB

Frank T. Krek

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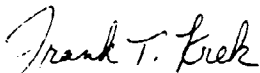
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FOREWORD

This research was performed under Program Element 6.44.15.03.4, Project 5708, Task 57082 and was funded by the Air Force Weapons Laboratory.

Inclusive dates of research were January 1967 through April 1967. The report was submitted 26 May 1967 by the Air Force Special Weapons Center Test Director, Frank T. Krek (SWTVS).

This report has been reviewed and is approved.



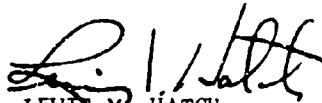
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ABSTRACT

Testing of a BDU-38/B practice bomb was performed by the Air Force Special Weapons Center at the request of the Air Force Weapons Laboratory. The purpose of these tests was to establish the N.T.W. Missile Engineering Inc. as a qualified producer of these test units. Testing was performed on one sample practice bomb, Serial Number 1. Testing was performed in general accordance with MIL-STD-810A and included low-temperature testing of the battery power supply system, vibration testing, shock testing, static load testing, functional load testing of the parachute deployment separation system, and simulated parachute opening shock load testing. The test results indicated a need for a number of improvements in the original design. Test results, notations of observations made during testing, and other pertinent test data are presented.

(Distribution limitation statement No. 2)

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SECTION I

INTRODUCTION

1. General

This report presents the results of an investigation that was conducted on a BDU-38/B practice bomb. The authority for this work is contained in AF Form 111 for Project 5708, Task 57082, entitled "Nuclear Weapon Support." This authority was issued by Headquarters, Air Force Special Weapons Center, Kirtland Air Force Base, New Mexico, by work authorization, AFSWC Form 35, dated 24 August 1966.

2. Purpose

The purpose of this investigation was, primarily, the testing of a BDU-38/B practice bomb to determine if the manufacturer was a qualified producer of pre-production test samples and if the fabrication of these samples was in accordance with required specifications and would meet all design requirements.

SECTION II
TEST SPECIMEN

The BDU-38/B practice bomb used in these tests was manufactured by N.T.W. Missile Engineering Inc. The BDU-38/B was designed to provide practice in aircraft maneuverability, cruise control, supersonic flight testing, and aircraft drop testing. The bomb has provisions for the installation and deployment of a parachute. It consists of a forward section assembly and an aft section assembly. The forward section assembly contains the nose section, while the aft section assembly contains the parachute assembly, the deployment assembly, the aft cap, the fins, and a battery-operated explosive kit used to deploy the parachute. The forward section assembly contains ballast for internal component weight simulation. The bomb has lug locations for both the 30-inch suspension and the 14-inch suspension. The bomb is approximately 13.30 inches in diameter and 141.64 inches long. It has been designed to withstand the shock, vibration, and dynamic loads associated with the flight and handling environments during use.

SECTION III

REQUIREMENTS

The practice bomb was tested in accordance with the Air Force Weapons Laboratory (WLDM) test plan as delineated in the AFWL (WLDM) letter of 23 August 1966, Subject: Preproduction Testing of the BDU-38/B Practice Bomb. In general, the test plan called for the following characteristics of the BDU-38/B unit to be investigated:

1. Serial Number 1

- a. Weight, center of gravity, yaw moment of inertia, and roll moment of inertia.
- b. High Temperature Test--Expose unit to 300°F for 20 minutes. Temperature of the forward inside portion of the inner deployment tube not to exceed 200°F. This test was later deleted by the AFWL Project Officer.
- c. Low Temperature Test--Method 502, Procedure 1, MIL-STD-810A.
- d. Shock Test--Method 516, Procedure 1, MIL-STD-810A.
- e. Vibration Test--Method 514, Procedure 1, MIL-STD-810A.
- f. Static load test on the aft cap to determine the shear force required to deploy the parachute.
- g. Static load test to simulate the parachute opening shock load.
- h. Static load tests on the suspension lugs to simulate aerodynamic loads to the aircraft. The lug load conditions include a safety factor of 50 percent.

	<u>Load (pounds)</u>		
	<u>Vertical</u>	<u>Axial</u>	<u>Side</u>
Forward 30-inch	23,025	5,115	2,235
	15,375	3,735	10,770
Aft 30-inch	26,205	1,185	2,475
	0	5,115	9,900
Forward 14-inch	39,690	3,900	6,075
	31,110	3,900	12,345
	16,275	3,900	15,105

In addition to the above, an additional static test was requested to validate tail fin structural integrity.

2. Serial Number 2

This unit was to be flown supersonically and dropped in a retarded configuration with full photographic coverage and trajectory data recording. Flight testing and aircraft drop testing were to follow Serial Number 1 testing and were to be dependent upon this unit's meeting all of the design requirements.

SECTION IV

TEST PROCEDURES

1. Weight

The BDU-38/B practice bomb, Serial Number 1, complete with parachute assembly, tail fins, and battery was weighed by utilizing two Toledo Scales, Model No. 2181, 400-pound-capacity platform scales as shown in figure 1.

2. Center of Gravity

The longitudinal center of gravity (cg) location was established by the moment method on the same two Toledo Scales used for weighing. The unit was supported on the two scales as shown in figure 2. The support points were carefully measured and located from a known fixed station location on the unit. With the vertical forces (scale weight indication) required to hold the unit in balance and the distance between the support points, the center of gravity location was readily calculated.

3. Moment of Inertia

Moment of inertia determinations are made by using the torsional pendulum principle. The unit is suspended, at its center of gravity, from an accurately calibrated steel torsion rod and attach fixture. A small mirror is affixed to the unit or to the torsion rod in a position to reflect the light from a photoelectric transducer back to its pickup when the unit is hanging still and in equilibrium. When the specimen is allowed to oscillate through a small predetermined angle, the transducer signal from the mirror is relayed to a Berkeley Preset Counter, Model 5422 and also to two Berkeley Timers, Models 7360-9 and 5510. The purpose for using two timers is to serve as a cross check for accuracy. The time required for 10 complete oscillations or cycles is printed out by a Berkeley Digital Recorder, Model 1452. After the 10-cycle swing has been repeated 10 times (100 oscillations), the average period is known to one microsecond. When the torsional spring constant of the bar and the period of oscillation of the specimen are both known, the moment of inertia can be calculated.

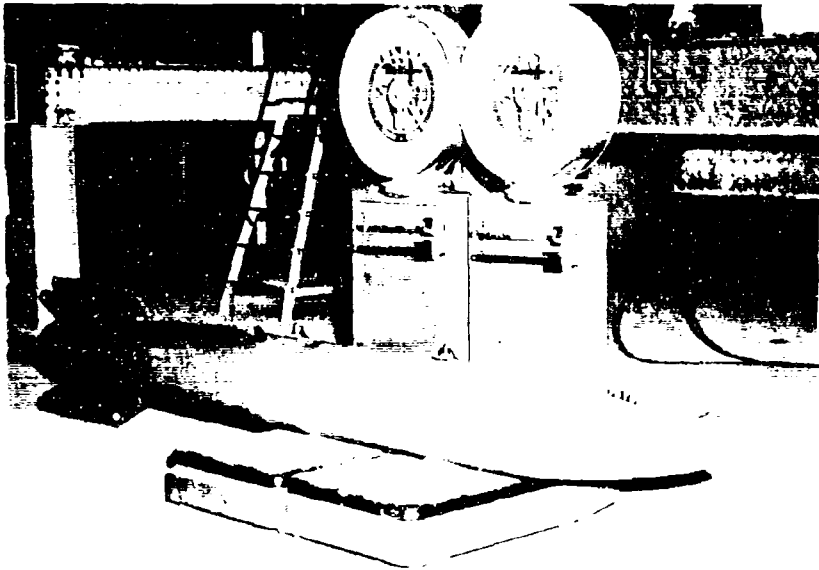


Figure 1. Test Setup for Weighing the BDU-38/B Unit.



Figure 2. Moment Method for Determining Center of Gravity.

Figures 3 and 4 show the test setup for determining the roll moment of inertia. Figure 3 shows the calibrated steel torsion rod and fixture attachment and figure 4 shows an overall view of the BDU-38/B unit in a roll suspension position at the Bomb Swing Facility.

Figure 5 shows the test setup used for determining the yaw moment of inertia. The readout instrumentation and the photoelectric light source are shown in the background.

4. Low-Temperature Test

The low-temperature test was limited to the battery only and deviated from Method 502, Procedure 1, of MIL-STD-810A. This alteration was requested by the AFWL Project Engineer. A reading was made on the battery under a load condition and under no-load condition at room temperature. The temperature was stabilized at 0°F in the chamber and the battery inserted for test. The chamber temperature was brought down to -65°F. After exposure to a -65°F environment for 1 1/2 hours, a reading was repeated for a load condition and for no-load condition. Figure 6 shows the test setup used for the low-temperature test on the battery. The oscilloscope to the right of the temperature chamber was used for making the voltage readings.

5. Vibration Testing

Vibration testing was performed on Serial Number 1 in accordance with Method 514, Procedure 1, MIL-STD-810A. The unit was mounted on a MAU-12B/A bomb rack at its 30-inch and 14-inch suspension systems. The unit and MAU-12B/A rack combination was mounted on a 25,000-pound Ling-Temco vibration exciter for the vertical axis test (see figure 7). For the lateral axis, the vibration exciter was rotated 90 degrees. The mounting of the rack and unit was then transferred onto an oil-film sliding plate. Figure 8 shows the test setup for lateral axis vibration. Due to the overall length of the BDU-38/B unit, the vibration exciter facility could not accommodate a longitudinal axis configuration test.

The unit was subjected to a resonance survey with accelerometers located on the nose section and near the end of the aft section assembly. At least one resonance point at each location was then continuously vibrated for 30 minutes.

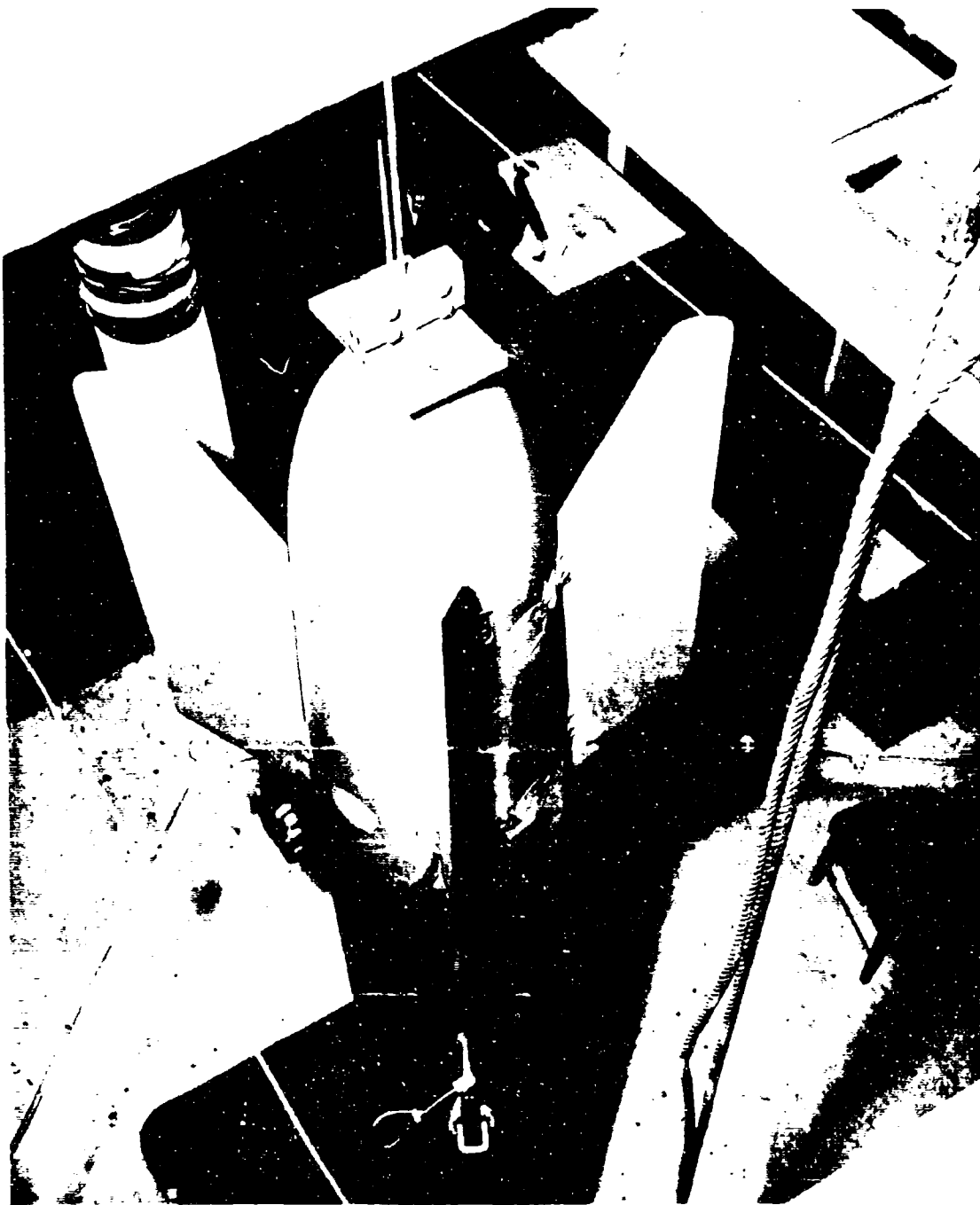


Figure 3. Roll Suspension Attachment.

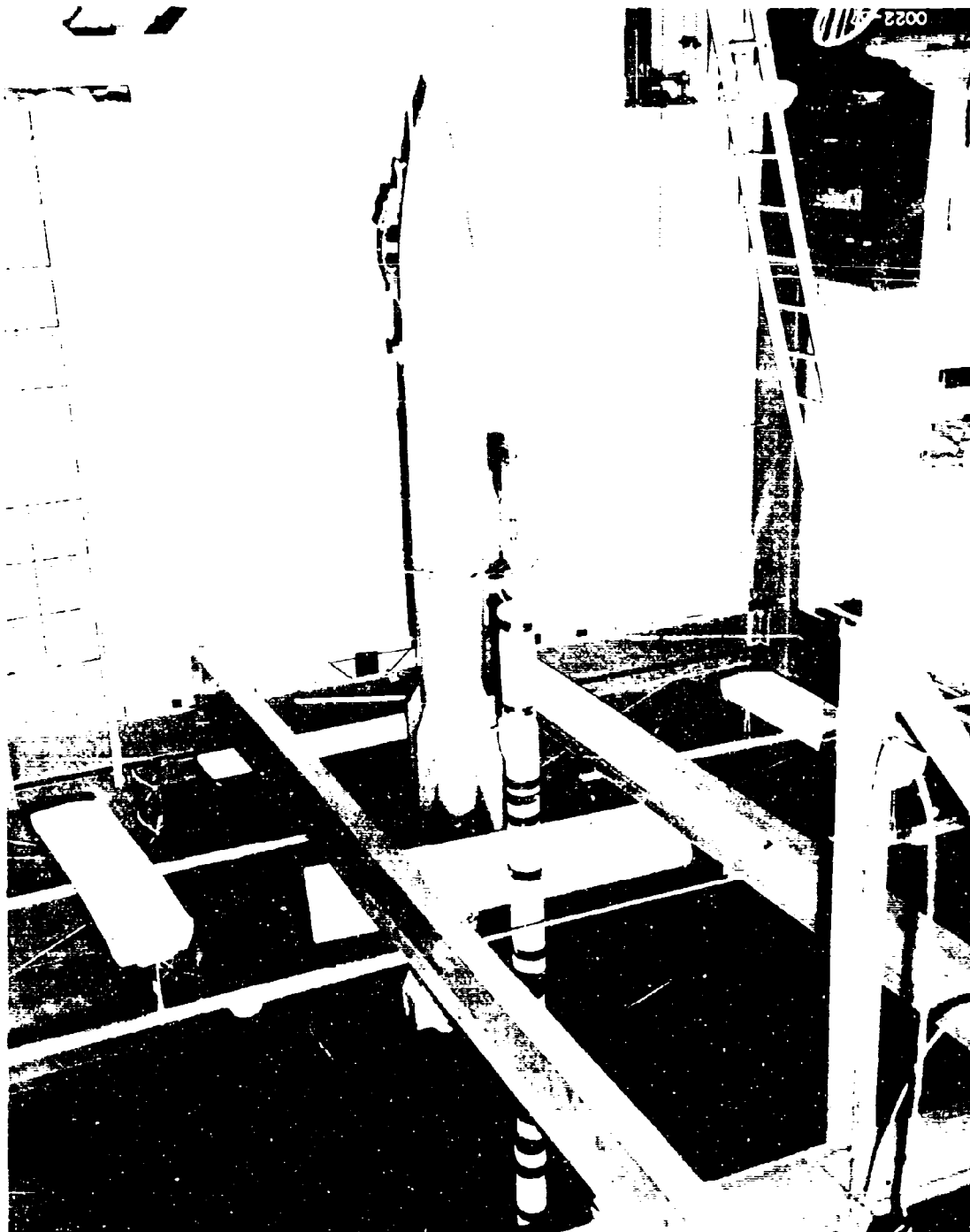


Figure 4. BDU-38/B Roll Suspension.



Figure 5. BDU-38/B Yaw Suspension and MI Instrumentation.

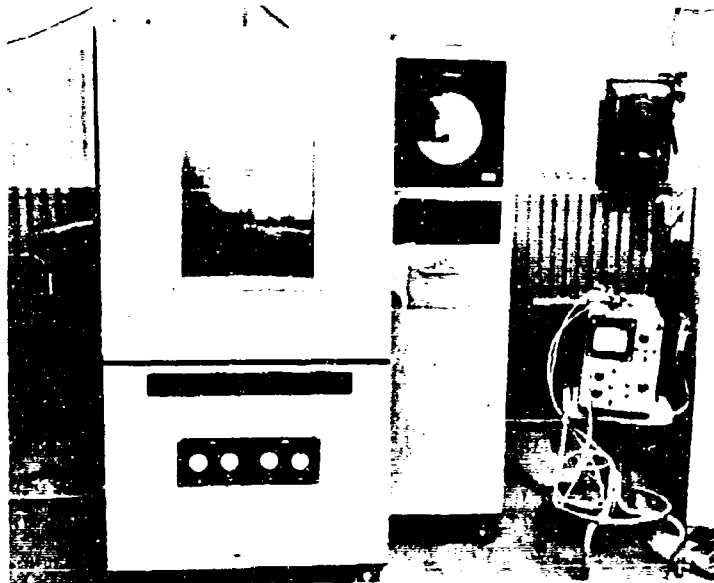


Figure 6. BDU-38/B Battery Low Temperature Test Setup.



Figure 7. Vertical Axis--Vibration Test Setup.



Figure 8. Lateral Axis--Vibration Test Setup.

6. Shock Testing

Shock testing was performed on Serial Number 1 in accordance with Method 516, Procedure 1, MIL-STD-810A. As in the case of vibration testing, the unit was mounted on a MAU-12B/A bomb rack for adaption to the shock test facility. However, only the 30-inch suspension system was used for shock testing. The unit and MAU-12B/A rack combination was suspended from a hinged frame capable of being dropped to impose the desired shock intensity and duration.

At least three test shocks in each direction of the vertical, lateral, and longitudinal axes were applied to the unit. The shock signature called out in MIL-STD-810A was a "sawtooth" curve which had an amplitude of 20 g and a duration of approximately 10 milliseconds. Since the facility could not duplicate this curve, the 20-g shock was established as the criterion.

Figure 9 shows the shock test setup in one direction for the vertical axis. The input accelerometer for all the shock tests was mounted on the MAU-12B/A rack support. The acceleration and time durations were recorded on a Tektronic, Inc., type 551 Dual-Beam Oscilloscope.

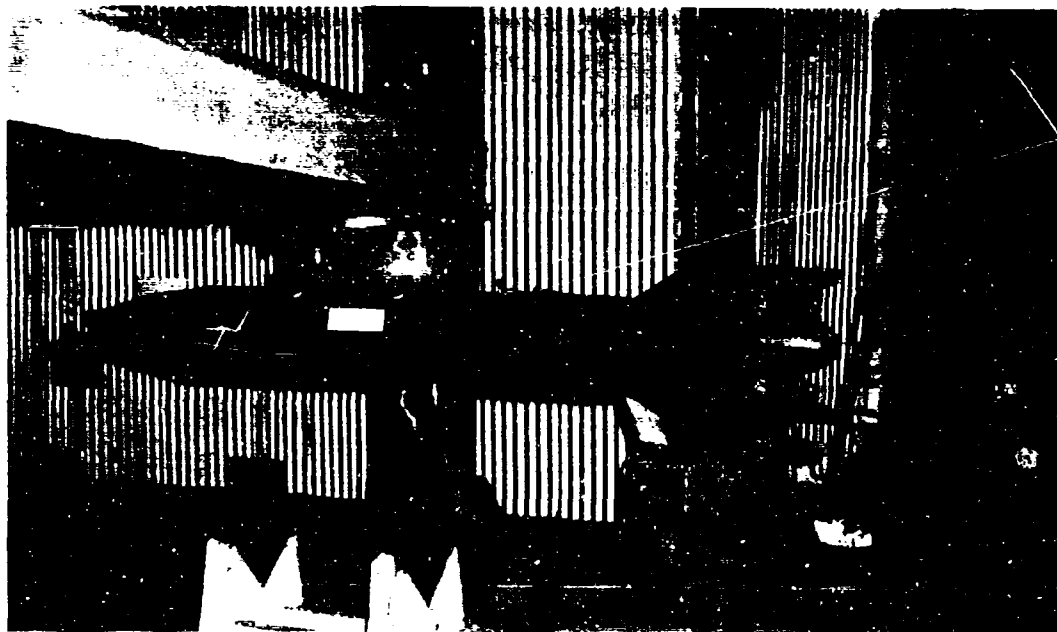


Figure 9. Vertical Axis--Shock Test Setup.

Figure 10 shows the test setup for one of the directions on the lateral axis and figure 11 shows a view of the mounting. Both views show safety straps around the unit as a protective measure, should the suspension system fail.

Figure 12 shows the typical setup for the longitudinal axis shock test in a nose-down configuration.

7. Aft Cap Static Pull Test

The aft cap of the unit was pulled to determine the force required to deploy the parachute. Figure 13 shows the method used for applying the pull force to the aft cap. In order to deploy the parachute, the four detailed T-shaped shear plates had to fail. Figure 14 shows the overall test setup showing the method used for restraining the unit during the aft cap pull test.

8. Tail Fin Static Load Test

The unit was secured just forward of the aft section assembly in a static test frame and firmly held in position by tie-down chains (see figure 15). Holes were drilled in the two opposite fins to be tested at station location 123.10 inches and 3.35 inches from the skin. Eye bolts, with steel plates, were placed through these holes. The steel plates, 4 inches by 6 inches, were used to ensure even load distributions over the largest available area. Load increments were then applied to the plates up to a total of 2,200 pounds on each fin. The 2,200-pound load includes a safety factor of 50 percent. The loads were applied by a hydraulic cylinder and controlled by a load cell in series with the cylinder, as shown in figure 15. Deflection gages were affixed to a third fin, not under test, in order to determine relative deflections at their respective points of force application. A detail of the deflection measurement method is shown in figure 16.

9. Suspension Lug Static Load Tests

The forward section assembly, without the nose section, was used for structural testing of the 30-inch and 14-inch lug suspensions. The forward section assembly was firmly fixed to a test fixture and the test fixture was secured in a static test frame. Figure 17 shows a typical test setup used for both the 30-inch and the 14-inch suspension lugs. The vertical-axis, lateral-axis, and longitudinal-axis loads were applied by hydraulic cylinders and controlled by load cells in series with the cylinders. Figure 18 shows a close-up view of



Figure 10. Lateral Axis--Shock Test Setup.



Figure 11. Lateral Axis--Shock Test Mounting.

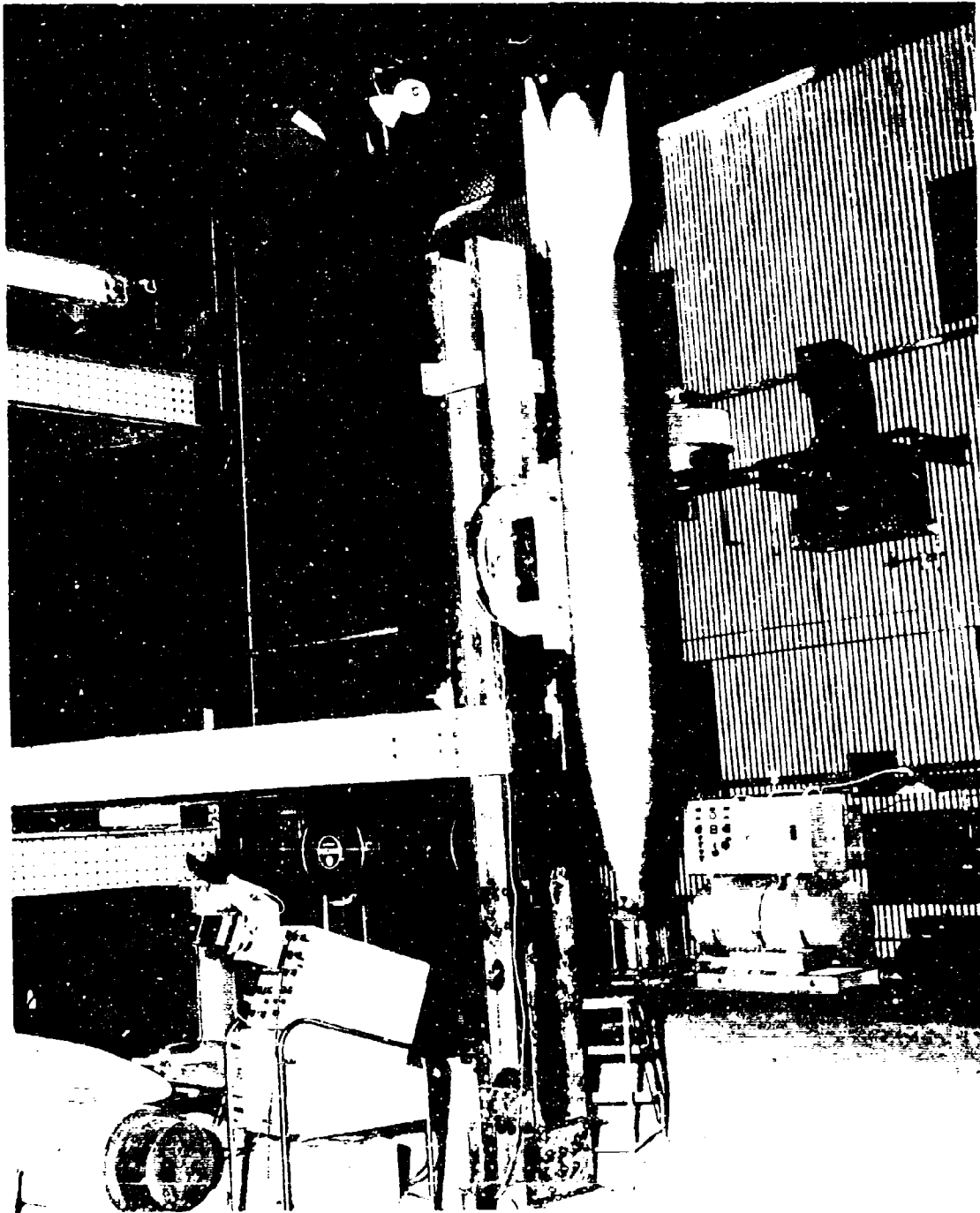


Figure 12. Longitudinal Axis--Shock Test Setup.

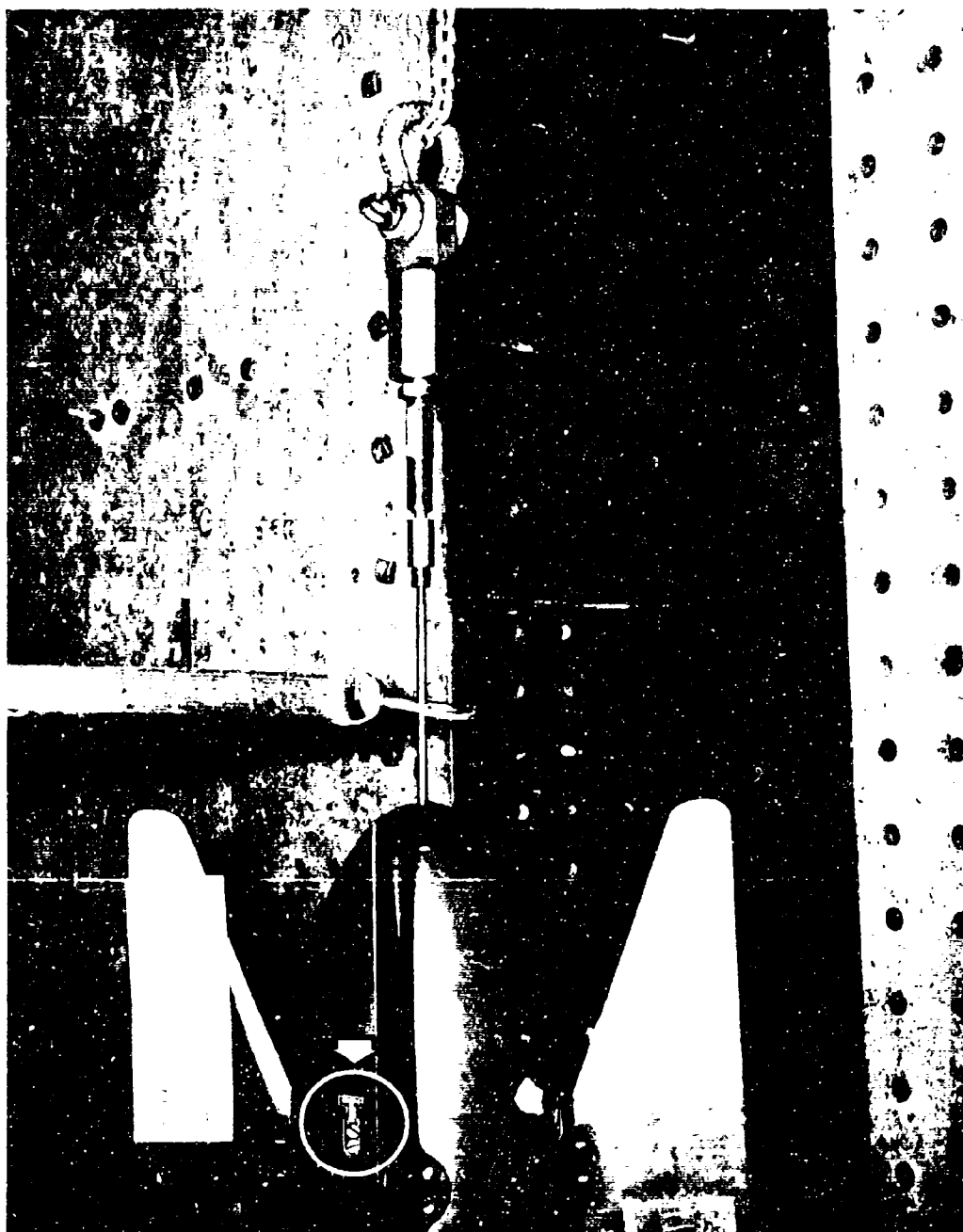


Figure 13. Aft Cap Pull Rod.



Figure 14. Aft Cap Static Pull Test.

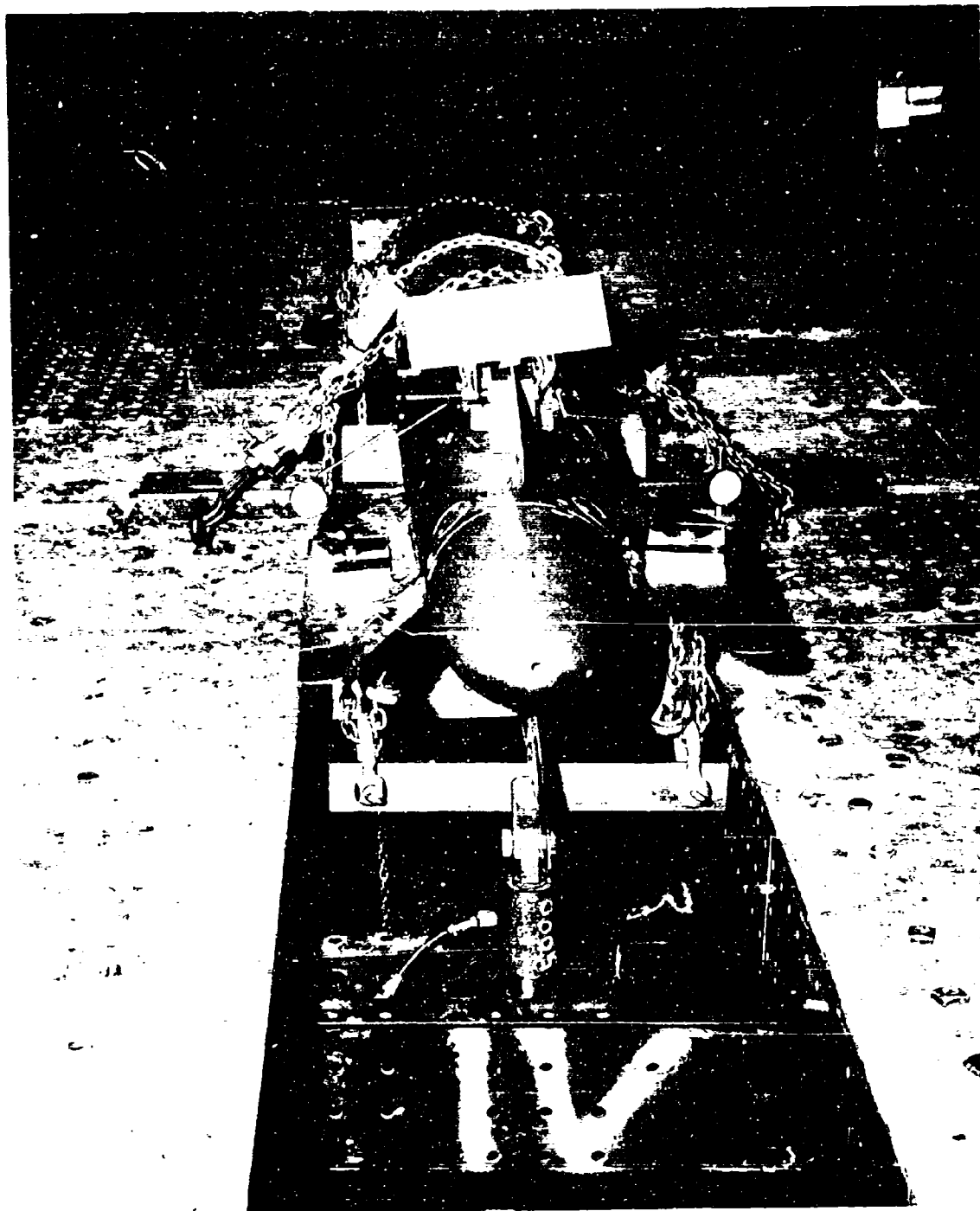


Figure 15. Tail Fin Static Pull Test.

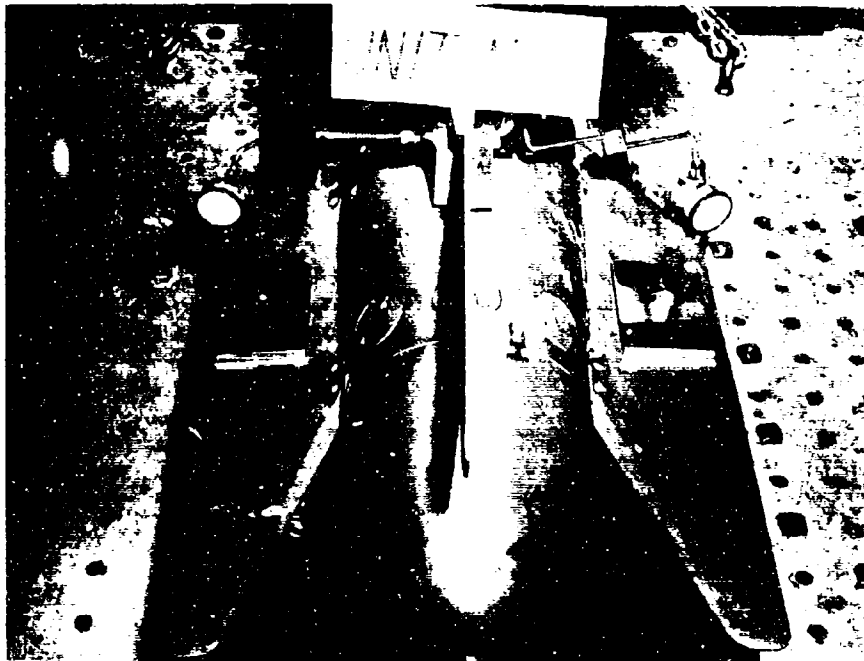


Figure 16. Tail Fin Deflection Measurement.

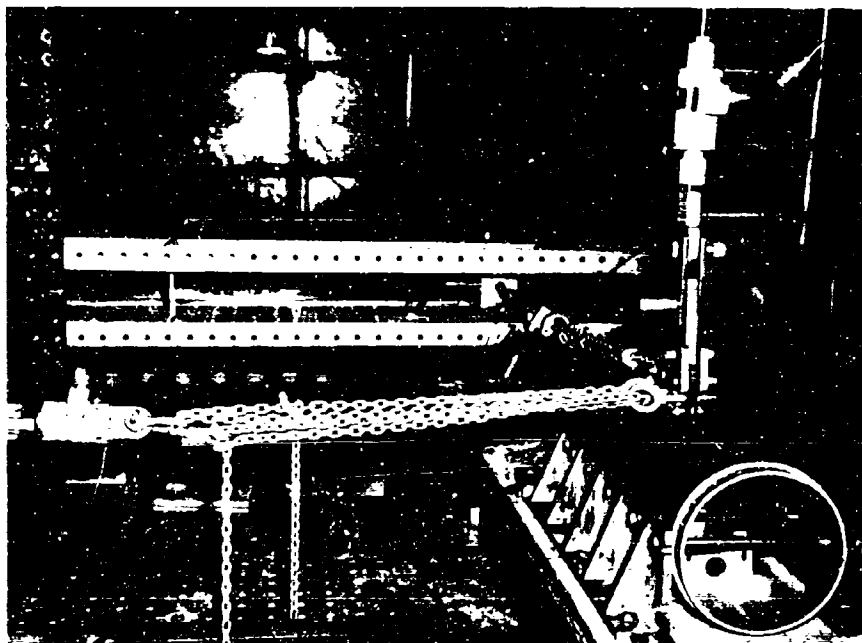


Figure 17. Suspension Lug Static Load Test Setup.

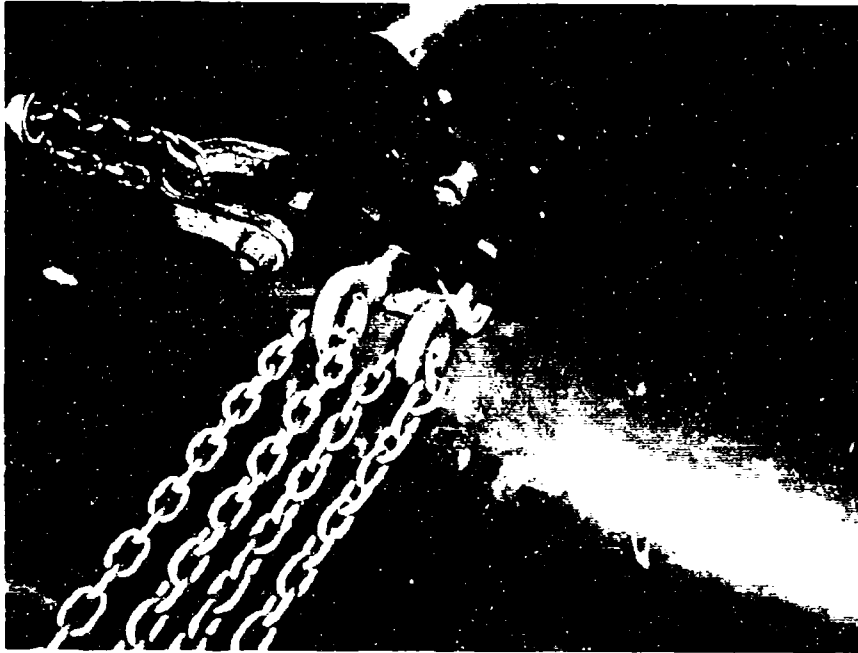


Figure 18. 30-inch Suspension Lug Static Load Test.

the fixturing required for a 30-inch suspension lug test. The 14-inch lug suspension was similar, except for the pull plate at the lug.

Loads were applied in 10-percent increments until failure occurred or the maximum loads were obtained.

10. Parachute Opening Static Load Test

The forward section assembly without the nose section, and the aft section assembly without the aft cap and tail fins were used for the parachute pull test. These two assemblies were joined and firmly fixed into the same test fixture used for the suspension lug tests. Primarily, the parachute support bracket and the joint between the two assemblies were being tested to determine their capability of withstanding a 120,000-pound parachute opening shock load.

The parachute opening load was applied, through 12 parachute shroud lines to the components, by a hydraulic cylinder. The overall test setup is shown in figure 19. Figure 20 shows a close-up view of the pull ring which was utilized to duplicate the parachute load on the shroud lines.

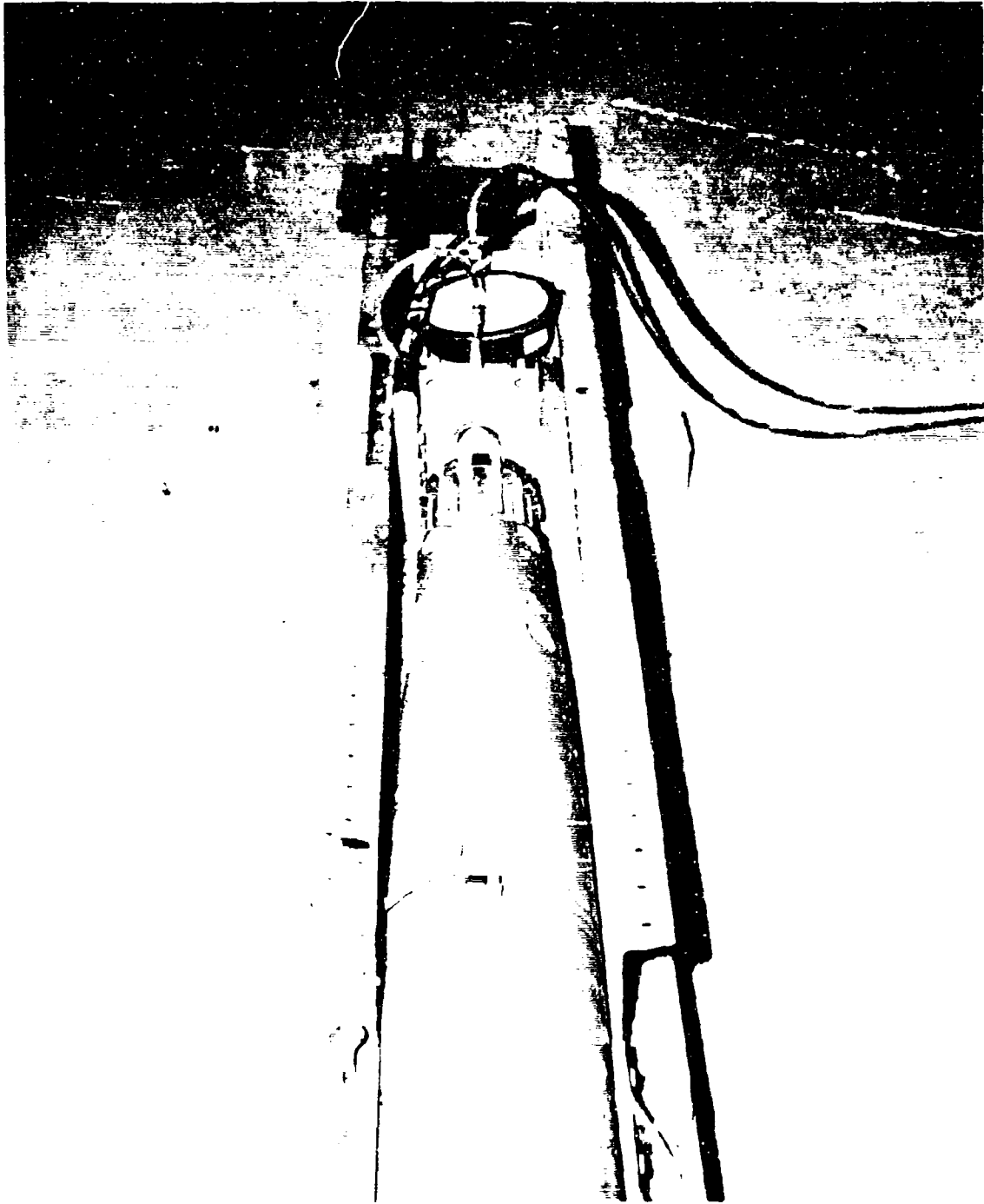


Figure 19. Parachute Opening Static Load Test.

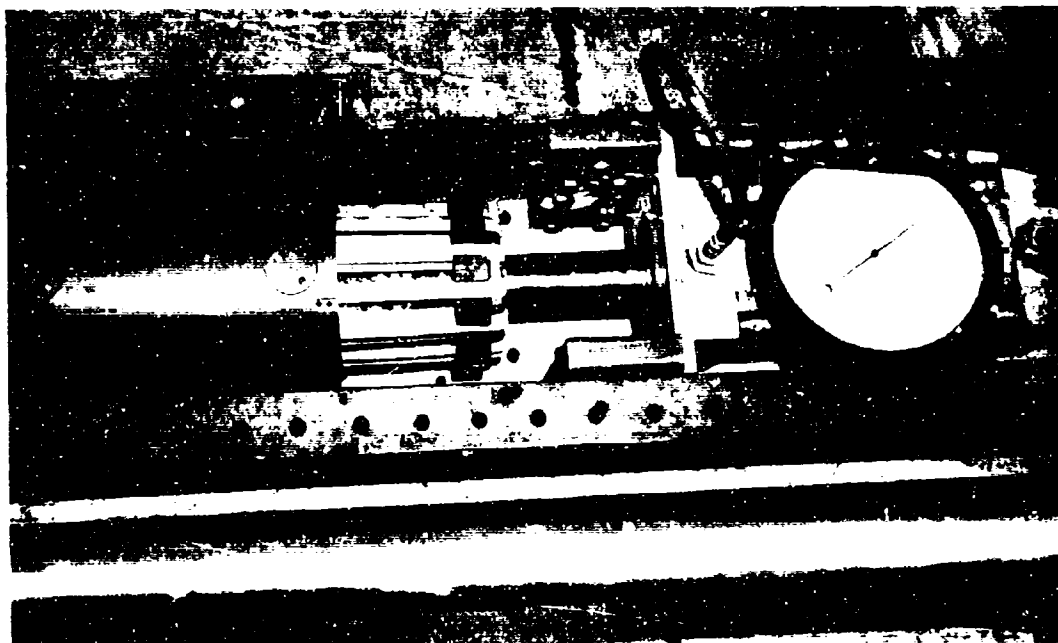


Figure 20. Parachute Opening Pull Ring.

Loads were applied in 10-percent increments until a failure occurred or the maximum load of 120,000 pounds was obtained.

SECTION V

TEST RESULTS AND DISCUSSION

1. Weight, Center of Gravity, and Moments of Inertia

The weight, center of gravity location, roll moment of inertia and yaw moment of inertia values for BDU-38/B Serial Number 1 are tabulated below:

Weight	684.63 pounds
Center of gravity location	60.075 inches from nose
Roll moment of inertia	16,196 lb-in ²
Yaw moment of inertia	810,598 lb-in ²

As noted in the test procedures section, the moments of inertia were determined by mounting the unit on a torsional pendulum. The unit was oscillated on the pendulum and an average period established from 100 oscillations. The moment of inertia was then calculated from the formula

$$I = KT^2 - I \text{ of the fixture}$$

where

I = moment of inertia, lb-in²

T = average period, seconds

K = 8,856 for yaw torsion rod and 393 for roll torsion rod (determined empirically with precisely measured billets)

I of the fixture = moment of inertia of the fixture (determined empirically)

2. Battery Low Temperature Test

A low-temperature functional test was conducted on the BDU-38/B battery pack number 1. A voltage output reading was compared at ambient temperature conditions and at -65° for both a no-load condition and a load condition. The following results were obtained at a room temperature of 79°F:

No load	17.0 volts
1-ohm load	11.0 volts

The temperature chamber was brought down to 0°F and stabilized. The battery was then inserted into the chamber to simulate actual battery installation on a typical winter morning before flight. The temperature was reduced to -65°F and

stabilized for 1-1/2 hours. The following results were obtained at -65°F:

No-load	17.0 volts
1-ohm load	11.0 volts

As a result of this test, it was concluded that the BDU-38/B battery pack number 1, as submitted for testing, may be expected to function satisfactorily.

3. Vibration Testing

a. Vertical Axis. The following events occurred during the testing of the BDU-38/B unit in the 30-inch suspension lug configuration:

(1) The lower frequencies loosened screws at the joint between the nose section and the forward section assembly.

(2) Several screws that contain the main ballast in the forward section assembly became loose during the sweep to 500 cps.

(3) One main ballast attaching screw, adjacent to the forward 30-inch lug location, failed in shear after becoming loose.

(4) During the resonance survey, a resonant point was found at 83 cps on the nose section and at 182 cps on the aft section assembly. The unit was then vibrated continuously at the two resonant points for 30 minutes with an input of 5 g. More screws, as mentioned above, became loose. The output loads for the 83 cps resonant point varied from 35 to 65 g at the nose section and from 18 to 22 g at the aft section assembly. The output loads for the 182 cps resonant point varied from 30 to 40 g at the nose section and from 15 to 32 g at the aft section assembly.

(5) After a 30-minute period of continual sweeping from 22.5 to 500 cps, six of the attach screws from the forward 30-inch suspension lug failed. It was ascertained that the failure occurred after the screws became loose. Figure 21 shows the screw failure with the lug still attached as well as the main ballast screw failure mentioned earlier. Figure 22 shows the same area with the lug removed.

The vertical axis test in the 30-inch suspension lug configuration was repeated after the following remedial steps were taken:

(a) All section joint and ballast screws were treated with a "Lock Tite" plastic sealer and torqued with a pneumatic tool.



Figure 21. 30-inch Forward Lug and Ballast Screw Failure.



Figure 22. Screw Failure at 30-inch Forward Lug.

(b) The lugs were installed with new screws and torqued to 156 in-lbs.

The unit was again subjected to a resonance survey with the output loads measured at the nose section and aft section assembly. During the survey, resonant points were found at 73 and 177 cps in the nose section and at 418 cps in the aft section assembly. The unit was then vibrated continuously at these three resonant points for 30 minutes each at an input of 5 g. The maximum output loads, during resonance, are tabulated in table I.

Table I
LOAD AT RESONANT FREQUENCIES
(Vertical axis, 30-inch suspension)

Frequency (cps)	Load (g)	
	Nose	Tail
73	15	36
177	11	32
418	2	53

No failures were observed during resonances and after the completion of resonant hold periods. Continual sweeping from 22.5 to 500 cps for an additional hour proved uneventful and no type of failure was observed.

For the vertical axis test the 14-inch suspension lug configuration, the two lugs were installed with new screws torqued to 156 in-lb. The resonant points and the maximum output loads at these resonant points are tabulated in table II.

Table II

LOAD AT RESONANT FREQUENCIES
(Vertical axis, 14-inch suspension)

Frequency (cps)	Load (g)	
	Nose	Tail
68	15	70
186	12	42
110	9	30
421	3	137

An approximate 1-inch amplitude (peak-to-peak) of one tail fin tip was observed during the 110 cps resonant point. A closer observation made on this tail fin, after the resonant runs, revealed two of the four attaching screws at the aft end of the tail fin had failed. A third screw at this location failed during the continual sweep from 22.5 to 500 cps in the first 5-minute period.

b. Lateral Axis. The 30-inch suspension lug configuration was used for the lateral axis vibration test. The results of holding at the two resonant points are tabulated in table III.

Table III

LOAD AT RESONANT FREQUENCIES
(Lateral axis, 30-inch suspension)

Frequency (cps)	Load (g)	
	Nose	Tail
96	7	24
131	6	19

No failures were observed during resonant periods, after the completion of resonant periods, during the sweeping from 22.5 to 500 cps, or after completion of the sweeps. However, approximately 3/16-inch maximum amplitude was observed at the fin tips of the two vertical tail fins.

4. Shock Testing

A minimum of three shocks were applied to the BDU-38/B unit in each direction of the three major axes. Examination of the unit after each shock revealed no failures. Figures 23 through 25 show typical oscilloscope traces obtained during the shock tests. As noted in the test procedures section, the input accelerometer (g load on the trace) for all the shock tests was mounted on the MAU-12B/A bomb rack support.

5. Tail Fin Static Load Test

A static load test of the tail fins was performed on BDU-38/B Serial Number 1 in accordance with procedures outlined in the test procedure section. The results of the test are shown in table IV. The tail fins were subjected to three load cycles in order to obtain a pure load test. The words "left" and "right" refer to the fin orientation as shown in figure 16.

The residual loads shown in load cycle numbers 1 and 2 can be attributed to screw hole clearance at the tail fin attach points and the screwed joint between the forward section assembly and the aft section assembly. The total load was cantilevered from the latter joint. These residual loads can be verified by subtracting their value from the last incremental load reading and comparing them to the last incremental load reading of load cycle number 3.

6. Aft Cap Static Pull Test

A total pull force of 8,998 pounds was required to fail the attached aft cap from the unit through the four T-shaped shear plates. This load represents the force required to deploy the parachute. Figures 26 and 27 show two views of the T-shaped shear plates after test. It was ascertained that two of the plates failed initially and the aft cap separated from the unit as the other two plates were released from the T-slots, through bending.

No permanent deformation or damage occurred to either the unit or the aft cap during any portion of the test.

7. Suspension Lug Static Load Tests

The forward and aft 30-inch lugs withstood 150-percent loads under the conditions delineated in the requirements section. Each particular lug was subjected to two conditions of loading, applied through the three axes. Each 150-percent load conduction was maintained for a period of 5 minutes. No damage to

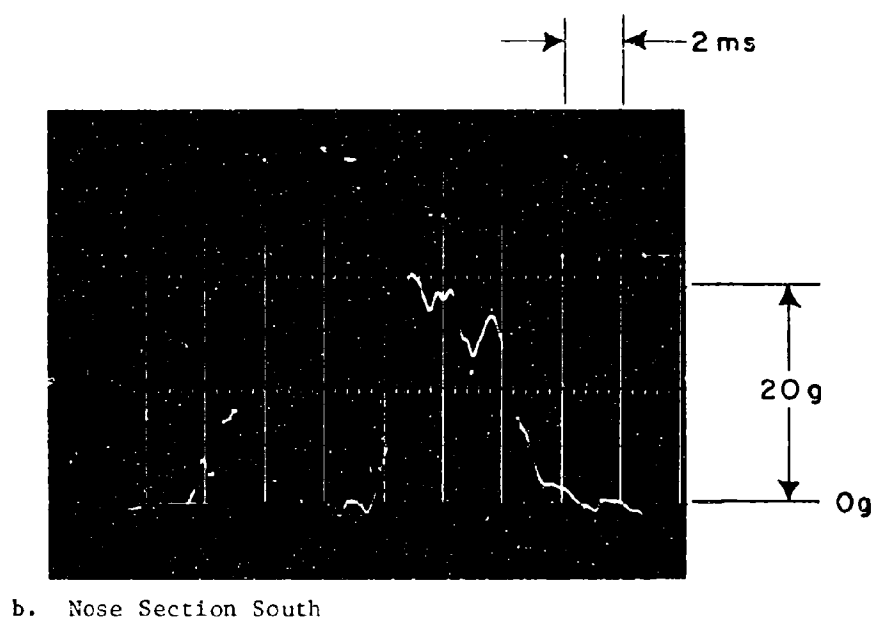
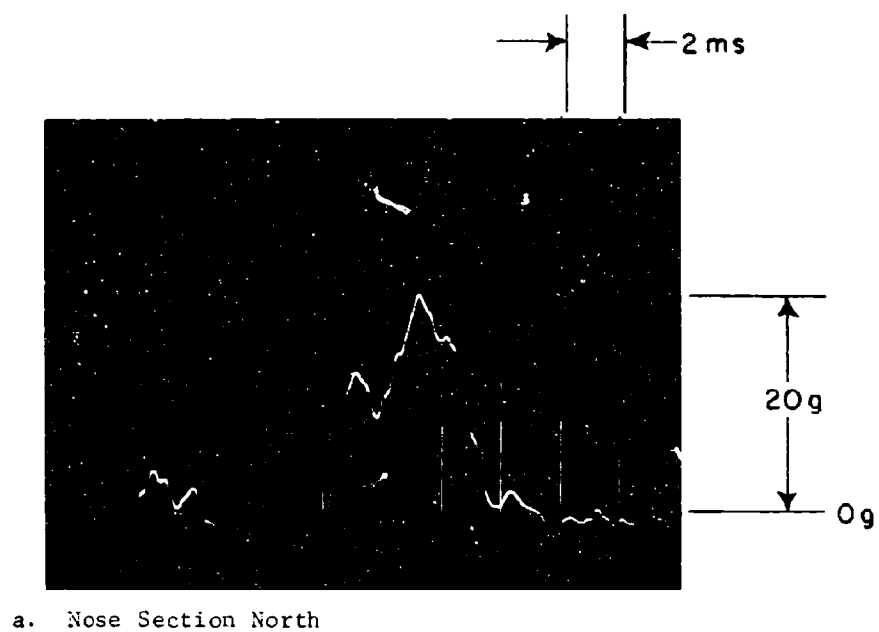


Figure 23. Lateral Axis Shock Test.

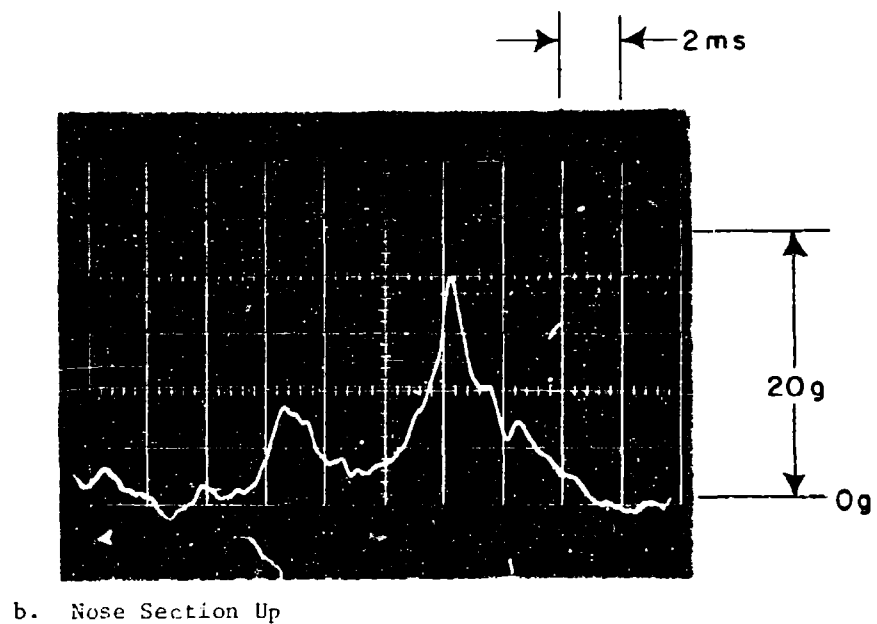
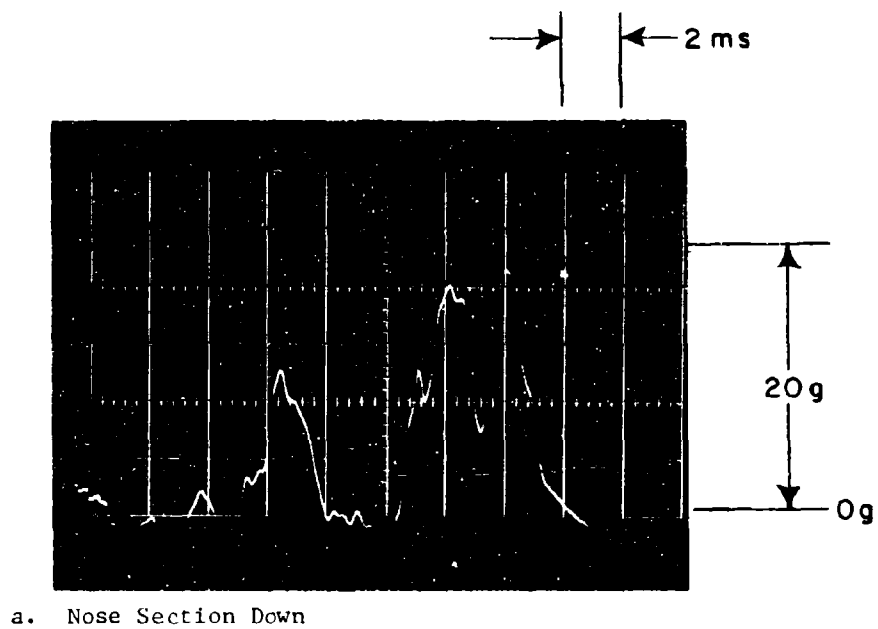
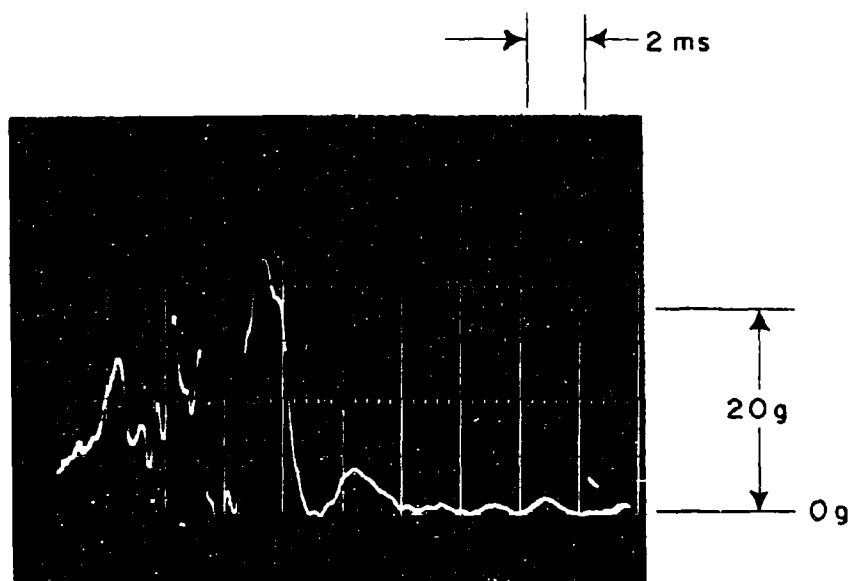
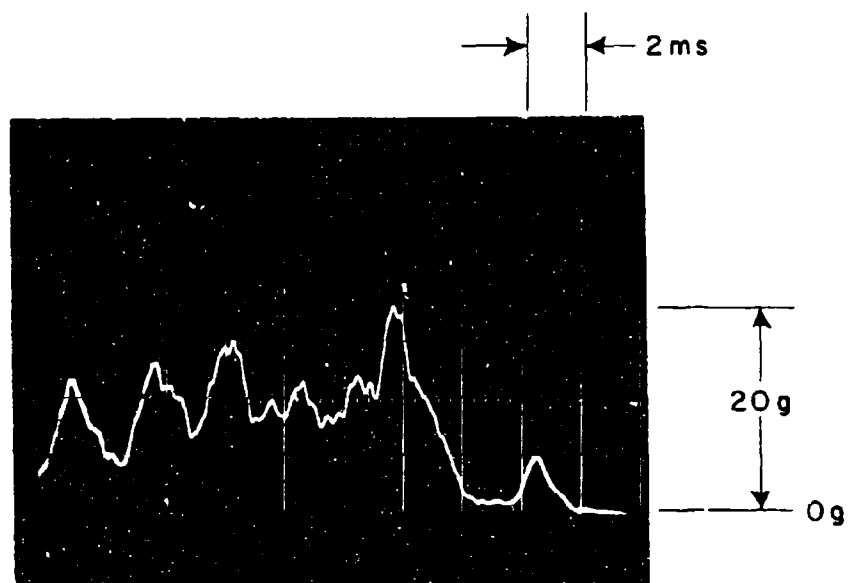


Figure 24. Longitudinal Axis Shock Test.



a. Top of BDU-38/B Through Rack



b. MAU-12B/A Rack Through Unit

Figure 25. Vertical Axis Shock Test.

Table IV
TAIL FIN LOAD VS. DEFLECTION

Load per tail fin (lb)	Load cycle No. 1		Deflection (in)		Load cycle No. 2		Load cycle No. 3	
	Left fin	Right fin	Left fin	Right fin	Left fin	Right fin	Left fin	Right fin
0	---	---	---	---	---	---	---	---
250	0.018	0.005	0.014	0.012	0.013	0.013	0.013	0.013
500	0.035	0.018	0.027	0.025	0.027	0.026	0.027	0.026
750	0.051	0.031	0.041	0.038	0.042	0.039	0.042	0.039
1,000	0.067	0.044	0.055	0.050	0.056	0.050	0.056	0.050
1,250	0.082	0.056	0.070	0.061	0.070	0.061	0.070	0.061
1,500	0.100	0.068	0.086	0.079	0.085	0.072	0.085	0.072
1,750	0.126	0.085	0.103	0.084	0.099	0.083	0.099	0.083
2,000	0.163	0.100	0.121	0.097	0.115	0.095	0.115	0.095
2,200	0.182	0.113	0.137	0.107	0.128	0.105	0.128	0.105
0	0.054	0.006	0.010	0.005	0.001	0.001	0.001	0.001

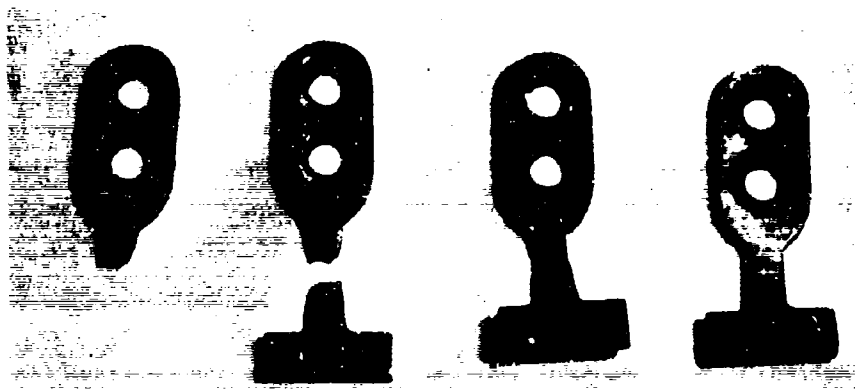


Figure 26. Aft Cap T-Plates After Test.

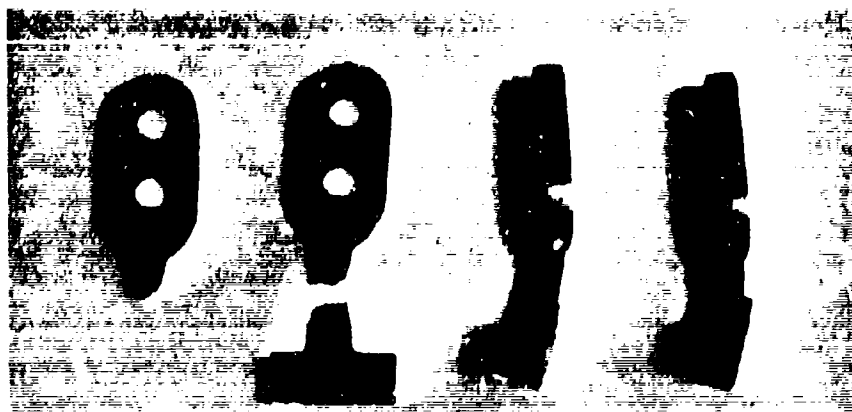


Figure 27. Aft Cap T-Plate Failure--Side View.

any part of the unit or the lug was noted after the completion of the tests.

The 14-inch lug failed at 139.5 percent of condition 1 load value. The 150-percent load values for this condition are: vertical, 39,690 pounds; axial, 3,900 pounds; and side, 6,075 pounds. Figure 28 shows that the failure occurred at the threaded portion of the aluminum unit between the insert and the unit. The side load was applied to the lug at the side where the four inserts pulled out. The cap screws failed at the five remaining hole locations.

A 148.5-percent load value was reached before failure occurred at load condition 2 on the 14-inch lug. The 150-percent load values for this condition are: vertical, 31,110 pounds; axial, 3,900 pounds; and side, 12,345 pounds. The type of lug failure, which was similar to condition 1 failure, is illustrated in Figure 29. As before, the threaded portion of aluminum unit between the insert and the unit failed. The side load, in combination with the vertical, caused this type of failure. The side load was applied at the side of failed inserts. The remaining four 1/4-28NF cap screws failed at those locations where the inserts remained intact. Hardness tests conducted on four identical unused screws indicated an average tensile strength of 185,000 psi. Permanent deformation on the lug necessitated the use of the other 14-inch lug for load condition 3 testing.

The 14-inch lug withstood the 150-percent value of condition 3 loads. The lug was subjected to a vertical load test (no axial and side loads) and failure occurred at a load of 43,700 pounds. The failure is illustrated in Figure 30. Once again initial failure at the inserts caused subsequent tensile failure in the cap screws.

8. Parachute Opening Static Load Test

The initial static test was terminated at a load of 89,408 pounds due to the failure of one of the parachute nylon shroud lines. A post-test examination of the shroud lines revealed that cuts occurred from grooves in the pull ring and from the parachute support bracket retainer plate in the unit. The examination also revealed that several of the 5/16-24NF joint screws had permanent set in bending.

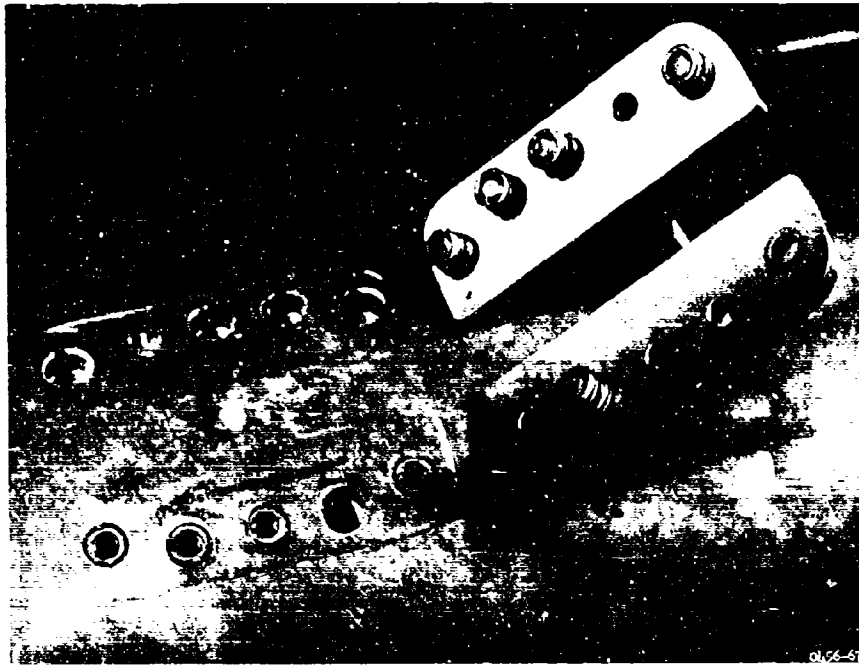


Figure 28. 14-inch Lug Load Condition 1 Failure.

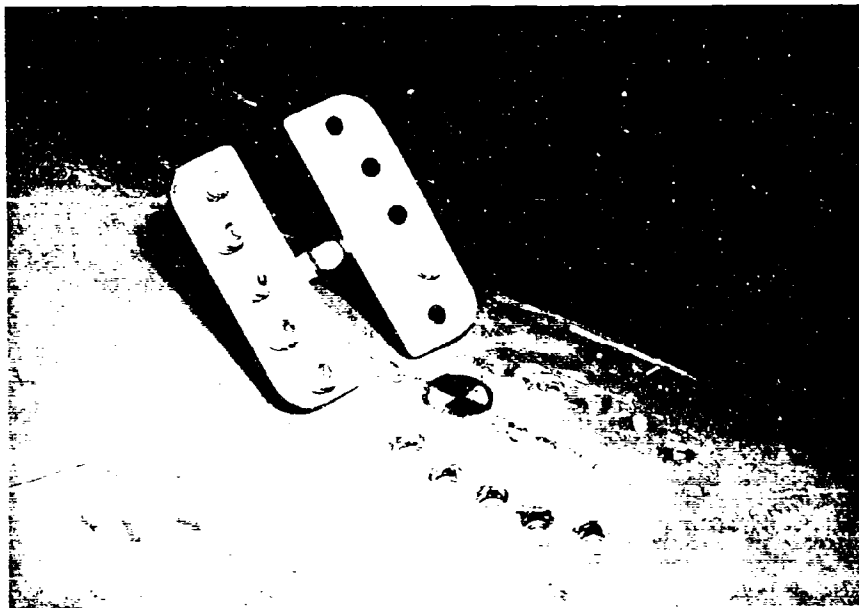


Figure 29. 14-inch Lug Load Condition 2 Failure.



Figure 30. 14-inch Lug Failure at 43,700 Pound Vertical Load.

The shroud lines were replaced with newer lines; all corners, edges, and surfaces mating with the shroud lines were rounded or cleaned; and all deformed joint screws were replaced for the next test. Failure in this test occurred at a load of 99,162 pounds. Failure occurred at the joint between the forward section assembly and the aft section assembly. The twenty 5/16-24NF screws failed in shear. Figure 31 shows the forward section assembly with the sheared screws. Figure 32 shows an overall view of the test failure with the aft section assembly up against the loading cylinder. Aft section assembly movement was the result of a "sling shot" effect from the stored-up energy in the nylon shroud lines. Figure 33 shows a close-up view of the impact damage to the aft section assembly from the high energy release.

Figure 34 shows a view of the forward section assembly joint, where the failure occurred. No visible damage was noted except a slight elongation of several holes. Slight cutting damage is noticeable on the shroud lines; however, no shroud line failed during the test.

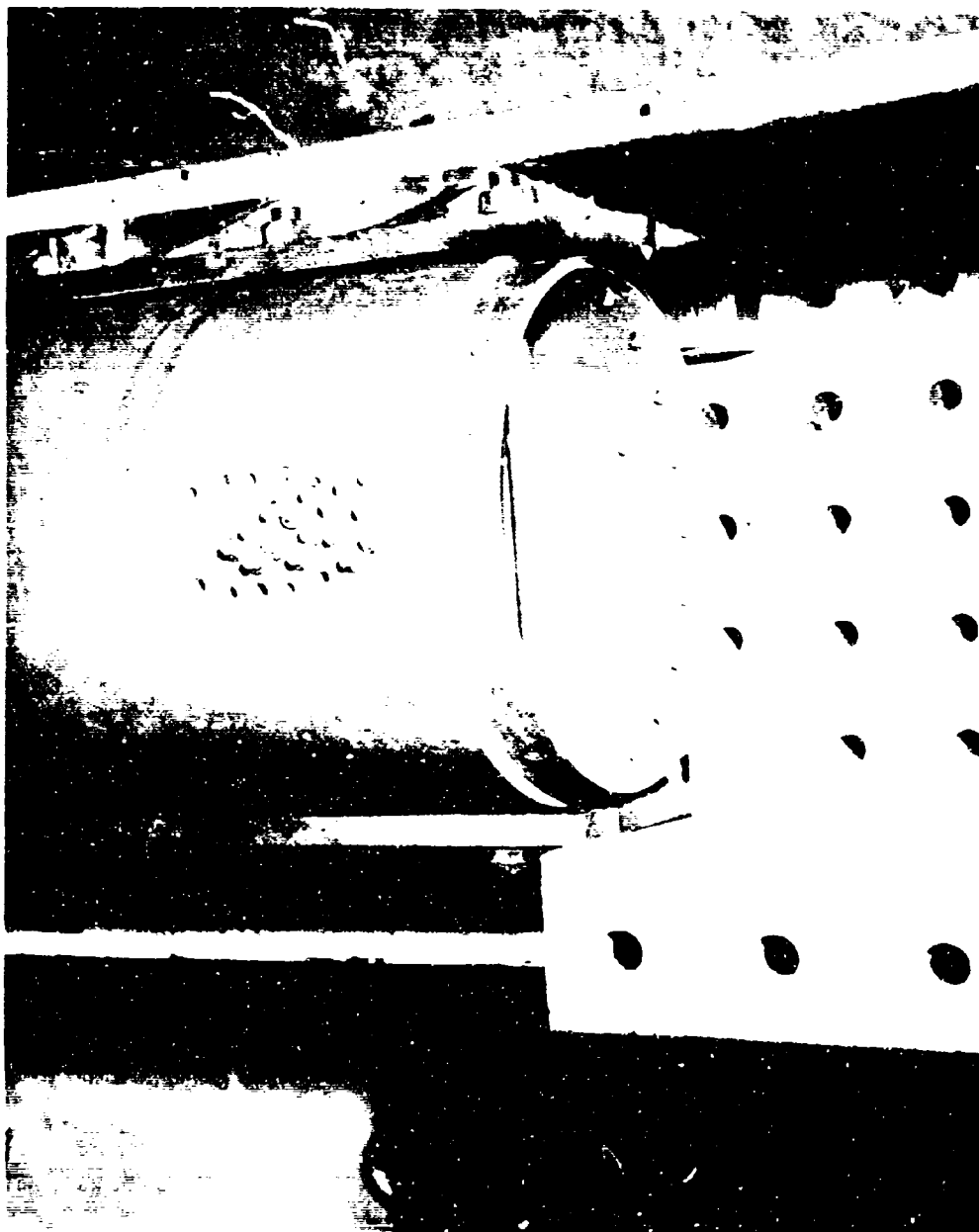


Figure 31. Screw Failure--Parachute Static Load Test.

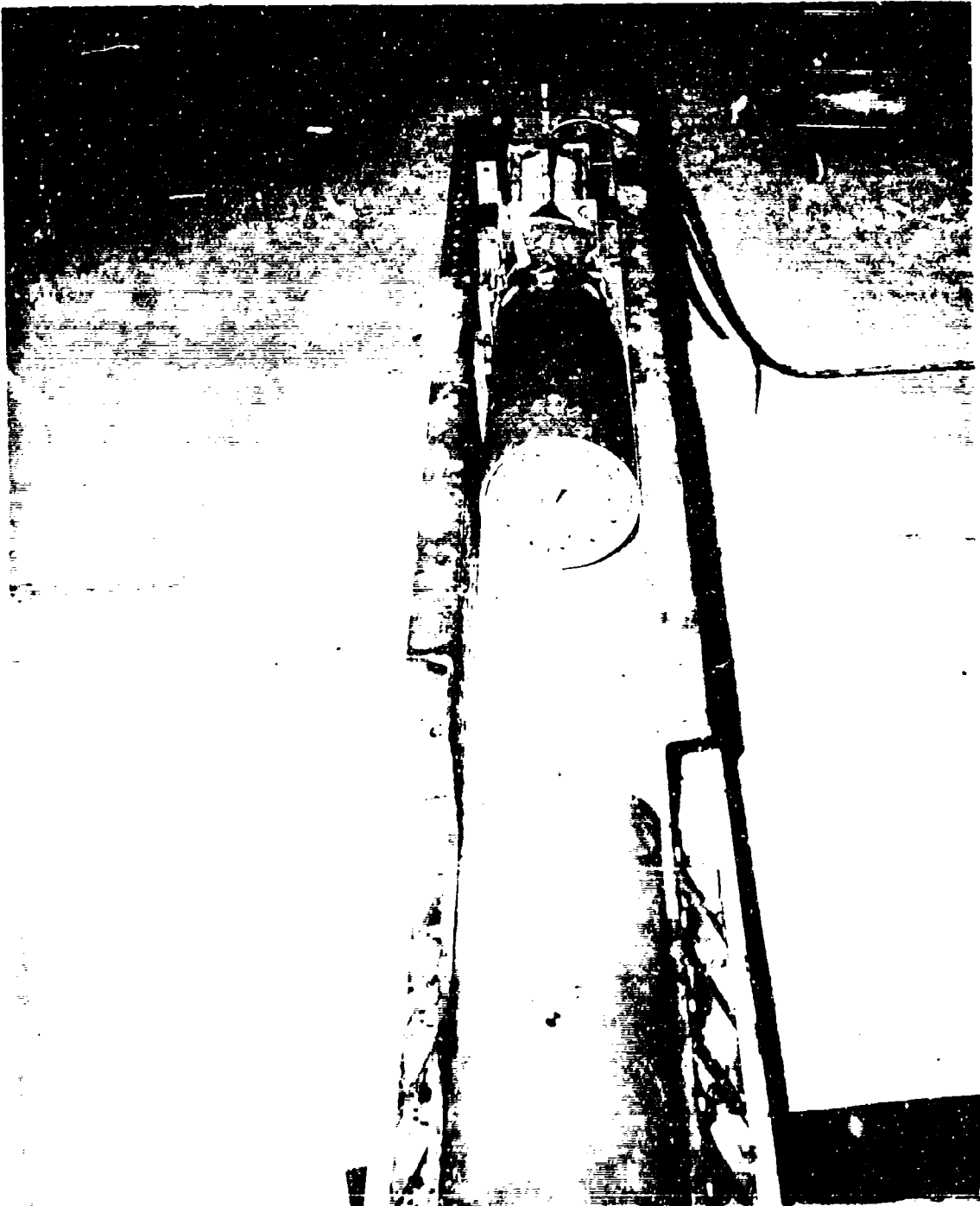


Figure 32. Failure--Parachute Opening Test.



Figure 33. Aft Section Damage--Parachute Opening Test.



Figure 34. Forward Section--Parachute Opening Test.

An additional test was conducted on the parachute support bracket to test its structural integrity. The test was conducted in the 200,000-pound-capacity Baldwin-Lima-Hamilton Corporation testing machine. Figure 35 shows a detail of the test setup. Twelve 1-inch-wide steel blocks were used to simulate the parachute shroud line pull on the support bracket ring. The bracket was loaded through the twelve blocks in increments up to 150,000 pounds. The maximum load of 150,000 pounds was held for 2 minutes. No permanent deformation or damage was noted during any portion of the test. A total bracket deflection of 0.0525 inch was measured at the 150,000-pound load.

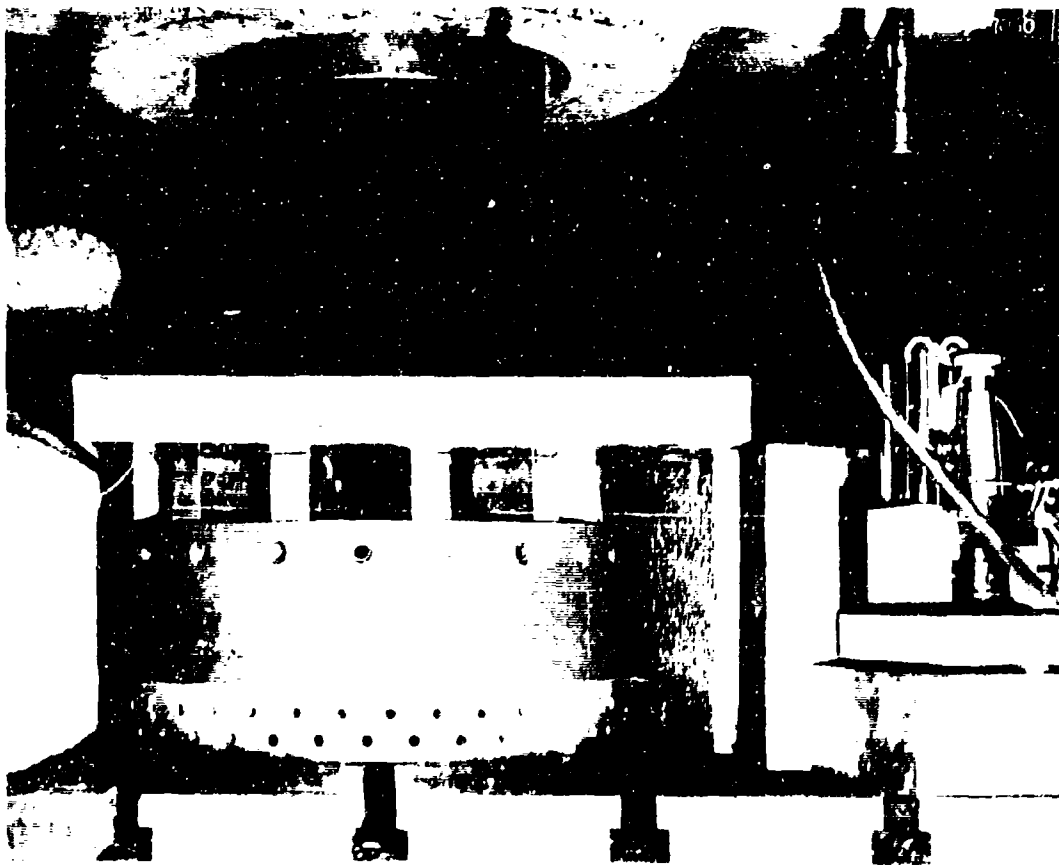


Figure 35. Parachute Support Bracket Load Test.

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

1. Conclusions

a. All test requirements were performed on Serial Number 1, BDU-38/B Practice Bomb. The test results on the unit originally submitted for testing showed conclusively that deficiencies existed.

b. The center of gravity and moments of inertia determined for the present configuration of Serial Number 1 unit, as originally submitted, are correct.

c. The BDU-38/B Battery Pack Number 1, as submitted for testing, successfully withstood the climatic environment and can be expected to function properly during a flight mission.

d. Loosening of the screws, which occurred during vibration testing, is considered to result from manufacturing techniques rather than faulty design.

e. The 8,998-pound force required to separate the aft cap from the unit for parachute deployment was within the anticipated range of 8,700 to 10,500 pounds.

f. Both the 30-inch-lug and 14-inch-lug suspension systems withstood 100-percent load conditions. The 30-inch-lug configuration withstood three 150-percent load conditions, whereas the 14-inch-lug configuration failed at 139.5 percent of load condition 1, 148.5 percent of load condition 2, and withstood 150 percent of load condition 3.

g. The unit, as submitted, will not withstand the parachute opening load. Without modifications, the unit will fail at the joint between the forward section assembly and the aft section assembly.

2. Recommendations

a. It is recommended that a final screw torque setting of 156 in-lb be applied to the suspension lug attach screws. This torque will prevent the screws from loosening, then eventually failing.

b. Because numerous screws on the unit became loose during vibration testing, it is recommended that every screw have a well-functioning lock insert to prevent loosening.

c. It is recommended that the joint between the forward section assembly and the aft section assembly be redesigned and made stronger, structurally.

d. It is recommended that the N.T.W. Missile Engineering Inc. be recognized as a technically qualified manufacturer of the BDU-38/B Practice Bomb only after modifications are made to the bomb that will permit it to meet the test requirements.

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