UNCLASSIFIED

AD NUMBER

AD911336

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies only; Test and Evaluation; MAY 1973. Other requests shall be referred to Armament Development and Test Center, Attn: DLA, Eglin AFB, FL 32542.

AUTHORITY

ADTC, per DTIC Form 55

THIS PAGE IS UNCLASSIFIED

ADTC-TR-73-31

T&PT / FOR DDC

Evaluation of a Ballute Retarder System for the MK 82 Bomb

TECHNICAL REPORT ADTC-TR-73-31

MAY 1973

Distribution limited to US Government agencies only, because document covers test and evaluation of military hardware (MAY 1973). Other requests for this document must be referred to ADTC (DLA), Eglin AFB, FL 32542.

3246TH TEST WING

ARMAMENT DEVELOPMENT AND TEST CENTER

AIR FORCE SYSTEMS COMMAND • UNITED STATES AIR FORCE

EGLIN AIR FORCE BASE, FLORIDA

EVALUATION OF A BALLUTE RETARDER SYSTEM FOR THE MK 82 BOMB

Richard A. Evors

FOREWORD

This test, ADTC Project 1559W055, was conducted in response to Air Force Armament Laboratory (DLA) letter, subject: "Request for Test of MK 82 500-lb Bomb Ballute Retarder System," dated 21 December 1971. Testing began 12 June 1972 and was completed 4 March 1973.

Personnel responsible for testing and report preparation were:

Munitions Test Engineer	Richard A. Evors
Test Design Engineer	Donald G. Cox
Development Engineer	P. G. McGirr, 2d Lt, USAF

This technical report is approved.

H. L. DIMMIG
Technical Director

WILLIAM A. CLARK, Colonel, USAF
Commander

ABSTRACT

This report contains results of tests conducted to evaluate a ballute retardation system (combination balloon/parachute) for a MK 82 bomb. The system tested provided for a low drag configuration of either of two types of high drag options. One high drag option (29-inch diameter ballute) was designed for mine application and the other (41-inch diameter ballute) for general purpose bomb application. Tests demonstrated the system was physically compatible with the F-100 and F-4 aircraft. Flight tests demonstrated the system could be safely carried and released from the F-100 aircraft in level flight up to 550 KTAS. Ballistic data were obtained on all configurations used during the flight test. The average time for the 29-inch and 41-inch diameter ballute to fully inflate after release was 0.8 second and 0.7 second, respectively. The G-loads experienced during deployment of the 41-inch diameter ballute were sufficient to arm three of four FMU-54/B fuzes tested. The fourth fuze did not arm. Burial characteristics for the 29-inch diameter ballute varied from 2 to 8 feet horizontal travel from impact point, 5 to 12 feet deep, and at an attitude of 45 to 90 degrees nose-down. The ballute system successfully functioned 12 of 15 times tested. One of the 41-inch diameter ballute fabrics tore loose from the canister during deployment and two 29-inch diameter ballutes fluttered from release to impact.

(The reverse of this page is blank.)

CONTENTS

ILLUSTRATIONS AND TABLE

ILLUSTRATIONS AND TABLE (Concluded)

SECTION I

INTRODUCTION

The ballute retarder system (combination balloon/parachute) is intended to improve performance of aerially-delivered bombs and mines, increase separation distance between aircraft and ground burst, and provide cockpit selectability of a high or low drag munition. This design is intended to replace the MK 15 high drag fin and MAU-93 low drag fin.

Specific objectives of this project were:

1. Conduct an aircraft vibration test on the bomb/ballute system.

2. Demonstrate fit of the bomb/ballute system on F-100 and F-4 aircraft.

3. Demonstrate the bomb/ballute system carriage and release compatibility on F-100 aircraft.

4. Evaluate the buildup, handling, and uploading procedures for the bomb/ballute system.

5. Obtain ballistic data for the bomb/ballute system in the low drag configuration.

6. Obtain ballistic data for the bomb/ballute system (including a terminal velocity value) for deployed ballutes for both the 29-inch and 41-inch diameter ballutes.

7. Demonstrate that sufficient G-load occurs during deployment of the 41-inch diameter ballute to allow arming of the FMU-54/B fuze.

8. Obtain burial characteristics including attitude, depth, and signature of the bomb/ballute using a 28-inch diameter ballute (mine application).

9. Demonstrate that the finned canister/bomb interface and finned canister/ballute interface will withstand ballute deployment at maximum dynamic pressures occurring during these drops.

10. Obtain time lapse from bomb release to full ballute deployment.

11. Establish bomb/ballute system reliability.

All objectives were accomplished.

SECTION II

DESCRIPTION

BALLUTE RETARDER SYSTEM

This ballute retarder system is designed to retard the descent rate of the 500-pound MK 82 bomb. The system consists of a finned cylindrical canister which contains the stowed ballute, the mechanical release mechanism (optional), and a retaining clamp for attaching the fin canister to the bomb (Figure 1). The finned aluminum cast canister serves as a low drag fin for the bomb until the ballute deploys. Ballute deployment occurs when the aft closure disk is released and pulled backward by aerodynamic drag forces. During the test program a popup air scoop was added to the canister and the release mechanism was redesigned to successfully extract the ballute from the canister. After the ballute is extracted, ram air inflates it to the high drag configuration (Figure 2). Two sizes of ballutes were tested during this project. One was approximately 29 inches in diameter and one was approximately 41 inches in diameter (Figure 3). The smaller size was designed for mining applications with a terminal velocity of 400 feet per second. The larger size was designed for general purpose bombs and a terminal velocity of 238 feet per second. See AFATL-TR-72-179, MK 82 Ballute Retarder System, Unclassified, September 1972, AD 907 851 L, for complete details of design and development effort.

TYPE I RELEASE MECHANISM

This release mechanism employs a spring-loaded slide to release the back plate. The slide mechanism was located inside the back plate (Figure 4). Prior to release, the slide could be seen projecting through the top and rear edge of the fin canister. It was held in the up position by lanyard wire or a safety pin (pulled prior to takeoff). At release the lanyard wire was withdrawn which allowed the spring-loaded slide to move down.

TYPE II RELEASE MECHANISM

This release mechanism was completely external to the fin canister (Figure 5). A continuous braided cable was passed through the rear of each fin blade. Sections of it were then criss-crossed over the rear of the fin and down to the center of the back plate where it was looped over a conical projection. After each of the four sections of braided cable was looped in place, a teflon washer was mounted on the conical projection and a lanyard wire was inserted through the tip to retain the washer and cable. A Fahnestock clip was used to hold the lanyard wire in place.

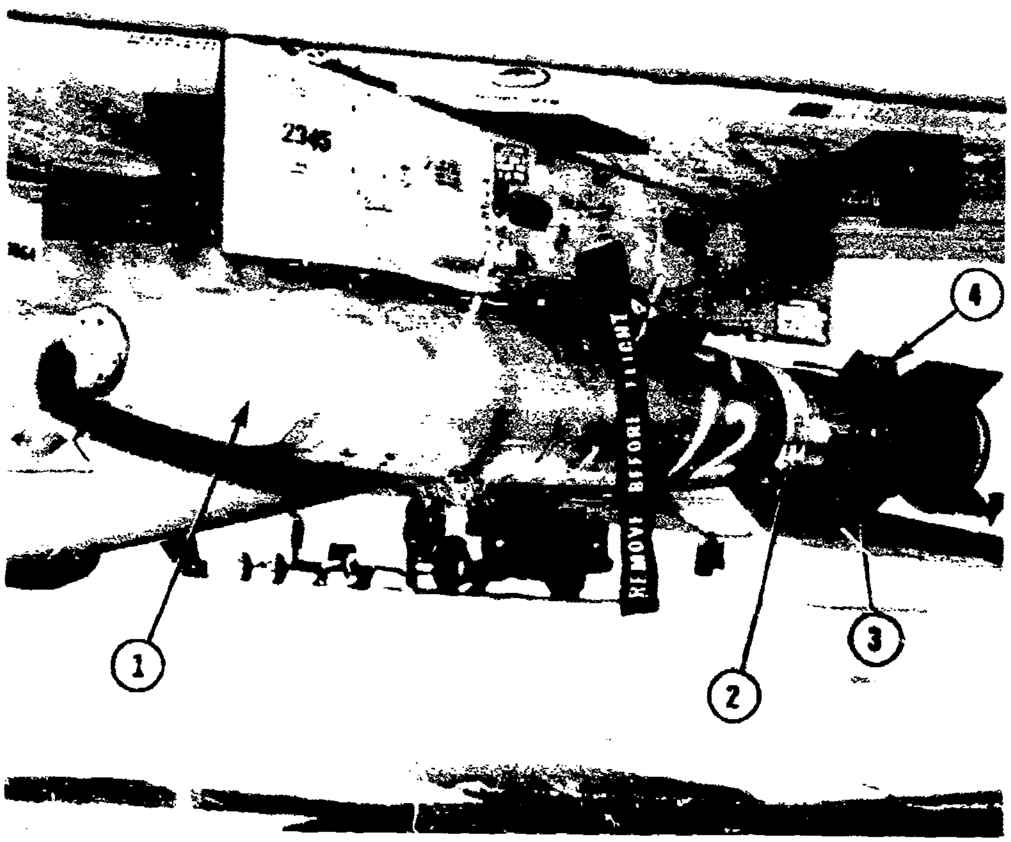

Figure 1. MK 82 bomb with ballute retarder system on an F-100 outboard pylon: (1) MK 82 bomb, (2) retaining clamp, (3) finned canister, and (4) mechanical timer

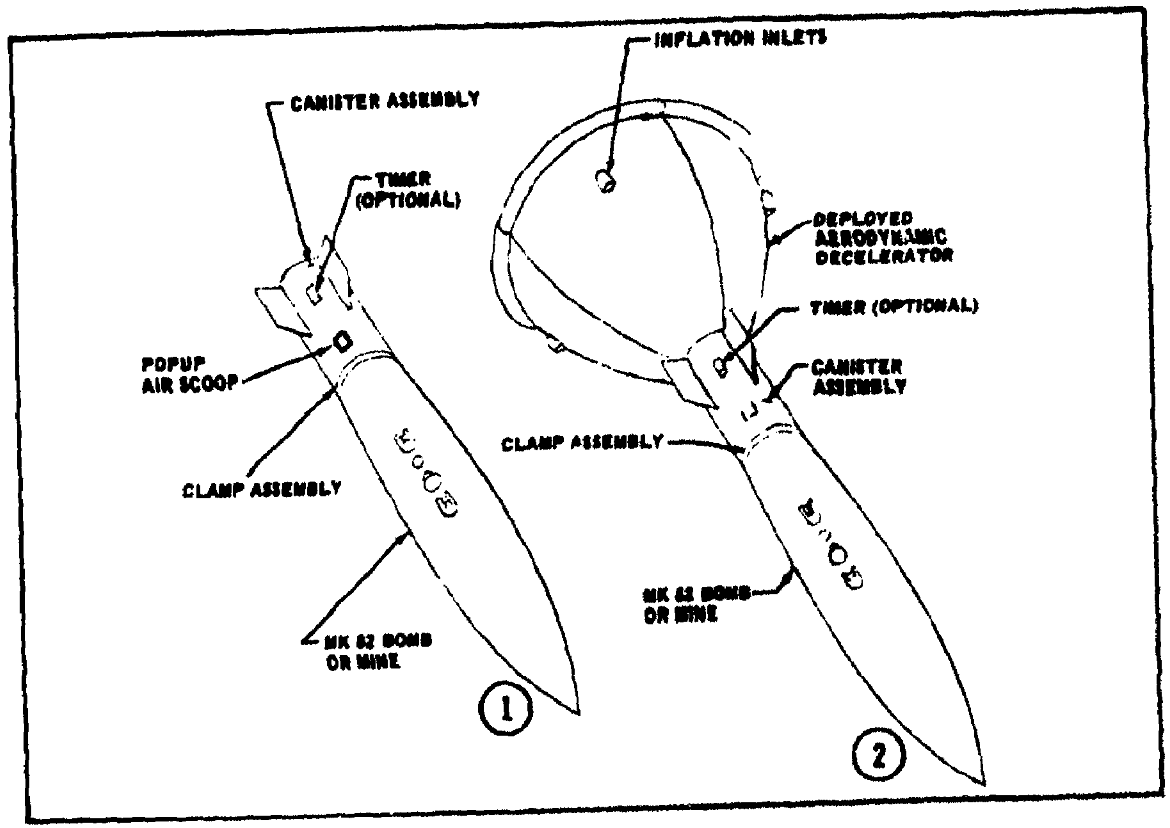

Figure 2. MK 82 bomb with ballute retarder system: (1) low drag mode and (2) high drag mode

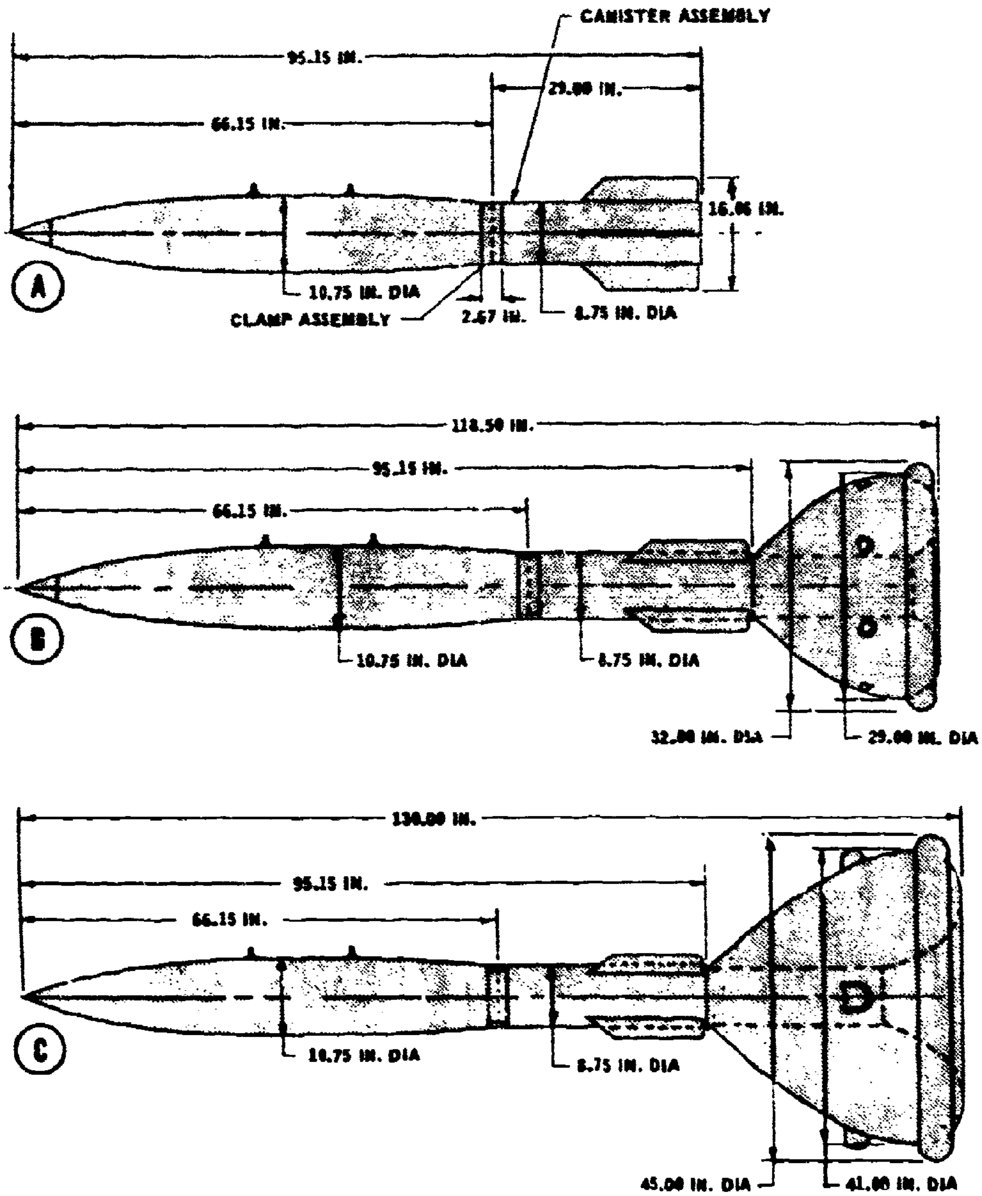

Figure 3. Physical comparison of the ballute retarder systems: (A) low drag, (B) 29-inch high drag, and (C) 41-inch high drag

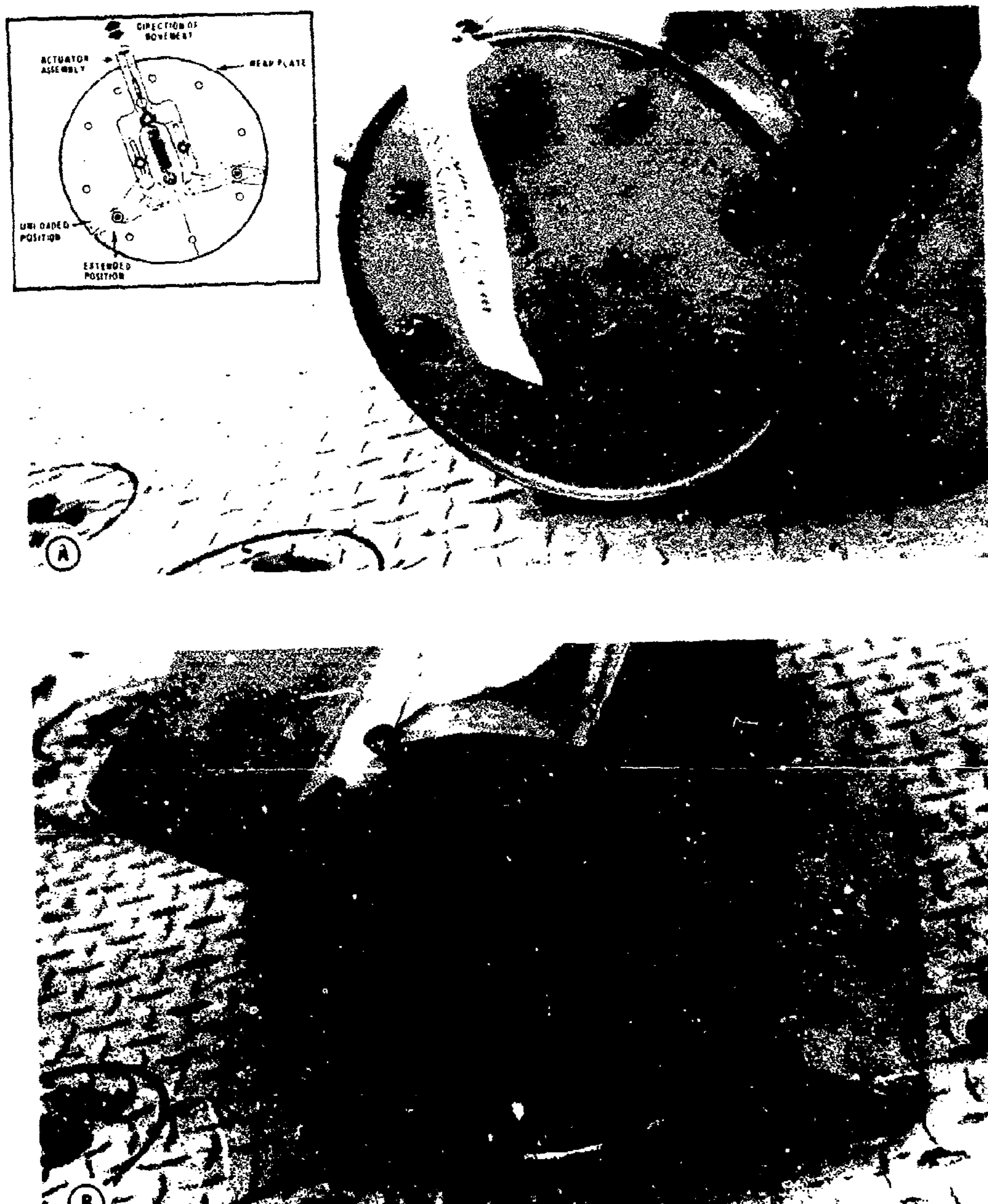

Figure 4. Type I release mechanism: (A) with back plate and (B) without back plate

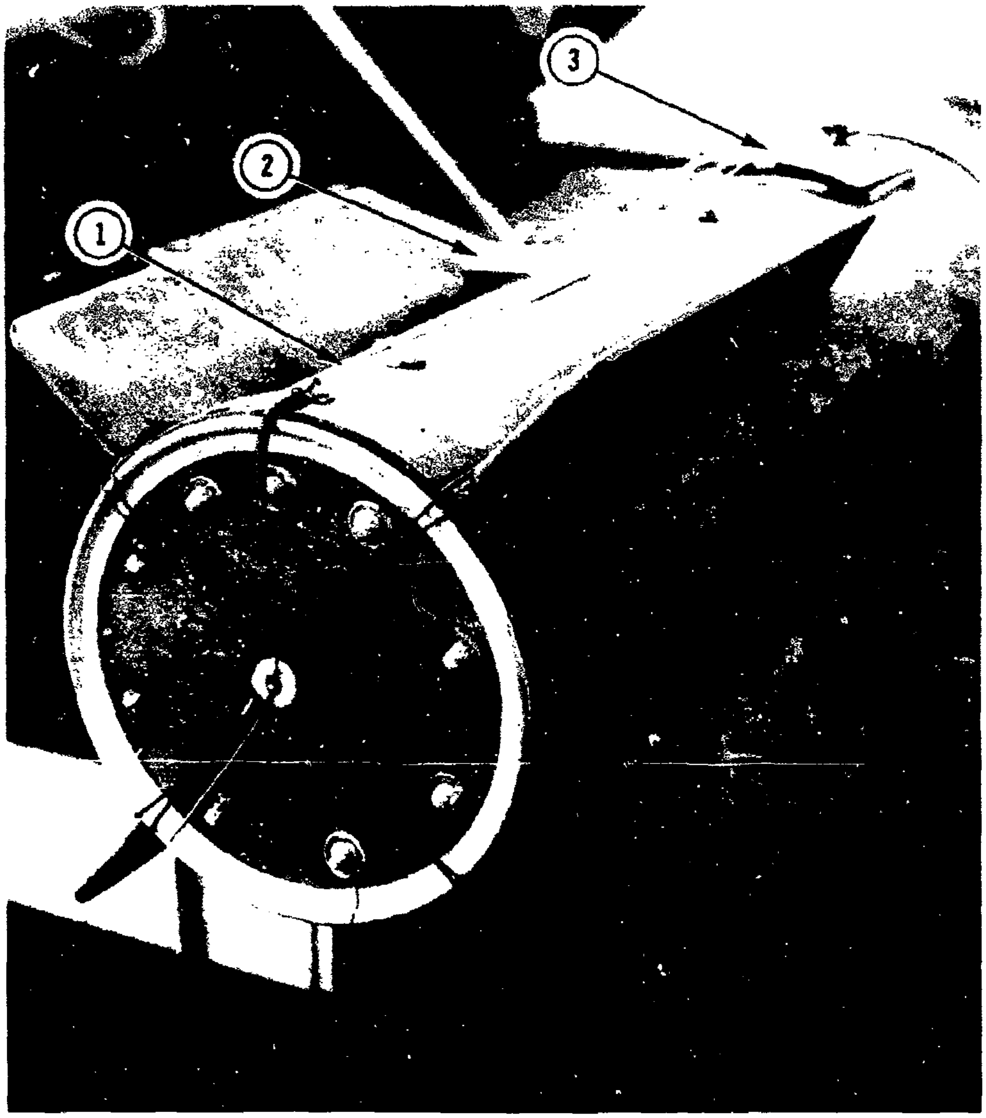

Figure 5. Type II release mechanism (arrows) and (1) lanyard, (2) mechanical timer mount, and (3) popup air scoop

SECTION III

INSTRUMENTATION

STATIC LOADS TEST

Four BLH 120-C rosette strain gages were mounted at orthogonal points on the restraining band. Strain gage output was then recorded for analysis on a CEC 1-1-24 recorder.

VIBRATION TEST

The Unholtz-Dickie 6,000 G-pound force vibrator machine was utilized to subject the fin/clamp combination to the required vibration spectrum. Accelerometers were mounted at orthogonal points on the table for control.

FLIGHT TESTS

Time-space-position data were obtained by cinetheodolite cameras operating at 30 frames per second. Ground mounted high speed cameras operating at 96 frames per second were also used to obtain supplemental inflight data. All ground mounted cameras were time-annotated and most items were tracked from release to impact. Release and fallaway characteristics within the immediate vicinity of the aircraft were recorded by an airborne hand-held camera operating at 200 frames per second.

SECTION IV

TEST PROCEDURES AND RESULTS

GROUND TESTS

STATIC LOAD TESTS. A static load test was conducted to verify that the retaining clamp could withstand aerodynamic loads expected during flight. Verification testing was necessary as the contractor's method of calculating the captive flight loads was not adequate to insure flight safety. Acceleration load factors had not been considered during flight maneuvers and consequently very brittle material had been used. In fact, during initial shipment a break occurred across the entire width of one of the clamp bands. The contractor was consulted, and his investigation revealed that an improper heat treatment procedure had been used. Corrections were made and new clamps were sent to Eglin AFB for tests.

The test consisted of mounting an inert MK 82 bomb to an F-100 Type III pylon and attaching an adapter to the rear of the bomb. The retaining clamp holding the adapter to the bomb was oriented with the joint area aligned with the bomb lugs. The joint area was considered the weakest point and thus this orientation subjected the joint area to the highest stress loads. Various weights were suspended from the adapter at a point 14.39 inches aft of the clamp to simulate the maximum expected aerodynamic loads for various mach numbers. Strain gages were mounted at orthogonal points on the clamp and monitored during the test. See Figures 6 and 7 for test setup.

The new clamps also proved inadequate as the first clamp tested broke (without any load) while its two adjustment cap screws were being alternately torqued to the design range of 150 to 180 inch-pounds. The break occurred at approximately 125 inch-pounds (Figure 8). The contractor changed the material of the clamp, reduced the hardness obtained during heat treating, and added gusset stiffners to the joint area.

During the tests, weights were added at 10 percent increments until a maximum load of 1,864 pounds was obtained. This represented 100 percent of the design load limit at 0.9 mach. The weights were then removed and the clamp was checked for deformation. Weights were added again at 10 percent increments until 115 percent (2,145 pounds) of the design load was obtained. This represented the yield point. No clamp deformation was observed after removal of the weights. The weights were added a third time until 150 percent (2,796 pounds) of the design load was obtained.

This condition was equivalent to 100 percent of the design load limit at 1.2 mach. No clamp deformation was observed after removal of the weights. Complete details of test procedures, results, and analysis will be published by ADTC/AFATL.

VIBRATION TESTS. Random vibration testing was conducted on the Unholtz-Dickie 600 G-pound force vibrator machine (Figure 9) to compliment earlier sinusoidal vibration testing performed by the contractor. The finned canister was mounted on the shake table with the clamp and randomly vibrated in the longitudinal and lateral axes. Test procedures were conducted in accordance with MIL-STD-810B, Method 514.1, Procedure 2, Part 3, Curve AF. No structural deficiencies were noted in the fin/clamp assembly.

COMPATIBILITY TESTS

GENERAL. Two lengths of canisters were used during these tests. Twenty-one of the 24 munitions tested used a canister which was 28.62 inches long and had a fin blade span of 16.06 inches. The remaining three used a canister which was 25.62 inches long and had a fin blade span of 15.06 inches.

FIT TESTS. One inert MK 82 munition with 16.06-inch fins was loaded on each wing pylon of the F-100 aircraft to determine physical compatibility. Clearance between ballute canister and each pylon was insufficient for mounting an ATU-35/B drive assembly which is 2 1/2 inches high (Figure 10). This imposed no problem because prior to final canister design the appropriate mounting recess could be rotated 90 degrees to either side. The fin blades were always in an X configuration with respect to the bomb lugs because of the mechanical timer mounting area. No other interference was observed between the munitions and any portion of the wing, flaps, ailerons, or struts. Ground clearance was in excess of the 6-inch minimum requirement and all clearances were of sufficient magnitude to preclude need for deflating the tires and depressing the struts. This test was conducted in accordance with MIL-STD-1289.

Three inert MK 82 munitions with 16.06-inch fins were loaded on the F-4 inboard triple ejection rack (TER) and two were loaded on right forward and aft shoulder stations of the centerline multiple ejection rack (MER). All fins were in the X configuration because of the mechanical timer mounting area. The landing gear was not retracted as the fin was recessed under the aft portion of the pylon approximately 14 inches (Figure 11). When loaded in tandem on the centerline MER, the distance between the nose of the aft bomb and the tail of the forward bomb precluded installing the M904 nose fuze (Figure 12). The shorter fin (15.06-inch) was not available for this test. No interference was observed between the munitions and any portion of the wing, flaps, ailerons, or struts. Ground clearance was in excess of the 6-inch minimum requirement. All clearances were of sufficient magnitude to preclude need for deflating the tires and depressing the struts. This test was conducted in accordance with MIL-STD-1289.

With a munition (16.06-inch fin) loaded on the aft center station of the centerline MER, the pick-up line was clear of the ground by 2 3/4 inches. With a 15.06-inch fin employed, the clearance is increased to approximately 3 1/4 inches. This nominal clearance precludes consideration of "plus" fin configuration.

CAPTIVE FLIGHT TESTS. Captive flights were conducted only on the F-100 aircraft to demonstrate safe carriage of the munitions throughout the limits provided by the Air Force Armament Laboratory (DLGC) at Eglin AFB. See Appendix I.

Munitions with 16.06-inch fins were loaded,one on each inboard and outboard pylon of an F-100 aircraft. An inert M904 nose fuze was installed in each bomb. Fuel tanks on the intermediate stations provided additional flight time. An ATU-35/B drive assembly was mounted on the fin of the left outboard and right inboard munitions. The fins were rotated so that the drive assemblies were projecting to the left side of each munition while maintaining an X configuration. The left inboard and right outboard munitions employed a mechanical timer on each fin.

Two consecutive sorties of approximately 45 minutes each were flown without downloading the munition between flights. Various maneuvers such as pushovers, pullups, aileron pulses and stick pulses were conducted at incremental airspeeds up to 550 KIAS. The munitions were flown to the maximum allowable airspeed of 550 KIAS (mach 0.9) at 5,000 feet mean sea level (MSL) for approximately 14 minutes. Postflight inspection indicated no physical degradation of the test items.

RELEASE TESTS. Twenty-one inert munitions with 16.06-inch fins and three inert munitions with 15.06-inch fins were singly released from the F-100 aircraft under various release conditions. No release tests were conducted using the F-4 aircraft. See Table I for mission summary. Analysis of photochase film showed safe bomb/aircraft separation during all tests. Ballistic data were obtained on all drops except number 11 when the cameras were lost in the sun. Ballistic analysis indicated no significant difference between munitions using either fin. Analysis of the data is given in Appendix II.

Drops 1, 2, 3, (using 16.06-inch fins) and 19, 20, and 23 (using 15.06-inch fins) were conducted to obtain low drag ballistic data only. The respective fin canisters did not employ either an operational ballute or release mechanism. Ballast material was used to simulate the weight and center of gravity. All remaining munitions did contain an operational ballute, but those on drops 4, 5, and 6, using a Type I release mechanism, failed. Photochase film indicated that all lanyards were positively withdrawn during drops 4 and 6. Consequently, the release mechanism was redesigned to add a popup air scoop to the canister and the ballute was wrapped in a nylon corset. All remaining munitions employed the Type II release mechanism. Except for drop 22, all 41-inch diameter ballutes functioned properly. During drop 22, the ballute fabric tore loose from the canister 0.43 second after release as it was being inflated by ram air. Reduced ballistic data indicated the finned canister/ballute interface failed at a maximum dynamic pressure of 750 pounds per square foot. No failure occurred at the finned canister/bomb interface during any test.

All 29-inch diameter ballutes functioned properly except on drops 7 and 17. During drop 7, the ballute had a distinct flagging motion from deployment until impact. Afterward, the entire fabric on all remaining 29-inch ballutes were coated with a synthetic rubber compound to reduce porosity. During drop 17, the bomb had a high spin rate throughout its flight. Although the fluttering continued, the bomb was stable throughout the flight and the rolling motion eventually began to dampen.

Review of the photochase film indicated the 29-inch diameter ballute required a longer time to fully inflate than did the 41-inch. The average time for the smaller ballute to fully inflate after release was 0.8 second, while the larger ballute averaged 0.7 second.

Terminal velocity data were obtained on the low drag configuration during drops 11, 12, 14, 15, and 16. Mechanical timers were used to delay the ballute opening until several thousand feet above ground level. Reduced ballistic data indicate the terminal velocity for the 29-inch diameter and 41-inch diameter ballutes were 454 and 333 feet per second, respectively.

An inert but mechanically functional FMU-54/B fuze was installed in the tail of each munition used for drops 4, 5, 10, 13, 18, and 22. The purpose of the test was to demonstrate that sufficient G-load occurs during deployment of the 41-inch diameter ballute to arm the fuze. For this purpose, drops 4 and 5 were no test as neither ballute deployed. The FMU-54 fuze did arm during drops 13, 18, and 22, but did not arm during drop 10 as the G-load was not sufficient to move the G weights within the fuze.

Burial data were obtained on 13 of the 15 munitions where the ballute functioned. No burial data were available on drops 20 and 22, as both test items skipped on impact. See Table I for specific results.

Assembly of the munition was accomplished by attaching the fin canister to the rear of the bomb by means of the retaining clamp. Some difficulty was experienced in the longitudinal and transverse alignment of the bomb/fin assembly. The misalignment was minimized by careful and time consuming readjustments. Frequently, C clamps were required to press and hold the ends of the retaining clamp together for initial installation of the two capscrews and nuts. After the nuts were started, the C clamps were removed and each capscrew was alternately adjusted until a torque of 150 to 180 inch-pounds was obtained.

Except for consideration of the mechanical timer (when used) no special handling procedures were used. Since all lanyards fell away with the bomb, the length of the lanyard which extended past the rear of the bomb was kept to a minimum to avoid cutting the ballute fabric after deployment.

Future ballute designs should consider the number of lanyards and D-rings required versus the number of arming solenoids available on a given aircraft pylon. Beginning with drop 7, one lanyard was routed from the popup air scoop through the standoff bracket at the rear lug, passing through the circular loop of each swivel and loop assembly, up to and around the front lug, back through one swivel, through the standoff bracket, and terminated at the release mechanism or mechanical timer (Figure 13). The FMU-54 tail fuze lanyard was routed through the remaining swivel. Because of the potential overstress of the available swivel and loop assemblies, the nose fuze lanyard was deleted starting with drop 7. This posed no problem as the M904 fuze was used only to provide realistic configuration and aerodynamic drag.

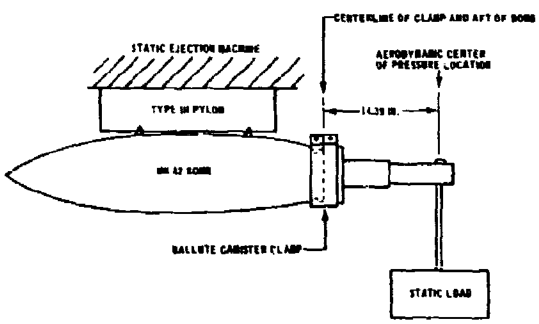

Figure 6. Static load test arrangement

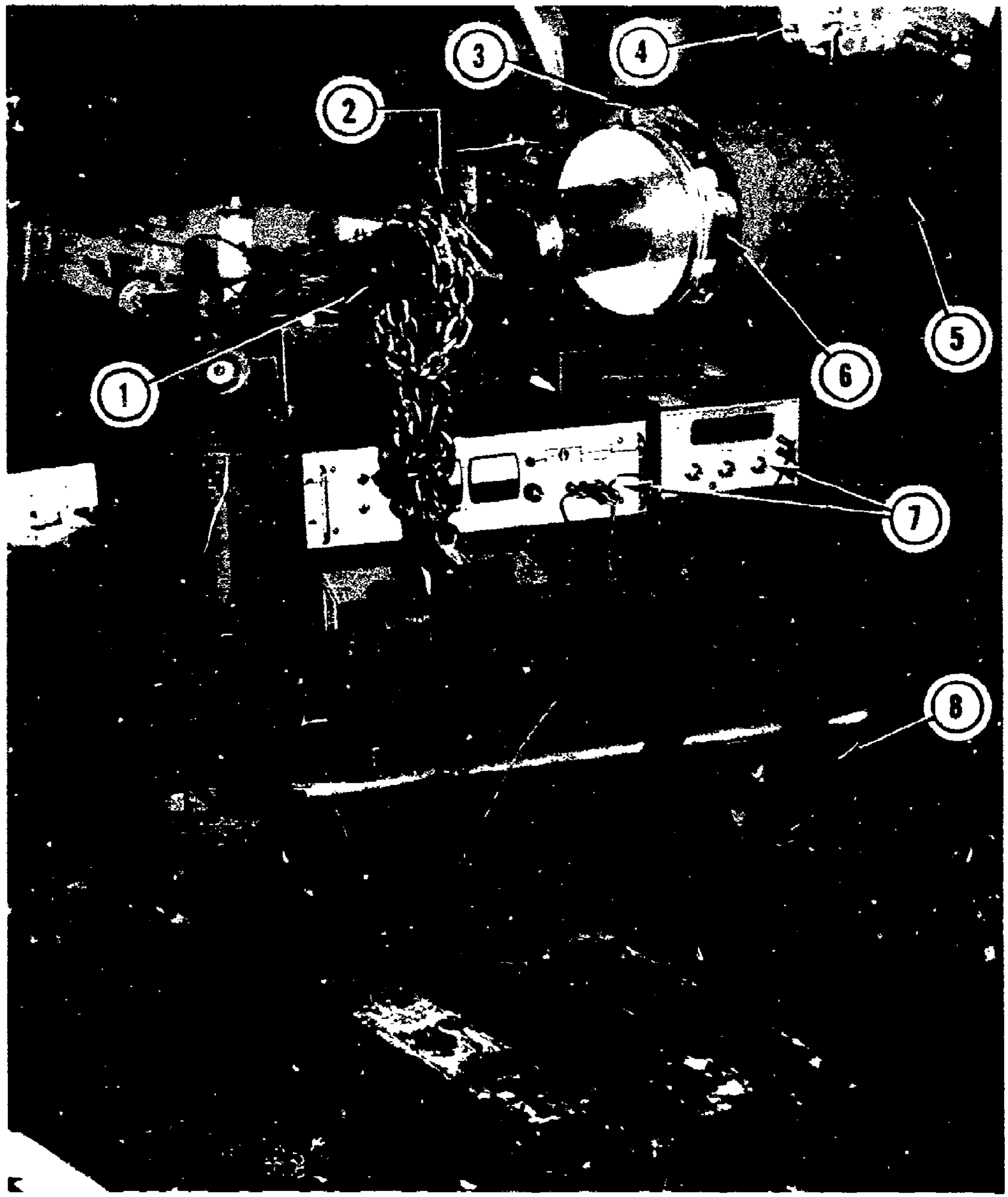

Figure 7. Static load test setup and strain gage locations: (1) adapter, (2) aerodynamic center of pressure, (3) redesigned retaining clamp, (4) pylon, (5) MK 82 bomb, (6) strain gage, (7) instrumentation, and (8) weights

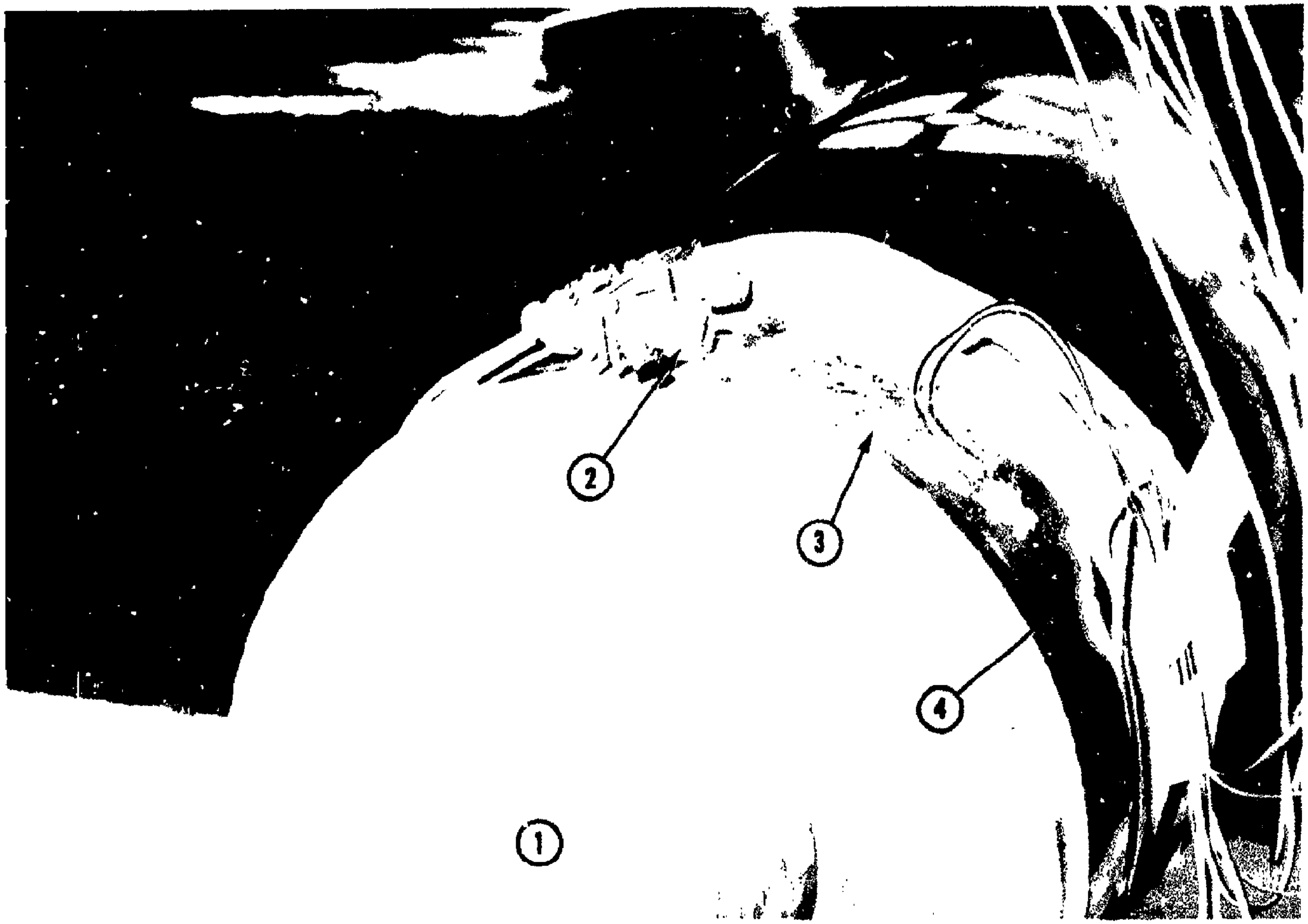

Figure 8. Restraining clamp failure during static load test: (1) adapter, (2) band break, (3) strain gages, and (4) retaining clamp

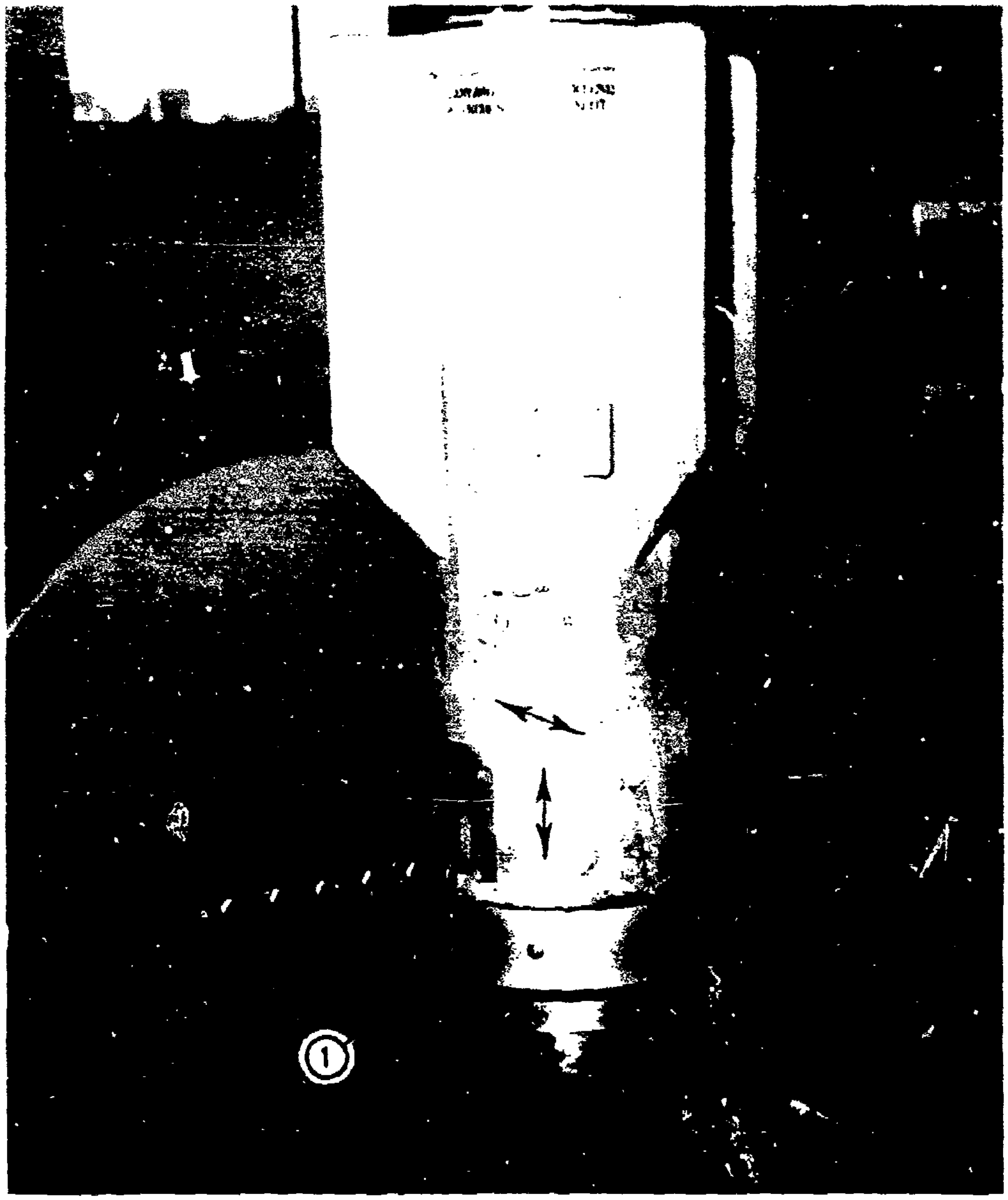

Figure 9. MIL-STD-810B vibration test setup: (1) redesigned retaining band (arrows show direction of vibration)

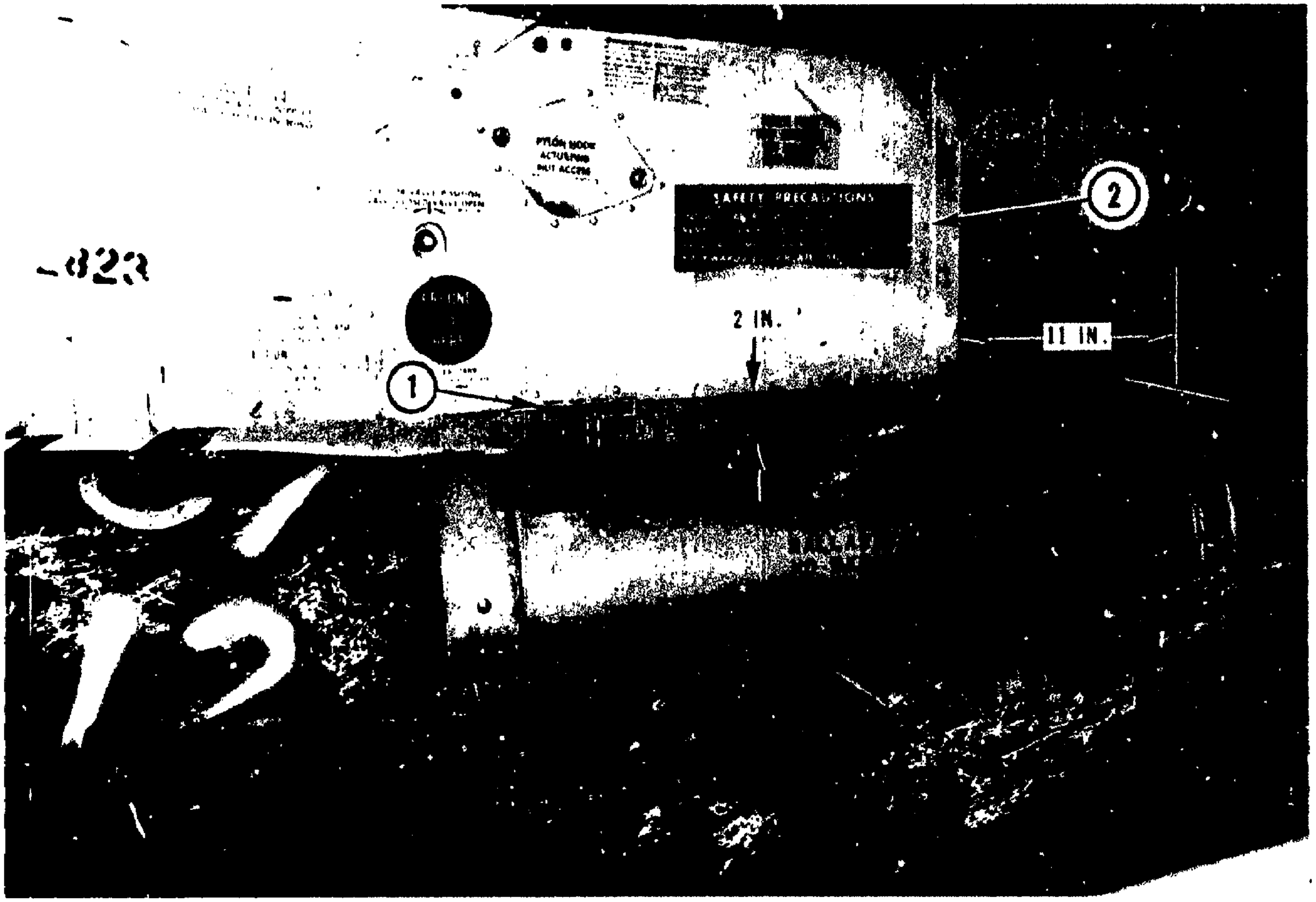

Figure 10. Interference of ATU-35A/B drive assembly (1, dotted lines) with inboard pylon of F-100 (2)

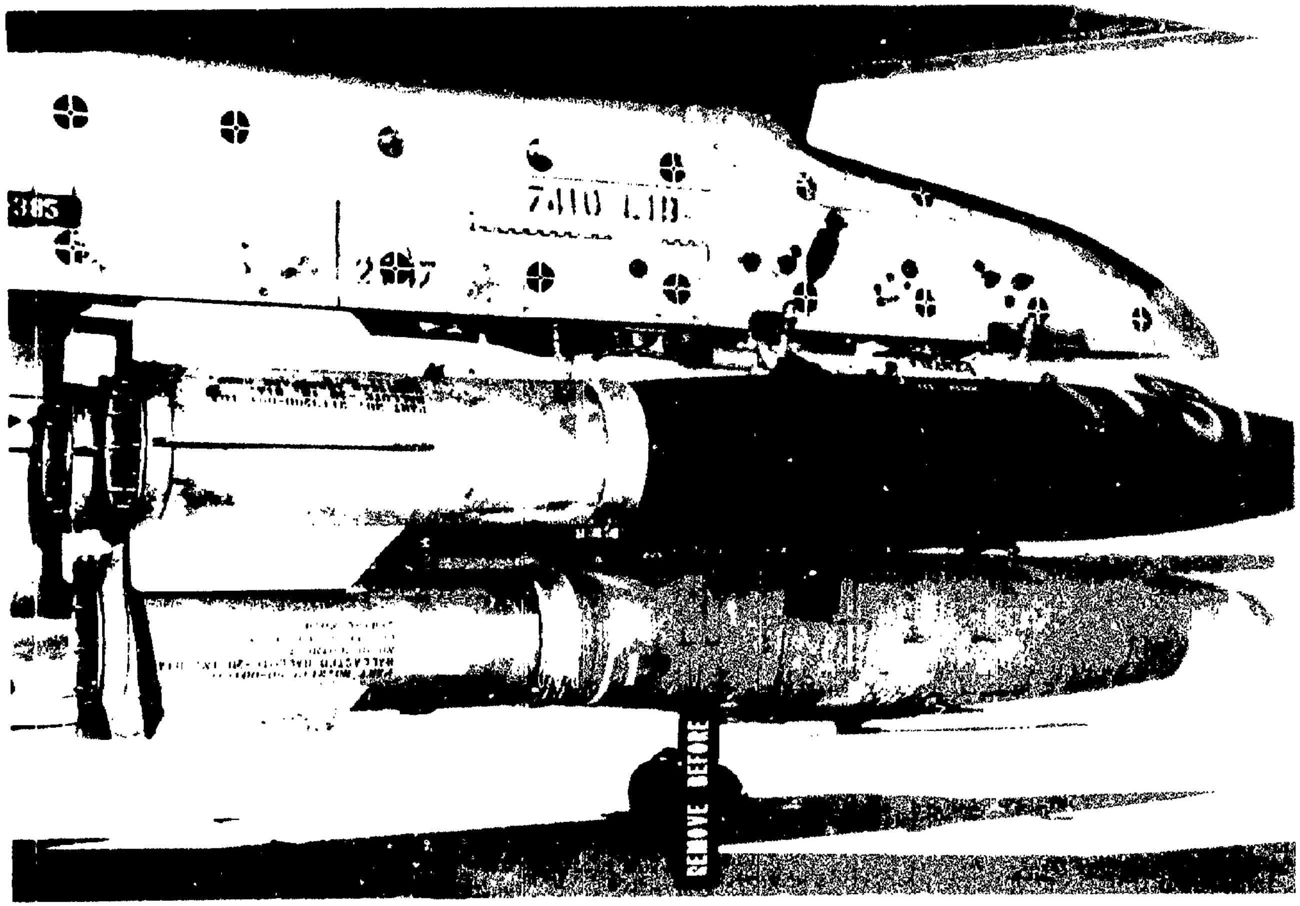

Figure 11. Ballute retarder system loaded on
F-4 inboard TER (satisfactory physical fit)

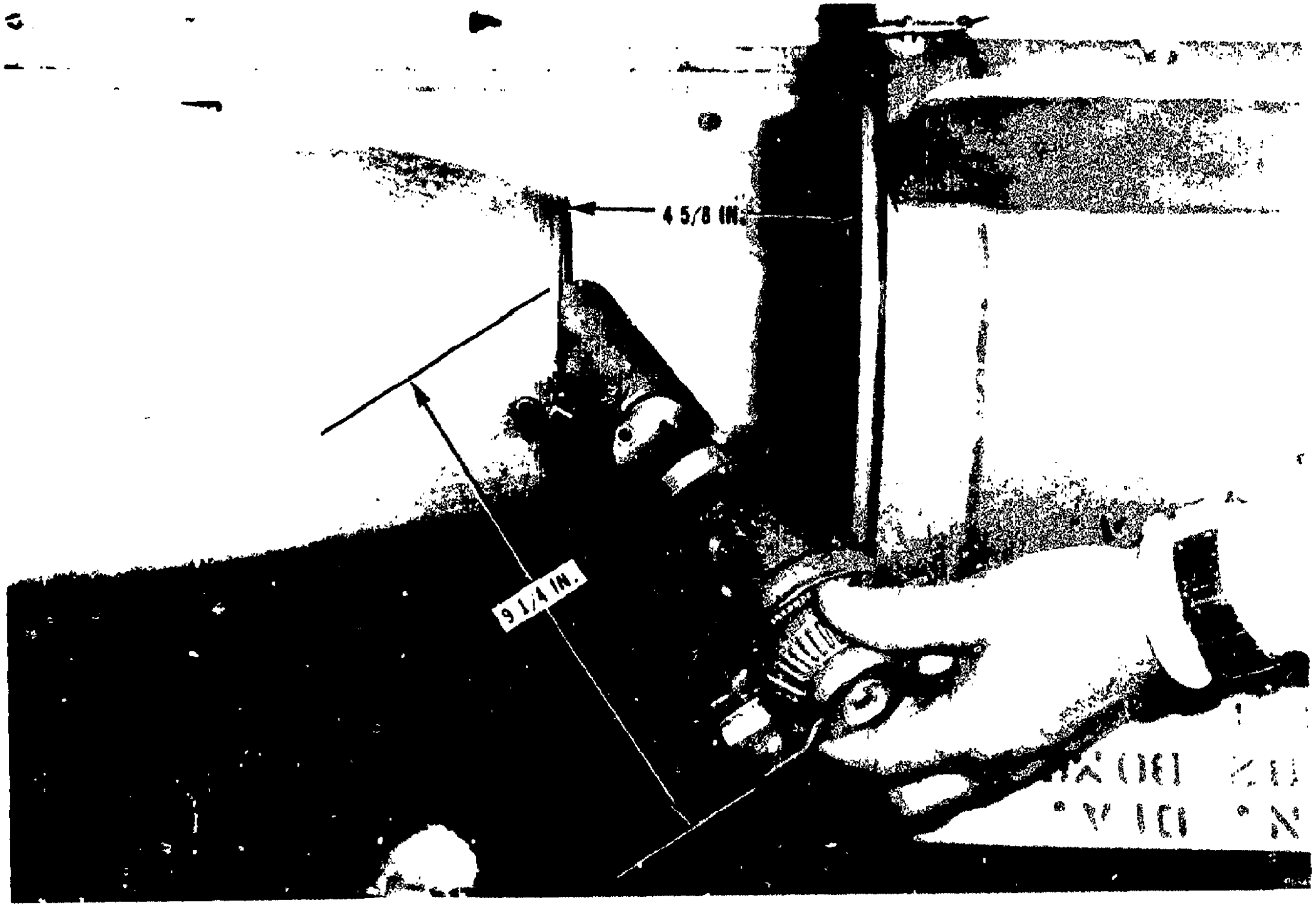

Figure 12. Insufficient clearance between munitions for post-load fuzing when bombs are loaded in tandum on a centerline MER

Table I. Summary of

Drop no.	Bomb no.	Ballute diameter (in.)	Type of release mechanism	Bomb weight (lb)	Bomb CG (in. fwd aft lug)	Moment of inertia (ft-lb-sec^2)	Loaded station	Actual release conditions Altitude (ft AGL)	Attitude	Airspeed (ft/sec)	Altitude of ballute deployment (ft AGL)	Airspeed at ballute function (ft/sec)	Time from release to full deployment (sec)
1	2	NA	NA	583	4 5/16	55.03	LOB	3,890	Level	665	NA	NA	NA
2	12	NA	NA	548	4 5/8	50.82	ROB	4,120	Level	840	NA	NA	NA
3	14	NA	NA	563	4 9/16	51.65	LINB	3,930	Level	910	NA	NA	NA
4	5	41	I	548	4 3/16	52.49	LOB	4,010	Level	645	---	---	NA
5	6	41	I	548	4	52.49	ROB	4,090	Level	640	---	---	NA
6	15	29	I	533	4 3/4	48.77	LOB	2,525	Level	640	---	---	NA
7	18	29	II	538	4 9/16	48.77	LOB	2,690	Level	610	2,830	545	0.80
8	1	41	II	551	3 7/8	52.49	ROB	2,785	Level	640	2,780	600	0.85
9	13	29	II	542	4 7/16	49.60	LOB	3,955	Level	665	3,880	550	1.80
10	8	41	II	554	4 1/4	52.91	ROB	3,920	Level	675	3,870	535	1.09
11	16	29	II	543	4 9/16	49.18	LINB	15,265	Level	900	---	---	---
12	3	41	II	555	4 7/8	53.33	RINB	15,350	Level	890	2,735	895	28.20
13	4	41	II	553	3 7/8	52.91	LOB	3,970	Level	775	3,960	700	0.60
14	7	41	II	547	4 1/16	52.91	ROB	15,320	-2 deg	885	4,570	930	27.80
15	11	41	II	550	3 13/16	52.91	LINB	15,530	-1 deg	870	4,490	970	27.60
16	17	29	II	549	4 5/8	50.00	RINB	15,340	Level	875	4,620	900	27.40
17	19	29	II	539	4 3/4	49.60	LOB	3,730	-1 deg	795	---	---	---
18	9	41	II	555	3 15/16	53.33	ROB	3,720	-1 deg	865	---	---	0.35
19	24	NA	NA	553	5 3/16	48.77	LINB	3,755	-1 deg	565	NA	NA	NA
20	22	NA	NA	533	5 3/8	45.57	RINB	3,755	-1 deg	750	NA	NA	NA
21	21	29	II	549	4 9/16	50.41	LINB	3,590	Level	885	3,585	865	0.35
22	10	41	II	548	4 1/16	52.08	ROB	3,415	Level	970	---	---	---
23	23	NA	NA	540	5 1/2	46.36	RINB	3,675	-1 deg	865	NA	NA	NA
24	20	29	II	542	4 5/8	49.59	LOB	3,505	-1 deg	945	3,495	900	0.35

[a] The dynamic pressure (Q) obtained from reduced ballistic data was the maximum value experienced during ballute deployment and not necessarily at the time of full inflation.
[b] No operational ballute installed in canister.

[c] Bomb was stable from release to impa
[d] FMU-54/B fuze was installed in tail fu
[e] Finned canister was 3 inches shorter i
and fin blade span was 1 inch shorter.

le I. Summary of flight tests

Airspeed at ballute function (ft/sec)	Time from release to full deployment (sec)	Q[a] (lb/ft²)	Impact crater Length (ft)	Impact crater Width (ft)	Impact crater Depth (ft)	Burial data Horiz travel (ft)	Burial data Depth (ft)	Burial data Attitude (deg)	Remarks
NA	NA	NA	NA	NA	NA	NA	NA	NA	See notes [b] and [c].
NA	NA	NA	NA	NA	NA	NA	NA	NA	See notes [b] and [c].
NA	NA	NA	NA	NA	NA	NA	NA	NA	See notes [c] and [d].
---	NA	NA	NA	NA	NA	NA	NA	NA	Ballute did not deploy. See note [c].
---	NA	NA	NA	NA	NA	NA	NA	NA	Ballute did not deploy. See note [c]
---	NA	NA	NA	NA	NA	NA	NA	NA	Ballute did not deploy. See note [c].
545	0.80	320	2 1/2	1 1/2	2	4	11	45	Ballute fabric fluttered from release to impact. Ballute fabric found below ground. See note [c].
600	0.85	390	1 1/2	1 1/2	2	3	8	60	Ballute fabric attached to canister and found above ground. See note [c].
550	1.80	410	1 1/2	2 1/2	2 1/2	8	8	45	Ballute fabric found above ground. See note [c].
535	1.00	410	2	2	2	8	9	60	At impact ballute fabric separated from canister and was found on top of ground 5 feet forward of impact hole. FMU-54 fuze did not arm. See notes [c] and [d].
---	---	---	3	3	2	2	12	90	Ballute fabric 5 feet below ground. Ground cameras lost item after release. See note [c].
895	28.20	1,060	2 1/2	2 1/2	1 1/2	2	8	20	Ballute fabric found above ground. See note [c].
700	0.60	575	2	3	1 1/2	3	6	105	Ballute fabric found above ground. FMU-54 fuze armed. See notes [c] and [d].
930	27.80	895	1 1/2	1	1	4	13	90 ND	Ballute fabric found 10 feet left of impact hole. See note [c].
970	27.60	970	1 1/2	2	1	2	9 1/2	90 ND	Ballute fabric found 50 feet left of impact hole. See note [c].
900	27.40	835	2	3	1	3	12	80 ND	Portion of ballute fabric found 8 feet below ground. See note [c].
---	---	600	3	2	1	7	5	60	Ballute fabric fluttered from release to impact. Bomb was stable but obtained high spin rate. Ballute fabric found 2 feet below ground with canister.
---	0.35	700	2	2	1	7	6	60	Ballute fabric found 4 feet below ground with canister on FMU-54 fuze armed. See notes [c] and [d].
NA	NA	NA	NA	NA	NA	NA	NA	NA	No ballute in fin. Ballast material only. See notes [b], [c] and [e].
NA	NA	NA	NA	NA	NA	NA	NA	NA	No ballute in fin. Ballast material only. Item skipped 800 feet downrange. See notes [b] and [e].
865	0.35	690	2	2	1 1/2	7	6	60	Ballute fabric on ground over impact hole. See notes [b], [c] and [e].
---	---	750	NA	NA	NA	NA	NA	NA	Ballute fabric separated from fin 0.43 second after release. Bomb became unstable. Item skipped. FMU-54 fuze armed. See note [d].
NA	NA	NA	NA	NA	NA	NA	NA	NA	No ballute in fin. Ballast material only. See notes [b], [c] and [e].
900	0.35	790	3	2	1 1/2	4	5	45	Ballute fabric 2 feet below ground. See note [c].

from release to impact.
as installed in tail fuze well.
as 3 inches shorter in length
was 1 inch shorter.

(The reverse of this page is blank.)

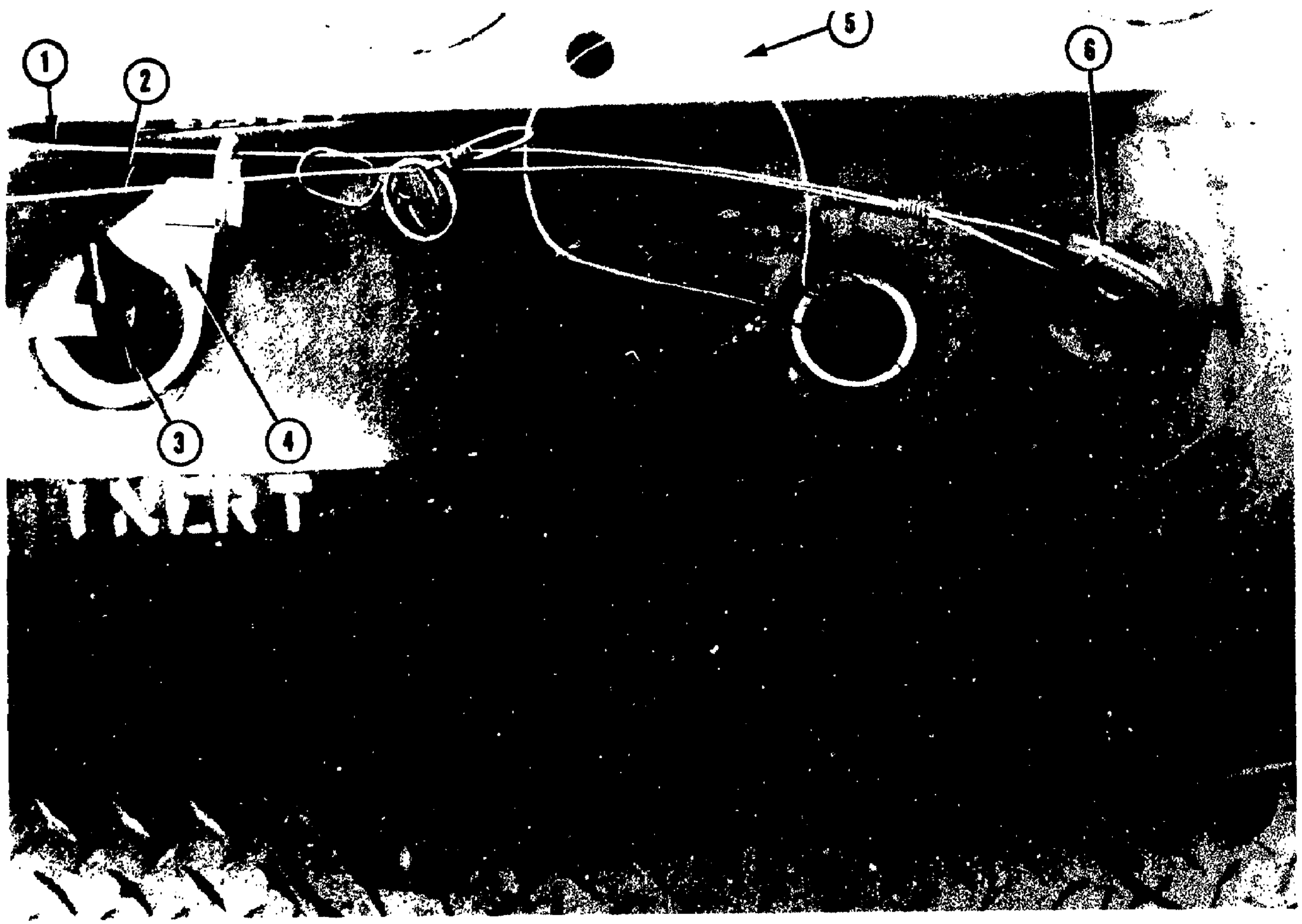

Figure 13. Lanyard arrangement: (1) lanyard for release mechanism or mechanical timer, (2) lanyard to popup air scoop, (3) rear lug, (4) standoff bracket, (5) FMU-54 fuze lanyard, and (6) front lug

SECTION V

SUMMARY OF FINDINGS

1. The structural integrity of the fin retaining clamp was verified by the following:

   a. MIL-STD-810B, Method 514.1, Procedure 2, Part 3, Curve AF, Vibration Tests.

   b. Static load test with a maximum of 2,796 pounds applied 14.39 inches from the center of the clamp, which represented 150 percent of the calculated design load limit at 0.9 mach, sea level.

2. The munition was physically compatible with the F-100 inboard and outboard pylons.

3. The munition was physically compatible with the F-4 inboard TER and centerline MER.

4. The M904 fuze cannot be installed after the munition is loaded in tandem on the F-4 centerline MER.

5. The bomb/ballute system was satisfactorily carried and released from the F-100 aircraft up to 550 KTAS in level flight.

6. Installation of the canister to bomb required careful and time-consuming readjustments. No special handling procedures were required.

7. Redesign of the lanyard arrangement is necessary for operational use of the ballute retarder system.

8. Ballistic data were obtained for the low and high drag configurations.

9. The average terminal velocity for the 29-inch and 41-inch diameter ballutes was 454 and 333 feet per second, respectively.

10. The G-load which occurs during deployment of the 41-inch diameter ballute was sufficient to allow three of four FMU-54/B fuzes tested to arm. The fourth fuze did not arm.

11. Burial characteristics for MK 82 bombs with the 29-inch ballute varied from 2 to 8 feet horizontal travel from impact point, 5 to 12 feet deep, and 45 to 90 degrees nose-down. Five of seven 29-inch diameter ballutes (mine application) were not visible above ground following impact.

12. The finned canister/bomb interface and finned canister/ballute interface withstood ballute deployment at a maximum dynamic pressure of up to 1,060 pounds per square foot, except for one finned canister/ballute interface which failed at 750 pounds per square foot.

13. The average time for the 29-inch ballute to fully inflate after release was 0.8 second, while the 41-inch ballute required an average of 0.7 second.

14. Using the Type II release mechanism, the ballute system successfully functioned as designed 12 of the 15 times tested. One of the 41-inch diameter ballute fabrics tore loose from the canister during deployment and two 29-inch diameter ballutes failed to fully deploy.

(The reverse of this page is blank.)

APPENDIX I

FLIGHT LIMITS

DLGC/Mr. Robertson/882-5646 15 Sep 1972

Local Flight Limits for the MK 82 Ballute Retarder System on the F-100 Aircraft

TSGA

1. Reference ADTC/TGPM Project Directive No. 1559W005, Evaluation of the MK 82 Ballute Retarder System, 1 June 1972.

2. Attached are recommended flight limitations for carriage and release of the MK 82 ballute retarder on the F-100 aircraft. These limits are required for flight tests as outlined in the referenced project directive for the 29-inch and 41-inch ballute retarder systems.

3. The MK 82 ballute retarder system is a combination balloon/parachute device designed to retard the descent rate of the MK 82 500-pound bomb. Two sizes of ballutes will be tested, one is 29 inches in diameter when fully deployed, and the other is 41 inches in diameter. Both ballute retarder systems consist of a finned cylindrical cannister which contains the stowed ballute, the actuating mechanism, and the fittings for attachment to the bomb. The finned cannister serves as a low-drag fin for the bomb until the ballute is deployed.

4. Physical properties of the MK 82 ballute include the following:

a. 29-inch retarder:

(1) Length: 95.15 inches (ballute stowed)

(2) Weight: 563 pounds

(3) Center of gravity: 41.95 inches aft of nose (with nose plug installed and ballute stowed)

(4) Moment of inertia (pitch and yaw): 54.53 slug-ft^2 (with ballute stowed)

b. 41-inch retarder:

(1) Length: 95.15 inches (ballute stowed)

(2) Weight: 570 pounds

(3) Center of gravity: 42.48 inches aft of nose (with nose plug installed and ballute stowed)

(4) Moment of inertia (pitch and yaw): 57.41 slug-ft^2 (with ballute stowed)

5. In addition, several MK 82 ballute systems with shortened cannisters will be dropped during these tests. Physical properties of the MK 82 ballute with shortened cannister include the following:

a. 29-inch retarder:

(1) Length: 92.0 inches (ballute stowed)

(2) Weight: 558.6 pounds

(3) Center of gravity: 41.5 inches aft of nose (with nose plug installed and ballute stowed)

(4) Moment of inertia (pitch and yaw): 51.38 slug-ft^2 (with ballute stowed)

b. 41-inch retarder

(1) Length: 92.0 inches (ballute stowed)

(2) Weight: 565.6 pounds

(3) Center of gravity: 42.0 inches aft of nose (with nose plug installed and ballute stowed)

(4) Moment of inertia (pitch and yaw): 53.94 slug-ft^2 (with ballute stowed)

NOTE: Mass properties of the subject munitions should be determined at the Precision Measurement Facility. Any deviation of more than 5 percent in weight or moment value, or 1/2 inch in CG, from the above stated values should be brought to the attention of DLGC.

6. Releases of the MK 82 ballute in low-drag (non-functioning ballute) mode should be conducted as specified in the test plan included in the referenced project directive. Any deviation to the plan as outlined should be coordinated with DLGC. In addition, the no-delay ballute functioning releases must be conducted from the aircraft outboard pylon stations only. These releases should begin at a maximum airspeed of 350 KIAS and work up to the maximum release allowed in 50-knot increments.

7. The attached flight limits are not valid until the subject project is reviewed and approved by the ADTC Airborne Test Project Safety Board.

/s/t/

JAMES T. CLAY, Lt Col, USAF
Chief, Aircraft Compatibility and
Weapons Flight Dynamics Branch

1 Atch
ADTC/DLGC Flight Limits,
7 Sep 72

Cy to: TGO
TGPM
TGW
DLJM

7 Sep 1972

AFATL (DLGC)
LOADING CONFIGURATIONS AND FLIGHT LIMITATIONS
F-100 AIRCRAFT
WITH BOTH 29-INCH AND 41-INCH MK-82 BALLUTE RETARD SYSTEMS

LOADING CONFIGURATIONS			CARRIAGE LIMITATIONS					EJECTION LIMITATIONS			DISPENSING LIMITATIONS			JETTISON LIMITATIONS	
OUTBOARD	INTERMEDIATE	INBOARD	MAX SPEED KIAS	SYMM LOAD "G"	UNSYMM LOAD "G"	C. G. RANGE % M.A.C. F-100D	C. G. RANGE % M.A.C. F-100F	MAX SPEED KIAS	MAX "G"	MAX DIVE ANGLE	MAX SPEED KIAS	MAX "G"	MAX DIVE ANGLE	MAX SPEED KIAS	MAX G
MK-82 Ballute	MK-82 Ballute or 275 Gal Fuel Tank	MK-82 Ballute	550 (2)(3)	+6.0 to -2.0 (3)(4)	+4.0 to -0.0	29.0 to 31.4 (5)	26.0 to 30.3 (5)	550 (Low drag or ballute)	+0.5 to +4.0	45°	N/A	N/A	N/A	300-325	13 S&L

NOTE: No-delay ballute functioning releases will be conducted from outboard station only.

STORE INDEX NOS.

	OUTBOARD	INTERMEDIATE	INBOARD PYLON
F-100D	30	14	-10
F-100F	29	16	- 9

NOTES:
1. Left wing loading shown, right wing loading symmetrical to left.
2. Do not exceed Mach .90 below 10,000 ft. Mach .95 between 10,000 and 25,000 ft. or Mach 1.0 above 25,000 ft.
3. Fuel tank limitations as outlined in T.O. 1F-100D(I)-1 must be observed where applicable.
4. Limit is 5.0 G when load is asymmetrical or when internal fuel is more than 4200 lbs.
5. C.G. ranges are calculated for full 275 gal. fuel tanks on intermediate stations, and MK-82 ballutes on inboard and outboard stations.

ATCH 1

APPENDIX II

BALLISTIC ANALYSIS FOR MK 82 WITH BALLUTE RETARDER SYSTEM

by

Munitions Ballistics and Delivery Data Analysis Branch
Weapons Systems Analysis Division
Air Force Armament Laboratory (AFSC)
Eglin Air Force Base, Florida 32542

This ballistic analysis covers data obtained from F-100 aircraft ballistic drops made at Eglin AFB, FL under Project 1559W055.

The objectives of this analysis were to determine the drag coefficients (K_D) for the bomb/ballute system in the low drag configuration, for both the 29-inch and 41-inch diameter ballutes and ballistic dispersion.

Release conditions were taken from aircraft flight data at T=O and from a point on the bomb trajectory data. Using these release conditions, the observed winds, temperatures, and densities aloft, and actual munition weights, theoretical trajectories were computed. The observed and theoretical trajectories were then compared. Based on this comparison, the drag coefficients were revised and new theoretical trajectories were computed. This process was repeated until a satisfactory match to the observed data was obtained and final comparisons were made. The ballistic dispersions were based upon this final ballistic comparison.

The ballistic results are tabulated in Tables II-1 and II-2. The data tabulated consist of the differences, ΔX (for range), ΔZ (for deflection), and ΔT (for the time of flight), between observed and computed data at the height of impact used along with the PE (probable error) and CEP (circular probable error) of the differences about their mean. The drag coefficients for all systems derived from these tests are shown in Figure II-1.

It should be noted that the drops in Table II-1 made on 16 January 1973, pass 4 and 19 January 1973 passes 2, 3, and 4 were delayed ballute opening trajectories. The item tracking data on these passes were obtained from a two station solution and some coverage was lost due to the size of the item, the sun angle, and distance from release point.

It should also be noted that there was no apparent difference between ballistics for the original configuration of the MK 82 w/GAC Canister (12 October 1972, pass 1, 2, and 3) from the ballistics of MK 82 w/GAC Canister with shortened length and fin span (24 January 1973, pass 3 and 4, 26 January 1973, pass 3).

Ballistic dispersion is commonly measured in terms of CEP in mils. Values of 3 to 7 mils are considered to be typical of low-drag general purpose bombs such as the MK 82. CEP values of 3 to 13 mils were obtained for the freefall MK 82 w/GAC Canister. A CEP value of 12 mils was obtained for the 41-inch ballute test drops. No ballute dispersion value was obtained for the 29-inch ballute due to insufficient data.

Both the 41-inch ballute and 29-inch ballute result in a higher drag for the MK 82 bomb. The terminal velocity calculated from the drag coefficients derived from this test is 333 feet per second for the 41-inch ballute retarded MK 82 bomb and 454 feet per second for the 29-inch ballute retarded MK 82 bomb.

The CEP is a measure of the dispersion and is defined as follows:

$$CEP(FT) = .8728(PE_{\Delta X} + PE_{\Delta Z})$$

$$CEP(MILS) = \frac{CEP(FT) \times 1000}{AVG\ TRAJ\ ARC\ LENGTH}$$

WHERE

$$PE = .6545 \sqrt{\frac{N}{N-1}}\ S$$

S = Standard Deviation

N = Number in Sample

Table II-1. Ballistic data for MK 82 w/ballute canister straight and level releases (F-100)

DATE	PASS	STATION	REL ALT ABOVE MSL	IMP ALT ABOVE MSL USED	REL MACH NO	OBS TIME OF FALL	COMP TRAJ ARC LENGTH	COMPARISON I (A/C RELEASE CONDITIONS)			COMP TRAJ ARC LENGTH	COMPARISON II (REL TAKEN FROM OBS BOMB TRAJ)		
								ΔX	ΔZ	ΔT		ΔX	ΔZ	ΔT
			FT	FT		SEC	FT	FT	FT	FT	FT	FT	FT	FT
12Oct72	1	LT OUTB	4057	677	.57	14.40	9404	11	41	.19	8541	-13	31	.08
17Oct72	1	LT OUTB	4145	631	.60	15.00	10203	44	-17	.06	9444	4	-16	-.05
	2	RT OUTB	4224	690	.59	14.20	9690	-39	-15	-.03	8967	21	0	.02
24Oct72	1	LT OUTB	2701	639	.58	11.00	7115	50	20	.08	6519	-4	15	-.04
24Jan73	1	LT OUTB	3945	695	.53	14.00	8443	34	-27	-.04	7835	49	-10	.01
						AVG(N=5)	8971	20	0	.05	8261	11	4	.00
						PE		24	19			16	13	
						CEP(FT)		38				26		
						CEP(MILS)		4.3				3.1		
12Oct72	2	RT OUTB	4314	778	.72	14.80	11883	-118	65	-.04	10856	-51	86	-.01
	3	LT INB	4115	700	.78	14.60	12584	-96	-31	-.16	11570	52	-3	-.04
24Jan73	4	RT INB	3923	689	.70	14.20	10813	-61	11	-.22	9806	28	-1	-.11
25Jan73	3	RT INB	3871	717	.76	13.80	11663	-93	54	-.24	10651	74	49	-.06
						AVG(N=4)	11736	-90	25	-.17	10721	26	33	-.06
						PE		19	30			37	29	
						CEP(FT)		42				57		
						CEP(MILS)		3.6				5.3		
16Jan73	4	RT INB	15498	4002	.85	26.40	24279	-377	203	-.41	22376	-237	97	-.37
1[illegible]Jan73	2	RT OUTB	15496	5024	.86	26.60	24163	-313	-78	-.06	22711	-148	-18	.09
	3	LT INB	15737	4533	.85	27.20	24726	-40	759	-.16	23738	45	798	-.10
	4	RT INB	15529	5079	.85	26.80	24092	-449	-44	.19	22906	-353	-80	.19
						AVG(N=4)	24315	-295	210	-.11	22933	-173	199	-.05
						PE		121	261			113	274	
						CEP(FT)		333				338		
						CEP(MILS)		13.7				14.7		

Table II-2. Ballistic data for no delay ballute (F-100)

DATE	PASS	STATION	REL ALT ABOVE MSL FT	IMP ALT ABOVE MSL USED FT	REL MACH NO	OBS TIME OF FALL SEC	COMP TRAJ ARC LENGTH FT	COMPARISON I (A/C RELEASE CONDITIONS) ΔX FT	ΔZ FT	ΔT FT	COMP TRAJ ARC LENGTH FT	COMPARISON II (REL TAKEN FROM OBS BOMB TRAJ) ΔX FT	ΔZ FT	ΔT FT
MK82 W/41-INCH BALLUTE														
22Nov72	2	RT OUTB	2963	492	.56	15.00	5357	-129	97	-.08	4731	-39	78	-.04
15Jan73	2	RT OUTB	4068	504	.59	18.60	6830	-112	-50	-.06	5628	-55	-50	-.06
						AVG(N=2)	6094	-121	24	-.07	5180	-47	14	-.05
						PE		9				8	61	
						CEP(FT)		70				60		
						CEP(MILS)		11.5				11.6		
19Jan73	1	LT OUTB	4144	541	.71	19.20	7341	26	-32	.03	6015	20	-22	.02
24Jan73	2	RT OUTB	3894	542	.77	18.20	7089	156	51	.08	5737	75	44	.04
						AVG(N=2)	7215	91	10	.05	5876	48	11	.03
						PE		62	40			27	31	
						CEP(FT)		89				51		
						CEP(MILS)		12.3				8.6		
MK82 W/29-INCH BALLUTE														
16Jan73	1	LT OUTB	4108	590	.59	17.00	7746	-296	-67	.01	6346	-32	-32	-.01
22Nov72	1	LT OUTB	2870	526	.55	BALLUTE DID NOT FULLY INFLATE								
26Jan73	1	LT OUTB	3794	616	.76	16.60	8749	-97	8	.02	8213	-65	33	.05
24Jan73	1	LT OUTB	3914	554	.73	BALLUTE DID NOT FULLY INFLATE								
25Jan73	4	LT OUTB	3704	563	.81	16.20	8815	42	57	.02	8299	19	50	-.01

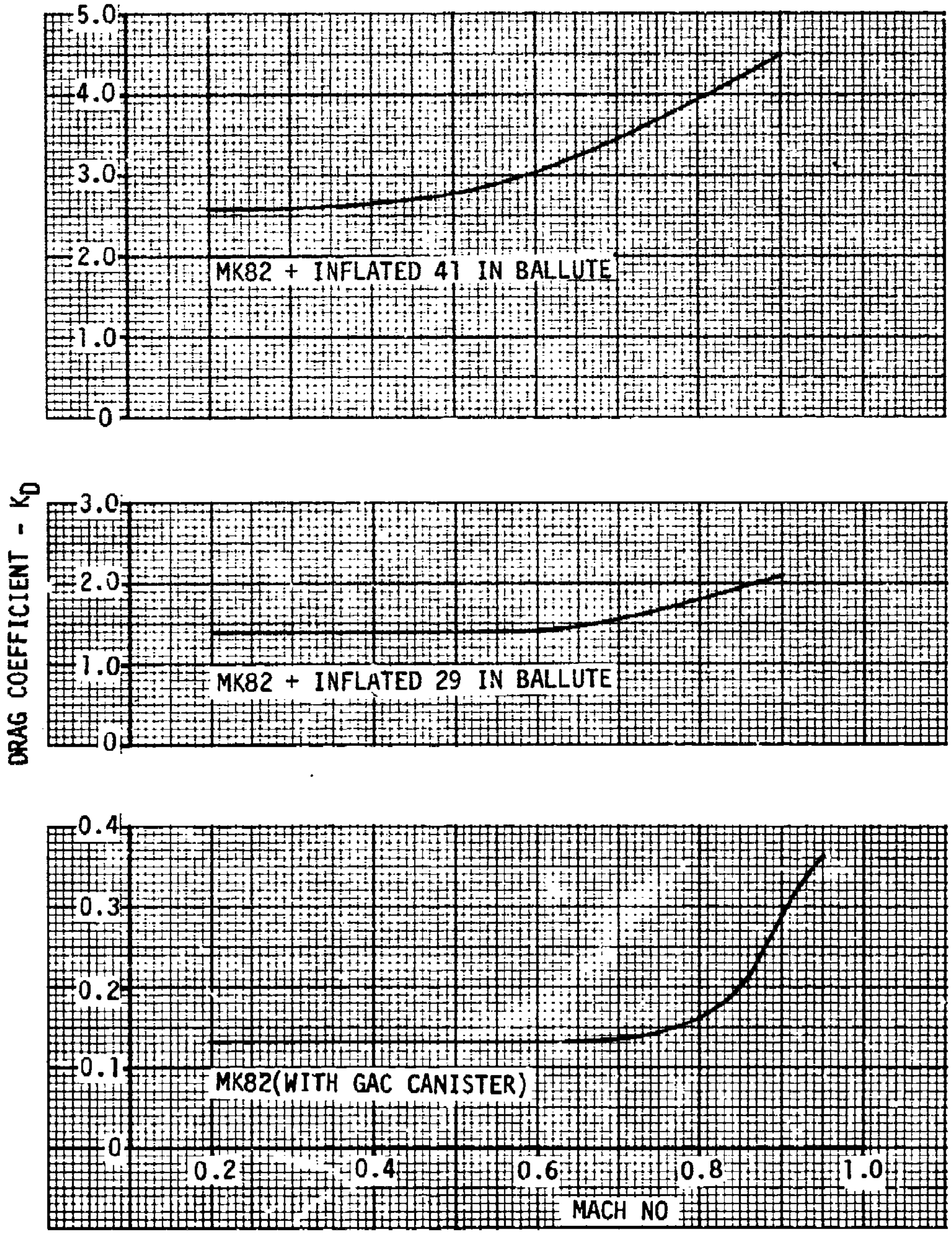

Figure II-1. Drag coefficients of MK 82 bomb with GAC ballutes and canister

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Armament Development and Test Center Eglin Air Force Base, Florida 32542	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP ---

3. REPORT TITLE
EVALUATION OF A BALLUTE RETARDER SYSTEM FOR THE MK 82 BOMB

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Final Report (12 June 1972 - 4 March 1973)

5. AUTHOR(S) (First name, middle initial, last name)
Richard A. Evors

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
May 1973	45	---

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S) ADTC-TR-73-31
b. PROJECT NO. 1559W055	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT
Distribution limited to US Government agencies only, because document covers test and evaluation of military hardware (MAY 1973). Other requests for this document must be referred to ADTC (DLA), Eglin AFB, FL 32542.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
Available in DDC	Armament Development and Test Center Eglin Air Force Base, Florida 32542

13. ABSTRACT

This report contains results of tests conducted to evaluate a ballute retardation system (combination balloon/parachute) for a MK 82 bomb. The system tested provided for a low drag configuration or either of two types of high drag options. One high drag option (29-inch diameter ballute) was designed for mine application and the other (41-inch diameter ballute) for general purpose bomb application. Tests demonstrated the system was physically compatible with the F-100 and F-4 aircraft. Flight tests demonstrated the system could be safely carried and released from the F-100 aircraft in level flight up to 550 KTAS. Ballistic data were obtained on all configurations used during the flight test. The average time for the 29-inch and 41-inch diameter ballute to fully inflate after release was 0.8 second and 0.7 second, respectively. The G-loads experienced during deployment of the 41-inch diameter ballute were sufficient to arm three of four FMU-54/B fuzes tested. The fourth fuze did not arm. Burial characteristics for the 29-inch diameter ballute varied from 2 to 8 feet horizontal travel from impact point, 5 to 12 feet deep, and at an attitude of 45 to 90 degrees nose-down. The ballute system successfully functioned 12 of 15 times tested. One of the 41-inch diameter ballute fabrics tore loose from the canister during deployment and two 29-inch diameter ballutes fluttered from release to impact.

DD FORM 1 NOV 65 1473

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Ballute retarder system						
MK 82 bomb						
F-100 aircraft						
F-4 aircraft						
M904 fuze						
FMU-54/B fuze						