SOFT RECOVERY SYSTEMS FOR GUN-FIRED PROJECTILE COMPONENTS

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ABSTRACT

Artillery projectile designers have found an ever increasing need to soft recover prototype hardware and componentry in actual gun firings. Further, as projectile fuzes and guidance systems become more sophisticated, and with the increased use of telemetry and on-board memory systems, the soft recovery technique has become a necessity for the projectile development community.

Described herein are parachute soft recovery techniques currently being used by the U.S. Army Armament Research and Development Center (ARDC), Large Caliber Weapon Systems Laboratory, Dover, NJ.

In one parachute recovery system, the complete projectile body section is recovered. In another system, the nose-fuze/TM section is recovered. And in a third system, a jettisoned canister, housing electro-mechanical components, is recovered.

INTRODUCTION

The gun firing environment is a specific combination of linear, angular, and radial accelerations. This environment can only be accomplished in actual gun firings. Hence, in projectile design and development, prototype hardware and componentry must be proof tested in actual gun firings.

It is desirable to examine the projectile or projectile components after gun firing and after in-flight component functioning (timed sequences). It is required, therefore, that the in-flight condition be preserved and not damaged or altered during the deceleration process.

The use of deployable aerodynamic decelerators (namely parachutes) for soft recovery of projectiles and projectile componentry is described in this report.

In Section A, a nose deployed parachute module assembly is described. This module replaces the fuze/ogive section of the projectile. In application, the test projectile is fired vertically and the parachute is deployed by a time fuze shortly after the projectile has started to fall back to earth. The complete, as-fired projectile, less the parachute module windshield, is soft-recovered by parachute. This system has been widely used with both 155mm and 8-inch test projectiles.

In Section B, two (2) base deployed parachute recovery systems, designed specifically for test firing and soft recovery of nose mounted, 155mm and 8-inch projectile fuze and TM packages, are described. In application, the test projectile is fired in a normal trajectory and the parachute is deployed at high velocity, by a time fuze, several seconds before impact.

In Section C, a modified standard M485E2 Illuminating Projectile for use as a parachute recovery test vehicle for small electromechanical componentry is described.

SECTION A: VERTICAL FIRING AND PARACHUTE SOFT RECOVERY

The nose-deployed parachute module, which is used to soft recover the complete projectile body section, replaces the nose/ogive section of the projectile. In application, the test projectile is fired nearly vertically (see Fig. 1&2), and the parachute is deployed by a time fuze shortly after the projectile has reached apogee (maximum altitude) and has started to fall back to earth, base first. The complete as-fired projectile, less the parachute module windshield is soft recovered by parachute (see Fig. 3). The ground impact is base first and the impact g's as a function of impact velocity is indicated in Fig. 4 for various projectile payloads.

The nose-deployed parachute module assembly is a pressure actuated device which uses a black powder expulsion charge initiated by a nose mounted, spin and setback actuated, time fuze. The pressure generated by the expulsion charge acts between the inner parachute canister and outer windshield, causing the windshield to move forward, shearing its restraints. The inner parachute canister is captured by the windshield and both parts are ejected off the nose of the projectile along its longitudinal axis.

The parachute is attached to the projecitle body by means of a bearing assembly which decouples the spinning payload from the parachute. The parachute is packed in a deployment bag which provides an ordered opening sequence of parachute lines first and then canopy deployment.

The nose-deployed parachute module was designed to withstand the 155mm (Zone 8S) proof test environment (17,000 g's, 2900 fps and 16,000 RPM). The module is

approximately 12.6 inches long (including the nose mounted fuze) and weighs 9.0 pounds. The module can be mounted directly to several standard type 155mm projectile bodies and by use of adapters or by modifying projectile bodies can adapt to most 155mm and 8-inch projectiles.

The (workhorse) parachute was sized to provide a 100fps descent rate for a 155mm (901b) payload and a 150fps descent rate for an 8-inch (200 lb) projectile payload. The ground impact g's are approximately 600 and 700 g's respectively.

It has been demonstrated that the nose-deployed parachute recovery concept is applicable over a broad range of projectile calibers, muzzle velocities, spin rates, and launch g's, and also provides long flight time for testing of in-flight functioning sequences. Not only is the capability of soft recovery of a complete gun-fired projectile realized, but also the capability of testing smaller electromechanical functioning components. The technique of vertical firing with parachute recovery has, however, not only a high potential in the field of artillery design and proof testing, but is also adaptable to a modular concept of storing various parachute modules and various carrier vehicles for a stockpiled "on-the-shelf" soft recovery testing capability.

The successful development of the nose-deployed parachute soft recovery system may be regarded as representing a breakthrough in the art of projectile diagnostic testing. It has permitted not only a reduction in test quantities and an increase in useful data, but has reduced complete projectile soft recovery test costs by an order of magnitude.

SECTION B: BASE-DEPLOYED PARACHUTE RECOVERY SYSTEMS

These systems were designed for field testing and soft recovery of nose mounted radar fuzes (and telemeter packages) so that the test conditions duplicate extreme launch and flight environments that the item could experience in use. The parachute system allows for recovery of the fuze and telemeter payload which permits analysis of each fuze subsystem and reuse of the telemeter components for future tests.

In application, the base deployed parachute recovery projectiles are fired in a normal ballistic trajectory (25-65°QE) and the parachute is deployed several seconds before ballistic impact (see Fig. 5, 6, and 7). The recovered fuze and telemeter package is decellerated to a nominal descent velocity of approximately 120 fps. and the nose-first impact into sandy soil is approximately 300 g's (see Fig. 8) with little or no impact damage to either the nose mounted fuze or telemetry instrumentation (see Fig. 9).

The 155mm base deployed parachute recovery projectile (see Fig. 5) has a single function which jettisons the projectile base plug and spacers and deploys the parachute (see Fig. 7).

This recovery projectile was designed for the 155mm proof test levels (17,000 g's) and uses the M549 projectile as a spotting round. Parachute deployment is initiated by a time fuze which ignites a black powder expulsion charge. The pressure generated by the expulsion charge moves the parachute/piston assembly rearward, jettisoning the base plug and split ring supports and deploying the parachute. The piston, to which the parachute/bearing assembly is attached, is then captured at the end of its piston-like stroke. The parachute is de-coupled from the spinning payload (16,000 RPM at launch) by a bearing system.

The 8-inch base deployed parachute recovery projectile has two (2) timed functions (see Fig. 6). The first function separates the heavy 8-inch projectile base section from the payload/parachute section, and the second function, several seconds later, deploys the parachute.

The recovery package, 65 lbs. after parachute deployment, is comparable to the 155mm recovery package, 75 lbs. Thus the same parachute and bearing assembly is used in both recovery systems.

The 8-inch base deployed parachute recovery projectile was designed for the 8-inch projectile proof test levels (11,000 g's) and uses the M650 projectile as a spotting round.

The ability to recover the fuzes intact, which these parachute recovery rounds made possible, is a very valuable tool to Harry Diamond Laboratories, HDL, for post mortem analysis of fuze performance. Without these rounds HDL had no satisfactory method of recovering gun-fired fuzes. Secondly, the prototype fuze hardware, which is extremely expensive and in short supply, can be rebuilt (several times) for additional tests.

SECTION C: COMPONENT TESTING AND RECOVERY SYSTEM

A modified 155mm M485E2 Illuminating Round was developed to perform as a parachute recovery system for the structual assessment of small developmental electromechanical components. The projectile is modified by replacing the illuminant charge in the illuminant container with a container that is packaged with the components to be tested. The space available for the components is approximately 7 inches long by 4 inches in diameter, and is limited to approximately 6.0 pounds.

The projectile, with fuze M565, is 28.4 inches long, 6.1 inches in diameter and weighs 93.6 pounds. The modified M485E2 illuminating projectile is considered safe to store, transport, and fire with fuze M565 between temperature extremes of -65°F and +145°F from the 155mm Howitzers, M45, M114 and M109 with propelling charges M3A1, M4A2

and M119A1 (with improved main parachute). The maximum environments are 11,300 g's, 13,470 RPM, and 2245 fps velocity.

In application, the projectile is fired for an airburst event where the drogue parachute and canister loading assembly is jettisoned from the base of the projectile. The drogue parachute decelerates the canister loading assembly for approximately 7 seconds after which a pyrotechnic delay train initiates a secondary event where the payload canister is ejected and the main parachute is deployed (see Fig.10). The payload descends at approximately 15 feet per second.

A major advantage of utilizing the modified M485E2 projectile as a soft recovery test vehicle is its low cost availability from standard Amy stockpile.

REFERENCES

Fritch, Paul L., "A System for Vertical Firing and Parachute Recovery of Military Projectiles", Technical Report 4627. Picatinny Arsenal, Dover, N.J. 07801, May 1984.

Fritch, Paul L., "Design and Development of 8-Inch Artillery-Fired, Parachute-Recovery Projectile System", Technical Report ARLCD-TR-77034. Picatinny Arsenal, Dover, N.J. 07801, June 1978.

Fritch, Paul L., "Parachute Recovery Systems for XM517 Projectile Development-Progress Report", Technical Report 4482. Picatinny Arsenal, Dover, N.J. 07801, March 1973.

Gratts, A., "Report on the Development of a Modified PXR 6142 155mm, M485E2 Illuminating Round as a Parachute Soft Recovery System for the Structual Assessment of Small Developmental Electro-Mechanical Components", Picatinny Arsenal, Dover, N.J. 07801, February 1971.

VERTICAL FIRING AND PARACHUTE SOFT RECOVERY FOR 155MM AND 8-INCH PROJECTILES

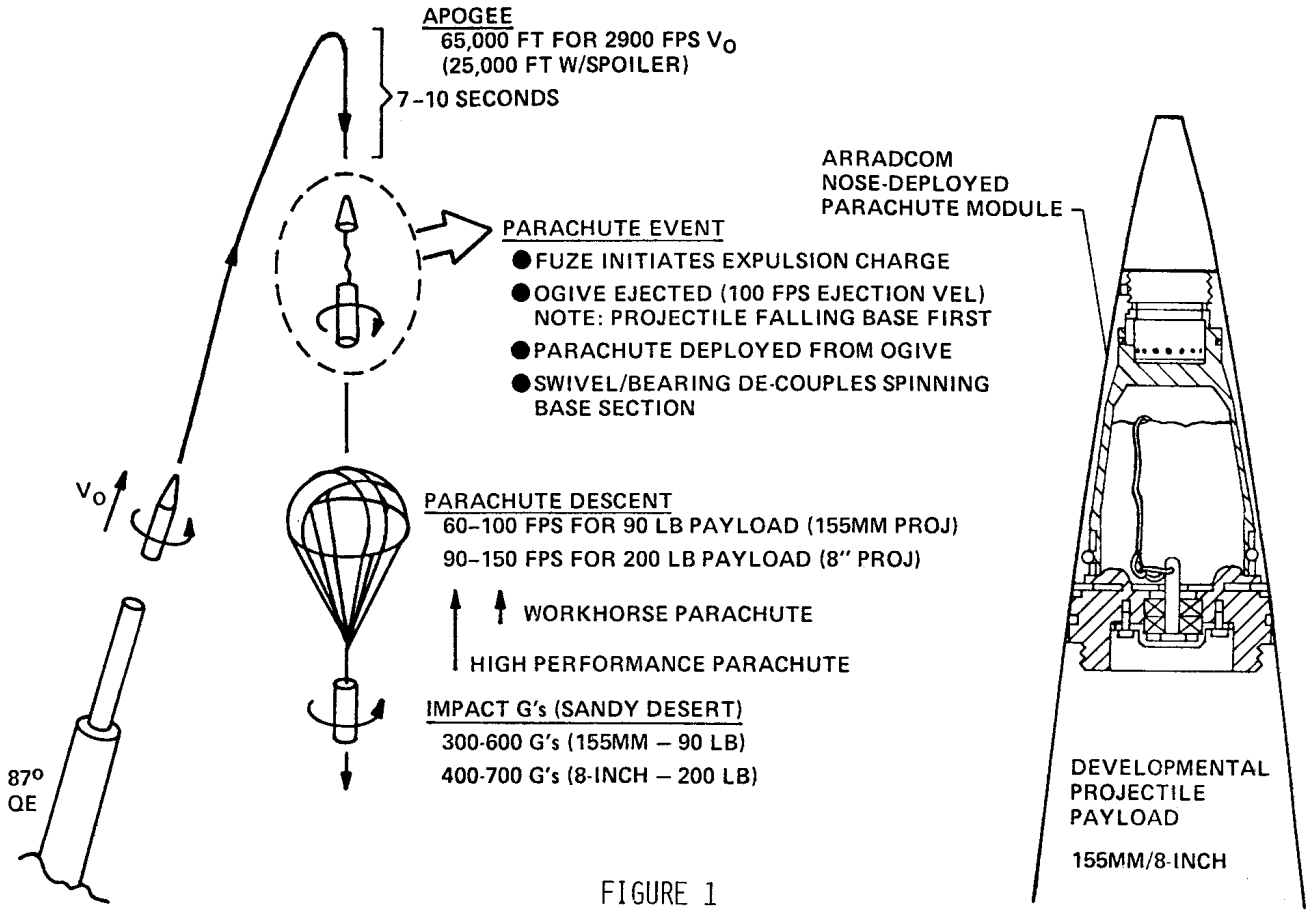

FIGURE 1

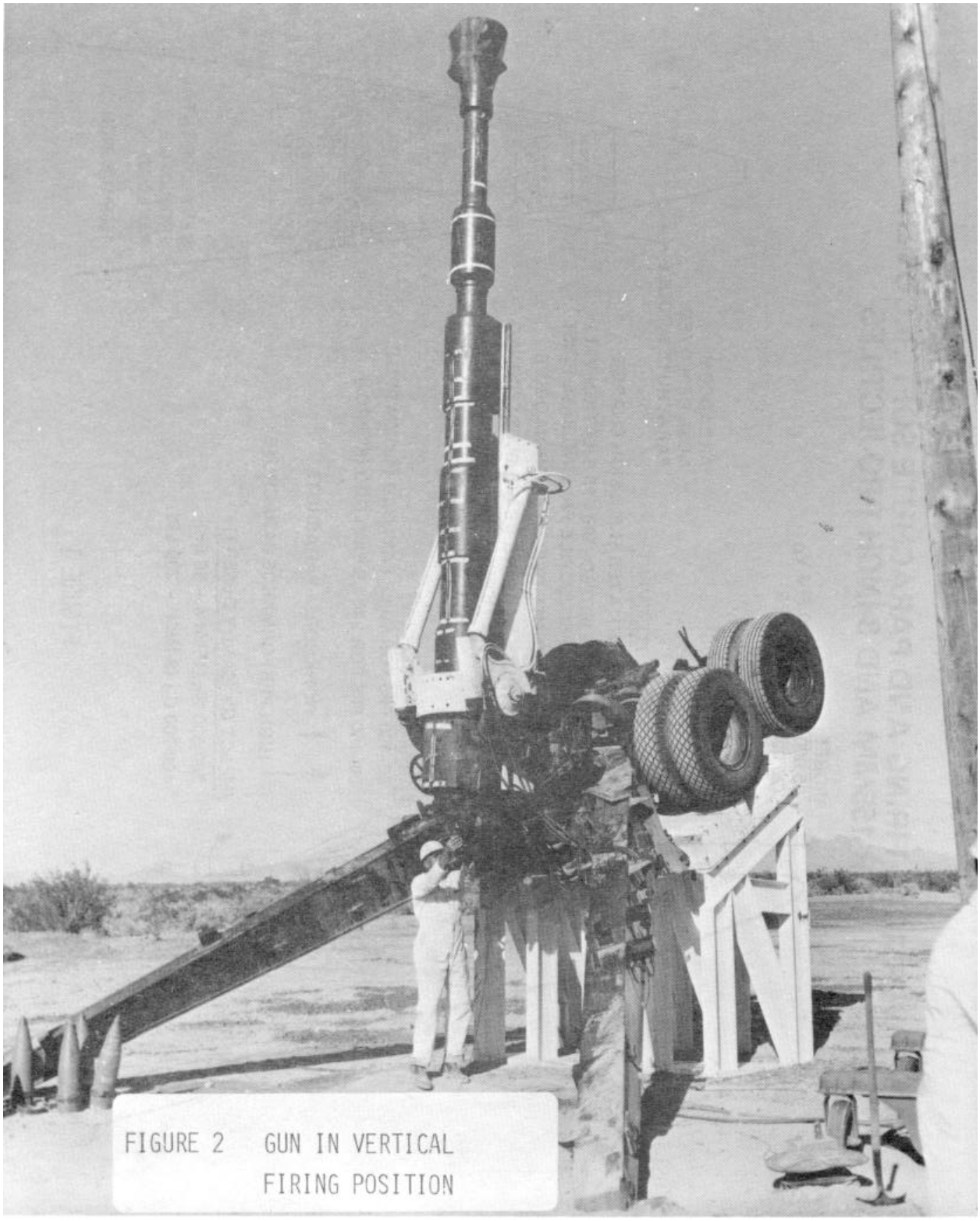

FIGURE 2 GUN IN VERTICAL FIRING POSITION

FIGURE 3 RECOVERED PROJECTILE - VERTICAL RECOVERY

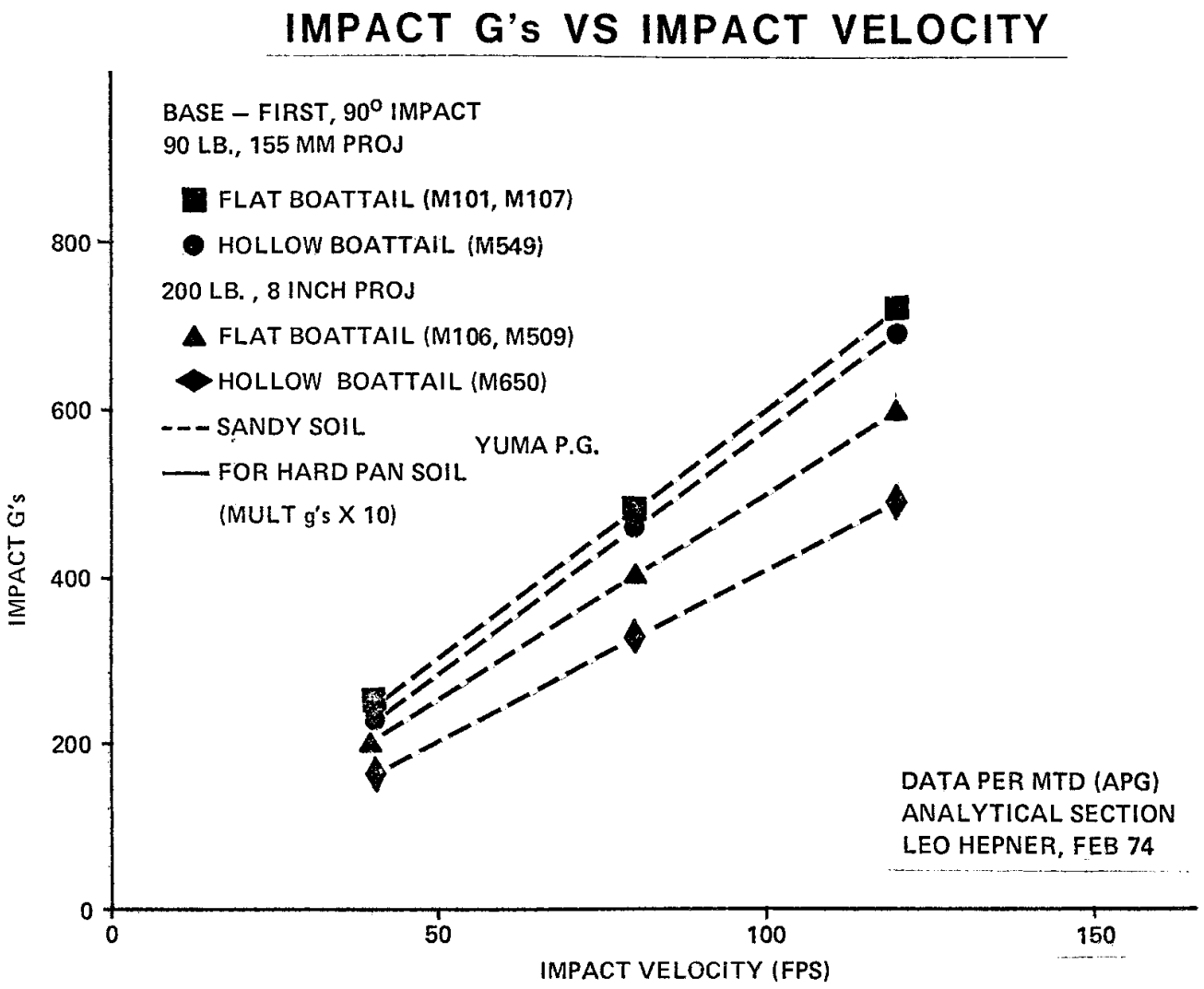
IMPACT G's VS IMPACT VELOCITY
BASE – FIRST, 90° IMPACT
90 LB., 155 MM PROJ
FLAT BOATTAIL (M101, M107)
HOLLOW BOATTAIL (M549)
200 LB. , 8 INCH PROJ
FLAT BOATTAIL (M106, M509)
HOLLOW BOATTAIL (M650)
SANDY SOIL
FOR HARD PAN SOIL
(MULT g's X 10)
YUMA P.G.
DATA PER MTD (APG)
ANALYTICAL SECTION
LEO HEPNER, FEB 74
IMPACT G's
IMPACT VELOCITY (FPS)
0
200
400
600
800
0
50
100
150

FIGURE 4

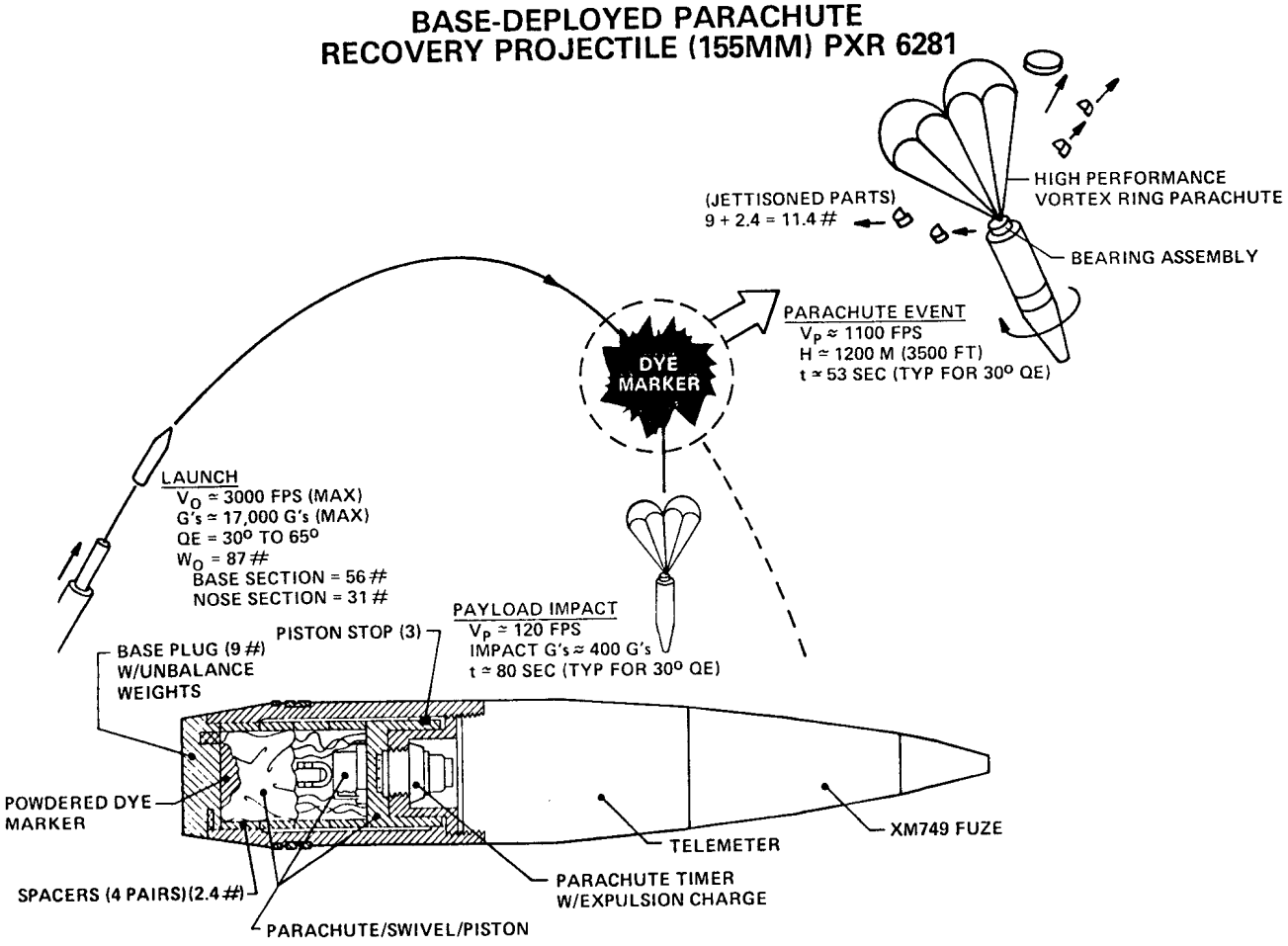
BASE-DEPLOYED PARACHUTE
RECOVERY PROJECTILE (155MM) PXR 6281
HIGH PERFORMANCE
VORTEX RING PARACHUTE
(JETTISONED PARTS)
9 + 2.4 = 11.4 #
BEARING ASSEMBLY
PARACHUTE EVENT
$V_P \approx$ 1100 FPS
H ≈ 1200 M (3500 FT)
t ≈ 53 SEC (TYP FOR 30° QE)
DYE MARKER
LAUNCH
$V_O \simeq$ 3000 FPS (MAX)
G's ≈ 17,000 G's (MAX)
QE = 30° TO 65°
W_O = 87 #
BASE SECTION = 56 #
NOSE SECTION = 31 #
PAYLOAD IMPACT
$V_P \simeq$ 120 FPS
IMPACT G's ≈ 400 G's
t ≈ 80 SEC (TYP FOR 30° QE)
PISTON STOP (3)
BASE PLUG (9 #)
W/UNBALANCE
WEIGHTS
POWDERED DYE
MARKER
SPACERS (4 PAIRS)(2.4 #)
PARACHUTE/SWIVEL/PISTON
PARACHUTE TIMER
W/EXPULSION CHARGE
TELEMETER
XM749 FUZE

FIGURE 5

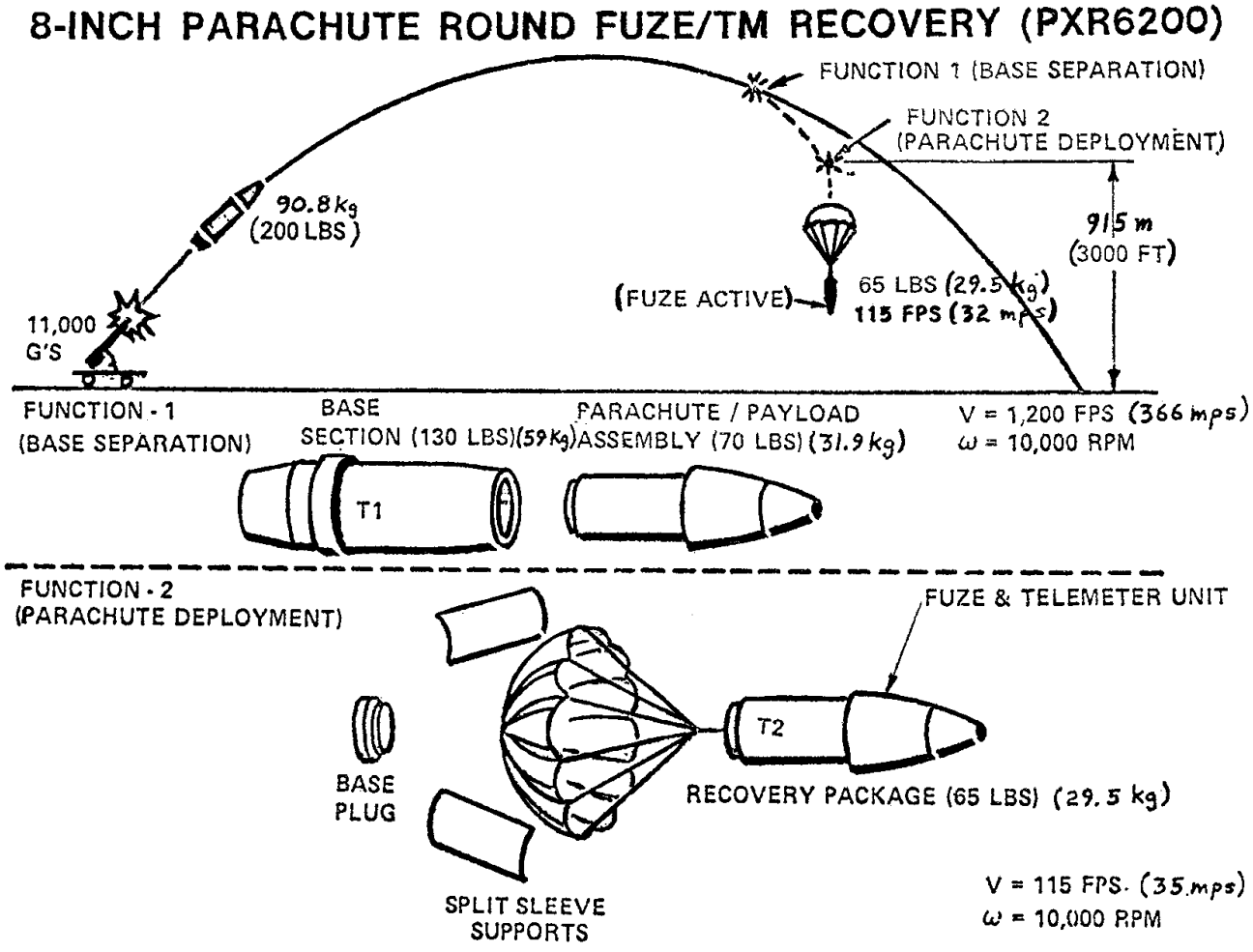
8-INCH PARACHUTE ROUND FUZE/TM RECOVERY (PXR6200)
FUNCTION 1 (BASE SEPARATION)
FUNCTION 2
(PARACHUTE DEPLOYMENT)
90.8 kg
(200 LBS)
915 m
(3000 FT)
(FUZE ACTIVE)
65 LBS (29.5 kg)
115 FPS (32 mps)
11,000
G'S
FUNCTION - 1
(BASE SEPARATION)
BASE
SECTION (130 LBS)(59 kg)
PARACHUTE / PAYLOAD
ASSEMBLY (70 LBS) (31.9 kg)
V = 1,200 FPS (366 mps)
ω = 10,000 RPM
T1
FUNCTION - 2
(PARACHUTE DEPLOYMENT)
FUZE & TELEMETER UNIT
T2
BASE
PLUG
RECOVERY PACKAGE (65 LBS) (29.5 kg)
V = 115 FPS. (35 mps)
ω = 10,000 RPM
SPLIT SLEEVE
SUPPORTS

FIGURE 6

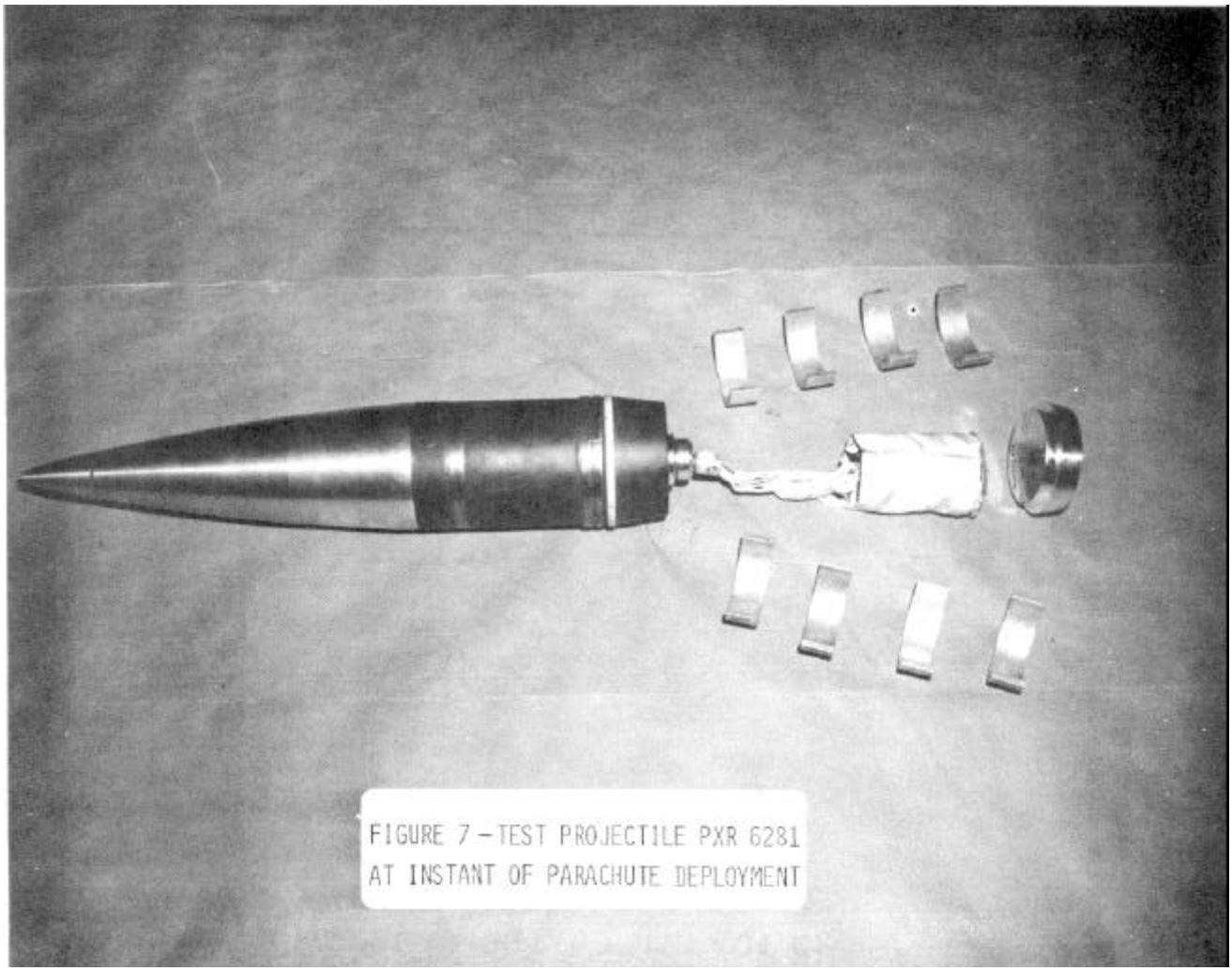

FIGURE 7 – TEST PROJECTILE PXR 6281
AT INSTANT OF PARACHUTE DEPLOYMENT

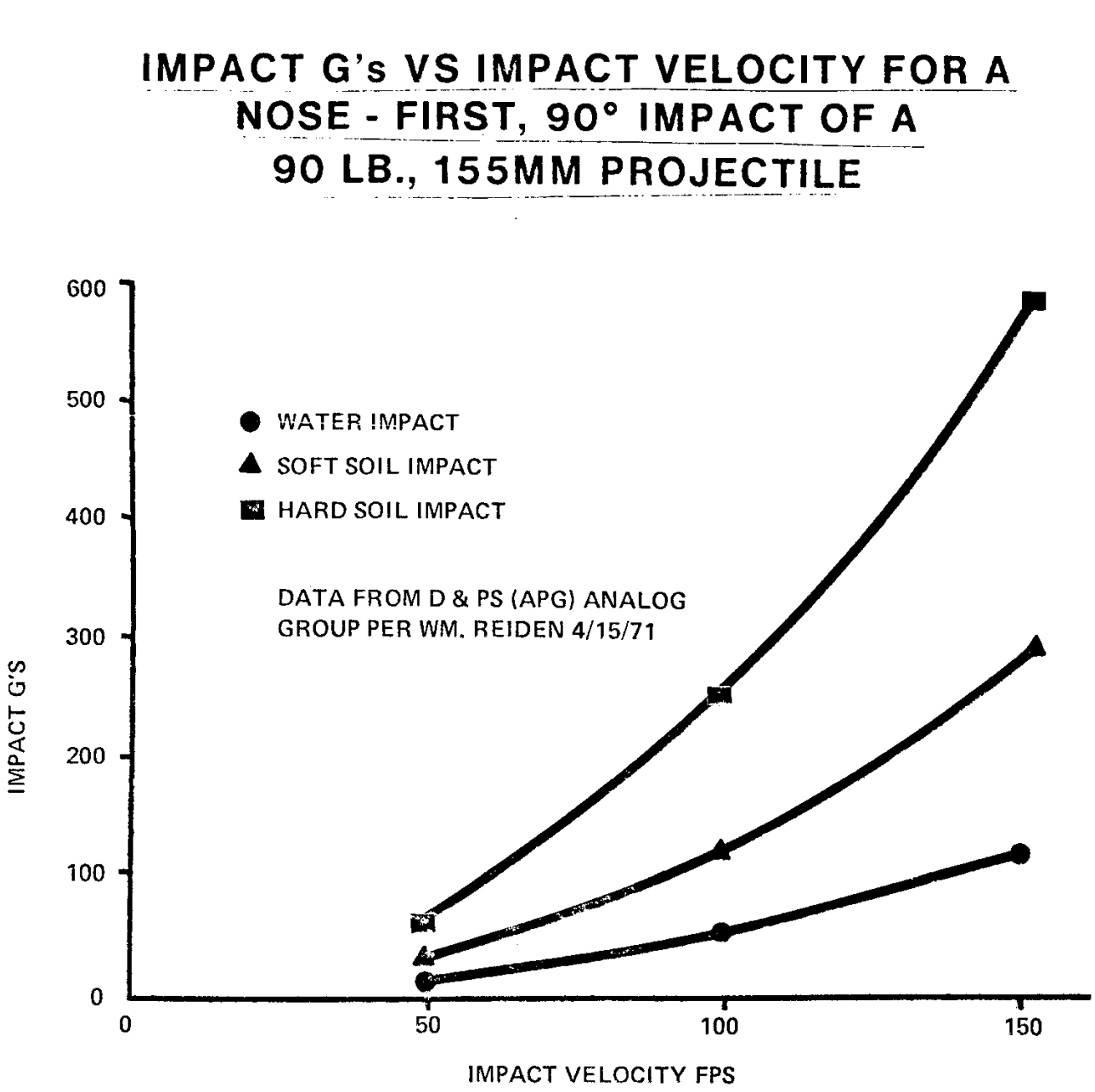
IMPACT G's VS IMPACT VELOCITY FOR A NOSE - FIRST, 90° IMPACT OF A 90 LB., 155MM PROJECTILE
600
500
400
300
200
100
0
IMPACT G'S
WATER IMPACT
SOFT SOIL IMPACT
HARD SOIL IMPACT
DATA FROM D & PS (APG) ANALOG GROUP PER WM. REIDEN 4/15/71
0
50
100
150
IMPACT VELOCITY FPS

FIGURE 8

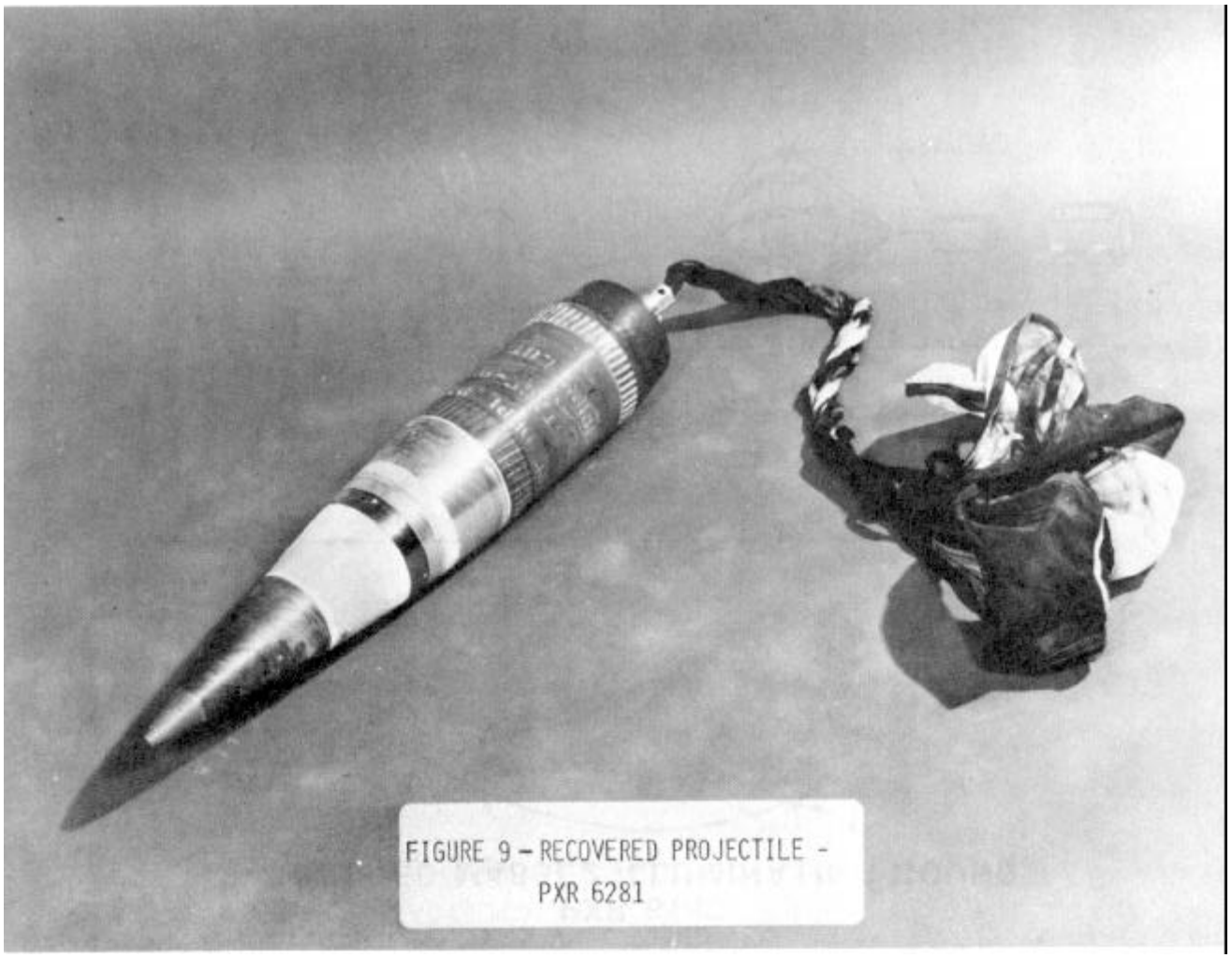

FIGURE 9 - RECOVERED PROJECTILE - PXR 6281

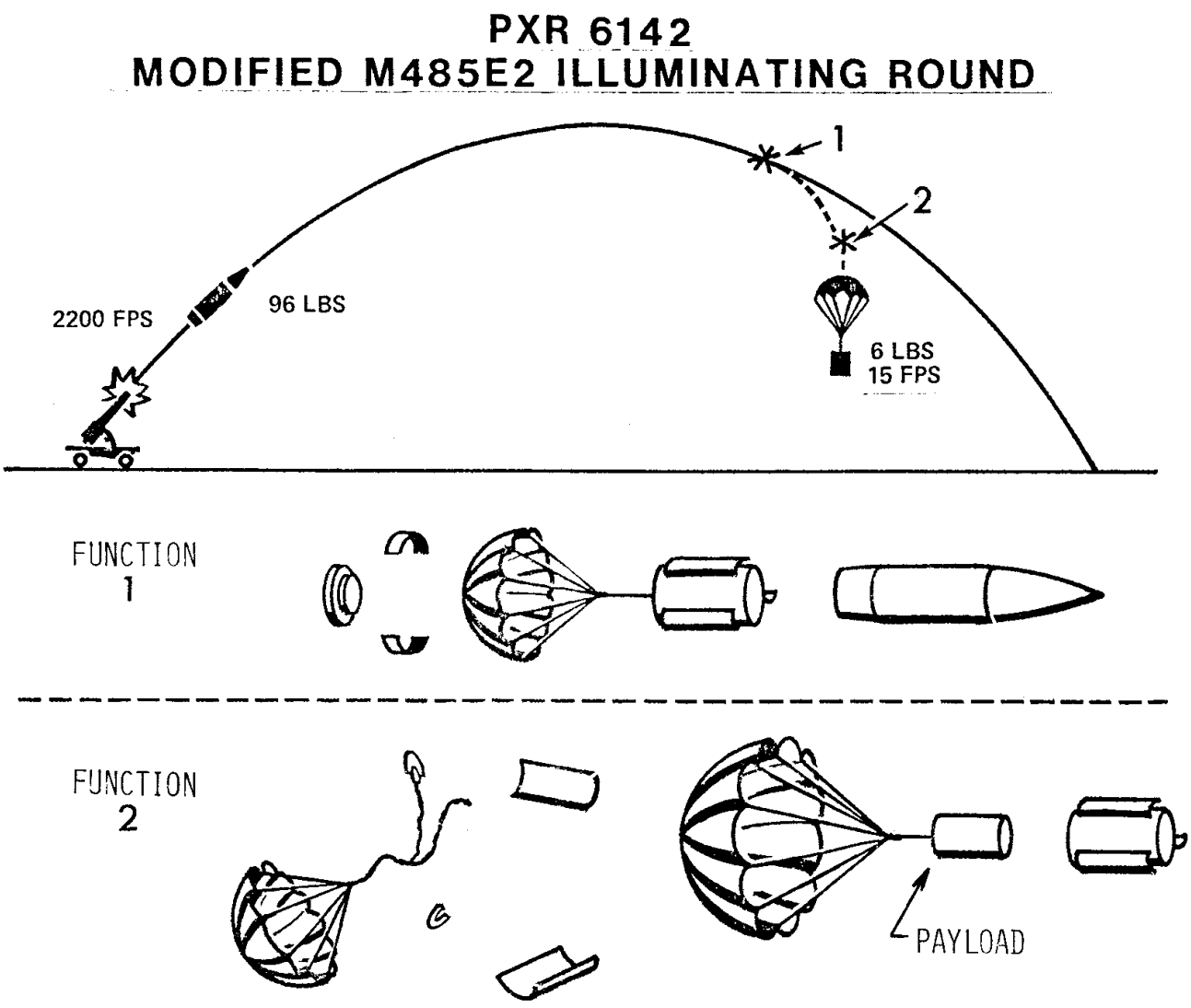
PXR 6142
MODIFIED M485E2 ILLUMINATING ROUND
1
2
2200 FPS
96 LBS
6 LBS
15 FPS
FUNCTION
1
FUNCTION
2
PAYLOAD

FIGURE 10