AD-A187 171 STRESS ANALYSIS OF M549 AND PXR PROJECTILES(U) ARMY BALLISTIC RESEARCH LAB ABERDEEN PROVING GROUND MD M B KRUMMERICH AUG 87 BRL-MR-3633 1/1

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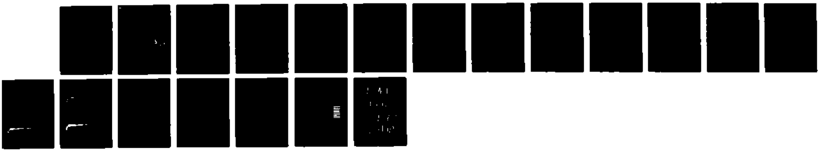

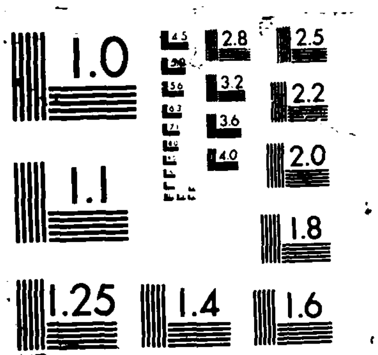
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MEMORANDUM REPORT BRL-MR-3633

STRESS ANALYSIS OF M549 AND PXR PROJECTILES

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MELINDA B. KRUMMERICH

AUGUST 1987

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US ARMY BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MARYLAND

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SECURITY CLASSIFICATION OF THIS PAGE

AD-A187171

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704 0188
Exp Date Jun 30 1986

1a REPORT SECURITY CLASSIFICATION	Unclassified
1b RESTRICTIVE MARKINGS	
2a SECURITY CLASSIFICATION AUTHORITY	
2b DECLASSIFICATION/DOWNGRADING SCHEDULE	
3 DISTRIBUTION/AVAILABILITY OF REPORT	
4 PERFORMING ORGANIZATION REPORT NUMBER(S)	BRL-MR-3633
5 MONITORING ORGANIZATION REPORT NUMBER(S)	
6a NAME OF PERFORMING ORGANIZATION	USA Ballistic Research Laboratory
6b OFFICE SYMBOL (If applicable)	SLCBR-IB
7a NAME OF MONITORING ORGANIZATION	
6c ADDRESS (City, State, and ZIP Code)	Aberdeen Proving Ground, MD 21005-5066
7b ADDRESS (City, State, and ZIP Code)	
8a NAME OF FUNDING/SPONSORING ORGANIZATION	
8b OFFICE SYMBOL (If applicable)	
9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c ADDRESS (City, State, and ZIP Code)	

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
1L162618	AH80		

11 TITLE (Include Security Classification)

Stress Analysis of M549 and PXR Projectiles

12 PERSONAL AUTHOR(S)

Melinda B. Krummerich

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
FINAL	FROM ____ TO ____		

16 SUPPLEMENTARY NOTATION

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
19	04	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Finite Element Analysis, Projectile Deformation
Projectile Design Analysis,
Projectile Stresses

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

A finite element analysis of the M549 and PXR projectiles was performed to determine the possible causes of unexpected gun tube deformations. Also investigated was the feasibility of adding a scoop to the front of each projectile.

Keywords.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT	21 ABSTRACT SECURITY CLASSIFICATION
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	Unclassified

22a NAME OF RESPONSIBLE INDIVIDUAL	22b TELEPHONE (Include Area Code)	22c OFFICE SYMBOL
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I. INTRODUCTION

This study analyzed the deformation and stress concentrations of the M549 and PXR projectiles using finite element models. The stress analysis program subjected these models to a static loading which simulated the in-bore environment. The deflection of each projectile outer surface was examined for unusual deformations which might cause excessive gun tube wear.

A second phase of the study examined the feasibility of adding a scoop to the front end of each projectile. The scoop, assumed to be the same steel as its associated projectile, was modeled on the 155-mm water scoop designed by Honeywell. Results show that both the M549 and the PXR may be so modified.

II. STRUCTURAL ANALYSIS

The inert model of the M549 is a thin-walled, two-piece projectile of high-yield warhead steel (180,000 psi minimum) with an aluminum plug (simulating a rocket nozzle) force fit into the base. Figure 1 shows the configuration of the projectile; the finite element model used in the analysis is shown in Figure 2. The PXR, a single piece M549 simulator round, has thicker walls than the M549 but is made of a much lower strength steel (65,000 psi minimum). The general outside dimensions and the loaded weight are the same for both projectiles. The dimensions of the PXR and its associated finite element model are shown in Figures 3 and 4, respectively.

Both projectiles are loaded externally by a 40,800 psi chamber pressure which extends from the base to the rearward edge of the rotating band seat. Acting along the seat are a 45,000 psi normal pressure and a 9,364 psi shear pressure.

Internally, a fill material exerts a pressure distribution which is assumed to be linear. The pressure increases from zero at the forward edge of each projectile's interior cavity to a maximum pressure at the cavity base. The magnitude of this pressure is dependent on the weight of the fill, the acceleration of the projectile and the average cross-sectional area of the cavity. In the M549, this distribution is slightly different, since there are two cavities. The peak fill pressure is reached at the rear of the longer cavity; the pressure in the smaller cavity increases only to about 80% of the peak.

To balance both the internal and external pressures, an acceleration is applied in the direction of projectile motion. For the M549, this acceleration is 8905 g (286,740 ft/sec2); for the PXR, 8830 g (284,33[illegible] ft/sec2). The accelerations differ since the finite element scheme is based on the unfilled weight of the projectiles.

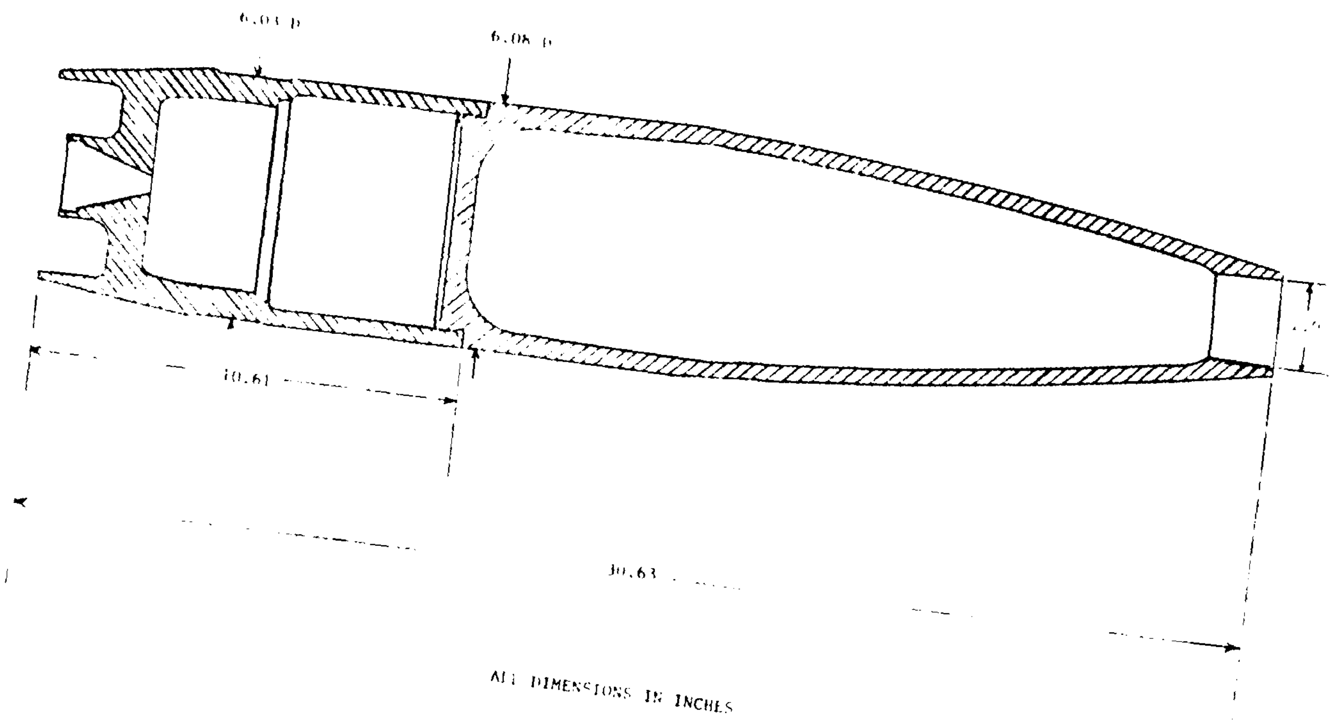

Figure 1. M549 Projectile

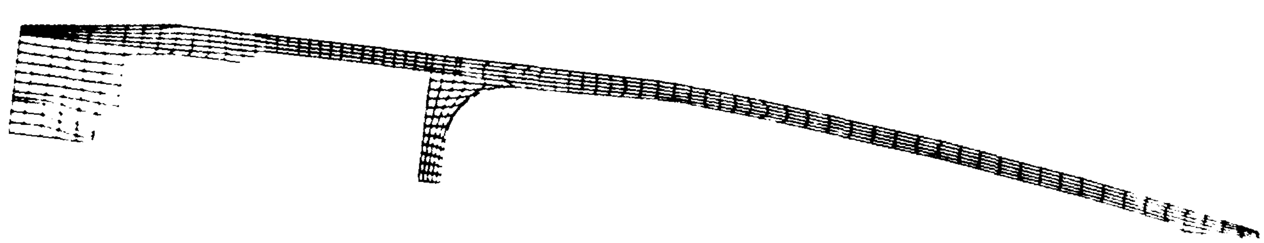

Figure 2. Finite Element Model of M549 Projectile

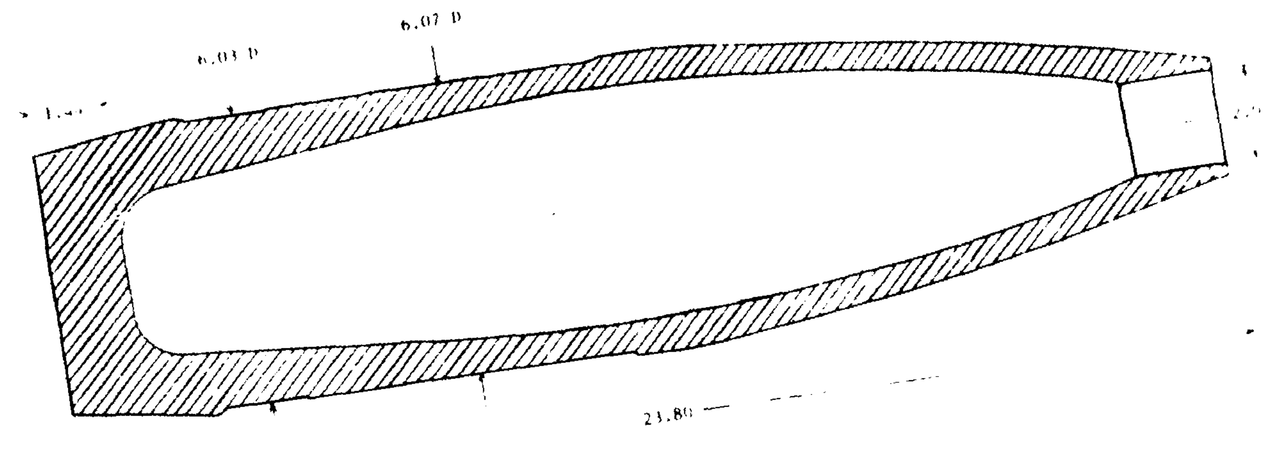

Figure 3. PXR Simulator Projectile

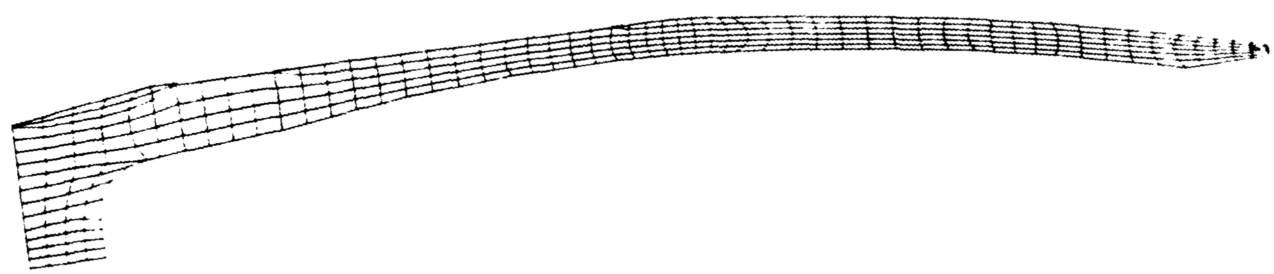

Figure 4. PXR Projectile Finite Element Model

After examining the stresses and deformations of the standard projectiles, design modifications were made to both the M549 and PXR. A scoop, weighing approximately 13.8 pounds, was placed at a point 16.40 inches from the base of the PXR and at 21.10 inches from the base of the M549. The scoop, shown in Figure 5, was assumed to be of the same steel as the projectile on which it was placed. The redesigned finite element models are shown in Figures 6 and 7.

The pressure conditions on the redesigned projectiles were similar to those described earlier. The exterior pressures on the base and along the band seat are the same; the interior pressures are slightly different due to changed weights and interior cavity alterations. Acceleration remained about the same for the M549 (8860 g or 285,290 ft/sec2) and the PXR (8870 g or 285,610 ft/sec2).

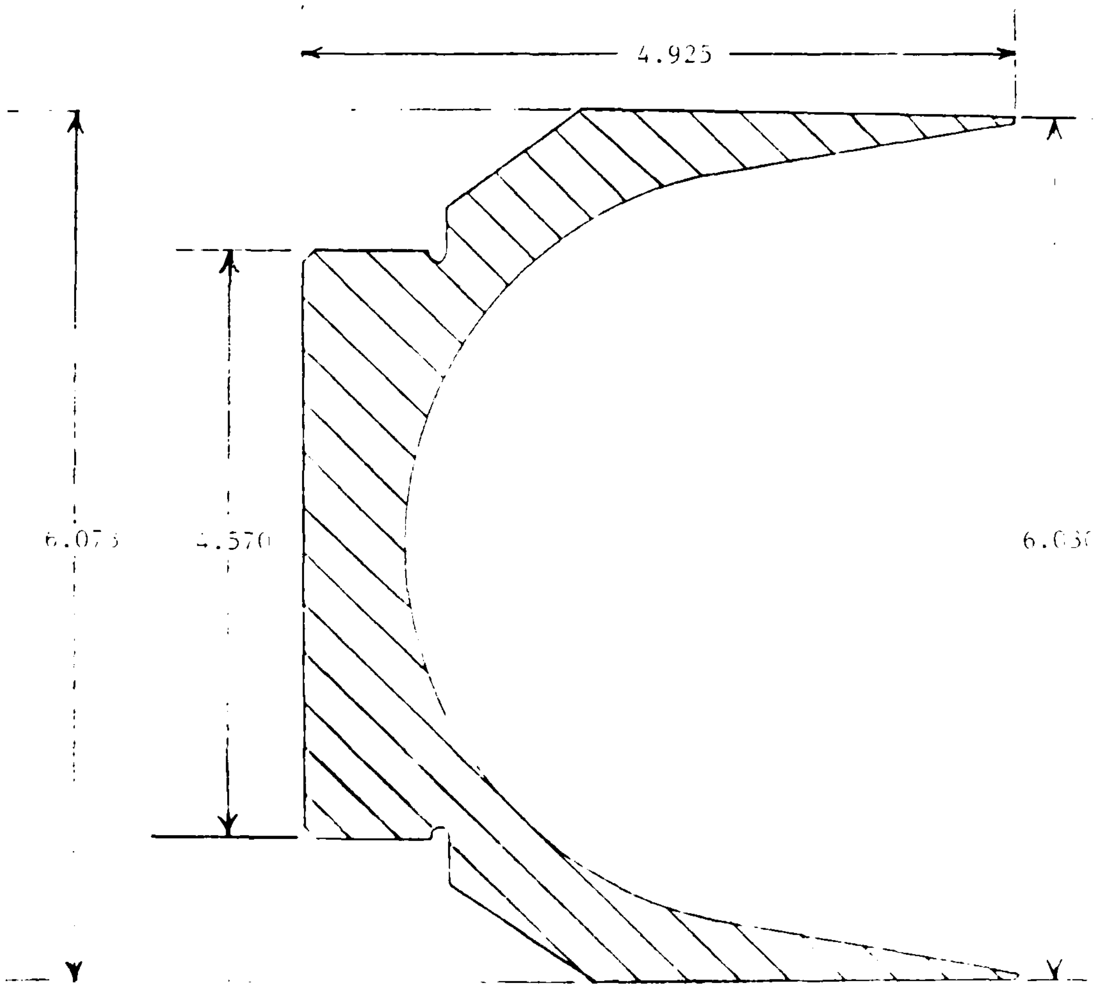

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Figure 5. Modified 155-mm Scoop

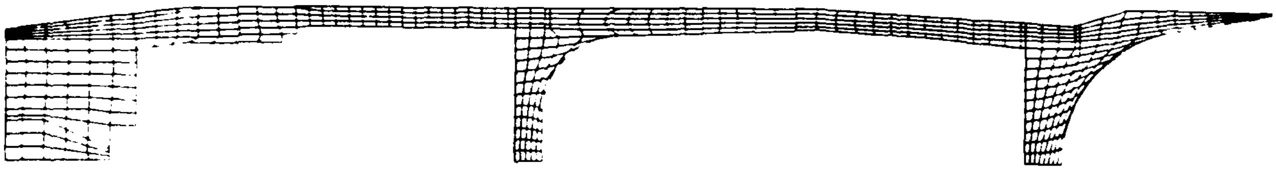

Figure 6. Finite Element Model of M549 with Scoop Modification

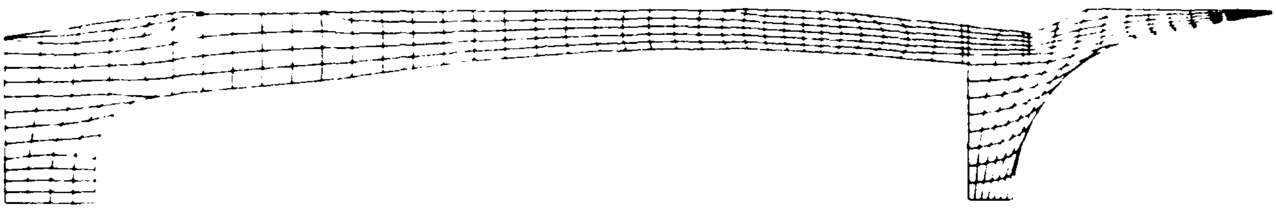

Figure 7. Finite Element Model of PXR with Scoop Modification

III. RESULTS

The inner diameter of the 155-mm gun ranges from 6.100 to 6.102 inches. The M549 develops a maximum deformed diameter of 6.1018 inches in the bourrelet area, about 13 to 15 inches from the base of the projectile. If the gun tube is small, the M549 could cause unexpected wear on the land surface. However, the deformed PXR diameter remained below 6.1 inches, with a maximum deformed diameter of 6.0974 inches. Figures 8 and 9 show the deformation of the exteriors of the two projectiles, exaggerated for clarity.

The M549 and PXR both withstood the initial stress loading; no part of either projectile bore stresses exceeding the materials' yield stresses by more than two percent. Figures 10 and 11 show the stress distribution throughout the projectiles, with the darker areas indicating areas of higher stress.

The redesign analysis showed that both the M549 and the PXR may successfully be altered. Figures 12 and 13 show the resulting stress distributions throughout the projectiles after application of the forces described previously.

IV. CONCLUSIONS

The PXR projectile under the loading expected in firing displayed no unusual deformations which would cause excessive tube wear. However, the M549 could cause downbore wear in a small and/or new gun tube. Neither projectile, when modified with a scoop, developed an interference fit with the tube land surface.

Both the M549 and the PXR withstood the stresses caused by firing in normal and scoop-front models.

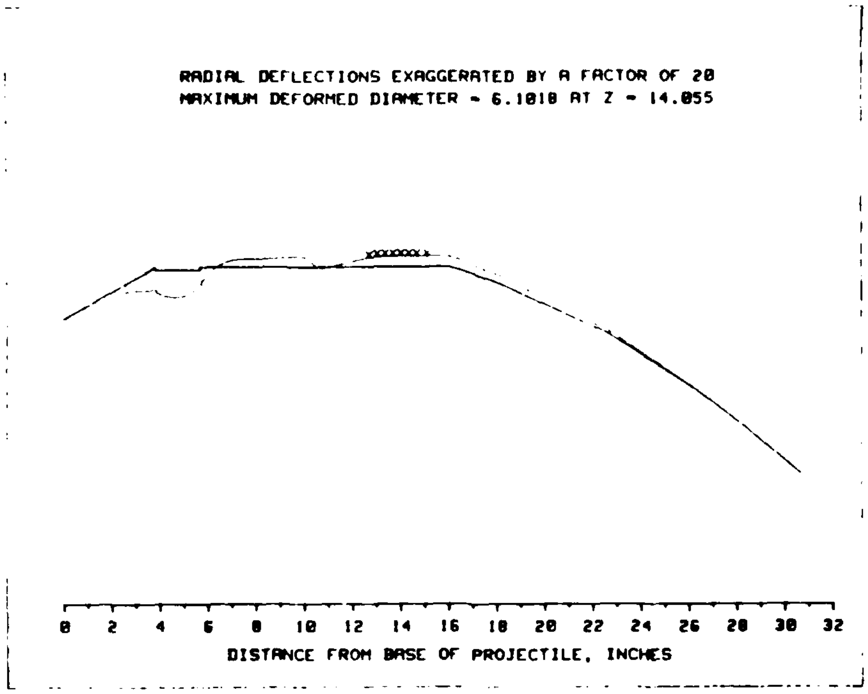

Figure 8. Deformation of Outer Shell of M549 Projectile

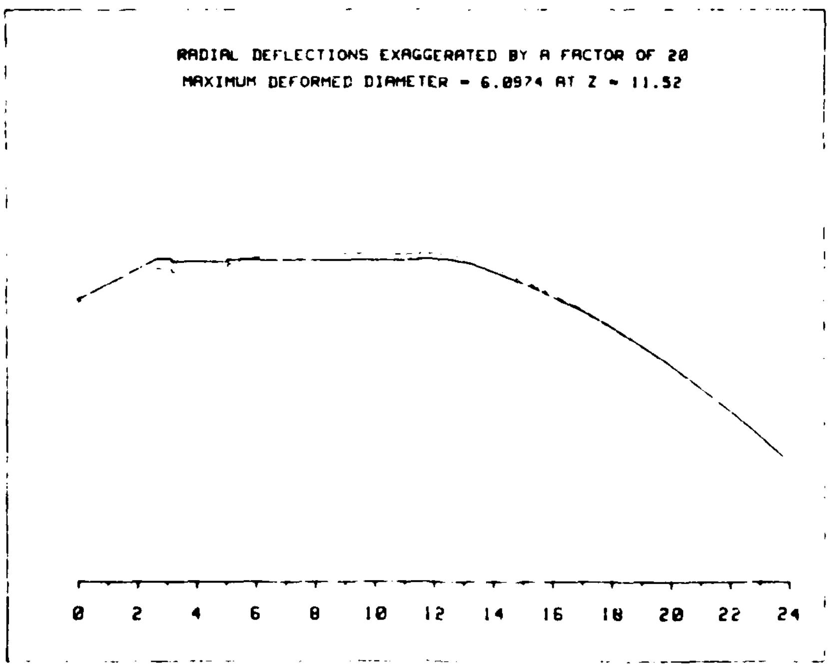

Figure 9. Deformation of Outer Shell of PXR Projectile

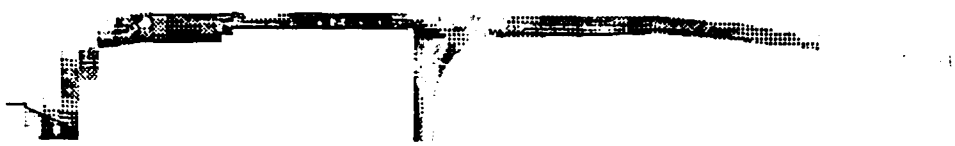

Figure 10. Stress Distribution of M549 Projectile

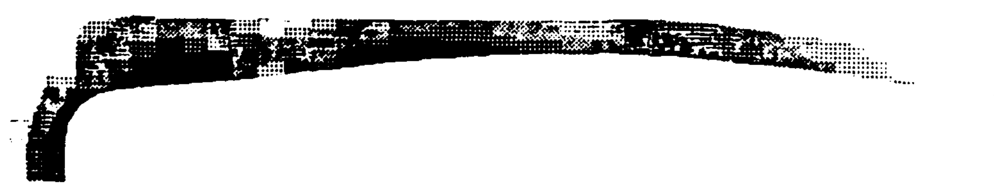

Figure 11. Stress Distribution of PXR Projectile

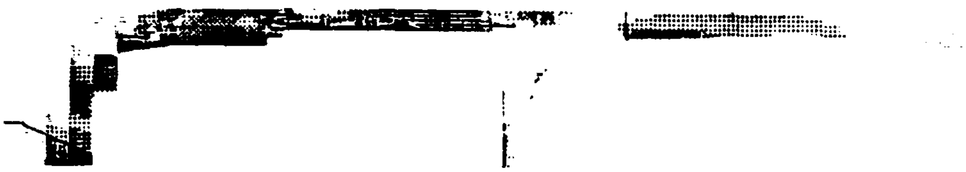

Figure 12. Stress Distribution of M549 with Scoop Modification

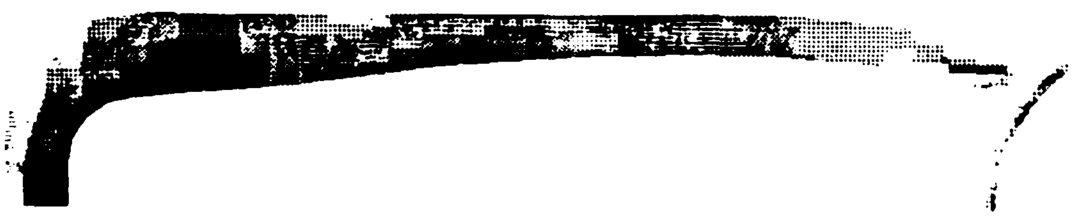

Figure 13. Stress Distribution of PXR with Scoop Modification

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