SPECIAL REPORT ARLCB-SP-79012

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1978

B. Rahrer
Technical Publications and Editing Unit

June 1979

US ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND
LARGE CALIBER WEAPON SYSTEMS LABORATORY
BENÉT WEAPONS LABORATORY
WATERVLIET, N. Y. 12189

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1. REPORT NUMBER: ARLCB-SP-79012	2. GOVT ACCESSION NO.
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TABLE OF CONTENTS

TECHNICAL REPORTS 1978

REPORT NUMBER	TITLE	AUTHOR	DATE
ARLCB-TR-78002	Friction of Rotating Band Material During Engraving and Initial Projectile Travel	R.S. Montgomery	Feb 78
ARLCB-SP-78003	Index to Benet Weapons Laboratory (LCWSL) Technical Reports-1977	R.F. Tario	Feb 78
ARLCB-TR-78004	Fatigue-Crack Propagation Through a Measured Residual Stress Field in Alloy Steel	J.H. Underwood L.P. Pook J.K. Sharples	Feb 78
ARLCB-TR-78005	Fourth Order Elastic Constants for Sodium Chloride to 270 Kbar by Wave Dynamics	M.A. Hussain J. Frankel R.D. Scanlon	Mar 78
ARLCB-TR-78006	Heat Treating Gun Steel	F. Heiser	Mar 78
ARLCB-MR-78007	Feasibility Study of Filament Wound Cartridge Cases	G. D'Andrea R. Cullinan P. Croteau	Mar 78
ARLCB-TR-78008	Reversible Effects of Temperature on the Structure of Amorphous NiP	P.J. Cote G.P. Capsimalis L.V. Meisel	Mar 78
ARLCB-TR-78009	175MM/8 Inch Howitzer Spindle Problem-Final Report	R.L. Rosenblum B.J. Rowekamp J.E. Brower V.J. Colangelo	Apr 78
ARLCB-TR-78010	The Influence of Tip Mass Offset on the Stability of Beck's Column	G.L. Anderson J.D. Vasilakis J.J. Wu	May 78
ARLCB-MR-78011	8 Inch M201 Muzzle Inclusion Fatigue Study	B. Brown	Apr 78
ARLCB-TR-78012	A Metallographic Study of White Layers in Gun Steel	M.H. Kamdar A. Campbell T. Brassard	Aug 78
ARLCB-SP-78013	Proceedings, Second U.S. Army Symposium on Gun Dynamics	T.E. Simkins J.J. Wu	Sep 78
ARLCB-TR-78014	Temperatures and Stresses Due To Quenching of Hollow Cylinders	J.D. Vasilakis	Aug 78

TECHNICAL REPORTS 1978 (CONTINUED)

REPORT NUMBER	TITLE	AUTHOR	DATE
ARLCB-MR-78015	Failure Analysis of 81MM Mortar Tube, SN 13299	P. Thornton	Sep 78
ARLCB-TR-78016	Comparison of Properties of Several Heats of ESR Melted 4335 + V Steel	V.J. Colangelo G.P. Lessen	Sep 78
ARLCB-TR-78017	Preliminary Study of the Effect of a Recoil Keyway on the Fatigue Life of M185 Cannon Tubes	M.A. Hussain S.L. Pu	Nov 78
ARLCB-TR-78018	A Photoplastic Study of Residual Stress in an Overloaded Breech Ring	Y.F. Cheng	Nov 78
ARLCB-TR-78019	Stress Concentration Around Inclined Holes in Pressurized Thick-Walled Cylinders	Y.F. Cheng	Nov 78
ARLCB-TR-78020	A Comparison of Blast Data from a 105MM Recoilless Rifle and a Laboratory Simulator	G.C. Carofano	Nov 78
ARLCB-TR-78021	Friction of Gilding Metal Sliding on Chromium-Plated Steel	R.S. Montgomery	Nov 78
ARLCB-TR-78022	Bi Phase Transitions Below 80° to 150 Kbars in an Ar Pressure Medium	C.G. Homan J. Frankel D.P. Kendall	Dec 78
ARLCB-TR-78023	Refractory-Lined Composite Pressure Vessels	G. D'Andrea R.L. Cullinan P.J. Croteau	Dec 78
ARLCB-TR-78025	Asymptotic Solutions to a Stability Problem	D.A. Peters J.J. Wu	Dec 78
ARLCB-TR-78026	Singular Plastic Element: Nastran Implementation and Application	M.A. Hussain S.L. Pu W.E. Lorensen	Dec 78

AUTHOR INDEX--1978

SUBJECT INDEX--1978

REPORT DOCUMENTATION PAGE

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2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): FRICTION OF ROTATING BAND MATERIAL DURING ENGRAVING AND INITIAL PROJECTILE TRAVEL

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7. AUTHOR(s): R. S. Montgomery

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Aluminum, Friction on Gun Steel
Engraving, Rotating Band
Friction, Projectile
Friction, Rotating Band
Gilding Metal, Friction on Gun Steel
Magnesium, Friction on Gun Steel
Nylon, Friction on Gun Steel
Rotating Band Materials
Sintered Iron, Friction on Gun Steel
Soft Iron, Friction on Gun Steel

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The sliding characteristics and coefficients of friction of rotating band and potential rotating band material on steel were studied in the laboratory at velocities corresponding with projectile velocities near the origin-of-rifling. The band materials investigated were gilding metal, 7075 aluminum alloy, AZ61A magnesium alloy, sintered iron, soft iron, nylon 6-6, and vulcanized fiber. It is possible to draw a number of conclusions and make a number

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Continued from Block 19.

Vulcanized Fiber, Friction on Gun Steel

Continued from Block 20.

of conjectures about the engraving and initial travel of cannon projectiles from the results of this study. A comparison of the different sliding characteristics and laboratory friction coefficients provides insight into the behavior of projectiles and will help to allow the design of rotating bands without the expensive extensive firing of an actual cannon.

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7. AUTHOR(s): Roy F. Tario
Technical Publications and Editing Unit (BWL)

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2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): FATIGUE-CRACK PROPAGATION THROUGH A MEASURED RESIDUAL STRESS FIELD IN ALLOY STEEL

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
J. H. Underwood
L. P. Pook
J. K. Sharples

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
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Crack Propagation
Fracture (materials)
Alloys

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Fatigue crack-propagation tests were performed using 5 by 30mm cross-section bend specimens of a nickel-chromium-molybdenum steel. The fatigue crack-propagation rate was determined from a group of stress-free specimens by measuring crack length on the specimen surfaces at intervals during cycling. Residual stress was produced in a second group of specimens by using a localized plastic deformation process. Resistance strain gages were first applied

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Continued from Block 20.

near one edge of each specimen along the line of intended crack growth. A series of 1mm deep plastic indentations was then made along the opposite edge of the specimen using a 25mm diameter pin. The strain gages provided a direct, accurate measure of the elastic, residual stress produced on one side of the specimen due to the local plastic deformation on the opposite side.

Measured crack-propagation rates in the specimens with residual stress are compared with rates in residual stress-free specimens. Crack-propagation rates are lower, as expected, near the edge of the specimen where the initial residual stress is compressive. Propagation rates remain lower even as the crack grows deeper into the specimen where the initial residual stress is tensile, which is not what would be expected from a simple superposition of stresses. However, an analysis involving the combination of the applied stress-intensity factor with that estimated from a redistribution of the residual stress in the specimens can account for the lower crack-propagation rates.

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1. REPORT NUMBER: ARLCB-TR-78005

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): FOURTH ORDER ELASTIC CONSTANTS FOR SODIUM CHLORIDE TO 270 KBAR BY WAVE DYNAMICS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
Moayyed A. Hussain
Julius Frankel
Raymond D. Scanlon

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
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Continuum Mechanics
Equation of State
Pressure
Ultrasonic Velocities

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

We derive the dilatational and shear velocities and the equation of state for an isotropic material under high hydrostatic pressures by the methods of continuum mechanics using the theory of small deformation superposed on a finite strain. The strain energy density of the material is taken to fourth order in terms of the strain invariants.

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4. TITLE *(and Subtitle)*: HEAT TREATING GUN STEEL	5. TYPE OF REPORT & PERIOD COVERED
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7. AUTHOR(s): F. Heiser	8. CONTRACT OR GRANT NUMBER(s)
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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Tempering
Gun Steel
Alloy Steel
Heat Treating

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A study was conducted to evaluate the effect of tempering time on the mechanical properties of gun steel, a medium C, Ni-Cr-Mo steel used in cannon tube forgings. The results on small specimen tests show that in tempering at temperatures up to 1100°F, time is not important beyond 60 minutes. Above 1100°F, time becomes a more important factor. For the yield strength range of many tubes, 160-180 ksi, tempering at 1000-1100°F is required. Thus, for

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Continued from Block 20.

these tubes, the tempering cycle can be drastically shortened.

Data were also developed for two austenitizing temperatures, 1550°F (which is usually used) and 1750°F (which is used in some furnaces which utilize a high thermal head and allow a short austenitizing cycle). It is demonstrated that the latter would not allow the tube forging requirements to be satisfied, and dictate that austenitizing temperatures must be maintained at lower temperature.

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1. REPORT NUMBER: ARLCB-MR-78007
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: FEASIBILITY STUDY OF FILAMENT WOUND CARTRIDGE CASES

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
G. D'Andrea
R. Cullinan
P. Croteau

8. CONTRACT OR GRANT NUMBER(s):

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*:
Cartridge Cases
Composites
Filament Winding

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:

The feasibility of fabricating a 60mm composite cartridge case by the filament winding process has been demonstrated. Fabrication procedures for the manufacturing of this type of case are presented in this report.

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1. REPORT NUMBER: ARLCB-TR-78008
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: REVERSIBLE EFFECTS OF TEMPERATURE ON THE STRUCTURE OF AMORPHOUS NiP

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): P.J. Cote, G.P. Capsimalis, L.V. Meisel

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Reversible Effects
Structure
Amorphous
Thermal Expansion

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The influence of temperature on the structure of amorphous NiP was determined by means of x-ray and thermal-expansion measurements. The results compare well with the theorteical predictions for the static x-ray structure factor of an amorphous Debye solid. Observed changes in the structure factor with temperature are of the correct magnitude to explain the temperature dependences of the resistivity of amorphous metals in terms of the Ziman liquid-metal theory; this is taken as further experimental confirmation of the validity of liquid-metal theory for electron transport in these systems.

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4. TITLE *(and Subtitle)*: 175MM/8 INCH HOWITZER SPINDLE PROBLEM - FINAL REPORT	5. TYPE OF REPORT & PERIOD COVERED
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7. AUTHOR(s): Robert L. Rosenblum, Bernard J. Rowekamp, John E. Brower, Vito J. Colangelo	8. CONTRACT OR GRANT NUMBER(s)
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Obturator Spindle	Cannon
Primer	175MM Gun, M107
Erosion	8 In. Howitzer, M110

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The failure of an FRG Army M110 SP Howitzer spindle assembly during practice firing initiated an extensive investigation of US spindles in CONUS and Europe and Allied spindles in Europe. The objective was to verify the extent of the problem, find cracked spindles, if any, and develop a spindle condemnation criteria. Of all spindles inspected only one exhibited cracks. Erosion and pitting were found in some of the primer chambers. It was resolved that no hazardous condition of US or Allied spindles had existed

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except for FRG spindle, Identification Number 1, which is considered an isolated instance. A spindle condemnation criteria was, however, issued based on primer extraction difficulty.

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-78010
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE *(and Subtitle)*: THE INFLUENCE OF TIP MASS OFFSET ON THE STABILITY OF BECK'S COLUMN
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): G.L. Anderson, J.D. Vasilakis, J.J. Wu
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102.11.H4500.30 (7PA), DA Project No. 1L161102AH45, PRON No. EJ-7-Y0011-EJ-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801
12. REPORT DATE: May 1978
13. NUMBER OF PAGES: 13
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*:
18. SUPPLEMENTARY NOTES:
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*: Non-Conservative Stability, Beam Vibrations, Tip Mass
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:

In this report, the stability of a slender cantilever carrying a tip mass at its free end and subjected there to a follower force is investigated.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-MR-78011	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: 8" M201 MUZZLE INCLUSION FATIGUE STUDY	5. TYPE OF REPORT & PERIOD COVERED / 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Bruce Brown	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3110.15.2224 PRON No. M7-5-P4847-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command Large Caliber Weapons Systems Laboratory Dover, New Jersey 07801	12. REPORT DATE: June 1978 13. NUMBER OF PAGES: 23
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Fatigue
Inclusions
Gun Barrel
Ultrasonics
Fracture Mechanics

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The fatigue performance of production barrel segments containing inclusion clusters was compared to that of normal barrel segments. The inclusion filled specimens gave significantly poorer performance in fatigue life and the stress level causing crack initiation and growth.

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-78012
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE *(and Subtitle)*: A METALLOGRAPHIC STUDY OF WHITE LAYERS IN GUN STEEL
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): M. H. Kamdar, A. Campbell, T. Brassard
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102.H540011, DA Proj. No. 1L161102AH54, PRON No. 1A7233A5GGM7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801
12. REPORT DATE: August 1978
13. NUMBER OF PAGES: 23
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:
15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Erosion
Guns
Steel
Wear

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A metallographic investigation has been made of the white layers formed on the bore surface of a fired Army and Navy cannon and those produced in gun steel specimens in laboratory where firing conditions were simulated. White layers are produced in laboratory specimens in reducing environments (e.g. methane gas) but not in argon or nitrogen and appear similar to those produced in the fired cannons. These are formed at the melting as well as lower temperatures. The

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effects of increase in the pressure of the environment appears first to aid the formation of white layers and furthermore to increase their thickness. These results and the earlier studies of the characterization of white layers from fired cannons suggests that carbon from the gaseous environment of the propellant combustion products and the pressures of gases have significant effects on the formation and growth of white layers.

The white layers produced in the Navy cannon where NACO, low flame temperature propellant was used are compared with those produced in the Army cannons where high flame temperature propellant was used. These observations are also discussed.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-SP-78013	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Proceedings, Second U.S. Army Symposium on Gun Dynamics	5. TYPE OF REPORT & PERIOD COVERED: FINAL
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): EDITORS: T. E. Simkins, J. J. Wu	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Watervliet Arsenal, Watervliet, NY	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: September 1978
	13. NUMBER OF PAGES
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Ballistics, Precision, Target Acquisition, Dynamics, Barrel Vibration, Stabilization

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Twenty papers on various aspects of analysis, design and instrumentation of gun dynamics are presented by authors from five universities, five industrial research laboratories and various laboratories of the U.S. Army, Navy, and Air Force.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-78014

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): TEMPERATURES AND STRESSES DUE TO QUENCHING OF HOLLOW CYLINDERS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): John D. Vasilakis

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Benet Weapons Laboratory
Watervliet Arsenal, Watervliet, N.Y. 12189
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11. CONTROLLING OFFICE NAME AND ADDRESS:
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12. REPORT DATE: August 1978

13. NUMBER OF PAGES: 24

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Finite Differences
Transformation Stresses
Transient Heat Conduction

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

After forging, gun tube blanks are heated to a high temperature and quenched to near room temperature before tempering to achieve the required material properties. The purpose of the quench is to bypass the knee of the pearlite phase. This program was undertaken to establish cooling curves while the material is being quenched and to compute the thermal and transformation stresses involved.

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The temperatures are computed using implicit finite difference schemes. The problem treated is a nonlinear one in radial heat flow. The problem with cylindrical geometry is assumed to be axisymmetric and the coefficients in the equation such as thermal conductivity are treated as functions of temperature. The boundary conditions are written in a general form allowing the use of temperature, convection or heat flux boundary conditions. The nonlinear problem is solved by using two finite difference schemes in tandem. The first computes the temperatures at the $n+\frac{1}{2}$ time step assuming constant coefficients computed from a previous temperature distribution. This generates a temperature distribution throughout the thickness which is used to compute new coefficients for the second finite difference scheme which calculates the temperature distribution at the n+1 time step. This process is continued until a steady state or some desired level is reached.

At each time step, the program computes the thermal stresses associated with the temperatures. In addition to this, when the temperature reaches a certain level, called martensite start (M_S), the material begins to undergo the martensite transformation. This transformation involves an increase in material volume of about 3%-4%. A simple view of these transformation stresses is taken and the stresses due to this volume change are computed as the temperature cools to below the martensite start temperature throughout the wall thickness.

Results are presented for various boundary conditions including those expected to exist in the quenching facility.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-MR-78015	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): FAILURE ANALYSIS OF 81MM MORTAR TUBE, SN 13299	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): P. Thornton	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3210.16.0008, PRON No. M1-6-00996-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: September 1978
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

81mm Mortar
Failure

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report summarizes the investigation of a failed 81mm Mortar Tube, SN 13299. This weapon was involved in a malfunction, 14 June 1977, in Germany. The analysis included a metallurgical examination and a limited mechanical property evaluation of the tube material. The conclusion of this investigation is that the malfunction occurred as a result of premature detonation of the projectile. The mortar tube material did not contribute to the failure.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-78016
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: COMPARISON OF PROPERTIES OF SEVERAL HEATS OF ESR MELTED 4335 + V STEEL

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Vito J. Colangelo, Gary P. Lessen

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR LCB TL

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3297.06.7500, PRON No. M1-5A-1731-01-M7-M7

11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon System Laboratory, Dover, New Jersey 07801

12. REPORT DATE: September 1978

13. NUMBER OF PAGES: 25

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

ESR
Steel
Mechanical Properties
Segregation

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

In order to compare the mechanical properties of ESR material from different manufactures, material was obtained from five producers with all material being of the same nominal composition. In order to compare quality of each, samples from each manufacturer were subjected to a water quench and tempering at a temperature of 975°F. Subsequent to this heat treatment, mechanical testing, consisting of Charpy, tensile, ductility and microhardness tests was done on samples from each producer.

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1. REPORT NUMBER: ARLCB-TR-78017

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: PRELIMINARY STUDY OF THE EFFECT OF A RECOIL KEYWAY ON THE FATIGUE LIFE OF M185 CANNON TUBES

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
M. A. Hussain
S. L. Pu

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
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PRON No. 64-8-27276-GG-M7

11. CONTROLLING OFFICE NAME AND ADDRESS:
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12. REPORT DATE: November 1978

13. NUMBER OF PAGES: 35

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Autofrettage
Crack Propagation
Stresses

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This report contains a preliminary study of the effect of a keyway on the fatigue life of a 155 mm, M185 tube with an assumption that a crack starts from the base of the keyway. This analysis is carried out for guidance in the processes of design and configuration changes within the constraints specified and also for further refined studies.

It is indicated that the tube life can be increased by a factor of three with the reduction of autofrettage to 70%.

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1. REPORT NUMBER: ARLCB-TR-78018
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: A PHOTOPLASTIC STUDY OF RESIDUAL STRESS IN AN OVERLOADED BREECH RING

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Y.F. Cheng

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 61110191A0011, PRON No. 1A-8-25567-GG-M7

11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801

12. REPORT DATE: November 1978

13. NUMBER OF PAGES: 24

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Breech Ring
Photoplasticity
Residual Stress

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A two-dimensional model of the meridian section of a breech ring was made of a photoplastic material which had been calibrated optically and mechanically. The maximum fillet stress was determined for an elastic load as well as an elastoplastic load. Residual stress resulting from complete unloading was calculated by subtractive superposition of elastic and plastic solutions. An elastic process is assumed during unloading. Transition from model to prototype was discussed.

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-78019
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: STRESS CONCENTRATION AROUND INCLINED HOLES IN PRESSURIZED THICK-WALLED CYLINDERS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Y.F. Cheng

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
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11. CONTROLLING OFFICE NAME AND ADDRESS:
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12. REPORT DATE: November 1978

13. NUMBER OF PAGES: 24

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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Hole
Pressurized Cylinders
Stress Concentration
Thick-Walled Cylinders

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Photoelastic investigation has been conducted to study stress concentration around inclined holes in pressurized thick-walled cylinders. It has been found that an inclination in the transverse plane reduces the stress concentration and an inclination in the meridianal plane increases the stress concentration. Also, the stress concentration depends upon the bore-to-hole diameter ratio among other parameters.

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1. REPORT NUMBER: ARLCB-TR-78020
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)*: A COMPARISON OF BLAST DATA FROM A 105MM RECOILLESS RIFLE AND A LABORATORY SIMULATOR

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): G.C. Carofano

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Benet Weapons Laboratory
Watervliet Arsenal, Watervliet, N.Y. 12189
DRDAR-LCB-TL

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11. CONTROLLING OFFICE NAME AND ADDRESS:
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17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Blast Simulator
Recoilless Guns
Rifles

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

A comparison was made between the blast data obtained from an experimental 105mm recoilless rifle and that produced by a laboratory blast simulator. The data agree sufficiently well to justify use of the simulator in the comparative type experiments in which it has been used in the past.

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1. REPORT NUMBER: ARLCB-TR-78021
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): FRICTION OF GILDING METAL SLIDING ON CHROMIUM-PLATED STEEL

5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): R.S. Montgomery

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
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Watervliet Arsenal, Watervliet, N.Y. 12189
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Friction
Rotating Bands

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A comparison of friction for gilding metal sliding on chrome plate with that for gilding metal sliding on gun steel is important because a number of cannon tubes are chrome plated and it is important to know how this affects their interior ballistics. The frictional resistance of the projectile is largely that of the rotating bands on the bore of the cannon tube and gilding metal is the most common material of rotating bands. It was found that the

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coefficients of friction for gilding metal sliding on chrome plate are identical with those for gilding metal sliding on steel at velocities of 300 fps and higher at least for bearing pressures greater than about 2 ksi. This would be predicted for melt lubricated sliding at high velocities. At lower velocities (somewhere between 150 fps and 300 fps) the coefficients become different with those for gilding metal sliding on chrome plate significantly less than those for gilding metal sliding on gun steel.

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4. TITLE *(and Subtitle)*: Bi PHASE TRANSITIONS BELOW 80^0K TO 150 KBARS IN AN Ar PRESSURE MEDIUM

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7. AUTHOR(s):
C. G. Homan
J. Frankel
D. P. Kendall

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
Bismuth Phase Transitions
High Pressure
Cryogenics
Pressure Calibration

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Resistometric measurements on thin film Bi specimens embedded in a solid Ar pressure medium were made to 150 kbars in the temperature range of 40^0 to 80^0K. The ratio of longitudinal to transverse acoustic velocity was simultaneously measured on the Ar medium and the EOS of Ar deduced. Correlation is made between the changes in the resistance due to polymorphic phase transitions in Bi and the pressure deduced from the Ar EOS. The present data will be com-

Continued on next page.

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pared with earlier results on Bi embedded in a pyrophyllite medium which suggests large non-hydrostatic medium effects in pyrophyllite at low temperatures. Experimental details will be discussed.

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4. TITLE (and Subtitle): REFRACTORY-LINED COMPOSITE PRESSURE VESSELS
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): G. D'Andrea, R. L. Cullinan, P. J. Croteau
8. CONTRACT OR GRANT NUMBER(s):
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Ceramic Materials
Composite Materials
Filaments
Residual Stress
Shrink Fitting
Steel Wire
Winding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Refractory lined pressure vessels, possessing good corrosion and erosion resistance at low and high temperatures, seem to be ideal for extending the wear life of conventional gun tubes

Since refractory materials exhibit high compressive and low tensile strength, prescribed residual stresses must be introduced to elminate the significant

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tensile stresses produced during firing.

The prominent problem in fabricating such vessels is to restrict the refractory material from expanding axially during the application of the residual stresses.

This report presents manufacturing procedures to prevent the axial expansion; theoretical and experimental analyses predicting the residual and firing stress state in the vessel; and test results on 12.5 mm and 60 mm ceramic liners.

Preliminary work on 6.4 mm Tungsten-Carbon Alloy is also reported.

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4. TITLE (and Subtitle): ASYMPTOTIC SOLUTIONS TO A STABILITY PROBLEM

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6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):

D. A. Peters
J. J. Wu

8. CONTRACT OR GRANT NUMBER(s):

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18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Approximate Solutions	Finite Element
Asymptotic Method	Missiles
Dynamics	Nonconservative Forces
Eigenvalues	Non-self-adjoint Problems
Elastic Stability	Vibration

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This paper is concerned with the lateral stability of a free flying column subjected to an axial thrust with directional control. The stability curve (i. e., eigenvalue vs thrust, in the neighborhood of zero eigenvalues) and the associated eigenfunctions of this problem have not been fully understood. Here, asymptotic expansions are used to examine closely, for all values of the thrust directional control parameter, both the intersection of the eigenvalue curves

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with the zero branch and the associated eigenfunctions of zero and nearly zero eigenvalues. Several analytical proofs are provided substantiating previous numerical findings.

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3. RECIPIENT'S CATALOG NUMBER

4. TITLE *(and Subtitle)*: SINGULAR PLASTIC ELEMENT: NASTRAN IMPLEMENTATION AND APPLICATION

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
M. A. Hussain
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W. E. Lorensen

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19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Finite Elements
NASTRAN
Singular Elements

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The elastic and plastic singularities near a crack tip are obtained from higher order isoparametric elements. This is simply accomplished by collapsing the quadrilateral element into a triangular element and by judicious choice of adjacent mid-side nodes.

Specifically for the cubic element, the elastic singularity is obtained by

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placing the mid-side nodes adjacent to the crack tip at 1/9th and 4/9th locations. The plastic singularity is constructed using the sliding node concept. These elements have been implemented in NASTRAN as user dummy elements.

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