AD-A134 509 INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1982(U) ARMY ARMAMENT RESEARCH AND DEVELOPMENT COMMAND WATERVLIET NY L.. R D NEIFELD 1/2

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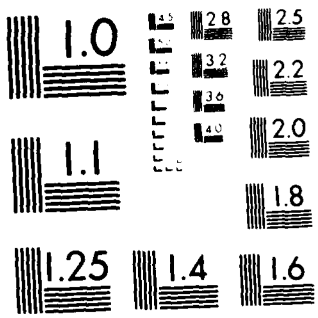

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SPECIAL REPORT ARLCB-SP-83013

A134509

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1982

R. D. NEIFELD

TECHNICAL PUBLICATIONS AND EDITING UNIT

APRIL 1983

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

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7. AUTHOR(s): R. D. Neifeld	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U.S. Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a compilation of Benet Weapons Laboratory technical reports published during 1982.

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1. REPORT NUMBER: ARLCB-TR-82001	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): EXPLICIT DIFFERENCE SCHEMES FOR WAVE PROPAGATION AND IMPACT PROBLEMS	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Joseph E. Flaherty	8. CONTRACT OR GRANT NUMBER(s): Grant No. AFOSR 80-0192
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H5710011, DA Project No. 1L161102BH57, PRON No. 1A1235821A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: January 1982
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Conservation Laws	Riemann Problems
Wave Propagation	Finite Differences
Shock Problems	Exponential Fitting

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

Explicit finite difference and finite element schemes are constructed to solve wave propagation, shock, and impact problems. The schemes rely on exponential functions and the solution of linearized Riemann problems in order to reduce the effects of numerical dispersion and diffusion. The relationship of the new schemes to existing explicit schemes is analyzed and numerical results and comparisons are presented for several examples.

18. SUPPLEMENTARY NOTES (CONT'D)

Presented at 27th Conference of Army Mathematicians, US Military Academy, West Point, NY, 10-12 June 1981.

Published in proceedings of the conference.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER ARLCB-TR-82002	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECT OF SUPPORT CONDITIONS ON BEAM VIBRATIONS SUBJECTED TO MOVING LOADS		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Julian J. Wu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 PRON No. 1A1283121A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE January 1982
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Support Conditions
Beam Vibrations
Moving Loads
Finite Elements
Initial Boundary Value Problems

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

Solutions of beam vibrations under moving loads are presented with a variety of support conditions. The purpose is to demonstrate how the support conditions will effect such beam motions. The solution method and mathematical background will be reviewed including the introduction of various support parameters. By slightly modifying an existing computational scheme, the desired results have been obtained and presented in several tables and plots showing the effect of support stiffness on beam motions.

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1. REPORT NUMBER ARLCB-TR-82003	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STRESS INTENSITY FACTORS FOR RADIAL CRACKS AT OUTER SURFACE OF A PARTIALLY AUTOFRETTAGED CYLINDER SUBJECTED TO INTERNAL PRESSURE		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. L. Pu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A225004lA1A
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18. SUPPLEMENTARY NOTES

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

Stress Intensity Factors
Thick-Wall Cylinder
Multiple Exterior Cracks
Fracture Mechanics
Autofrettaged Cylinder
Finite Elements
Functional Intensity factors

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

The functional stress intensity factor approach which combines the finite element, thermal simulation and weight function methods developed for the computation of stress intensity factors for multiple radial cracks at the inner surface of a partially autofrettaged cylinder is applied in this report to external cracks. Numerical results of stress intensity factors are obtained for a cylinder with outer diameter twice the inner diameter.

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20. ABSTRACT (CONT'D)

A slight decrease in the degree of autofrettage will increase stress intensity factors of inner cracks slightly but will decrease stress intensity factors of external cracks considerably. As in the inner crack case, the cylinder with two diametrically opposed external cracks is in general the weakest configuration and for more than two cracks, the stress intensity factor decreases as the number of external cracks increases.

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): THERMAL RELAXATION IN AUTOFRETTAGED CYLINDERS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Joseph F. Throop, John H. Underwood, and Gregory S. Leger	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6121.05.HB40.0, PRON No. AW-1-RBWL1-AW1A
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Published in proceedings of the conference.

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

Autofrettaged Cylinders
Overstrain
Residual Stresses
Thermal Gradient
Thermal Stresses
Relaxation
Bore Closure

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

This report presents an experimental study on the loss of bore expansion and change of residual stresses in autofrettaged cylinders, resulting from internal heating combined with external cooling. It provides information useful in the design of pressure vessels operating at high temperature. Two-foot long cylinders were heated internally to bore temperatures up to 950°F and simultaneously cooled externally to produce a temperature difference of as

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20. ABSTRACT (CONT'D)

much as 725°F from bore to outside surface. Reduction of the autofrettage bore expansion and reduction of residual stresses resulted, because the thermal stresses added to the residual stresses and exceeded the lowered yield strength at elevated temperature, permitting relaxation to occur.

The data reveals that under certain temperature conditions a considerable portion of the autofrettage induced bore expansion and the associated residual stresses can be lost in a few minutes when external cooling occurs. The experimental results indicate that partial overstrain in autofrettage may be preferable to full overstrain in order to minimize the loss in residual stress.

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	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Editors: Dr. T. E. Simkins, Dr. J. J. Wu	8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

Presented at the Third U. S. Army Symposium on Gun Dynamics, 11-14 May 1982, at the Institute on Man and Science, Rensselaerville, New York.

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

Acquisition
Ballistics
Barrel Vibration
Dynamics
Precision
Stabilization
Target Acquisition

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

This represents a compilation of twenty-seven technical papers concerning analyses, design, measurement, and automation of gun dynamics. The authors represent a cross section of the scientific and technical community, including universities, industrial, and Government research laboratories.

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7. AUTHOR(s) R. D. Neifeld		8. CONTRACT OR GRANT NUMBER(s)
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		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. H. Underwood and D. P. Kendall		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 61110191A0011 DA Project No. 1L161101A98 PRON No. 1A2231491A1A
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18. SUPPLEMENTARY NOTES

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Presented to: ASTM E-24 Committee on Fracture, Philadelphia, PA, 27-29 April 1982.

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

Fracture Analysis	Residual Stress
Pressure Vessels	Fracture Mechanics
Fatigue Life	Crack Shape

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

Fracture mechanics analysis of cylindrical pressure vessels is described in a brief fracture case study. Also included in this report are additional examples of crack growth in pressure vessels and cannons.

The case study is of an early brittle failure and subsequent redesign of a cannon tube. Fracture mechanics test methods are described which were

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20. ABSTRACT (CONT'D)

developed specifically for testing of cylindrical geometries. Three examples of current fracture analysis of cylindrical pressure vessels are presented. Fast fracture of a vessel is described, including effects of tension residual stress and crack shape. Evidence of environmentally assisted fracture of a cannon tube is presented. Fatigue crack growth and life calculation methods for cylindrical pressure vessels are developed and checked with experimental results; effects of compressive residual stress due to overstrain are analyzed, including reductions from the expected theoretical residual stress due to reduced compressive strength of the alloy steel.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82008	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SERVICE SIMULATION TESTS TO DETERMINE THE FATIGUE LIFE OF OD NOTCHED THICK-WALL CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Kapp and J. H. Underwood		8. CONTRACT OR GRANT NUMBER(s) AMCMS No. 6111.01.91A0.0 PRON No. 1A-1-2ZC36-0
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE April 1982
		13. NUMBER OF PAGES 26
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Published in Proceedings of Fourth SESA International Congress (1980).

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

Residual Stress
Fracture (Materials)
Cylinders
Stress Concentration Factor
Fatigue Life

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

Simulation specimens were used to model the fatigue behavior of an OD notched internally pressurized cylinders of alloy steel. Results from continuum mechanics and finite element analyses are described for use in selection of simulation test conditions. The effects of notch depth and residual stress on fatigue life are determined from the simulation tests.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-82009	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): IMPROVED ELECTRODEPOSITED LOW CONTRACTION CHROMIUM	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): E. S. Chen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011; DA Project No. 1L161102AH60; PRON No. 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: April 1982
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18. SUPPLEMENTARY NOTES

Submitted for publication to Plating and Surface Finishing - American Electroplating Society.

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

Chromium Plating	Microhardness
Low Contraction Chromium	Electroactive Chemical
Tensile Strength	Impurity Codeposition

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

A systematic study was made to optimize the parameters for plating high quality LC chromium using standard chromic acid solutions and solutions containing vanadium additions. The results indicate that deposit strengths were improved substantially by aging the plating solution at 250 A hr/liter and by using current densities in excess of 120 A/dm^2. Under these conditions, hydrogen incorporation was reduced five-fold while hardness, strength, and cathode

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20. ABSTRACT (CONT'D)

efficiency were maximized. A further improvement in deposit strength was obtained by adding vanadium as V_2O_5 at a concentration of 10 g/l to standard chromic acid solutions. At higher concentrations, inferior deposits were produced that showed surface roughness, porosity, low strength, and higher hydrogen content.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82010	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A SINGLE SPECIMEN J-BASED FRACTURE TOUGHNESS TEST FOR HIGH STRENGTH STEELS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Kapp and J. H. Underwood		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 53970M6350 DA Project No. PRON No. A-1-9-P6350-01-AWGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1982 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

Presented at Fourteenth National Symposium on Fracture Mechanics, UCLA, Los Angeles, CA, 29 June - 1 July 1981.
Published in ASTM Special Technical Publication.

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

Cracks	Mechanical Testing
Toughness	Charpy Specimen
J-Integral	Bending

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

A single specimen J-based fracture toughness test has been developed which results in accurate and reliable measurements for a high strength, low alloy steel with several yield strengths. The specimen used is a ' ply cracked Charpy specimen tested in slow, three-point bending. A simple plastic stress analysis was performed which identifies a single point on the load-displacement trace at which the J-integral is calculated as an estimate of fracture toughness (K_{Ic}). The method can be applied inexpensively and may be used as a quality control measure of fracture toughness.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82011	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) REINFORCEMENT OF STABALLOY WITH HIGH STRENGTH TUNGSTEN FILAMENT		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) I. Ahmad, J. Barranco, and J. Cox		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6126.18.H80E.0 PRON No. 1A0216251A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1982
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14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
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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)

KE Penetrators
Composites
Depleted Uranium
Tungsten Filament
Infiltration
Compatibility
Mechanical Properties
Microstructure

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

As a result of a limited investigation, composites of U-0.75 Ti (depleted) containing 0.42/0.50 V_f W-2% ThO_2, and doped tungsten filament (GE and GTE Sylvania) have been fabricated by the infiltration technique. A pour temperature of 1280°C and mold temperature of 1100°C (top)/900°C (bottom) were found to be necessary for good infiltration. Well infiltrated composite specimens had Young's modulus approaching rule of mixtures values (34×10^6 psi).

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20. ABSTRACT (Cont'd)

However, the tensile and yield strength were approximately 30 percent lower than the theoretically predicted values. Degradation of the filament ductility as a result of oxygen or carbon pickup when the filaments were exposed to 1000°C in the mold prior to melting, was considered to be the reason. Application of 0.0005 in. thick coating of copper by conventional electroplating and tantalum by electrodeposition from fused fluoride electrolyte were found to eliminate this problem.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER ARLCB-TR-82012	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE COMBINED EFFECTS OF MEAN STRESS AND AGGRESSIVE ENVIRONMENTS ON FATIGUE CRACK GROWTH		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Kapp		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111019lA0011 DA Project No. 1L161101A9A PRON No. 1A2231491A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1982
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18. SUPPLEMENTARY NOTES

Presented at 1982 Joint JSME-SESA Conference on Experimental Mechanics, Honolulu, HI, 23-30 May 1982.
Published in proceedings of the conference.

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

Fatigue Crack Growth
Mean Stress Effects
Liquid Metal Embrittlement
Fracture Mechanics

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

Experiments have been performed to study the combined effects of aggressive environment and mean stress on fatigue crack growth. Since mean stress changes also change the stress ratio, $R(R = \sigma_{min}/\sigma_{max})$, experiments were performed to measure fatigue crack growth rates for various values of constant R. The experimental results were approximated mathematically using a modified superposition model. The results show that for negative values of R, the

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20. ABSTRACT (CONT'D)

modified superposition model yields excellent agreement with the experiments. When R was positive, the mathematical model significantly overestimated the experimental results, suggesting that the full environmental effect condition cannot be achieved in the embrittling system chosen. By including a factor to account for the less than 100 percent environmental effect, excellent agreement between the model and the experimental results was obtained when R was positive. Throughout the study, a high strength, low alloy steel embrittled by liquid mercury was used.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82013	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A PHOTOELASTIC STUDY OF LOAD DISTRIBUTIONS AND STRESSES IN MULTI-GROOVE CONNECTIONS OF THE SAME MATERIAL UNDER TENSION		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 US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 61110191A0011 DA Project No. 1L161101A9A PRON No. 1A2231491A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE May 1982 13. NUMBER OF PAGES 23
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18. SUPPLEMENTARY NOTES

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

Groove Connections
Photoelasticity
Maximum Fillet Stresses
Load Distributions
Stress Concentrations
Stress Distributions
Critical Regions

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

This report is a continuation of Technical Report ARLCB-TR-81008 and describes a three-dimensional photoelastic study on load distributions and stresses in multi-groove connections of the same material under tension. Two groove profiles were investigated, namely, the British Standard Buttress (BSB), and the new profile. It was found that in both profiles the maximum fillet stress $(\sigma_f)_{max}$ does not occur at the groove root. Therefore, the narrowest transverse

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20. ABSTRACT (CONT'D)

section is not the critical section. The critical stress, i.e., $(\sigma_f)_{max}$, in the new profile is higher than that in the BSB profile. Moreover, $(\sigma_f)_{max}$ in the first groove is higher than that in subsequent grooves. Hence, the first groove is the critical region.

In an ideal multi-groove (> 7) connection, the first two lugs could take approximately 50 and 60 percent of the load in the BSB and new profile, respectively. However, the ideal contact could not be expected due to machining tolerances. The worst possible case would occur when only one groove is in contact and the situation is reduced to a single-groove connection.

Further work on the effect of different materials is in progress.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER Contractor Report ARLCB-CR-82014	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CHARACTERIZATION OF "WHITE LAYER" AND CHROME PLATING ON FIRED CANNON AND ON LABORATORY SIMULATION SAMPLES		5. TYPE OF REPORT & PERIOD COVERED Final Jan. 1981 - Jan. 1982 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. M. Fisher and A. Szirmae United States Steel Corporation Dr. M. H. Kamdar, Research Engineer, ARRADCOM		8. CONTRACT OR GRANT NUMBER(s) DAAA22-81-C-0121
9. PERFORMING ORGANIZATION NAME AND ADDRESS United States Steel Corporation Research Laboratory Monroeville, PA 15146		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1982 13. NUMBER OF PAGES 55
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18. SUPPLEMENTARY NOTES

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

Weapons, Artillery--Guns, Stresses, White Layer, Chromium, Plating, Iron Carbide, Alloy Steels, Alloy Steels--4000 Series, Chemical Composition, Cracking-Failure, Surface Properties, Microstructure, Grain Structure, 4340 Steel, Simulation, Ordnance, Austenite, Cementite.

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

This work confirms that the effect of exposure of 4340 steel cannon tubes to firing is the formation of Fe_3C and 1% C-austenite on the surface. The stress generated by the explosion results in the formation of rather uniform networks of shallow and deep cracks. Particular attention was given to the structure of these cracks because they contained TiO_2 (sometimes added to the charge), Cu, S, and Al. Examination of the microstructure of electrodeposited

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20. ABSTRACT (CONT'D)

chromium revealed a strong dependence of grain structure on plating conditions. The void space between the aligned cylindrical grains is probably responsible for the high tensile stresses in chrome plating and the propensity for severe cracking.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82015	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) NUMERICAL SOLUTION TO AN AUTOFRETTAGED TUBE WITH CONSTRAINING WALLS AND END CLOSURES		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Peter C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1982
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18. SUPPLEMENTARY NOTES

Presented at 1982 Army Numerical Analysis and Computers Conference, US Army Engineers Waterways Experiment Station, Vicksburg, MS, 3-4 February 1982. Published in proceedings of the conference.

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

Container Autofrettage
Elastic-Plastic
Finite Difference
Gun Tube

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

This report presents a numerical study of a container autofrettage process. This process uses internal hydraulic pressure to expand the tube, restraining containers to control the amount of tube expansion and the press force to hold the end closures. The incremental finite-difference approach developed recently by the author is extended to obtain numerical results. The effects of restraining walls and the press force on the displacements and stresses are discussed.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82016	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A FRACTURE AND BALLISTIC PENETRATION RESISTANT LAMINATE		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Joseph F. Throop		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A225004IA1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE June 1982
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18. SUPPLEMENTARY NOTES

Presented at 1982 Army Science Conference, West Point, NY, 15-18 June 1982. Published in proceedings of the conference.

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

Ballistic Protection	Laminate
Damage Tolerance	Titanium
Fatigue	Aluminum

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

A new metal/metal laminate has been conceived and developed in ARRADCOM, consisting of explosively bonded alternate layers of titanium and aluminum alloy sheets. Intended at first to give improved fatigue resistance in helicopter components, the laminate is found to provide improved impact and ballistic penetration resistance as well. In comparison to monolithic metal components or adhesively bonded laminates it can provide decreased weight and

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20. ABSTRACT (CONT'D)

increased durability and survivability for vehicles and craft subject to ballistic impact damage.

Three-layer and five-layer specimens of Ti-6AL-4V/2024-T3 laminate have been tested for resistance to through-the-thickness impact and ballistic penetration and for after-damage fatigue crack propagation. They were compared with rolled plate specimens of 6061-T6 aluminum alloy and rolled homogeneous steel armor (RHS) using 0.30 caliber fragment simulator projectiles (FSP). The Protection (V_{50}) Ballistic Limit Velocity and the fatigue life (N_f) remaining after ballistic penetration damage were measured on the same specimens. The fatigue crack propagation life was measured in compact specimens made from the ballistically damaged panels, with the crack initiated in the penetration damage site and grown to failure of the specimen.

The five-layer laminate having volume proportions of 60 percent aluminum and 40 percent titanium alloy gave the optimum overall performance. Its V_{50} limit velocity is 22 percent greater than the RHS of equal area density, and it has longer after-damage fatigue life. Increasing the volume fraction of aluminum is found to decrease the protection V_{50} limit and increase the after-damage fatigue life, and vice versa.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER ARLCB-TR-82017	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle) ANALYSIS OF A SCHNEIDER-TYPE RECOIL MECHANISM FOR THE 120 mm XM256 TANK GUN	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) H. J. Sneck	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612603H181011 DA Project No. 1L162603AH18 PRON No. 1A0216111A1A
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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)

Tank Guns
Recoil
Counter-Recoil
Recuperator
Non-Concentric
Schneider

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

This report examines the feasibility of using externally mounted recoil and recuperator mechanisms on tank guns. A Schneider-type recoil mechanism for the 120 mm XM256 tank gun is investigated as an example. Methods of calculating the performance of the proposed system are shown. The calculated results indicate that the concept can be made to operate satisfactorily for this application.

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1. REPORT NUMBER	ARLCB-TR-82018
2. GOVT ACCESSION NO.	
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle)	THE SLIDING BEHAVIORS OF COPPER ALLOYS
5. TYPE OF REPORT & PERIOD COVERED	Final
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	R. S. Montgomery
8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189
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18. SUPPLEMENTARY NOTES

Presented at Gordon Conference, New London, NH, 14-18 June 1982.
To be presented at International Conference on Wear of Materials, Reston, VA, 11-14 April 1983.

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

Friction	Sliding	M650 Projectiles
Wear	Chromium Electroplate	M549 Projectiles
Scuffing	Tantalum	Microstructure
Metal Transfer	Rotating Bands	Hardness
Copper Alloys	M483 Projectiles	

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

The unlubricated behaviors of a number of copper alloys and especially their metal transfers and scuffing tendencies were investigated on steel, chromium electroplate, and tantalum using a specially designed pin-on-disk friction and wear machine. This machine limited the sliding time to about 100 msec. It was not possible to correlate metal transfer, scuffing (rough deposits), or friction with the properties of the alloys. There was a correlation of wear with

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20. ABSTRACT (Cont'd)

hardness for similar alloys with higher hardness alloys having lower wear. The effect of hardness was different for different mating surfaces. The data from aluminum bronze and the welded overlay rotating band materials investigated did not fall into this correlation. This could not be attributed to a special microstructure or to crystalline orientation in the case of the welded overlay band materials. Mutual solubility of the pin and disk metals and relative position in the periodic table also did not control metal transfer and scuffing with the copper alloys investigated. While position in the periodic table is identical and mutual solubilities are certainly very similar for most of the copper alloys, there were great differences in metal transfer and scuffing. While there was a tendency for more transfer to occur at higher wear rates, heavy and very heavy transfer do occur even at very low rates. Heavy and very heavy transfer were not usually associated with high wear and rough deposits were not usually associated with high wear and heavy transfer. The first step in wear was not transfer to the mating surfaces. In addition, small amounts of iron in the copper alloys did not result in scuffing and high metal transfer even when sliding on steel.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82019	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECT OF PRESSURE ON ELECTRICAL RESISTANCE OF TRANSITION-METAL-BASED ALLOYS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. J. Cote and L. V. Meisel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 DA Project No. 1T161101A91A PRON No. 1A1281501A1A
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18. SUPPLEMENTARY NOTES

Published in Physical Review B, Volume 25, Number 4, 15 February 1982, pages 2138-2143.

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

Electrical Transport
Pressure Effects
Amorphous Alloys
Crystalline Alloys
Mooij Correlation

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

Measurements have been made of the effect of hydrostatic pressure to 8 kbar, at room temperature, on the electrical resistance of five transition-metal-based amorphous alloys and their crystalline counterparts. The resistivity dependence of the pressure coefficient of resistance of these alloys, and results from other alloys taken from the recent literature, exhibit a trend analogous to the Mooij correlation. The pressure coefficient of resistance for crystalline and disordered systems and these data are discussed in terms of the

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20. ABSTRACT (CONT'D)

diffraction model of electrical transport. It is suggested that the observed correlation of the pressure coefficient of resistance with resistivity is a manifestation of the breakdown of standard theory for high-resistivity metals, i.e., another example of Mooij phenomena.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-82020	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): FRACTURE MECHANICS ANALYSIS OF THE EFFECTS OF RESIDUAL STRESS ON FATIGUE LIFE	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Joseph F. Throop	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
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18. SUPPLEMENTARY NOTES

To be published in the ASTM Journal of Testing and Evaluation.

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

Residual Stresses
Metal Fatigue
Crack Propagation
Stress Intensity Factor Range
S-N Curve

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

It is re-emphasized here that the effect of residual stress in fatigue is analogous to but not the same as the mean stress effect from applied loads.

The inclusion of a residual stress term in the stress intensity factor range of the fatigue crack propagation rate equation permits one to use the residual stress in calculations of fatigue life estimates. Using crack shape factors

(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

calculated for given aspect ratios of surface flaws and integrating da/dN, one obtains an equation for the S-N curve which includes the residual stress effect on fatigue performance.

This process of calculation reveals that compressive residual stress has a much stronger influence on fatigue life than tensile residual stress does, mainly because the former decreases the stress intensity factor range and increases the critical crack size while the latter only decreases the critical crack size. Numerical solution of an example illustrates an application of these concepts.

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1. REPORT NUMBER ARLCB-TR-82021	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SALOME, A STRUCTURED AND LOGICALLY MINIMAL ENSEMBLE OF PROGRAMMING CONSTRUCTS		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Royce W. Soanes, Jr.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801		12. REPORT DATE July 1982
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at 1982 Army Numerical Analysis and Computers Conference, US Army Engineers Waterways Experiment Station, Vicksburg, MS, 3-4 February 1982. Published in proceedings of the conference.

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

Structured Language	Strings	Program Generator
Structured Programming	Compiler	Source Language
Language Translation	Precompiler	Target Language
Language Translator		

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

An overview of the Salome structured programming language will be given, along with an appendix briefly describing its syntax and semantics. Salome has been designed with the Fortran programmer in mind. The Salome source language is supported by a translator having a target language of standard Fortran, and Fortran code may be injected into Salome source code when needed. The Salome translator has been written in Salome and Fortran.

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1. REPORT NUMBER: ARLCB-SP-82022	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): THE REGENERATIVE LIQUID PROPELLANT GUN	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): A. R. Graham	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 612603H180011, PRON No. 1A2237881A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: November 1982
	13. NUMBER OF PAGES: 54
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18. SUPPLEMENTARY NOTES

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

Combustion Instability
Fluid Physics
Gas Dynamics
Special Gun Sealing Techniques
Liquid Propellant Ignition Techniques
Regenerative Liquid Propellant Guns

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

Since its successful introduction into the liquid propellant gun field by the author in 1974, the Regenerative Liquid Propellant Gun has found much favor over the bulk loaded liquid propellant gun. This is due to its inherent ability to (a) yield extremely repeatable pressure time curves under the same conditions, (b) allow the engineer to virtually "design" the shape of the pressure time curve at will, called P-T curve tailoring, and (c) lend itself to rational engineering design procedures.

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20. Abstract (Cont'd)

The paper describes how a regenerative LP gun works in a tutorial sense by comparing the open literature results, obtained with three different regenerative liquid propellant gun test fixtures, all designed by the author. These test fixtures had bore diameters of 8.89, 25, and 40mm. The first two of these were tested at General Electric; the last at Benet Weapons Laboratory, ARRADCOM.

Emphasis is placed on design ease and scaling this type LP gun - demonstrated dramatically by the fact that the 8.89, 25, and 40mm regenerative LP gun test fixtures were designed, built and successfully tested within a three-year time frame. Performance results are discussed.

In one instance (the 40mm test fixture), high frequency (acoustical) combustion instability was encountered. It was demonstrated that this could be controlled through the use of baffles located in front of the propellant injector/piston - a technique used in liquid propellant rocket thrust chambers. This is important, since as one increases bore size, the chances of combustion instability become increasingly more likely; this could become especially critical at large bore sizes such as 155mm. It could become necessary to use another technique, known as the "multi-cell piston concept," to control combustion instability. This concept offers some unique scaling and development advantages, as discussed.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER ARLCB-TR-82023	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EFFECTS OF R-RATIO ON CRACK INITIATION AT EXTERNAL DISCONTINUITIES IN AUTOFRETTAGED CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Robert R. Fujczak		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0011 DA Project No. 1L161101A91A PRON No. 1A2251491A1A
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18. SUPPLEMENTARY NOTES

Presented at 1982 Spring Meeting of Society for Experimental Stress Analysis, Honolulu, Hawaii, 22-30 May 1982.
Published in Experimental Mechanics.

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

Positive Stress Ratios
Autofrettage
Fatigue Crack Initiation
Residual Tensile Stresses
Stress Concentration
Fatigue Strength Reduction Factor
Modified Goodman Diagram

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

Experimental work shows the effects of positive stress ratios, or tensile minimum stress, during the fatigue cycle on the fatigue crack initiation from holes. This simulates the effect of the residual tensile stresses at the outside surface of autofrettaged cylinders. S-N (stress life) curves and modified Goodman diagrams are shown for fatigue crack initiation.

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1. REPORT NUMBER: ARLCB-TR-82024	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): ELIASHBERG FUNCTION IN AMORPHOUS METALS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): L. V. Meisel and P. J. Cote	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 61110191A0011, DA Project No. 1L161101A9A, PRON No. 1A2231491A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: September 1982
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18. SUPPLEMENTARY NOTES

Published in Physical Review B, Volume 23, Number 11, 1 June 1981, pages 5834-5838.

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

Amorphous Alloys
Disordered Alloys
Eliashberg Function
Superconductivity

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

An expression for the Eliashberg function $\alpha^2F(\omega)$ is derived for amorphous metals beginning with a formulation in terms of the Van Hove dynamical structure factor. The result is equivalent to the one derived from a different starting point by Poon and Geballe. At low energy, $\alpha^2F(\omega)$ is shown to vary linearly with ω and inversely with the electron mean free path Λ in agreement with Bergmann's expression derived for a Gaussian-disordered crystalline

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20. ABSTRACT (CONT'D)

metal. Modification of the theory for short mean free paths is discussed in terms of the Pippard-Ziman condition on the electron-phonon interaction. Invoking a prescription derived by Pippard for the reduction of the electron-phonon interaction in ultrasonic attenuation, one finds a quadratic dependence of $\alpha^2F(\omega)$ on ω at low energies in high-resistivity amorphous metals; an even sharper reduction in the electron-phonon interaction and hence in $\alpha^2F(\omega)$ has been found by Poon, who treated the problem in transition-metal systems in the context of the Barisic-Labbe-Friedel rigid-ion approximation.

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1. REPORT NUMBER ARLCB -TR-82025	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) THE EFFECTS OF PARTIAL LENGTH CHROMIUM PLATING ON THE WEAR AND ACCURACY BEHAVIOR OF THE 105 MM M68 CANNON	5. TYPE OF REPORT & PERIOD COVERED Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) V. Peter Greco	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6436.28.00700 PRON No. GG-8-25521-GG-M7
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18. SUPPLEMENTARY NOTES

Presented at Tri-Service Manufacturing Technology Metals Subcommittee Surface Treatment WK, Hyannis Port, MA, July 1981.

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

Chromium Coatings	Deposit Spalling
Wear and Accuracy	Thickness Effects
Erosion	Dispersion

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

Ammunition additive has been introduced in the 105 mm M68 gun system to resist primary erosion at the commencement of rifling. However, the use of the additive has resulted in the formation of a down bore erosion profile called "secondary erosion". Secondary erosion has caused unacceptable target dispersion with the M392 projectile.

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20. ABSTRACT

This report describes a series of efforts taken to retard both primary and secondary erosion and restore tube life to its expected 1000 rounds. A major part of the investigation includes a new concept which was introduced to eliminate chipping and spalling of chromium down bore during early stages of firing. This involved the use of partially plated gun bores which successfully retarded primary and secondary erosion without degradation in target dispersion.

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REPORT DOCUMENTATION PAGE

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): VARIATIONAL PRINCIPLE FOR GUN DYNAMICS WITH ADJOINT VARIABLE FORMULATION	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): C. N. Shen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011, DA Project No. 1L161102AH60, PRON No. 1A2250041A1A
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18. SUPPLEMENTARY NOTES

Presented at the Third US Army Symposium on Gun Dynamics, Institute on Man and Science, Rensselaerville, NY, 11-14 May 1982.
Published in proceedings of the conference.

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

Gun Dynamics
Euler-Bernoulli Beam
Adjoint Variational Principle
Bilinear Forms
Finite Elements
Spline Functions
Boundary and Initial Value Problems

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

Gun dynamics problems involving a moving shell have several delta functions in the forcing terms of the equations of motion. The use of a variational method in conjunction with finite elements smooths the differentiability of the variables in the expression involving the delta functions. This report suggests that solutions of the gun dynamics problems be obtained numerically by a variation principle where the far end conditions in time are not required
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20. ABSTRACT (CONT'D)

for purposes of computation. In solving mixed boundary and initial value problems of a high order partial differential equation using spline functions, the computation may be simplified considerably if the variable in time can be truncated into arbitrary sections. Each section may have several node points for the spline functions in the time domain. This is true because we found from previous papers that the initial value problem can be solved in one direction using variational principle and cubic Hermite Polynomials, without worrying about the conditions at the far end.

The end conditions of the ajoint system can be adjusted according to the end conditions of the original system so that the bilinear concomitant is identically zero. This satisfies the variational principle. A bilinear form of the original and adjoint variables is employed in determining the coefficients of the variations of the functions and their derivatives. For the spatial variables Hermite Polynomial spline functions will be used. Algorithm and procedure of computation are given.

The variational principle for spatial and temporal problems with boundary and initial conditions are investigated. This variational principle is very general in scope and can be applied to many linear partial differential equations. The Euler-Bernoulli beam equation satisfies these variational principles. This lays the foundation for gun dynamics problems to be studied.

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1. REPORT NUMBER ARLCB-TR-82027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STRESS INTENSITY AND FATIGUE CRACK GROWTH IN A PRESSURIZED, AUTOFRETTAGED THICK CYLINDER		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A. P. Parker[1] J. F. Throop[2] J. H. Underwood[2] C. P. Andrasic[3]		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

Presented at Fourteenth National Symposium on Fracture Mechanics, UCLA, Los Angeles, CA, 29 June - 1 July 1981.
Published in ASTM Special Technical Publication.

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

Crack Growth	Fracture (Materials)
Fatigue Crack	Residual Stress
Cylinders	Stress Intensity Factor

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

Stress intensity factors are determined, using the modified mapping collocation (MMC) method for a single, radial, straight-fronted crack in a thick cylindrical tube which has been subjected to full autofrettage treatment (100 percent overstrain). By superposition of these results and existing solutions, stress intensity factors are determined for the same geometry with internal pressure and any amount of overstrain from zero to 100 percent.

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7. AUTHOR(S) (CONT'D):

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20. ABSTRACT (CONT'D):

Correction factors for crack shape and non-ideal material yielding are determined from various sources for the pressurized, autofrettaged tubes containing semi-elliptical cracks. These results are employed in the life prediction of pressurized thick tubes with straight-fronted and semi-circular cracks, for various amounts of autofrettage. Experimentally determined lifetimes for tubes having zero and 30 percent nominal overstrain are significantly greater than the predictions for both straight fronted and semi-circular cracks. This is related to multiple initiation and early growth of cracks from the notch.

Experimentally determined lifetimes for a tube with a 60 percent nominal overstrain are somewhat less than predicted. This effect is partially explained by additional experimental work which shows that the angle of opening of rings cut from autofrettaged tubes is somewhat less than the ideal predictions. The latter effect is attributed to the Bauschinger effect and the associated reduced yield strength in compression during the unloading of tubes during the autofrettage process.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
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4. TITLE (and Subtitle) NUMERICAL SOLUTIONS USING ADJOINT VARIATIONAL FORMULATION TO STRESS WAVE PROBLEMS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen and J. J. Wu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
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18. SUPPLEMENTARY NOTES Presented at 1982 Army Numerical Analysis and Computers Conference, US Army Engineers Waterways Experiment Station, Vicksburg, MS, 3-4 February 1982. Published in proceedings of the conference.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Adjoint Variational Principle Initial and Boundary Value Problems Wave Equation Spline Function Finite Elements Assembly of Matrices Matrix Row Elimination		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report deals with the numerical implementation of an involved analysis in conjunction with cubic Hermite polynomials as the approximate functions. The specific example used for numerical results is the longitudinal stress wave of a uniform bar. (CONT'D ON REVERSE)		

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20. ABSTRACT (CONT'D)

First, the adjoint principle associated with this problem is stated. It is followed by the discretized counterparts in spatial and temporal dimensions. The procedures involving the assemblage of the "mass" and "stiffness" matrices in the two dimensions are described. Due to the null variations of some adjoint variables, certain rows of the matrices are eliminated. Because certain variables are known at the boundaries, the unknown variables for the next interval of time can be computed by inversion of a band matrix in terms of their present values.

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1. REPORT NUMBER: ARLCB-TR-82029	2. GOVT ACCESSION NO.
	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): FAILURE DESIGN OF THICK-WALLED CYLINDERS CONSIDERING THE OD AS A FAILURE INITIATION SITE	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. A. Kapp and S. L. Pu	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 72801213000, PRON No. 1A1258731A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: September 1982
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18. SUPPLEMENTARY NOTES

Presented at ASME Pressure Vessel Design Conference, Orlando, FL, June 1982. Published in proceedings of the conference.

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

Fatigue
Thick-Walled Cylinders
Fracture Mechanics
Crack Initiation
Crack Growth

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

The outside diameter (OD) of thick-walled pressure vessels is considered as the initiation site for fatigue failure of the cylinder. OD failures can occur in pressurized cylinders which have discontinuities machined on their outside surfaces, and have been strengthened by the autofrettage process. Both the crack initiation and crack propagation phases are discussed. To do this, finite element stress solutions for OD notched thick-walled cylinders and

(CONT'D ON REVERSE)

20. ABSTRACT (CONT'D)

specialized fracture mechanics solutions are presented. Life and crack growth predictions based on these analyses are compared to previously performed experiments.

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1. REPORT NUMBER
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2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
FRACTURE TOUGHNESS OF HIGH STRENGTH STEEL PREDICTED FROM CHARPY ENERGY OR REDUCTION-IN-AREA

5. TYPE OF REPORT & PERIOD COVERED
Final

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
J. H. Underwood and G. S. Leger

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
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Benet Weapons Laboratory, DRDAR-LCB-TL
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18. SUPPLEMENTARY NOTES
Presented at 15th National Symposium on Fracture Mechanics, ASTM, University of Maryland in College Park, MD, 7-9 July 1982.
Published in proceedings of the symposium.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Fracture Toughness
Alloy Steel
Statistical Analysis
Mechanical Tests
Forged Cylinders

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Analysis is presented of the results of an extensive mechanical and fracture test program. Ninety-six hollow cylinder forgings of A723 steel with five different manufacturing processes were tested at two locations with different outer diameters. Yield strength, plane-strain fracture toughness, Charpy impact energy, and tensile reduction-in-area were measured and analyzed for statistical variation and difference of mean value. Linear regression was
(CONT'D ON REVERSE)

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20. ABSTRACT (CONT'D)

used to fit lines to the data and to determine correlation coefficients. Conclusions were drawn as to the suitability of Charpy energy and reduction-in-area as predictors of plane-strain fracture toughness.

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1. REPORT NUMBER ARLCB-TR-82031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ASYMPTOTIC AND NUMERICAL METHODS FOR VECTOR SYSTEMS OF SINGULARLY-PERTURBED BOUNDARY VALUE PROBLEMS	5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Joseph E. Flaherty, USA ARRADCOM and RPI Robert E. O'Malley, Jr., RPI	8. CONTRACT OR GRANT NUMBER(s) Grant No. AFOSR 80-0192
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111O191A0011 DA Project No. 1L161101A9A PRON No. 1A2231491A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE October 1982 13. NUMBER OF PAGES 24
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18. SUPPLEMENTARY NOTES

To be published in the Proceedings of US Army Numerical Analysis & Computers Conference, 3-4 February 1982. This Research was partially sponsored by US Air Force Office of Scientific Research, Air Force Systems Command, USAF and by the Office of Naval Research.

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

Asymptotic Analysis
Singular Perturbations
Nonlinear Two-Point Boundary Value Problems
Numerical Analysis
Collocation
Nonlinear Beams

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

Procedures are developed for constructing asymptotic solutions for certain nonlinear singularly-perturbed vector two-point boundary value problems having boundary layers at one or both end points. The asymptotic approximations are generated numerically and can either be used as is or to furnish a two-point boundary value code (e.g. COLSYS) with an initial approximation and a nonuniform computational mesh. The procedures are applied to several examples involving the deformation of nonlinear elastic beams.

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1. REPORT NUMBER: ARLCB-TR-82032	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): CONSTRAINED AND UNCONSTRAINED VARIATIONAL FINITE ELEMENT FORMULATION OF SOLUTIONS TO A STRESS WAVE PROBLEM - A NUMERICAL COMPARISON	5. TYPE OF REPORT & PERIOD COVERED: Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Julian J. Wu and C. N. Shen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, NJ 07801	12. REPORT DATE: October 1982 13. NUMBER OF PAGES: 27
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18. SUPPLEMENTARY NOTES

To be published in the Proceedings of the U.S. Army Numerical Analysis & Computer Conference, February 1982 at Vicksburg, MS.

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

Variational Methods
Numerical Analysis
Stress Wave

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

Unconstrained variational formulation has been applied to initial, boundary value problems previously with some numerical success. More recently, an adjoint bilinear variational principle has also been developed for initial and initial-boundary value problems which requires that the initial conditions be satisfied exactly and hence is a constrained variational formulation. This present report compares the numerical results of these two variational formulations for the case of a stress wave problem in a uniform bar.

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1. REPORT NUMBER ARLCB-TR-82033	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A FINITE DIFFERENCE PROGRAM FOR COMPUTING THE THERMO-ELASTIC-PLASTIC RESPONSE OF LINED GUN BARRELS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John D. Vasilakis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111019lA0011 DA Project No. 1L161101A9A PRON No. 1A2231491A1A
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18. SUPPLEMENTARY NOTES

Presented at 1982 Army Numerical Analysis and Computers Conference, US Army Engineers Waterways Experiment Station, Vicksburg, MS, 3-4 February 1982. Published in proceedings of the conference.

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

Transient Temperature Response
Thermo-Elastic-Plastic Stresses
Multi-Layered Cylinders
Repeated Firing Loads

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

A finite difference computer program for computing the thermo-elastic-plastic response of multi-layered cylinders due to repeated firing loads was discussed at the 27th Conference of Army Mathematicians. The multi-layered cylinder is a representation of a lined gun barrel. The program can accommodate several layers and can compute the transient temperatures and/or the stresses. It has been upgraded to include an initial program which computes heat transfer

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20. ABSTRACT (CONT'D)

coefficients, pressures and gas temperatures in the firing cycle for input to the main program. The effect of contact resistance between layers is now included. Results are shown for the behavior of a TZM liner in a steel tube.

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4. TITLE (and Subtitle)
CYCLIC TORSION OF A CIRCULAR CYLINDER

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

7. AUTHOR(s)
P. C. T. Chen
M. R. Aboutorabi (University of Iowa)
H. C. Wu (University of Iowa)

8. CONTRACT OR GRANT NUMBER(s)

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18. SUPPLEMENTARY NOTES
Presented at US Army Symposium on Solid Mechanics, Red Jacket Beach Motor Inn, So. Yarmouth, Cape Cod, MA, 21-23 September 1982.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Circular Cylinder
Torsional Loading
Cyclic Loading
Plasticity Theory
Endochronic Theory

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
The improved endochronic theory of plasticity is applied to the case of a solid bar with circular cross-section subjected to cyclic fully-reversed torsional loading. Numerical techniques are employed to obtain the solution. The parameters of the constitutive equations are determined from the test data of thin-walled specimens. These parameters are then used without alteration of compute stress distributions within the solid specimen. The relation of torque

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20. ABSTRACT (CONT'D)

vs. strain at the outermost fiber of the solid specimen provides an ultimate check of this theory. This report demonstrates an expanded use of improved theory.

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1. REPORT NUMBER ARLCB-TR-82035	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DYNAMIC FORCES IN GUN TUBE MOTIONS ANALYSIS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Julian J. Wu		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Command Benet Weapons Laboratory, DRDAR-LCB-TL Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600011 DA Project No. 1L161102AH60 PRON No. 1A2250041A1A
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18. SUPPLEMENTARY NOTES

Presented at the Third US Army Symposium on Gun Dynamics, Institute on Man and Science, Rensselaerville, NY, 11-14 May 1982.
Published in proceedings of the conference.

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

Gun Tube Dynamics
Vibrations
Moving Loads
Finite Elements
Variational Methods

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

As a continuing effort in the analytical study of gun tube dynamics, this report attempts to assess the relative importance of several dynamic forces on tube motions during firing. Specifically, the forces considered here are: (1) the force produced by the moving projectile, which, in turn, consists of a centrifugal part, a coriolis part, and an inertia part; (2) the axial force associated with recoil action; (3) the force produced by the combined effect of the tube

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20. ABSTRACT (CONT'D)

curvature and the chamber pressure; and (4) the projectile eccentricity as a moving couple.

The dynamic equation of a Bernoulli-Euler beam is first reviewed which includes the various forces as mentioned above. General boundary conditions and initial conditions are also stated. Thus, the stated objective becomes a parametric study of a very general initial boundary value problem. The solution formulation and procedure to this non-self-adjoint problem are then briefly reviewed. The procedure is a finite element discretization based on a variational problem shown to be equivalent to the stated initial boundary problem.

By taking one or several forces at a time in the governing equations, the dynamic deflections (or the gun tube motions) as affected by these forces can be evaluated. In this report, data from an idealized M68-105 mm cannon tube are used for comparisons. Results of tube motions are presented for each set of dynamic forces. It is shown that for the forces listed in items (1) through (3) above, the magnitude for the tube motion is small compared with experimental data. However, for the case of projectile eccentricity, the moving couple may be large enough to cause significant gun tube motions.

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1. REPORT NUMBER: ARLCB-TR-82036	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): LABORATORY TESTING OF LONG ROD PENETRATOR AND SABOT COMPONENTS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): M. A. Scavullo and J. H. Underwood	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 4111.16.2991.6, PRON No. 1A1242221A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon Systems Laboratory, Dover, NJ 07801	12. REPORT DATE: October 1982
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at US Army Symposium on Solid Mechanics Problems in Systems Design, So. Yarmouth, Cape Cod, MA, 21-23 September 1982.

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

Penetrator
Sabot
Launch
Structural Integrity
Kinetic Energy Projectiles

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

Laboratory testing apparatus is described which can be used to simulate the launch loading of penetrator and sabot components from kinetic energy penetrator rounds. The load and deflection to failure of production components has been measured and compared for different materials and configurations.
Results are described from penetrators made from a uranium alloy and two tungsten alloys. Results from sections of sabots are described, including two aluminum alloys and different configurations.

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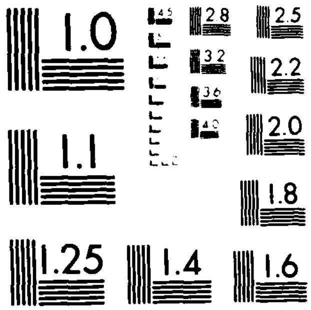

MICROCOPY RESOLUTION TEST CHART

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1. REPORT NUMBER ARLCB-TR-82037	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THERMAL WARNING DEVICE PROGRAM 155mm M185 HOWITZER M109A1/A2/A3		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John E. Brower		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

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

Thermal Warning Device
Propelling Charge
Cook-Off
Slot
Fatigue Life
Independent Design Review

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

A Product Improvement Program was undertaken to provide a thermal warning device to measure the temperature of the M185 Howitzer tube forcing cone area from the tube outside diameter and provide a readout to the user at the breech end. This would warn the gun crew when a dangerous temperature level had been attained, as well as permit a higher rate of fire than current procedures allow.

(CONT'D ON REVERSE)

20. Abstract (Cont'd)

The plan was to adapt the thermal warning device from the 155mm M198 Howitzer to the 155mm M109A1/A2/A3 Howitzer. The major problem required developing a method to attach the temperature sensor to a cannon tube which recoils through concentric recoil bearings without reducing the fatigue life of the cannon. After a suitable attachment method had been developed and successfully tested, the program was terminated by ARRCOM because of funding priorities.

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-82038	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): TRANSVERSE MOTION OF AN ELASTICALLY SUPPORTED 30 MM GUN TUBE DURING FIRING	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): T. E. Simkins, R. D. Scanlon, and R. Benedict*	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Command, Benet Weapons Laboratory, DRDAR-LCB-TL, Watervliet, NY 12189	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600011; DA Project No. 1L161102AH60; PRON No. 1A2250041A1A
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Presented at the Third US Army Symposium on Gun Dynamics, Institute on Man and Science, Rensselaerville, NY, 11-14 May 1982.
Published in proceedings of the conference.

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

Structural Dynamics
Gun Tube Dynamics

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

The work herein reports on the motion of a 30 mm gun tube as measured via strain gages mounted along its length. Simultaneous and independent measurements of motion at mid-tube and at the muzzle supply sufficient corroboration to remove all doubt as to the magnitude and character of the motion in space and time. Cubic interpolating splines are used to determine the bending strains along the tube at any time through shot ejection. Tube deformations

(CONT'D ON REVERSE)

7. AUTHOR(S) (CONT'D)

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20. ABSTRACT (CONT'D)

at many instants in time are obtained by spatial integration of the strain distribution to form a motion picture of the shape of the centroidal axis of the tube. The motion clearly shows the formation and propagation of a waveform near the breech end of the tube. Wave dispersion, whereby short wave lengths separate from the early waveform and travel faster toward the muzzle - as predicted by elementary beam theory - is clearly evident. The arrival and relfection of these short waves cause significant displacement and rotation of the muzzle.

Despite the clarity and confidence level inherent in the measurements, their magnitude remains five to ten times above that which can be explained at the present time. Mass eccentricity of the breech, barrel, or projectile is not sufficient to induce such motions - nor are interactions of the tube supports (deliberately of low stiffness) or loads arising from the tube curvature or asymmetric stiffness. While the discrepancies between measured and predicted motions are considerably less than those noted at the Second Gun Dynamics Symposium (1978), their magnitudes are still unsatisfactory.

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): THE EFFECT OF VELOCITY ON THE SLIDING BEHAVIORS OF COPPER ALLOYS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): R. S. Montgomery	8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

To be published in technical journal Wear.

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

Friction	Sliding	M650 Projectiles
Wear	Chromium Electroplate	M549 Projectiles
Scuffing	Tantalum	Hardness
Metal Transfer	Rotating Bands	Velocity of Sliding
Copper Alloys	M483 Projectiles	

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

This report is a study of the sliding behaviors of a number of copper alloys and other metals at various velocities. The research was carried out using the "pin-on-disk" friction and wear machine used for the work in ARRADCOM Technical Report ARLCB-TR-82018. The same three disk metals (AISI 4340 steel, chromium electroplate, and tantalum) and the same pin metals were also used. Previous experiments were at a sliding speed of 1.70 meters per second (m/s). In this

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20. ABSTRACT (CONT'D)

work sliding speeds of 3.05 m/s and 0.58 m/s were added for most of the alloys sliding on steel.

The amount of transferred metal generally increased with sliding velocity for copper alloys sliding on both steel and chromium electroplate but not for sliding on tantalum. The wear rates for the copper alloys sliding on steel usually increased as the sliding velocity increased from 0.58 m/s to 1.70 m/s, and then generally decreased as the sliding velocity increased still further from 1.70 m/s to 3.05 m/s sliding both on steel and tantalum. The wear rates sliding on chromium electroplate, on the other hand, remained about the same or increased as the sliding velocity increased from 1.70 m/s to 3.05 m/s. The coefficients of friction usually dropped as the speed of sliding was increased from 0.58 m/s to 1.70 m/s (only sliding on steel was investigated) and then usually remained about the same as the velocity was further increased from 1.70 m/s to 3.05 m/s.

It was not possible to correlate metal transfer, scuffing (rough transfer), or friction with the properties of the metal pair and, contrary to the situation at 1.70 m/s, there was no effect of hardness on wear at 3.05 m/s. At the faster sliding speed both wear and metal transfer of aluminum bronze and welded overlay band materials were not essentially different from the other copper alloys. (A difference had been found at a sliding speed of 1.70 m/s.)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-82040	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EROSION AND ITS CONTROL		5. TYPE OF REPORT & PERIOD COVERED Final
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7. AUTHOR(s) R. S. Montgomery and F. K. Sautter		8. CONTRACT OR GRANT NUMBER(s)
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18. SUPPLEMENTARY NOTES

To be presented at Spring Meeting ASLE, Houston, TX, 25-28 April 1983.
To be published in Transactions of ASLE Meeting.

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

Erosion
Bore Temperature
Temperature Resistance
Propellant Additives

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

Gun erosion is a complicated process which involves a number of interrelated factors. There is general agreement that erosion is a function of bore temperature but this does not eliminate controversy about its causes or the relative importance of different factors. The three effects involved in gun erosion are thermal, chemical, and mechanical. In the case of the most important erosion, that of steel bores at the origin-of-rifling, the chief factor is probably

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20. ABSTRACT (CONT'D)

thermal. However, no matter what the specific mechanism of erosion, it is a function of the rate of heat transferred to the bore. It can only be controlled by making the steel bore more resistant to temperature by coating it with a layer of another material or by lowering the rate of heat transfer from the propellant gases.

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