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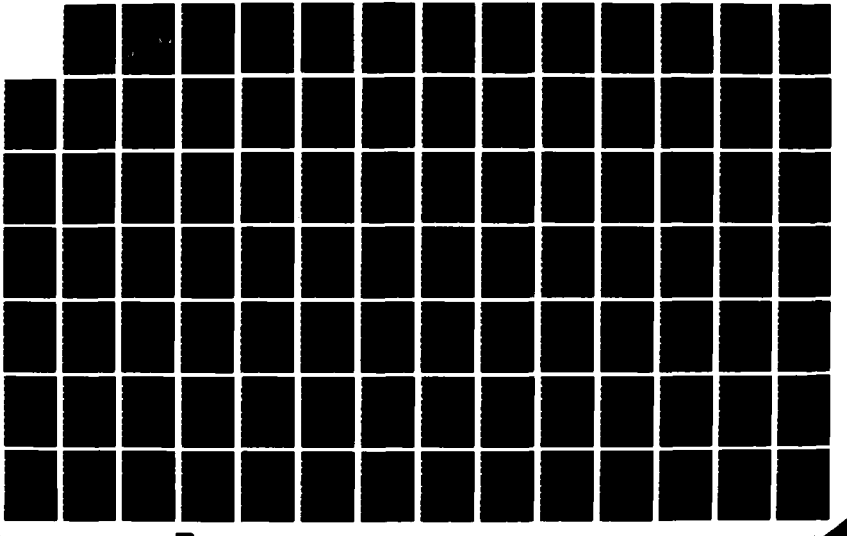

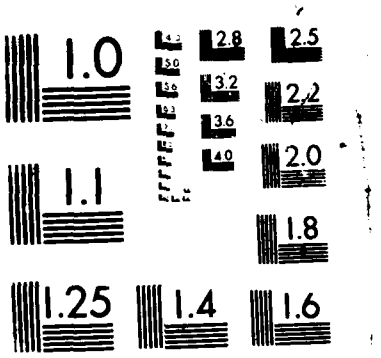

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INDEX TO BENET LABORATORIES TECHNICAL REPORTS - 1986

R. D. NEIFELD

TECHNICAL PUBLICATIONS AND EDITING UNIT

AUGUST 1987

US ARMY ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
CLOSE COMBAT ARMAMENTS CENTER
BENÉT WEAPONS LABORATORY
WATERVLIET, N.Y. 12189-4050

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ARCCB-TR-86039	Summary of the Proceedings of the Seventeenth National Symposium on Fracture Mechanics	J.H. Underwood R. Chait C.W. Smith D.P. Wilhem W.R. Andrews J.C. Newman	Dec 86
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Bell Aerospace Textron Buffalo, NY	ARCCB-CR-86041
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FMC Corporation Minneapolis, MN	ARCCB-CR-86017
Rensselaer Polytechnic Institute Troy, NY	ARCCB-CR-86006 ARCCB-CR-86011 ARCCB-CR-86038
Virginia Polytechnic Institute and State University Blacksburg, VA	ARCCB-CR-86029 ARCCB-CR-86036
Western Design Corporation Irvine, CA	ARCCB-CR-86030

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1. REPORT NUMBER: ARCCB-TR-86001	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): J_{Ic} TESTING USING ARC-TENSION SAMPLES	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. A. Kapp and W. J. Bilinsky (see reverse)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-CCB-TL, Watervliet, NY 12189-4050	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011, PRON No. 1A425M541A1A
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18. SUPPLEMENTARY NOTES

Presented at the 17th National Fracture Mechanics Symposium, Albany, NY, 7-9 August 1984.
Published in Proceedings of the Symposium.

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

J_{Ic} Testing
Alternate Specimens
J Analysis
Fracture Mechanics
Arc-Shaped Specimens

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

J_{Ic} was determined in two materials (6061-T651 aluminum and ASTM A-723 grade 1, class 4 pressure vessel steel) using arc-tension (A(T)) and compact tension (C(T)) samples. The J-R curves were determined by using both the multispecimen method and the compliance unloading method. J was determined for the A(T) specimen by the Merkle-Corten method of analysis as modified by Clarke and Landes. A correction factor was included to account for the tensile loading
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7. AUTHORS (CONT'D)

W. J. Bilinsky
General Electric Company
Selkirk, NY

20. ABSTRACT (CONT'D)

component, and both the plastic and elastic components of J were necessary when using the A(T) sample. With the proper formulas for J in the A(T) sample, the same J-R curves were determined in both materials using either A(T) or C(T) samples. This preliminary study suggested that the A(T) sample was totally adequate for J_{Ic} testing and should be included in subsequent versions of ASTM Method E-813 on J_{Ic}, A Measure of Fracture Toughness.

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3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: CORROBORATIVE MEASUREMENTS OF THE TRANSVERSE MOTION OF A GUN TUBE DURING FIRING	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): T. E. Simkins, G. A. Pflegl, and R. D. Scanlon	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research & Development Center, Benet Weapons Laboratory, SMCAR-CCB-TL, Watervliet, NY 12189-4050	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011, PRON No. 1A52F51D1A1A
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18. SUPPLEMENTARY NOTES

Presented at the Fourth U.S. Army Symposium on Gun Dynamics, Hilton Inn of the Palm Beaches, Riviera Beach, FL, 7-9 May 1985, and published in the proceedings.

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

Ballistics
Dynamics
Transverse Motion
Gun Dynamics
Muzzle Rotation

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

This work presents new measurements of transverse motion of the 30 mm (GAU-8) gun tube first reported at the Third Gun Dynamics Symposium in 1982. The measurements are unique and fully corroborated through the use of two independent measuring devices. In particular, the work discusses three items of interest. First, there definitely exists a 'base-line' transverse tube movement, the cause of which has yet to be determined. The magnitude of this

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20. ABSTRACT (CONT'D)

motion is of the same order as that due to other causes intentionally introduced for study. Second, intentionally introducing an eccentric breech mass produces muzzle displacements in good agreement with theoretical models, provided the 'base-line' component is accounted for. Finally, the muzzle rotation created by the moving projectile - though insignificant when operating alone - is strongly coupled to, and capable of greatly modifying the rotation due to other causes. This coupling does not appear to strongly affect muzzle displacement. It is concluded that predictions from gun dynamics models which agree well with displacement measurements, may err greatly when used to predict muzzle rotation, the quantity of which is of central interest.

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1. REPORT NUMBER ARCCB-TR-86003	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) AN AUTOMATED IN SITU MEASUREMENT OF CHROMIUM PLATE THICKNESS IN GUN TUBES DURING PLATING		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. Frankel and W. J. Korman		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 2080.18.6000.000 PRON No. 1A3223B91A1A
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18. SUPPLEMENTARY NOTES

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

Chromium Plating
Ultrasonic Measurement

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

An application of ultrasonic techniques is described by which the thickness of chromium plated by the flow-through technique on the bore of large caliber tubes, can be measured automatically and displayed during the plating process in analog or digital form.

The in situ thickness determination is facilitated by a novel chromium thickness calibrator, which continuously measures a known chromium thickness.

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20. ABSTRACT (CONT'D)

Eight ultrasonic transducers are mounted in two harnesses. The harnesses are tightly gripped to the tube at different axial points, each to provide four thickness readings around the bore.

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1. REPORT NUMBER ARCCB-TR-86004	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) YOUNG'S MODULUS AND POISSON'S RATIO OF STEEL AS STRESS DEPENDENT QUANTITIES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) W. Scholz and J. Frankel		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.011 PRON No. 1A52F59W1A1A
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18. SUPPLEMENTARY NOTES

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

Elastic Constants
Young's Modulus
Poisson's Ratio
Steel

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

Second and third-order elastic constants of 4340 steel obtained from ultrasonic measurements of specimens under zero and moderate uniaxial stresses are used under a continuum mechanics analysis of finite deformation to predict Young's modulus and Poisson's ratio, not only in the stress range of the measurement, but at stresses near the yield point (150,000 psi), where Young's modulus changes by about 2.5 percent, Poisson's ratio by 5 percent (both decrease in tension and increase in comparison).

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1. REPORT NUMBER ARCCB-TR-86005	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) MECHANICAL PROPERTY DEVELOPMENT IN HOT ISOSTATIC PRESSED (HIP) LOW ALLOY STEEL POWDER		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Peter Thornton John Senick John Atchinson		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.8241.1 PRON No. 1A228597lA1A
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Alloy Steel
Powder Metallurgy
Mechanical Properties
Hot Isostatic Pressing

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

The mechanical properties of a low alloy steel gas atomized powder, which was hot isostatically pressed (Hipped) to full density, were developed using typical commercial heat treatment practices. Tempering temperatures were varied systematically from 1000°F to 1200°F and the tensile and impact properties evaluated along with the corresponding microstructural conditions. Yield strengths on the order of 180,000 psi accompanied by low temperature,

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20. ABSTRACT (CONT'D)

impact toughness values of 18-20 ft-lb were developed in billets of this material, 4 inches in diameter. The results of this study demonstrate that hot isostatic pressing of low alloy steel powder can be utilized to produce high quality components for critical applications which will benefit from near-net shape manufacturing techniques.

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1. REPORT NUMBER ARCCB-CR-86006	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STUDY OF HIGH MODULUS GRAPHITE/HIGH TEMPERATURE POLYMERIC MATRICES - PHASE I		5. TYPE OF REPORT & PERIOD COVERED Summary - Phase I 31 Jul 84 - 1 Aug 85 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) S. J. Calabrese, J. D. Cogdell, S. F. Murray, and V. Paedelt		8. CONTRACT OR GRANT NUMBER(s) DAAA 22-84-C-0211
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rensselaer Polytechnic Institute Troy, NY 12180-3590		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government Agencies and their contractors only because of critical technology; February 1986. Other requests for this document must be referred to Commander, US Army Armament Research and Development Center, ATTN: Benet Weapons Laboratory, SMCAR-CCB-RT, Watervliet, NY 12189-4050.

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

18. SUPPLEMENTARY NOTES

Glenn S. Friar - Benet Weapons Laboratory Project Engineer

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

Resin Matrix Composites	Adhesive Bonding
Graphite Fiber-Reinforced Composites	Polyimides
High Temperature Composites	Bismaleimides
Surface Preparation	Fabrication Techniques

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

The objective of this work is to select candidate high temperature resins and develop fabrication techniques for making concentric, graphite fiber-reinforced composite tubes, bonded to the outside diameter of steel tubes. The purpose of the composite overlay is to strengthen and stiffen the steel tubes up to temperatures of at least 500°F.

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20. ABSTRACT (CONT'D)

This Phase I report describes the results of initial evaluations that were necessary to accomplish this objective. These included: 1) evaluation of methods for surface preparation of the steel and the use of adhesives to promote higher bond strengths between the steel and the composites; 2) initial selection of candidate resins; 3) development of suitable composite fabrication methods; and 4) measurements of the elastic properties and bond strengths of the fabricated composites.

The candidate high temperature resins that were selected for these preliminary evaluations included one bismaleimide and three different types of polyimides.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86007	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ANALYSIS OF GRADIENT CHANGE THRESHOLDS IN THE DETECTION OF EDGES OF OBJECTS FROM RANGE DATA		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen and R. L. Racicot		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.011 PRON No. 1A52F59W1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE February 1986 13. NUMBER OF PAGES 22
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18. SUPPLEMENTARY NOTES

Presented at the Third Army Conference on Applied Mathematics and Computing, Georgia Institute of Technology, Atlanta, Georgia, 13-16 May 1985. Published in Proceedings of the Conference.

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

Gradient Change
Detection
Threshold
Probabilities
Scanning Scheme
Laplacian Method
Second Residual Method

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

Edges of objects setting on or within a flat terrain can be defined by the slope or gradient change occurring at the edge. A simple estimate of slope change is to calculate the Laplacian using incremental range measurements taken at different elevation angles. The Laplacian is defined as the second difference of the range data. Since the range data contains noise in the form of measurement error, consideration must be given to the statistical aspects of

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20. ABSTRACT (CONT'D)

detecting edges in order to differentiate between actual edges and noise effects. In this report, results are presented which describe the effects on minimum detectable slope change of (1) noise levels, (2) probability of miss, (3) probability of false alarm, (4) spacing of the measurements, and (5) random distribution of edges near range measurement points.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86008	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ON THE ELECTRODEPOSITION AND CHARACTERIZATION OF NIOBIUM FROM FUSED FLUORIDE ELECTROLYTES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. P. Capsimalis, E. S. Chen, R. E. Peterson, and I. Ahmad (See Reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A52F51D1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE February 1986 13. NUMBER OF PAGES 17
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18. SUPPLEMENTARY NOTES

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

Electrodeposition
Molten Salt
Refractory Coatings
High Temperature Resistant Erosion Material
Microstructure Characterization

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

The electrodeposition of niobium from a binary electrolyte consisting of KF and NaF was characterized and compared with the ternary electrolyte of LiF, NaF, and KF. The deposition experiments were conducted at current densities between 5 and 35 mA/cm^2 and electrolyte temperatures between 725° and 800°C. DTA measurements indicated the melting points to be 450° and 710°C for the ternary and binary electrolytes with added K_2NbF_7; however, it was necessary

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7. AUTHORS (CONT'D)

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20. ABSTRACT (CONT'D)

to operate both electrolytes above 725°C to obtain dense coherent deposits. Coating morphology was described by optical and scanning electron microscopy (SEM) morphology, while coating structure and properties were characterized by x-ray diffraction analysis. In particular, a series of diffraction measurements were reported to describe the changes in the microstructure of the deposited material as a function of the preparation conditions.

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1. REPORT NUMBER ARCCB-TR-86009	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A DESIGN METHOD FOR AUTOFRETTAGED THICK-WALLED CYLINDERS WITH OUTSIDE DIAMETER DISCONTINUITIES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. J. Busuttil, Jr. and J. A. Kapp		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 69400R2400022 PRON No. 1A62ZH43NMSC
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE February 1986 13. NUMBER OF PAGES 21
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18. SUPPLEMENTARY NOTES

To be presented at ASME 1986 Pressure Vessel and Piping Conference, Chicago, IL, 21-25 July 1986.
To be published in Proceedings of the Conference.

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

Stress Concentration
Cylinders
Pressure Vessels
Cannon
Fracture
Fatigue
High Strength Steel

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

A design method has been developed to determine the fatigue life of thick-walled autofrettaged cylinders containing outside diameter (OD) notches which act as failure initiation sites. The method uses local strain analysis for fatigue crack initiation and fracture mechanics analysis for crack propagation to failure. The method is relatively easy to program and thus can be used to optimize cylinder designs with respect to OD initiated failures. The computer
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20. ABSTRACT (CONT'D)

program developed requires only minimal input to estimate life: cylinder dimensions, notch depth and root radius, internal pressure, and material yield strength. Other material properties (low cycle fatigue data, fracture toughness, and crack growth law) are permanently stored.

The program calculates the elastic stress concentration factor using a Neuber diagram as a default. If the elastic k_t is known from other sources, this feature of the program can be overridden. The stress concentration factor is used to calculate notch root stresses from which local strains are estimated. Once the local strains are known, crack initiation life is estimated using the stored low cycle fatigue data. A crack is then assumed to exist and a power law is integrated to determine crack propagation life to failure. The total life is the sum of the initiation and propagation lives.

The applicability of the design method is demonstrated by using it to predict the total fatigue lives of existing cylinder designs with measured fatigue lives. The method's predictive capability is very good to conservative. In no case was life substantially overestimated. In addition, a design example is presented.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86010	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A HIGH SPATIAL RESOLUTION DIGITAL SYSTEM FOR ULTRASONIC IMAGING		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. F. McDonald, P. K. Das, K. C. Laprade, C. J. Hidalgo, K. S. Goekjian, L. Jones, H. Shyu, and G. Capsimalis (See Reverse)		8. CONTRACT OR GRANT NUMBER(s) DAAA22-81-C-0170 (Phase 1) DAAA22-81-C-0185 (Phase II)
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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)

Ultrasonic Imaging	Fourier Holography
Digital Holography	High Spatial Resolution
VLSI in Ultrasonics	Parallel Processing

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

In recent years, the authors have investigated some of the fundamental theoretical physical limtations imposed on ultrasonic array performance. This has led to the extensive study of energy trapping as one means of enhancing the spatial confinement of element radiation in the array. In this report, we describe a system designed to explore the quality of the images produced by practical trapped energy mode, hybrid trapped energy mode, and other types of

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7. AUTHORS (CONT'D)

J. F. McDonald, P. K. Das, K. C. Laprade, C. J. Hidalgo, K. S. Goekjian,
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20. ABSTRACT (CONT'D)

arrays. The system implements a 256 channel parallel set of A/D and D/A converters for attachment to an arbitrary array. All 256 channels operate simultaneously at a maximum sampling frequency of 10 MHz. Hence, the total throughput of signal samples reaches 2.5 billion samples per second in a "burst" mode. The multiple-ported DRAM memory has $1x10^6$ bytes of local high speed storage. Since all of the input and output signals are in digital form, a wide variety of image processing techniques can be employed. For example, from a single pulse, it is possible to reconstruct the two-dimensional hologram of the ultrasonic imaging using fast digital hardware. The images can also be prepared by pulse-echo techniques using the same system. Transmission from one portion of the array and monitoring the signal in another portion simultaneously to detect interelement coupling is possible. In this way, all of the key array parameters can be controlled and calibrated. Because of the D/A capability of the system, various signals can be transmitted from each array element, thereby permitting focusing and design of optimum probing signals.

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1. REPORT NUMBER ARCCB-CR-86011	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ULTRASONIC IMAGING AND AUTOMATED FLAW DETECTION SYSTEM		5. TYPE OF REPORT & PERIOD COVERED Final Contract Report 6. PERFORMING ORG. REPORT NUMBER UI84-1
7. AUTHOR(s) L. Jones, J. F. McDonald, and G. P. Capsimalis (See Reverse)		8. CONTRACT OR GRANT NUMBER(s) DAAA22-80-C-0170
9. PERFORMING ORGANIZATION NAME AND ADDRESS Rensselaer Polytechnic Institute Center for Integrated Electronics Troy, NY 12180-3590		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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18. SUPPLEMENTARY NOTES

George P. Capsimalis - Benet Weapons Laboratory Project Engineer

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

Flaw Detection
Array Imaging
Computer Controlled
Acoustic System

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

An automated inspection system is described for detecting, imaging, and classifying flaws in cannon billets. The first phase of the project has produced a flaw detection system capable of triggering rapidly and reliably on flaws down to one-fourth inch in cross-section in billets up to 18 feet in length and 22 inches in diameter. This portion of the system has been optimized for low cost, high speed, simplicity, and maintainability utilizing

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

7. AUTHORS (CONT'D)

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20. ABSTRACT (CONT'D)

many commercially available components with a minimum use of one-of-a-kind electronic interface boards. It is a versatile, programmable stand-alone unit capable of scanning one billet every half hour. The second phase system is designed to considerably enhance the images of flaws which have been detected and located using the first phase system by providing a much larger ultrasonic array aperture and digitizing capacity. The resulting hardware is capable of both quasi-optic lens processing and digital holography.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86012	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A NEW METHOD OF PREDICTING RESIDUAL STRESSES IN AUTOFRETTAGED GUN BARRELS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.0 PRON No. 1A6DZ602NMSC
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To be published in Proceedings of the Conference.

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

High Strength Steel	Strain-Hardening
Gun Barrel	Residual Stress
Bauschinger Effect	Autofrettage

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

The determination of residual stresses in autofrettaged gun barrels has been considered by many investigators using different mathematical methods and material models. Most of the earlier solutions were based on the assumption that the material behaves elastically on the release of the autofrettaged pressure. However, many materials, particularly the quenched and tempered, low alloy steels generally used for high pressure vessels, exhibit a significant

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20. ABSTRACT (CONT'D)

Bauschinger effect. In a recent paper, this author presented a closed-form solution of residual stresses in autofrettaged tubes based on a theoretical model considering the Bauschinger and hardening effects during unloading, but neglecting the strain-hardening during loading. A more general theoretical model without this restriction was proposed earlier, but only part of the final results were shown. In the present report, the complete method of stress and deformation analysis based on the general theoretical model is stated. The new model is a better representation of the actual loading/unloading behavior in a high strength steel. The Bauschinger effect factor is treated as a function of overstrain. The strain-hardening effect is taken into account with different parameters used for loading and unloading processes. The formulas for calculating stresses, strains, and displacements are given. The new results indicate that the influence of the Bauschinger and hardening effects on residual stresses is significant. A comparison with two experimental results has been made.

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1. REPORT NUMBER ARCCB-MR-86013	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A THIN CYLINDER PROBLEM		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. P. O'Hara		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6940.0R.2200.022 PRON No. 1A62RD2YNMSC
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18. SUPPLEMENTARY NOTES

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

Stress
Deformation
Cylinder
Thin
Hole

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

The purchase of a computer aided design (CAD) system for Benet Weapons Laboratory required the use of a set of demonstration problems which potential contractors would be asked to perform on the different systems. One of these was to be a finite element stress analysis problem which would not be difficult or time-consuming. However, it did have to demonstrate a mesh generation in three dimensions. The problem selected was a thin-walled cylinder with a
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20. ABSTRACT (CONT'D)

single hole at mid-length and loaded with a simple axial tension. This report is an outline of the work done to define this problem and demonstrate a typical solution to it.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86014	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* EMBRITTLEMENT OF A HIGH AND A LOW STRENGTH STEEL IN LIQUID LEAD ENVIRONMENT		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6658.01.M420.0 PRON No. 1A-6-7Z623-NMSC
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18. SUPPLEMENTARY NOTES

Presented at American Society for Metals International Conference and Exhibition on Fatigue, Corrosion Cracking, Fracture Mechanics, and Failure Analysis, Salt Lake City, Utah, 2-6 December 1985.
Published in Proceedings of the Conference.

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

Liquid Metal Embrittlement
Fracture
Steel
Lead

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

A study has been made of the cyclic fatigue fracture behavior of single-edge notched specimens of 4340 type high strength (yield stress 160 Ksi) and alloy steel of low strength (yield stress 100 Ksi) with and without a fatigue precrack tested in liquid lead and argon at 700°F. The high strength steel specimens were severely embrittled by liquid lead with stress intensity at fracture some two orders of magnitude lower in liquid lead than in the argon
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20. ABSTRACT (CONT'D)

environment. The embrittlement susceptibility was the same for both the notched specimens and for the specimens that had a fatigue precrack at the root of the notch. On the other hand, identical as-notched specimens of low strength steel were immune to lead embrittlement. However, when these specimens were fatigue precracked, they were severely embrittled by liquid lead. This variation in susceptibility to embrittlement is discussed in terms of the prevalent "reduction in cohesion" mechanism of liquid metal embrittlement. The implications of these results in determining the embrittlement susceptibility or elimination are also discussed.

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1. REPORT NUMBER ARCCB-TR-86015	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* LINEAR ELASTIC FRACTURE TESTING: CURRENT STATUS WITHIN ASTM COMMITTEE E-24 ON FRACTURE		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John H. Underwood		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research & Development Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO. 7280123000 PRON NO. 1A52N5L51A1A
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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)*

Elastic Stress
Fracture Mechanics
Test Methods
Pressure Vessel

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

The current status of elastic-stress-controlled fracture testing within ASTM is summarized, including example test results from high-strength steel forgings used for cannon. Plane-strain fracture toughness test methods were emphasized. Areas for future work were also discussed, including rapid crack growth tests, correlative tests, and tests for composite materials.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARCCB-CR-86016	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: FINAL REPORT GENERIC AMMUNITION LOADING SYSTEM (GALS) PHASE I	5. TYPE OF REPORT & PERIOD COVERED: Final Report - Phase I Aug 1985 - Feb 1986
	6. PERFORMING ORG. REPORT NUMBER: EE2803
7. AUTHOR*(s)*	8. CONTRACT OR GRANT NUMBER*(s)*: DAAA22-85-C-0213
9. PERFORMING ORGANIZATION NAME AND ADDRESS Emerson Electric Company Electronics and Space Division St. Louis, MO 63136	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001	12. REPORT DATE: May 1986 13. NUMBER OF PAGES: 233
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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

Donald E. Jones - Benet Weapons Laboratory Project Engineer

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

GALS, Autoloader, Manual Loading, Human Factors, Ammunition Logistics, Ammunition Packaging, Technology, Universal Ammunition Package/Container, Unit Package, Reliability Modeling, Electric Devices, Separated Ammunition, Fixed Ammunition, Robotic, Flexible Automation

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

The Generic Ammunition Loading System (GALS) demonstrator program identifies and matures key technologies to address user deficiencies in the Close Combat, Heavy and Combat Service Support Mission Areas. The GALS concept stresses improved resupply of ammunition, rapid rearm, and automatic loading of the main gun for combat vehicles. Phase I of the program required the identification of technologies, the generation of a conceptual design, and the fabrication of a full-scale model of the design. Phases II and III of the

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20. ABSTRACT (CONT'D)

program are planned to mature the technologies for a laboratory breadboard and a live firing prototype, respectively.

This report describes the work done on Contract DAAA22-85-C-0213 by Emerson Electric Company in Phase I. It includes a description of the conceptual design, an assessment of ammunition logistics, and human engineering analysis performed. An ammunition packaging materials evaluation and an outline test plan for the demonstrator are included.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARCCB-CR-86017	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: GENERIC AMMUNITION LOADING SYSTEM (GALS) FINAL REPORT - PHASE I	5. TYPE OF REPORT & PERIOD COVERED: Final Report - Phase I Jul 1985 - Dec 1985
	6. PERFORMING ORG. REPORT NUMBER: E-2499
7. AUTHOR(s): M. W. Osborne, R. A. Dahl, D. Cole, R. V. Hettwer, M. Janssen, R. C. Schmidt, J. Polai	8. CONTRACT OR GRANT NUMBER(s): DAAA22-85-C-0207
9. PERFORMING ORGANIZATION NAME AND ADDRESS: FMC Corporation, Northern Ordnance Division, 4800 East River Road, Minneapolis, MN 55421	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center, Close Combat Armaments Center, Dover, NJ 07801-5001	12. REPORT DATE: May 1986
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14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*: US Army Armament Research, Develop, & Engr Center, Benet Weapons Laboratory, SMCAR-CCB-TL, Watervliet, NY 12189-4050	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

Donald E. Jones - Benet Weapons Laboratory Project Engineer

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

GALS, Autoloader, Manual Loading, Human Factors, Ammunition Logistics, Ammunition Packaging, Technology, Universal Ammunition Package/Container, Unit Package, Reliability Modeling, Electric Devices, Separated Ammunition, Fixed Ammunition, Robotic, Flexible Automation

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

The Generic Ammunition Loading System (GALS) demonstrator program identifies and matures key technologies to address user deficiencies in the Close Combat, Heavy and Combat Service Support Mission Areas. The GALS concept stresses improved resupply of ammunition, rapid rearm, and automatic loading of the main gun for combat vehicles. Phase I of the program required the identification of technologies, the generation of a conceptual design, and the fabrication of a full-scale model of the design. Phases II and III of the

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20. ABSTRACT (CONT'D)

program are planned to mature the technologies for a laboratory breadboard and a live firing prototype, respectively.

This report describes the work done on Contract DAAA22-85-C-0207 by FMC Corporation, Northern Ordnance Division, in Phase I. It includes a description of the technology identification and conceptual design effort. A systems engineering effort was conducted based on an analysis of the ammunition logistics and the loader performance requirements. Reliability predictions and manual loading operations are included.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86018	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE ELASTIC CONSTANTS OF Ni_3Al to 1.4 GPa		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. Frankel, J. Vassiliou, J. C. Jamieson, D. P. Dandekar, and W. Scholz (see reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.011 PRON No. 1A52F59W1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE May 1986 13. NUMBER OF PAGES 11
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18. SUPPLEMENTARY NOTES

Presented at the Xth AIRAPT International High Pressure Conference, Amsterdam, The Netherlands, 8-11 July 1985.
Published in Proceedings of the Conference.

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

High Pressure
Elastic Constants
Ultrasonics
Single Crystals

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

The pressure derivatives of the elastic constants of single-crystal Ni_3Al have been determined to 1.4 GPa by both pulse superposition and pulse-echo overlap techniques. Measurements were made on single-crystal specimens of orientation <100> and <110>, thus providing at least one cross-check. The values of c_{11}, c_{12}, and c_{44} at one atmosphere are found to be 223.5, 149.0, and 122.9 GPa, respectively. The pressure derivatives of the elastic constants have been determined.

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4. AUTHORS (CONT'D)

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1. REPORT NUMBER ARCCB-SP-86019	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INDEX TO BENET WEAPONS LABORATORY TECHNICAL REPORTS - 1985		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. D. Neifeld		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		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 1985.		

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1. REPORT NUMBER ARCCB-TR-86020	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) STRESS AND DEFORMATION ANALYSIS OF AUTOFRETTAGED HIGH PRESSURE VESSELS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. C. T. Chen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.0 PRON No. 1A6DZ602NMSC
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18. SUPPLEMENTARY NOTES

To be presented at ASME 1986 Pressure Vessel and Piping Conference, Chicago, IL, 21-26 July 1986.
To be published in Proceedings of the Conference.

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

High Strength Steel	Strain Hardening
Pressure Vessel	Residual Stress
Bauschinger Effect	Autofrettage

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

A method of stress and deformation analysis based on a new theoretical model is reported. The new model is a close representation of the actual loading/unloading behavior in a high strength steel. The Bauschinger effect factor is treated as a function of overstrain. The strain-hardening effect is taken into account with different parameters used for loading and unloading processes. The formulas for calculating stresses, strains, and displacements are given and new results of residual stresses in autofrettaged high pressure vessels are presented.

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1. REPORT NUMBER ARCCB-TR-86021	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) UNLOADING-COMPLIANCE AND LOAD-DROP ANALYSIS OF J_{Ic} TESTS OF IRRADIATED 348 STAINLESS STEEL		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. H. Underwood, F. M. Haggag, and W. G. Reuter (See Reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO 7280.12.12.000 PRON NO. 1A423M891A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE June 1986 13. NUMBER OF PAGES 24
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18. SUPPLEMENTARY NOTES Presented at the 18th. Symposium on Fracture Mechanics at University of Colorado, 24-27 June 1985, Boulder, CO. and printed in the Proceedings.

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

J_{Ic} Tests	Three-Point Bend Specimen
Unloading-Compliance	Side Grooves
Load-Line Displacement	Load-Drop
Effective Modulus	

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

Procedures for determining J integral fracture toughness were applied to load versus load-line displacement data from a series of three-point bend specimens of irradiated 348 stainless steel tested at 23°C and 427°C. ASTM Method E813 for J_{Ic} was emphasized, using both unloading-compliance and load-drop measures of crack growth.

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7. AUTHORS (CONT'D)

F. M. Haggag* and W. G. Reuter
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Idaho Falls, ID

*Currently Battelle Columbus Laboratory, Columbus, OH

20. ABSTRACT (CONT'D)

An effective modulus procedure was included in the unloading-compliance method using recently published load-line displacement results. Two procedures were used for calculating J_{Ic} from the J versus unloading-compliance crack growth plots: the linear fit procedure from E813 and a power law fit with a 0.2 mm offset value of J_{Ic}.

Based on the results of these various procedures, conclusions were reached regarding the most consistent measures of fracture toughness from these data. Suggestions were given regarding the use of effective modulus with unloading-compliance measurement of crack growth and the limitations of the load-drop method for measuring crack growth.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86022	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SIMULATION FATIGUE TESTING OF AN AUTOFRETTAGED CYLINDER WITH AN OUTSIDE DIAMETER NOTCH: THE EFFECTS OF ROOT RADIUS AND SURFACE CONDITION PART I - VERY LOW CYCLE APPLICATIONS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. A. Kapp, V. P. Greco, and R. T. Abbott		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS NO. 2080.18.6000.000 PRON NO. 1A3223B91A1A
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18. SUPPLEMENTARY NOTES

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To be published in the Journal of Pressure Vessel Technology

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

Fatigue Life
Notch Root Radius
Thick-Wall Cylinder
Crack Initiation
Ball Peening

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

The effects of notch root radius, electropolishing after machining, and glass ball peening after machining have been studied in simulation tests of an outside diameter (OD) notched, autofrettaged thick-walled cylinder subjected to cyclic internal pressure. Fatigue life measurements were made using specimens designed such that the stress at the notch root due to both autofrettage and pressure were simulated exactly. Fatigue life was defined as the number of

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20. ABSTRACT (CONT'D)

cycles required to initiate a crack at the notch. Crack initiation was determined by ultrasonic measurement and verified by visual examination of the fracture surface. The notch root radius was varied from about 0.010 in. (0.254 mm) to 0.020 in. (9.508 mm). This range of root radius corresponds to stress concentration factors from between 3.9 and 5.4. The total fatigue life of full-size cylinders in this configuration is between 3000 and 5000 cycles. Attempts were made to predict fatigue crack initiation using local strain analysis. The experimental results show that fatigue initiation life may be increased by about 300 percent with increased root radius. Neither electropolishing nor glass peening showed any improvement over the as-machined notch. Further testing is needed to determine if surface treatments affect fatigue life at longer lives. Also, the local strain analysis yielded a lower limit prediction of the actual behavior.

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1. REPORT NUMBER ARCCB-MR-86023	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF CORROSION RESISTANT SURFACES ON 6061 ALUMINUM ALLOY		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Edward Troiano		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)

Anodizing
Chemical Conversion Coating
Solid Film Lubricants
Bore Evacuator

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

This study was undertaken in order to provide corrosion protection for 6061 aluminum. Anodizing (Type II and III), chemical conversion coating, and solid film lubricants were tested and evaluated. It was found that anodizing Type II offers excellent corrosion protection, but in cases where anodizing cannot be used, chemical conversion coating and solid film lubricants offer ample corrosion protection.

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1. REPORT NUMBER ARCCB-TR-86024	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) COMPUTATION OF RESIDUAL STRESSES DUE TO PHASE TRANSFORMATIONS DURING QUENCHING OF HOLLOW CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. D. Vasilakis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.02.H600.011 PRON No. 1A52F51D1A1A
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14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

Presented at the Third Army Conference on Applied Mathematics and Computing, Georgia Institute of Technology, Atlanta, Georgia, 13-16 May 1985. Published in Proceedings of the Conference.

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

Quenching
Thermal and Transformation Stresses
ADINA Finite Element Code

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

In a previous paper, a method for computing the stresses due to the combined effects of transient temperatures and material phase transformations was described. The general purpose finite element program ADINAT/ADINA was used for the computation of both the transient temperatures and the associated stresses. The problem considered was that of an axisymmetric hollow cylinder undergoing a water-spray quench. The present work considers a similar model,
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20. ABSTRACT (CONT'D)

but is better able to describe the residual stress state because of the availability of a more accurate set of properties for the material expansion due to the phase transformation. Effects on the transient and residual stresses due to modifications of the material expansion and varying quench rates are discussed.

It was found that the stresses due to the transformation are more severe than those due to the transient temperatures alone. Inelastic behavior is found to occur in all the cases considered and high residual stresses can exist on the inner and outer surfaces. While dependent on actual material composition, these residual stresses can lead to quench cracking.

The model describes the rapid quenching of steel gun tubes for the purpose of developing a martensitic grain structure and desired physical properties in the tube.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86025	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DEVELOPMENT OF AN EXPERIMENTAL MANIPULATOR ARM FOR APPLICATIONS IN THE CLOSE COMBAT MISSION AREAS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Donald E. Jones and Glenn S. Friar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6126.03.H180.011 PRON No. A1-6-20334-A11A
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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Robotics
Material Handling
Combat Vehicles
Experimental Manipulator
Kinematics
Dynamics
Control

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

Robotics has been identified as an emerging technology with potential for use in tank gun ammunition loading systems. Under some circumstances the requirements of combat vehicle applications are at odds with those for which general purpose industrial robots are intended. This report describes the kinetic and dynamic approaches and formulations leading to current investigations in the areas of modeling, control theory and application, and design. An experimental device which is being developed to test some of the theory is described.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARCCB-TR-86026	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): PRESSURE DEPENDENCE OF ELECTRICAL RESISTIVITY FOR MAGNESIUM-BASED AMORPHOUS ALLOYS	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): L. V. Meisel, P. J. Cote, T. Matsuda, and U. Mizutani (See Reverse)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.02.H600.011 PRON No. 1A52F51D1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001	12. REPORT DATE: August 1986
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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

Submitted for publication in Journal of Physics.

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

Disordered Metals
Pressure Effects
Thermal Expansion
Electrical Transport

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

Measured pressure coefficients of resistance and the corresponding pressure coefficients of resistivity, estimated using "law of mixtures" isothermal compressibility values, are reported for a series of magnesium-based amorphous alloys. The pressure coefficients correlate with the thermopower and the resistivity. When combined with results for non-magnetic amorphous alloys containing transition metals, there are suggestions of universal correlations between the pressure coefficients and the electrical resistivity. Data are discussed in the framework of the diffraction model.

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7. AUTHORS (CONT'D)

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ULTRASONIC SCANNING FOR FINDING INTERFACE VOIDS OF COMPOUND CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Y. F. Cheng and C. E. Cobb		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6940.00.3410.012 PRON No. 1A525FCP1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE August 1986 13. NUMBER OF PAGES 22
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18. SUPPLEMENTARY NOTES

Presented at the 32nd International Instrumentation Symposium (Instrument Society of America), Seattle, WA, 5-8 May 1986.
Published in Proceedings of the Symposium.

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

Nondestructive Evaluation
Ultrasonics
Metal-Composite Compound Cylinders

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

In this report, a review is made of the pulse-echo method of ultrasonic imaging as a technique in nondestructive evaluation. A discussion on the image formation of A-, B-, C-scans and three-dimensional display is included. Scanning patterns obtained from a testing block are shown. Finally, the method is evaluated for finding interface voids of metal-composite compound cylinders. Preliminary experiments were made and the results are given. A special probe with multiple transducers is suggested.

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1. REPORT NUMBER ARCCB-TR-86028	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE NATURE OF WHITE LAYERS FORMED ON GUN STEEL SURFACES		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6910.00.H840.221 PRON No. 1A52G5FN1A1A
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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)

White Layers	Spectroscopy
Cracks	Mechanism of Formation of White Layers
Mossbauer	Surface Sensitive Analytical Techniques
Auger	High Voltage Microscopy
Secondary Ion Mass Spectroscopy	

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

Previous metallographic studies of the nature of the white layer on fired cannon tubes and on laboratory simulation samples have been extended. Further work has confirmed that the effect of exposure of 4340 steel to firing or analogous conditions is the formation of cementite (Fe_3C) and one percent carbon-austenite on the surface. These results suggest that carbon from reducing gases of burnt propellants incorporated in the surface layer of the

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20. ABSTRACT (CONT'D)

heated gun steel, produces non-equilibrium phases which are the so-called white layers. The thermal stresses generated by the explosion of the firing charge 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 were found to contain titanium oxide (TiO_2) (sometimes added to the charge), copper, sulfur, and aluminum.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-CR-86029	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) FATIGUE CRACK GROWTH OF GUN TUBE STEEL UNDER SPECTRUM LOADING		5. TYPE OF REPORT & PERIOD COVERED Final Report Sept 1985 - Sept 1986 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Kathleen R. Dennis and Norman E. Dowling (See Reverse)		8. CONTRACT OR GRANT NUMBER(s) DAAA22-85-C-0255
9. PERFORMING ORGANIZATION NAME AND ADDRESS Virginia Polytechnic Institute & State University Engineering Science & Mechanics Department Blacksburg, VA 24061		10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE September 1986 13. NUMBER OF PAGES 112
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18. SUPPLEMENTARY NOTES

John H. Underwood and Howard D. McAlonie - Benet Weapons Laboratory Project Engineers.
To be presented at the 1986 Army Symposium on Solid Mechanics, U.S. Military Academy, West Point, NY, 7-9 October 1986.

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

Gun Tubes	Crack Growth
Fatigue	Residual Stress
Spectrum Loading	Computer Models

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

Due to various internal pressures generated by different classes of ammunition, the service loads of a gun tube are variable in nature. Previous investigations into the service lives of gun tubes have shown that fatigue lives are often shorter than the bore wear lives; hence, accurate prediction of gun tubes' fatigue lives is important.

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7. AUTHORS (CONT'D)

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Captain, U.S. Army
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West Point, NY 10996

20. ABSTRACT (CONT'D)

Several fatigue crack growth models for variable amplitude loading exist. This study compares three models, a no-load-interaction model, a Modified Wheeler model, and a Generalized Willenborg model, for four variable amplitude load histories. Predicted fatigue crack growth lives were compared with actual test lives and good correlation was achieved for all models. The Generalized Willenborg model yields the best overall load spectrum life prediction, but all three models predicted lives within a factor of 2.0 of the experimental lives.

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1 REPORT NUMBER ARCCB-R-86-3	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4 TITLE and Subtitle FINAL REPORT [illegible] AMMUNITION LOADING SYSTEM [illegible] IDENTIFICATION AND MODELING		5 TYPE OF REPORT & PERIOD COVERED Final Report - Phase I Jul 1985 - Dec 1985 6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s)		8 CONTRACT OR GRANT NUMBER(s) DAAA22-85-C-0205
9 PERFORMING ORGANIZATION NAME AND ADDRESS [illegible]		10 PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS
11 CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center [illegible] Armament Center [illegible]		12 REPORT DATE September 1986 13 NUMBER OF PAGES [illegible]
14 MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		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

[illegible] Jones - Benet Weapons Laboratory Project Engineer

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

AMS, Autoloader, Manual Loading, Human Factors, Ammunition Logistics, Ammunition Packaging, Technology, Universal Ammunition Package/Container, Unit Package, Reliability Modeling, Separated Ammunition, Fixed Ammunition, [illegible], Flexible Automation

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

The Generic Ammunition Loading System (GALS) demonstrator program identifies and matures key technologies to address user deficiencies in the Close Combat, Combat Service Support Mission Areas. The GALS concept stresses [illegible] principles of ammunition, rapid rearm, and automatic loading of the [illegible] combat vehicles. Phase I of the program required the identification [illegible], the generation of a conceptual design, and the [illegible] full scale model of the design. Phases II and III of the

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20. ABSTRACT (CONT'D):

program are planned to mature the technologies for a laboratory breadboard and a live firing prototype, respectively.

This report describes the work done on Contract DAAA22-85-C-0203 by Western Design Corporation in Phase I. It includes a description of the conceptual design and the full-scale model which was fabricated.

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1. REPORT NUMBER: ARCCB-TR-86031	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)*: AN ACCEPTANCE TEST METHOD FOR MATERIALS USED IN KINETIC ENERGY PROJECTILES	5. TYPE OF REPORT & PERIOD COVERED: Final
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): M. A. Scavullo, J. H. Underwood, and J. J. Zalinka	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center, Benet Weapons Laboratory, SMCAR-CCB-TL, Watervliet, NY 12189-4050	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6960.0R.2920.0, PRON No. 1A62RZARNMLC (See Reverse)
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center, Close Combat Armaments Center, Dover, NJ 07801-5001	12. REPORT DATE: September 1986 / 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)*

Depleted Uranium Alloy
90% Tungsten Alloy
7075-T6 Extruded Aluminum Alloy
Kinetic Energy Projectiles
Materials Test

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

A material acceptance test method is proposed, and data are presented to show the applicability of the test method to the selection of materials that can withstand the kinetic energy projectile launch environment. Minimum values for specific notch bend energy (SNBE), the proposed test, are presented for the following three types of materials: (a) uranium alloy, (b) tungsten alloy, [illegible] alloy.

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10. PROGRAM ELEMENT, PROJECT, TASK
AREA & WORK UNIT NUMBERS (CONT'D)

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-MR-86032	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THE USE OF EMBRITTLING METALS IN SMALL CALIBER PENETRATORS TO INCREASE THEIR LETHALITY		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.011 PRON No. 1A52F59W1A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE September 1986 13. NUMBER OF PAGES 26
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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)

Liquid Metal	Penetrator
Solid Metal	Fracture
Embrittlement	Effects of Fast Strain Rate
Lethality	Effects of Time on Embrittlement

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

A study has been made to access the feasibility of inducing low energy, fast fracture in armor by embrittling metals delivered by a penetrator or a shell. The effects of time and strain rate on the susceptibility to embrittlement by liquid lead and copper were investigated for low and medium strength steel. The single-edge notched, fatigue precracked specimens of low strength steel (yield strength ~ 75 Ksi) tested in cyclic fatigue were severely embrittled by

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20. ABSTRACT (CONT'D)

liquid lead. The gun steel specimens (yield strength ~ 120 Ksi) containing a notch and plated with a layer a few microns thick of copper were severely embrittled when pulse heated in a unique "Capacitive Discharge Heating System" to temperatures above and below the melting point of copper. It was noted that embrittlement by copper occurred in times of order milliseconds. Smooth specimens of the same steel were also severely embrittled by liquid copper and by solid copper at 1000°C when tested at very fast strain rates in a Gleeble hot-tensile testing machine. The initiation and propagation of low energy, fast fracture in steel in liquid metal environments in a short time and at fast strain rates in the temperature range 350°C to 1100°C is discussed with regard to the use of liquid/solid metals in small caliber penetrators or shells to increase their lethality and to induce fast fracture in light armor.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARCCB-TR-86033

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): THE BAUSCHINGER EFFECT ON STRESS INTENSITY FACTORS FOR A RADIALLY CRACKED GUN TUBE

5. TYPE OF REPORT & PERIOD COVERED: Final

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): S. L. Pu and P. C. T. Chen

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
US Army Armament Research, Develop, & Engr Center
Benet Weapons Laboratory, SMCAR-CCB-TL
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18. SUPPLEMENTARY NOTES:
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Published in Proceedings of the Conference.

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

Bauschinger Effect
Stress Intensity Factors
Radial Cracks
Thick-Wall Cylinders
Residual Stresses
Elastic-Plastic Unloading
Reverse Yielding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number):
The theoretical predicted fatigue life of a high strength steel tube which has undergone an autofrettage procedure is significantly higher than the experimental prediction. To account for the discrepancy, attention is now turned to developing better elastic-plastic models for a high strength steel. An improved material model shows that reverse yielding may occur in the inner portion of the tube. This reverse yielding reduces the residual compressive
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20. ABSTRACT (CONT'D)

hoop stress considerably which has an adverse effect on bore crack propagation. This study considers the stress intensity factors due to a radial crack taking the Bauschinger effect into consideration.

The elastic-plastic interfaces during loading and unloading in the autofrettage process divide the tube into three-ring regions. The residual stress distribution in each region is quite different. When a crack grows from one region into another, the previous method using functional stress intensity fails. A new method is used to obtain stress intensity factors for a radial crack growing out of the reverse yielding zone. This approach is based on crack face weight functions obtained by Sha using stiffness derivative finite element techniques coupled with singular crack-tip elements.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARCCB-TR-86034	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) ACOUSTOELASTIC EFFECTS IN AUTOFRETTAGED STEEL CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) W. Scholz and J. Frankel (see reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Ctr Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A.0.11 PRON No. 1A52E59WIA1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Ctr Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE October 1986 13. NUMBER OF PAGES 13
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18. SUPPLEMENTARY NOTES

Presented at Ultrasonics International 1985, Kings College, London, Great Britain, 2-4 July 1985.
Published in Proceedings of the Conference.

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

Ultrasonics
Residual Stress
Acoustoelasticity
Steel
Third Order Elastic Constants

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

Residual stresses in short cylinder sections cut from autofrettaged larger steel tubes have been measured by means of the acoustoelastic effect. Ultrasonic shear waves polarized along the hoop and radial direction and propagating in the axial direction, as well as longitudinal waves, were used. Calibration specimens cut from similar type material were used to determine the velocity changes of longitudinal and shear waves propagating perpendicular to an applied

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7. AUHTORS (CONT'D)

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Watervliet, NY 12189-4050

20. ABSTRACT (CONT'D)

stress. Third order elastic constants were derived from these measurements. Velocity measurements for zero applied stress along different axes of the cube-shaped calibration specimens indicate the presence of orthorhombic texture. Stress distributions and texture dependent effects within the cylinders have been determined.

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1 REPORT NUMBER: ARCCB-TR-80015	2 GOVT ACCESSION NO / 3 RECIPIENT'S CATALOG NUMBER
4 TITLE (and Subtitle): EQUATION OF STATE AND SOUND VELOCITIES FROM ISOTROPIC CONTINUUM MECHANICS	5 TYPE OF REPORT & PERIOD COVERED: Final
	6 PERFORMING ORG. REPORT NUMBER
7 AUTHOR(s): L. Frankel and M. A. Hussain (See Reverse)	8 CONTRACT OR GRANT NUMBER(s)
9 PERFORMING ORGANIZATION NAME AND ADDRESS: US Army Armament Research, Development & Engineering Center, Benet Weapons Laboratory, SMCAR-CCB-TL, Watervliet, NY 12189	10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
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16 DISTRIBUTION STATEMENT (of this Report):	
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18 SUPPLEMENTARY NOTES	
19 KEY WORDS (Continue on reverse side if necessary and identify by block number): Equation of State; Sound Velocities; High Pressure; Finite Elasticity	

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

We use the methods of finite elasticity in continuum mechanics of homogeneous isotropic materials to obtain the pressure dependence of the equation of state and the shear and longitudinal velocity to fifth order elastic constants. The resulting expressions are implicit in terms of the pressure and explicit in terms of the strain. The use of a symbolic program allows us to eliminate the strain parameter. Even though the expressions are extremely lengthy,

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7. AUTHORS (CONT'D)

M. A. Hussain
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Schenectady, New York 12301

20. ABSTRACT (CONT'D)

approximations for each order of elastic constants can be easily obtained by using Taylor's expansion to any degree desired.

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	6 PERFORMING ORG. REPORT NUMBER: [illegible]
7 AUTHOR(s): [illegible]	8 CONTRACT OR GRANT NUMBER(s): DAAG29-[illegible]
9 PERFORMING ORGANIZATION NAME AND ADDRESS: [illegible]	10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: [illegible]
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16 DISTRIBUTION STATEMENT (of this Report)

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)

Residual Analysis
Randomness
Runs
Trees
Recursion
Moments
Asymptotic Normality

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

[illegible] the hypothesis of residual randomness in a curve fit. The test is based on a binomial process where the main problem involved is [illegible] finding the distribution of the number of runs in a sequence of [illegible] runs. Although this distribution turns out to be quite simple in form [illegible] to apply, its use in testing curve fit seems to have been neglected in the statistical literature. We also obtain the more general distribution of the number of runs in a sequence of throws of a multifaceted die, which is used to test sequences for randomness per se.

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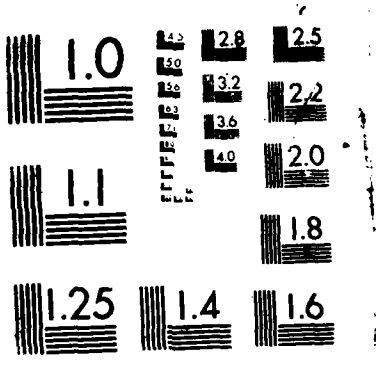

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1. REPORT NUMBER: ARCCB-CR-86038	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): WALL THICKNESS AND FLOW MACH NUMBER EFFECTS ON PRESSURE DISTRIBUTION IN THE VENT HOLE FOR PERFORATED MUZZLE BRAKES	5. TYPE OF REPORT & PERIOD COVERED: Final Contract Report
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): H. T. Nagamatsu, K. Y. Choi, and R. E. Duffy	8. CONTRACT OR GRANT NUMBER(s): DAAA22-84-C-0204
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Rensselaer Polytechnic Institute, Troy, NY 12180-3590	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research, Develop, & Engr Center, Close Combat Armaments Center, Dover, NJ 07801-5001	12. REPORT DATE: November 1986
	13. NUMBER OF PAGES: 46
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Patrick M. Vottis - Benet Weapons Laboratory Project Engineer

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

Perforated Muzzle Brakes
Muzzle Blast
Shock Waves

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

The Rensselaer Polytechnic Institute (RPI) high pressure four-inch diameter shock tube was used to investigate the flow through the three-fourths inch diameter vent hole for the 105 mm M68 cannon perforated muzzle brake. The pressure distributions in the vent hole were determined for several ratios of vent length to hole diameter. For a ratio of vent length-to-diameter of one and pressure orifices located at L/D = 0.67 from the entrance, the maximum

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20. ABSTRACT (CONT'D)

pressure on the downstream side was approximately 0.40 of the static pressure for subsonic and supersonic flows, and the calculated value was 0.35 by the Godunov method for a two-dimensional slot. At the upstream location the vent hole pressure was 0.12 and the calculated value was 0.095. The vent pressure at the side location was slightly higher than the value for the upstream location.

For a vent length of two diameters and pressure orifices located at L/D = 1.34 from the entrance, the maximum pressure ratio of 0.17 was located at the upstream side, and on the downstream side the pressure ratio was 0.07. For a vent length of three diameters and pressure orifices located at L/D = 2.67, the highest pressure ratio of 0.17 occurred at the downstream location, and at the upstream and side locations the pressure ratios were approximately 0.10.

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1. REPORT NUMBER ARCCB-TR-86039	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) SUMMARY OF THE PROCEEDINGS OF THE SEVENTEENTH NATIONAL SYMPOSIUM ON FRACTURE MECHANICS		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John H. Underwood, Richard Chait, C. William Smith, David P. Wilhem, Wayne R. Andrews, and James C. Newman (See Reverse)		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 7280.12.1200.0 PRON No. 1A52NZMZ1A1A
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18. SUPPLEMENTARY NOTES

Published in ASTM STP 905, titled Fracture Mechanics: Seventeenth Volume.

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

Fracture Mechanics
Applications
Ductile Fracture
Test Methods
Surface Crack

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

This report gives a brief summary of the Symposium and a more detailed description of the proceedings. A summary is given of each of the forty-four papers appearing in the proceedings. The papers are grouped into five categories used as session topics at the Symposium: applications, subcritical crack growth, fracture testing, ductile fracture, and analysis and mechanisms.

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7. AUTHORS (CONT'D)

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1. REPORT NUMBER ARCCB-MR-86040	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* COMMENT ON PAPER BY YAU AND CHOU TITLED "NOTCHED STRENGTH OF WOVEN FABRIC COMPOSITES WITH MOLDED-IN HOLES"		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. H. Underwood		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Benet Weapons Laboratory, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6940.00.6570.012 PRON No. 1A62ZH7QNMSC
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18. SUPPLEMENTARY NOTES

Submitted to ASTM publication, Composite Materials: Testing and Design (Eighth Conference).

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

Composites
Isotropic Mechanics
Stress Concentration
Hole Size

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

A comment is offered on the Yau and Chou paper, presented at the Eighth ASTM Conference on Composite Materials: Testing and Design, which discussed the failure strength of fabric composite plates with holes. Classical mechanics is used to describe the change in failure strength with hole size.

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1. REPORT NUMBER ARCCB-CR-86041	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CAPABILITY ENHANCEMENT OF THE PROPELLANT COMBUSTOR PERFORMANCE TESTER		5. TYPE OF REPORT & PERIOD COVERED Final Report October 1985 - October 1986
		6. PERFORMING ORG. REPORT NUMBER 8906-953002
7. AUTHOR(s) Kurt Berman		8. CONTRACT OR GRANT NUMBER(s) DAAA22-85-C-0275
9. PERFORMING ORGANIZATION NAME AND ADDRESS Bell Aerospace Textron Post Office Box One Buffalo, NY 14240-0001		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 PRON No. 1A325D021A1A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research, Develop, & Engr Center Close Combat Armaments Center Dover, NJ 07801-5001		12. REPORT DATE December 1986 13. NUMBER OF PAGES 12
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18. SUPPLEMENTARY NOTES

Alfred R. Graham - Benet Weapons Laboratory Project Engineer

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

Experimental Propellant Performance
Regenerative Liquid Propellant Gun
Fractional Burning Rate
Combustion Liquid Monopropellant
Characteristic Exhaust Velocity
Completeness of Combustion

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

The Propellant Combustor Performance Tester (PCPT), conceived by Dr. A. R. Graham of Benet Weapons Laboratory, has the ability to measure the performance of various liquid monopropellants under steady state conditions at gun pressures. A rocket-like combustion chamber is used and the length may be varied so the flame length as well as fractional burning rate may be measured.

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20. ABSTRACT (CONT'D)

Testing of the original device built surfaced some deficiencies, such as the inability to reach very high chamber pressures. The purpose of this program was to reassess the design concept to eliminate these deficiencies. A new design concept was evolved, designed, and fabricated.

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