

AD-A170 266

INDEX TO BENET WEAPONS LABORATORY (LCHSL) TECHNICAL  
REPORTS - 1985(U) ARMY ARMAMENT RESEARCH AND  
DEVELOPMENT CENTER WATERVLIET NY L.. R D NEIFELD

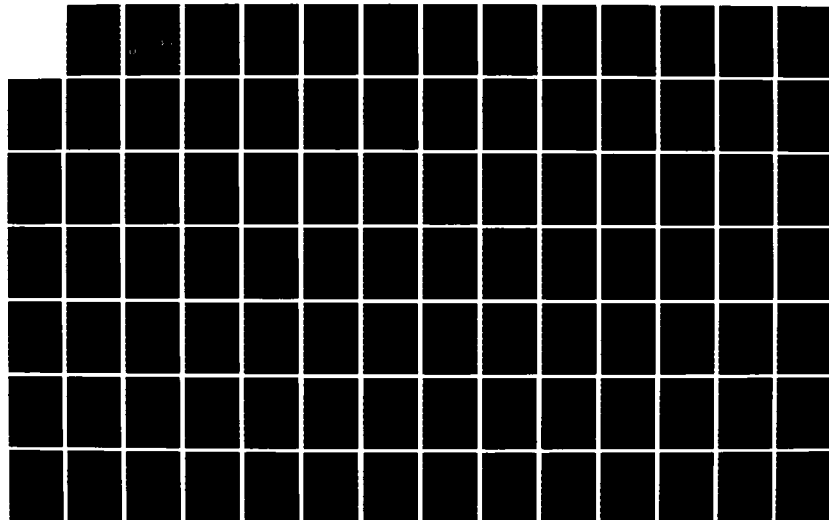
1/2

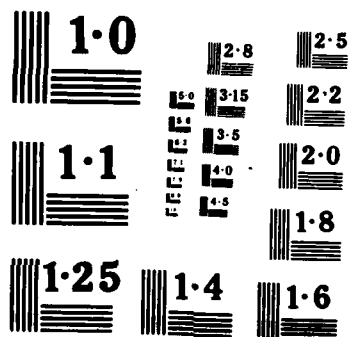
UNCLASSIFIED

JUN 86 ARCCB-5P-86019

F/G 5/2

NL





12

AD

SPECIAL PUBLICATION ARCCB-SP-86019

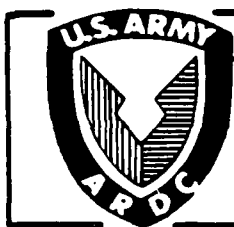
# INDEX TO BENET WEAPONS LABORATORY TECHNICAL REPORTS - 1985

R. D. NEIFELD

TECHNICAL PUBLICATIONS AND EDITING UNIT

JUNE 1986

DTIC  
ELECTE  
JUL 28 1986  
S D



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

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

AD-A170 266

ONC FILE COPY

#### DISCLAIMER

The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents.

The use of trade name(s) and/or manufacturer(s) does not constitute an official indorsement or approval.

#### DESTRUCTION NOTICE

For classified documents, follow the procedures in DoD 5200.22-M, Industrial Security Manual, Section II-19 or DoD 5200.1-R, Information Security Program Regulation, Chapter IX.

For unclassified, limited documents, destroy by any method that will prevent disclosure of contents or reconstruction of the document.

For unclassified, unlimited documents, destroy when the report is no longer needed. Do not return it to the originator.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                      |                                      | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|----------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARCCB-SP-86019                                                                                                                                                             | 2. GOVT ACCESSION NO.<br>AD-A170 266 | 3. RECIPIENT'S CATALOG NUMBER                                  |
| 4. TITLE (and Subtitle)<br>INDEX TO BENET WEAPONS LABORATORY<br>TECHNICAL REPORTS - 1985                                                                                                       |                                      | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                    |
| 7. AUTHOR(s)<br>R. D. Neifeld                                                                                                                                                                  |                                      | 6. PERFORMING ORG. REPORT NUMBER                               |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research, Develop, & Engr Center<br>Benet Weapons Laboratory, SMCAR-CCB-TL<br>Watervliet, NY 12189-4050                        |                                      | 8. CONTRACT OR GRANT NUMBER(s)                                 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research, Develop, & Engr Center<br>Close Combat Armaments Center<br>Dover, NJ 07801-5001                                          |                                      | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                    |                                      | 12. REPORT DATE<br>June 1986                                   |
|                                                                                                                                                                                                |                                      | 13. NUMBER OF PAGES<br>103                                     |
|                                                                                                                                                                                                |                                      | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED           |
|                                                                                                                                                                                                |                                      | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                  |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                        |                                      |                                                                |
| 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)<br>Benet Weapons Laboratory<br>Technical Publications<br>Bibliography<br>Abstracts<br>Document Control Data |                                      |                                                                |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>This is a compilation of Benet Weapons Laboratory technical reports published during 1985.            |                                      |                                                                |

# TABLE OF CONTENTS

|                                                     | <u>Page</u> |
|-----------------------------------------------------|-------------|
| LIST OF REPORTS                                     | 1           |
| AUTHOR INDEX                                        | 5           |
| SUBJECT INDEX                                       | 8           |
| AD NUMBERS                                          | 17          |
| ABSTRACTS--REPORT DOCUMENTATION PAGE (DD FORM 1473) | 19          |

The information on the limited 1473s is for public release.  
 Per Ms. R. D. Neifeld, Benet Weapons Lab.,  
 ATTN: SMCAR-CCB-TL

|                          |                                     |
|--------------------------|-------------------------------------|
| Accession For            |                                     |
| NTIS CRA&I               | <input checked="" type="checkbox"/> |
| DTIC TAB                 | <input type="checkbox"/>            |
| Unannounced              | <input type="checkbox"/>            |
| Justification            |                                     |
| By <i>per phone call</i> |                                     |
| Distribution             |                                     |
| Availability Codes       |                                     |
| Dist                     | Availability or Special             |
| <i>A-1</i>               |                                     |

# TECHNICAL REPORTS 1985

| <u>REPORT NUMBER</u> | <u>TITLE</u>                                                                                                | <u>AUTHOR</u>                             | <u>DATE</u> |
|----------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------|-------------|
| ARLCB-TR-85001       | Electrical Resistivity in Amorphous Metals: Consequences of Phonon Ineffectiveness in the Diffraction Model | L.V. Meisel<br>P.J. Cote                  | Jan 85      |
| ARLCB-TR-85002       | Solid Metal Induced Embrittlement of Metals                                                                 | M.H. Kamdar                               | Jan 85      |
| ARLCB-TR-85003       | The Fatigue Effects of the M119A1 Zone 8 Round on the 155 mm M199 Howitzer Tube                             | B.B. Brown                                | Feb 85      |
| ARLCB-TR-85004       | Fatigue Performance of 105 mm M68 Tube Under Differing Pressure Conditions                                  | B.B. Brown                                | Feb 85      |
| ARLCB-TR-85005       | Thermal-Expansion Effects in Electrical Transport in Amorphous Metals                                       | L.V. Meisel<br>P.J. Cote                  | Feb 85      |
| ARLCB-TR-85006       | Cyclic Torsion of a Circular Cylinder and Its Residual Stress Distribution                                  | H.C. Wu<br>M.R. Aboutorabi<br>P.C.T. Chen | Feb 85      |
| ARLCB-TR-85007       | A More Accurate Solution to the Elastic-Plastic Problem of Pressurized Thick-Walled Cylinders               | P.C.T. Chen                               | Feb 85      |
| ARLCB-TR-85008       | Wear of Projectile Rotating Bands                                                                           | R.S. Montgomery                           | Mar 85      |
| ARLCB-SP-85009       | Proceedings, Fourth U.S. Army Symposium on Gun Dynamics (Volumes I and II)                                  | T.E. Simkins, ed.<br>J. Vasilakis, ed.    | May 85      |
| ARLCB-TR-85010       | Shear Deflection in a Three-Point Bend Beam of a Solid Circular Cross-Section                               | B. Avitzur                                | Mar 85      |
| ARLCB-TR-85011       | Stress Concentration in the Elastoplastic State and Residual Stress After Unloading                         | Y.F. Cheng                                | Mar 85      |
| ARLCB-TR-85012       | Autonomous Detection of Objects From Range Data Measurements                                                | R.L. Racicot<br>C.N. Shen                 | Apr 85      |
| ARLCB-TR-85013       | Fracture in Liquid Metal Environments                                                                       | M.H. Kamdar                               | Apr 85      |

# TECHNICAL REPORTS 1985 (CONT.)

| <u>REPORT NUMBER</u> | <u>TITLE</u>                                                                                                 | <u>AUTHOR</u>                                                   | <u>DATE</u> |
|----------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|-------------|
| ARLCB-TR-85014       | Fracture Testing with Arc Bend Specimens                                                                     | J.H. Underwood<br>J.A. Kapp<br>M.D. Witherell                   | May 85      |
| ARLCB-MR-85015       | More on Compliance of the Three-Point Bend Specimen                                                          | J.H. Underwood<br>J.A. Kapp<br>F.I. Baratta                     | May 85      |
| ARLCB-TR-85016       | A Mesh Moving Technique for Time Dependent Partial Differential Equations in Two Space Dimensions            | D.C. Arney<br>J.E. Flaherty                                     | Jun 85      |
| ARLCB-TR-85017       | New Powder Technologies for Molybdenum Alloy Gun Barrel Liners                                               | J.M. Barranco<br>S. Isserow                                     | Jun 85      |
| ARLCB-TR-85018       | Stress Intensity Factors at Radial Cracks of Unequal Depth in Partially Autofrettaged, Pressurized Cylinders | S.L. Pu                                                         | Jun 85      |
| ARLCB-TR-85019       | Dynamic Response in an Elastic-Plastic Projectile Due to Normal Impact                                       | P.C.T. Chen<br>J.E. Flaherty<br>J.D. Vasilakis                  | Jun 85      |
| ARLCB-TR-85020       | Electrolytic Deburring of Bore Evacuator Holes in Smooth Bore Cylinders                                      | V.P. Greco<br>J. Barnes<br>R. Siska                             | Jun 85      |
| ARLCB-TR-85021       | Variational Principle for Penetrator Dynamics Using Bilinear Functional and Adjoint Formulation              | C.N. Shen                                                       | Jun 85      |
| ARLCB-TR-85022       | Recursive Gradient Estimation Using Splines for Navigation of Autonomous Vehicles                            | C.N. Shen                                                       | Jul 85      |
| ARLCB-SP-85023       | Index to Benet Weapons Laboratory (LCWSL) Technical Reports - 1984                                           | R.D. Neifeld                                                    | Jul 85      |
| ARLCB-CR-85024       | Development of a Computer-Aided Thermal Analysis for an Improved 155 mm Howitzer Recoil Mechanism            | CPT J.M. McMurray<br>COL M.A. Paolino<br>R.G. Gast<br>(BWL POC) | Jul 85      |
| ARLCB-TR-85025       | The Densification of Molybdenum and Molybdenum Alloy Powders Using Hot Isostatic Pressing                    | J. Barranco<br>I. Ahmad<br>S. Isserow<br>R. Warchak             | Aug 85      |

# TECHNICAL REPORTS 1985 (CONT.)

| <u>REPORT NUMBER</u> | <u>TITLE</u>                                                                                                                         | <u>AUTHOR</u>                                 | <u>DATE</u> |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|-------------|
| ARLCB-TR-85026       | Terrain Scene Analysis and Obstacle Reconstruction for Navigation of Mobile Robots                                                   | C.N. Shen                                     | Aug 85      |
| ARLCB-TR-85027       | Deflection in Tapered Cantilever Beams - Deflection (Gap Opening) in Double Cantilever Type Fracture Toughness Specimens             | B. Avitzur                                    | Aug 85      |
| ARLCB-TR-85028       | A Local Refinement Finite Element Method for Time Dependent Partial Differential Equations                                           | J.E. Flaherty<br>P.K. Moore                   | Aug 85      |
| ARLCB-TR-85029       | Analysis of Elastic-Plastic Ball Indentation to Measure Strength of High Strength Steels                                             | J.H. Underwood<br>G.P. O'Hara<br>J.J. Zalinka | Aug 85      |
| ARLCB-TR-85030       | Machinability Data Bases for Metal Cutting                                                                                           | MAJ W.W. Olson                                | Sep 85      |
| ARLCB-MR-85031       | Fatigue Tests of Two 105 mm L119 British Light Gun Breech Rings and Breech Blocks                                                    | R.R. Lasselle                                 | Sep 85      |
| ARLCB-TR-85032       | Elastic-Plastic Loading and Unloading in a Thick Tube with Kinematic Hardening Theory                                                | P.C.T. Chen                                   | Sep 85      |
| ARLCB-SP-85033       | Procedure for Electrodeburning Bore Evacuator Holes in 120 mm Gun Tubes (To Improve the Erosion Resistance of Chromium Plated Bores) | V.P. Greco<br>J. Barnes<br>R. Siska           | Sep 85      |
| ARLCB-TR-85034       | Crack Growth Behavior of Aluminum Alloys Tested in Liquid Mercury                                                                    | J.A. Kapp<br>D.J. Duquette<br>M.H. Kamdar     | Sep 85      |
| ARLCB-TR-85035       | Predicting Catastrophic Outside Diameter Initiated Fatigue Failure of Thick-Walled Cylinders Using Low Cycle Fatigue Data            | J.A. Kapp                                     | Sep 85      |
| ARLCB-TR-85036       | Structure of Electrodeposited Chromium on Gun Steel                                                                                  | M.H. Kamdar<br>R.M. Fisher                    | Sep 85      |
| ARLCB-TR-85037       | Assessment of J-R Curves Obtained From Precracked Charpy Samples                                                                     | J.A. Kapp<br>M.I. Jolles                      | Sep 85      |

# TECHNICAL REPORTS 1985 (CONT.)

| <u>REPORT NUMBER</u> | <u>TITLE</u>                                                              | <u>AUTHOR</u>                                                | <u>DATE</u> |
|----------------------|---------------------------------------------------------------------------|--------------------------------------------------------------|-------------|
| ARCCB-TR-85001       | Material Property and Fracture<br>Testing of 7075-T6 Extruded<br>Aluminum | M.A. Scavullo<br>J.H. Underwood<br>J.A. Kapp<br>J.J. Zalinka | Nov 85      |
| ARCCB-TR-85002       | The Electroplating of Laminated<br>Chromium                               | E.S. Chen<br>G.P. Capsimalis<br>G.R. Weigle                  | Nov 85      |
| ARCCB-TR-85003       | Computer Model for the<br>Solidification of Composition B                 | J.D. Vasilakis                                               | Dec 85      |
| ARCCB-TR-85004       | Thermal Shutdown System for<br>IBM 4341 Computers                         | M. Johnson                                                   | Dec 85      |

# AUTHOR INDEX--1985

| <u>AUTHOR</u>     | <u>REPORT NUMBER</u>                                                 |
|-------------------|----------------------------------------------------------------------|
| Aboutorabi, M. R. | ARLCB-TR-85006                                                       |
| Ahmad, I.         | ARLCB-TR-85025                                                       |
| Arney, D. C.      | ARLCB-TR-85016                                                       |
| Avitzur, B.       | ARLCB-TR-85010<br>ARLCB-TR-85027                                     |
| Baratta, F. I.    | ARLCB-MR-85015                                                       |
| Barnes, J.        | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |
| Barranco, J. M.   | ARLCB-TR-85017<br>ARLCB-TR-85025                                     |
| Brown, B. B.      | ARLCB-TR-85003<br>ARLCB-TR-85004                                     |
| Capsimalis, G. P. | ARCCB-TR-85002                                                       |
| Chen, E. S.       | ARCCB-TR-85002                                                       |
| Chen, P. C. T.    | ARLCB-TR-85006<br>ARLCB-TR-85007<br>ARLCB-TR-85019<br>ARLCB-TR-85032 |
| Cheng, Y. F.      | ARLCB-TR-85011                                                       |
| Cote, P. J.       | ARLCB-TR-85001<br>ARLCB-TR-85005                                     |
| Duquette, D. J.   | ARLCB-TR-85034                                                       |
| Fisher, R. M.     | ARLCB-TR-85036                                                       |
| Flaherty, J. E.   | ARLCB-TR-85016<br>ARLCB-TR-85019<br>ARLCB-TR-85028                   |
| Gast, R. G.       | ARLCB-CR-85024                                                       |
| Greco, V. P.      | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |

# AUTHOR INDEX--1985 (CONT.)

| <u>AUTHOR</u>        | <u>REPORT NUMBER</u>                                                                                     |
|----------------------|----------------------------------------------------------------------------------------------------------|
| Isserow, S.          | ARLCB-TR-85017<br>ARLCB-TR-85025                                                                         |
| Johnson, M.          | ARCCB-TR-85004                                                                                           |
| Jolles, M. I.        | ARLCB-TR-85037                                                                                           |
| Kamdar, M. H.        | ARLCB-TR-85002<br>ARLCB-TR-85013<br>ARLCB-TR-85034<br>ARLCB-TR-85036                                     |
| Kapp, J. A.          | ARLCB-TR-85014<br>ARLCB-MR-85015<br>ARLCB-TR-85034<br>ARLCB-TR-85035<br>ARLCB-TR-85037<br>ARCCB-TR-85001 |
| Lasselle, R. R.      | ARLCB-MR-85031                                                                                           |
| McMurray, J. M., CPT | ARLCB-CR-85024                                                                                           |
| Meisel, L. V.        | ARLCB-TR-85001<br>ARLCB-TR-85005                                                                         |
| Montgomery, R. S.    | ARLCB-TR-85008                                                                                           |
| Moore, P. K.         | ARLCB-TR-85028                                                                                           |
| Neifeld, R. D.       | ARLCB-SP-85023                                                                                           |
| O'Hara, G. P.        | ARLCB-TR-85029                                                                                           |
| Olson, W. W., MAJ    | ARLCB-TR-85030                                                                                           |
| Paolino, M. A., COL  | ARLCB-CR-85024                                                                                           |
| Pu, S. L.            | ARLCB-TR-85018                                                                                           |
| Racicot, R. L.       | ARLCB-TR-85012                                                                                           |
| Scavullo, M. A.      | ARCCB-TR-85001                                                                                           |

# AUTHOR INDEX--1985 (CONT.)

| <u>AUTHOR</u>    | <u>REPORT NUMBER</u>                                                 |
|------------------|----------------------------------------------------------------------|
| Shen, C. N.      | ARLCB-TR-85012<br>ARLCB-TR-85021<br>ARLCB-TR-85022<br>ARLCB-TR-85026 |
| Simkins, T. E.   | ARLCB-SP-85009                                                       |
| Siska, R.        | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |
| Underwood, J. H. | ARLCB-TR-85014<br>ARLCB-MR-85015<br>ARLCB-TR-85029<br>ARCCB-TR-85001 |
| Vasilakis, J. D. | ARLCB-SP-85009<br>ARLCB-TR-85019<br>ARCCB-TR-85003                   |
| Warenchak, R.    | ARLCB-TR-85025                                                       |
| Weigle, G. R.    | ARCCB-TR-85002                                                       |
| Witherell, M. D. | ARLCB-TR-85014                                                       |
| Wu, H. C.        | ARLCB-TR-85006                                                       |
| Zalinka, J. J.   | ARLCB-TR-85029<br>ARCCB-TR-85001                                     |

# SUBJECT INDEX--1985

| <u>SUBJECT</u>                | <u>REPORT NUMBER</u>                               |
|-------------------------------|----------------------------------------------------|
| Abstracts                     | ARLCB-SP-85023                                     |
| Adaptive Systems              | ARLCB-TR-85016<br>ARLCB-TR-85028                   |
| ADINA Computer Program        | ARLCB-TR-85019                                     |
| ADINAT Computer Program       | ARCCB-TR-85003                                     |
| Adjoint Variables             | ARLCB-TR-85021                                     |
| Aluminum                      | ARCCB-TR-85001                                     |
| Aluminum Alloys               | ARLCB-TR-85034                                     |
| Amorphous Materials           | ARLCB-TR-85001<br>ARLCB-TR-85005                   |
| Autofrettage                  | ARLCB-TR-85018<br>ARLCB-TR-85035                   |
| Automated Plating System      | ARCCB-TR-85002                                     |
| Autonomous Vehicle Navigation | ARLCB-TR-85022                                     |
| Ball Indentation              | ARLCB-TR-85029                                     |
| Ballistics                    | ARLCB-SP-85009                                     |
| Bauschinger Effect            | ARLCB-TR-85032                                     |
| Beams                         | ARLCB-TR-85010<br>ARLCB-TR-85027                   |
| Bend Specimens                | ARLCB-TR-85014<br>ARLCB-MR-85015                   |
| Bibliographies                | ARLCB-SP-85023                                     |
| Bores                         | ARLCB-TR-85008<br>ARLCB-TR-85020<br>ARLCB-SP-85033 |
| Breech Mechanisms             | ARLCB-MR-85031                                     |
| Brittle Fracture              | ARLCB-TR-85013                                     |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>          | <u>REPORT NUMBER</u>                                                                   |
|-------------------------|----------------------------------------------------------------------------------------|
| Cannon                  | ARLCB-MR-85031                                                                         |
| Cantilever Beams        | ARLCB-TR-85027                                                                         |
| Charpy Impact Tests     | ARLCB-TR-85037                                                                         |
| Chipping                | ARLCB-TR-85020<br>ARLCB-SP-85033                                                       |
| Chromium                | ARLCB-TR-85020<br>ARLCB-SP-85033<br>ARLCB-TR-85036<br>ARCCB-TR-85002                   |
| Circular Beams          | ARLCB-TR-85010                                                                         |
| Compliance              | ARLCB-MR-85015                                                                         |
| Composition B           | ARCCB-TR-85003                                                                         |
| Computer-Aided Design   | ARLCB-TR-85030                                                                         |
| Computerized Simulation | ARLCB-CR-85024<br>ARCCB-TR-85003                                                       |
| Computers               | ARCCB-TR-85004                                                                         |
| Convection              | ARLCB-CR-85024                                                                         |
| Crack Propagation       | ARLCB-TR-85002<br>ARLCB-TR-85013<br>ARLCB-TR-85034<br>ARLCB-TR-85037                   |
| Cracks                  | ARLCB-TR-85018<br>ARLCB-TR-85036<br>ARCCB-TR-85002                                     |
| Cylindrical Bodies      | ARLCB-TR-85006<br>ARLCB-TR-85014<br>ARLCB-TR-85018<br>ARLCB-TR-85032<br>ARLCB-TR-85035 |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>                   | <u>REPORT NUMBER</u>                                                 |
|----------------------------------|----------------------------------------------------------------------|
| Data Bases                       | ARLCB-TR-85030                                                       |
| Deburring                        | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |
| Deflection                       | ARLCB-TR-85010<br>ARLCB-TR-85027                                     |
| Deposits                         | ARCCB-TR-85002                                                       |
| Dynamic Response                 | ARLCB-TR-85019                                                       |
| Dynamic Tests                    | ARLCB-MR-85031                                                       |
| Dynamics                         | ARLCB-SP-85009                                                       |
| Elastic-Plastic                  | ARLCB-TR-85007<br>ARLCB-TR-85019<br>ARLCB-TR-85029<br>ARLCB-TR-85032 |
| Elastoplastic State              | ARLCB-TR-85011                                                       |
| Electrical Transport             | ARLCB-TR-85001<br>ARLCB-TR-85005                                     |
| Electrodeposition                | ARLCB-TR-85036                                                       |
| Electrolytic Polishing           | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |
| Electron-Phonon Interaction      | ARLCB-TR-85001                                                       |
| Electroplating                   | ARCCB-TR-85002                                                       |
| Embrittlement                    | ARLCB-TR-85002<br>ARLCB-TR-85013<br>ARLCB-TR-85034                   |
| Endochronic Theory of Plasticity | ARLCB-TR-85006                                                       |
| Engraving                        | ARLCB-TR-85008                                                       |
| Equivalent Full Charge (EFC)     | ARLCB-TR-85003<br>ARLCB-TR-85004                                     |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>            | <u>REPORT NUMBER</u>                                                                                                       |
|---------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Erosion                   | ARLCB-TR-85020<br>ARLCB-SP-85033                                                                                           |
| Erosion Resistance        | ARLCB-TR-85017<br>ARLCB-TR-85025                                                                                           |
| Explosives                | ARCCB-TR-85003                                                                                                             |
| Extrusion                 | ARCCB-TR-85001                                                                                                             |
| Failure (Mechanics)       | ARLCB-TR-85035                                                                                                             |
| Fatigue Life              | ARLCB-TR-85003                                                                                                             |
| Fatigue (Mechanics)       | ARLCB-TR-85034<br>ARLCB-TR-85035                                                                                           |
| Fatigue Tests (Mechanics) | ARLCB-TR-85004<br>ARLCB-MR-85031                                                                                           |
| Finite Difference Theory  | ARLCB-TR-85007                                                                                                             |
| Finite Element Analysis   | ARLCB-TR-85016<br>ARLCB-TR-85019<br>ARLCB-TR-85028<br>ARCCB-TR-85003                                                       |
| Flow Plating              | ARCCB-TR-85002                                                                                                             |
| Fracture (Mechanics)      | ARLCB-TR-85002<br>ARLCB-TR-85013<br>ARLCB-MR-85015<br>ARLCB-TR-85018<br>ARLCB-TR-85034<br>ARLCB-TR-85037<br>ARCCB-TR-85001 |
| Fracture Toughness        | ARLCB-TR-85014<br>ARLCB-TR-85027                                                                                           |
| Gap Opening               | ARLCB-TR-85027                                                                                                             |
| Grain Size                | ARLCB-TR-85036                                                                                                             |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>             | <u>REPORT NUMBER</u>                               |
|----------------------------|----------------------------------------------------|
| Gun Barrels                | ARLCB-TR-85017<br>ARLCB-TR-85025                   |
| Gun Tubes                  | ARLCB-TR-85003<br>ARLCB-TR-85004                   |
| Guns                       | ARLCB-SP-85009<br>ARLCB-SP-85023                   |
| Hardness                   | ARLCB-TR-85029                                     |
| High Strength Alloys       | ARLCB-TR-85029                                     |
| High Voltage Microscopy    | ARLCB-TR-85036                                     |
| Hot Isostatic Pressing     | ARLCB-TR-85017<br>ARLCB-TR-85025                   |
| Howitzers                  | ARLCB-TR-85003<br>ARLCB-CR-85024                   |
| IBM 4341 Computers         | ARCCB-TR-85004                                     |
| Impact                     | ARLCB-TR-85019                                     |
| Indentation                | ARLCB-TR-85029                                     |
| J Integrals                | ARLCB-TR-85037                                     |
| Kalman Filters             | ARLCB-TR-85012                                     |
| Kinematic Hardening        | ARLCB-TR-85032                                     |
| Kinetic Energy Projectiles | ARCCB-TR-85001                                     |
| Laminates                  | ARCCB-TR-85002                                     |
| Lasers                     | ARLCB-TR-85012<br>ARLCB-TR-85022<br>ARLCB-TR-85026 |
| Liquid Metal Embrittlement | ARLCB-TR-85013<br>ARLCB-TR-85034                   |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>             | <u>REPORT NUMBER</u>                                                 |
|----------------------------|----------------------------------------------------------------------|
| Load-Line Displacement     | ARLCB-MR-85015                                                       |
| Local Refinement           | ARLCB-TR-85028                                                       |
| M-68 Guns                  | ARLCB-TR-85004                                                       |
| M-119A1 Propelling Charges | ARLCB-TR-85003                                                       |
| M-198 Howitzer System      | ARLCB-TR-85003                                                       |
| M-199 Howitzer Tubes       | ARLCB-TR-85003                                                       |
| Machinability              | ARLCB-TR-85030                                                       |
| Material Properties        | ARCCB-TR-85001                                                       |
| Matrix Variation Method    | ARLCB-TR-85021                                                       |
| Mechanical Properties      | ARLCB-TR-85025                                                       |
| Melt-Lubrication           | ARLCB-TR-85008                                                       |
| Mercury                    | ARLCB-TR-85034                                                       |
| Mesh Moving Methods        | ARLCB-TR-85016                                                       |
| Metallography              | ARLCB-TR-85036                                                       |
| Metals                     | ARLCB-TR-85001<br>ARLCB-TR-85002<br>ARLCB-TR-85005<br>ARLCB-TR-85030 |
| Microprocessors            | ARCCB-TR-85004                                                       |
| Molybdenum Alloys          | ARLCB-TR-85017<br>ARLCB-TR-85025                                     |
| Nodules                    | ARLCB-TR-85020<br>ARLCB-SP-85033                                     |
| Obstacle Detection         | ARLCB-TR-85012                                                       |
| Obstacle Reconstruction    | ARLCB-TR-85026                                                       |
| Optimization               | ARLCB-TR-85021                                                       |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>                 | <u>REPORT NUMBER</u>                                                                   |
|--------------------------------|----------------------------------------------------------------------------------------|
| Partial Differential Equations | ARLCB-TR-85016<br>ARLCB-TR-85028                                                       |
| Penetration                    | ARLCB-TR-85021                                                                         |
| Photoelasticity                | ARLCB-TR-85011                                                                         |
| Plastic Properties             | ARLCB-TR-85006<br>ARLCB-TR-85011                                                       |
| Polynomial Splines             | ARLCB-TR-85022                                                                         |
| Powder Metallurgy              | ARLCB-TR-85017<br>ARLCB-TR-85025                                                       |
| Precision                      | ARLCB-SP-85009                                                                         |
| Pressure Vessels               | ARLCB-TR-85035                                                                         |
| Projectiles                    | ARLCB-TR-85008<br>ARLCB-TR-85019                                                       |
| Radial Cracks                  | ARLCB-TR-85018                                                                         |
| .Radiation                     | ARLCB-CR-85024                                                                         |
| Range Finding                  | ARLCB TR-85012<br>ARLCB-TR-85022<br>ARLCB-TR-85026                                     |
| Rapid Solidification           | ARLCB-TR-85017<br>ARLCB-TR-85025                                                       |
| Recoil Mechanisms              | ARLCB-CR-85024                                                                         |
| Recursive Smoothing Algorithm  | ARLCB-TR-85022                                                                         |
| Reports                        | ARLCB-SP-85023                                                                         |
| Residual Stress                | ARLCB-TR-85006<br>ARLCB-TR-85007<br>ARLCB-TR-85011<br>ARLCB-TR-85032<br>ARLCB-TR-85035 |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>                           | <u>REPORT NUMBER</u>             |
|------------------------------------------|----------------------------------|
| Reverse Yielding                         | ARLCB-TR-85032                   |
| Robotics                                 | ARLCB-TR-85022<br>ARLCB-TR-85026 |
| Rotating Bands                           | ARLCB-TR-85008                   |
| Sabots                                   | ARCCB-TR-85001                   |
| Safe Service Life                        | ARLCB-TR-85003<br>ARLCB-TR-85004 |
| 7075-T6                                  | ARCCB-TR-85001                   |
| Sharp Corners                            | ARLCB-TR-85020<br>ARLCB-SP-85033 |
| Shear Stresses                           | ARLCB-TR-85010                   |
| Shutdowns                                | ARCCB-TR-85004                   |
| Slip-Line Field                          | ARLCB-TR-85029                   |
| Solid Metal Induced Embrittlement (SMIE) | ARLCB-TR-85002                   |
| Solidification                           | ARCCB-TR-85003                   |
| Space-Time Elements                      | ARLCB-TR-85028                   |
| Stabilization                            | ARLCB-SP-85009                   |
| Steel                                    | ARLCB-TR-85029<br>ARLCB-TR-85036 |
| Strain Hardening                         | ARLCB-TR-85007                   |
| Stress Analysis                          | ARLCB-TR-85014                   |
| Stress Concentration                     | ARLCB-TR-85011                   |
| Stress Intensity                         | ARLCB-MR-85015<br>ARLCB-TR-85018 |
| Surface Slopes                           | ARLCB-TR-85026                   |
| Symposia                                 | ARLCB-SP-85009                   |

# SUBJECT INDEX--1985 (CONT.)

| <u>SUBJECT</u>         | <u>REPORT NUMBER</u>                               |
|------------------------|----------------------------------------------------|
| Target Acquisition     | ARLCB-SP-85009                                     |
| Technical Publications | ARLCB-SP-85023                                     |
| Temperature Control    | ARCCB-TR-85004                                     |
| Tensile Strength       | ARLCB-TR-85029                                     |
| Terrain                | ARLCB-TR-85022<br>ARLCB-TR-85026                   |
| Test Methods           | ARLCB-MR-85031                                     |
| Texture                | ARLCB-TR-85036                                     |
| Thermal Analysis       | ARLCB-CR-85024                                     |
| Thermal Expansion      | ARLCB-TR-85005<br>ARCCB-TR-85002                   |
| Thick-Wall Cylinders   | ARLCB-TR-85007<br>ARLCB-TR-85032<br>ARLCB-TR-85035 |
| Tool Wear              | ARLCB-TR-85030                                     |
| Torsion                | ARLCB-TR-85006                                     |
| Toughness              | ARLCB-TR-85014                                     |
| Variational Principles | ARLCB-TR-85021                                     |
| Vibration              | ARLCB-SP-85009                                     |
| Vision Systems         | ARLCB-TR-85012                                     |
| Warning Systems        | ARCCB-TR-85004                                     |
| Wear                   | ARLCB-TR-85008                                     |

# AD NUMBERS--1985

| <u>REPORT NUMBER</u> | <u>AD NUMBER</u> |
|----------------------|------------------|
| ARLCB-TR-85001       | A152 130         |
| ARLCB-TR-85002       | A152 732         |
| ARLCB-TR-85003       | B091 479L        |
| ARLCB-TR-85004       | B091 478L        |
| ARLCB-TR-85005       | A152 477         |
| ARLCB-TR-85006       | A153 347         |
| ARLCB-TR-85007       | A153 151         |
| ARLCB-TR-85008       | A156 666         |
| ARLCB-SP-85009       |                  |
| Volume I             | A162 134         |
| Volume II            | A162 135         |
| ARLCB-TR-85010       | A154 458         |
| ARLCB-TR-85011       | A155 628         |
| ARLCB-TR-85012       | A155 301         |
| ARLCB-TR-85013       | A155 629         |
| ARLCB-TR-85014       | A156 172         |
| ARLCB-MR-85015       | A156 565         |
| ARLCB-TR-85016       | A156 663         |
| ARLCB-TR-85017       | A158 315         |
| ARLCB-TR-85018       | A157 866         |
| ARLCB-TR-85019       | A157 901         |
| ARLCB-TR-85020       | B094 636L        |
| ARLCB-TR-85021       | A157 964         |
| ARLCB-TR-85022       | A159 883         |
| ARLCB-SP-85023       | A158 022         |

AD NUMBERS--1985 (CONT.)

| <u>REPORT NUMBER</u> | <u>AD NUMBER</u> |
|----------------------|------------------|
| ARLCB-CR-85024       | B095 459L        |
| ARLCB-TR-85025       | A159 886         |
| ARLCB-TR-85026       | A159 469         |
| ARLCB-TR-85027       | A159 887         |
| ARLCB-TR-85028       | A159 885         |
| ARLCB-TR-85029       | A159 882         |
| ARLCB-TR-85030       | A161 646         |
| ARLCB-MR-85031       | B096 960L        |
| ARLCB-TR-85032       | A161 733         |
| ARLCB-SP-85033       | B096 932L        |
| ARLCB-TR-85034       | A162 852         |
| ARLCB-TR-85035       | A161 805         |
| ARLCB-TR-85036       | A162 853         |
| ARLCB-TR-85037       | A161 806         |
| ARCCB-TR-85001       | A164 933         |
| ARCCB-TR-85002       | A162 751         |
| ARCCB-TR-85003       | A163 443         |
| ARCCB-TR-85004       | A165 296         |

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>ELECTRICAL RESISTIVITY IN AMORPHOUS METALS:<br>CONSEQUENCES OF PHONON INEFFECTIVENESS IN THE<br>DIFFRACTION MODEL                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>L. V. Meisel and P. J. Cote                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.02.H600.011<br>PRON NO. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 12. REPORT DATE<br>January 1985                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 13. NUMBER OF PAGES<br>47                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br>Published in Physical Review B Journal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Amorphous Metals<br>Electron-Phonon Interaction<br>Electrical Transport                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Electrical transport in amorphous metals is analyzed in the context of the Baym-Faber-Ziman theory. The theory is generalized to incorporate electron mean free path effects through the Pippard-Ziman condition on the electron-phonon interaction. A variety of model t-matrices are considered. The geometrical structure factors are modeled by Percus-Yevick hard sphere forms and a single branch Debye phonon spectrum is assumed. Detailed results for electrical<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 20. ABSTRACT (CONT'D)

resistivity  $\rho$  vs. temperature  $T$  and the TCR are presented for extensive ranges of  $2k_F/k_p$  and electron mean free path. The results, incorporating the Pippard-Ziman condition, are consistent with the observed  $\rho$  vs.  $T$  in low resistivity glassy metals. However, although inclusion of the Pippard-Ziman condition dramatically improves agreement with the data, quantitative agreement is not obtained in high resistivity amorphous metals.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85002                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>SOLID METAL INDUCED EMBRITTLEMENT OF METALS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>M. H. Kamdar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.001<br>PRON No. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 12. REPORT DATE<br>January 1985                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 13. NUMBER OF PAGES<br>22                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Published in the Proceedings of the Sixth International Conference on Fracture (New Delhi, India, 4-11 December 1984).                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Solid Metal Induced Embrittlement<br>Fracture in Solid Metal Environments<br>Effects of Stress, Time, and Temperature on Embrittlement<br>Mechanisms of Solid Metal Embrittlement                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Many ductile metals in intimate contact with thin coatings of low melting solid metal which exhibit liquid metal embrittlement, also manifest severe embrittlement when tested at temperatures below the melting point of the coating. A significant decrease in stress, strain, and reduction-in-area occurs at fracture. Fracture propagates fast, but at a rate which is one or two orders of magnitude slower than that in liquid metal environments. Fracture occurs by<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 20. ABSTRACT (CONT'D)

brittle intergranular or transcrystalline mode with multiple cracks and branching. This new phenomena is known as solid metal induced embrittlement of metals (SMIE). SMIE also occurs when the embrittling metal is present as an internal environment in the base metal such as inclusions. This report describes the occurrence of SMIE in metals and alloys used in industry and presents results of recent investigations. It describes the effects of time, temperature, and stress on SMIE. It discusses the occurrence, the mechanisms of SMIE, and its similarity to LME. This new phenomena must be considered while investigating environmentally induced failure of failure analysis of metals and alloys.

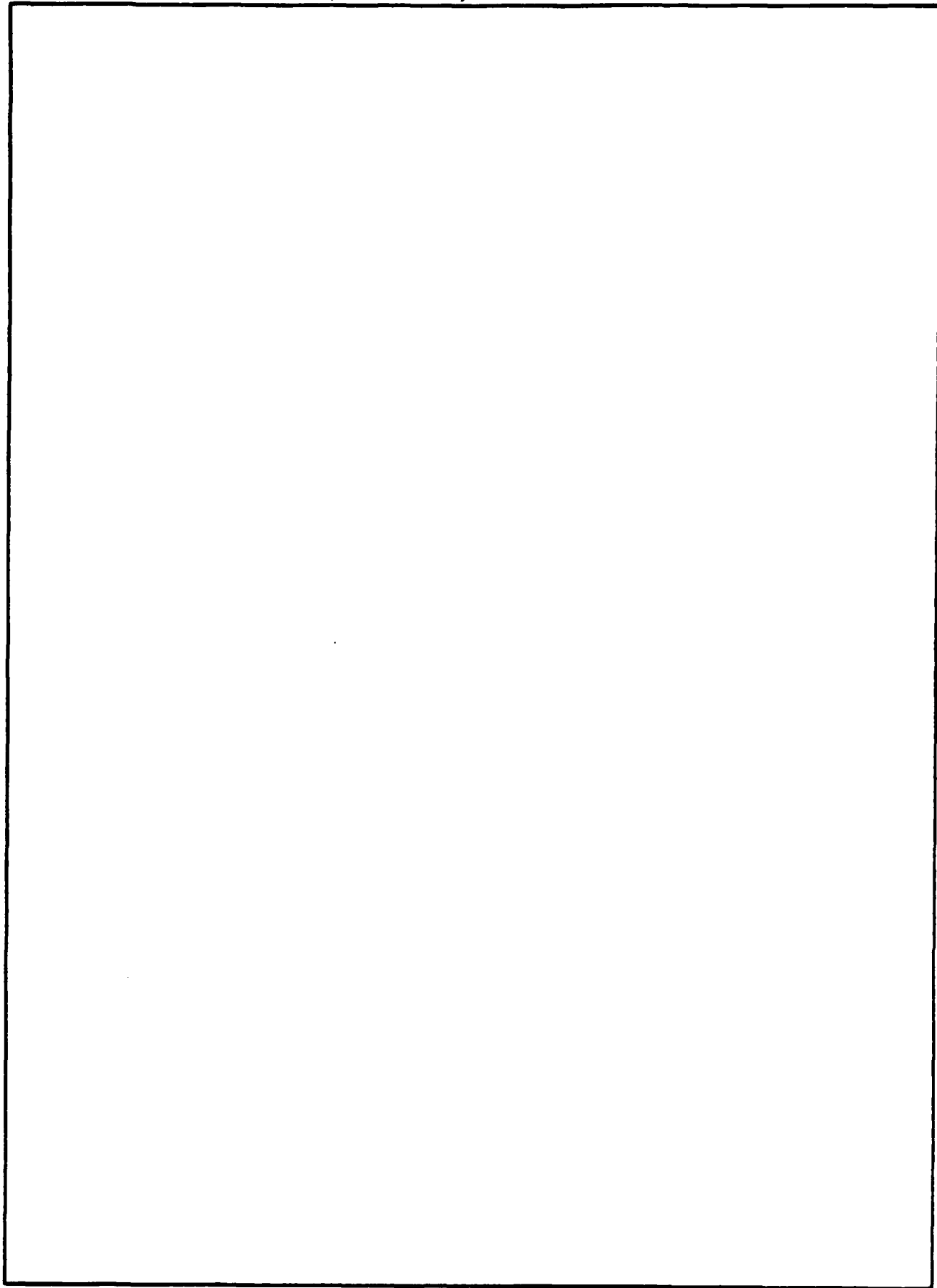
| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                       |
| 4. TITLE (and Subtitle)<br>THE FATIGUE EFFECTS OF THE M119A1 ZONE 8 ROUND<br>ON THE 155 MM M199 HOWITZER TUBE                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                    |
| 7. AUTHOR(s)<br>Bruce B. Brown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 2080.15.6000.0<br>PRON No. 1A1221B81A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 12. REPORT DATE<br>February 1985                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 13. NUMBER OF PAGES<br>28                                                                                           |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                       |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Distribution limited to US Government Agencies only because of test and evaluation; February 1985. Other requests for this document must be referred to Commander, US Army Armament Research and Development Center, ATTN: Benet Weapons Laboratory, SMCAR-LCB-RM, Watervliet, NY 12189.                                                                                                                                                                                                                                        |                       |                                                                                                                     |
| 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)<br>155 mm M198 Howitzer System      EFC<br>155 mm M199 Howitzer Tube      M203 Propellant Charge<br>Fatigue      M119A1 Propellant Charge<br>Safe Service Life      M4A2 Propellant Charge<br>Equivalent Full Charge Factor                                                                                                                                                                                                                                                                     |                       |                                                                                                                     |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>The safe service life of the 155 mm M199 howitzer tube has previously been established based on the M203 Zone 8 propellant charge. This study was conducted to evaluate the effects of a lower pressure propelling charge, the M119A1 Zone 8, on the tube fatigue life. Testing and analysis were based on the 'worst case' mix of the two pressure levels to determine an Equivalent Full Charge (EFC) factor for the M119A1 Zone 8 charge. An Equivalent Full Charge<br>(CONT'D ON REVERSE) |                       |                                                                                                                     |

20. ABSTRACT (CONT'D)

factor of 0.25 is recommended for the M119A1 Zone 8 charge in the 155 mm M199 howitzer tube. From other available data, this same EFC factor is recommended for the M119A2 Zone 7 and M4A2 Zone 7 charges.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                         |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85004                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                       |
| 4. TITLE (and Subtitle)<br>FATIGUE PERFORMANCE OF 105 MM M68 TUBE UNDER<br>DIFFERING PRESSURE CONDITIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                    |
| 7. AUTHOR(s)<br>Bruce B. Brown                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 2080.15.6000.0<br>PRON No. 1A1221B81A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 12. REPORT DATE<br>February 1985                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 13. NUMBER OF PAGES<br>34                                                                                           |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                       |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Distribution limited to US Government Agencies only because of test and evaluation; February 1985. Other requests for this document must be referred to Commander, US Army Armament Research and Development Center, ATTN: Benet Weapons Laboratory, SMCAR-LCB-RM, Watervliet, NY 12189.                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                     |
| 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)<br>Fatigue<br>Expected Safe Life<br>105 mm M68<br>Tank Gun<br>Equivalent Full Charge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                     |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This test program was conducted to assess the effects of fatigue over a span of pressures which would be encountered when the 105 mm M68 tank gun is fired using differing round types. Previous tests had established the failure mode locations and safe life for the standard M735 (APFSDS-T) round at maximum service temperature, and these data are included in the analysis. The new tests were at pressures above and below this level such that the analysis has resulted in an expected safe life curve available for Equivalent Full Charge (EFC) factor assignment to round types whose pressures fall within this span. |                       |                                                                                                                     |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85005                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>THERMAL-EXPANSION EFFECTS IN ELECTRICAL<br>TRANSPORT IN AMORPHOUS METALS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>L. V. Meisel and P. J. Cote                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 12. REPORT DATE<br>February 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 13. NUMBER OF PAGES<br>26                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for public release; distribution unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br>To be published in Physical Review B Journal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Disordered Metals<br>Thermal Expansion<br>Electrical Transport                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Theoretical treatments of electrical transport in amorphous metals are usually performed at constant volume, although most experimental studies are performed at constant pressure. Recent studies of the influence of pressure on the electrical resistivity of a variety of amorphous metals indicate that thermal expansion effects can not be ignored in a theoretical description of the temperature dependence of the isobaric resistivity. In this report, general<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 20. ABSTRACT (CONT'D)

ideas pertinent to a theoretical description of non-isochoric electrical transport are presented. Results for isobaric electrical transport based on the Gruneisen theory of thermal expansion, which are independent of the model employed to treat isochoric transport, are also given. The implications of the theory are illustrated in the context of the diffraction model by: (1) detailed results specific to the well-characterized low resistivity alloy,  $\alpha$ -Mg<sub>7</sub>Zn<sub>3</sub>; and (2) a selection of model calculations incorporating thermal expansion effects for cases with positive and negative pressure coefficients of resistivity.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85006                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>CYCLIC TORSION OF A CIRCULAR CYLINDER AND ITS<br>RESIDUAL STRESS DISTRIBUTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>Han C. Wu, M. R. Aboutorabi, and Peter C. T. Chen<br>(see reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A425M541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 12. REPORT DATE<br>February 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 13. NUMBER OF PAGES<br>22                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>To be published in <u>ASME Journal of Engineering Materials and Technology</u> .                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Circular Cylinder<br>Cyclic Torsion<br>Residual Stresses<br>Endochronic Theory of Plasticity                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>The endochronic theory of plasticity is applied to discuss the cyclic fully-reversed torsional loading of a solid bar with circular cross-section. 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 to compute stress distributions within the solid specimen. Special attention is given to the<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

7. AUTHORS (CONT'D)

Han C. Wu (Professor) and M. R. Aboutorabi (Graduate Student)  
Department of Civil Engineering  
University of Iowa  
Iowa City, Iowa 52242

20. ABSTRACT (CONT'D)

residual stress distribution. It is shown that reasonable results are obtained. The relation of torque versus strain at the outermost fiber of the solid specimen provides an ultimate check of the theory as applied to this case.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85007                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>A MORE ACCURATE SOLUTION TO THE ELASTIC-PLASTIC<br>PROBLEM OF PRESSURIZED THICK-WALLED CYLINDERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>Peter C. T. Chen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON NO. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 12. REPORT DATE<br>February 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 13. NUMBER OF PAGES<br>16                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at the Second Army Conference on Applied Math & Computing, RPI,<br>Troy, NY, 22-24 May 1984. Published in the Conference Proceedings.                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br><br>Strain-Hardening Materials<br>Pressurized Thick-Walled Cylinders<br>Residual Stresses<br>Finite-Difference Method                                                                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>A new method has been developed for solving the partially plastic problems of<br>thick-walled cylinders made of strain-hardening or ideally-plastic materials<br>subjected to any combination of internal pressure, external pressure, and end<br>loads. The incremental strains are chosen as the basic unknowns in the<br>finite-difference formulation. The incremental sizes of the applied loading<br>are determined automatically and no iteration is needed. Complete solutions<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

20. ABSTRACT (CONT'D)

for the stresses, strains, and displacement have been obtained and all numerical results are very accurate. This approach is also efficient and simple, yet quite general, when compared with many solutions in the literature.

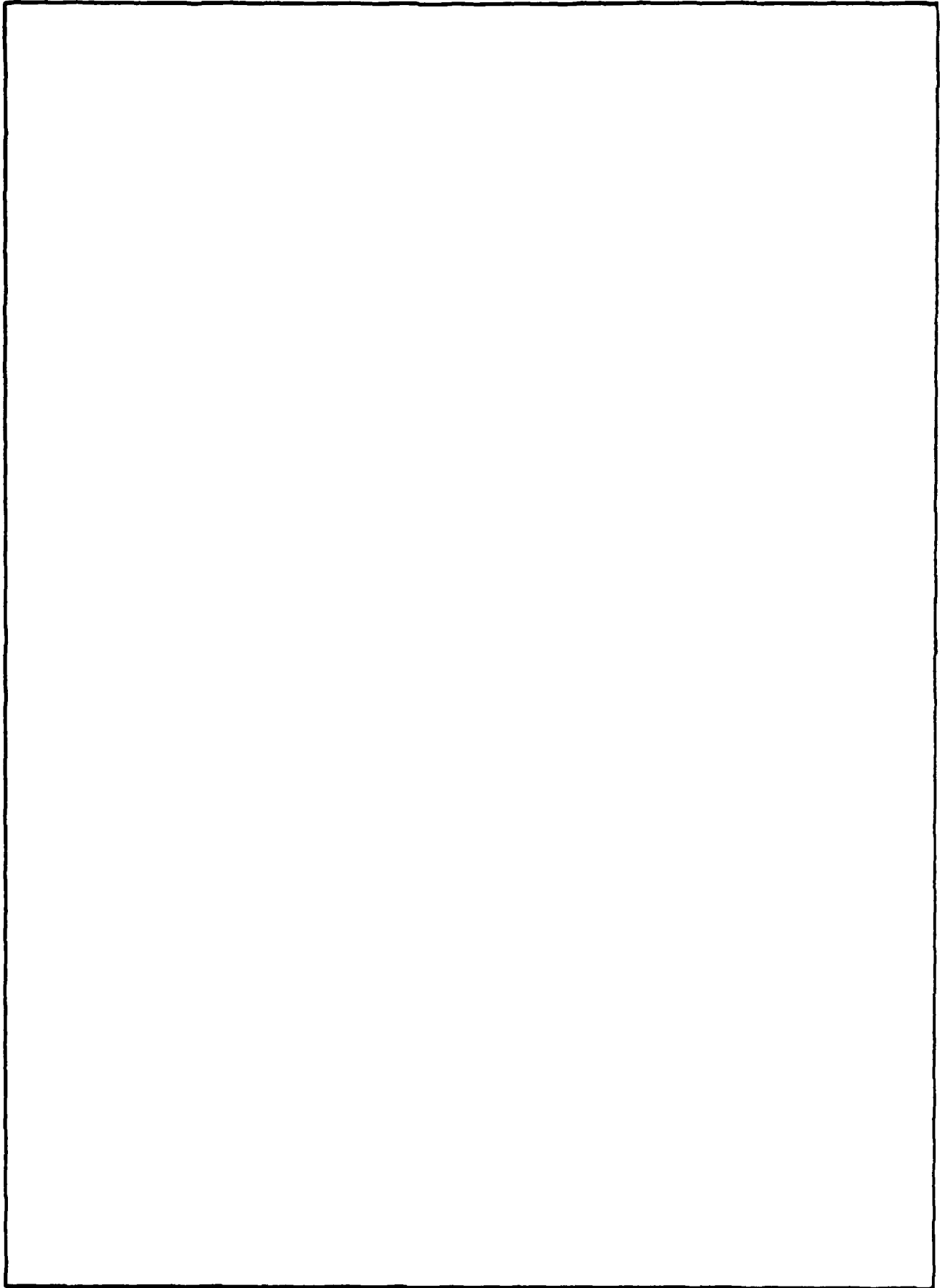
| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85008                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>WEAR OF PROJECTILE ROTATING BANDS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>R. S. Montgomery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.02.H600.011<br>PRON NO. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 12. REPORT DATE<br>March 1985                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 13. NUMBER OF PAGES<br>20                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       |                                                                                                                       |
| 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)<br>Melt-Lubricating                      Cannon Bores<br>Rotating Bands                        Body Engraving<br>Projectile Wear                        Interior Ballistics                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Rotating or driving bands are bands of relatively soft materials surrounding a projectile. They have a number of functions the chief of which is probably that they produce stabilizing rotating of the projectile when they are "engraved" or keyed into the rifling. These bands are used on spin-stabilized projectiles as small as 20 mm caliber, but this discussion concerns especially the larger cannon, i.e., in excess of 105 mm. Excess wear of projectile<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 20. ABSTRACT (CONT'D)

rotating bands has a number of important negative consequences including inaccuracy and "short rounds". There are two distinctly different mechanisms of wear. At low speeds near the beginning of motion, wear is by adhesion, abrasion, and even under some conditions, scuffing. After a few centimeters of sliding, a thin surface film of molten band material is formed and the remainder of the sliding is melt-lubricated. While metal-on-metal sliding is limited to the first few centimeters, it is very important and can result in serious wear problems down bore. The exact wear of rotating bands depends on the motion of the projectile in the bore of the cannon. Therefore, this motion can be inferred from the wear.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                        |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-SP-85009                                                                                                                                                                                                                                                                                                                                                               | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                          |
| 4. TITLE (and Subtitle)<br>PROCEEDINGS, FOURTH U.S. ARMY SYMPOSIUM<br>ON GUN DYNAMICS VOL.I of II VOLS.                                                                                                                                                                                                                                                                                          |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                            |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 6. PERFORMING ORG. REPORT NUMBER                                       |
| 7. AUTHOR(s)<br>Editors: Dr. T. E. Simkins<br>Dr. J. Vasilakis                                                                                                                                                                                                                                                                                                                                   |                       | 8. CONTRACT OR GRANT NUMBER(s)                                         |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                             |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>N.A. |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                     |                       | 12. REPORT DATE<br>May 1985                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 13. NUMBER OF PAGES<br>292                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                      |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                   |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                          |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; Distribution unlimited                                                                                                                                                                                                                                                                                           |                       |                                                                        |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                       |                       |                                                                        |
| 18. SUPPLEMENTARY NOTES<br>Presented at the Fourth U.S. Army Symposium on Gun Dynamics, 7-9 May 1985,<br>at the Hilton Inn of the Palm Beaches, Riviera Beach, Florida.                                                                                                                                                                                                                          |                       |                                                                        |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Acquisition Precision<br>Ballistics Stabilization<br>Barrel Vibration Target Acquisition<br>Dynamics                                                                                                                                                                                                       |                       |                                                                        |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This represents a compilation of thirty-four technical papers concerning<br>analyses, design, measurement, and automation of gun dynamics. The authors<br>represent a cross-section of the scientific and technical community,<br>including universities, industrial, and Government research laboratories. |                       |                                                                        |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                        |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-SP-85009                                                                                                                                                                                                                                                                                                                                                               | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                               |
| 4. TITLE (and Subtitle)<br>PROCEEDINGS, FOURTH U.S. ARMY SYMPOSIUM<br>ON GUN DYNAMICS VOL II of II.                                                                                                                                                                                                                                                                                              |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 6. PERFORMING ORG. REPORT NUMBER                                            |
| 7. AUTHOR(s)<br>Editors: Dr. T. E. Simkins<br>Dr. J. Vasilakis                                                                                                                                                                                                                                                                                                                                   |                       | 8. CONTRACT OR GRANT NUMBER(s)                                              |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                             |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br><br>N. A. |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                     |                       | 12. REPORT DATE<br>May 1985                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 13. NUMBER OF PAGES<br>236                                                  |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                      |                       | 15. SECURITY CLASS. (of this report)<br><br>Unclassified                    |
|                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                               |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; Distribution unlimited                                                                                                                                                                                                                                                                                           |                       |                                                                             |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                       |                       |                                                                             |
| 18. SUPPLEMENTARY NOTES<br>Presented at the Fourth U.S. Army Symposium on Gun Dynamics, 7-9 May 1985,<br>at the Hilton Inn of the Palm Beaches, Riviera Beach, Florida.                                                                                                                                                                                                                          |                       |                                                                             |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Acquisition Precision<br>Ballistics Stabilization<br>Barrel Vibration Target Acquisition<br>Dynamics                                                                                                                                                                                                       |                       |                                                                             |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This represents a compilation of thirty-four technical papers concerning<br>analyses, design, measurement, and automation of gun dynamics. The authors<br>represent a cross-section of the scientific and technical community,<br>including universities, industrial, and Government research laboratories. |                       |                                                                             |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

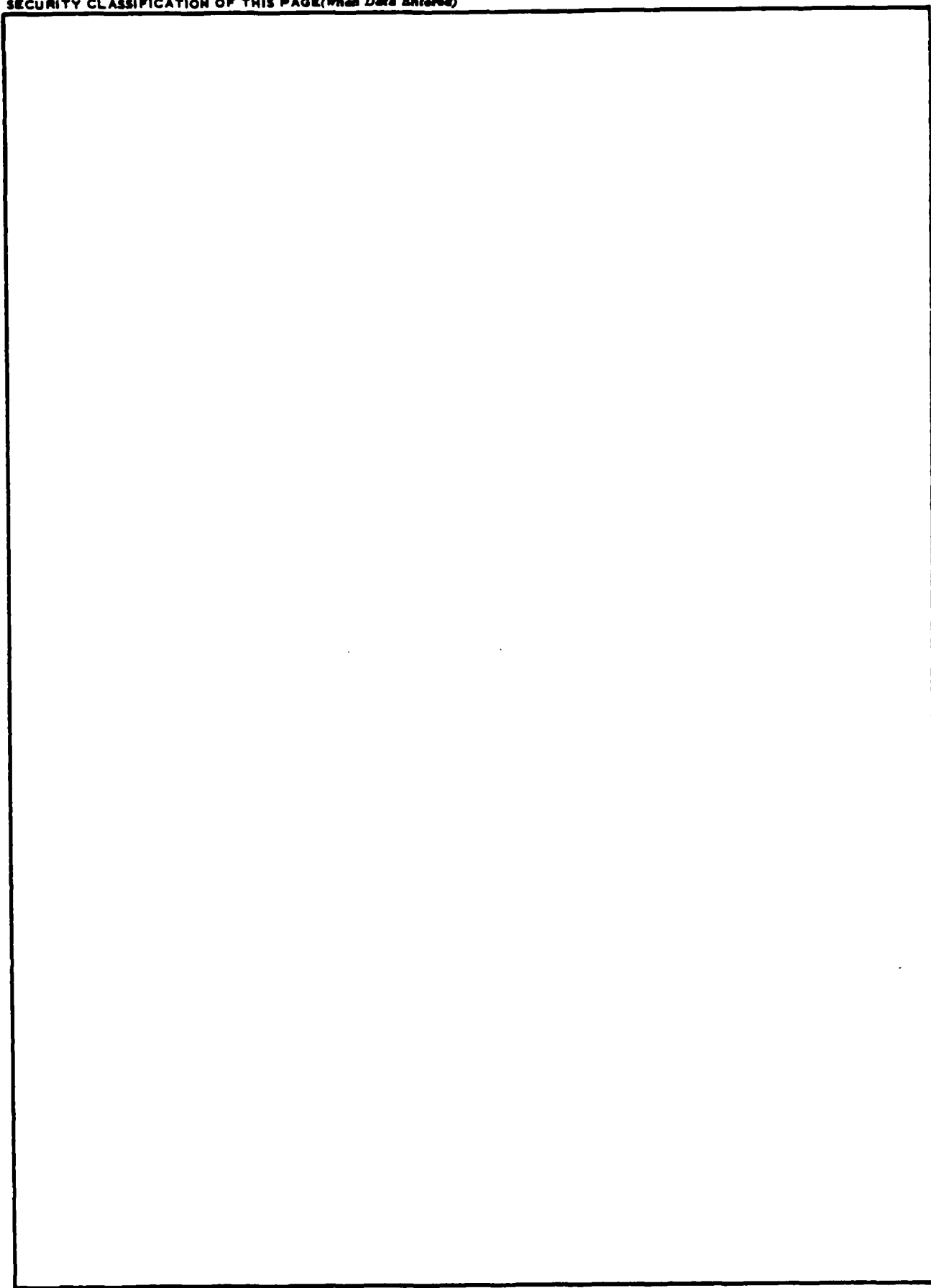
| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                    |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85010                                                                                                                                                                                                                                                                                                                                                           | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>SHEAR DEFLECTION IN A THREE-POINT BEND BEAM<br>OF A SOLID CIRCULAR CROSS-SECTION                                                                                                                                                                                                                                                                                  |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
| 7. AUTHOR(s)<br>Boaz Avitzur                                                                                                                                                                                                                                                                                                                                                                 |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                         |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 3111.16.0003.600<br>PRON No. 1A227D111A1A |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                  |                       | 12. REPORT DATE<br>March 1985                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                              |                       | 13. NUMBER OF PAGES<br>11                                                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 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)<br>Deflection<br>Shear Stresses<br>Circular Beams                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>An equation, correlating the elastic deflection of a simply supported beam of a circular cross-section, with the applied load and beam's material properties and dimensions is being offered here. The contributions due to the bending moment and due to shear stresses are computed and compared. |                       |                                                                                                                       |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85011                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>STRESS CONCENTRATION IN THE ELASTOPLASTIC STATE<br>AND RESIDUAL STRESS AFTER UNLOADING                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>Y. F. Cheng                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A425M541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 12. REPORT DATE<br>March 1985                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 13. NUMBER OF PAGES<br>32                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at 1984 Army Symposium on Solid Mechanics, Newport, Rhode Island,<br>1-3 October 1984.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Photoelasticity                      Elastoplastic State<br>Photoplasticity                      Stress Concentration<br>Photoelastic Coating                Residual Stress                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Photoplasticity and photoelastic coating techniques have been successfully<br>employed to study stress concentration in the elastoplastic state and residual<br>stress after unloading. Principles are described herein, and examples of the<br>application of both methods are given. The results show that stress<br>concentration in the elastoplastic state is lower than that in the elastic<br>state and decreases continuously as yielding progresses. A good agreement<br>exists between results from both methods. |                       |                                                                                                                       |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                        |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85012                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                      |
| 4. TITLE (and Subtitle)<br>AUTONOMOUS DETECTION OF OBJECTS FROM RANGE DATA MEASUREMENTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                   |
| 7. AUTHOR(s)<br>Ronald L. Racicot and C. N. Shen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                     |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.01.91A0.011<br>PRON No. 1A425M511A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 12. REPORT DATE<br>April 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 13. NUMBER OF PAGES<br>16                                                                                          |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                    |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                    |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at Mini and Microcomputers in Control, Filtering & Signal Processing Conference, Caesars Palace, Las Vegas, Nevada, 10-12 December 1984.                                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                    |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Vision Systems<br>Laser Rangefinder<br>Object Detection<br>Kalman Filter                                                                                                                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                    |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>The overall objective of this study is to provide autonomous detection of obstacles or objects within a given field of view using noisy range data measurements as might be obtained from a laser rangefinder. Specifically, the goal is to provide simplified and efficient computer procedures suitable for filtering and processing the range data to detect objects. The particular procedure studied involves a single term state vector (range) with adaptive<br>(CONT'D ON REVERSE) |                       |                                                                                                                    |

## 20. ABSTRACT (CONT'D)

procedures for handling objects on a sloped plane. The range data is processed by incrementally varying elevation angle for fixed azimuth angle. The edges of objects are detected using a Bayesian decision procedure on the filtered range data.

Results are presented showing the minimum object size that can be detected as a function of false alarm rate, Bayesian decision criteria, measurement noise level, and covariances of the artificial noise levels added to the filter to minimize false alarms. The artificial noise covariances can be either in the form of system (plant) noise or measurement noise. Results indicate that the most efficient approach to minimizing false alarms in terms of minimizing detectable object size is to adjust the Bayesian decision criteria. The least efficient approach is to artificially add system noise covariances.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85013                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>FRACTURE IN LIQUID METAL ENVIRONMENTS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>M. H. Kamdar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6910.00.H840.021<br>Pron NO. 1A425Q781A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 12. REPORT DATE<br>April 1985                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 13. NUMBER OF PAGES<br>56                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 15. SECURITY CL. ASS. (of this report)<br>Unclassified                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br>Presented at the Sixth International Fracture Conference, New Delhi, India,<br>4 December, 1984.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Fracture in Liquid Metals<br>Liquid Metal Embrittlement<br>Effects of Metallurgical, Mechanical, Chemical Parameters<br>Mechanisms of Embrittlement                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Many ductile metals fracture in a brittle manner when tested in the presence of<br>a thin surface coating of certain liquid metals. The severity of embrittlement<br>depends upon the metallurgical, mechanical, and physical factors and also on the<br>chemical nature of the liquid and the solute dissolved in the liquid metals.<br>Liquid metal embrittlement is considered a special case of brittle fracture and<br>it is generally accepted that embrittlement is caused by the liquid metal<br>"Adsorption Induced Reductions in the Cohesion" of atomic bonds at the crack<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

20. ABSTRACT (CONT'D)

tip. This report describes the phenomena of fracture in liquid metal environments and discusses the effects of variables related to the solid, the liquid, the liquid metal solutions, and to the test conditions on the severity of embrittlement. It also discusses various mechanisms of embrittlement. Also, a summary with suggestions for future work is presented.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85014                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                       |
| 4. TITLE (and Subtitle)<br>FRACTURE TESTING WITH ARC BEND SPECIMENS                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 5. TYPE OF REPORT & PERIOD COVERED<br><br>Final                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                    |
| 7. AUTHOR(s)<br>J. H. Underwood, J. A. Kapp, and M. D. Witherell                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6940.0R.2200.0<br>Pron NO. 1A323G471A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                           |                       | 12. REPORT DATE<br>May 1985                                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 13. NUMBER OF PAGES<br>32                                                                                           |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br><br>Unclassified                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                       |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                                                     |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                     |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at the 17th National Symposium on Fracture Mechanics, Albany, N.Y.<br>7-9 August, 1985, Albany Hilton.                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                     |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Fracture Toughness<br>Specimen Design<br>Cylindrical Geometry<br>Bend Specimen<br>Stress Analysis                                                                                                                                                                                                                                                                                |                       |                                                                                                                     |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>A limited review of existing stress, stress intensity factor, and displacement analyses is compared with new work in order to select arc bend geometries appropriate for fracture testing. Results from the literature for rectangular and arc bend specimens are compared with finite element and boundary collocation results from the present work.<br><br>(CONT'D ON REVERSE) |                       |                                                                                                                     |

## 20. ABSTRACT (CONT'D)

Two series of comparative tests were performed, one with arc specimens cut from a steel forging with outer-to-inner radius ratio of 2.5, the other from an aluminum cylinder with outer-to-inner radius ratio of 1.3. Fracture toughness tests,  $K_{IC}$  and  $J_{IC}$ , when appropriate, were performed with standard arc tension specimens and with three-point arc bend specimens both arc and chord support.

Conclusions were drawn regarding the appropriate stress intensity factor, crack mouth displacement, and load-line displacement solutions for arc bend fracture specimens. Recommendations were offered for practical ranges of specimen geometry and for reliable test procedures.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                             |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-MR-85015                                                                                                                                                                                                                                                                                    | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                    |
| 4. TITLE (and Subtitle)<br>MORE ON COMPLIANCE OF THE THREE-POINT BEND SPECIMEN                                                                                                                                                                                                                                        |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                      |
|                                                                                                                                                                                                                                                                                                                       |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                 |
| 7. AUTHOR(s)<br>John H. Underwood, Joseph A. Kapp, and Francis I. Baratta (AMMRC)                                                                                                                                                                                                                                     |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                   |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                  |                       | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>AMCMS No. 7280.12.12.000<br>PRON No. 1A423M891A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                          |                       | 12. REPORT DATE<br>May 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                       |                       | 13. NUMBER OF PAGES<br>9                                                                                         |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                           |                       | 15. SECURITY CL. ASS. (of this report)<br>UNCLASSIFIED                                                           |
|                                                                                                                                                                                                                                                                                                                       |                       | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE                                                                       |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                               |                       |                                                                                                                  |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                            |                       |                                                                                                                  |
| 18. SUPPLEMENTARY NOTES<br><br>Submitted to <u>International Journal of Fracture.</u>                                                                                                                                                                                                                                 |                       |                                                                                                                  |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Fracture Test Methods<br>Load-Line Displacement<br>Bend Specimen                                                                                                                                                                |                       |                                                                                                                  |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Comparison and analysis of load-line displacement for the three-point bend specimen was performed. Expressions were developed for displacement as a function of crack length and for crack length as a function of displacement. |                       |                                                                                                                  |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85016                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                   |
| 4. TITLE (and Subtitle)<br>A MESH MOVING TECHNIQUE FOR TIME DEPENDENT<br>PARTIAL DIFFERENTIAL EQUATIONS IN TWO SPACE<br>DIMENSIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                |
| 7. AUTHOR(s)<br>David C. Arney and Joseph E. Flaherty<br>(see reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                  |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.01.011<br>PRON No. 1A425M51A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 12. REPORT DATE<br>June 1985                                                                                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 13. NUMBER OF PAGES<br>34                                                                                       |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                   |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for public release; distribution unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       |                                                                                                                 |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                 |
| 18. SUPPLEMENTARY NOTES<br>Presented at the Second Army Conference on Applied Math & Computing, RPI, 22-24<br>May 1984. The authors were partially supported by the U.S. Army Research Office<br>under Contract Number DAAG-82-K-0197 and the U.S. Air Force Office of Scientific<br>Research, Air Force Systems Command, USAF, under Grant Number AFOSR 80-0192.                                                                                                                                                                                                                                      |                       |                                                                                                                 |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Adaptive Methods<br>Hyperbolic Partial Differential Equations<br>Mesh Moving<br>Finite Volume                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                 |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>We discuss an adaptive mesh moving technique that can be used with a finite<br>difference or finite element scheme to solve initial-boundary value problems<br>for vector systems or partial differential equations in two space dimensions<br>and time. The mesh moving technique is based on an algebraic node movement<br>function determined from the propagation of significant error regions. The<br>algorithm is designed to be flexible, so that it can be used with many existing<br>(CONT'D ON REVERSE) |                       |                                                                                                                 |

7. AUTHOR(S) (CONT'D)

David C. Arney  
 Department of Mathematics  
 United States Military Academy  
 West Point, NY 10996  
 and  
 Department of Mathematical Sciences  
 Rensselaer Polytechnic Institute  
 Troy, NY 12181

Joseph E. Flaherty  
 Armament Research and Development Center  
 Large Caliber Weapon Systems Laboratory  
 Benet Weapons Laboratory  
 Watervliet, NY 12189-5000  
 and  
 Department of Computer Science  
 Rensselaer Polytechnic Institute  
 Troy, NY 12181

20. ABSTRACT (CONT'D)

finite difference and finite element methods. To test the algorithm, we implemented the mesh mover in a system code along with an initial mesh generator and a MacCormack finite volume integrator on quadrilateral cells to solve hyperbolic vector systems. Results are presented for several computational examples. This moving mesh reduces dispersion errors near shocks and wave fronts and thereby reduces the grid requirements necessary to compute accurate solutions while increasing efficiency.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85017                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>NEW POWDER TECHNOLOGIES FOR MOLYBDENUM ALLOY<br>GUN BARREL LINERS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>J. M. Barranco and Saul Isserow (see reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6910.00.H840.021<br>PRON No. 1A425Q781A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 12. REPORT DATE<br>June 1985                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 13. NUMBER OF PAGES<br>35                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at Powder Metallurgy in Defense Technology Seminar, AMCCOM,<br>Dover, New Jersey, 24-26 September 1984.<br>Published in Seminar Proceedings.                                                                                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Molybdenum Alloy Powder<br>Gun Barrel Liner<br>Hot Isostatic Pressing<br>Bend Rupture Strength<br>Compression Strength                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Molybdenum is an attractive material for resisting gun barrel erosion because of its high melting point and mechanical properties. In previous efforts, molybdenum has been unsatisfactory because of the coarse grains and strong anisotropy in conventionally processed material. Powder metallurgy offers the opportunity to overcome these deficiencies. New technologies for preparing and consolidating powders are therefore being investigated to permit<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

7. AUTHORS (CONT'D)

Saul Isserow  
Army Materials and Mechanics Research Center  
Watertown, MA 02172

20. ABSTRACT (CONT'D)

utilization of the benefits of molybdenum for this and related applications. Work will be reported on alloy powders prepared by various methods with emphasis on rapid solidification, either by rotating electrode (REP and PREP) or by plasma melting (PMRS, plasma melted rapidly solidified). To date, consolidation has been primarily by hot isostatic pressing (HIP).

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85018                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>STRESS INTENSITY FACTORS AT RADIAL CRACKS OF<br>UNEQUAL DEPTH IN PARTIALLY AUTOFRETTAGED,<br>PRESSURIZED CYLINDERS                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
| 7. AUTHOR(s)<br>S. L. Pu                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A425M541A1A |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 12. REPORT DATE<br>June 1985                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 13. NUMBER OF PAGES<br>24                                                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 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)<br>Stress Intensity Factors<br>Multiple Cracks<br>Autofrettaged Cylinders<br>Cracks of Unequal Lengths<br>Fracture Mechanics                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Stress intensity factors are estimated for radial cracks of unequal depths emanating from the inner surface of a partially autofrettaged cylinder subjected to various bore pressures. The approximate method developed for uneven radial cracks in a non-autofrettaged cylinder is applied to functional stress intensities. Linear superposition is then used to obtain the final stress intensity factors of uneven cracks due to a stress field which varies<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

20. ABSTRACT (CONT'D)

with the magnitude of bore pressure, the degree of autofrettage, and the elastic-plastic behavior of the cylinder material. The autofrettage residual stress reduces the level of stress intensity factors at inner radial cracks due to internal pressure, but has little effect on variations in stress intensity factors caused by changes in crack depths.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85019                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>DYNAMIC RESPONSE IN AN ELASTIC-PLASTIC<br>PROJECTILE DUE TO NORMAL IMPACT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>P. C. T. Chen, J. E. Flaherty, and<br>J. D. Vasilakis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.01.91A0.011<br>PRON No. 1A425M511A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 12. REPORT DATE<br>June 1985                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 13. NUMBER OF PAGES<br>27                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at Second Army Conference on Applied Mathematics and Computing,<br>Rensselaer Polytechnic Institute, Troy, NY, 22-24 May 1984.<br>Published in Conference Proceedings.                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br><br>Elastic-Plastic Analysis<br>Projectile Impact<br>Finite Elements<br>ADINA<br>Different Integration Schemes                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>A numerical study of the dynamic response of an elastic-plastic projectile due to normal impact has been made using the finite element structural response code ADINA. The projectile is a finite length circular cylindrical bar striking a rigid target. First, three (central-difference, Newmark, Wilson) direct integration schemes have been used for the uniaxial stress wave problem in a linear-hardening material, and the results are compared with an exact<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

20. ABSTRACT (CONT'D)

analytical solution in order to evaluate accuracy and stability. Then, additional numerical results for perfectly-plastic materials are discussed in order to show the effect of strain-hardening. Finally, some results for a multi-linear material model based on two-dimensional elements are presented in order to show the lateral effect.



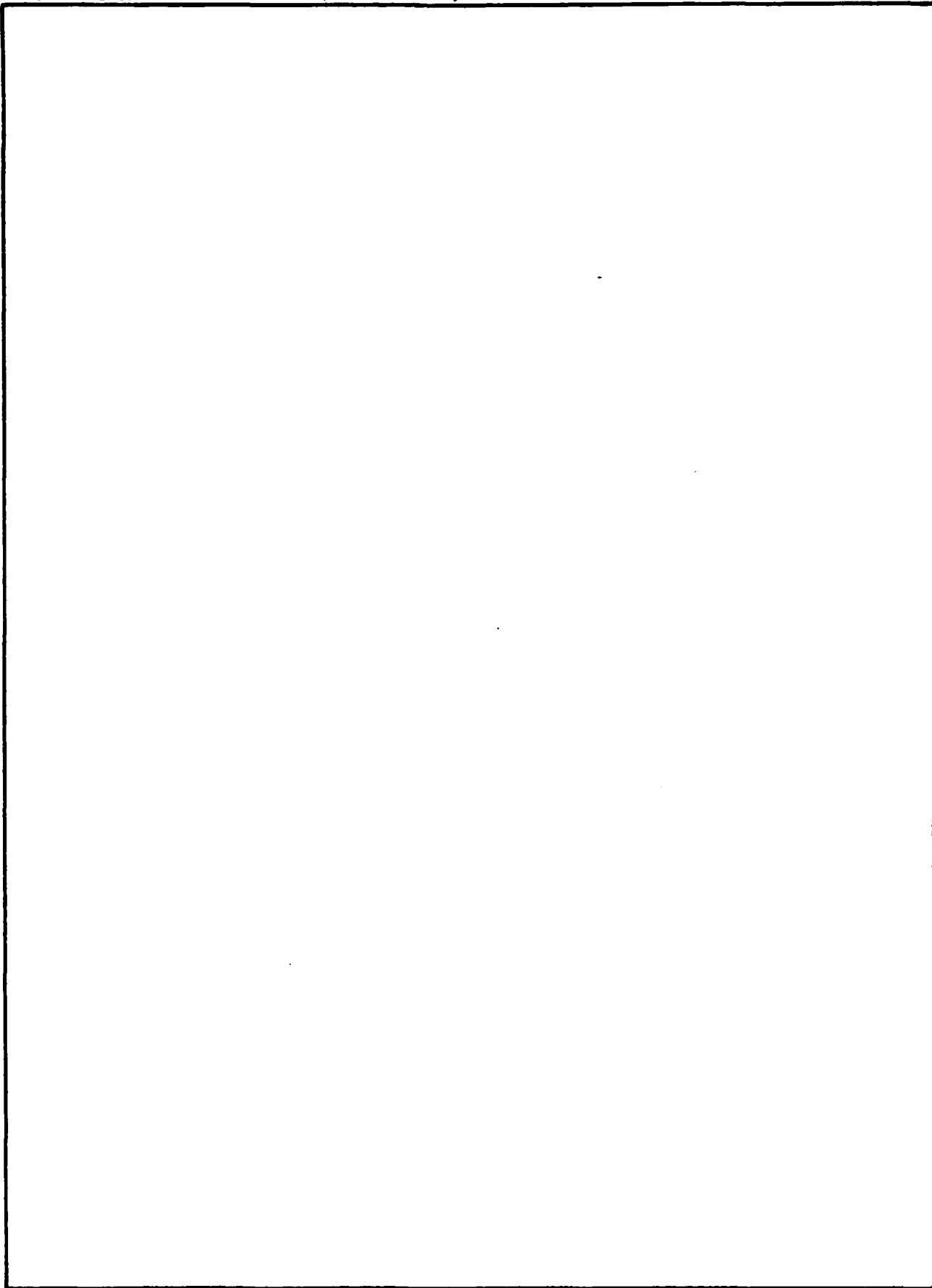
## 20. ABSTRACT (CONT'D)

undermining of the hot propellant gases leading to early condemnation of the gun tube.

The use of a mechanical tool to round off the sharp corners prior to plating was unsatisfactory and electrochemical machining was not practical. The application of an electrochemical deburring technique using an electro-polishing electrolyte has been found to be most successful and is reported here. The use of specially designed electrodes and associated apparatus for deburring the corners of small holes is described and the resulting profiles are shown.

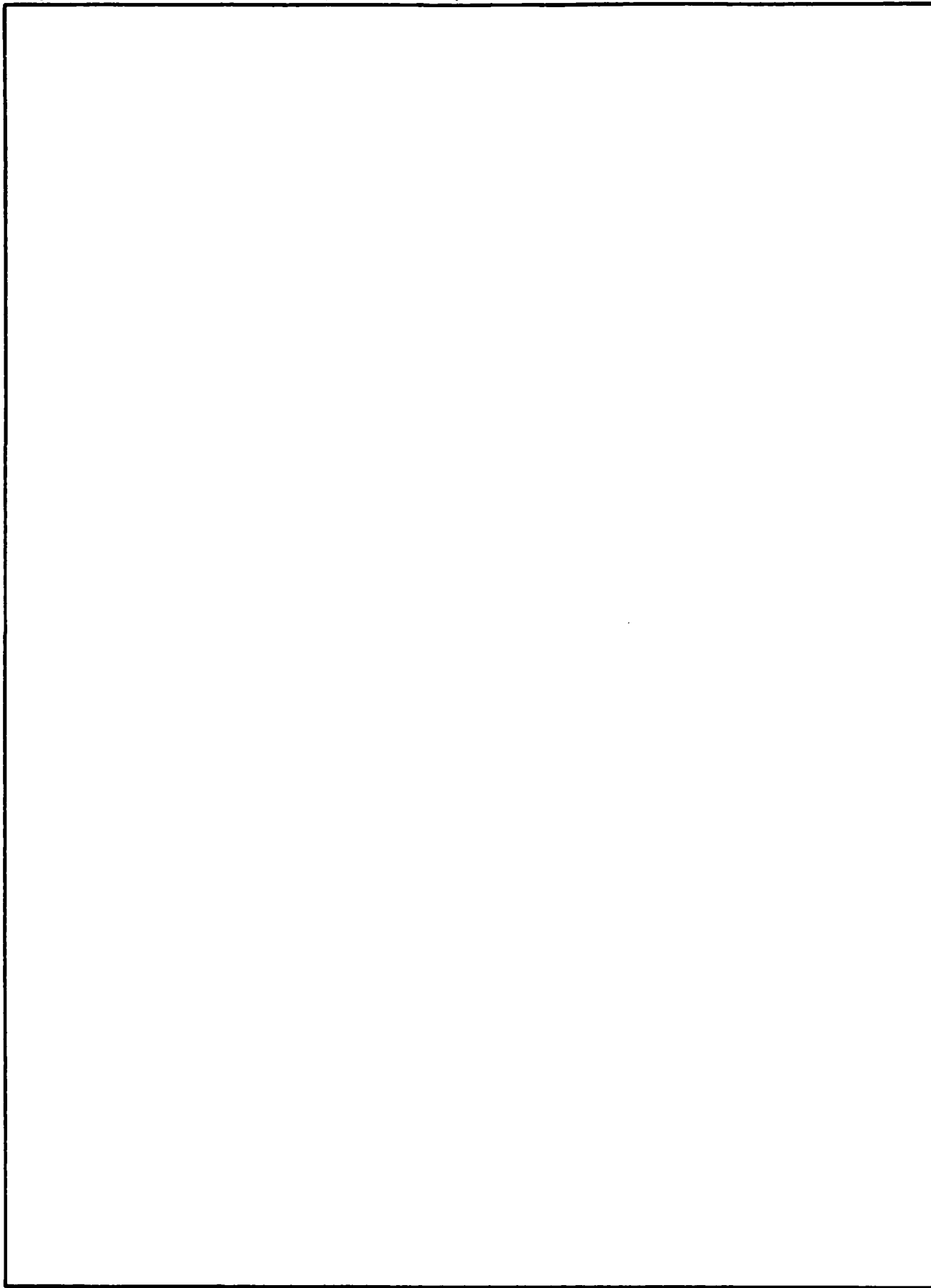
| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85021                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>VARIATIONAL PRINCIPLE FOR PENETRATOR DYNAMICS<br>USING BILINEAR FUNCTIONAL AND ADJOINT FORMULATION                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>C. N. Shen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                         |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.01.91A0.011<br>PRON No. 1A425MS11A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                 |                       | 12. REPORT DATE<br>June 1985                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 13. NUMBER OF PAGES<br>18                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at Second Army Conference on Applied Mathematics and Computing,<br>Rensselaer Polytechnic Institute, Troy, NY, 22-24 May 1984.<br>Published in Conference Proceedings.                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Variational Principle<br>Penetrator Dynamics<br>Matrix Vector Coupling Systems<br>Adjoint System<br>Optimization                                                                                                                                                                                                                                                                                                                                       |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>The solution to problems in both spatial and time domains using the finite element method can be based on the variational principle employing bilinear functional and adjoint formulation. This principle is extended to matrix vector coupling systems such as in penetration dynamics. The present hyperbolic type partial differential equation of interest has two dependent and two independent variables with the coupling in the spatial domain. |                       |                                                                                                                       |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

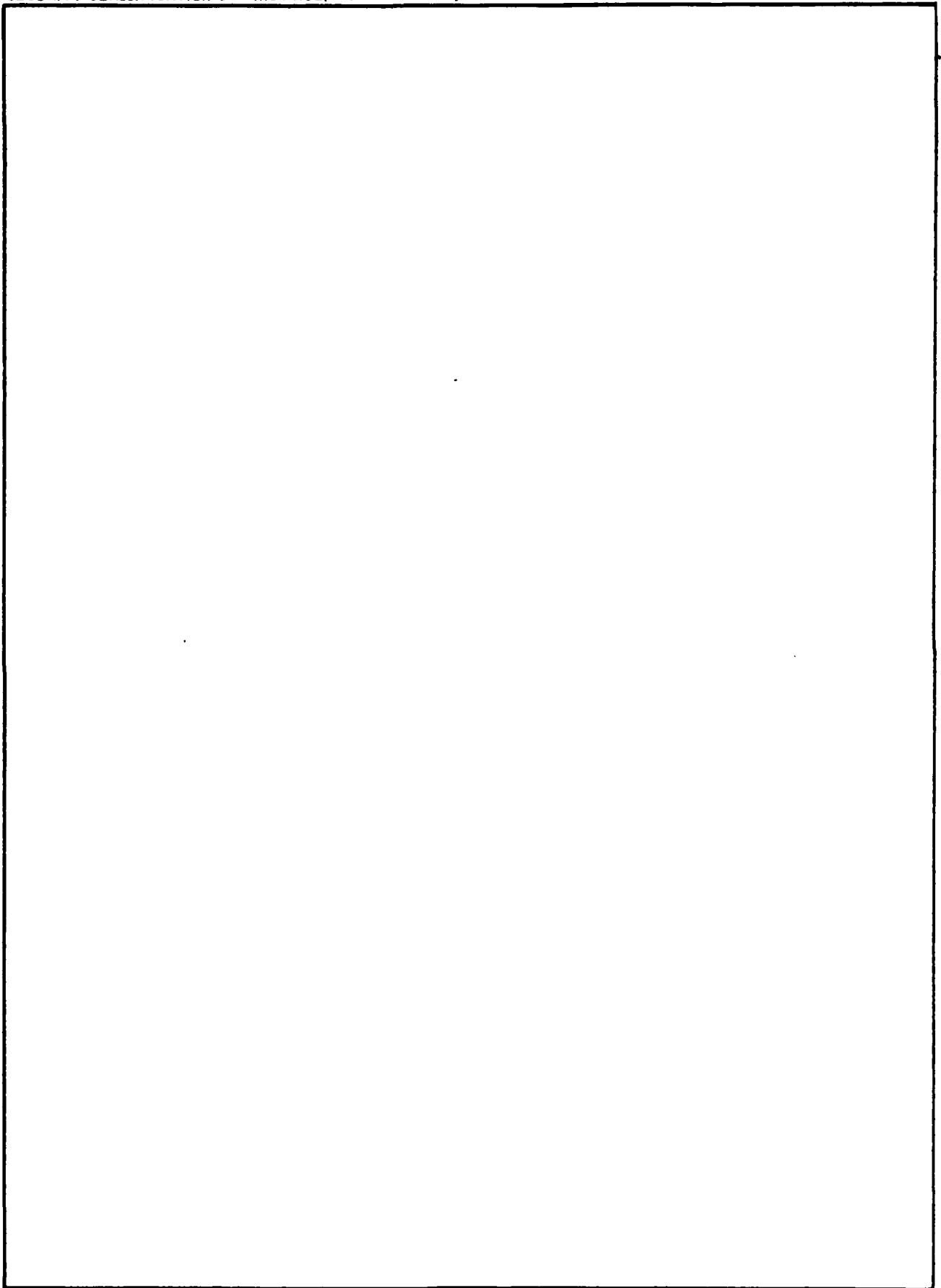


| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85022                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>RECURSIVE GRADIENT ESTIMATION USING SPLINES FOR<br>NAVIGATION OF AUTONOMOUS VEHICLES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>C. N. Shen                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.01.91A0.011<br>PRON No. 1A425M511A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 12. REPORT DATE<br>July 1985                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 13. NUMBER OF PAGES<br>38                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at Second Army Conference on Applied Mathematics and Computing,<br>Rensselaer Polytechnic Institute, Troy, NY, 22-24 May 1984.<br>Published in Conference Proceedings.                                                                                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Terrain Slope Estimation<br>Autonomous Vehicle Navigation<br>Two-Dimensional Recursive Smoothing<br>Polynomial Splines<br>Laser Range Matrix                                                                                                                                                                                                                                                                                                                                                                     |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Terrain gradient estimation is needed for navigation of an autonomous vehicle<br>in climbing the hills. The in-path and cross-path terrain slopes are estimated<br>from the set of corresponding range slopes. A two-dimensional recursive<br>smoothing algorithm using polynomial splines in the third dimension is<br>developed for this purpose. Approximations are introduced in the sub-optimal<br>system so that the computation time increases only linearly with the size of<br>the two-dimensional data. |                       |                                                                                                                       |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



| REPORT DOCUMENTATION PAGE                                                                                                                                                                      |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-SP-85023                                                                                                                                                             | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                  |
| 4. TITLE (and Subtitle)<br>INDEX TO BENET WEAPONS LABORATORY (LCWSL)<br>TECHNICAL REPORTS - 1984                                                                                               |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                    |
|                                                                                                                                                                                                |                       | 6. PERFORMING ORG. REPORT NUMBER                               |
| 7. AUTHOR(s)<br>R. D. Neifeld                                                                                                                                                                  |                       | 8. CONTRACT OR GRANT NUMBER(s)                                 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                           |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                   |                       | 12. REPORT DATE<br>July 1985                                   |
|                                                                                                                                                                                                |                       | 13. NUMBER OF PAGES<br>105                                     |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                    |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED           |
|                                                                                                                                                                                                |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                  |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for public release; distribution unlimited.                                                                                            |                       |                                                                |
| 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)<br>Benet Weapons Laboratory<br>Technical Publications<br>Bibliography<br>Abstracts<br>Document Control Data |                       |                                                                |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This is a compilation of Benet Weapons Laboratory technical reports<br>published during 1984.             |                       |                                                                |





## 20. ABSTRACT (CONT'D)

parameter node. After a simulated round is fired, and during the four idle minutes, an energy balance is made between all nodes. Energy transfer by radiation and convection is considered. The rise in the temperature of each node is calculated from the energy absorbed. Numerical results obtained from the computer program show that unacceptable temperatures will be reached in the recoil mechanism unless forced-convection heat transfer cooling is used. A mechanical scheme for incorporating forced-convection cooling is suggested and predicted temperatures are presented.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85025                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>THE DENSIFICATION OF MOLYBDENUM AND MOLYBDENUM<br>ALLOY POWDERS USING HOT ISOSTATIC PRESSING                                                                                                                                                                                                                                                                                                                                              |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>J. Barranco, I. Ahmad, S. Isserow, and R.<br>Warenchak (See reverse)                                                                                                                                                                                                                                                                                                                                                                                 |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6910.00.H840.021<br>PRON No. 1A2279141A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                         |                       | 12. REPORT DATE<br>August 1985                                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 13. NUMBER OF PAGES<br>59                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at TMS-AIME Fall Meeting, Detroit, Michigan, 16-20 September 1984.                                                                                                                                                                                                                                                                                                                                                          |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Powder Metallurgy<br>Molybdenum Alloys<br>Hot Isostatic Pressing<br>Mechanical Properties                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This study was conducted to determine a superior erosion resistant gun barrel<br>liner material with improved properties at higher temperatures. Four<br>categories of powders were examined:<br><br>1. TZM spherical containing 0.5 titanium, 0.08 zirconium, and 0.02 carbon<br>(wt. % nominally), balance molybdenum (Mo), produced by REP ((Rotating<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 7. AUTHORS (CONT'D)

Saul Isserow  
Army Materials and Mechanics Research Center  
Watertown, MA 02172

## 20. ABSTRACT (CONT'D)

Electrode Process), PREP (Plasma Rotating Electrode Process), and PMRS (Plasma Melted and Rapidly Solidified);

2. Mo reduced 2 and 5  $\mu\text{m}$ ;
3. Mo-0.1% cobalt, co-reduced;
4. Mo-5 wt. % alumina ( $\text{Al}_2\text{O}_3$ ), dispersion strengthened.

Hot Isostatic Pressing (HIP) densification occurred at 15-30 Ksi, 1300-1600°C, for 1.5 to 3.0 hours. The TZM REP/PREP powders (220/74  $\mu\text{m}$ ) were not fully densified even at 1600°C, 30 Ksi, 3 hours. Point particle contact prevented complete void elimination. TZM PMRS powder (24.7  $\mu\text{m}$ ) achieved 99 percent of theoretical density while maintaining a small grain size (10.4 ASTM eq.) Bend deflection and fracture energies were approximately three times those for PREP powder at a bend rupture strength of about 120 Ksi. Mo reduced and Mo-0.1% Co powders showed less (or the same) ductility with increasing HIP temperatures. Fractures were intergranular with decreased bend rupture and compression strength. The Mo-5 $\text{Al}_2\text{O}_3$  powder maintained a fine grain size (13 ASTM eq.), but with fracture energies usually less than 0.6 in.-lbs. Included are results from bending and compression testing with metallographic and fracture mode interpretation.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85026                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                     |
| 4. TITLE (and Subtitle)<br>TERRAIN SCENE ANALYSIS AND OBSTACLE<br>RECONSTRUCTION FOR NAVIGATION OF MOBILE ROBOTS                                                                                                                                                                                                                                                                                                                                                                          |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                  |
| 7. AUTHOR(s)<br>C. N. Shen (See Reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                    |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                      |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.01.91A1A<br>PRON NO. 1A425M51A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                              |                       | 12. REPORT DATE                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 13. NUMBER OF PAGES                                                                                               |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                     |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                   |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                |                       |                                                                                                                   |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at the Conference on Intelligent Systems and Machines, Oakland<br>University, Rochester, MI, 24-25 April, 1984.                                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                   |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Terrain Scene Analysis<br>Object Reconstruction<br>Robot Navigation<br>Surface Slopes<br>Three-Dimensional Space Curves                                                                                                                                                                                                                                                                             |                       |                                                                                                                   |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>For a robot to be able to perform a task in a dynamic worksce, it must be<br>able to identify the objects in the scene. To achieve this objective, a form<br>of sight must be provided. The first stage in achieving sight is the<br>collection of visual input data. This input is in the form of depth<br>information, such as that received from a laser range finder.<br><br>(CONT'D ON REVERSE) |                       |                                                                                                                   |

## 7. AUTHOR (CONT'D)

C. N. Shen  
Armament Research & Development Center  
Large Caliber Weapon Systems Laboratory  
Benet Weapons Laboratory  
Watervliet, NY 12189-5000  
and  
Professor, Electrical, Computer, and Systems Engineering  
Rensselaer Polytechnic Institute  
Troy, NY 12181

## 20. ABSTRACT (CONT'D)

The laser range finder for a mobile robot is mounted on a mast from which a noisy measurement matrix is generated. This range matrix has a grid with azimuth angles as its abscissa and elevation angles as its ordinates. With these noisy measurements, a rapid estimation scheme is used to detect the presence of horizontal and vertical edges on a terrain by processing the range data successively along each column and row of the range matrix. Map points in a three-dimensional space are generated by estimating sudden change in the range and range slopes using detection scheme with a decision tree. The result of the estimation is a collection of data points to form a curve in space that belongs to some edge of an obstacle from the vantage point where the laser range finder is located. The orthogonal surface slopes of an obstacle can be determined from the range slopes which are estimated from the range matrix. The segmentation of range data on the basis of surface slopes provides groups of connected data points that belong to one particular face of some observed obstacles. The problem of grouping range data points of different planar surfaces on the basis of their surface slopes becomes an application of clustering analysis.

A data clustering and surface fitting operation must be performed and the location of edges and vertices must be determined. Objects are then assembled from these surfaces, edges, and vertices. There are no a priori knowledge of the number of objects in the worksce, however, it is assumed that all the objects in the scene can be approximated modeled as having many planar surfaces. Limitations of a sight system depend on the form of input data used. Systems such as laser range finder systems, which use range information directly, cannot determine edges between objects which are in close alignment. Clearly none of these input data styles can determine the scene description perfectly; therefore, any object recognition scheme would strive for consistency.

The first approach of a heuristic scheme for object reconstruction and formation is presented here based on input data containing depth information. This scheme will reconstruct plane faceted objects from a worksce described as edges, faces, and vertices in cartesian coordinates. The set of heuristic rules is based on geometric considerations and insight into the characteristics of objects, which are found to be the convexity and colinearity of edges. Methods for determining if an edge is convex or concave and if two edges are colinear are developed. These methods are consistent, regardless of the viewer's point of observation. If parts of the image of the worksce in the input information exhibit certain properties, then these parts will be grouped as an object.

Unclassified

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|---------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85027                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                       |
| 4. TITLE (and Subtitle)<br>DEFLECTION IN TAPERED CANTILEVER BEAMS<br>DEFLECTION (GAP OPENING) IN DOUBLE CANTILEVER<br>TYPE FRACTURE TOUGHNESS SPECIMENS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                    |
| 7. AUTHOR(s)<br>Boaz Avitzur                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 7280.12.12.000<br>PRON No. 1A423M891A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 12. REPORT DATE<br>August 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 13. NUMBER OF PAGES<br>38                                                                                           |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                       |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                     |
| 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)<br>Gap Opening<br>Fracture Toughness<br>Tapered Beam                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                     |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>When an otherwise homogeneous material under stress contains small defects (i.e., internal cracks and/or voids), the stresses at parts of the material-defect interface significantly exceed the ones anticipated at that location in the absence of such irregularities. Consequently, a structural member, otherwise calculated to safely sustain the applied loads, might unpredictably fail. That branch of engineering which intends to account for such 'stress-raisers' is known as fracture mechanics. Fracture mechanics studies have found that<br>(CONT'D ON REVERSE) |                       |                                                                                                                     |

## 20. ABSTRACT (CONT'D)

different materials (and even the same material when loaded in different orientations) reflect different sensitivity to such 'stress-raisers'--a material property known as fracture toughness. Test samples and testing procedures have been devised in order to quantify this material property. The relation between the applied load and its displacement (or gap opening) at the point of crack growth is being used herein to determine (compute) material fracture toughness.

While the equations derived for the stress field near the edge of a defect in an otherwise uniform field assume an infinite volume of material to surround the (relatively) very small defect, the crack to width and/or height in these laboratory size testing samples is definitely a finite one. This report offers a mathematical relation between the applied load and that part of the deflection (gap opening) which is due to the cantilever-like part of the sample, for that class of fracture toughness test specimens which can be described as double cantilever. A beam theory approach is used.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85028                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                        |
| 4. TITLE (and Subtitle)<br>A LOCAL REFINEMENT FINITE ELEMENT METHOD FOR<br>TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATIONS                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                     |
| 7. AUTHOR(s)<br>Joseph E. Flaherty and Peter K. Moore<br>(See Reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                       |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.01.91A0.011<br>PRON NO. 1A425M51A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 12. REPORT DATE<br>August 1985                                                                                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 13. NUMBER OF PAGES<br>17                                                                                            |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                        |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                      |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                                                      |
| 18. SUPPLEMENTARY NOTES Presented at the Second Conference on Applied Math and<br>Computing, 22-25 May 1984, RPI, Troy, New York.                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                      |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Finite Element Method<br>Partial Differential Equations<br>Space-Time Elements<br>Local Refinement<br>Adaptive Methods                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                      |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>We discuss an adaptive local refinement finite element method for solving<br>initial-boundary value problems for vector systems of partial differential<br>equations in one space dimension and time. The method uses piecewise bilinear<br>rectangular space-time finite elements. For each time step, grids are<br>automatically added to regions where the local discretization error is<br>estimated as being larger than a prescribed tolerance. We discuss several<br>(CONT'D ON REVERSE) |                       |                                                                                                                      |

7. AUTHORS (CONT'D)

Joseph E. Flaherty  
Armament Research and Development Center  
Large Caliber Weapon Systems Laboratory  
Watervliet, NY 12189-5000  
and  
Department of Computer Science  
Rensselaer Polytechnic Institute  
Troy, NY 12181

Peter K. Moore  
Department of Mathematical Sciences  
Rensselaer Polytechnic Institute  
Troy, NY 12181

20. ABSTRACT (CONT'D)

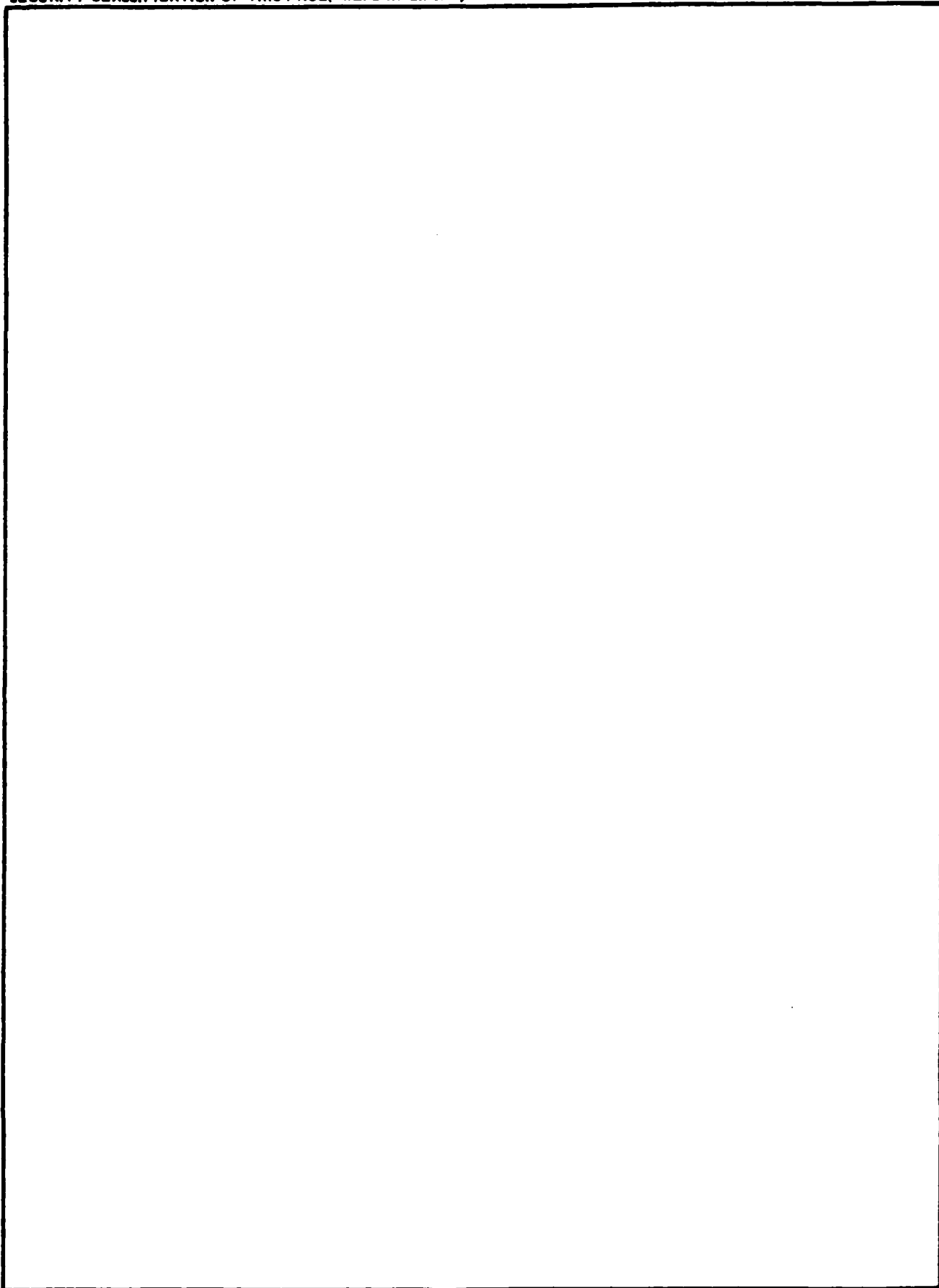
aspects of our algorithm, including the tree structure that is used to represent the finite element solution and grids, an error estimation technique, and initial and boundary conditions at coarse-fine mesh interfaces. We also present computational results for a simple linear hyperbolic problem, a problem involving Burgers' equation, and a model combustion problem.



20. ABSTRACT (CONT'D)

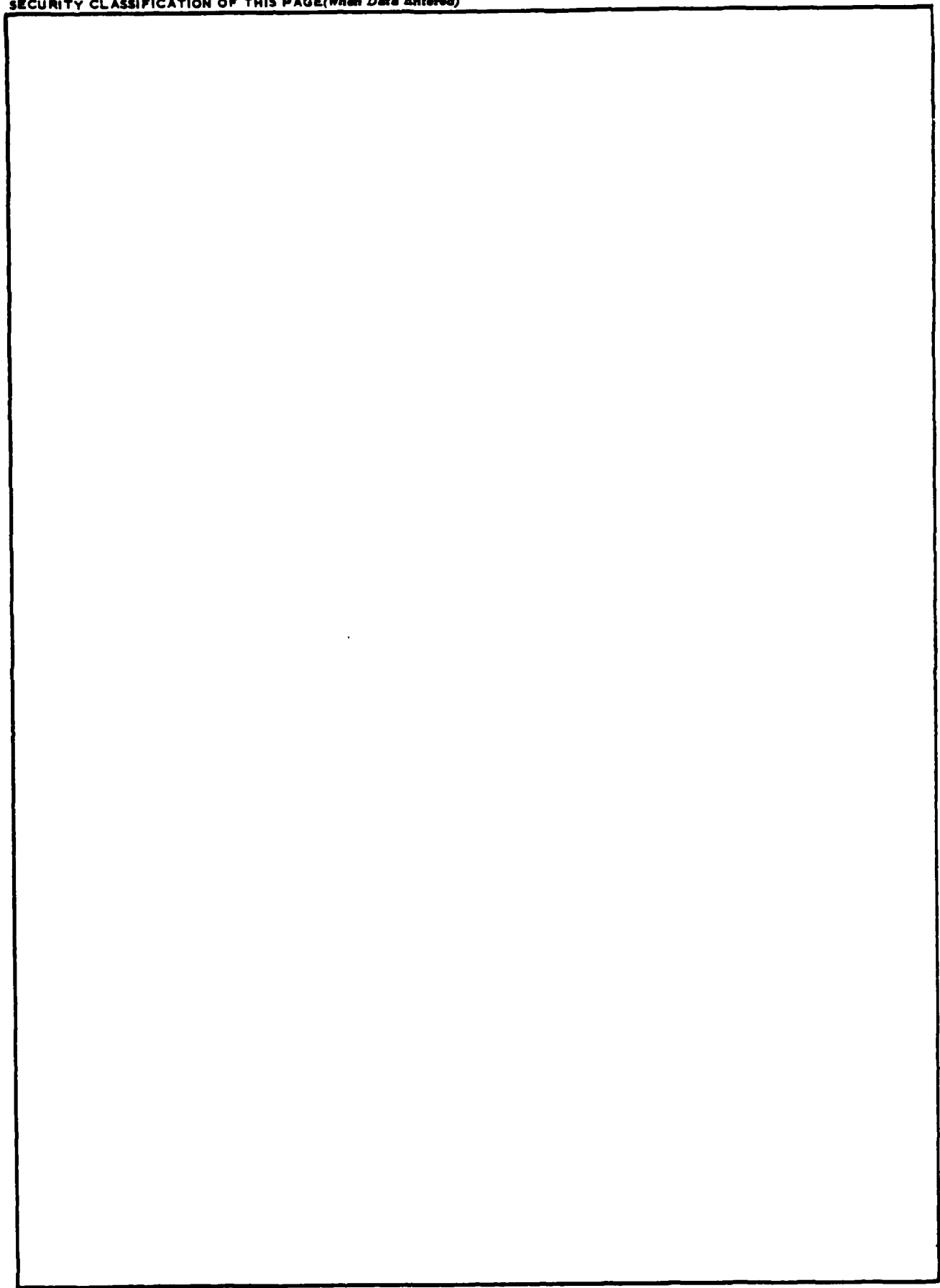
conditions: using a large ball size and a fixed ratio of indentation depth to ball size; ignoring initial ball contact; accounting for directional material properties; accounting for extraneous system deflections.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                     |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85030                                                                                                                                                                                                                                                                                                            | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                                                 |
| 4. TITLE (and Subtitle)<br>Machinability Data Bases for MetalCutting                                                                                                                                                                                                                                                                          |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                                                   |
|                                                                                                                                                                                                                                                                                                                                               |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                                              |
| 7. AUTHOR(s)<br>Major Walter W. Olson                                                                                                                                                                                                                                                                                                         |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                                                |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research and Development Center<br>Benet Weapons Laboratory, DRSMC-LCB-TL<br>Watervliet, NY 12189 - 5000                                                                                                                                                                      |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 665808-E860035<br>DA Project 6837724<br>PRON No. M7-3-F1900-M7-1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research and Development Center<br>Large Caliber Weapon System Laboratory<br>Dover, New Jersey 07801-5001                                                                                                                                                                         |                       | 12. REPORT DATE<br>September 1985                                                                                                             |
|                                                                                                                                                                                                                                                                                                                                               |                       | 13. NUMBER OF PAGES<br>26                                                                                                                     |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                   |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                                          |
|                                                                                                                                                                                                                                                                                                                                               |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                                                 |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                            |                       |                                                                                                                                               |
| 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)<br>Machinability<br>Material properties for machining<br>Tool wear<br>Data Base Structures                                                                                                                                                                 |                       |                                                                                                                                               |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Machinability data bases are discussed with respect to content, form and methods. Machinability data is needed to implement the factory of the future. Therefore, data sources and current formulas are featured in addition to formation of structures. |                       |                                                                                                                                               |



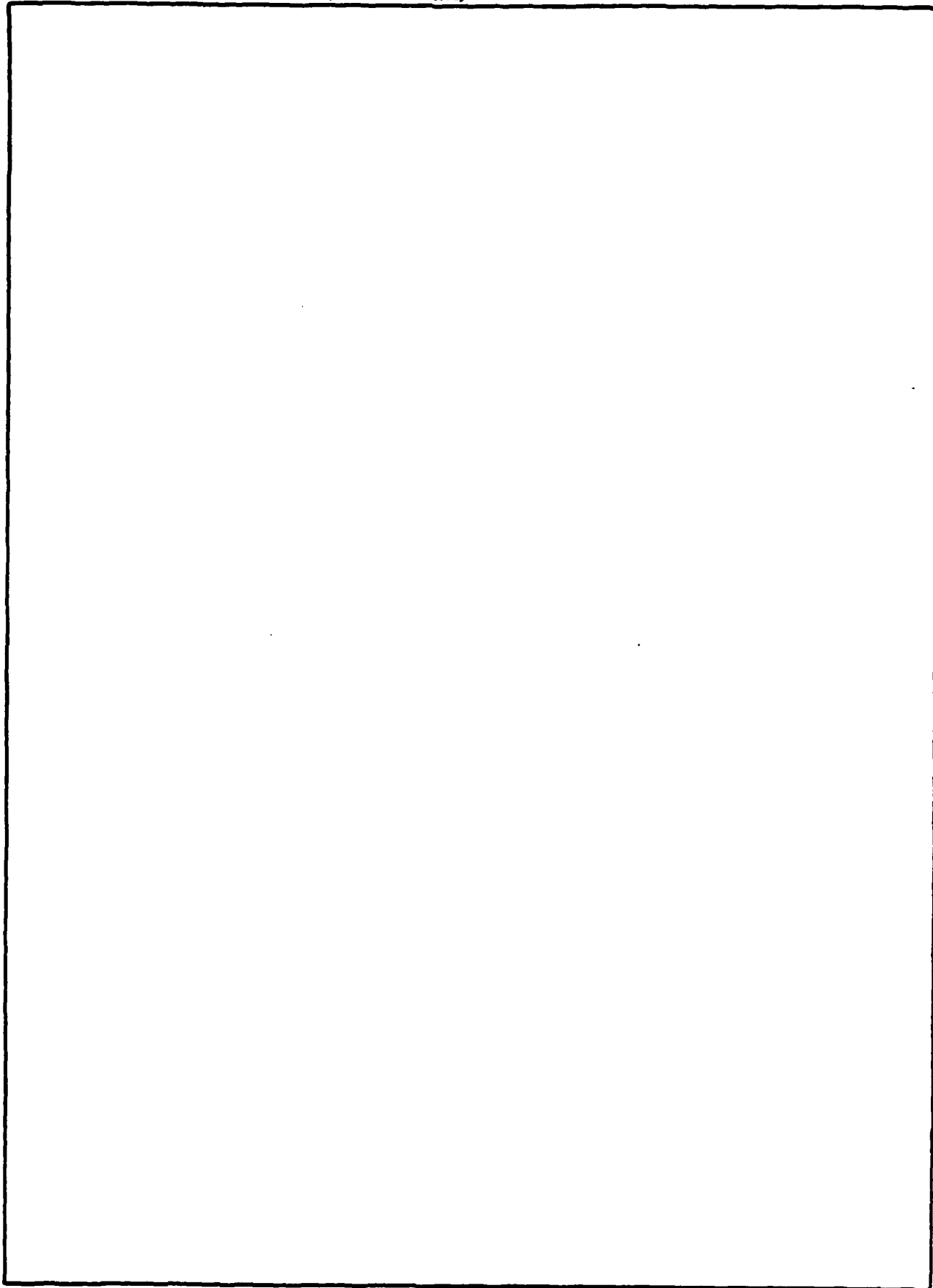
| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-MR-85031                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>FATIGUE TESTS OF TWO 105 MM L119 BRITISH LIGHT<br>GUN BREECH RINGS AND BREECH BLOCKS                                                                                                                                                                                                                                                                                                                                                                                                |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
| 7. AUTHOR(s)<br>R. R. Lasselle                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                           |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6446.31.2860.012<br>PRON No. 1A425M921A1A |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 12. REPORT DATE<br>September 1985                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 13. NUMBER OF PAGES<br>17                                                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Distribution limited to US Government Agencies only because of test and<br>evaluation; September 1985. Other requests for this document must be referred<br>to Commander, US Army Armament Research and Development Center, ATTN: Benet<br>Weapons Laboratory, SMCAR-LCB-RA, Watervliet, NY 12189.                                                                                                                                                              |                       |                                                                                                                       |
| 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)<br>Cannon<br>Breech<br>Breech Ring<br>Fatigue Test<br>Dynamic Test                                                                                                                                                                                                                                                                                                                                                          |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Fatigue tests of two breech rings and breech blocks of the 105 mm L119 British<br>Light Gun (BLG) are described. The tests were run at 60,000 psi with failures<br>occurring in the jaws of the two breech rings at 9,919 and 14,480 test cycles.<br>Before the laboratory tests, the breeches had been fired 617 rounds and 666<br>rounds, respectively. A description of the test method is included in this<br>report. |                       |                                                                                                                       |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                        |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85032                                                                                                                                                                                                                                                                                                                                                                                                                                         | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                      |
| 4. TITLE (and Subtitle)<br>ELASTIC-PLASTIC LOADING AND UNLOADING IN A THICK TUBE WITH KINEMATIC HARDENING THEORY                                                                                                                                                                                                                                                                                                                                                           |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                        |
| 7. AUTHOR(s)<br>Peter C. T. Chen                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                   |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                       |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                     |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                               |                       | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A52F51D1A1A |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                |                       | 12. REPORT DATE<br>September 1985                                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 13. NUMBER OF PAGES<br>17                                                                                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                    |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                 |                       |                                                                                                                    |
| 18. SUPPLEMENTARY NOTES<br>Presented at the Third Army Conference on Applied Mathematics and Computing, Georgia Institute of Technology, Atlanta, Georgia, 13-16 May 1985.<br>Published in Conference Proceedings.                                                                                                                                                                                                                                                         |                       |                                                                                                                    |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Thick Tube Kinematic Hardening<br>Residual Stress Bauschinger Effect<br>Elastic-Plastic Reverse Yielding                                                                                                                                                                                                                                                                             |                       |                                                                                                                    |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Using Tresca's yield criterion, its associated flow rule, and the linear hardening law, analytical solutions have been obtained for elastic-plastic loading and unloading problems in a thick tube subjected to uniform internal pressure. Explicit expressions for the displacement, strains, and stresses are presented herein, along with numerical results for a closed-end tube. |                       |                                                                                                                    |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)





20. ABSTRACT (CONT'D)

the base metal occurs due to undermining of the hot propellant gases leading to early condemnation of the gun tube.

An electrochemical deburring technique for rounding off the sharp corners prior to plating has been established and is reported here. Design of a special apparatus and a procedure for its use are described in detail.

Also included are the specifications for the material and equipment, with instructions to construct the apparatus and associated tooling which make up the work kit to deburr the holes.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARL/CB-TR-85034                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>CRACK GROWTH BEHAVIOR OF ALUMINUM ALLOYS<br>TESTED IN LIQUID MERCURY                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>J. A. Kapp, D. J. Duquette (see reverse), and<br>M. H. Kamdar                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A425M541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 12. REPORT DATE<br>September 1985                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 13. NUMBER OF PAGES<br>32                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br><br>Presented at ASME Symposium on Crack Growth Behavior of Material Susceptible<br>to Stress Corrosion, New Orleans, LA, December 1984.<br>Submitted to <u>ASME Journal of Engineering Materials and Technology</u> .                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br><br>Fracture Mechanics<br>Liquid Metal Embrittlement<br>Aluminum Alloys<br>Mechanisms<br>Fracture                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br><br>Crack growth rate measurements have been made in three mercury embrittled<br>aluminum alloys each under three loading conditions. The alloys were 1100-0,<br>6061-T651, and 7075-T651. The loading conditions were fixed displacement<br>static loading, fixed load static loading, and fatigue loading at two<br>frequencies. The results showed that mercury cracking of aluminum was not<br>unlike other types of embrittlement (i.e. hydrogen cracking of steels). Under<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 7. AUTHORS (CONT'D)

D. J. Duquette  
Materials Engineering Department  
Rensselaer Polytechnic Institute  
Troy, NY 12181

## 20. ABSTRACT (CONT'D)

fixed load static conditions no crack growth was observed below a threshold stress intensity factor ( $K_{ILME}$ ). At  $K$  levels greater than  $K_{ILME}$  cracks grew on the order of cm/s, while under fixed displacement loading, the crack growth rate was strongly dependent upon the strength of the alloy tested. This was attributed to crack closure. In the fatigue tests, no enhanced crack growth occurred until a critical range of stress intensity factor ( $\Delta K_{th}$ ) was achieved. The  $\Delta K_{th}$  agreed well with the  $K_{ILME}$  obtained from the static tests, but the magnitude of the fatigue growth rate was substantially less than was expected based on the static loading results. Observations of the fracture surfaces in the scanning electron microscope (SEM) suggested a brittle intergranular fracture mode for the 6061-T651 and the 7075-T651 alloys under all loading conditions. The fractographic features of the 1100-0 alloy under fixed load and fatigue loading conditions were also brittle intergranular. Under fixed displacement loading the cracks grew via a ductile intergranular mode.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85035                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>PREDICTING CATASTROPHIC OUTSIDE DIAMETER<br>INITIATED FATIGUE FAILURE OF THICK-WALLED<br>CYLINDERS USING LOW CYCLE FATIGUE DATA                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>Joseph A. Kapp                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.02.H600.011<br>PRON NO. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 12. REPORT DATE<br>September 1985                                                                                     |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 13. NUMBER OF PAGES<br>13                                                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15. SECURITY CLASS. (of this report)<br>Unclassified                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; Distribution unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                       |                                                                                                                       |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       |                                                                                                                       |
| 18. SUPPLEMENTARY NOTES<br>Presented at the IX Airapt High Pressure Conference, 25-28 July 1983                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       |                                                                                                                       |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Thick-Walled Cylinders                      Residual Stress Effects<br>Fatigue                                          Predictive Methods<br>Autofrettage                                  Pressure Vessels                                                                                                                                                                                                                                                                                   |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>A procedure is presented to predict fatigue failure of thick-walled cylinders containing discontinuities at the outside diameter (OD). Both crack initiation life and crack growth are considered. The elastic-plastic strains at an OD discontinuity are estimated using elastic analysis and stress concentration factors. The strain estimates are then used in conjunction with low cycle fatigue data to determine the initiation life. Crack growth life is estimated (CONT'D ON REVERSE) |                       |                                                                                                                       |

20. ABSTRACT (CONT'D)

by integration of a power law relationship. The results obtained by using this analysis method compared to measured fatigue life data for several OD initiated failures in thick-walled cylinders agrees to within about ten percent.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85036                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>STRUCTURE OF ELECTRODEPOSITED CHROMIUM<br>ON GUN STEEL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>M. H. Kamdar and R. M. Fisher (see reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                       |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6910.00.H840.021<br>PRON No. 1A52G5FN1A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                               |                       | 12. REPORT DATE<br>September 1985                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 13. NUMBER OF PAGES<br>27                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       |                                                                                                                       |
| 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)<br>Chromium Plating                      Grain Size<br>Cracks                                      Metallography<br>Texture                                      High Voltage Microscopy                                                                                                                                                                                                                                                                                                                |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>Scanning and transmission electron microscope examination of electrodeposited chromium has revealed that plating conditions affect the size and orientation of the very fine individual crystallites. Plating at 55°C results in a bright, very hard, 1180 Knoop-hardness number (KHN), coating comprised of 0.1 µm diameter grains with a strong <111> fiber texture oriented perpendicular to the surface of the base metal. Plating at higher temperatures such as 85°C, or<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

7. AUTHORS (CONT'D)

R. M. Fisher  
U.S. Steel Corporation  
Research Laboratory  
Monroeville, PA 15146

20. ABSTRACT (CONT'D)

with a well-aged plating solution, produces a much softer deposit (600 KHN) composed of 1.5  $\mu$ m grains with a much less pronounced crystallographic texture. High tensile stresses and the resulting crack formation in the deposit appear to be due to the very large and aligned void space associated with the unequilibrated grain boundaries. Heating during firing or annealing results in one or two percent shrinkage of the chromium as the grain boundary void space is eliminated.

AD-A170 266

INDEX TO BENET WEAPONS LABORATORY (LCMSL) TECHNICAL  
REPORTS - 1985(U) ARMY ARMAMENT RESEARCH AND  
DEVELOPMENT CENTER WATERVLIET NY L. R D NEIFELD  
JUN 86 ARCCB-SP-86019

2/2

UNCLASSIFIED

F/G 3/2

NL





1.0



1.1



1.25

2.0  
2.2  
2.5  
2.8  
3.15  
3.6  
4.0  
4.5



1.4

2.8

3.15

3.6

4.0

4.5

2.5

2.2

2.0

1.8

1.6

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|--------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARLCB-TR-85037                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                      |
| 4. TITLE (and Subtitle)<br>ASSESSMENT OF J-R CURVES OBTAINED FROM<br>PRECRACKED CHARPY SAMPLES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                   |
| 7. AUTHOR(s)<br>J. A. Kapp and M. I. Jolles (see reverse)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                     |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-LCB-TL<br>Watervliet, NY 12189-5000                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS NO. 6111.H600.001<br>PRON NO. 1A325B541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Large Caliber Weapon Systems Laboratory<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 12. REPORT DATE<br>September 1985                                                                                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 13. NUMBER OF PAGES<br>20                                                                                          |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED                                                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                      |
| 16. DISTRIBUTION STATEMENT (of this Report)<br>Approved for Public Release; Distribution Unlimited                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       |                                                                                                                    |
| 17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                                                                    |
| 18. SUPPLEMENTARY NOTES<br>Presented at 17th National Fracture Mechanics Symposium, Albany, NY,<br>7-9 August 1984, and published in the Symposium proceedings.                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       |                                                                                                                    |
| 19. KEY WORDS (Continue on reverse side if necessary and identify by block number)<br>Fracture Testing<br>Precracked Charpy<br>J-Integral Testing<br>Estimated Crack Growth                                                                                                                                                                                                                                                                                                                                                                                                                            |                       |                                                                                                                    |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>J-R curves were determined for five materials (7075-T651; 2024-T351; HY130;<br>HY80; and A723, Class 1, Grade 4) using precracked Charpy samples and standard<br>size C(T) and SE(B) samples. Crack growth in the Charpy samples was estimated<br>using the "load drop" method of analysis of the load displacement trace, and<br>crack extension in the C(T) and SE(B) specimens was determined using the<br>electric potential method. The results show that physical crack extension in<br>(CONT'D ON REVERSE) |                       |                                                                                                                    |

## 7. AUTHORS (CONT'D)

M. I. Jolles  
Naval Research Laboratory  
Washington, D.C. 20375

## 20. ABSTRACT (CONT'D)

the larger sample was not well estimated by the Charpy sample results. However, if the crack extension is presented as relative crack growth (as a percentage of the uncracked ligament), the agreement between the two widely different specimen sizes is much better, although not exact. With the exception of the relatively brittle 7075-T651, the J corresponding to zero, one percent, and two percent crack growth was higher in the Charpy samples than in the larger samples. This was attributed to the inability of the "load drop" method to determine the exact location of the crack initiation. Although nonconservative, we believe the "load drop" method analysis of precracked Charpy data is adequate for quality control toughness testing provided that it is realized that  $J_{IC}$  and J-R curves may be overestimated slightly.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                          |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARCCB-TR-85001                                                                                                                                                                                                                                                                                                                                                                                       | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                        |
| 4. TITLE (and Subtitle)<br>MATERIAL PROPERTY AND FRACTURE TESTING OF 7075-T6 EXTRUDED ALUMINUM                                                                                                                                                                                                                                                                                                                           |                       | 5. TYPE OF REPORT & PERIOD COVERED<br><br>Final                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                     |
| 7. AUTHOR(s)<br>M. A. Scavullo, J. H. Underwood, J. A. Kapp, and J. J. Zalinka                                                                                                                                                                                                                                                                                                                                           |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                       |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-CCB-TL<br>Watervliet, NY 12189-4050                                                                                                                                                                                                                                                     |                       | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br><br>AMCMS No. 4111.16.2990.0<br>PRON No. 1A327F751A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Close Combat Armaments Center<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                       |                       | 12. REPORT DATE<br>November 1985                                                                                     |
|                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 13. NUMBER OF PAGES<br>21                                                                                            |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                              |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                             |
|                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE                                                                           |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                  |                       |                                                                                                                      |
| 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)<br>Aluminum                                          Fracture<br>7075-T6                                              Sabots<br>Extrusion                                           Kinetic Energy Projectiles<br>Material Properties                                                                                                 |                       |                                                                                                                      |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>The results of an experimental investigation into the material properties of 7075-T6 extruded aluminum used in the production of sabots for kinetic energy projectiles are presented. A comparison is made of two suppliers' materials, and a test is described that will show a difference exists in the two suppliers' materials. |                       |                                                                                                                      |

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)



18. SUPPLEMENTARY NOTES (CONT'D)

Presented at Electrodeposition Phenomena From Molten Salts Workshop, Imperial College of Science & Technology, London, England, 8-9 July 1985.

To be published in Proceedings of Electrodeposition Workshop.

Submitted to Journal of Electrochemical Society.

20. ABSTRACT (CONT'D)

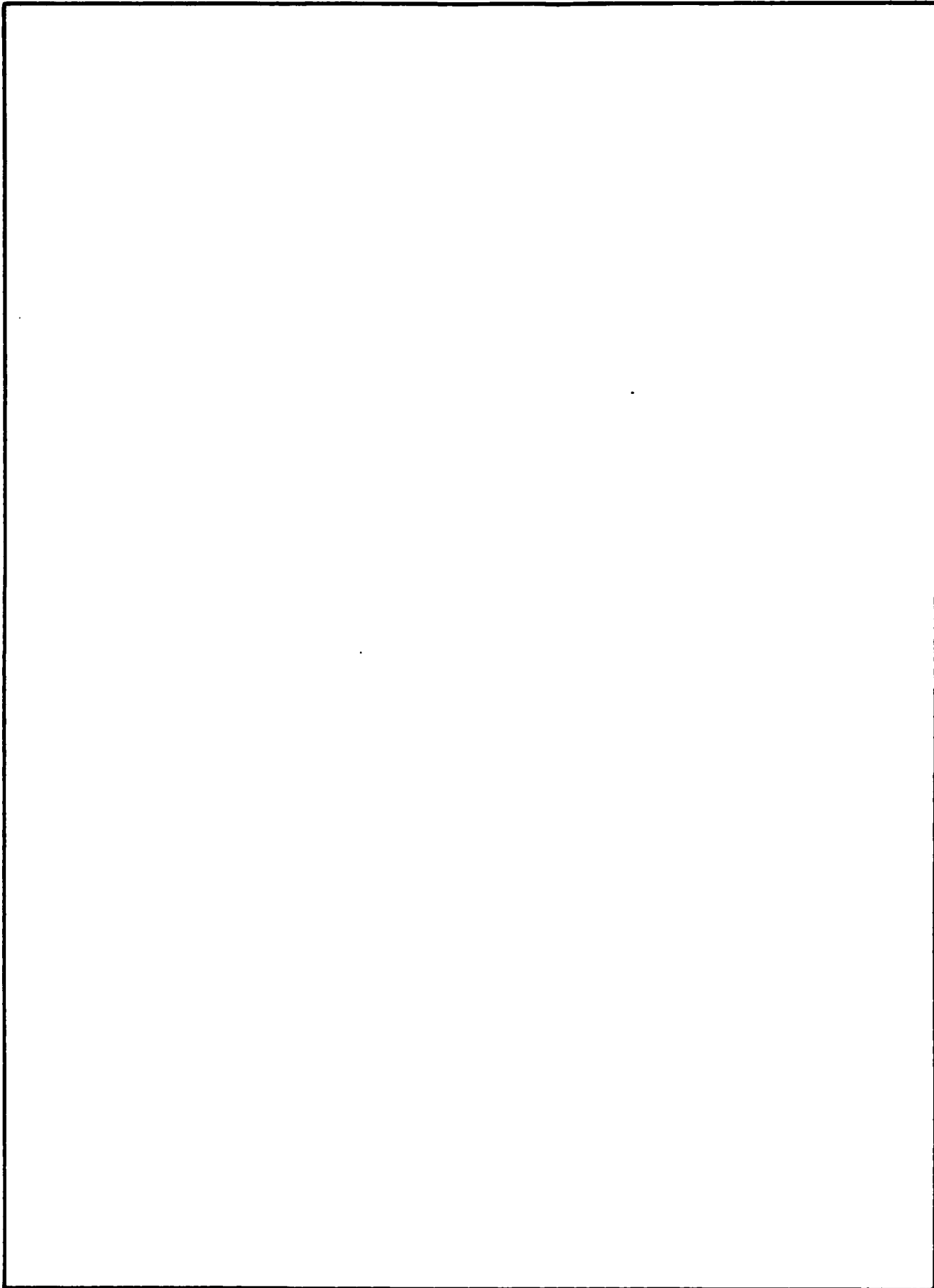
The laminated plating experiments were conducted at LC/HC solution temperatures of 85 and 55°C, current densities of 120 and 45 A/dm<sup>2</sup>, and at LC/HC duty cycles to produce spacings between 0.01 and 2.7 μm. Under these plating conditions, deposits with hardness values between 655 and 1089 KHN and tensile strengths between 6.8 and 57.2 were obtained.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                                                                           |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARCCB-TR-85003                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                                                                         |
| 4. TITLE (and Subtitle)<br>COMPUTER MODEL FOR THE SOLIDIFICATION OF<br>COMPOSITION B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                                                                           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 6. PERFORMING ORG. REPORT NUMBER                                                                                      |
| 7. AUTHOR(s)<br>John D. Vasilakis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                       | 8. CONTRACT OR GRANT NUMBER(s)                                                                                        |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-CCB-TL<br>Watervliet, NY 12189-4050                                                                                                                                                                                                                                                                                                                                                                                                                 |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS<br>AMCMS No. 6111.02.H600.011<br>PRON No. 1A425M541A1A |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Close Combat Armaments Center<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                                                                                                                   |                       | 12. REPORT DATE<br>December 1985                                                                                      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 13. NUMBER OF PAGES<br>34                                                                                             |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                       | 15. SECURITY CLASS. (of this report)<br><br>UNCLASSIFIED                                                              |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                                                                         |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                       |                                                                                                                       |
| 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)<br>Composition B<br>Solidification Model<br>Finite Element Analysis<br>Explosive Compound                                                                                                                                                                                                                                                                                                                                                                                                         |                       |                                                                                                                       |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>A computer model of an explosive compound, Composition B, solidifying in an M155 mm artillery shell is presented. Shells having been cast with the compound are frequently found with cracks seriously affecting their use. By developing a two-dimensional temperature-dependent model of the solidification process, it is hoped that some of the reasons for the crack initiation can be found. A general purpose finite element program, ADINAT, is used to evaluate<br>(CONT'D ON REVERSE) |                       |                                                                                                                       |

## 20. ABSTRACT (CONT'D)

the model. The properties of both the Composition B and steel shell are treated as functions of temperature, and the boundary conditions are considered to be functions of both temperature and time. While the crack initiation cannot be predicted, following the solidification front will give information towards understanding the process. The work will establish the transient temperature distributions and solidification front motions for the various boundary conditions used. An extension of this work, to be performed later, will consider the stresses in the solidifying shell and the residual stress state after solidification is complete.

| REPORT DOCUMENTATION PAGE                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                       | READ INSTRUCTIONS<br>BEFORE COMPLETING FORM                    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------------|
| 1. REPORT NUMBER<br>ARCCB-TR-85004                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 2. GOVT ACCESSION NO. | 3. RECIPIENT'S CATALOG NUMBER                                  |
| 4. TITLE (and Subtitle)<br>THERMAL SHUTDOWN SYSTEM FOR IBM 4341 COMPUTERS                                                                                                                                                                                                                                                                                                                                                                                                           |                       | 5. TYPE OF REPORT & PERIOD COVERED<br>Final                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 6. PERFORMING ORG. REPORT NUMBER                               |
| 7. AUTHOR(s)<br>Mark Johnson                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                       | 8. CONTRACT OR GRANT NUMBER(s)                                 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Benet Weapons Laboratory, SMCAR-CCB-TL<br>Watervliet, NY 12189-4050                                                                                                                                                                                                                                                                                                                |                       | 10. PROGRAM ELEMENT, PROJECT, TASK<br>AREA & WORK UNIT NUMBERS |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>US Army Armament Research & Development Center<br>Close Combat Armaments Center<br>Dover, NJ 07801-5001                                                                                                                                                                                                                                                                                                                                  |                       | 12. REPORT DATE<br>December 1985                               |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 13. NUMBER OF PAGES<br>11                                      |
| 14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)                                                                                                                                                                                                                                                                                                                                                                                                         |                       | 15. SECURITY CLASS. (of this report)<br>UNCLASSIFIED           |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                       | 15a. DECLASSIFICATION/DOWNGRADING<br>SCHEDULE                  |
| 16. DISTRIBUTION STATEMENT (of this Report)<br><br>Approved for public release; distribution unlimited.                                                                                                                                                                                                                                                                                                                                                                             |                       |                                                                |
| 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)<br>IBM 4341<br>Microprocessor<br>Shutdown<br>Temperature<br>Computer                                                                                                                                                                                                                                                                                                                             |                       |                                                                |
| 20. ABSTRACT (Continue on reverse side if necessary and identify by block number)<br>This report describes a thermal shutdown system designed to augment an IBM 4341 processor running the VM/CMS operating system. The microprocessor system monitors room temperature and alerts computer users to an impending shutdown when the temperature becomes too high. A user defined shutdown procedure is then executed prior to powering off the processor and all local peripherals. |                       |                                                                |



# TECHNICAL REPORT INTERNAL DISTRIBUTION LIST

|                                         | <u>NO. OF<br/>COPIES</u> |
|-----------------------------------------|--------------------------|
| CHIEF, DEVELOPMENT ENGINEERING BRANCH   |                          |
| ATTN: SMCAR-CCB-D                       | 1                        |
| -DA                                     | 1                        |
| -DP                                     | 1                        |
| -DR                                     | 1                        |
| -DS (SYSTEMS)                           | 1                        |
| -DC                                     | 1                        |
| -DM                                     | 1                        |
| CHIEF, ENGINEERING SUPPORT BRANCH       |                          |
| ATTN: SMCAR-CCB-S                       | 1                        |
| -SE                                     | 1                        |
| CHIEF, RESEARCH BRANCH                  |                          |
| ATTN: SMCAR-CCB-R                       | 2                        |
| -R (ELLEN FOGARTY)                      | 1                        |
| -RA                                     | 1                        |
| -RM                                     | 1                        |
| -RP                                     | 1                        |
| -RT                                     | 1                        |
| TECHNICAL LIBRARY                       | 5                        |
| ATTN: SMCAR-CCB-TL                      |                          |
| TECHNICAL PUBLICATIONS & EDITING UNIT   | 2                        |
| ATTN: SMCAR-CCB-TL                      |                          |
| DIRECTOR, OPERATIONS DIRECTORATE        | 1                        |
| DIRECTOR, PROCUREMENT DIRECTORATE       | 1                        |
| DIRECTOR, PRODUCT ASSURANCE DIRECTORATE | 1                        |

NOTE: PLEASE NOTIFY DIRECTOR, BENET WEAPONS LABORATORY, ATTN: SMCAR-CCB-TL,  
OF ANY ADDRESS CHANGES.

# TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST

|                                                                                                                                                                                                             | <u>NO. OF<br/>COPIES</u>             |                                                                                                                        | <u>NO. OF<br/>COPIES</u> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|------------------------------------------------------------------------------------------------------------------------|--------------------------|
| ASST SEC OF THE ARMY<br>RESEARCH & DEVELOPMENT<br>ATTN: DEP FOR SCI & TECH<br>THE PENTAGON<br>WASHINGTON, D.C. 20315                                                                                        | 1                                    | COMMANDER<br>US ARMY AMCCOM<br>ATTN: SMCAR-ESP-L<br>ROCK ISLAND, IL 61299                                              | 1                        |
| COMMANDER<br>DEFENSE TECHNICAL INFO CENTER<br>ATTN: DTIC-ODA<br>CAMERON STATION<br>ALEXANDRIA, VA 22314                                                                                                     | 12                                   | COMMANDER<br>ROCK ISLAND ARSENAL<br>ATTN: SMCRI-ENM (MAT SCI DIV)<br>ROCK ISLAND, IL 61299                             | 1                        |
| COMMANDER<br>US ARMY MAT DEV & READ COMD<br>ATTN: DRCDE-SG<br>5001 EISENHOWER AVE<br>ALEXANDRIA, VA 22333                                                                                                   | 1                                    | DIRECTOR<br>US ARMY INDUSTRIAL BASE ENG ACTV<br>ATTN: DRXIB-M<br>ROCK ISLAND, IL 61299                                 | 1                        |
| COMMANDER<br>ARMAMENT RES & DEV CTR<br>US ARMY AMCCOM<br>ATTN: SMCAR-FS<br>SMCAR-FSA<br>SMCAR-FSM<br>SMCAR-FSS<br>SMCAR-AEE<br>SMCAR-AES<br>SMCAR-AET-O (PLASTECH)<br>SMCAR-MSI (STINFO)<br>DOVER, NJ 07801 | 1<br>1<br>1<br>1<br>1<br>1<br>1<br>2 | COMMANDER<br>US ARMY TANK-AUTMV R&D COMD<br>ATTN: TECH LIB - DRSTA-TSL<br>WARREN, MI 48090                             | 1                        |
|                                                                                                                                                                                                             |                                      | COMMANDER<br>US ARMY TANK-AUTMV COMD<br>ATTN: DRSTA-RC<br>WARREN, MI 48090                                             | 1                        |
|                                                                                                                                                                                                             |                                      | COMMANDER<br>US MILITARY ACADEMY<br>ATTN: CHMN, MECH ENGR DEPT<br>WEST POINT, NY 10996                                 | 1                        |
| DIRECTOR<br>BALLISTICS RESEARCH LABORATORY<br>ATTN: AMXBR-TSB-S (STINFO)<br>ABERDEEN PROVING GROUND, MD 21005                                                                                               | 1                                    | US ARMY MISSILE COMD<br>REDSTONE SCIENTIFIC INFO CTR<br>ATTN: DOCUMENTS SECT, BLDG. 4484<br>REDSTONE ARSENAL, AL 35898 | 2                        |
| MATERIEL SYSTEMS ANALYSIS ACTV<br>ATTN: DRXSY-MP<br>ABERDEEN PROVING GROUND, MD 21005                                                                                                                       | 1                                    | COMMANDER<br>US ARMY FGN SCIENCE & TECH CTR<br>ATTN: DRXST-SD<br>220 7TH STREET, N.E.<br>CHARLOTTESVILLE, VA 22901     | 1                        |

NOTE: PLEASE NOTIFY COMMANDER, ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER, US ARMY AMCCOM, ATTN: BENET WEAPONS LABORATORY, SMCAR-CCB-TL, WATERVLIET, NY 12189-4050, OF ANY ADDRESS CHANGES.

# TECHNICAL REPORT EXTERNAL DISTRIBUTION LIST (CONT'D)

|                                  | <u>NO. OF<br/>COPIES</u> |                               | <u>NO. OF<br/>COPIES</u> |
|----------------------------------|--------------------------|-------------------------------|--------------------------|
| COMMANDER                        |                          | DIRECTOR                      |                          |
| US ARMY LABCOM                   |                          | US NAVAL RESEARCH LAB         |                          |
| MATERIALS TECHNOLOGY LAB         | 2                        | ATTN: DIR, MECH DIV           | 1                        |
| ATTN: SLCMT-IML                  |                          | CODE 26-27, (DOC LIB)         | 1                        |
| WATERTOWN, MA 01272              |                          | WASHINGTON, D.C. 20375        |                          |
| COMMANDER                        |                          | COMMANDER                     |                          |
| US ARMY RESEARCH OFFICE          |                          | AIR FORCE ARMAMENT LABORATORY |                          |
| ATTN: CHIEF, IPO                 | 1                        | ATTN: AFATL/DLJ               | 1                        |
| P.O. BOX 12211                   |                          | AFATL/DLJG                    | 1                        |
| RESEARCH TRIANGLE PARK, NC 27709 |                          | EGLIN AFB, FL 32542           |                          |
| COMMANDER                        |                          | METALS & CERAMICS INFO CTR    |                          |
| US ARMY HARRY DIAMOND LAB        |                          | BATTELLE COLUMBUS LAB         | 1                        |
| ATTN: TECH LIB                   | 1                        | 505 KING AVENUE               |                          |
| 2800 POWDER MILL ROAD            |                          | COLUMBUS, OH 43201            |                          |
| ADELPHIA, MD 20783               |                          |                               |                          |
| COMMANDER                        |                          |                               |                          |
| NAVAL SURFACE WEAPONS CTR        |                          |                               |                          |
| ATTN: TECHNICAL LIBRARY          | 1                        |                               |                          |
| CODE X212                        |                          |                               |                          |
| DAHLGREN, VA 22448               |                          |                               |                          |

NOTE: PLEASE NOTIFY COMMANDER, ARMAMENT RESEARCH, DEVELOPMENT, AND ENGINEERING CENTER, US ARMY AMCCOM, ATTN: BENET WEAPONS LABORATORY, SMCAR-CCB-TL, WATERVLIET, NY 12189-4050, OF ANY ADDRESS CHANGES.

END

DT/C

8-86