SPECIAL REPORT ARLCB-SP-80035

INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1979

R. D. Neifeld
Technical Publications and Editing Unit

September 1980

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

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-SP-80035	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1979		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. D. Neifeld		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TI		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE September 1980 13. NUMBER OF PAGES 91
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15e. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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)*

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

This is a compilation of technical reports published during 1979.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79001
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): INVESTIGATION OF THE ERRATIC PENETRATION PERFORMANCE OF THE 105MM M735 ROUND (U)

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
T. E. Davidson
E. Bloore
R. Hulbert
D. P. Kendall
T. Myhre
T. DeSisto

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS:
Commander, ARRADCOM
LCWSL (DRDAR-LC)
Dover, NJ 07801

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 4111.16.2978.6
PRON No. A1-7-29167

11. CONTROLLING OFFICE NAME AND ADDRESS:
Commander, ARRADCOM
Benet Weapons Laboratory (DRDAR-LCB-R)
Watervliet, NY 12189

12. REPORT DATE: May 1978

13. NUMBER OF PAGES: 63

14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office):

15. SECURITY CLASS. (of this report): CONFIDENTIAL

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE: Declassify on 31 May 1984

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U.S. Government Agencies only because of Test and Evaluation, May 1978. Other requests for this document must be referred to the Commander, ARRADCOM, Benet Weapons Laboratory (DRDAR-LCB-R), 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)

Kinetic Energy Munitions
Penetrator Materials

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

A study by a select committee to investigate the penetration performance of the 105mm M735 round. (U)

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79002	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* FEASIBILITY STUDY OF 105MM M68 COMPOSITE BORE EVACUATOR		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) G. D'Andrea R. Cullinan P. Croteau		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111019A0011 DA Proj No. 1L161101A91A PRON No. GG825567GGM7
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE April 1979 13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

Bore Evacuator
Composite Materials
Fiberglass
Filament Winding

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

The feasibility of fabricating a 105 MM M68 composite bore evacuator by the filament winding process has been demonstrated. Design and fabrication procedures for the manufacturing of this type of bore evacuator are presented in this report.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79003	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* Automatic Ultrasonic Detection and Measurement of Cracks in Cannon		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* D. C. Winters		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 32910673190 DA Project No. 6797319 PRON No. 1A827046GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapons Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE April 1979 13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

Presented at the 27th Defense Conference on Nondestructive Testing, Yuma, Arizona, Oct. 1978

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

Automatic
Cracks
End-On
Ultrasonic

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

ABSTRACT

The "end-on" ultrasonic crack measurement technique has been refined and perfected to provide reliable automatic sensing and read out of the maximum crack depth and its location for each crack encountered as the probe moves in

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

(Block No. 20 continued)

helical path down the cannon tube. A mechanical scanning machine has been constructed and tested which inspects full length 105 millimeter cannon. An ultrasonic flaw detector senses, measures and continuously reads out the distance from the outside surface to the crack tip or bore surface. Digital logic circuits evaluate successive measurements and determine the maximum crack depth reading. Encoders determine the location of each maximum crack depth reading. This data is transferred to a data acquisition system.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79004	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* DIAMAGNETIC ANOMALY IN PRESSURE QUENCHED CdS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. G. Homan D. P. Kendall		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600211 D.A. Project No. 1L1161102H60 PRON No. 1A924324GGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE May 1979 13. NUMBER OF PAGES 18
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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 Meeting of American Physical Society, 19-23 March '79, Chicago, IL.
To be published in Physical Review Letters

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

Diamagetism
Excitonic Solids
High Pressure
Magnetism
Phase Transitions

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

Compacted powder samples of CdS, pressure quenched at approximately 10^6 bars/sec at room temperature from pressure above the semiconducting to conducting transition pressure (about 40 kilobars) exhibit an ac diamagentic anomaly and an increase in electrical conductivity in the diamagnetic state at temperatures near 150K. These samples, as well as samples pressure quenched from lower pressures but above 10 kbars reveal a layered structure consisting of amorphous platelets in a compact powder matrix. Other changes in the physical properties of these samples are reported.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79005

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): ACOUSTIC VELOCITY RATIOS IN SOLID ARGON AT 75 K UP TO STATIC PRESSURES OF 150 KBAR

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
C. G. Homan
J. Frankel
D. P. Kendall
J. A. Barrett
T. E. Davidson

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 611102.H540011
D.A. Project No. 1L161102AH54
PRON No. M1-7-51700-01-M7-M7

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

12. REPORT DATE: May 1979

13. NUMBER OF PAGES: 12

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

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 6th AIRAPT International High Pressure Conference, July '77, Boulder, Colorado.
Published in High-Pressure Science and Technology, Vol. 1 (1979).

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

Argon
Ultrasonic Velocities
Pressure
Cryogenic

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

The ratio of longitudinal to shear ultrasonic velocities in solid Ar has been measured by an interferometric technique in a variably supported Bridgeman anvil device. Pressure was determined by the simultaneous measurement of the polymorphic phase transitions of a Bismuth sample imbedded in the Ar. The 75°K isotherm of the equation of state of Ar was calculated and is compared to earlier experimental results below 20 kbar and the 0°K EOS suggested by Anderson and Swenson to 100 kbar.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-79006
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: MAGNETIC MOMENT OF PRESSURE QUENCHED CADMIUM SULFIDE

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
C. G. Homan
R. K. MacCrone
D. P. Kendall

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 611102H600211
DA Project No. 1L1161102H60
PRON No. 1A924324GGGG

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

12. REPORT DATE: May 1979

13. NUMBER OF PAGES: 16

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*

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 Physics Colloquium at RPI, 18 April '79, Troy, NY.

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

Cadmium Sulfide
High Pressure
Magnetic Properties
Paramagnetism
Phase Transitions

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

Magnetic moment measurements of cadmium sulfide (CdS) polycrystalline samples, pressure quenched from above the semi-conducting to conducting transition pressure (40 kbars) at rates approaching 10^6 bars/sec, have been made in a vibrating sample magnetometer to fields approaching 1000 Oersted. The samples exhibit the complex magnetic behavior of low field diamagnetism ($\chi_V > -5 \times 10^{-5}$ cgs units) transforming at fields of several hundred Oersted

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Continued from Block 20

to positive magnetism ($\chi_v > 3x10^4$ cgs units). This magnetic behavior contrasts with unquenched samples which yield the normal diamagnetism of CdS ($\chi_v = -1.5x10^{-6}$ cgs units). These anomalous magnetic effects are observed at both RT and LN_2 temperatures at atmospheric pressure.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79007
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: COOPERATIVE PLANE STRAIN FRACTURE TOUGHNESS TESTS WITH C-SHAPED SPECIMENS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
J. H. Underwood
D. P. Kendall

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 5397.0M.6350
PRON No. A1-8-P5276-AW-1A

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

12. REPORT DATE: May 1979

13. NUMBER OF PAGES: 9

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*:
Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES:
Published in Journal of Testing and Evaluation.

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

Cooperative Tests	Strains
Fractures (Materials)	Test Method
Hollow Cylinder	Toughness

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

The results of a cooperative test program on plane strain fracture toughness (K_{Ic}) testing with C-shaped specimens are reported and discussed. Results of 48 tests by eight laboratories using specimens with two different loading hole locations are included. The effects of specimen geometric variables, such as eccentricity of the inner and outer surfaces and nonperpendicularity of these surfaces with the specimen faces, on the measured and calculated K_{Ic} are discussed. The C-shaped specimen results are compared with measured

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K_{Ic} values obtained with standard compact specimens. Results show that both versions of the C-shaped specimen yield accurate values of measured K_{Ic}. Normal geometric variations, as would be expected from machining of the specimen from an existing hollow cylinder, have no significant effect on the measured K_{Ic}.

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1. REPORT NUMBER: ARLCB-TR-79008	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: THE EQUIVALENCE OF K_{Ic} AND J_{Ic} FRACTURE-TOUGHNESS MEASUREMENTS IN NI-CR-MO STEELS	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): John H. Underwood	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB- TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102.H420011 DA Project No. 1L161102AH42 PRON No. GG-8-25791-GG-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801	12. REPORT DATE: May 1979 13. NUMBER OF PAGES: 10
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

Presented at 1977 SESA Spring Meeting, 15-20 May '77, Dallas, TX.
Published in Experimental Mechanics, Vol. 18, No. 9, September 1978.

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

Alloy Steel
Cannon Tube
Fracture Toughness
Test Methods
Ultrasonic Testing

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

Several series of fracture-toughness measurements were made in 4340 type steels, using both the standard K_{Ic} test method and the J_{Ic} test method described by Landes and Begley. K_{Ic} results and J_{Ic} results converted to K_{Ic} units are nearly identical for a given steel over a range of specimen size. The fracture toughness of steels produced by vacuum-degassing, remelt, and airmelt processes are compared over a range of yield stress. Simplified J_{Ic}

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test procedures are suggested for use with Ni-Cr-Mo steels within certain ranges of yield stress and specimen geometry.

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1. REPORT NUMBER ARLCB-MR-79009	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) APPLICATION OF RAPID HEAT TREATING TO CANNON TUBES		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. A. Thornton		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.7236 PRON No. M1-6-A1735-01-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon System Laboratory Dover, New Jersey 07801		12. REPORT DATE June 1979 13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to U.S. Army Armament Materiel Readiness Command in June 1978.

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

Heat Treatment
Austenite Transformation
Gun Tubes
Alloy Forgings

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

In order to demonstrate the feasibility of shortened heat treatment cycles for gun tubes, eight forgings (four 105mm M68 and four 155mm M185) were subjected to reduced austenitizing and tempering times. Austenitizing time was held to 30 minutes at temperature as measured by thermocouples. Quenching was accomplished by either vertical immersion, horizontal immersion or horizontal spray. The results showed that accepted mechanical properties

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could be attained with these shortened cycles. However, the shortened cycles must be established for a particular component with consideration for material variation, especially chemical segregation, which seriously affects transformation behavior. Nevertheless, in view of the present and future costs of firing heat treat furnaces and the potential increases in production capacity, reduced heating times can be highly significant.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-MR-79010	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ABRASIVE MACHINING OF MAJOR COMPONENTS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* John Rocd		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 3297.06.7408 PRON No. M1-4-A1530-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE May 1979 13. NUMBER OF PAGES 65
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15e. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T project to US Army Armament Materiel Readiness Command on 7 December 1977.

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

Abrasive Machining	Crush Form Grinding
Abrasive Surface Finishing	Cylindrical Surface Generation
Contour Grinding	Plunge Grinding

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

The term "abrasive machining" has been expressed in many ways. It is generally used to denote stock removal operations that are more economically performed by abrasive grinding methods than the more conventional means of turning or milling. The two largest fields for abrasive machining are the production of flat surfaces and form grinding from the solid. This report is concerned with the latter; grinding various complex external shapes from the solid forging, bar stock or hollow cylindrical items.

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1. REPORT NUMBER: ARLCB-MR-79011	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: GUN TUBE MANUFACTURE BY AUTOMATION	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)*: C. LaRoss	8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3297.06.7242, DA Project No. 6737242, PRON No. M1-3-23022-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: June 1979
	13. NUMBER OF PAGES: 24
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15e. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T report to the US Army Armament Materiel Readiness Command on 6 January 1978.

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

Line Flow
Tube Face Milling
Hollow Spindle Loading

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

This report describes three areas of the production line in manufacture of gun tubes that, with improvement, would be beneficial to gun tube manufacture by automation. The purpose of the project was to highlight and improve these areas to result in an improved gun tube manufacturing facility.

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1. REPORT NUMBER ARLCB-SP-79012	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* INDEX TO BENET WEAPONS LABORATORY (LCWSL) TECHNICAL REPORTS - 1978		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) B. Rahrer		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE June 1979 13. NUMBER OF PAGES 60
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

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

This is a compilation of technical reports published during 1978.

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1. REPORT NUMBER ARLCB-MR-79013	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A SHORT STUDY OF LARGE ROTARY FORGED CYLINDERS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) F. Heiser		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612603H181011 DA Proj No. 1L1626603AH18 PRON No. 1A924362GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE June 1979 13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

ESR Steel
Hollow ESR Steel
Rotary Forge
Vacuum Degassed Steel

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

The Integrated Forging Line was used to produce steel for the Advanced Breech Technology program. Cylinders were rotary forged from cast hollow ESR and from vacuum degassed steel. Anomalies in the data prompted a more detailed metallurgical study. The results are presented. Satisfactory properties were produced from the vacuum degassed steel. However, the very light forging reduction coupled with the very rapid and short austenitizing inherent in the Selas heat treatment system were inadequate to develop satisfactory properties

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in the cast ESR steel.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-MR-79014
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): APPLICATION OF ELECTRON BEAM WELDING TO HEAVY COMPONENTS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): V. Colangelo

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 3297.06.7480
DA Project No. 6747480
PRON No. M1-4-A1561-M7-M7

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

12. REPORT DATE: June 1979

13. NUMBER OF PAGES: 28

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T report to the US Army Armament Materiel Readiness Command on 6 January 1978.

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

Alloy Steels
Electron Beam Welding
Mechanical Properties
Steel Castings

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

The current investigation evaluates the mechanical properties and weld soundness of an electron beam welded casting which was substituted for a complex forging. The mechanical properties obtained were adequate, however, radiographic studies indicated considerable porosity in the welds which was not tolerable. This porosity was the result of the agglomeration of porosity on forged specimens of the same alloy and configuration. The study showed

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that weldments made from forged sub-sections could meet the mechanical property and soundness requirements.

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-MR-79015	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): EFFECTS OF PROCESSING VARIABLES ON EROSION OF GUN TUBES	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. Passmore	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 3297.06.7026, DA Project No. 6747026, PRON No. M1-4-A1532-M7-M7
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: June 1979
	13. NUMBER OF PAGES: 16
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Originally submitted as an MM&T report to the US Army Armament Materiel Readiness Command on 31 January 1978.

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

Erosion
Wear
Gun Steel
Thermal Conductivity
Gun Tubes

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

A reduction in silicon with an associate increase in molybdenum is known to increase the wear life of gun steel when fired under subscale firing conditions. However, when this same material is employed in a full scale firing test utilizing the 105mm M68 gun tube, the wear life of the tube, as measured at the origin of rifling (i.e. OR), remains the same regardless of silicon and molybdenum content. A few inches beyond the OR (27 inches from the rear face of the tube and beyond), the results of the full scale firing test agree with

Continued from Block 20

the results of the subscale firing tests, in that the low silicon steel exhibits a lower erosion rate than for a normal gun steel composition.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79016
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): PRELIMINARY ANALYSIS OF A MANDREL FOR 105MM GUN TUBE FORGINGS

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s)
M. A. Hussain
S. L. Pu
J. D. Vasilakis

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
AMCMS No. 3110.15.0003
PRON No. 32-6-P4941-01-M7-M7

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

12. REPORT DATE: June 1979

13. NUMBER OF PAGES: 36

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

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)

Crack Analysis
Fatigue Analysis
Radial Forge
Thermal Stress

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

A simplified stress analysis of a mandrel used in rotary forging of 105mm M68 gun tube forgings is presented. High tensile stress occurs at the inner bore during a fraction of a forging cycle when two hammers are engaged with the billet. The combination of the tensile stresses due to mechanical and thermal loading is responsible for the fracture of the mandrel.

Assuming a semi-circular crack initiated at the inner bore of the mandrel and propagated in the radial direction, the stress intensity factors are

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Continued from Block 20

computed based on the penny shaped crack under arbitrary loading. The remaining life of a mandrel having a semi-circular crack of 0.003 inch is predicted based on the most severe loading conditions and using the propagation equation for gun steel.

The effect of the reduction of the inner diameter of the mandrel on the mandrel life is studied. A four-fold life increase is predicted if the bore diameter is reduced from 1.969 to 1.4 inches. The effect of autofrettage is also studied. The mandrel life can be increased as much as 48 times if the mandrel is overstrained 50 percent.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-MR-79017	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: CORROSION PROTECTION OF 416 STAINLESS STEEL FIRING PROBES	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): S. Tauscher	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 728012.12000, PRON No. M7-79F-1726-M7-1A
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: July 1979
	13. NUMBER OF PAGES: 18
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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)*

Accelerated Test
416 Stainless Steel
Non-Metallic Coatings
Pitting Corrosion

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

The effectiveness of several protective coatings in resisting pitting corrosion on 416 stainless steel 152mm firing probes was investigated using an accelerated corrosion test. Test specimens with selected metallic and non-metallic coatings were immersed in ferric chloride and examined periodically for damage. This report concludes that on the basis of these tests, the non-metallic coatings investigated generally provided better resistance to corrosive attack than the metallic coatings investigated.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79018

2. GOVT ACCESSION NO.:

3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): RESULTS OF THE 1978 USAREUR STARGAGE SURVEY OF 105MM M68 GUN TUBES

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
R. Campolmi
B. Rowekamp

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 41111699896
PRON No. 1A-7-28319-GG-M7

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

12. REPORT DATE: June 1979

13. NUMBER OF PAGES: 25

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to US Government Agencies only because of test and evaluation; June 1979. Other requests for this document must be referred to Commander, ARRADCOM, ATTN: Benet Weapons Laboratory, DRDAR-LCB-DP, Watervliet Arsenal, 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)

Stargage Survey
Secondary Wear

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

Description of procedures, results and conclusions for secondary wear survey of 105mm M68 gun tubes (M60 Tank) with active US Army units in Germany.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79019	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): A COMPUTER PROGRAM AND APPROXIMATE SOLUTION FORMULATION FOR GUN MOTIONS ANALYSIS	5. TYPE OF REPORT & PERIOD COVERED
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): J. J. Wu	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111-01-91A0011, PRON No. 1A92ZA01NMLC
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: June 1979
	13. NUMBER OF PAGES: 31
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

To be published in an open literature journal.

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

Finite Element
Gun Barrel Motions
Gun Dynamics
Internal Ballistics

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

The purpose of this paper is to describe some of the features associated with a finite element computer program for approximate solutions of a gun dynamics problem. The lateral motion of a gun tube is modeled by an Euler-Bernoulli beam. The difficulties of the problem are due to various complicated loadings and support conditions which can be nonconservative, highly discontinuous and time dependent. The solution formulation for this generally non-self-adjoint problem has been presented in an earlier paper. In

Continued from Block 20

terms of finite element discretization, the two-dimensional shape function of spatial and time coordinates is chosen as a product of two one-dimensional shape functions; each for its respective coordinate and both being Hermitian polynomials. The generalized coordinates are then the displacement, slope, velocity and time derivatives of the slope at each node point. The correspondence between local and global generalized coordinates is described. The "stiffness matrices" of spatial and time-effect, contributed by the recoil force, pressure and curvature induced force and the moving mass of a projectile are derived. It is interesting to observe that the strong discontinuities associated with these forces disappear as a result of the smoothing effect of integration in spatial as well as in time coordinates. The present approach to deal with the moving support problem efficiently is also pointed out in this paper. Numerical results of a demonstrative problem are presented.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-MR-79020
2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): The Effect of Wall Thickness Variation of K_I for the Proposed C-Shaped Specimen.
5. TYPE OF REPORT & PERIOD COVERED
6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s): J. A. Kapp; G. A. Pflegl; J. H. Underwood
8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102.H420011; PRON. No. GG-8-25791-GG-M7

11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon System Laboratory, Dover, New Jersey 07801
12. REPORT DATE: August 1979
13. NUMBER OF PAGES: 8

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES

Reprinted from The International Journal of Fracture Vol. 13 (1977)

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

Calibration
Crack Propagation
Finite Elements
Fracture Mechanics
Fracture Properties
Toughness

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

Finite element stress intensity factor solutions have been developed for the C-shaped specimen to study the effect of wall thickness variation on K_I. Wall thickness variation arises when the inside and outside radii of the specimen are not concentric resulting in a specimen which is not symetric with respect to the plane of the crack. This nonsymentry causes shear stresses to develop on the plane of the crack which results in Mode II sliding in addition to the Mode I opening of the crach surfaces.

(Con't from block #20)

Three basic specimen geometries were studied: 1. A symetric specimen; 2. A specimen with $\pm$ 5% wall thickness variation; and, 3. A $\pm$ 10% wall thickness variation specimen. Each case was studied at three different crack depths for a total of nine solutions. All specimens have a radius ratio R_1/R_2 of .5; and a loading position of X/W of .5. The results show that there is virtually no difference between K_I for a nonsymetric specimen compared with a symetric specimen and that only negligable amounts of Mode II sliding develop with nonsymetry due to wall thickness variation.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79021
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): CALCULATED SHIFTS IN ELECTRONIC STATES FOR fcc HYDROGEN

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
D. M. Gray
A. M. Gray

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 611102H600211
D.A. Proj No. 1L1161102H60
PRON No. 1A924324GGGG

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

12. REPORT DATE: August 1979

13. NUMBER OF PAGES: 11

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report):

Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES:

Published in Physical Review B, Volume 19, Number 10, 15 May 1979.

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

Energy Shifts
fcc Hydrogen
Hydrostatic Compression
Modified-Plane-Wave Method
Perturbation Procedure

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

First-order shifts in electron energy levels at k_F and at high-symmetry points are claculated for hypothetical fcc hydrogen using a perturbation procedure in conjunction with the modified-plane-wave method. The shifts are calculated for hydrostatic, tetragonal, and trigonal strains. For hydrostatic compression the general trend is that levels $\lesssim E_F$ shift downward while levels $\gtrsim E_F$ shift upward; there is a general widening of the gap between first and second bands. For the shear cases the numerical results satisfy symmetry

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requirements where tested. For comparable strain parameter e the shifts at E_F under shear are considerably larger than in the hydrostatic case.

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79022	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ARMAMENT CONCEPTS STUDY FOR A NEW SELF-PROPELLED HOWITZER (SPH) - 155MM		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* J. K. Jorczak		8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612603.H1.80011 DA Project No. (SPEF) TA-10 PRON No. GG-8-25538-GG-M7
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE August 1979 13. NUMBER OF PAGES 35
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

Distribution limited to US Government Agencies only because of test and evaluation; August 1979. Other requests for this document must be referred to Commander, ARRADCOM, ATTN: Benet Weapons Laboratory, DRDAR-LCB-DS, Watervliet Arsenal, Watervliet, N. Y. 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)*

Cannon Auto Loader
Rotary Breech Block
Telescoped Round

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

Various ammunition and integral automatic loading cannon concepts for a new Self-Propelled Howitzer are described and discussed in this report. The intent of this preliminary report is to document various concepts which may be useful in future development of artillery test beds.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79023	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): GIANT MAGNETISM IN PRESSURE QUENCHED CADMIUM SULFIDE	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): R. K. MacCrone C. G. Homan	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600211 DA Project No. 1L1161102H60 PRON No. 1A932A03NMLC
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801	12. REPORT DATE: Sept 1979 13. NUMBER OF PAGES: 14
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED 15e. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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 International Conference on Amorphous Materials, Aug 79, RPI.
To be published in Solid State Communication.

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

Cadmium Sulfide
Paramagnetism
Pressure Quenched

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

Large positive magnetism (paramagnetism) is reported in poly-crystalline CdS samples pressure quenched from above the semiconducting-conducting phase transition. This positive magnetism reaches a maximum magnetization approaching four gauss at fields between five and twelve KOe.

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79024	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* A NUMERICAL COMPARISON BETWEEN TWO UNCONSTRAINED VARIATIONAL FORMULATIONS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. J. Wu T. E. Simkins		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.0191A011 PRON No. 1A924225GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon System Laboratory Dover, New Jersey 07801		12. REPORT DATE Sept 1979 13. NUMBER OF PAGES 30
14. MONITORING AGENCY NAME & ADDRESS*(If different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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 25th (Silver Jubilee) Conference of Army Mathematicians, 6-8 June 79, Johns Hopkins Univ. Baltimore, Maryland.
To be published in Journal of Applied Mechanics.

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

Approximation Methods
Finite Element
Initial Boundary Problems
Variational Methods

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

In an effort to relieve the often cumbersome burden of meeting the requirements on the end conditions and to unify the solution formulation for boundary- and initial-value problems, unconstrained variational statements have been introduced in conjunction with some approximate methods. In the case of a boundary value problem, it is shown in this paper that two different variational statements can be established: one is arrived at by the use of the

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LaGrange multipliers, the other by energy considerations. The numerical convergence of the solutions associated with finite element schemes using one of these two different variational statements is compared with that of the other. In the case of an initial value problem, both formulations can again be established when the adjoint field variable and the adjoint variational statement are introduced. The numerical data presented here indicate that while both methods generate excellent convergent results for the boundary value problem, the method of stiff springs yields results which show much better convergence for the initial value problem than those achieved by LaGrange multipliers.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79025
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE (and Subtitle): THERMO-ELASTIC-PLASTIC STRESSES IN HOLLOW CYLINDERS DUE TO QUENCHING

5. TYPE OF REPORT & PERIOD COVERED:

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s):
J. D. Vasilakis
P. C. T. Chen

8. CONTRACT OR GRANT NUMBER(s):

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
AMCMS No. 6111.01.91A0.0
DA Project No. 1L161101A91A
PRON No. 1A-9-2ZA01-Y

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

12. REPORT DATE: October 1979

13. NUMBER OF PAGES: 20

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):

15. SECURITY CLASS. (of this report): UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT (of this Report)

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 25th (Silver Jubilee) Conf of Army Mathematicians, 6-8 Jun 79, Johns Hopkins Univ, Baltimore, MD.
To be published in the proceedings of the 25th Conf of Army Mathematicians.

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

Finite Difference Method
Transient Temperatures
Thermo-Elastic Plastic Stresses
Transformation Stresses

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

A hollow cylindrical tube rapidly quenched for the purpose of developing a high strength material structure is analyzed. The quenching creates severe thermal stresses early in the quenching cycle while later the material transformation by virtue of a volume change in the transformed material causes large transformation stresses. The transient temperature distributions and the elastic treatment of the stresses has been treated previously. The present work is an attempt to consider the thermo-elastic-plastic aspects of the

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problem. The von Mises' yield criterion and the Prandtl-Reuss stress strain relations are used. Results are calculated based on a new finite difference approach.

SECURITY CLASSIFICATION OF THIS PAGE *(When Date Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79026	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: A NUMERICAL APPROACH TO ELASTIC-PLASTIC PLANE-STRAIN PROBLEMS OF THICK-WALLED CYLINDERS	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): P. C. T. Chen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 DA Project No. 1L161101A91A PRON No. 1A-9-2Za01-Y
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801	12. REPORT DATE: October 1979 13. NUMBER OF PAGES: 17
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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 Tenth Southeastern Conf on Theoretical & Applied Mechanics, 17-18 Apr 80, Univ of Tennessee, Knoxville, Tennessee.
To be published in an open literature journal.

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

Elastic-Plastic Deformation
Finite-Difference Method
Gun Tube

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

A new finite-difference approach has been developed for solving the elastic-plastic plane-strain problems of thick-walled cylinders subjected to internal or external pressure. The material is assumed to obey the von Mises' yield criterion, the Prandtl-Reuss flow theory and the isotropic hardening rule. The numerical scheme is stable for ideally-plastic as well as straining-hardening materials. The approach is simpler than others, and very accurate solutions can be obtained by reducing the grid sizes and load increments. The results

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for the stresses and strains in all principal directions have been computed as functions of loading history.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-MR-79027	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) A CONCEPT FOR A MINIMUM SIGNATURE ENVELOPE RECOILLESS GUN (MISER)		5. TYPE OF REPORT & PERIOD COVERED FINAL 1 Oct 76 - 1 Oct 77 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) MALCOLM K. DALE		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory US Army Armament Research & Development Command Watervliet Arsenal, Watervliet, NY 12189		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE-61101A Proj - 1T161101A91A WU - 167
11. CONTROLLING OFFICE NAME AND ADDRESS Large Caliber Weapon Systems Laboratory US Army Armament Research & Development Command Dover, NJ 07801		12. REPORT DATE May 1978 13. NUMBER OF PAGES 28
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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

18. SUPPLEMENTARY NOTES

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

Recoilless Guns
Urban Warfare
Signature

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

This report introduces a concept for a low signature recoilless gun applicable to Urban conflict, i.e., the Military Operations in Urban Terrain (MOUT) application, and proposes a small test program to establish concept feasibility. This is a launch or delivery system concept, and no warhead effort is included.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79028	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SENSITIVITY COEFFICIENT OF EXTERIOR BALLISTICS WITH VELOCITY SQUARE DAMPING		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) C. N. Shen		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 DA Project No. 1L161101A91A PRON No. 1A-9-2ZA01-Y
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE October 1979 13. NUMBER OF PAGES 22
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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 25th (Silver Jubilee) Conf of Army Mathematicians, 6-8 Jun 79, Johns Hopkins Univ, Baltimore, MD.
To be published in the proceedings of the 25th Conf of Army Mathematicians.

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

Sensitivity Coefficients
Perturbation of Initial Velocity
Initial Elevation Angle Correction
Target Hitting
Ballistics with Drag
Nonlinear Dynamics
Variation of Integrals

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

The principal equation of exterior ballistics has a drag term which, in this case, is proportional to the square of the velocity in the tangential direction of the trajectile. The sensitivity coefficient is expressed as the ratio of the initial elevation angle deviation to the initial percentage velocity deviation. The work in this paper is to find analytically the sensitivity coefficient of the exterior ballistics with velocity square damping which comes from the nonlinear air resistance for a projectile. This prin-

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cipal equation is integrated analytically in obtaining the solution for tangential velocity in terms of the elevation angle, together with all the necessary initial conditions. The horizontal range and the vertical range are also expressed as integrals of certain function of the elevation angles. In order to obtain the sensitivity coefficient it is necessary to find the perturbations of the horizontal and vertical ranges. This procedure is similar to that of evaluating differentiation under the integral sign. The perturbation of the ranges is the sum of the perturbations due to the initial velocity, the initial elevation angle, and the impact elevation angle. By setting to zeroes the range perturbations we can group the coefficients of the perturbations into two separate equations. The ratio of the perturbations for initial elevation angle to that for initial velocity is the sensitivity coefficient for exterior ballistics that we are seeking.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79029
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE *(and Subtitle)*: UNCONSTRAINED VARIATIONAL STATEMENTS FOR INITIAL AND BOUNDARY-VALUE PROBLEMS
5. TYPE OF REPORT & PERIOD COVERED:
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): T. E. Simkins
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, NY 12189, DRDAR-LCB-TL
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 611102H600211; DA Project No. 1L1161102H60; PRON No. 1A924324GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801
12. REPORT DATE: October 1979
13. NUMBER OF PAGES: 20
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:
15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT *(of this Report)*: 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 25th (Silver Jubilee) Conf of Army Mathematicians, 6-8 Jun 79, Johns Hopkins Univ, Baltimore, MD.
To be published in the proceedings of the 25th Conf of Army Mathematicians.
19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*:
Variational Methods
Initial/Boundary Value Problems
Finite Elements
Lagrange Multipliers
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:

A procedure is developed for generating variational statements suitable for obtaining approximate solutions to boundary-initial value problems. The essence of the procedure is to introduce all boundary and initial conditions into the variational statement as natural boundary conditions. This is accomplished through the use of Lagrange multipliers in which all initial condition terms as well as boundary terms are determined analytically. The result is a variational statement in which completely unconstrained trial functions may be assumed as a basis for an approximate solution. Several applications are

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given, including the response of a beam subject to a moving concentrated mass loading.

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARLCB-TR-79030	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* DYNAMIC STABILITY OF COLUMNS SUBJECTED TO NONCONSERVATIVE FORCES		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) J. J. Wu J. D. Vasilakis		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PRON No.1A-9-2ZA01-y AMCMS No. 6111.01.91A0.0 DA PRO.No.1L161101A91A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE October 1979 13. NUMBER OF PAGES 21
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

Presented at the 25th (Silver Jubilee) Conf of Army Mathematicians, 6-8 Jun 79, Johns Hopkins Univ, Baltimore, MD.
To be published in the Journal of Sound and Vibration.

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

Nonconservative Stability
Follower Forces
Unconstrained Variational Formulation
Finite Element

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

The numerical results of a class of problems of linear elastic stability problems subjected to nonconservative forces and under various support conditions are presented here. A single solution formulation by which these results have been obtained is described. Accuracy of these results compared with those reported in the literature is discussed.

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1. REPORT NUMBER ARLCB-TR-79031	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* SOME OBSERVATIONS ON LIQUID METAL EMBRITTLEMENT		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) M. H. Kamdar		8. CONTRACT OR GRANT NUMBER(e)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 611102H600211 DA Project No. 1L1161102H60 PRON No. 1A924324GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE November 1979 13. NUMBER OF PAGES 39
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15e. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

Liquid-Solid Embrittlement
Embrittlement Mechanisms
Fatigue Fracture

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

In this paper the phenomena of liquid and solid metal induced embrittmement of metals are described. It is shown that liquid metal embrittlement is a special case of brittle fracture. A mechanism of liquid metal embrittlement is proposed which involves liquid metal chemisorption-induced reduction in cohesive strength of bonds at the crack tip. An alternative possibility is discussed when chemisorption-induced reduction in shear strength of atomic bonds may lead to embrittlement via ductile failure mode. A new phenomenon is

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described where a solid metal induces embrittlement in a ductile metal. A mechanism is described which may be responsible for the solid metal induced embrittlement.

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1. REPORT NUMBER: ARLCB-MR-79032	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Comparative Evaluation Test of the Lightweight Company Mortar Auxiliary Baseplate, XM82E2, Modified	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): J. J. Battaglia	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 4111.16.2050.6, PRON NO. 1A-9-29346-0 NMAE
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: August 1979
	13. NUMBER OF PAGES: 17
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

Mortar
Mortar Baseplate
Mortar Ammunition
Mortar Test Data

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

A test was conducted to evaluate a proposed design change for the Lightweight Company Mortar, XM8E2 baseplate. The mortar was test fired with the standard XM8E2 baseplate and a modified baseplate representing the design change. The performance of the modified baseplate appeared equal to that of the standard baseplate.

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1. REPORT NUMBER ARLCB-TR-79033	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)* A Breech Technology Program and Technical Review	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR*(s)* F. J. John	8. CONTRACT OR GRANT NUMBER*(s)*
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, N.Y. 12189 DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 612603H181011 PRON. No. 1A-9-AZA07-Y-NMLC
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research & Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801	12. REPORT DATE August 1979 13. NUMBER OF PAGES 45
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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

18. SUPPLEMENTARY NOTES

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

Breeches, Cannon
Breech Fatigue
Breech Seals
Breech Mechanisms

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

This is an interim review of the breech technology program being conducted on slide block breeches. These breeches are planned for high pressure, large caliber applications in 120mm and 155mm cannon.

The technology encompasses three principal areas: means of increasing strength, means of self sealing combustible charges and development of mechanisms to operate seals and primer loaders. Innovations to accomplish all of these are described and test results are presented where available.

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1. REPORT NUMBER ARLCB-TR-79034	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) IMPLEMENTATION OF A TRAPEZOIDAL RING ELEMENT IN NASTRAN FOR ELASTIC-PLASTIC ANALYSIS		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) P. Chen P. O'Hara		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Benet Weapons Laboratory Watervliet Arsenal, Watervliet, NY 12189 DRDAR-LCB-TL		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6111.01.91A0.0 DA Project No. 1L161101A91A PRON No. 1A-9-2ZA01-Y
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Armament Research and Development Command Large Caliber Weapon Systems Laboratory Dover, New Jersey 07801		12. REPORT DATE December 1979 13. NUMBER OF PAGES 20
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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 8th NASTRAN Users' Colloquium, Goddard Space Flight Center, Oct 79.
To be published in the proceedings of the 8th NASTRAN Users' Colloquium.

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

Elastic-Plastic Analysis
NASTRAN Program
Gun Tube
Ring Element

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

The explicit expressions for an elastic-plastic trapezoidal ring element are presented and implemented in NASTRAN computer program. The material is assumed to obey the von Mises' yield criterion, isotropic hardening rule, and the Prandtl-Reuss flow relations. For the purpose of demonstration, two elastic-plastic problems are solved and compared with previous results. The first is a plane-strain tube under uniform internal pressure and the second a finite-length tube loaded over part of its inner surface. A very good agreement has been found in both test problems.

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READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79035	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: EFFECT OF CVD TUNGSTEN AND TaC COATINGS ON THE MECHANICAL BEHAVIOR OF SiC(C)	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): I. Ahmad, N. Hill, W. Heffernan	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, NY 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 612105H8400, DA Proj No. 1L162105AH84, PRON No. 1A926178GGGG
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research and Development Command, Large Caliber Weapon Systems Laboratory, Dover, New Jersey 07801	12. REPORT DATE: Dec 1979
	13. NUMBER OF PAGES: 45
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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)*

Filament	Tantalum carbide
Silicon carbide	Chemical vapor desposition
Coating	Adhesion
Tungsten	Tensile strength

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

Effects of the chemically-vapor-deposited tungsten and TaC coatings on the mechanical properties of silicon carbide (carbon core) filament have been investigated. In the temperature range of interest, because of the possible chemical interaction of tungsten with carbon rich silicon carbide phase on its surface and the columnar grain structure of the coating the filament was found to be embrittled. However, by controlling the initial

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Stress-to-rupture
High temperature

20. Cont'd

nucleation of tunsten by adjusting the temperature, the direction of flow of reactants and filament speed, the degraduation effect of the coating can be minimized. TaC coating did not decrease the strength of the filament, because it did not react with the filament and had fine grain structure. Coatings of tungsten and TaC decreased the 100 hr 2000°F, rupture strength of the filament from 1.9 GN/M^2 (280 Ksi) to respectively 1.05 GN/M^2 (150 Ksi) and 1.6 GN/M^2 (240 Ksi). The tensile strength of the W coated filament was superior to that coated with TaC in the temperature range 1000 - 1500°C. Thermal cycling (room temperature - 1600°C) induced cracks in the TaC coating while W coating remained unaffected.

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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARLCB-TR-79036	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Large Plastic Deformation in a Deep Drawing Process	5. TYPE OF REPORT & PERIOD COVERED
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): Dr. P.C.T. Chen	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Benet Weapons Laboratory, Watervliet Arsenal, Watervliet, N.Y. 12189, DRDAR-LCB-TL	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: AMCMS No. 6111.01.91A0, D.A. Project: 1L161101A91A, PRON 1A-9-2ZA01-Y
11. CONTROLLING OFFICE NAME AND ADDRESS: US Army Armament Research & Development Command, Large Caliber Weapon System Laboratory, Dover, New Jersey 07801	12. REPORT DATE: Dec. 1979
	13. NUMBER OF PAGES: 4
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

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 Proceedings of the 16th Midwestern Mechanics Conference, Kansas State University, Manhattan, Kansas, Sept. 1979.

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

Anisotropy
Elastic Properties
Isotropism
Orthotropic Plasticity
Stresses
Plastic Deformation

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

The problem considered is the large plastic-deformation and stresses in the flange of a deep drawing process. An analytical large strain solution is obtained on the basis of a deformation theory of anisotropic plasticity. The orthotropic sheet is rigid-plastic, isotropic in its plane and hardens according to a power law. Some numerical results are presented and discussed.

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARLCB-TR-79037

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle): Potential Erosion Resistant Refractory Metal (and/or) Alloy Coatings for Gun Tubes

5. TYPE OF REPORT & PERIOD COVERED

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
I. Ahmad
P. Greco
G. D'Andrea
J. Barranco

8. CONTRACT OR GRANT NUMBER(s)

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

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
AMCMS No 611102H 600011
DA Project N0.1L161102AH60
Pron No. GG825497GGM7

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

12. REPORT DATE
Dec 1979

13. NUMBER OF PAGES
14

14. MONITORING AGENCY NAME & AODRESS(if different from Controlling Office)

15. SECURITY CLASS. (of this report)
UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRAOING SCHEDULE

16. OISTRIBUTION STATEMENT (of this Report)

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

18. SUPPLEMENTARY NOTES
Presented at Tri-Service Conference on Corrosion, New Orleans, La., Oct. 1978.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Erosion Resistant Materials
Coatings
Gun Barrel Erosion
Refractory Metals
Wear

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

This report addresses the problem of erosion in gun tubes and the need to develop superior materials and techniques for its control in gun barrels.

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