# UNCLASSIFIED

# AD NUMBER

## AD814379

# NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

# FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; DEC 1966. Other requests shall be referred to U.S. Army Natick Laboratories, Attn: Director, Clothing and Organic Materials Division, Natick, MA 01760.

# AUTHORITY

USATSC ltr, 29 Jun 1989

THIS PAGE IS UNCLASSIFIED

THIS REPORT HAS BEEN DELIMITED AND CLEARED FOR PUBLIC RELEAS. UNDER DOD DIRECTIVE 5200.20 AND NO RESTRICTIONS ARE IMPOSED UPON ITS USE AND DISCLOSURE. DISTRIBUTION STATEMENT A

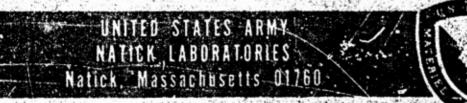
APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.

# RESEARCH DESIGN STUDY OF VARIABLE ARMOR CONCEPTS

R. Rodzen, F. Scribano and M. Burns IIT Research Institute Technology Center Chicago, Illinois

ond

E. R. Borron BAY 26 1967. U S. Army Natick Laboratories U L'Astroct No. DA19-129-AMC 555(N)



(0) Cił

AD 81

Clothing, and Organic Materials. Division

This document may be further distributed by any holder only with specific prior approval of the Director, Clothing and Organic Materials Division, U.S. Army Natick Daboratories, Natick, Massachusetts.

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.

Citation of trade names in this report does not constitute an official indorsement or approval of the use of such items.

Destroy this report when no longer needed. Do not return it to the criginator. This document may be further distributed by any holder <u>only</u> with specific prior approval of the Director, Clothing and Organic Materials Division, U. S. Army Natick Laboratories, Natick, Massachusetts

> TECHNICAL REPORT 67-40-CM

RESEARCH DESIGN STUDY

OF VARIABLE ARMOR CONCEPTS

by

R. Rodzen, F. Scribano and M. Burns IIT Research Institute and

E. R. Barron

U. S. Army Natick Laboratories

Contract No. DA-19-129-AMC-555(N)

Project reference: 1M624101D503 Series: TS-148

December 1966

Clothing and Organic Materials Division U. S. ARMY NATICK LABORATORIES Natick, Massachusetts 01760

**Best Available Copy** 

#### FOREWORD

ł

This is the final report for the "Research Design Study of Variable Armor Concepts." The research and development in the preliminary investigative phase of this program has been directed toward the design of armor with variable levels of protective capability to accommodate varying combat hazards. Considerable progress has been achieved in this program to demonstrate the feasibility of a unique concept in protective armor for the infantryman.

The IIT Research Institute has prepared this report under Contract No. DA19-129-AMC-555(N). Mr. Richard Rodzen, Mr. Frank Scribano and Mr. Marvin Burns are responsible for the generation of this document. The models fabricated for the concepts were tailored in a large part by Mr. Rodzen and Mr. Scribano. These prototypes employed ballistic elements representative of the final armor with respect to weight, rigidity, and thickness of material.

The contract was administered by Mr. Edward Barron, Project Officer, Clothing and Organic Materials Division, U. S. Army Natick Laboratories. Mr. Barron's contributions to the program were invaluable. His guidance and suggestions channeled IITRI's efforts in the development of an entirely new approach to the protection of infantrymen.

Anthropometric data necessary to the contract were supplied by Technical Report EP-150, Anthropometry of Army Aviators by Robert M. White, Physical Anthropologist for the U. S. Army Natick Laboratories. Important supplementary data were derived from the Aircrew Armor Program DA-19-129-AMC-641(N) and Technical Report TS-130, Design and Development of an Articulated Armor Garment.

#### **APPROVED:**

S. J. KENNEDI Director Clothing & Organic Materials Division

DALE H. SIELING, Ph.D. Scientific Director

W. M. MANTZ Brigadier General, USA Commanding

111

#### Preceding Page Blank

÷.

#### CONTENTS

	Page
Abstract	viii
Introduction	1
PART I. SUMMARY OF CONCEPTS AND MODELS FOR VARIABLE ARMOR SYSTEMS	3
PART II. PARAMETERS RELATED TO DEVELOPMENT OF VARIABLE ARMOR SYSTEMS	24
<ul> <li>A. Wound Ballistic Considerations</li> <li>1. Hazard Study</li> <li>2. Vulnerability</li> </ul>	24 24 24
B. Anthropometric and Sizing Considerations	26
<ul> <li>C. Human Factors Considerations</li> <li>1. Mobility</li> <li>2. Weight</li> <li>3. Confort</li> <li>4. Donning and Doffing</li> <li>5. Access to Wounds</li> </ul>	26 26 27 27 27 28
D. Naterials Parameters	28
PART III. DESIGN CHARACTERISTICS OF VARIABLE ARMOR CONCEPTS AND MODELS	29
A. Concept 1	29
B. Concept 2	36
C. Concept 3	45
PART IV. CONCLUSIONS AND RECOMMENDATIONS	52
A. Conclusions	52
<ul> <li>B. Recommendations</li> <li>1. Variability Design Studies</li> <li>2. Closure and Suspension Design Study</li> <li>3. Compatibility Studies</li> <li>4. Armor Configuration Studies</li> </ul>	55 55 56 56 56
References	59

iv

.

## LIST OF FIGURES

Selection of the

		Page
1.	Armor Weight Versus Area Coverage	2
2.	Model A Layout, USANL Fragmentation Vest, Basic Garment and Anatomical Rigid Elements	4
з.	Model B Layout, IITRI Jacket (Modified) Basic Garment and Anatomical Articulated Rigid Elements	5
4.	Model C Layout, IITRI Integrated Jacket, Basic Garment and Anatomical Front and Rear Single-Piece Elements	6
5.	Model D Layout, Basic Carrier with Rigid Elements, Anatomically Contoured	7
6.	Model E Layout, Basic Carrier with Rigid Articulated Elements (Anatomically Contoured)	8
7.	Model F, Maximum Protection Overlay Worn over Basic Jacket (Models D or E)	9
8.	Model H, Basic Carrier with Front and Rear Elements Removed (Anatomically Contoured)	10
9.	Model G Layout, Basic Carrier with Rigid Overlay Elements (Small-Arms Protection)	11
10.	Model H, Rigid Front Element Overlay, Reduced Area Coverage (Small-Arms Protection)	12
11.	Model A, USANL Fragmentation Vest (Modified), Front Closure, Showing Folding Pocket, without Rigid Element	30
12.	Model A, USANL Fragmentation Vest (Modified), Front Closure Showing Rigid Single-Piece Front Element Retained in Pocket (Anatomically Contoured)	31
13.	Model A, USANL Fragmentation Vest (Modified), Rigid Single-Piece Rear Element Retained in Pocket (Anatomically Contoured)	32
14.	Model B, IITRI Jacket (Modified), Peripheral Protection Added, Overhead Donning, Rigid Articulated Front Elements	34
15.	Model B, IITRI Jacket (Modified), Rigid Articulated Rear Elements Retained in Pocket (Anatomically Contoured)	35
16.	Model C, IITRI Integrated Jacket, Removable Single-Piece Front and Rear Elements, Side Closure, Overhead Donning	37

#### LIST OF FIGURES (Cont'd)

Page 17. Model C, IITRI Integrated Jacket, Rigid Rear 38 Element Retained in Integrated Pocket, Single Piece (Anatomically Contoured) 18. Model C, IITRI Integrated Jacket, Reduced Area 39 Coverage, Front Element Permits Shouldering of Rifle 19. Nodel C, IITRI Integrated Jacket, Side Adjust-40 ment, Shoulder Break (Auxiliary Protective Coverage) Model C, IITRI Integrated Jacket, Shoulder 41 20. Articulation While Gymnasticating 21. Model C, IITRI Integrated Vest, Standing 42 Firing Position 22. Model C, IITRI Integrated Vest, Kneeling 43 Firing Position 23. Model C, IITRI Integrated Vest, Prone Firing 44 Position Model D, IITRI Rigid-Element Jacket, Non-24. 46 articulated, Overhead Donning 25. Model D, IITRI Rigid-Element Jacket, Rigid 47 Single-Piece Rear Element Model E, IITRI Rigid-Element Jacket, 26. 48 Articulated, Overhead Donning Model E, IITRI Rigid-Element Jacket Rigid 27. 49 Articulated Rear Elements Rigid Rear Element Overlay, Reduced Area 51 28. Coverage (Small-Arms Protection) Recommended Variable Armor Concept, 29. 57 Apron Closure 30. Projected Rigidized Frame Approach 58

VI

:

THE REAL PROPERTY AND A

## LIST OF TABLES

ŝ

.

·

120

いいまでいたのです

		Page
1	Concept and Model Description, Area Coverage and Weight	13
2	Protective Levels, Area Coverage and Weight; Concept 1A, Modified USANL Felt Jacket, Nonarticulated Rigid Elements	14
3	Protective Levels, Area Coverage and Weight; Concept 1B, IITRI Modified Jacket, Articulated Rigid Elements	15
4	Protective Levels, Area Coverage and Weight; Concept 1C, IITRI Integrated Jacket, Basic Carrier + Nonarticulated Rigid Elements	16
5	Protective Levels, Area Coverage and Weight; Concept 2D, IITRI Rigid Element Jacket, Nonarticulated	17
6	Protective Levels, Area Coverage and Weight; Concept 2E, IITRI Rigid Element Jacket, Articulated	18
7	Combined Levels of Protection, Area Coverage and Weight; Concept 2F, Models D and E with Overlay Elements Maximum and Reduced Area Overlays	19
8	Protective Levels, Area Coverage and Weight; Concept 3G, Rigid Element Overlay, Maximum Area, Small-Arms Protection	20
9	Protective Levels, Area Coverage and Weight; Concept 3H, Rigid Element Overlay, Reduced Area, Small-Arms Protection	21
10	Possible Armor Combinations, Weight and Area Summary	22
11	Regional Distribution and Types of Wounds in Men Wounded and Killed in Action	25
12	Evaluation of Variable Armor Concepts and Models	53



#### ABSTRACT

This program was directed toward investigating the feasibility of "Variable Armor Concepts" which would provide selective and variable levels of protection to the infantryman. Three concepts of variable armor comprising differential protection were originated. Variations of approaches to utilizing rigid and flexible ballistic materials of varying arcal densities were represented through the fabrication of eight models.

The models suggest guidelines for improved future families of infantry protective garments. They are not intended to suggest an optimum design but to portray the results of our preliminary investigation. These results enable the investigator to conduct a trade-off study which will form the basis for an optimum approach in a finalized system.

The theme of variability of protective coverage is carried throughout the development of all concepts. Variability of ballistic protection is accomplished through several approaches.

- A. Rigid elements of varying areal densities are inserted into pockets of a basic ballistic garment. The basic garment provides protection against low level fragmentation for the posterior and anterior thoracic-abdominal torso and peripheral areas.
- B. Rigid or flexible elements of varying areal densities are inserted into a basic carrier resulting in differential protection. Flexible elements for low-level fragmentation protection are provided in the peripheral areas; rigid elements for the anterior and posterior torso are employed to protect the vital organs from small arms fire.
- C. A basic flexible garment for maximum coverage and low-level fragmentation protection is combined with overlay rigid clements of varying areal densities and area coverage, in a separate carrier.

The work accomplished thus far indicates the feasibility of providing significantly greater protection for the infantryman than has been achicvable previously.

viii

where the response of the representation of the

#### RESEARCH DESIGN STUDY

OF VARIABLE ARMOR CONCEPTS

#### Introduction

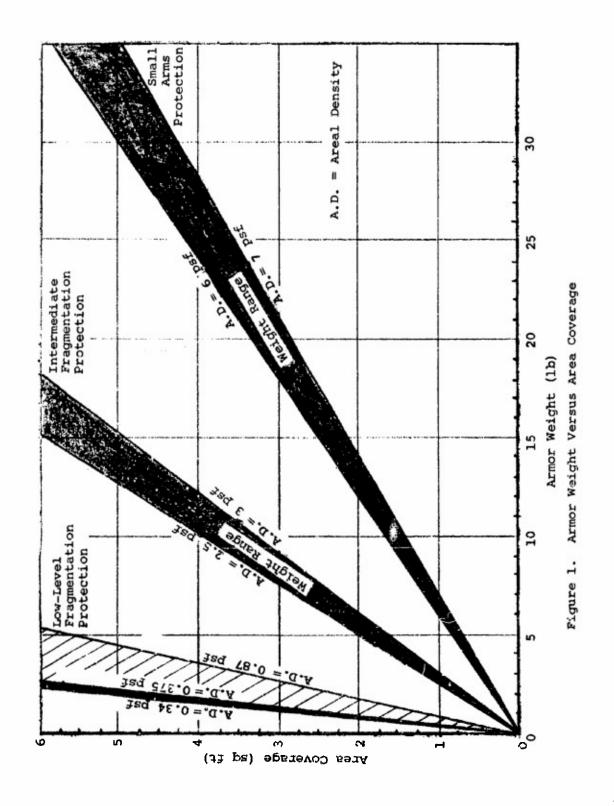
Past efforts to provide infantrymen with protection against small-arms fire have shown limited results because of excessive weight, discomfort and degradation of combat efficiency. With recent technological advances in ballistic materials, it has become possible to produce elements that can defeat both fragments and small-arms projectiles and still be light enough to be worn comfortably by military personnel. The degree of ballistic protection aftorded is a direct function of the material employed. Similarly, the total garment weight is directly related to the area coverage and areal density (Figure 1).

Since the modern soldier may be exposed to a broad range of ballistic hazards (fragmentation hazards and smallarms fire, including caliber .30 AP projectiles), a variable armor system is most desirable.

Under Contract DA19-129-AMC-555(N), IITRI has developed several unique and distinct approaches to provide variable ballistic protection for the infantrymen. Three concepts were generated from which eight models were fabricated for evaluation. The theme of "variability" was followed in all approaches. The variable armor systems can be adapted to a particular tactical necd by allowing the infantrymen to select the level of protection required for a particular combat situation. Variability of protection is achieved by adding appropriate ballistic elements or modules in the anatomical regions of the vital organs (specifically, the thoracic-abdominal cavity).

The concepts developed are capable of providing maximum protection to the vital body organs with decreasing protection to the peripheral areas or non-vital organs. Both rigid and flexible materials encompassing a broad range of areal densities are employed to accomplish variability.

Three models for Concepts 1 and 2 and two models for Concept 3 were fabricated. The eight models developed have been evaluated on a laboratory basis with respect to area coverage, weight, degree of variability, method of donning and doffing, and other significant design parameters.



A DESCRIPTION OF THE OWNER.

instructure line and

And a standard of a sub-

and the state of the second second

understation of the second s

Constant of the local division of the local

#### PART I. SUMMARY OF CONCEPTS AND MODELS FOR VARIABLE ARMOR SYSTEMS

The objective of this program has been the investigation and development of variable armor concepts demonstrated in models using actual ballistic materials, or simulated materials with the same characteristics and weights.

The variable armor systems designed under this program are such that they can be adapted to a particular tactical need, thus allowing troop units to select the level of protection for a particular situation consistent with the performance required of the individual. In addition, the armor can be varied to provide differential protection over parts of the torso so as to concentrate the highest levels over the anatomical regions containing the vital organs.

The concepts and models (Figures 2 through 10) are summarized in Table 1 and described 1 ndividually in Tables 2 - 9. A summary of the combinations and variations possible between the different concepts is contained in Table 10.

The finished models were donned by a limited sampling of medium-size individuals (height 68-71 inches; weight 154-179 pounds) and gymnasticated through the range of motions described in USANL Technical Report TS-130, (1) which includes various modes of bending, reaching, and firing. These were repeated for each level of protection. The advantages and disadvantages of each concept and model were noted. The results are included in Table 12.

The basic garments were designed to provide at least as much coverage as the standard Army Body Armor fragmentation vest titanium nylon composite. Special attention was given to methods of closure, donning and doffing, and containment of the rigid elements.

The areas and shapes of the rigid elements are consistent with the requirements for protecting the vital organs. Wound Ballistics and Body Armor<sup>(2)</sup> was used as one source of data to substantiate the element size and location related to vulnerability of vital areas. These elements provide protection to the thoracic and abdominal cavities which include the heart, great blood vessels, lungs, liver, kidneys, spleen, and spinal column.

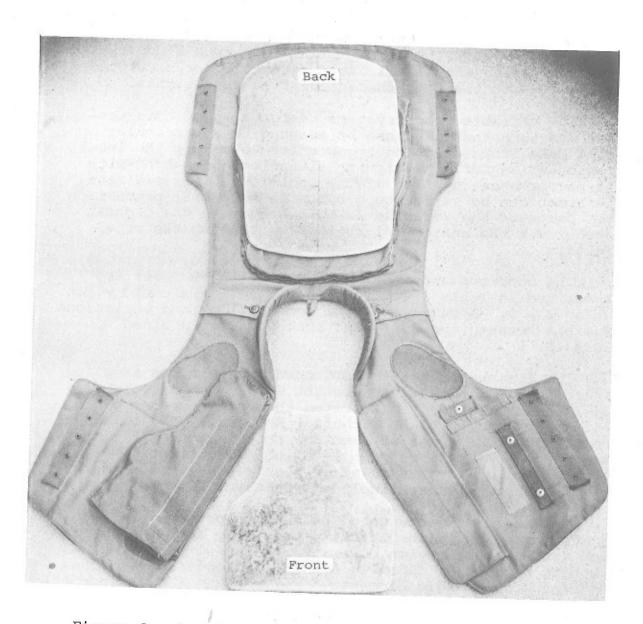


Figure 2. Model A Layout, USANL Fragmentation Vest, Basic Garment and Anatomical Rigid Elements



Figure 3. Model B Layout, IITRI Jacket (Modified) Basic Garment and Anatomical Articulated Rigid Elements

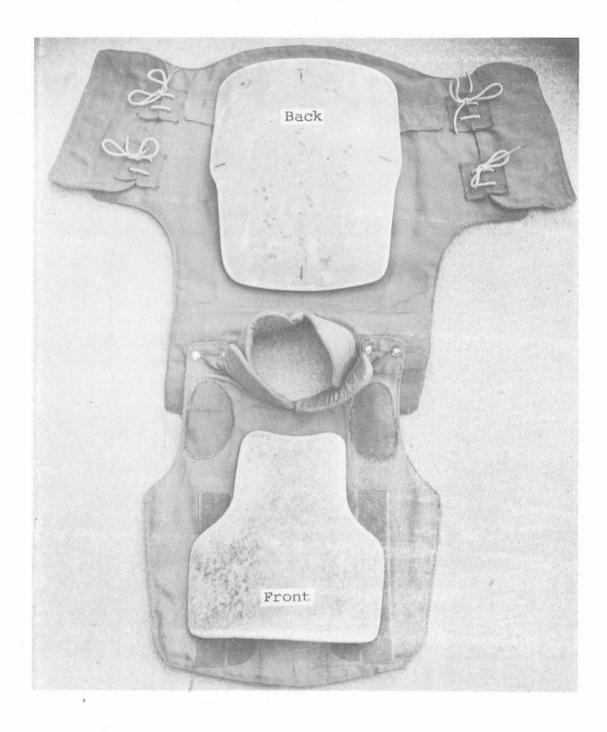


Figure 4.

Model C Layout, IITRI Integrated Jacket, Basic Garment and Anatomical Front and Rear Single-Piece Elements

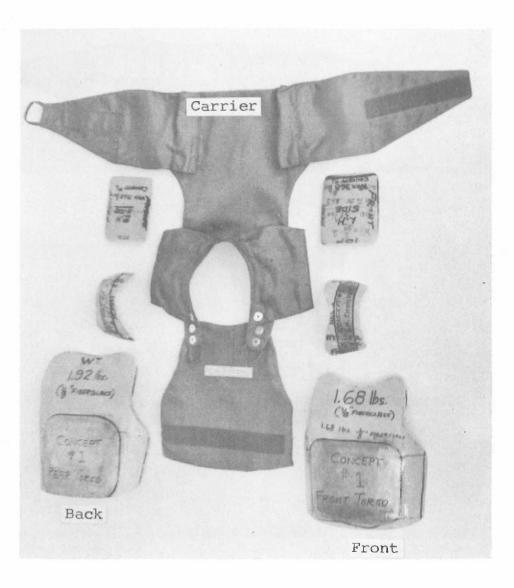


Figure 5. Model D Layout, Basic Carrier with Rigid Elements, Anatomically Contoured

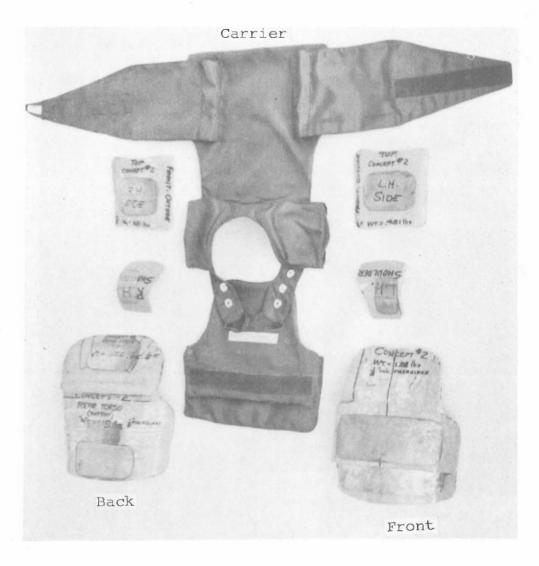


Figure 6.

Model E Layout, Basic Carrier with Rigid Articulated Elements (Anatomically Contoured)

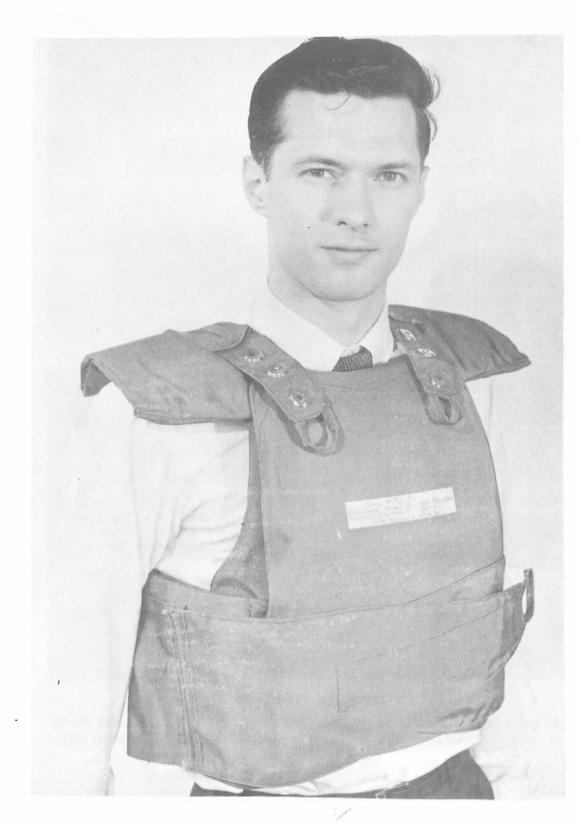


Figure 7. Model F, Maximum Protection Overlay Worn over Basic Jacket (Models D or E)



Figure 8. Model H, Basic Carrier with Front and Rear Elements Removed (Anatomically Contoured)

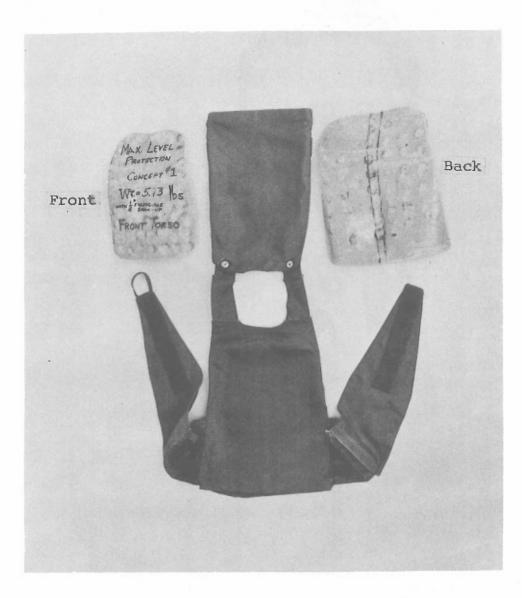


Figure 9. Model G Layout, Basic Carrier with Rigid Overlay Elements (Small-Arms Protection)

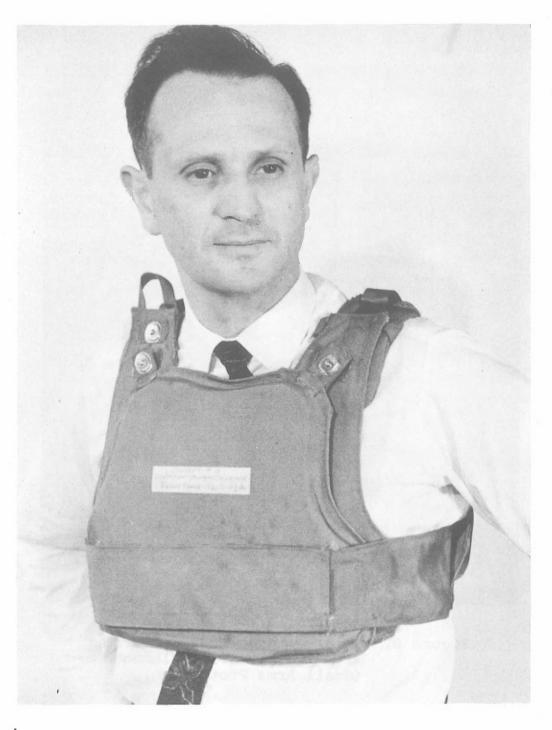


Figure 10. Model H, Rigid Front Element Overlay, Reduced Area Coverage (Small-Arms Protection)

この時代はないであった。

the state of

CONCEPT AND MODEL DESCRIPTION, AREA COVERAGE AND WEIGHT

Concept Model						
	fodel	Description	Table No.	Figure No.	Total Area Coverage (sqft)	Total Weight (1b)
	Æ	USANL Fragmentation Vest (Modified) - Front Closure	5	2	5.75	4.8 to 20.2
	<u>م</u>	IITRI Jacket (Modified) Addition to Peripheral Protection	3	3	5.75	2.3 to 20.7
l	υ	IITRI Integrated Jacket (Basic Garment + Pocketed Elements)	4	4	5.75	4.8 to 20.2
	6	IITRI Rigid Element Jacket (Nonarticulated Elements)	2	Ś	3.89	1.8 to 22
l	μ	IITRI Rigid Element Jacket (Articulated Elements)	Q	છ	3.77	1.8 to 21.1
!	μ	Model D with Maximum and Minimum Coverage Overlays Model E with Maximum and Minimum Coverage Overlays	7	7,9	3.89	18.3 to 26.2
	U	Rigid Element Overlay Worn with Basic Garment (Small Arms)	ω	¢Ò	5.75	4.8 to 20.6
<u> </u>	Ħ	(Reduced Coverage) Rigid Element - Overlay Worn with Basic Garment - Small Arms	6.	9 and 10	5.75	4.8 to 16.3

13

Ë,

**BERGE** 

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 1A, MODIFIED USANL FELT JACKET,\* NONARTICULATED RIGID ELEMENTS

Levels of	Area Coverage (sq ft)		Wei(	ght b)
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84 to 0.87 psf)		5.75		4.8 to 5
Low Level Fragmentation + Increased Fragmentation (Areal Density: 2½ to 3 psf)	2.17	5.75	5.5 to 6.5	10.3 to 11.5
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.17	5.75	13 to 15.2	17.8 to 20.2

\*Reference Figure 2.

のないのないのである。

\*\* Includes area of basic garment.

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 1B, IITRI MODIFIED JACKET,\* ARTICULATED RIGID ELEMENTS

Levels of	Area Co (sq		Weig (1	ght b)
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84to 0.87 psf)		3,20		2.3 to 2.8
Low-Level Fragmentation + Increased Fragmentation (Areal Density: 2½ to 3 psf)	2.55	5.75	6.4 to 7.7	8.7 to 10.5
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.55	5.75	15.3 to 17.9	17.6 to 20.7

\*Reference Figure 3.

States Int and

\*\* Includes area of basic garment.

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 1C, IITRI INTEGRATED JACKET,\* BASIC CARRIER + NONARTICULATED RIGID ELEMENTS

Levels of		Area Coverage (sq ft)		ght b)
Protection	Rigiā Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84to 0.87psf)	. Na bin ping	5.75	विद्यों किंद प्रमुख	4.8 to 5
Low-Level Fragmentation + Increased Fragmentation (Areal Density: 2 <sup>1</sup> / <sub>2</sub> to 3 psf)	2.17	5.75	5.5 to 6.5	10.3 to 11.5
Low-Leval Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.17	5.75	13 to 15.2	17.8 to 20.2

\*Reference Figure 4.

\*\* Includes area of basic garment.

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT, CONCEPT 2D, IITRI RIGID ELEMENT JACKET,\* NONARTICULATED

Levels of		Area Coverage (sq ft)		ght b)
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84 to 0.87 psf)	199 KB 65	1.03		1.8 to 2
Low-Level Fragmentation + Increased Fragmentation (Areal Density: 25 to 3 psf)	2.86	3,89	7.2 to 8.5	9 to . 10.5
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.86	3.89	17.2 to 20	19 to 22

\*Reference Figure 5.

\*\* Includes area of basic garment.

# PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 2E, IITRI RIGID ELEMENT JACKET,\*

ARTICULATED

Levels of		Area Coverage (sq ft)		ght b)
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84 to 0.87 psf)		1.14		1.8 to 2
Low-Level Fragmentation + Increased Fragmentation (Areal Density: 2 <sup>1</sup> / <sub>2</sub> to 3 psf)	2.74	3.88	6.8 to 8.2	8.6 to 10.2
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.74	3.88	16.4 to 19.1	18.2 to 21.1

\*Reference Figure 6.

\*\* Includes area of basic garment.

## COMBINED LEVELS OF PROTECTION, AREA COVERAGE AND WEIGHT; CONCEPT 2F, MODELS D AND E WITH OVERLAY ELEMENTS\* MAXIMUM AND REDUCED AREA OVERLAYS

		ويتحصر ويترجي والمحاج المراج	
Combined Levels of Protection	Total Area Coverage (sq ft)	Total Weight (lb)	Figure No.
Model D with Low-Level and Increased Fragmentation 4 Model G Small Arms Protection - Overlay	3.89	22.2 to 26.2	. 7
Model D with Low-Level and Increased Fragmentation + Model H (Reduced Coverage) Small Arms Protection - Overlay	3.89	18.5 to 21.9	8
Model E with Low-Level and Increased Fragmentation + Model G Small Arms Protection - Overlay	3.77	22.0 to 25.8	7
Model E with Low-Level and Increased Fragmentation + Model H (Reduced Coverage) Small Arms Protection - Overlay	3.77	18.3 to 21.5	8

\*Reference Figures 9 and 10.

A.

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 3G, RIGID ELEMENT OVERLAY,\* MAXIMUM AREA, SMALL-ARMS PROTECTION

Levels of		Area Coverage Weight (sq ft) (1b)		
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84 to 0.87 psf)		5.75		4.8 to 5
Low Level Fragmentation + Increased Fragmentation (Areal Density: 2 <sup>1</sup> / <sub>2</sub> to 3 psf)	2.22	5.75	5.5 to 6.6	10.3 to 11.6
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	2.22	5.75	13.3 to 15.6	18.1 to 20.6

\*Reference Figure 9.

\*\*Includes area of basic garment.

\*Includes weight of basic garment.

#### <u>Table 9</u>

## PROTECTIVE LEVELS, AREA COVERAGE AND WEIGHT; CONCEPT 3H, RIGID ELEMENT OVERLAY,\* REDUCED AREA, SMALL-ARMS PROTECTION

Levels of		Area Coverage (sq ft)		ght b)
Protection	Rigid Elements	Total**	Rigid Elements	Total***
Low-Level Fragmentation (Areal Density: 0.84 to 0.87 psf)		5.75		4.8 to 5
Low-Level Fragmentation + Increased Fragmentation (Areal Density: 2 <sup>1</sup> / <sub>2</sub> to 3 psf)	1.61	5.75	4 to 4.8	8.8 to 9.8
Low-Level Fragmentation + Small Arms Protection (Areal Density: 6 to 7 psf)	1.61	5.75	9.6 to 11.3	14.4 to 16.3

\*Reference Figure 10.

\*\* Includes area of basic garment.

Combinations	System Weight (1b) min max		Area Covered by Rigid Elements (sq ft)	Total Area Covered (sq ft)
1 2 3 4 5	4.88 5.43 7.13 8.06 8.58	5.0 7.51 8.7 8.81 10.11	2.17 0.90 1.27 2.17	5.75 2.17 5.75 5.75 2.17
6 7 8 9 10	9.32 10.16 10.28 9.72 10.31	10.18 11.16 11.3 11.34 12.51	0.74 0.88 0.90 1.62 2.17	5.75 5.75 5.75 1.62 5.75
11 12 13 14 15	9.88 9.87 10.71 10.83 12.51	12.6 12.69 13.67 13.81 13.9	2.17 2.17 2.17 2.17 2.17 1.27	2.17 2.17 2.17 2.17 2.17 5.75
16 17 18 19 20	11.97 13.46 12.90 13.03 14.60	15.04 15.11 15.15 15.2 16.34	1.78 2.17 2.01 2.17 1.62	1.78 5.75 2.01 2.17 5.75
21 22 23 24 25	13.06 14.76 14.75 15.15 15.28	16.41 17.6 17.69 18.85 18.9	2.17 2.17 2.17 2.17 2.17 2.17	2.17 5.75 5.75 2.17 2.17
26 27 28 29 30	16.21 17.91 18.46 20.03 23.34	19.01 20.2 22.71 23.85 27.71	2.17 2.17 2.17 2.17 2.17 2.17	2.17 5.75 2.17 5.75 5.75

POSSIBLE ARMOR COMBINATIONS, WEIGHT AND AREA SUMMARY

Low-Level Fragmentation		eased	Small	-	
-		Increased Fragmentation		Small Arms Protection	
	$(2\frac{1}{2} - 3 \text{ psf})$		(6-7 psf)		
(5½-6 oz/sq ft Carrier Wt)	Front	Back	Front	Back	
x					
1	x	х			
x	x				
x		х			
		х	x		
x			Х*		
X			A	X*	
x			x	•	
<b>^</b>			x*	х*	
х	<b>X</b> -	х			
	X			х	
	x	х	Х*		
	х	Х		X*	
	х	x	х		
x			51	х	
	x		Х*	X*	
x	×1	x	x	-	
	24	x	X*	X*	
			x	X	
x			X*	X*	
	X	х		X	
x x	X X	х	X*	х	
~ }	X	X	X*	X*	
	X	A	X	X	
	~ 2				
		x	x	x	
x			х	х	
	x	x	x	X	
x	x	x	X*	X*	
x	x	x	х	X	

## Table 10 (Cont.)

-

\*Reduced Area Coverage

#### PART II. PARAMETERS RELATED TO DEVELOPMENT

#### OF VARIABLE ARMOR SYSTEMS

A number of basic principles must be applied in the development of variable armor for the infantryman. Design considerations must be evolved accordingly, based on the type of hazard the infantryman may be exposed to, and the areas of the body which require protection.

Personnel wearing armored garments must be able to perform their required tactical duties without degradation of performance. Human factors parameters are, therefore, extremely important. A subject must be able to articulate adequately and fire a weapon effectively. The armor must be comfortable, versatile, relatively light, easily donned and doffed, particularly in the case of wounded personnel, and generally acceptable to the Army personnel who will use it.

#### A. Wound Ballistics Considerations

#### 1. Hazard Study

The mortality and morbidity of war wounds depend on the wounding agent and the anatomic region involved. It has been known that in all conflicts since the Civil War, shell fragments cause the greatest number of wounds, and small arms projectiles cause the greatest number of deaths. The relative morbidity of small arms fire to shell fragmentation is about one to four. The relative mortality of small arms fire to shell fragmentation is about two to one. In the Korean conflict, mortars and grenades accounted for the majority of those killed in action by small-arms fire. These figures vary somewhat with the type of combat tactics, but they are applicable to continued aggressive land warfare. In combat in which patrolling action predominates, casualty incidence due to small arms tends to rise.

#### 2. Vulnerability

The number of wounds, particularly to the thorax and abdomen, is closely related to the mortality rate, that is, the rate almost doubles if more than one wound occurs. Data show that hits on the thorax and abdomen account for about 30 per cent of the wounds among men wounded in action and 46 per cent among those killed in action. The data further show the incidence of thoracic wounds to be considerably higher than those of the abdomen (Table 11).

## REGIONAL DISTRIBUTION AND TYPES OF WOUNDS IN MEN WOUNDED AND KILLED IN ACTION

A.	<u>Disabling Wounds</u>	% without	% with		
	Region Wounded	Armor	Armor		
	Head	14.4	14.2		
	Neck	3.0	2.5		
	Thorax	19.0	8.7		
	Abdomen	11.0 30.0	10.8 19.5		
	Upper extremities	25.0	28.3		
	Lower extremities	27.0	35.0		
	Genitalia	0.6	0.5		
	Type or Cause of Wound				
	Multiple wounds	53.0	59.0		
	Small arms missile	15.3	15.4		
	Shell fragment	84.7	84.6		
в.	Lethal Wounds	% without	% with		
	Region Wounded	% without Armor	% with Armor		
	Head	39.0	38.0		
	Face	1.0	8.0		
	Neck	3.0	8.0		
ł	Thorax	37.2	26.0		
	Abdomen	9.2	6.0		
	Upper extremities	2.0	4.0		
	Lower extremities	7.	8.0		
	Buttocks	1.5	2.0		

# B. Anthropometric and Sizing Considerations

The prototype jacket and models were designed to fit the median man as described by anthropometric data from Army Reports No. 180(3) and EP-150, (4) and the USAF Report AMRC-TDR-63-55. (5) Reference 5 contains supplementary data necessary for the design of the rigid elements.

The over-all dimensions for the basic garments were taken from the experimental lightweight felt fragmentation vest and standard fragmentation vests supplied by USANL. This was done in order that the armor designs utilizing a basic garment might be compared to existing protective garments from the standpoint of size and coverage.

The design of the large one-piece rigid elements for intermediate and maximum levels of protection required the use of complex, three-dimensional shapes. The anthropometric and sizing data for the design of the flexible garments could not be directly applied to these rigid shapes. Principles and techniques developed under the aircrew armor program<sup>(6)</sup> for the fabrication of anatomical torso elements were used. Of primary concern was the design of the profile and cross-section shapes.

# C. Human Factors Considerations

#### 1. <u>Mobility</u>

The body shapes, dimensions and movements to which the protective garment must conform were given appropriate consideration in the systems designs.

The basic garment, consisting of flexible ballistic materials, imposes little restriction on mobility. Articulation is accomplished by the buckling or flexing of these materials.

The configurations of the rigid elements, on the other hand, are such that they do not cover areas of maximum articulation and therefore need not be articulated. Changes in body contour due to articulation are accommodated in the element shapes.

USANL Technical Report TS-130 $^{(1)}$  was used as a source of data for the range of body movements and associated changes in body dimensions.

# 2. Weight

Factors which contributed to reducing the systems weight were the elimination of plate overlap, anatomical contouring, and plate size.

Weight can also be adjusted to the users' requirements by the ability to select materials of varying areal densities, and by the addition or removal of ballistic elements.

Weight ranges for different element and material combinations are given in Table 10.

#### 3. Comfort

Wearer comfort is directly related to the distribution of armor weight on the body. The basic garment, in addition to providing low-level fragmentation protection, also serves as padding for the rigid elements.

The anatomical contour of the rigid elements serves to localize the armor weight at regions of the torso best suited for load bearing, i.e., chest, back, shoulders, while providing adequate clearances over such sensitive areas as the spine, shoulder blades, sternum and clavicles.

The ability to ventilate is another factor affecting comfort. Ventilation can be accomplished in the overhead-donning models by releasing the velcro closure and allowing the front element to hang freely. This feature does not result in a temporary loss of protection as in the vest-donning models which must be opened at the front.

# 4. Donning and Doffing

The ability to quickly don and doff the protective garment is a feature of the type of closure used. Overheaddonned models with side closures and shoulder breaks and a vest-donned model with front closure have been fabricated.

Overhead-donning best lends itself to the use of large, one-piece front and back elements. There is the disadvantage, however, of having to remove the helmet in donning. The jacket is easily broken at the shoulder for rapid doffing; however, the shoulder break must then be reconnected for donning. It is not necessary to remove the helmet with the vest-donned model; however, it is clumsy to handle and requires more time to don and doff than the overhead models.

In both of the above concepts, the closures are conveniently located, utilize velcro fasteners which require no threading or unthreading, can be quickly secured or released, and are jam-proof.

# 5. Access to Wounds

Both the overhead and vest-donned models permit rapid access to wounds. In the vest model, the front closure can be opened and the side laces cut to expose the torso. In the overhead models, the shoulders can be broken and the side closures opened, or elastic side laces cut, whichever is more direct.

# D. <u>Materials Parameters</u>

Variability of protection is achieved by using materials of varying areal densities, flexible or rigid, over the anatomical regions containing the vital organs and in peripheral areas. The protection provided and the areal densities considered are divided into three distinct levels:

- 1. Low-level fragmentation protection, 5-1/2 to 6 oz per sq ft (Flexible material for protection to vital organs and peripheral torso areas)
- Increased fragmentation protection, 2-1/2 to 3 psf (Rigid material for protection of vital organs)
- 3. Small arms protection, 6 to 7 psf (Rigid material for protection of vital organs).

#### PART III. DESIGN CHARACTERISTICS OF VARIABLE

#### ARMOR CONCEPT'S AND MODELS

# A. Concept 1

Concept 1 (Tables 2, 3 and 4) utilizes a basic flexible garment with pockets in front and back to accept rigid elements. The basic garment is capable of providing low-level fragmentation protection to vital and nonvital areas of the torso at a minimum weight. The protection of vital areas can be selectively upgraded to defend against increased fragmentation hazards or small arms fire by inserting rigid ballistic elements into the pockets which are an integral part of the basic garment. The weight of the upgraded system is solely a function of the areal density of the rigid materials since the areas and configurations of the pockets are fixed.

A feature of this concept is that variability can be achieved within a single garment. This advantage, however, is partially offset by the necessity, in some instances, of having to remove the basic garment in order to vary the levels of protection, thus increasing the user's vulnerability.

Three models, A, B and C, were fabricated to demonstrate the workability of this concept.

Model A

Model A (Table 2; Figures 2, 11, 12 and 13) is a modified version of the USANL felt fragmentation jacket which is vest-type donning with velcro front closure and side adjustment. Pockets to support the rigid elements are sewn to the outer covers. Because of the front closure, the front pocket is only sewn to the right side of the front. With the rigid elements inserted, the front is secured at the left side with snap fasteners. This was later improved by replacing the snaps with a vertical flap which overlaps the pocket and is secured at the centerline with a velcro fastener. With the rigid element removed, the pocket can be folded in on itself and closure accomplished in the normal manner.



Figure 11. Model A, USANL Fragmentation Vest (Modified), Front Closure, Showing Folding Pocket, without Rigid Element



Figure 12. Model A, USANL Fragmentation Vest (Modified), Front Closure Showing Rigid Single-Piece Front Element Retained in Pocket (Anatomically Contoured)

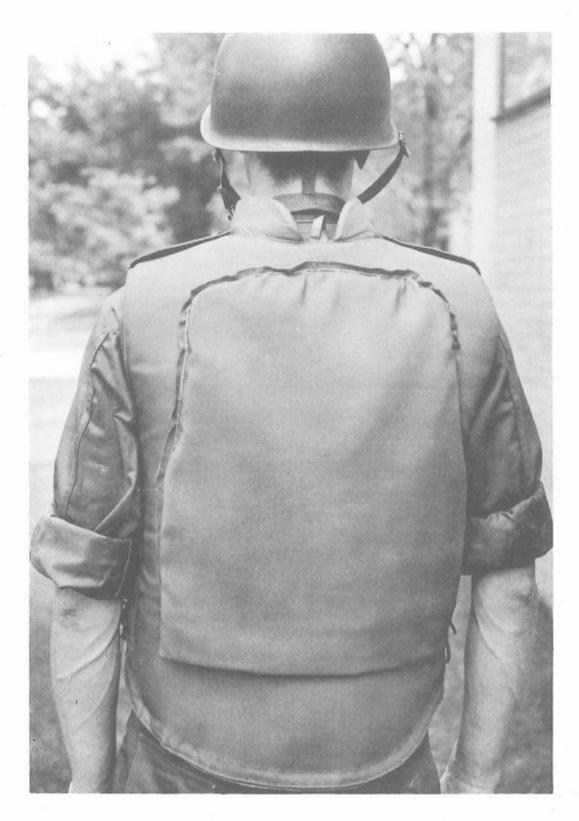


Figure 13. Model A, USANL Fragmentation Vest (Modified), Rigid Single-Piece Rear Element Retained in Pocket (Anatomically Contoured) The simulated ballistic elements used in this model represent the maximum level of protection; areal density, 6-7 psf. They are anatomically contoured and provide front coverage from the iliac crest to the suprasternum and back coverage from the iliac crest to the base of the neck. Sufficient material has been removed in the scye area to permit shouldering of the rifle.

The excessive thickness build-up along the front centerline does not allow the front element to lie comfortably against the body. It is suggested that the felt be skived in this area to reduce thickness or that the cross section of the rigid element be modified.

The vest-donning feature permits the jacket to be donned and doffed without necessitating removal of the helmet, as in the overhead-donning models; however, it does prove to be more unwieldy than overhead donning.

#### Model B

Model B (Table 3; Figures 3, 14 and 15) consists of an overhead-donning basic garment with front and rear pockets to accept flexible or rigid ballistic elements. Low-level fragmentation protection (felt) is provided for the non-vital peripheral areas as an integral part of the garment. Low-level protection can also be applied to the vital torso areas by inserting flexible ballistic elements into the pockets. A split collar of flexible ballistic material provides neck protection.

Vertical flaps with velcro fasteners at either side of the front centerline are used for closure. Elastic laces at the sides permit expansion in girth to allow for size variations and articulation. Shoulder breaks with directional snap fasteners permit rapid doffing. An elastically closed slit was incorporated in the rear felt element at the base of the neck to permit expansion of the head opening durdonning and to eliminate the need for adjustment at the shoulders.

The simulated rigid elements used in this model represent the intermediate level of protection, 2-1/2 - 3 psf. These elements were taken from Model E for



Figure 14. Model B, IITRI Jacket (Modified), Peripheral Protection Added, Overhead Donning, Rigid Articulated Front Elements

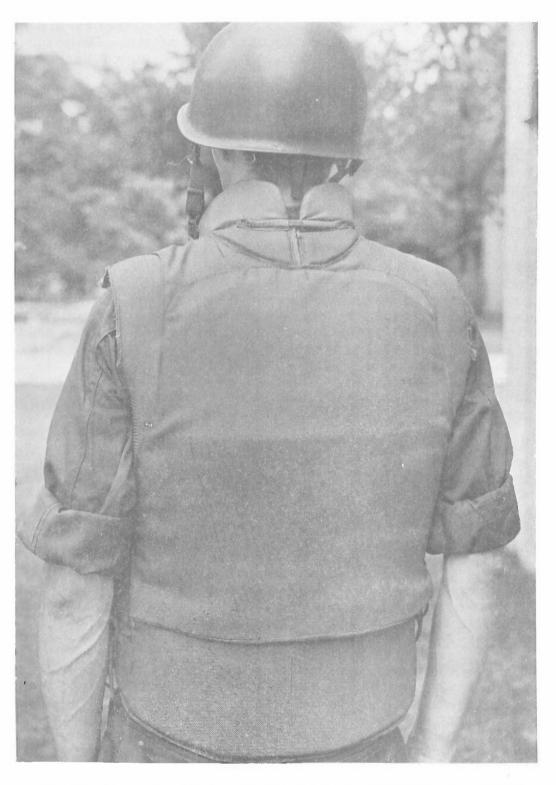


Figure 15. Model B, IITRI Jacket (Modified), Rigid Articulated Rear Elements Retained in Pocket (Anatomically Contoured)

use in this model. Both front and rear elements are articulated to increase comfort in bending. Coverage is provided from the iliac crest to the suprasternum in front and from the iliac crest to the base of the neck in back. Sufficient clearance is provided in the scye area to permit shouldering of the rifle. iner.

si ∎ P

「日本の日本」を見ていていたのである」を見ていたのである」を見ていたのである。

187 239

Although the elimination of felt in areas covered by the rigid elements results in a slight weight reduction, it is accompanied by a decrease in comfort resulting from the lack of padding.

#### Model C

Model C (Table 4; Figures 4, 16 through 19) consists of an overhead-donning basic garment with pockets front and rear to accommodate rigid ballistic elements. Lowlevel fragmentation protection is provided for vital and nonvital areas of the torso when worn without the rigid elements. Neck protection is provided by a split collar of flexible ballistic material. Shoulder breaks with snap fasteners permit rapid doffing. Vertical flaps with velcro fasteners at each side of the front centerline are used for closures, and elastic laces are used at the sides to permit adjustability in girth.

The rigid elements used in this model are the same as those used in Model A. Large, one-piece elements are used to eliminate the need for overlapping plates which result in increased weight, thickness, and bulk. The elements are retained in their pockets by velcro closures at the bottom of the pockets.

Model C was gymnasticated through the range of motions required of the combat infantryman, including the shouldering of his weapon. Some of these movements and positions are shown in Figures 20 through 23.

#### B. Concept 2

The Children of the Second second

Concept 2 (Tables 5, 6 and 7) consists of rigid elements in a carrier which can be worn separately or with an overlay of rigid elements. No basic garment is worn in this concept. Fragmentation or small arms protection is provided for vital areas. Low-level fragmentation can be provided at the sides and shoulders by inserting flexible ballistic material into pockets in the carrier. Levels of protection for vital areas can be varied by changing elements in their carrier or by selection of overlays.



Figure 16. Model C, IITRI Integrated Jacket, Removable Single-Piece Front and Rear Elements, Side Closure, Overhead Donning



Figure 17. Model C, IITRI Integrated Jacket, Rigid Rear Element Retained in Integrated Pocket, Single Piece (Anatomically Contoured)

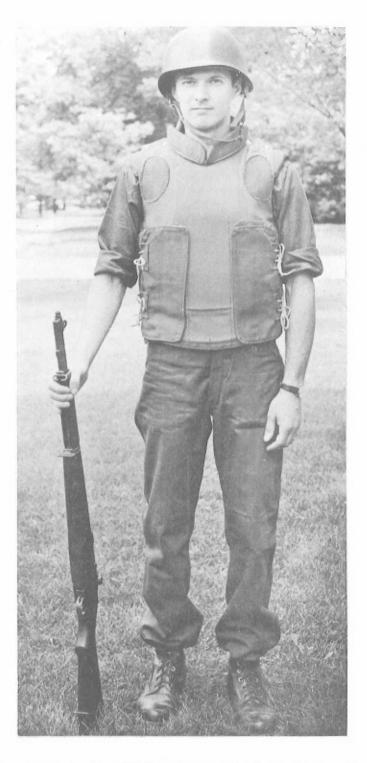


Figure 18.

Model C, IITRI Integrated Jacket, Reduced Area Coverage, Front Element Permits Shouldering of Rifle



Figure 19. Model C, IITRI Integrated Jacket, Side Adjustment, Shoulder Break (Auxiliary Protective Coverage)

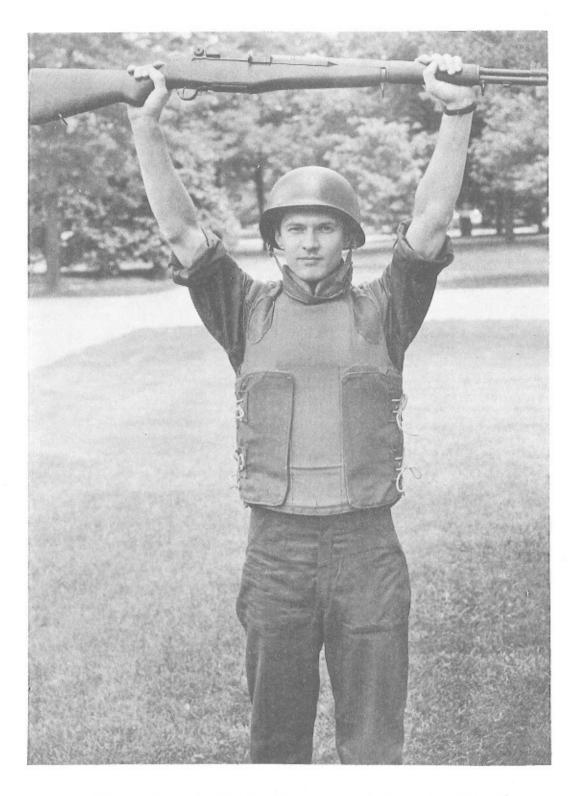
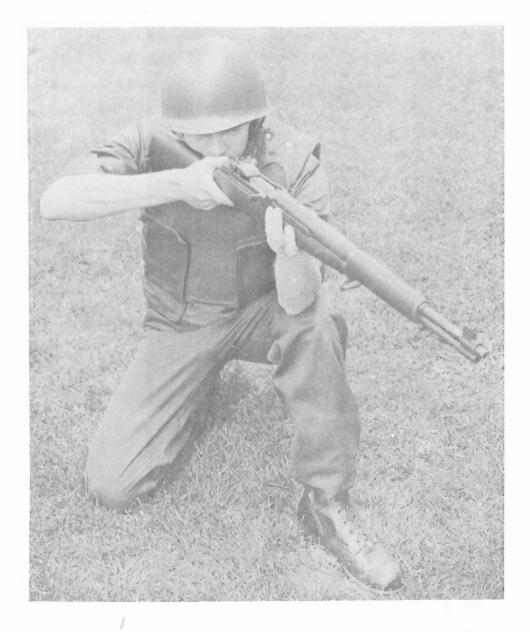


Figure 20. Model C, IITRI Integrated Jacket, Shoulder Articulation While Gymnasticating



Figure 21 Model C, IITRI Integrated Vest, Standing Firing Position



'Figure 22.

Model C, IITRI Integrated Vest, Kneeling Firing Position Note Articulation of Basic Garment at Waist



Model C, IITRI Integrated Vest, Prone Firing Position Figure 23.

Three models, D, E and F, were fabricated to demonstrate this concept.

#### <u>Model D</u>

Model D (Table 5; Figures 5, 24 and 25), which consists of rigid front, back, side and shoulder clements suspended in a carrier, simulates increased fragmentation protection to vital and nonvital torso areas. Coverage is provided from the iliac crest to the suprasternum in front and the iliac crest to the base of the neck in back.

The carrier is overhead donning with quick-release shoulder breaks. It is secured at the waist with overlapping straps and velcro fasteners.

# Model E

Model E (Table 6; Figures 6,26 and 27), which consists of rigid articulating front and back elements, shoulder and side elements suspended in a carrier, simulates increared fragmentation protection. Coverage is provided from the iliac crest to suprasternum in front and from the iliac crest to the base of the neck in back. The articulation of the front and rear elements aids in bending by adding flexibility to the clements.

The carrier is overhead donning with quickrelease shoulder breaks. It is secured at the waist with overlapping flaps and velcro fasteners.

The front and back clements are similar to those used with Model B, Concept 1.

Model F

Model F (Table 7; Figures 7 and 8) consists of Models D and E worn in combination with Models G and H of Concept 3 as overlays.

C. <u>Concept 3</u>

「たい」のないないたちになるのでいた。「「「「「「」」」の「」」「「」」」」」

Concept 3 (Tables 8 and 9) utilizes a basic flexible garment which can accept an overlay of rigid ballistic elements. The basic garment is capable of providing low-level fragmentation protection to vital and nonvital torso areas. The protection of vital areas can be selectively upgraded

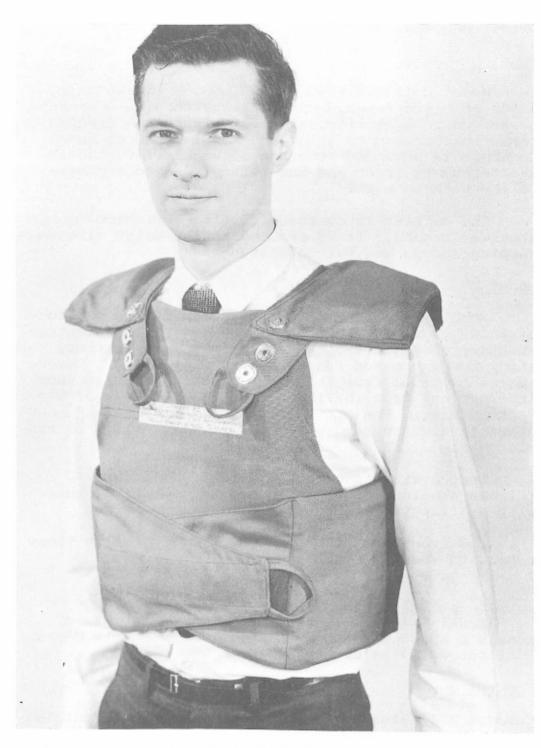


Figure 24. Model D, IITRI Rigid-Element Jacket, Nonarticulated, Overhead Donning

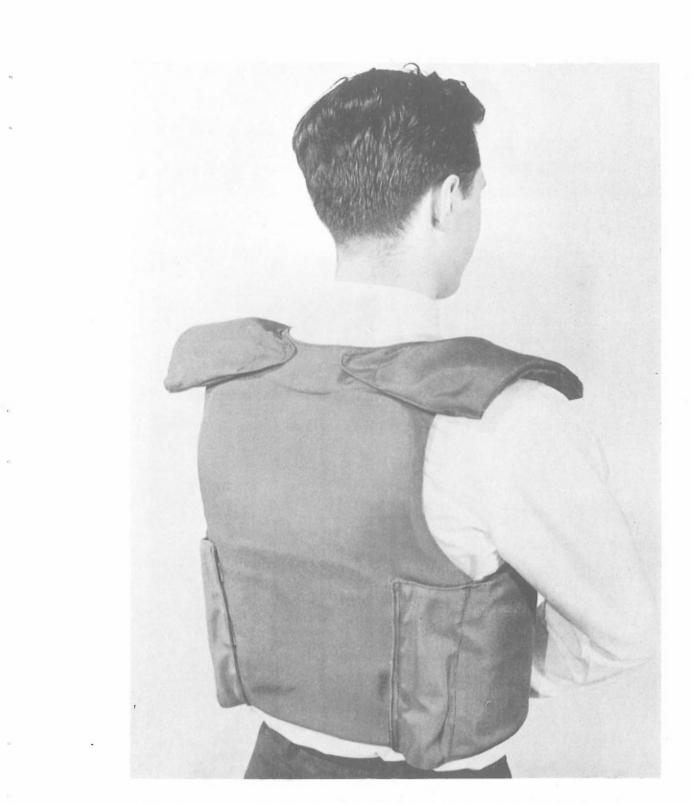


Figure 25. Model D, IITRI Rigid-Element Jacket, Rigid Single-Piece Rear Element

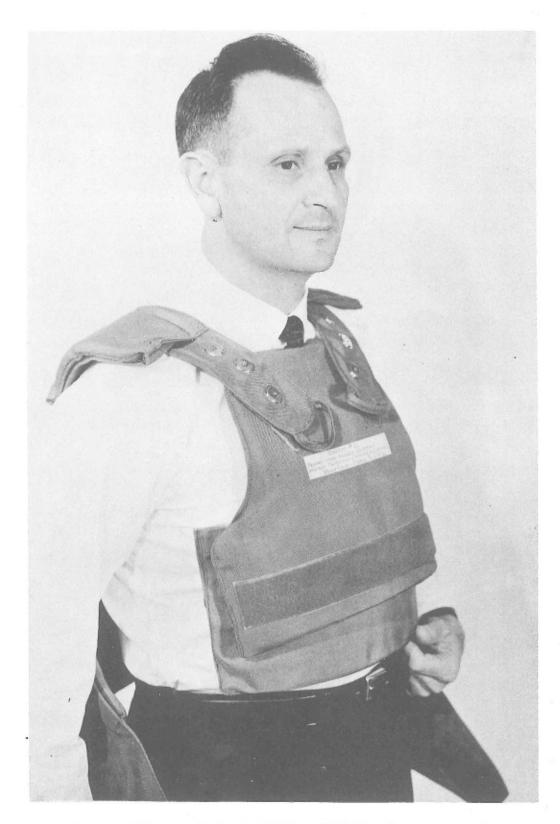


Figure 26. Model E, IITRI Rigid-Element Jacket, Articulated, Overhead Donning



Figure 27. Model E, IITRI Rigid-Element Jacket, Rigid Articulated Rear Elements

to defend against increased fragmentation or small arms by an overlay of rigid ballistic elements suspended in an independent carrier.

Both area coverage and levels of protection can be varied. This feature permits the user to optimize weight in the selection of a system to protect against an anticipated hazard.

Another feature of the overlay concept is that the user does not have to remove the basic garment when changing levels of protection. The overlay can also be quickly doffed compared with the time required to remove pocketed elements.

The overlay concept has the disadvantage of being a twogarment system requiring additional fasteners and closures as compared with a single-garment system.

Two models, G and H, were fabricated to demonstrate the workability of this concept. These models are used with the basic garments for models A and C.

#### Model G

Model G (Table 8; Figure 9) consists of rigid front and back elements suspended in a carrier and simulates small arms protection, 6-7 psf. Coverage is provided from the iliac crest to the suprasternum in front and the iliac crest to the base of the neck in back.

The carrier is overhead donning with shoulder breaks for quick release. It is secured at the waist with overlapping straps and velcro fasteners.

#### Model H

Mcdel H (Table 9; Figures 10 and 28), which consists of rigid front and back elements externally fastened to a carrier, simulates small-arms protection. It differs from Model G in that area coverage has been reduced to provide front and back thoracic protection only.

The carrier is overhead donning with shoulder breaks for quick release. It is secured to the torso with overlapping straps and velcro fasteners.

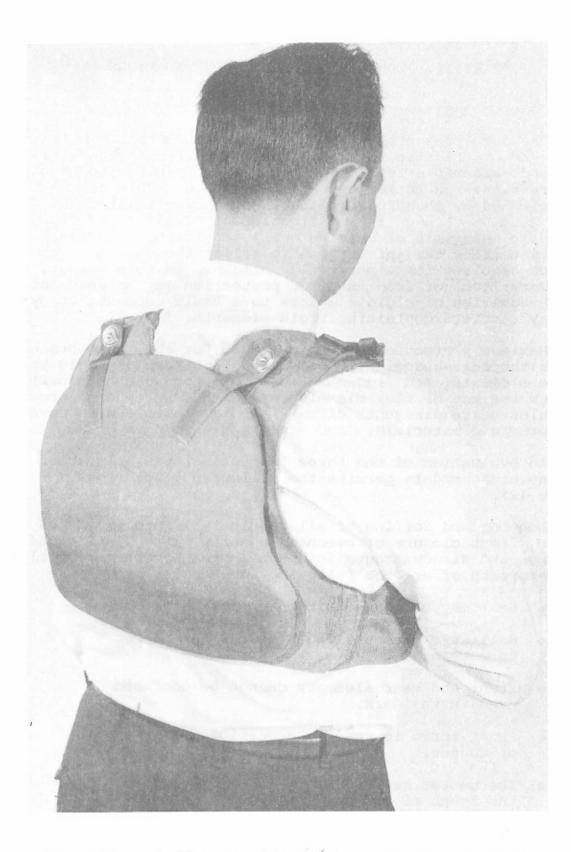


Figure 28. Rigid Rear Element Overlay, Reduced Area Coverage (Small-Arms Protection)

#### PART IV. CONCLUSIONS AND RECOMMENDATIONS

### A. <u>Conclusions</u>

The data presented in this report indicate that it is feasible and practicable to provide the infantryman with variable and selectable levels of ballistic protection to combat different hazards including small-arms fire. This can be accomplished by changing the ballistic characteristics of a basic garment through the application of flexible and rigid ballistic materials of varying areal densities. This variability enables the infantryman to select the degree of protection required for a particular hazard. In this manner, a primary level of fragmentation protection may be upgraded by the addition of rigid elements to a basic garment, or by overlay carriers containing rigid elements.

Maximum protection can be provided for the vital organs of the thoracic-abdominal torso through the use of rigid ballistic elements, and fragmentation protection can be provided through the use of flexible elements in the peripheral areas. Articulation requirements dictate the permissible area coverage for rigid materials.

An evaluation of the three concepts of variable armor and the eight models permits the following conclusions (Table 12).

Donning and doffing of all models fall into two categories, front closure or overhead donning, with distinct advantages and disadvantager for each approach. The front closure approach offers the following advantages:

- Vest may be donned without removing helmet.
- Ballistic elements are stable with respect to each other.
- Front and rear elements cannot be confused even in the dark.
- Front torso is readily accessible for treatment of wounds.
- The wearer may ventilate easily by opening the front of the garment.

Ta	b1	e	1	2
		_	_	

# EVALUATION OF VARIABLE ARMOR CONCEPTS AND MODELS

	) <b>3</b>	Concept		1			2			3
	Advantages	Model	A	В	С	D	E	F	G	H
1	One garment system		x	x	х					
2	Easily donned		х	x	х	х	х	х	x	x
3	Easily doffed		x	x	x	х	x	x	x	x
4	Level of protection be changed without a moving basic garment	re-							x	x
5	Reduced bulk		х	х	х					
6	Basic garment serve: padding	s as	x	x	x	10			x	x
7	Minimum restriction mobility and articu tion		х	x	x	x	x	x	x	x
	Disadvantages								••••	
1	Two-garment system					х	x	х	x	х
2	Helmet must be remove while donning	veđ		x	x	х	x	x	x	x
3	Basic garment must h removed to change le of protection		x	x	x					
4	No basic garment			2		x	x	х		
5	Increased bulk					x	x	x	x	x

The disadvantages of the front closure approach are as follows:

- Donning is difficult with heavy ballistic element in the jacket.
- Donning and doffing time is slow.
- The front closure requires some type of overlap at the juncture. This introduces additional bulk which detracts from comfort, and also obviates some of the benefits of the anatomical shape of the front torso armor.
- Protection is compromised when the front closure is opened.
- The jacket must be removed to change the back elements, thereby increasing the wearer's vulnerability.

Model A of Concept 1 (Figure 2) falls into the front closure category.

The overhead donning approach has the following advantages:

- The heavy elements can be handled more securely and balanced more readily while donning and doffing.
- The sides of the jacket may be opened for ventilating.
- Protection is not compromised when ventilating.
- Accessibility to anterior or posterior wounds is excellent because of the shoulder breaks and side fasteners which may be opened quickly and easily.
- Front and rear elements may be changed without removing the jacket.

The disadvantages of the overhead donning approach are as follows:

- The helmet must be removed while donning the jacket, thereby compromising protection of the wearer.
- Rotating the jacket on the wearer to change-back elements is time-consuming and difficult.

 It is possible to confuse front and rear elements when donning.

Models B through H fall into the overhead-donning category.

A significant conclusion which may be drawn from the preceding study is that a basic garment which utilizes flexible ballistic materials should be worn under or in conjunction with the heavier ballistic rigid elements. The effect of this padding improves comfort immeasurably, and the rigid elements need not fit the body as precisely. The basic garment provides peripheral protection, augmenting the coverage provided by the rigid elements. When the rigid elements are properly integrated with a basic garment, stability is provided with reduced bulk and maximum comfort.

Variability may be realized quickly and easily with a broad range of ballistic elements which may be selected to fit the particular hazard. Models A, B, C, G and H utilize a basic "low-level fragmentation" garment. Our conclusion is that the use of a basic garment is highly desirable. Whether the elements are integrated into the jacket or applied through the use of overlays, the basic garment is still desirable. The overhead-donning approach, in our estimation, is superior to the front-closure approach because of the case of donning and the increased stability of the jacket while wearing either front or rear elements alone.

The use of single-piece front and rear ballistic elements improves the ballistic integrity of the elements. Butting or overlapping of plates introduces vulnerable areas, increased complexity in design, and excessive bulk.

The integrated jacket (Model C, Figure 4) combines most of the desirable features required in a versatile and acceptable variable armor concept.

# B. <u>Recommendations</u>

The preceding effort has highlighted four areas germane to variable infantry armor which we feel merit future investigation and development work. The four areas are as follows:

# 1. Variability Design Studies

a. Design concepts or approaches which will simplify handling, insertion or attachment of ballistic elements to a carrier or basic garment.

- b. Approaches which will facilitate varying the protective elements more easily, particularly the rear ballistic element, without removal of the basic carrier.
- 2. <u>Closure and Suspension Design Study</u>
  - a. Investigate the possibility of combining the advantages of the overhead and sideclosure donning jackets into an aprontype closure jacket (Figure 29).
  - b. Improved closure approaches to facilitate rapid donning and doffing in normal and emergency conditions, including adaptability of the armor for medical treatment of the torso under combat conditions.
  - c. Closure approaches which will minimize vulnerability while varying elements, or while donning and doffing.
- 3. <u>Compatability Studies</u>
  - a. A study to establish whether the protective garments developed can be used in conjunction with the equipment normally carried by the infantryman. Items such as canteens, bedrolls, grenade and ammunition belts, weapons, and mess equipment must be considered since the efficiency of the fighting man must not be compromised through the use of protective clothing.
  - b. The possibility of developing an integrated carrier which uses a rigidized frame similar to a rucksack carrier, to which armored elements may be fastened quickly and easily to achieve variability (Figure 50).
- 4. Armor Configuration Studies
  - a. Investigate the possibility of using a basic carrier design and standardized rigid element configurations in other armor applications, such that a universal armor system approach applicable to all military services would be evolved.
  - b. Conduct operational studies to establish whether a universal armor system based on the variable armor concept would be practical for all services.

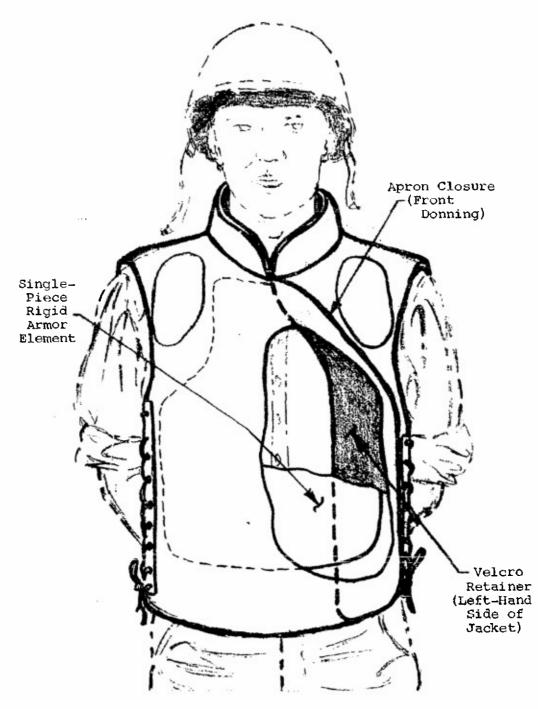


Figure 29. Recommended Variable Armor Concept, Apron Closure

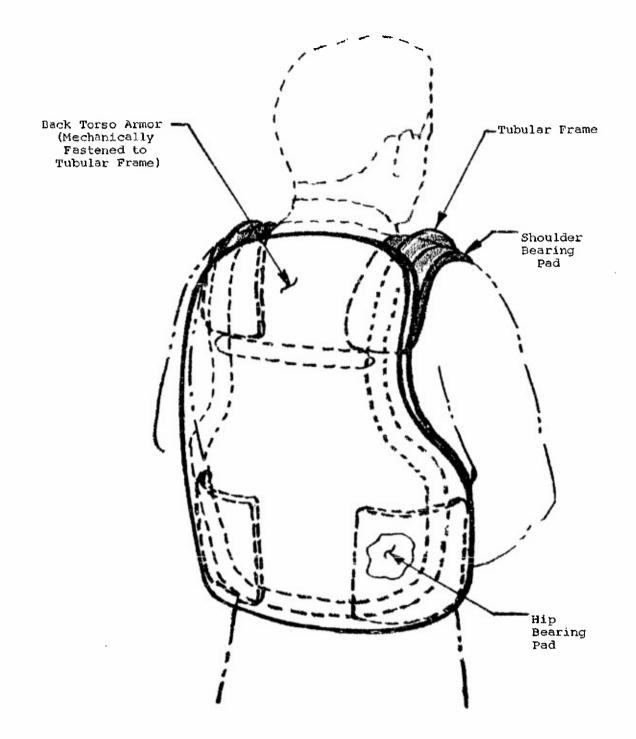


Figure 30. Projected Rigidized Frame Approach

dented billing the sound of the line of the

.

# REFERENCES

- 1. Weir, W.R., "Design and Development of an Articulated Armor Garment," USANL Technical Report TS-130, prepared by the IIT Research Institute under Contract DA19-129-QM-1809, March 1965.
- Holmes, Lieut. Col. Robert H., (MC, U.S. Army) "Wound Ballistics and Body Armor," J. Am. Med. Assoc. <u>150</u> No. 2, 1952.
- White, Robert M., "Reference Anthropometry of Army Men" USANL Technical Report EP-180, Environmental Protection Research Division, U.S. Army Natick Laboratories, Natick, Mass., September 1951.
- White, Robert M., "Anthropometry of Army Aviators," USANL Technical EP-150, Environmental Protection Research Division, U.S. Army Natis Laboratories, Natick, Mass., June 1961.
- McConville, John T., and Miller, Alexander, "Anthropometric Data in Three-Dimensional Form: Development and Fabrication of USA Height-Weight Manikins," AMRC-TDR-63-55, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio 1963.
- Pernini, H.M., "Research and Development of Aircrew Armor Systems, IIT Research Institute Proposal 65-727K, April 1965.

UNCIASSIFIED

Security Classification			
DOCUMENT CO (Security classification of title, body of abetract and indexi	NTROL DATA - R&D	ed when f	he overell taport is classified)
1. ORIGINATING ACTIVITY (Concerts outhor)			T SECURITY CLASSIFICATION
IIT Research Institute			inclassified
Chicego, Illinois 60616	20	GROUP	· · · · · · · · · · · · · · · · · · ·
3. REPORT TITLE			
RESEARCH DESIGN STUDY OF VARIABLE ARM	IOR CONCEPTS		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
Final Report 5. AUTHOR(S) (Lest name, first name, intile!)			
Rodzen, R., Scribano, F., Burns, M.,	Barron, E.R.		
6 REPORT ONTE	74. TOTAL NO. OF PAGE	E.	75. NO. OF REFS
December 1966	59		6
8. CONTRACT ON GRANT NO. DA-19-129-AMC-555(N) 6. project но. 1MG-24101-D503	94. ORIGINATOR'S REPO	SRT NUM	B α R(S)
e.		(F) (A	
	this report)	(3) (A NY	other numbers that may be seeigned
d.	67-40-CM	TS-14	48
This document may be further distributed approval of the Director, Clothing and Natick Jaboratories, Natick, Mass.	Orgenic Material 12. Sponsoning Militan	S DIV.	ision, U.S. Army
	U.S. Army Natic Natick, Mass.		oratories
13. ABSTRACT This program was directed towerd : Armor Concepts" which would provide so the infantryman. Concepts of variable were originated. Guidelines are sugges protective garments. They are not into portray the results of preliminary inv tigator to conduct a tr.de-off study wi proach in a finalized sy tem. Veriabil through several approaches.	elective and veri armor comprising sted for improved ended to suggest estigetion. Thes hich will form th	ieble diff i futu an op se res ne bas	levels of protection to erential protection re families of infantry timum design but to ults enable the inves- is for an optimum ap-
Rigid elements of verying ereel d sic ballistic garment. The basic garm fragmentation for the posterior and an pherel areas. Rigid or flexible eleme into e basic carrier resulting in diff low level fragmentation protection ar elements for the anterior and posterio organs from small erms fire. A basic low-level fragmentation protection is ing area densities and area coverage.	ent provides prot terior thoracic-a nts of verying ax erential protecti e provided in the r torso are emplo flexible garment combined with ove	tectio abdomi real d ion. F a peri oyed t for m erlay	n against low-level nal torso and peri- ensities are inserted lexible elements for pheral areas; rigid to protect the vital maximum coverege and rigid elements of vary.

DD .FORM 1473

1

.1

UNCLASSIBIED

Security Classification

ļ.,

1

The second s

10.11

.

Unclassified Security Classification

REP WORDS       note         Feasibility study       8         Armor       9         Variable armor concept       9         Protective clothing       1         Military personnel       1         Armod Forces equipment       1         ORIGINATING ACTIVITY: Enter the name and address researching or the organization (concrete studie) in the contractor, subcontextor, grantes, Department of Demes activity or other organization (concrete studie) in aggred by security included markings have been used for other argent in aggred to security regulations.       10. AVAILABILITY/ listicons of further di nergort aggregation in a gregori aggregation in all capital is in promotes a subord of the apport, aggregation in all capital is propriate security regulations.       10. AVAILABILITY/ listicons of the apport, aggregation in a gregori.       10. AVAILABILITY/ listicons of the apport is aggregation in aggregation in aggregation in a gregori.         AUTHOR(S): Exter the uname(i of a subord) as shown on the proprise aggregation in all capital is project aggregation in all capital is project aggregation.       11. We report has a subord of services. The name of the proprise, entri is a project aggregation.         AUTHOR(S): Exter the uname(i of subord) as stown on former active in proprise, entri is all capitaggregation proced by security.       11. We report has ag	A	LINK B		LINKC	
Armor       9         Variable armor concept       9         Protective clothing       1         Military personnel       1         Armod Forces equipment       1         Armod Forces equipment       1         ORIGINATING ACTIVEY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mes activity of other organization (conposed euron) issuing as FEPORT SECURTY CLASSIFICATION: Enter the over the report as for a programment is the proof.       10. AVAILABILITY, issuing of the programment is the proof.         ORIGINATING ACTIVEY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mes activity of other organization (conposed euron) issuing is report to grant and is a subcord on a subcontract is a programment is the proof.       10. AVAILABILITY, issuing a subcontractor grantee, Department of De- report issuing is to be in acyord.         ORGUNATING ACTIVE NOTES: Enter the total function in sill cases should be unclassified- in eroor on the issuing and issuing in the proof.       10. AVAILABILITY, issuing a subcontractor grantee, Department or proof.         ORGUNATING ACTIVE NOTES: H sproprise, enter in the report.       10. AVAILABILITY, issuing a subcontractor is subcontractor in the report.       10. AVAILABILITY, issuing a subcontractor is subcontractor in the report.         . ATDHOR(S): Enter the using of subcontractor is subcontractor is subcontractor is subcontractor.       10. SUPLEMENT/ tory notes.         . ATDHOR(S): Enter the using of subcontractor grant under whichis in thereport.       11. SUPONSONINO M the	WT	ROLE	ΨT	ROLE	٣T
Armor       9         Variable armor concept       9         Protective clothing       1         Military personnel       1         Armod Forces equipment       1         Armod Forces equipment       1         ORIGINATING ACTIVEY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mes activity of other organization (conposed euron) issuing as FEPORT SECURTY CLASSIFICATION: Enter the over the report as for a programment is the proof.       10. AVAILABILITY, issuing of the programment is the proof.         ORIGINATING ACTIVEY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mes activity of other organization (conposed euron) issuing is report to grant and is a subcord on a subcontract is a programment is the proof.       10. AVAILABILITY, issuing a subcontractor grantee, Department of De- report issuing is to be in acyord.         ORGUNATING ACTIVE NOTES: Enter the total function in sill cases should be unclassified- in eroor on the issuing and issuing in the proof.       10. AVAILABILITY, issuing a subcontractor grantee, Department or proof.         ORGUNATING ACTIVE NOTES: H sproprise, enter in the report.       10. AVAILABILITY, issuing a subcontractor is subcontractor in the report.       10. AVAILABILITY, issuing a subcontractor is subcontractor in the report.         . ATDHOR(S): Enter the using of subcontractor is subcontractor is subcontractor is subcontractor.       10. SUPLEMENT/ tory notes.         . ATDHOR(S): Enter the using of subcontractor grant under whichis in thereport.       11. SUPONSONINO M the	1		[		
Armor     9       Variable armor concept     9       Protective clothing     1       Military personnel     1       Armed Forces equipment     1       ORIGINATING ACTIVITY: Enter the name and address     1       ORIGINATING ACTIVITY: Enter the name and address     1       Inscrute classification of the reports.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report.       Inscrute classification of the report.     10. AVAILABILITY, the origination of the report is a capacity of the origination.       Inscrute classification of the report is a solutor.     10. AVAILABILITY, the origination of the report is a solutor.       Inscrute classification is all capatals in proceed as subort.     10. AVAILABILITY, the origination proceed without classification.       Inscrute classification is all capatals in proceed as subort.     10. AVAILABILITY, the origination proceed without classification.   <			1		1
Variable armor concept       9         Variable armor concept       9         Protective clothing       14         Nilltary personnel       14         Armed Forces equipment       14         ORIGINATING ACTIVITY: Enter the name and address in the contract, subcontractor, grantee, Department of De- rese activity or other organization (concortet author) issuing are report.       10         A REPORT SECURTY CLASSIFICATION: Enter the over- the security classification of the report. Indicate whether report the contract of subcondib studies in a security is classification of the report. Indicate whether report me with appropriate security regulations.       10       AVAILABILITY/ itations on further its increases.         ORIGINATING ACTIVITY: Enter the complete report.       10       AVAILABILITY/ itations of the security report.         0. GROUP: Autonatic downgreding is specified in DoD Di- crease.       10       AVAILABILITY/ itations of the security report is a security regulations.         0. REPORT TILE? Enter the complete report as author.       11       Content the classified in port direction in the report.         0. DESCRIPTVE NOTES It spropriate, enter the typ: on, show ithe classified in procedures, i.e., enter the prime outhor is an about the minimum requirement.       11         0. AUTHOR(S): Enter the usame(s) of author(s) as show on in the report.       13. USPFLEMENTS iter of a dec of publication.       13. USPFLEMENTS iter of a dec of publication.         0. MOMBER OF REFERENCES: Enter the total page count heri				Į	l
Variable armor concept       9         Protective clothing       4         Nilitary personnel       4         Armed Forces equipment       4         ORIGINATING ACTIVITY: Enter the name and address resort.       10         ORIGINATING ACTIVITY: Enter the name and address resort.       10         ORIGINATING ACTIVITY: Enter the name and address resort.       10         Armed Forces equipment       11         Armed Forces equipment       10         ORIGINATING ACTIVITY: Enter the name and address resort.       10         ACHORACT subcontractor, grantation (corporere curbor) issuing a resort of the organization (corporere curbor) issuing a resort of the organization of the report.       10         A EEPORT SECURTY CLASSIFICATION: Enter the oversit a compose of the address of the superstate security regulations.       10         A REPORT THILE: Enter the compfete report tile in all resorts build be unclassified.       11         A DESCREPTIVE NOTES II sporopriate, enter the try: of the the classified in intimum requirement.       11         AUTHORSY: Enter the table of the report as day, fonth, was, or momth, year. If more than one date supersort.       13. USPPLEMENTS         A. WOMBER OF REFERENCES: Enter the total number of the contract or grant under which the document will be identified of the information.       13. USPTROCT: Enter and the secort or grant under which the adjord was written.         A. CRICHARCY OR CRANT NUMERE Ent	1				
Protective clothing       4         Nilitary personnel       4         Armed Forces equipment       4         Armed Forces equipment       4         ORIGINATING ACTIVITY: Enter the name and address       10. AVAILABILITY         Instructor, subcontractor, granizeto, Department of Demas activity or other organization (corporate eacthor) issuing that and the disting on other organization (corporate eacthor) issuing the security regulations.       10. AVAILABILITY         A REPORT SECURTY CLASSEFICATION: Enter the over- mes with appropriate scenarity regulations.       10. AVAILABILITY         A REPORT SECURTY CLASSEFICATION: Enter the over- ced.       10. AVAILABILITY, U.S. Gove this report and the security regulations.         B REPORT THLE: Enter the complete report tills in all certure 5200.10 and Armed Forces Inducties whether report direct association in sil capitals in pro- entities could be and activity for the security regulations.       10. AVAILABILITY, W.S. Gove this report direct shall requer         B REPORT THLE: Enter the complete report tills in all certures 500.10 and Armed box be of publics to nor time of in the report. Enter isst neme, first neme, of the port, is an absolute minimum requirement.       11. SUPPLEMENTY try notes.         AUTHOR(S): Enter the stand or the department inuber of pages containing information.       11. SUPPLEMENTY try notes.         A. NOMER OF REFERENCES: Enter the total number of the report.       11. additional so the report.         A. ONTRACT OR GRANT NUMERE (S): Enter the oring index entries for cation in the report num					
Protective clothing       4         Nilitary personnel       4         Armed Forces equipment       4         Armed Forces equipment       4         Instructions       4         ORIGINATING ACTIVITY: Enter the name and address       10. AVAILABILITY         It contractor, subcontractor, grantze, Department of Demas activity or other organization (corporate scatchor) issuing       10. AVAILABILITY         It security classification of the report.       10. AVAILABILITY         It security classification (corporate catchor) issuing       10. AVAILABILITY         It security classification is classifications.       10. AVAILABILITY         It security classification (corporate catchor) issuing       10. AVAILABILITY         It security classification is classifications.       10. AVAILABILITY         It security classification is classifications.       10. AVAILABILITY         It security classification is classifications.       10. AVAILABILITY         It security classification sentof       10. Secondations     <					
Nilitary personnel       4         Armed Forces equipment       4         Armed Forces equipment       4         ORIGINATING ACTIVITY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mess activity or other organization (corporete cuthor) issuing a REPORT SECURTY CLASSIFICATION: Enter the over it security or classification of the report. Indicate whether Restricted Data <sup>11</sup> is included. Marking is to be in accord- its report, automatic downgrading is specified in DD DI- ced.       10. AVAILABILITY/ itations on further dis- incluses         0. GREORT SECURTY CLASSIFICATION: Enter the over it security or land Armed Forces Inductate whether Restricted Data <sup>11</sup> is included. Marking is to be in accord- is on aning the for Group 3 ecd Group 4 as author- ed.       10. AVAILABILITY/ itations on further dis- incluses         0. GREORT THLE: Enter the complets report title in all operit (sp. interim, progress, summery, annual, or final. its the report is an absorb to selected without - lensifica- shall teques       (3) "U. S. Gow this report direction shall reques         (3) MUBCS(): Enter the uame(s) of author(s) as shown on in the report, use date of public/clino. a. TOTAL NUMBER OF PAGES. The total page count heudbol number of public/clino. be applicable numbers, i.e., enter the application is all-approprise, enter he application procedures h.e., enter the anther oport. So appert enter oport was written.       11. SUPPLEMENT/ fory notes.         13. USTRACT: ENC. interport MACT TOR GRANT NUMBER: Enter the appropriate end with a indication interport number, system numbers, i.e., enter the application langer of the contract or grant under which enexplored numbers, tasks number, etc. a. ORIGNATOR'S REPORT NUMBER(	1				
Military personnel       4         Armed Forces equipment       5         A REPORT SECURTY CLASSEFICATION: Enter the oreas equipment       6         Armed Forces foulded Marking Is to be in accord       5         Armed Forces foulded Marking Is to be in accord       6         Armed Forces foulded Marking Is to be in accord       6         AREPORT THLE: Enter the complete report title in all apitel ietters. Titles In stll cases should be unclassified.       10         Arthort, GS: Enter the sume(s) of author(s) as shown on in the report. Inter Isst neme, first name, middle initiel.       11         Instruction.       6       NUBBER OF PACES. The total page couth the determent were foreacces containing aufornation.       13. USTRUCTIONS         AUTHOR(S): Enter the use of the copters is day, ionthy yeac; or month, year; or month, year; for the conthact or gr					
Armed Forces equipment Armed Forces equipment (Armed Forces equipment) (Armed Forces equipment) (Armed Forces equipment) (Armed Forces equipment) (Armed Forces equipment) (Armed Forces for exports extractor, subcontractor, grantee, Department of De- mes activity or other organization (corporete extrolor lisuing as REPORT SECURTY CLASSEFICATION: Enter the organization for there in more with appropriate security regulations. (AREPORT SECURTY CLASSEFICATION: Enter the organization for the report. (AREPORT SECURTY CLASSEFICATION: Enter the organization for the report. (AREPORT THILE: Enter the complete report title in all apital letters, Titles In sil cases should be unclassified. a meaningful title cannot be selected without -leastfice- on, show title classification in sil capitals in prembersis mediately following the title. (AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report. Enter the street is a properiate, enter the super- a, TOTAL, NUMBER OF PAGES. The total page count hould follow ronnal pagination procedures, L.e., enter the appent was written. (ANTHOR OR GRANT NUMBER: Enter the total page count hould follow ronnal pagination procedures, L.e., enter the appent was written. (ANTHOR OR GRANT NUMBER: Enter the total page count hould follow ronnal pagination procedures, L.e., enter the appent was written. (ANTHOR OR GRANT NUMBER: Enter the total page count hould follow ronnal pagination procedures, L.e., enter the appent was written. (ANTHOR OR GRANT NUMBER: Enter the total page count hould follow ronnal pagination procedures, L.e., show ranks and branchot a grant under which is highly dealing and controlled by the originating activity. This number musch (ANTHOR'S REPORT NUMBER(S): If the report has been shall be attrached. (ANTHOR'S REPORT NUMBER(S): If the originator and controlled by the origination gravity. This number musch (ANTHOR'S REPORT NUMBER(S): If the originator (ANTHOR'S REPORT NUMBER(S): If the report has beren shighed any other report nu			1		
<ul> <li>INSTRUCTIONS</li> <li>ORIGINATING ACTIVITY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mase activity or other organization (corporate author) issuing as REPORT SECURITY CLASSIFICATION: Enter the over- it security classification of the report. Indicate whether Restricted Dutat" is included. Marking is to be in aggord- mee with appropriate security regulations.</li> <li>(1) "Qualified r report form I report automatic downgrading is specified in DoD Di- sective S200.10 and Armed Forces Industrial Manual, Enter are group, number. Also, when splicable, show that option unditally following the title.</li> <li>DESCRIPTIVE NOTES: If sppropriate, enter the type of a meaningful title cannot be selected without classified- port, or, g., itterim, progress, summery, annual, or final ive the inclusive datos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report, use date of publication.</li> <li>TEPORT DATE: Enter the date of the report as day, ionth, yaac, or month, yeas. If more than one date uppears in the report, use date of publication.</li> <li>CONTACT OR GRANT NUMBER: Enter the total page count hould follow normal pagination procedures, i.e., enter the umber of pages containing information.</li> <li>CONTACT OR GRANT NUMBER: Enter the total number of the applicable number of the contract or grant under which information in a. CONTACT OR GRANT NUMBER: Enter the appropriate, enter the applicable numbers of the contract or grant under which at controlle by the originating activity. This unmber must of the information in signed any other report numbers (sither by the aponson), also enter this number(s).</li> </ul>					
<ul> <li>INSTRUCTIONS</li> <li>ORIGINATING ACTIVITY: Enter the name and address (the contractor, subcontractor, grantee, Department of De- mase activity or other organization (corporate author) issuing as REPORT SECURITY CLASSIFICATION: Enter the over- it security classification of the report. Indicate whether Restricted Dutat" is included. Marking is to be in aggord- mee with appropriate security regulations.</li> <li>(1) "Qualified r report form I report automatic downgrading is specified in DoD Di- sective S200.10 and Armed Forces Industrial Manual, Enter are group, number. Also, when splicable, show that option unditally following the title.</li> <li>DESCRIPTIVE NOTES: If sppropriate, enter the type of a meaningful title cannot be selected without classified- port, or, g., itterim, progress, summery, annual, or final ive the inclusive datos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report, use date of publication.</li> <li>TEPORT DATE: Enter the date of the report as day, ionth, yaac, or month, yeas. If more than one date uppears in the report, use date of publication.</li> <li>CONTACT OR GRANT NUMBER: Enter the total page count hould follow normal pagination procedures, i.e., enter the umber of pages containing information.</li> <li>CONTACT OR GRANT NUMBER: Enter the total number of the applicable number of the contract or grant under which information in a. CONTACT OR GRANT NUMBER: Enter the appropriate, enter the applicable numbers of the contract or grant under which at controlle by the originating activity. This unmber must of the information in signed any other report numbers (sither by the aponson), also enter this number(s).</li> </ul>			}		
<ul> <li>ORIGINATING ACTIVITY: Enter the name and address if the contractor, subcontractor, grantee, Department of Demans activity or other organization (corporete author) issuing it ations on further disimposed by security a subcontractor. Subcontractor, Barbon is subcontracted.</li> <li>a. REPORT SECURITY CLASSIFICATION: Enter the overative stations of the report. Indicate whether report. Indicate whether report is propriate security regulations.</li> <li>b. GROUP: Automatic downgrading is specified in DoD Districtive S200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when splicable, show that opticable, show that opticable, show that opticable.</li> <li>c. REPORT TITLE: Enter the complete report title in all apitel iettera. Titles in sill cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lausifice-" on, show title classification in sill capitals in promethesis mendiately following the title.</li> <li>c. DESCRIPTIVE NOTES: If spropriate, enter the type of a some of the report. Enter the some, first mame, middle inlited. Training progress, summery, annual, or final. Invertee in clusive detos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uname(s) of author(s) as shown on it in the report. Enter the some chat spects and entime principal ewhor is an absolute minimum requirement.</li> <li>REPORT DATE: Enter the date of the report as day, both, year, or month, year. If more than one date spects and the department identification.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the total number of the report. Subtem numbers, task mumber, etc.</li> <li>CONTRACT OR GRANT NUMBER: Enter the officiation of the information is a proper termine in the report. Subtem numbers, task mumber, etc.</li> <li>B. OTHER REPORT NUMBER(S): If the report has been signed any other r</li></ul>				ł	ł
<ul> <li>ORIGINATING ACTIVITY: Enter the name and address if the contractor, subcontractor, grantee, Department of Demans activity or other organization (corporete author) issuing it ations on further disimposed by security a subcontractor. Subcontractor, Barbon is subcontracted.</li> <li>a. REPORT SECURITY CLASSIFICATION: Enter the overative stations of the report. Indicate whether report. Indicate whether report is propriate security regulations.</li> <li>b. GROUP: Automatic downgrading is specified in DoD Districtive S200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when splicable, show that opticable, show that opticable, show that opticable.</li> <li>c. REPORT TITLE: Enter the complete report title in all apitel iettera. Titles in sill cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lausifice-" on, show title classification in sill capitals in promethesis mendiately following the title.</li> <li>c. DESCRIPTIVE NOTES: If spropriate, enter the type of a some of the report. Enter the some, first mame, middle inlited. Training progress, summery, annual, or final. Invertee in clusive detos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uname(s) of author(s) as shown on it in the report. Enter the some chat spects and entime principal ewhor is an absolute minimum requirement.</li> <li>REPORT DATE: Enter the date of the report as day, both, year, or month, year. If more than one date spects and the department identification.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the total number of the report. Subtem numbers, task mumber, etc.</li> <li>CONTRACT OR GRANT NUMBER: Enter the officiation of the information is a proper termine in the report. Subtem numbers, task mumber, etc.</li> <li>B. OTHER REPORT NUMBER(S): If the report has been signed any other r</li></ul>					
<ul> <li>ORIGINATING ACTIVITY: Enter the name and address if the contractor, subcontractor, grantee, Department of Demans activity or other organization (corporete author) issuing it ations on further disimposed by security a subcontractor. Subcontractor, Barbon is subcontracted.</li> <li>a. REPORT SECURITY CLASSIFICATION: Enter the overative stations of the report. Indicate whether report. Indicate whether report is propriate security regulations.</li> <li>b. GROUP: Automatic downgrading is specified in DoD Districtive S200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when splicable, show that opticable, show that opticable, show that opticable.</li> <li>c. REPORT TITLE: Enter the complete report title in all apitel iettera. Titles in sill cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lausifice-" on, show title classification in sill capitals in promethesis mendiately following the title.</li> <li>c. DESCRIPTIVE NOTES: If spropriate, enter the type of a some of the report. Enter the some, first mame, middle inlited. Training progress, summery, annual, or final. Invertee in clusive detos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uname(s) of author(s) as shown on it in the report. Enter the some chat spects and entime principal ewhor is an absolute minimum requirement.</li> <li>REPORT DATE: Enter the date of the report as day, both, year, or month, year. If more than one date spects and the department identification.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the total number of the report. Subtem numbers, task mumber, etc.</li> <li>CONTRACT OR GRANT NUMBER: Enter the officiation of the information is a proper termine in the report. Subtem numbers, task mumber, etc.</li> <li>B. OTHER REPORT NUMBER(S): If the report has been signed any other r</li></ul>					
<ul> <li>ORIGINATING ACTIVITY: Enter the name and address if the contractor, subcontractor, grantee, Department of Demans activity or other organization (corporete author) issuing it ations on further disimposed by security a subcontractor. Subcontractor, Barbon is subcontracted.</li> <li>a. REPORT SECURITY CLASSIFICATION: Enter the overative stations of the report. Indicate whether report. Indicate whether report is propriate security regulations.</li> <li>b. GROUP: Automatic downgrading is specified in DoD Districtive S200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when splicable, show that opticable, show that opticable, show that opticable.</li> <li>c. REPORT TITLE: Enter the complete report title in all apitel iettera. Titles in sill cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lausifice-" on, show title classification in sill capitals in promethesis mendiately following the title.</li> <li>c. DESCRIPTIVE NOTES: If spropriate, enter the type of a some of the report. Enter the some, first mame, middle inlited. Training progress, summery, annual, or final. Invertee in clusive detos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uname(s) of author(s) as shown on it in the report. Enter the some chat spects and entime principal ewhor is an absolute minimum requirement.</li> <li>REPORT DATE: Enter the date of the report as day, both, year, or month, year. If more than one date spects and the department identification.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the appropriate, enter the sport was written.</li> <li>B. ONTRACT OR GRANT NUMBER: Enter the total number of the report. Subtem numbers, task mumber, etc.</li> <li>CONTRACT OR GRANT NUMBER: Enter the officiation of the information is a proper termine in the report. Subtem numbers, task mumber, etc.</li> <li>B. OTHER REPORT NUMBER(S): If the report has been signed any other r</li></ul>					1
<ul> <li>I the contractor, subcontractor, grantee, Department of Demans activity or other organization (comporer author) issuing the report.</li> <li>a. REPORT SECURTY CLASSIFICATION: Enter the overality security regulations.</li> <li>b. GROUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>b. GROUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>c. GREUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>c. REPORT TITLE: Enter the complete report title in all apital letters. Titles in sil cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lassifice" on, show title classification in sil capitals in promites in the report. Grifts and the selective detos when a specific reporting period is worred.</li> <li>AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report. Buter last neme, first name, middle initial. If the report has the alter of the croperts as day, bonth, year, or month, year. If more than one date appears in the report.</li> <li>a. COTTACT OR GRANT NUMBER: Enter the total number of pages containing information.</li> <li>b. ONMBER OF PACEES: Enter the total number of the contract or grant under which he application and the report.</li> <li>a. ORIGINATOR'S REPORT NUMBER: Enter the appropriste, enter the suggested in the report.</li> <li>b. ORIER REPORT NUMBER(S): If the report has been saigned any other reput numbers (either by the originator r by the Aponsor), also enter this number(s).</li> </ul>					<u> </u>
<ul> <li>I the contractor, subcontractor, grantee, Department of Demans activity or other organization (comporer author) issuing the report.</li> <li>a. REPORT SECURTY CLASSIFICATION: Enter the overality security regulations.</li> <li>b. GROUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>b. GROUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>c. GREUP: Automatic downgreding is specified in DoD Disctive S200.10 and Armed Forces Industrial Manual. Enter the group. Author discussified.</li> <li>c. REPORT TITLE: Enter the complete report title in all apital letters. Titles in sil cases should be unclassified.</li> <li>a meaningful title cannot be selected without "lassifice" on, show title classification in sil capitals in promites in the report. Grifts and the selective detos when a specific reporting period is worred.</li> <li>AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report. Buter last neme, first name, middle initial. If the report has the alter of the croperts as day, bonth, year, or month, year. If more than one date appears in the report.</li> <li>a. COTTACT OR GRANT NUMBER: Enter the total number of pages containing information.</li> <li>b. ONMBER OF PACEES: Enter the total number of the contract or grant under which he application and the report.</li> <li>a. ORIGINATOR'S REPORT NUMBER: Enter the appropriste, enter the suggested in the report.</li> <li>b. ORIER REPORT NUMBER(S): If the report has been saigned any other reput numbers (either by the originator r by the Aponsor), also enter this number(s).</li> </ul>		-	NOTION	. Bailan	
<ul> <li>a. REPORT SECURTY CLASSIFICATION: Enter the overalt security classification of the report. Indicate whether report directive 5200.10 and Armed Forces Industrial Manual. Enter the socurity regulations.</li> <li>b. GROUPF: Automatic downgrading is specified in DoD Ditective 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when splicible, show that optional arkings have been used for Group 3 and Group 4 as author.</li> <li>c. REPORT TITLE: Enter the complete report till in all upital lettera. Titles in sill cases should be unclassified.</li> <li>a. REPORT TITLE: Enter the complete report tills in all cases should be unclassified.</li> <li>a. DESCRIPTIVE NOTES: If sppropriate, enter the typ: of a south or in the report. Use date of publication.</li> <li>A. TOTAY. NUMBER OF PAGES: The total page count hould follow normal pagination procedures, i.e., anter the applicable number of the report.</li> <li>b. CNUMBER OF PAGES: The total page count hould follow normal pagination procedures, i.e., anter the applicable number of the report.</li> <li>c. CONTRACT OR GRANT NUMBER: If appropriste, enter the appropriste of the contract or grant under which he applicable number of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers of the contract or grant under which he applicable numbers, (sicher by the originating activity. This number must ever, the suggested is what a suce as equipared to other approxit. The o</li></ul>	lissemina	tion of	the report	rt, other th	nan tho
<ul> <li>a. REPORT SECURTY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether restit security classification of the report. Indicate whether restit security classification. Secure 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when splicible, show that optional undrings have been used for Group 3 and Group 4 as authorated.</li> <li>a. REPORT TITLE: Enter the complete report title in all spital lettera. Title an sel in cases should be unclassification. A maningful title cannot be selected without "lassification, show title classification in sil cases should be unclassified in the report.</li> <li>b. OESCRIPTIVE NOTES: If spropriate, enter the type of a ges containing anformation.</li> <li>c. AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report, use date of publication.</li> <li>a. TOTAL. NUMBER OF PAGES. The total page count hould follow normal pagination procedures, i.e., enter the use also appear to the application in sufferences cited in the report.</li> <li>a. CONTRACT OR GRANT NUMBER: If approprise, enter the appropriate of the contract or grant under which he application low morel of the contract or grant under which he application in summers, etc.</li> <li>a. ORIGINATOR'S REPORT NUMBER(S): If the report has been signed any other reput numbers (eicher by the origination a reput to this report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been signed any other reput numbers (eicher by the origination are of the origination a cities of the sponeor), also enter this number(s).</li> </ul>					
<ul> <li>It security classification of the report. Indicate whether</li> <li>Restricted Data" is included. Marking is to be in accord- noe with appropriate security regulations.</li> <li>(2) "Foreign an report by DI- ceitve 5200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as author- read.</li> <li>(3) "U. S. Gove this report by DI- ceitve 5200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as author- read.</li> <li>(4) "U. S. milit report directions is meaningful title cannot be selected without "lausifice- on, show title classification in sll capitals in p."enthesis mediately following the title.</li> <li>DESCRIPTIVE NOTES: If sppropriate, enter the type. "/ in the report. Enter the uame(s) of author(s) as shown on in the report, use date of publication.</li> <li>a. TOTA". NUMBER OF PAGES: The total page count hould folfow normal pagination procedures, i.e., enter the the apport, as date of publication.</li> <li>b. ONMBER OF REFERENCES: Enter the total number of ferences cited in the report.</li> <li>contract or Breger NUMBER: If appropriate, enter the aport number of the contract or grant under which he report number, system numbers, task number, etc.</li> <li>contract or MS REPORT NUMBER(S): Enter the offi- ial report numbers, system numbers, task number, etc.</li> <li>context The suggested at out the suggested and outrolled by the originating activity. This number must e unique to this report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been assigned any other reput numbers (either by the origination r by the sponear), also enter this number(s).</li> </ul>			abtain -	oniar of th	ai a
<ul> <li>(2) "Foreign an report is to be in according to be inclassified.</li> <li>(2) "Foreign an report by DE to be in according to be inclassified to be inclassified to a mean of the accurding to be accurding to be accurding to be accurding to the accurding to be accurding to the accurding to</li></ul>	DDC,"	rs may	obtain c	opies of ti	115
<ul> <li>3. COVER: Automatic downgrading is specified in DoD Discretive S200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when splicible, show that optional unkrings have been used for Group 3 and Group 4 as authorated.</li> <li>(3) "U. S. Gover this report discrete the complete report title in all apital letters. Titles in sil cases should be unclassified.</li> <li>(4) "U. S. millt report direct shall request the inclusion of the selected without "lausifice."</li> <li>(5) "All distribution of the contract or grant under which if the report has shown on r in the report. Enter the undre(s) of author(s) as shown on r in the report. Enter the undre(s) of author(s) as shown on r in the report. Enter the undre(s) of author(s) as shown on r in the report. Enter the undre(s) of author(s) as shown on r in the report. Enter the undre(s) of author(s) as shown on r. in the report. If more than one date topearts in the report, use date of publication.</li> <li>a. TOTAL. NUMBER OF PAGES: The total page count hould follow normal pagination procedures, i.e., enter the total number of the contract or grant under which he report.</li> <li>b. CONTRACT OR GRANT NUMBER: If appropriste, enter the splic able number of the contract or grant under which he report.</li> <li>b. ORGINATOR'S REPORT NUMBER: If appropriste, enter the signed any other report.</li> <li>b. OTHER REPORT NUMBER(S): Enter the official to a for the document will be identified ial report.</li> <li>c. ONTRACT OR MUMBER(S): If the report has been ssigned any other report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been ssigned any other report.</li> </ul>	nnouncer	ment an	d dissem	ination of	this
<ul> <li>active 5200.10 and Armed Forces Industrial Manual. Enter the group, number. Also, when spalicable, show that optional intrings have been used for Group 3 and Group 4 as authored.</li> <li>(3) "4U. S. Gover this report direct spatials in presentable in all spatial letters. Titles In sII cases should be unclassified. I a meaningful title cannot be selected without "lausification, show title classification in sII capitals in presentable.</li> <li>(4) "40. S. millit report direct shall request meaningful title cannot be selected without "lausification, show title classification in sII capitals in presentable.</li> <li>(5) "All distributed be unclassification.</li> <li>(6) "AUTHOR(S): Enter the uame(s) of author(s) as shown on the principal euthor is an absolute minimum requirement.</li> <li>(7) "All distributed bDC uservice. The name of the principal euthor is an absolute minimum requirement.</li> <li>(8) THER REPORT DATE: Enter the date of the report as day, ionth, year, or month, year. If more than one date speers in the report.</li> <li>(9) "All distributed bDC uservices. The name of the principal euthor is an absolute minimum requirement.</li> <li>(9) "All distributed bDC uservices. The name of the principal euthor is an absolute minimum requirement.</li> <li>(1) SUPPLEMENTY tory notes.</li> <li>(2) SPONSORING M the department of publication.</li> <li>(3) USSTRACT: Enter the date of the report is a shall be attached.</li> <li>(4) "All distributed bDC uservices. The name of the document which he applicable number of pages containing information.</li> <li>(3) NSTRACT: Enter the date of the report is a shall be attached.</li> <li>(4) "All distributed bDC uservices. The name of the document which he applicable number of pages containing information.</li> <li>(5) NUMBER OF PAGES: The total page count hould folfow normal pagination procedures, i.e., enter the date of the counter the due of the report.</li> <li>(6) Sc, &amp; Sd. PROJECT NUMBER: Enter the appropriate enter the suggested is a report.</li> <li>(7) O</li></ul>					
<ul> <li>a. REPORT TITLE: Enter the complete report title in all gapitel leiters. Titles in sll cases should be unclassified.</li> <li>a. REPORT TITLE: Enter the complete report title in all gapitel leiters. Titles in sll cases should be unclassified.</li> <li>(4) <sup>17</sup>U. S. millt report direct shall request signed any other report NUMBER (S): Enter the type of the department identification.</li> <li>b. NUMBER OF REFERENCES: Enter the total number of pages containing information.</li> <li>b. NUMBER OF REFERENCES: Enter the total number of pages containing information.</li> <li>c. CONTRACT OR GRANT NUMBER: Inter the appropriate, enter the isport so sopear e uniber of the contract or grant under which he application sockes. The spropriate, enter the signed any other report numbers (either by the originating activity. This number must (s).</li> <li>b. OTHER REPORT NUMBER(S): If the report has been ssigned any other reput numbers (either by the origination enter this number(s).</li> </ul>	ernment	igencie	es may ot	btain conie	es of
<ul> <li>ced.</li> <liced.< li=""> <li>ced.</li> <li>ced.</li> <li>ced.</li> <li>ced.<td></td><td></td><td></td><td>er querare</td><td></td></li></liced.<></ul>				er querare	
<ul> <li>a meaningful title cannot be selected without "lausifica."</li> <li>b DESCRIPTIVE NOTES: If sppropriate, enter the typ: "lipport, e.g., interim, progress, summery, annual, or final.</li> <li>c AUTHOR(S): Enter the uame(s) of author(s) as shown on in the report. Enter last name, first name, middle initial.</li> <li>c AUTHOR(S): Enter the uame(s) of author(s) as shown on it in the report. Enter last name, first name, middle initial.</li> <li>c AUTHOR(S): Enter the uame(s) of author(s) as shown on the principal euthor is an-absolute minimum requirement.</li> <li>c REPORT DATE: Enter the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication.</li> <li>a. TOTAL, NUMBER OF P AGES: The total page count hould follow normul pagination procedures, i.e., enter the total number of pages containing information.</li> <li>b. NUMBER OF REFERENCES: Enter the total number of the contract or grant under which he applicable number of the contract or grant under which he an indication in f(C), or (U).</li> <li>There is no limit ever, the suggestied al report number of the contract or grant under which ha indication fuel, he applicable number of the contract or grant under which ha indication fuel, he applicable number of the contract or grant under which he appropriate, and an indication in f(C), or (U).</li> <li>There is no limit ever, the suggestied al report number of which the document will be identified in text. The suggested as that no fiels, such as equip truy project code na selected so that no fiels, such as equip truy project code na selected so that no fiels.</li> </ul>		10			
<ul> <li>a meaningful title cannot be selected without "lausifica-" show title classification in sll capitals in p renthesis mediately following the title.</li> <li>b DESCRIPTIVE NOTES: If spiropriate, enter the type of inclusive datos when a specific reporting period is overed.</li> <li>AUTHOR(S): Enter the uame(s) of author(s) as shown on i in the report. Enter the uame(s) of author(s) as shown on i in the report. Enter the uame(s) of author(s) as shown on i in the report. Enter the uame first name, middle initial. I military, show rank and branch of service. The name of the principal eathor is an absolute minimum requirement.</li> <li>REPORT DATE: Entar the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, used ate of publication.</li> <li>A TOTAL. NUMBER OF PAGES: The total page count hould folfow normal pagination procedures, i.e., enter the tamber of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of seferences cited in the report.</li> <li>CONTRACT OR GRANT NUMBER: If appropriste, enter the applicable number of the contract or grant under which he report was written.</li> <li>Sciences cited in the report.</li> <li>CONTRACT OR GRANT NUMBER: Enter the appropriate initiary department luentification, such as project number, ubproject numbar, system numbers, task number, etc.</li> <li>CONTRACT OR GRANT NUMBER(S): Enter the offi- ial report. Mumber by which the document will be identified ind controlled by the originating activity. This number must e unique to this report.</li> <li>OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating a r by the sponsor), also enter this number(s).</li> </ul>	Itary agen	ncles m	ay obtain	n copies o	f this
<ul> <li>10.7, show title classification in sil capitals in p-renthésis in mediately following the title.</li> <li>DESCRIPTIVE NOTES: If sporopriate, enter the typ: -// is port, e.g., interim, progress, summery, annual, or final.</li> <li>11. Support, e.g., interim, progress, summery, annual, or final.</li> <li>11. AUTHOR(S): Enter the uame(s) of author(s) as shown on r in the report. Enter the uame(s) of author(s) as shown on r in the report. Enter the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication.</li> <li>A. TOTAL, NUMBER OF PAGES: The total page count hould folfow normul pagination procedures, i.e., enter the total number of pages containing information.</li> <li>A. NUMBER OF REFERENCES: Enter the total number of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing information.</li> <li>A. ONTAL, NUMBER OF PAGES: The total page count hould folfow normul pagination procedures, i.e., enter the appropriate differences cited in the report.</li> <li>B. ONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which he report was written.</li> <li>B. ORIGINATOR'S REPORT NUMBER(S): Enter the offlial report numbers, task number, etc.</li> <li>B. ORIGINATOR'S REPORT NUMBER(S): Enter the offlial report numbers which the document will be identified in (C), or (U). There is no limit ever, the suggestied any other repurt numbers (either by the originating activity. This number must equipate to this report.</li> <li>B. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating activity. This number must for easing the sponsor), also enter this number(s).</li> </ul>			Other qu	aliyied us	er s
<ul> <li>DESCRIPTIVE NOTES: If sppropriate, enter the type of the principal enthor is an absolute minimum requirement.</li> <li>AUTHOR(S): Enter the uame(s) of author(a) as shown on in the report. Enter the uame(s) of author(a) as shown on in the report. Enter the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication.</li> <li>ACONTAL NUMBER OF PAGES: The total page count hould folfow normal pagination procedures, i.e., enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REFERENCES: Enter the total number of pages containing unformation.</li> <li>NUMBER OF REPERENCES: Enter the total number of the applicable numbers, task number, etc.</li> <li>ORIGINATOR'S REPORT NUMBER(S): Enter the offlial report numbers, system numbers, task number, etc.</li> <li>ORIGINATOR'S REPORT NUMBER(S): If the report has been ssigned any other report numbers (either by the originating activity. This number must selected so that no fiels, such as equip truy project code na selected so that no fiels, such as equip truy project code na selected so that no fiels.</li> </ul>	est (inong	<u>g</u> n			
<ul> <li>initiant of the report.</li> <li>AUTHOR(S): Enter the uame(s) of author(a) as shown on i hat he report. Enter last name, first name, middle initial. i military, show rank and branch of service. The name of it principal euthor is an-absolute minimum requirement.</li> <li>REPORT DATE: Entar the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication.</li> <li>TOTAL, NUMBER OF PAGES. The total page count hould follow normul pagination procedures, i.e., enter the tamber of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of isferences cited in the report.</li> <li>CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which he report was written.</li> <li>Set, &amp; 8d. PROIECT NUMBER: Enter the appropriate ial report number by which the document will be identified al report. Heapartment luentification, such as project number, ubproject numbar, system numbers, task number, etc.</li> <li>ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report.</li> <li>OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating sciences), also enter this number(s).</li> </ul>	ibution of	f this re	mort is c	entrolled.	Oual-
<ul> <li>a. AUTHOR(S): Enter the name(s) of author(s) as shown on rin the report. Enter last name, first name, middle initial. Initiary, show rank and branch of service. The name of initiary, show rank and branch of service. The name of the principal euthor is an-absolute minimum requirement.</li> <li>b. REPORT DATE: Enter the date of the report as day, tory notes.</li> <li>c. TOTAL. NUMBER OF PAGES: The total page count hould follow normal pagination procedures, i. e., enter the the department alon procedures, i. e., enter the tumber of pages containing information.</li> <li>a. TOTAL. NUMBER OF PAGES: The total page count hould follow normal pagination procedures, i. e., enter the the department of the document with the department is number of the contract or grant under which he réport was written.</li> <li>b. 8d, 8d, PROJECT NUMBER: Enter the appropriate inflitary department identification, such as project number, ubbroject number, system numbers, task number, etc.</li> <li>a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified in report.</li> <li>c. ONTRACT OR GRANT NUMBER(S): Enter the official report number by which the document will be identified in the report.</li> <li>a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report numbers by which the document will be identified to report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating activity. This number must rips code na sequip truy project code na key words but will be context. The passigned any other repurt numbers (either by the origination in r by the sponsor), also enter this number(s).</li> </ul>					
If the report has r in the report. Enter list name, first name, middle initial. Inilitary, show rank and branch of service. The name of the principal eathor is an-absolute minimum requirement. REPORT DATE: Entar the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication. a. TOTAL NUMBER OF PAGES The total page count hould follow normul pagination procedures, i.e., anter the tumber of pages containing information. b. NUMBER OF REFERENCES Enter the total number of sferances cited in the report. a. CONTRACT OR GRANT NUMBER: If appropriate, anter he applicable number of the contract or grant under which he réport was written. b, &, &, & 8d. PROJECT NUMBER: Enter the appropriate illitary department identification, such as project number, ubproject numbar, system numbers, task number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating activity. This number side and other report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the origination scienced by the originating activity. This number must r r by the sponsor), also enter this number(s).					"
r in the report. Enter last name, first name, middle initial. I military, show rank and branch of service. The name of the principal eathor is an-absolute minimum requirement. REPORT DATE: Entar the date of the report as day, ionth, year, or month, year. If more than one date uppears in the report, use date of publication. A. TOTAL. NUMBER OF PAGES. The total page count hould folfow normul pagination procedures, i.e., enter the tumber of pages containing information. A. NUMBER OF REFERENCES: Enter the total number of ferences cited in the report. B. ONTRACT OR GRANT NUMBER: If appropriste, enter the applicable number of the contract or grant under which he réport was written. b, &c, & 8d. PROIECT NUMBER: Enter the appropriate ilitary department luentification, such as project number, ubproject numbar, system numbers, task number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified ial report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other report numbers ( <i>either by the originating</i> activity. This number must r by the sponsor), also enter this number(s).					
<ul> <li>Initiary, show rank and branch of service. The name of the principal eathor is an-absolute minimum requirement.</li> <li>REPORT DATE: Entar the date of the report as day, tory notes.</li> <li>REPORT DATE: Entar the date of the report as day, tory notes.</li> <li>SPONSORING M the department in pagination procedures, i.e., anter the department in pagination procedures, i.e., anter the department of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of the document which he report was written.</li> <li>NUMBER OF REFERENCES: Enter the total number of the document which he report was written.</li> <li>ONTRACT OR GRANT NUMBER: If appropriste, enter the applicable number of the contract or grant under which he report was written.</li> <li>ORIGINATOR'S REPORT NUMBER(S): Enter the official report number sy which the document will be identified in de outies and controlled by the originating activity. This number must e unique to this report.</li> <li>OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originator is by the sponsor), also enter this number(s).</li> </ul>					blic, in
<ul> <li>REPORT DATE: Entar the date of the report as day, ionth, year, or month, year. If more than one date appears in the report, use date of publication.</li> <li>TOTAL. NUMBER OF PAGES: The total page count hould follow normul pagination procedures, i.e., enter the intermeter of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of the document which he applicable number of the contract or grant under which is highly desity ports be unclassified end with an indication in the report.</li> <li>ONTRACT OR GRANT NUMBER: If appropriste, enter the appropriate, enter the applicable number of the contract or grant under which the information in f(C), or (U). There is no limit ever, the suggestied al report number sy which the document will be identified in leport.</li> <li>ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified in decentries for cat selected so that no fields, such as equip truy project code na selected so that no fields, such as equip truy project code na selected so that no fields to this numbers (s).</li> </ul>					explane
<ul> <li>ionth, year, or month, year. If more than one date appears in the report, use date of publication.</li> <li>a. TOTAL, NUMBER OF PAGES. The total page count hould follow normul pagination procedures, i.e., enter the total number of pages containing information.</li> <li>b. NUMBER OF REFERENCES. Enter the total number of segreaces cited in the report.</li> <li>c. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which he report was written.</li> <li>b. dc, dc 3d. PROJECT NUMBER: Enter the appropriate, enter initiary department identification, such as project number, ubproject number, system numbers, task number, etc.</li> <li>a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified ind controlled by the originating activity. This number must e unique to this report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originating activity.</li> </ul>		、			
a. TOTAL. NUMBER OF PAGES. The total page count hould follow normal pagination procedures, i.e., enter the tumber of pages containing information. b. NUMBER OF REFERENCES: Enter the total number of sferences cited in the report. c. CONTRACT OR GRANT NUMBER: If appropriste, enter the applicable number of the contract or grant under which he report was written. b, &, &, & & & PROJECT NUMBER: Enter the appropriate ilitary department identification, such as project number, ubproject numbar, system numbers, task number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified ind controlled by the originating activity. This number must e unique to this report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other report numbers (either by the originator r by the sponsor), also enter this number(s).					
<ul> <li>a. IDTAL: NUMBER OF PAGES The total page count hould follow normal pagination proceedures, i.e., enter the total number of pages containing information.</li> <li>b. NUMBER OF REFERENCES Enter the total number of the document which the applicable number of the contract or grant under which the applicable number of the contract or grant under which the appropriste, enter the appropriate information in the report.</li> <li>cONTRACT OR GRANT NUMBER: If appropriste, enter the appropriate be unclassified of the information in the information in the report was written.</li> <li>contest. The originating activity. This number must e unique to this report.</li> <li>d. OTHER REPORT NUMBER(S): If the report has been ssigned any other reput numbers (either by the originator r by the sponsor), also enter this number(s).</li> </ul>	in and dev	volopino	ont. Incl	ude addre	ng (pay ssi,
<ul> <li>timber of pages containing information.</li> <li>timber of pages containing information.</li> <li>NUMBER OF REFERENCES: Enter the total number of the document of clerences cited in the report.</li> <li>a. CONTRACT OR GRANT NUMBER: If appropriste, enter the applicable number of the contract or grant under which the applicable number of the contract or grant under which the document will be identified in an indication, such as project number, ubproject numbar, system numbers, task number, etc.</li> <li>a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified ind controlled by the originating activity. This number must e unique to this report.</li> <li>b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originator r by the sponsor), also enter this number(s).</li> </ul>	nter an ab	stract i	giving a	brief and i	actus1
<ul> <li>NUMBER OF REFERENCES Enter the total number of scieness cited in the report.</li> <li>CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which he report was written.</li> <li>CONTRACT OR GRANT NUMBER: If appropriate, enter the appropriate initiary department identification, such as project number, task number, etc.</li> <li>CORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified ind controlled by the originating activity. This number must e unique to this report.</li> <li>COTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originator r by the sponsor), also enter this number(s).</li> </ul>	uncot ind	dicative w in the	e of the r ⊳body of	eport, eve	n thoug ical re
shall be attached. a. CONTRACT OR GRANT NUMBER: If appropriste, enter he applicable number of the contract or grant under which he report was written. b, b, c, & 8d. PROJECT NUMBER: Enter the appropriate ilitary department identification, such as project number, ubproject numbar, system numbers, (ask number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- tal report number by which the document will be identified nd controlled by the originating activity. This number must e unique to this report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other repurt numbers (either by the originator r by the sponsor), also enter this number(s).	space is	require	d, a cont	tinuation s	heet
he splicable number of the contract or grant under which he report was written. $\delta, \&, \&, \&$ al. PROJECT NUMBER: Enter the appropriate iilitary department identification, such as project number, ubproject numbar, system numbers, task number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified ial report number by which the document will be identified ind controlled by the originating activity. This number must e unique to this report. $\delta, OTHER REPORT NUMBER(S): If the report has beenssigned any other repurt numbers (either by the originatorr by the sponsor), also enter this number(s).$					
he report was written, b, bc, & 8d. PROJECT NUMBER: Enter the appropriate inilitary department identification, such as project number, ubproject numbar, system numbers, task number, etc. a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified nd controlled by the originating activity. This number must b. OTHER REPORT NUMBER(S): If the report has been ssigned any other reput numbers (either by the originator r by the sponsor), also enter this number(s). Here is no limit even the suggested the transfer that number must b. OTHER REPORT NUMBER(S): If the report has been r by the sponsor), also enter this number(s). Here is no limit even the sponsor of the information in field, or (V). There is no limit even the suggested the sponsor of the information in field with an indication of the information in (C), or (V). There is no limit even the suggested the sponsor of the information in field with an indication of the information in even the sponsor of the information in the	ed. Each	paragr	raph of th	he abstract	t shall
(C), or (U). (C), or (U). (	ion of the	e milite	ry securi	ity classif	ication
a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified nd controlled by the originating activity. This number must b. OTHER REPORT NUMBER(S): If the report has been ssigned any other report numbers (either by the originator r by the sponsor), also enter this number(s).	un the pari	agraph,	, represe	med sa ( 1	or (or
a. ORIGINATOR'S REPORT NUMBER(S): Enter the offi- ial report number by which the document will be identified and controlled by the originating activity. This number must e unique to this report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other reput numbers (either by the originator r by the sponsor), also enter this number(s). ever, the suggested 14. KEY WORDS: K or short phrases that index entries for cat selected so that no fiers, such as equip tary project code na key words but will b context. The ossig	itation on	the let	ngth of th	he abstrac	t. Hov
nd controlled by the originating activity. This number must e unique to this report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other reput numbers (either by the originator r by the sponsor), also enter this number(s). Context. The assign	d length is	is from	150 to 22	25 words.	
e unique to this report. b. OTHER REPORT NUMBER(S): If the report has been ssigned any other report numbers (either by the originator r by the sponsor), also enter this number(s). index entries for cat selected so that no fiers, such as equip tay project code na key words but will b context. The assig	Key word:	is are te	echnicall	ly meaning and may he	rui tari s used
signed any other report numbers (either by the originator r by the sponsor), also enter this number(s). For the signator is the sponsor of th	ataloging	the rep	part, Kej	y words m	ast be
r by the sponsor), also enter this number(s). the origination they project code na key words but will b context. The assig	nment mo	clossi	ification signation	is required, trade name	ne. nil
entext. The ussig	anue, geor	eraphic	: location	n, may be	used as
	be follow sument of	ved by a flinks	an Indica rules, a	nd weight:	conical s is
	al constraints of			5.53	2015
		- DIT			

Security Classification

Υ.

)

•

٦

•

ij,