TECHNICAL REPORT
66-23-CM

# POLYESTER BATTING FOR CLOTHING AND MITTEN INSULATING LAYERS

by

Herman Madnick



February 1966

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760



Clothing and Organic
Materials Division
C&ED-40

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED.

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 originator.

Distribution of this
document is unlimited

AD_____

TECHNICAL REPORT

66-23 CM

# POLYESTER BATTING FOR CLOTHING AND MITTEN INSULATING LAYERS

by

Herman Madnick

Clothing and Equipment Development Branch
Clothing and Organic Materials Division

Project Reference:
Applications Engineering

Series: C&ED-40

February 1966

U. S. Army Materiel Command
U. S. ARMY NATICK LABORATORIES
Natick, Massachusetts

## FOREWORD

It is essential that the Army make every effort to reduce the cost and weight of all items under its cognizance, providing that all other requirements are met. The experimental mitten and clothing liners discussed in this report meet both of these objectives.

The author wishes to express his appreciation to the following of his colleagues: Mr. Roger Long, for obtaining the material; Mr. Michael Carlucci, for making the items Mr. Edward B. Frederick, for seaming suggestions; and Miss Rena Lemoine, for providing the laboratory data for his report. He also acknowledges the assistance of Dr. Ralph F. Goldman, of the U. S. Army Research Institute of Environmental Medicine, for supplying the Clo-value data.

S. J. KENNEDY
Director
Clothing and Organic Materials Division

APPROVED:

Dale H. Sieling, Ph.D.
Scientific Director

W. W. Vaughn
Brigadier General, USA
Commanding

CONTENTS

## ABSTRACT

This report describes the feasibility of using a flame-bonded polyester insulating layer to replace a stitch-bonded insulating material for clothing and mitten environmental layers.

Substitution of this material would reduce the weight of the end product and lower the ultimate cost to the government because it would require fewer fabrication processes.

# POLYESTER BATTING FOR CLOTHING AND MITTEN INSULATING LAYERS

## A. Introduction

In order to provide environmental protection, warmth, and flexibility to the combat soldiers in cold-wet and cold-dry areas, they are issued a series of clothing layers.

The basic clothing layer for the upper part of the body is the long underwear. This is followed by a frieze insulating layer buttoned into a sateen field coat. An additional insulating layer is covered by a wind-proof parka.

The basic insulating layer of the cold-dry handwear system is a knitted wool mitten covered by an Arctic mitten set composed of two sections: the outer portion is leather and fabric, the snap-in insulating inner portion is 16-ounce double-faced wool pile (Fig. 1).

Weighted with this clothing, which is heavy, and the corresponding head and foot protection and the necessary field load and fighting equipment, the soldier must exert considerable effort to carry out his assigned tasks and missions.

Continuing efforts have been made to reduce the weight of the soldier's environmental clothing. In 1964, a new lightweight insulating polyester material was standardized for clothing use; this has reduced the weight of the insulating layers by approximately 50 percent. However, it has introduced certain construction problems. A new candidate material attempts to overcome these problems.

## B. Description of Present Insulating Materials

The standard insulating layers (Fig. 2), which are buttoned into each component of the upper and lower body clothing, are constructed of a polyester fiber material 4 ounces per square yard in weight and covered on each side with a 1.1-ounce per square yard rip-stop nylon cloth to provide a durable slippery surface in the finished garment and to protect the insulating layer. A dumbbell-shaped quilting stitch bonds the outer and inner materials together. The total weight of this three-layered material is 6.6 ounces per square yard. The same insulating material replaces the 16-ounce per square yard wool pile layer for the mittens (Fig. 3).

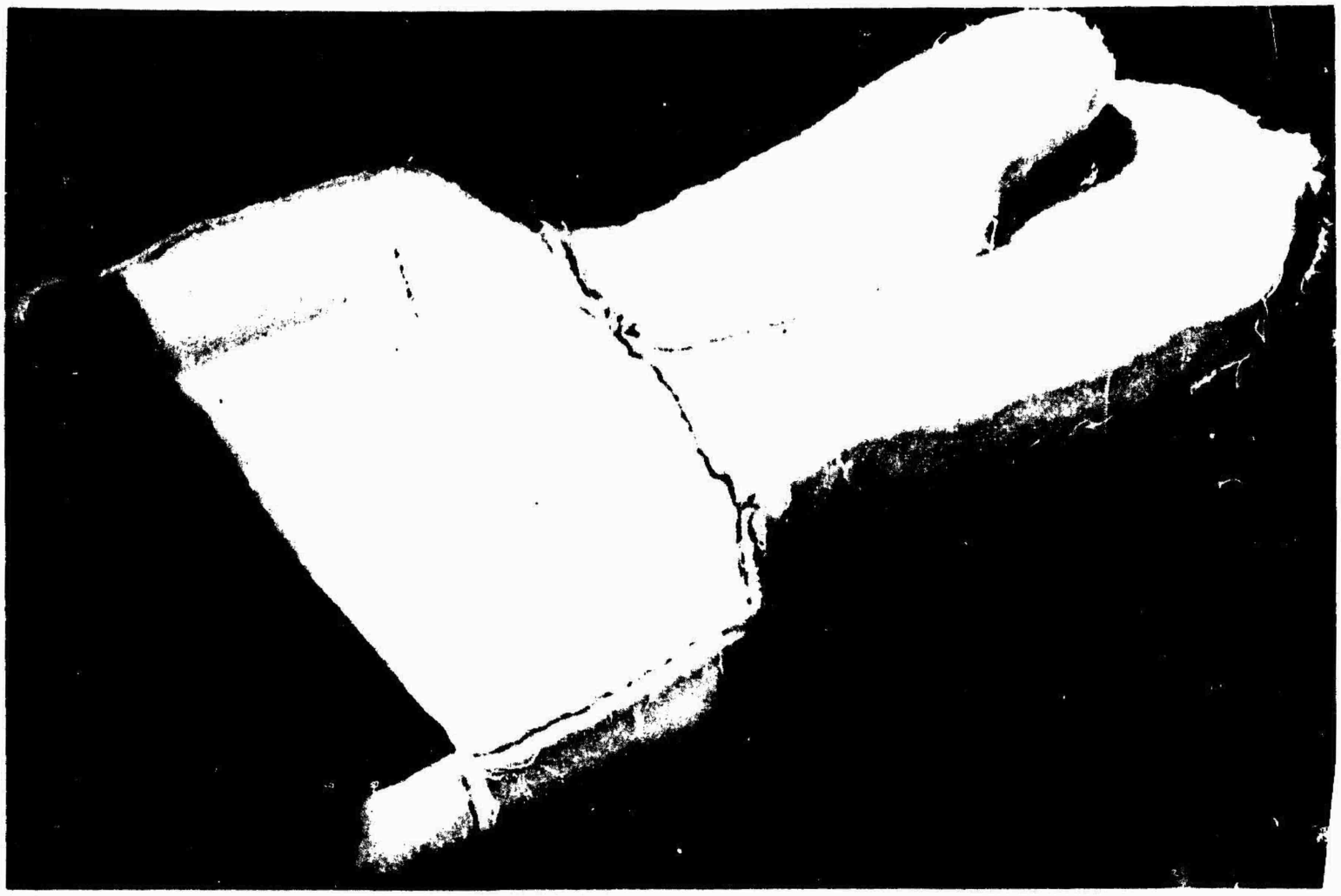

Figure 1. Standard Mitten Insulating Layer

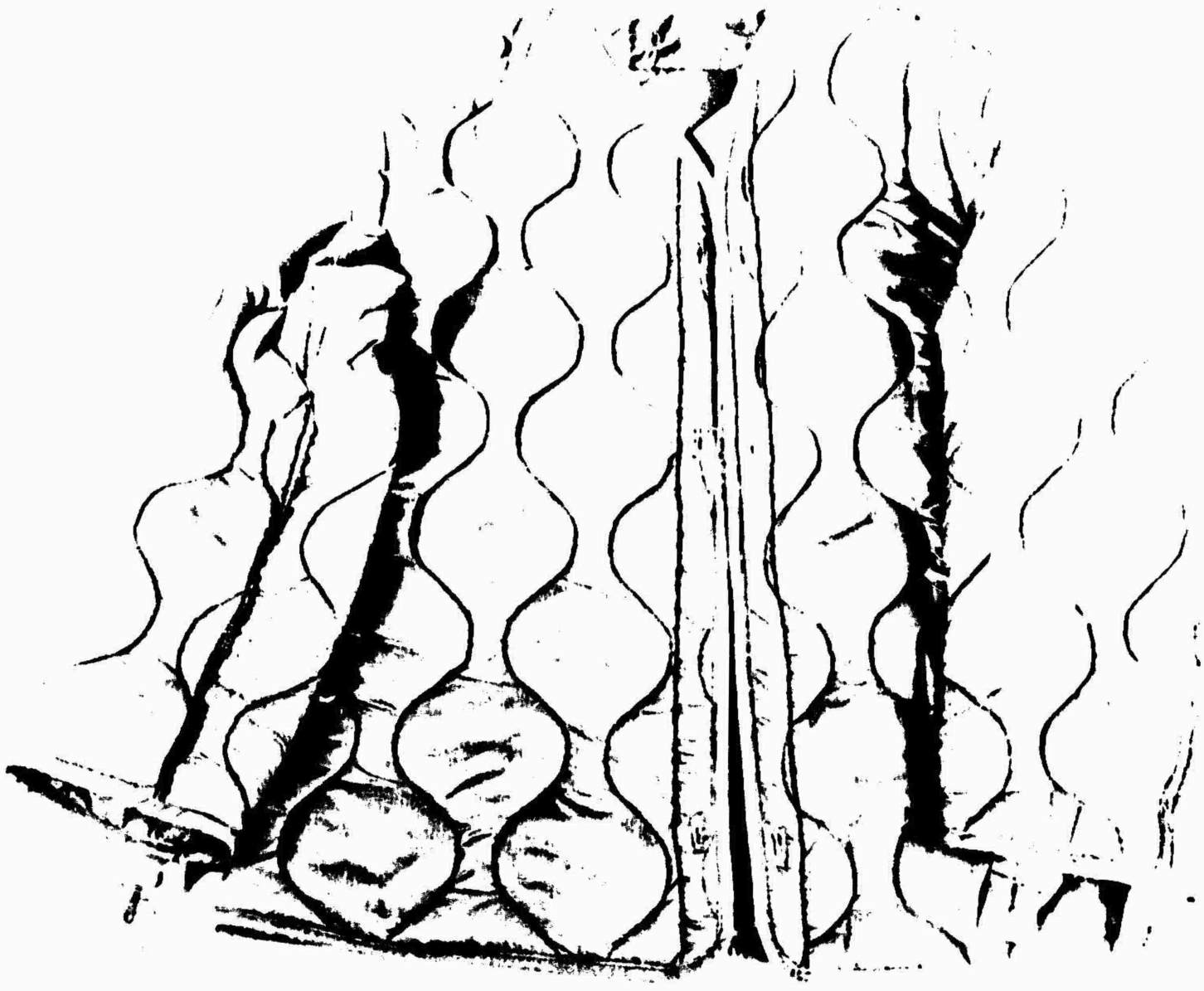

Figure 2. Standard Insulating Layer for Clothing

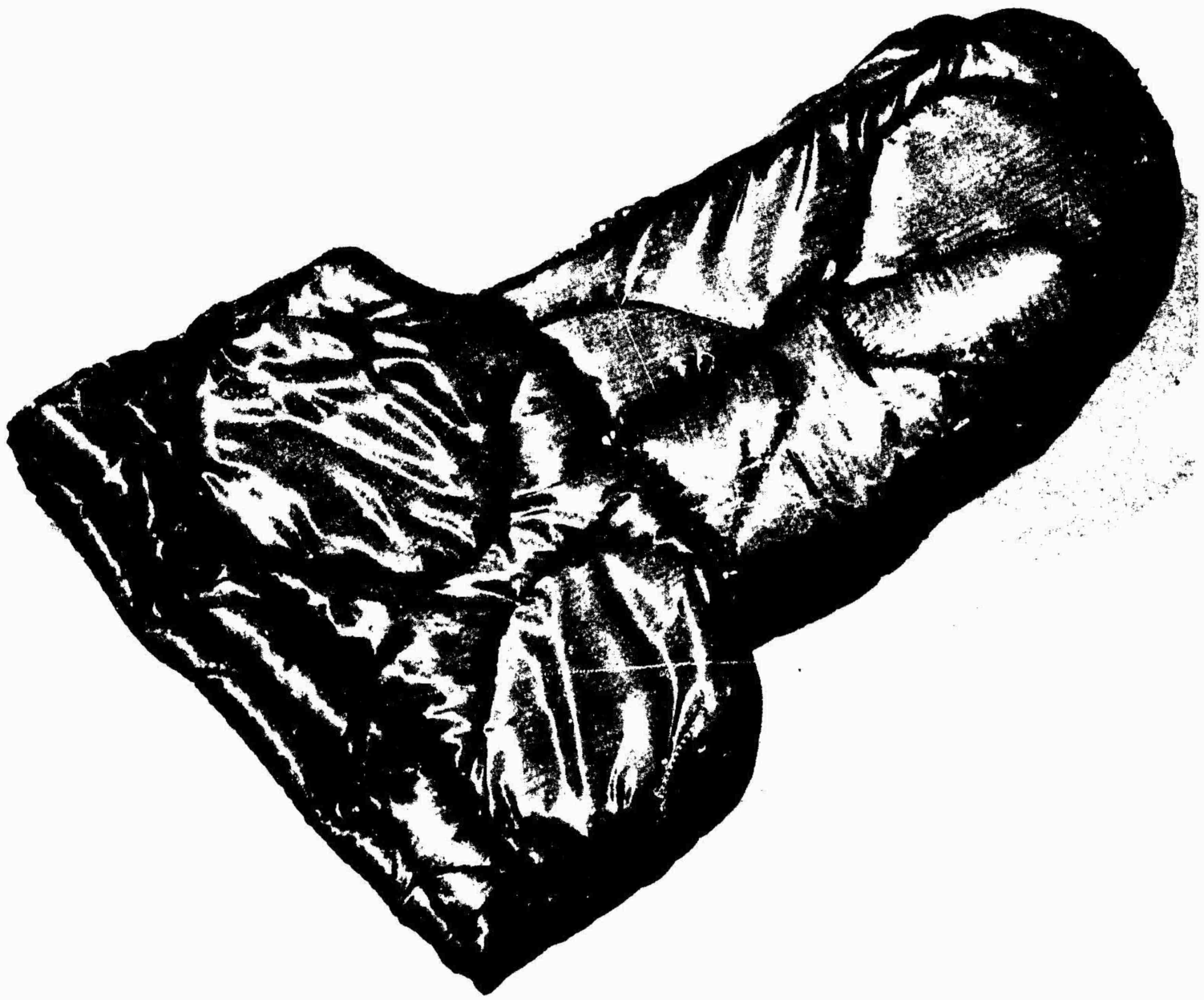

Figure 3. Mitten 6.6-oz. Insulating Layer

When this material is fabricated into garments, the rolls are laid flat, the pattern markings traced, and the components cut. Due to the smooth surface and the light weight of the nylon and polyester, each component has to be carefully overedged to insure that all edges are caught. The component layers are then stitched together, as required, to form the finished item. Thus, each section must be handled at least twice in the stitching operation: once to overedge and the second time to form the garment.

Wear-testing trials and subsequent inspection of insulating clothing layers fabricated by this method revealed numerous thread breaks in the dumbbell design and considerable raveling of the stitching. The thread failures had no effect on the characteristics of the liner but they were considered a nuisance problem. This difficulty might be partially overcome by extremely careful

quality control; however, since the commercial trade machinery does not lock-stitch each thread during a quilting operation, thread raveling or breaking will be a recurring problem until such time as an alternative method of constructing batt-type insulating layers can be found. Therefore, a study was made at the U. S. Army Natick Laboratories to eliminate the inherent construction problems in making these layers and thereby to reduce the cost.

C. Description of New Candidate Material

Through the efforts of the Fabric Engineering & Finishing Branch, a 3.4-ounce polyester batting, flame-bonded on both sides with a 15-denier nylon tricot, was obtained for study by this group and by physicists of the U. S. Army Research Institute of Environmental Medicine. The total weight of this new material (VEE-1599) is only 5 5 ounces per square yard (as against 6.6 ounces for the standard 4-ounce polyester batting covered with 1.1-ounce rip-stop and quilted with the dumbbell pattern)

The bonding process used is in the experimental material eliminates the need for stitching to hold the nylon to the polyester. This technique produces greater overall thickness while simultaneously allowing weight reduction. In addition, the use of nylon tricot (instead of rip-stop nylon) as the outer layer eliminated shredding close to the cut edges and thus allows overedging and stitching to be done by one operation.

D. Evaluation - Method and Results

The experimental material was compared with the standard in clothing and mitten layers in order to ascertain its insulating value and evidence of bonding separation.

The experimental fabric for clothing layers was cut by the procedure normally used for cutting component pieces of fabrics and was overedged and sewn together in one operation (Fig. 4). The insulating layer, flame-bonded to the tricot, was laundered 15 times (Fig. 5) by the Mobile Laundry Method (Federal Specification CCC-T-191b, Textile Test Methods, Method 5556.1) and showed no shringkage. Also, laundering made little or no difference in thickness, compressability, and weight (Table 1). Intrinsic Clo value* studies indicated that one layer of the dumbbell-patterned material was .731 before laundering and .799 after laundering. The experimental material, VEE-1599, had an initial Clo of .881, after 15 launderings, it had a Clo value of .799.

* One clo represents that amount of insulation that is required by an individual at rest in order for him to be comfortable at room temperature.

Figure 4. Experimental Insulating Layer for Clothing, Unlaundered

Figure 5. Experimental Insulating Layer for Clothing, Laundered and Tested

TABLE I

COMPARISON OF STANDARD VERSUS EXPERIMENTAL POLYESTER BATTING

| | Present Liner: Cloth, 4 oz, Polyester Batting Covered with 1.1 oz, Nylon Rip Stop | | | | Candidate Liner, VEE 1599: Cloth, 3.4 oz, Polyester Batting Covered with 15 Denier, Nylon Tricot | | | |
|---|---|---|---|---|---|---|---|---|
| | Initial | | Laundered | | Initial | | 15 Launderings (Coat Liner) | |
| | Alone | 2 Layers | Alone | 2 Layers | Alone | 2 Layers | Alone | 2 Layers |
| Initial thickness at .01 psi | 0.317 | 0.568 | 0.271 | 0.506 | 0.398 | 0.793 | 0.267 | 0.526 |
| Compressional Recovery | 86.100 | 84.500 | 84.900 | 84.000 | 90.700 | 91.000 | 89.100 | 89.400 |
| Weight, oz/sq yd | 6.600 | 13.200 | 7.000 | 14.100 | 5.500 | 11.000 | 5.800 | 11.600 |
| Clo Values* | | | | | | | | |
| Thickness at .01 psi | 0.293 | 0.597 | 0.268 | 0.520 | 0.396 | 0.800 | 0.266 | 0.525 |
| $U_1$ | 1.508 | 0.894 | 1.382 | 0.894 | 1.257 | 0.782 | 1.382 | 0.894 |
| $U_2$ | 1.555 | 0.911 | 1.422 | 0.911 | 1.290 | 0.794 | 1.422 | 0.911 |
| K | 0.456 | 0.544 | 0.381 | 0.474 | 0.511 | 0.635 | 0.378 | 0.478 |
| Clo, intrinsic | 0.731 | 1.248 | 0.799 | 1.248 | 0.881 | 1.432 | 0.799 | 1.248 |
| Clo, specific | 2.490 | 2.090 | 2.980 | 2.400 | 2.220 | 1.790 | 3.010 | 2.380 |
| Clo per inch | 2.490 | 2.090 | 2.980 | 2.400 | 2.220 | 1.790 | 3.000 | 2.380 |
| Clo per ounce | 0.997 | 0.851 | 1.027 | 0.796 | 1.442 | 1.172 | 1.240 | 0.968 |
| Thermal efficiency | 15.890 | 13.630 | 16.400 | 12.740 | 22.960 | 18.840 | 19.850 | 15.520 |

* A clo is a unit for measuring the insulation value of clothing.
One clo is the equivalent of a clothing conductance value of 1.14 Btu/ft$^2$ hr. F

In evaluating the arctic mitten insulating layers, sectionalized copper hand studies were conducted by the U. S Army Research Institute of Environmental Medicine of the experimental (Figs. 6 and 7) versus the dumbbell-sewn materials when worn over the standard arctic mitten which utilizes a 16-ounce double-faced wool pile layer. That there was close agreement between the various material structures is graphically shown in Figure 8. Copper hand studies were also conducted using eight ounces of a dumbbell-pattered material in the sidewalls of the actic mitten insulating layer versus 1) two layers of the new batting in the sidewalls, and 2) one layer of the dumbbell pattern material in the sidewall. Results of these studies indicated that the difference between one layer and two layers was so slight that the user probably could not tell the difference.

To erase any doubt concerning the separation of the nylon tricot from the polyester, consideration should be given to providing an insulating material with a minimal amount of stitching. This material should be evaluated along with the standard 6.6 ounce dumbbell-stitched type and the experimental type VE 1599 (5.5 oz).

## E. Conclusion

These studies indicate that it is possible to use a flame-bonded batting to reduce the weight and labor costs of clothing and mitten insulating layers; however, they give no information about the new material under conditions of actual wear.

## F. Continued Investigations

Investigations to determine the performance of flame-bonded materials, both with and without minimal rows of stitching, have been initiated. The most promising material will be subjected to a field test to ascertain its continued durability and comfort as compared to the present stitch-type batting.

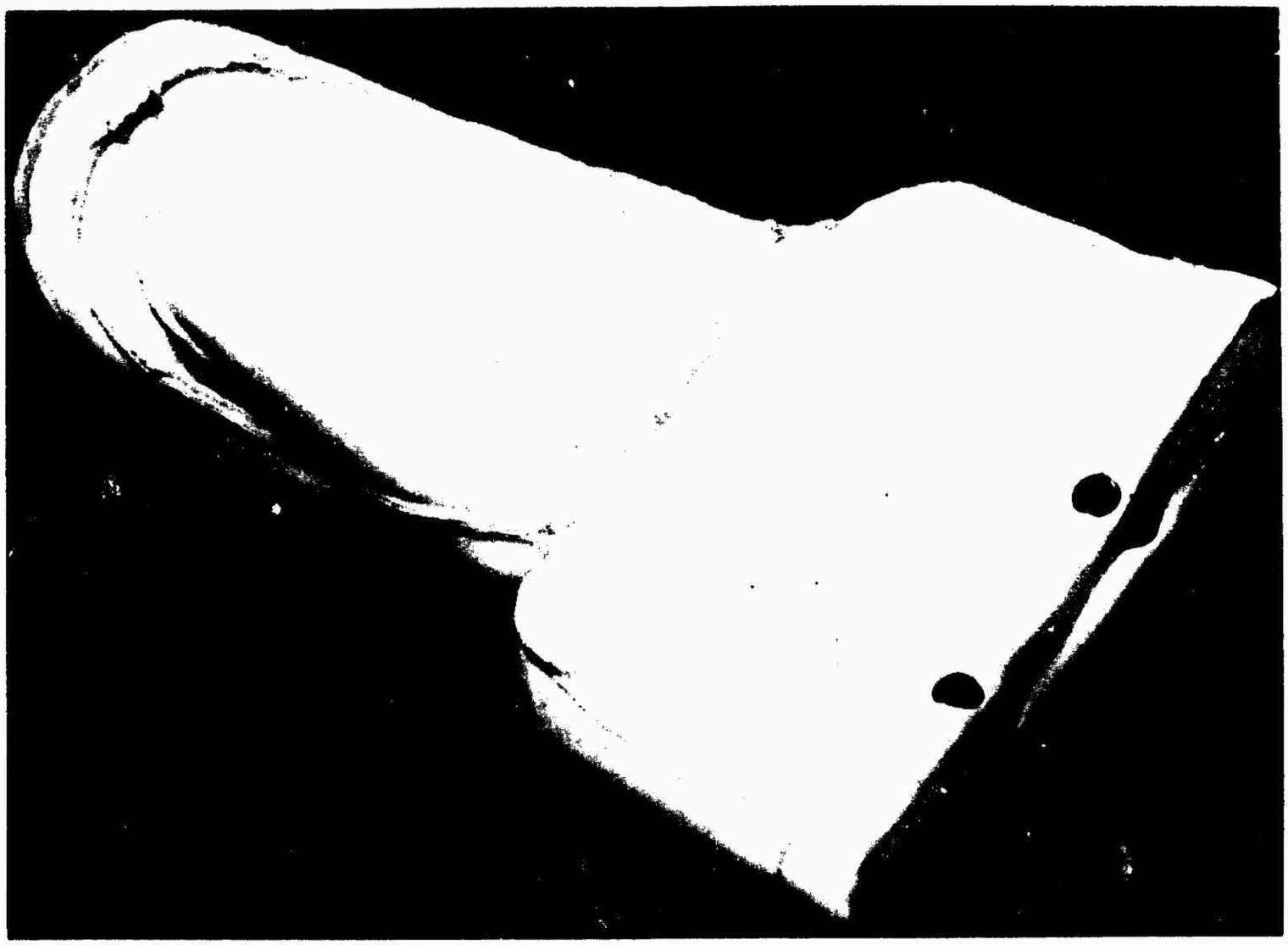

Figure 6. Experimental Mitten Insulating Layer, Overedged

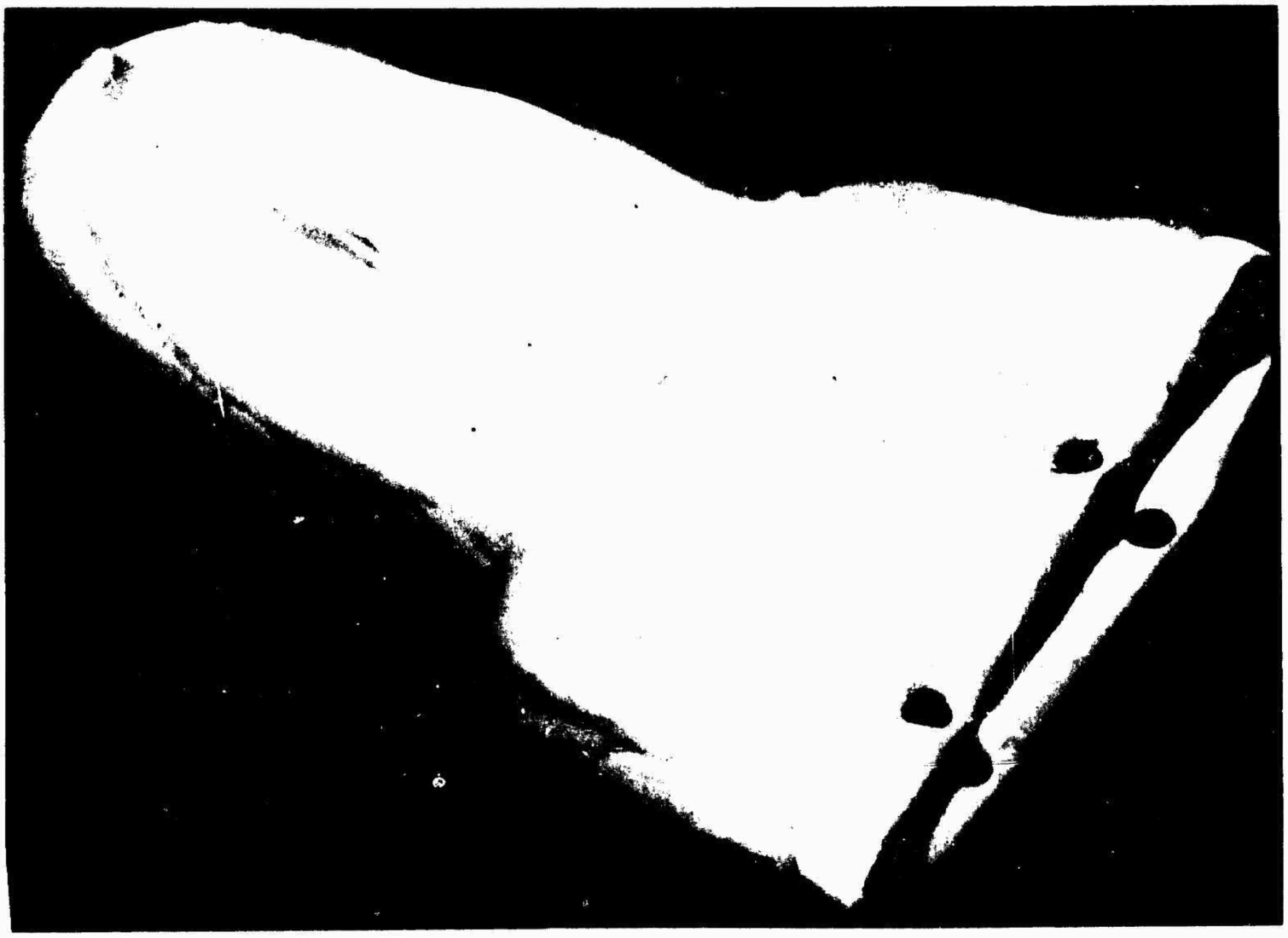

Figure 7. Experimental Mitten Insulating Layer, Sewn

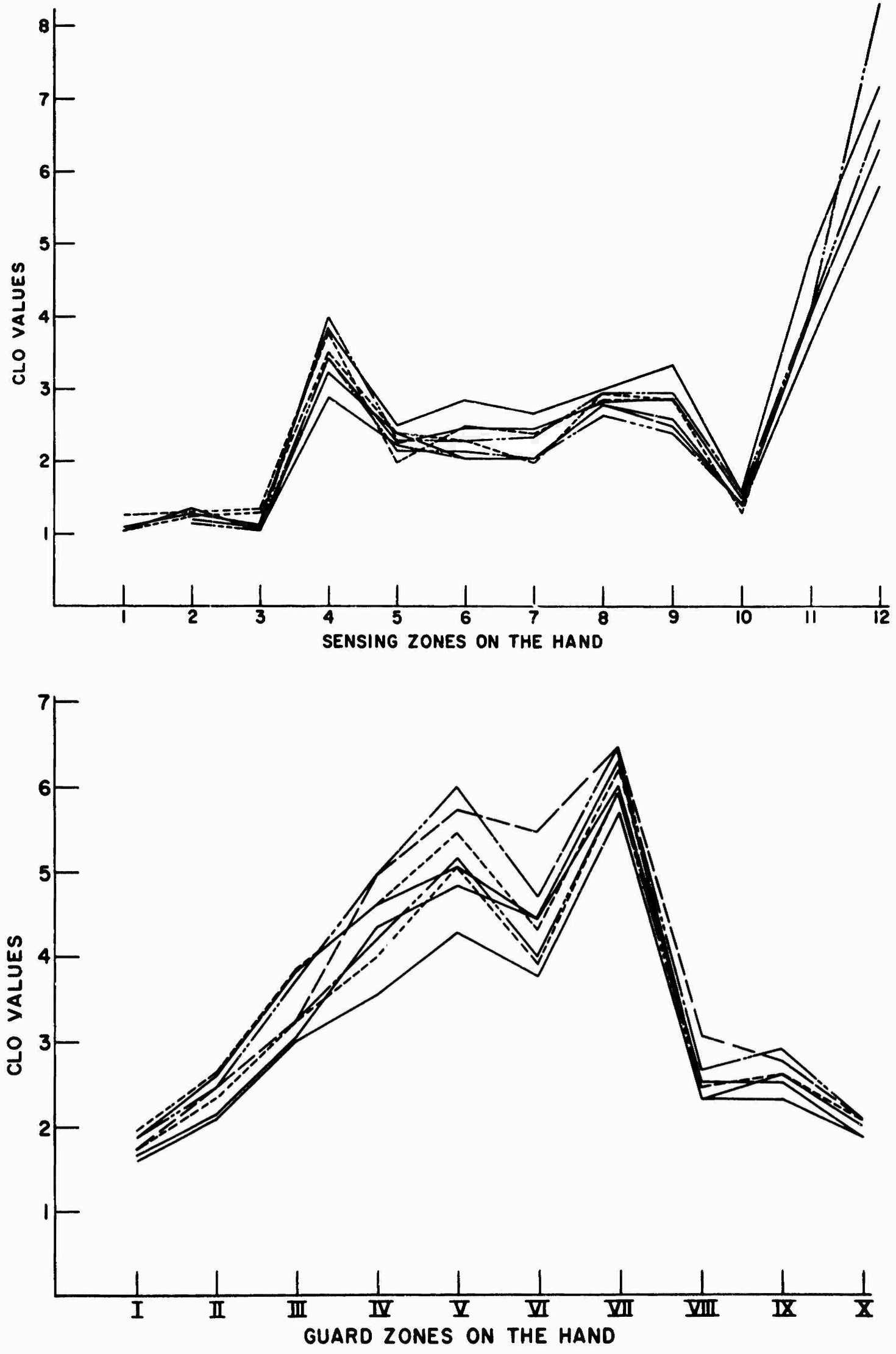


Figure 8. Clo Values of Arctic Mittens

Unclassified
Security Classification

## DOCUMENT CONTROL DATA - R&D

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)*

1. ORIGINATING ACTIVITY *(Corporate author)*
U.S.Army Natick Laboratories
Natick, Massachusetts 01760

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE
POLYESTER BATTING FOR CLOTHING AND MITTEN INSULATING LAYERS

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Applications engineering project covering period August through December 1965

5. AUTHOR(S) *(Last name, first name, initial)*
Radnick, Herman

| 6. REPORT DATE | 7a. TOTAL NO. OF PAGES | 7b. NO. OF REFS |
|---|---|---|
| February 1966 | 8 | 0 |

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
66-23-CM

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
AD Project 40

10. AVAILABILITY/LIMITATION NOTICES
Distribution of this document is unlimited
Release to CFSTI is authorized.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
U. S. Army Natick Laboratories
Natick, Massachusetts 01760

13. ABSTRACT

This report describes the feasibility of using a flame-bonded polyester insulating layer to replace a stitch-bonded insulating material for clothing and mitten environmental layers.

Substitution of this material would reduce the weight of the end product and lower the ultimate cost to the government because it would require fewer fabrication processes.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified
Security Classification

| 14. KEY WORDS | LINK A | | LINK B | | LINK C | |
|---|---|---|---|---|---|---|
| | ROLE | WT | ROLE | WT | ROLE | WT |
| Development | 8 | | | | | |
| Linings | 2 | | 4 | | | |
| Polyester plastics | 1 | | 4 | | | |
| Gloves | 4 | | 4 | | | |
| Arctic clothing | 4 | | | | | |
| Thermal insulation | 4 | | | | | |
| Flame bonding | 1 | | 9 | | | |
| Sewing | 1 | | 9 | | | |
| Comparisons | | | 8 | | | |

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 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 authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through _____."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through _____."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through _____."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, *or (U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Idenfiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, rules, and weights is optional.