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TECHNICAL REPORT

75-42-CE

PROTOTYPE COLD WEATHER HEADWEAR

by

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Los Angeles, California

Contract DAAK03-74-C-0030

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COLD WEATHER HEADGEAR	WIND	COMPATIBILITY (PHYSICAL)	
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Prototypes of an improved cold weather headgear ensemble have been developed which should provide protection from cold, wind, blowing snow, and frostbite in environments to -65° F and 35 miles per hour wind velocities. The ensemble provides physical compatibility with military clothing and equipment and does not occlude the field of vision. The design covers the face, head and neck and is provided with features that permit achieving varying degrees of protection in response to varying severity of the environmental threat. Provisions are			

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included to permit access to the oral-nasal area for eating, smoking, drinking, etc. The ensemble and its elements is composed largely of a helanca/urethane foam/cotton jersey laminate which provides excellent insulating properties, sound transparency, and permeability. The high permeability promotes easy breathing through the oro-nasal covering and facilitates the transfer of insensible or active perspiration from the skin surface to ambient. The prototypes were furnished in a single size suitable for accommodating approximately the 50th to the 95th percentile of the using population and it appears that due to the elastic nature of the design and construction the 1st to 99th percentile range can be accommodated in three sizes or less.

Donning instructions and instructions for cutting and assembly are included as appendices to the report.

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FOREWORD

The present standard cold weather headwear suffers from a number of disadvantages principally due to the interference of the various components with the soldier's ability to perform the full range of military tasks required in the field. Specifically, there is: direct interference with sensory communications, incompatibilities with clothing and equipment, and discomfort or annoyance caused by the bulky, heavy and restrictive components.

This report covers a nine-month system-oriented engineering program, the basic objective of which was to design, develop and fabricate an integrated cold weather headwear concept which would provide the thermal protective function, integrate with other equipment items, be compatible with military operations, and be subjectively acceptable to the wearer. The work was conducted by Synsis, Inc. under Contract No. DAAK03-74-C-0030 and directed by Mr. David Mangelsdorf.

The contract was initiated under Project No. 1T762713DJ40-Task 01, Energy Conservation Thru Lightweight Clothing and Equipment Systems and was administered under the direction of the Clothing and Equipment Division, Clothing, Equipment and Materials Engineering Laboratory of the U.S. Army Natick Laboratories. The Project Officer for the U.S. Army Natick Laboratories was Mrs. Mary E. Darby and the Alternate Project Officer was Mr. Norbert Rodil.

Technical personnel at the U.S. Army Natick Laboratories also cooperated in specialized phases of this program, namely, Mr. Robert M. White, Research Anthropologist and Mr. Edward Frederick, Textile Technologist.

ABSTRACT

Prototypes of an improved cold weather headwear ensemble have been developed which should provide protection from cold, wind, blowing snow, and frostbite in environments to -65° F and 35 miles per hour wind velocities. The ensemble provides physical compatibility with military clothing and equipment and does not occlude the field of vision. The design covers the face, head and neck and is provided with features that permit achieving varying degrees of protection in response to varying severity of the environmental threat. Provisions are included to permit access to the oronasal area for eating, smoking, drinking, etc. The ensemble and its elements is composed largely of a helanca/urethane foam/cotton jersey laminate which provides excellent insulating properties, sound transparency, and permeability. The high permeability promotes easy breathing through the oronasal covering and facilitates the transfer of insensible or active perspiration from the skin surface to ambient. The prototypes were furnished in a single size suitable for accommodating approximately the 50th to the 95th percentile of the using population and it appears that due to the elastic nature of the design and construction the 1st to 99th percentile range can be accommodated in three sizes or less.

Donning instructions and instructions for cutting and assembly are included as appendices to the report.

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Section I

INTRODUCTION

PROGRAM BACKGROUND

Providing protection for the human head against environmental extremes and the forces and stresses associated with the military environment is a particularly difficult problem. The head requires levels of protection against cold, wind, blowing snow, etc. which are comparable to or somewhat more demanding than those for other areas of the body. In addition, however, there are requirements for impact and ballistic protection, glare protection, respiratory protection, etc. which are peculiar to the head region and may be required in conjunction with protection against the natural environment.

A large number of pieces of clothing and equipment have been developed to provide the required protection for the head region. Helmets provide ballistic and impact protection. Gas masks provide ocular, cutaneous, and respiratory protection against chemical and biological warfare agents. Various clothing items provide protection against insects, rain, solar radiation, and help to camouflage the wearer. Each of the clothing and equipment items has been well developed to perform a single or limited number of functions.

Circumstances frequently occur in which it is necessary to achieve protection against a number of environmental stresses simultaneously. It might be necessary, for example, to simultaneously be protected against chemical and biological agents, cold, glare, a ballistic and/or impact threat, and to be adequately camouflaged against a snow background. The current equipment items necessary to provide these functions interfere with one another in a number of areas with the result that the performance of several items is degraded.

The problem is further complicated by the large number of man/operations interactions which occur in the head region and the sensitivity of these interactions to interference and degradation. Vision, audition, and speech are the most important means of communication in military operations and any degradation of these communication channels can be expected to reduce a soldier's effectiveness. Interference with audition or speech transmission through sound attenuation, generation of masking sounds, or incompatibilities with communications equipment reduces the individual's ability to detect threats, and to give and receive orders or other acoustic information. Interference with vision through optical distortion, light attenuation, reduction of binocular visual field, interference with head mobility or through incompatibility with optical devices reduces the individual's ability to detect, identify, and discriminate between threats, hazards, targets, or friendly troops. Such interference also degrades sighting speed and accuracy, and an individual's ability to receive visual signals from friendly troops.

Need for an improved method of providing cold weather protection to the individual soldier's head, face and neck was established by the U.S. Army Natick Laboratories. Under a previous contract (DAAG17-70-C-0113), a study leading to the development of a prototype cold weather face mask was performed (Reference 1) and resulted in a significant improvement in facial protection over the then-current standard protective face mask (Reference 2). Although the performance of this prototype met each of the objectives set for its development, it was apparent that further improvements in head protection were possible if the headwear ensemble could be dealt with as a modular system.

OBJECTIVE

The basic objective of this program was to design, develop, and fabricate an integrated cold weather headwear concept which would provide the protective function, integrate with other equipment items, be compatible with military operations, and be subjectively acceptable to the wearer.

SYSTEM DEVELOPMENT PROCESS

A systems engineering approach was required to resolve the above noted conflicts and incompatibilities. It was necessary to define the functions and combinations of functions to be provided, and to identify the interfaces which will exist between head protective equipment and military equipment, operations, and wearers. The performance required to adequately provide each of the protective functions had to be defined or derived. Concepts for providing the necessary performance were synthesized taking into account the necessity to integrate the functions into complete headwear ensembles. The concepts were then to be developed into specific items each of which provided one or more functions and was compatible with logistic, cost, durability, and other requirements.

The final prototype mask is defined in Section II of this report. Sections III and IV describe the requirements development and concept synthesis and development processes, respectively. Section V presents recommendations and conclusions.

Section II

FINAL PROTOTYPES

DESIGN DESCRIPTION

The integrated cold weather headwear ensemble developed under this program is shown in Figures 1 through 6. The ensemble consists of three elements: 1) an insulating hood, 2) a face covering, and 3) an integrating cape. These three items worn separately, or in conjunction with one another in various combinations, are designed to provide protection to the head, neck and the face of wearers who may be exposed to the range of environmental conditions from cold-wet to cold-dry. The elements and the ensemble are also designed to integrate and interact with the range of military equipment, clothing, and situations associated with the cold-wet to cold-dry environments while producing minimum interference with the wearers ability to perform his tasks.

The basic protective element of the ensemble is the insulating hood. The hood is designed to be worn in configurations as shown in Figures 3 through 6, depending upon the degree of protection desired. The hood is composed of a nylon helenca/polyurethane foam/cotton jersey laminate with a clo value of approximately 1.5. The hood is sized medium and is designed to fit snugly to discourage leakage of ambient air into the space between it and the wearer. The effective insulating value of the hood will, therefore, be close to that of the material of which it is made. Since the hood material is elastic, a snug fit is provided for a relatively wide range of head sizes and shapes. Permeable materials were selected to permit the loss by diffusion of insensible or active perspiration from the wearer's head, and to prevent the gradual buildup of moisture within the insulating material and the associated loss of insulating value.

The lower edge of the hood is designed to cover of the entire length of the neck and to flare out and cover a small region of the back and shoulders. The lower edge may be worn in any one of four modes with respect to the torso clothing as shown in Figures 3, 4, 5, and 6. The hood may be worn directly against the wearers skin, with the torso clothing overlapping it on the outside. In another mode, one or more pieces of the torso clothing may be overlapped by the insulating hood as shown in Figure 5. Alternatively, when the hood is worn with a field jacket or parka, the hood may be worn against the skin, with only the integrating flap overlapping and attaching to existing hook fastener material at the upper forward corners of the jacket or parka collar. The final mode uses the integrating collar as is shown in Figure 6. Note that the final three modes, though they provide a rain shedding seal at the interface between head and torso clothing, impose varying degrees of restriction on the wearers ability to bend and rotate his neck.

The integrating cape, as mentioned previously, is designed primarily to provide a wind and rain shedding seal or interface between the head and



Figure 1. Cold Weather Headwear Ensemble with Protective Goggles.



Figure 2. Cold Weather Headwear Ensemble with Corrective Lenses.



Figure 3. Insulating Hood Overlapped by Torso Clothing.



Figure 4. Insulating Hood with Integrating Flap Overlapping and Attaching to Hook Fastener Patches on Field Jacket Collar.



Figure 5. Insulating Hood Overlapping Collar on Torso Clothing.



Figure 6. Insulating Hood Used with Integrating Collar.

torso clothing. The inner surface of the cape collar is fitted with buttons which match corresponding buttonholes on the field jacket and parka. When the cape is attached to a field jacket or parka, and the two are closed at the front, the hood can be worn as shown in Figures 1, 2 and 6 to achieve an effective seal against wind, rain, blowing snow, and other sources of moisture. Sealing of the head/torso clothing interface may also have the effect of reducing the vertical flow of air through the torso clothing from ambient at the lower edge to ambient at the collar. This may reduce heat losses in the torso region, but may cause accumulations of moisture within the torso clothing as well.

The final item of clothing in the ensemble is the face covering element. This item is fabricated of a laminate composed of a napped nylon tricot material on the inner surface suitable for attaching to hook fastening material, a 1/16-inch-thick polyurethane foam interlayer, and an outer layer of olive green helenca. A soft, malleable metal stiffener is enclosed in a pocket at the upper edge of the mask to permit it being molded against the bridge of the nose and across the cheekbones under the eyes. The napped material on the inner surface of the face covering attaches to sections of hook tape on the insulating hood at the sides and under the chin. Excess mask material can be folded over and secured in place by means of additional hook and pile fastener tape as shown in Figures 1, 2 and 6. The resulting face covering encloses the wearer's nose and mouth, fits closely against the face at the upper edge, and is attached firmly to the insulating hood along its sides and lower edge. The face covering material is permeable and, because of its relatively large area, imposes very little impedance on the wearer's respiration. Additionally, since the folding process eliminates virtually all of the internal volume between the covering and the wearers face, increases in CO_2 in inspired air should be minimal. Previous experience with similar oronasal face coverings has indicated that exchanges of heat and moisture from the exhaled air to the mask, and from the mask to the inhaled air tend to produce inspired air temperatures which are markedly higher than ambient. This advantage has been shown to be extremely desirable at the lower limits of the cold-dry environmental range.

Section III

REQUIREMENTS

The current US Army cold weather protective clothing ensemble is designed to protect the individual soldier against thermal injury while he performs military tasks and operations under cold conditions. This clothing ensemble is described by Reference 3 and consists of a number of insulative layers which integrate into a complete body enclosure providing for passive control of the micro environment surrounding the soldier.

STATUS OF CURRENT PROTECTIVE CLOTHING ENSEMBLE

The cold weather protective ensemble serves as the basic field uniform for all troops working within the cold environment. In addition to its thermal protective function it is intended to meet all of the clothing requirements for a military uniform including compatibility with military tasks and equipment, size accommodation and comfort for the range of personnel within the military population, durability and launderability, etc. However, in meeting the requirement for thermal protection, the resulting bulk of the multiple insulating layers and components of this uniform have introduced a number of constraints on the wearer's ability to perform his functional tasks using the range of military equipment. These constraints include:

1. Increased load-bearing requirements due to the total uniform weight.
2. Restrictions on wearer's ability to move body parts freely.
3. Limitations on visual field due to both facemask and parka hood encroachment.
4. Limitations on visual acuity due to lens fogging with sunglasses, protective goggles and corrective glasses.
5. Reduction of communication capability due to sound attenuation at the ear because of insulation layers.
6. Reduction of communication intelligibility due to facemask occlusion of mouth area and due to poor coupling with the microphones of communications equipment.
7. Restrictions on wearer's ability to eat and drink (and smoke) while wearing the facemask.
8. Decreased thermal protection due to moisture accumulation and icing both inside and outside the facemask.
9. Facemask donning difficulties due to the need for mitten protection on the hands.
10. Requirement for doffing the insulating cap prior to donning the M17A1 Field Protective Mask and the M6A2 Field Protective Mask Hood.
11. Inability to don and doff facemask while wearing insulating cap.
12. Generation of acoustical masking noise due to facemask and/or insulating cap rubbing on parka hood.
13. Incompatibility of facemask for use with crewman's helmet (both poor fit of helmet and incompatibility with ear protection).

A number of these limitations were addressed during the development of the prototype cold weather protective face mask which is now Type Classified as a replacement for the standard facemask. However, it was possible to incorporate only those characteristics which were facemask design specific; improved performance for many of these parameters was limited due to the continued reliance on the standard headgear components of the cold-dry protective clothing ensemble.

INTEGRATED HEADGEAR PROTECTIVE ENSEMBLE

The integrated headgear protective ensemble was to be developed as an assembly of thermal insulative layers to replace and/or modify the current elements of the protective headgear ensemble. In this development effort only passive techniques were to be used in ensuring wearer thermal comfort or for meeting other requirements. The assembly was to be compatible with the unchanged elements of the cold weather protective clothing ensemble and was to provide thermal protection at least as good as presently obtained with the standard uniform. With respect to the overall performance of the integrated headgear it was to embody significant improvements as pertains to reduction in weight and bulk, compatibility with military tasks and equipment, and user comfort and acceptance.

DEVELOPMENT CONSTRAINTS

Only passive techniques were to be used for concept development. Electrical power supplies for increasing thermal comfort, prevention of lens fogging, prevention of ice and snow accretion, and for communications improvement were not to be considered.

New designs for protective goggles and sunglasses were not required; current standardized items were to be considered for inclusion with the integrated headgear ensemble.

Each protective concept developed was to be fabricated using off-the-shelf materials and was not to require the use of undeveloped materials unless the development was possible within the funding and schedule limitations of the present contract.

INTERFACE CONSTRAINTS

Use of the integrated protective headgear should not result in the degradation of either thermal protection levels or ventilation characteristics provided by the current protective clothing ensemble. To ensure this requirement, the integrated headgear was to be continuous, in its protection properties, with the clothing ensemble, or was to include a physical close-out at the neck of the clothing ensemble. This closeout was not to adversely affect the wearer's ability to ventilate his clothing independently of the headgear.

PRODUCIBILITY

The integrated headgear prototype was to be compatible in design, and materials with production in large quantities using available fabrication equipment and techniques. The developed concept was to be suitable for low cost production and maintenance using conventional laundering procedures or field repair facilities.

With respect to single use designs, a combination of replaceable and reuseable components was considered. For example, a liner may be used effectively as a means for preventing moisture accumulation by the insulative layers.

PROTECTION REQUIREMENTS

When properly clothed, the individual soldier is to be maintained at the same level of protection against injury by the cold environment as he is when using the current standard cold weather headgear.

Thermal Protection

The integrated headgear shall protect the wearer against cold injury at all temperatures down to -65° F and at all wind velocities up to 35 mph. This level of protection shall be maintained throughout the range of activities being performed by the wearer and while using any item of equipment which is cold-soaked to this thermal condition. Protection levels shall not depend on the wearer's body orientation with respect to the wind direction.

Protection Criteria

The threshold for skin damage due to low temperatures is at 60 to 65° F (Reference 4). Insensible perspiration rates for skin temperature below 90° F are to be considered as being approximately 3 grams/hr/ft² (References 5, 6, and 7). The maximum resulting evaporative heat loss is estimated at about 7 BTU/hr/ft².

Two other sources of moisture must be considered in the development of designs for meeting the thermal protection requirement. These are 1) sensible perspiration which can result if wearer activity levels are raised above the levels at which a balance can be maintained with system heat loss through some ventilation technique and 2) moisture contained within the exhaled air.

In achieving the required level of protection, the following conditions are to be assumed:

1. The individual wearer will be clothed in the standard cold-dry protective clothing ensemble. The integrated headgear will be used to completely enclose the head, neck and face of the wearer.

2. Calculations of thermal insulation properties are to assume that the wearer is relatively clean shaven in accordance with military cold-weather doctrine (Reference 3) which indicates that beards and mustaches do not provide for increased thermal protection; due to moisture deposition, beards and mustaches can effectively decrease the level of protection and will mask the presence of frost bite. With respect to head hair providing an increased layer of insulation, the assumption is that head hair length will be variable to the complete absence of hair.
3. Up to maximum wind chill conditions, the wearer will be exposed to blowing snow crystals ranging from one to three millimeters in diameter (Reference 8).
4. Under air temperature conditions of -37° F to -65° F ice fog may envelop the head region at low air flow velocities.
5. At any time during wear, it is to be assumed that a portion of the headgear may be compacted due to the applied forces of any item of military equipment used in the head area.

Area of Protection and Duration

Under the most severe windchill conditions, the integrated headgear is to provide equivalent protection to all portions of the head, face and neck. The period during which protection is to be worn will vary in duration. For any day, the headgear can be donned and used on several occasions.

Access for Visual Inspection of Frostbite

The onset of frostbite is often unobserved by the victim and can occur while using protective equipment. The integrated headgear shall provide a means for periodically examining the chin, nose, cheeks and ears for signs of frostbite. Examinations are to be performed visually using the buddy-system in accordance with Reference 3.

General Protection Requirement

During wear of the integrated headgear the user shall not be susceptible to other forms of injury which may be unique to the headgear performance or design characteristics. These sources of injury can result from loss of sensory perception, possible snagging of headgear elements on military equipment or other hazards which might induce loss of balance or impacts, and increased instability due to external forces (eg. wind blast) acting through the integrated headgear. Fabrication materials which can act as secondary hazards (eg. solid materials which can cause injuries when impacted by external forces) shall not be used within the design concept.

Flammability

In fabricating the integrated headgear either non-flammable or flame retardant materials are to be used to ensure wearer protection. The flammabil-

ity of headgear materials is to be no greater than that of other clothing items.

Static Charge

Textile materials often develop a static electrical charge. This is particularly true within cold dry environments and can be extremely hazardous near flammable and explosive materials. To ensure user safety, the integrated headgear shall resist development of an electrostatic potential and shall provide a means of dissipating a static electrical charge, at least to the extent provided by other clothing items.

CLOTHING AND EQUIPMENT COMPATIBILITY REQUIREMENTS

The integrated headgear shall be compatible for use with all items of clothing and equipment used within the cold environment and shall not impede the wearer's ability to perform any expected military task involving these items. Similarly, the use of any of these clothing and equipment items shall not degrade the protective performance of the integrated headgear.

Protective Clothing Compatibility

The cold weather uniform is an assemblage of insulative elements which are used as modules added to the wearer to progressively increase his total level of protection. Adjustments within this ensemble can be effected during wear to either increase or decrease the amount of ventilation. This enables the wearer to effectively balance his heat loss to ambient with heat gain due to changes in activity level. A major site for effecting ventilation control is at the neck.

The elements of the cold weather clothing ensemble which terminate at the juncture of the neck with the torso are as follows:

- Winter undershirt
- Wool nylon shirt
- Cotton/nylon coat (with nylon quilted liner)
- Cotton/nylon parka (with nylon quilted liner)

The primary closure at the neck is currently effected by the insulating cap which envelopes the neck in scarf fashion. The winter hood with fur ruff attaches to the upper portion of the parka (integrates with the collar; also optimally integrates with the coat) to extend this insulative barrier over the head. In effect, the hood maintains a warm air plenum (relative to ambient) which is partially heated by warm air vented from the torso area across the neck barrier.

The integrated cold weather headgear is to interface with torso clothing by providing an effective close-out to preclude an increase in heat loss at this interface. However, the close-out element is to function as a variable damper for increasing the ventilation rate as required by the wearer. Ideally, it is to provide for clothing ventilation from either or both the coat and the parka layers.

The integrated cold weather headgear is intended to replace the current standard headgear, including the winter hood.

Ballistic Headgear Compatibility

Typically, the cold weather headgear is used with the steel helmet and liner. These are worn over the insulating cap; in this use configuration the insulating cap is worn for full insulative capacity or with the neck flaps stowed over the helmet and liner.

With the integrated cold weather headgear no requirement exists for the helmet to be enclosed by the protective layers. However, the helmet and helmet liner (or helmet liner alone) are to be worn and retained on the head in a stable manner. This includes the requirement for effective use of the helmet chin strap, when needed.

When worn with the integrated cold weather headgear, the helmet and liner are to provide the same degree of head protection as achieved when it is worn independently. The bulk of the headgear shall not require modification of the helmet suspension system; however, wearer adjustment of the suspension for fit is permissible provided that: 1) adjustments do not decrease the clearance distance between the liner inner surface and the crown of the head below the minimum design separation provided by the suspension and 2) adjustments do not reduce the effective area of head coverage to less than that permitted by the standard headgear.

Overwhite Camouflage Compatibility

The overwhite garment used for camouflage purposes is typically worn over the complete cold-dry clothing ensemble. It is specifically designed for use during wear of the winter hood. Any significant reduction of bulk by elimination of hood usage may result in difficulties with proper retention of the overwhite hood in position and to prevent its closure about the face when a wide visual field is required. Similarly, a requirement exists to ensure that the overwhite hood will not balloon in response to wind blasts.

Manpack Equipment Compatibility

The integrated cold weather headgear is to be compatible with equipment carried by the wearer. Normally, this load is carried using a nylon rucksack which is supported over the wearer's back by means of two shoulder straps and a waist strap. Requirements exist for the individual to be able to don and doff the rucksack while fully protected by the integrated headgear.

Additional load carrying capability is provided by the suspenders and belt of the standard All Purpose Lightweight Individual Load-Carrying Equipment. This is worn beneath the rucksack.

The requirement exists for the integrated headgear to be donned and doffed while either or both of these manpack equipment items are in place.

Body Armor Compatibility

Body armor may be worn with the cold weather uniform. It is typically worn over the OG shirt and under the coat and liner or the parka and liner.

The integrated headgear shall not require repositioning of the body armor and shall be donnable and wearable when body armor is in use. When used the body armor shall not interact with the headgear to reduce cold protection.

Optical Equipment Compatibility

Use of the integrated cold weather headgear shall not prevent the concurrent use of any item of optical equipment. Generally, incompatibilities may arise due to inability of the headgear wearer to position his eye(s) within the design clear eye distance of the optical device or to locate his eye within the sighting axis because of increase bulk on the head. Additional problems may arise, when using a cold-soaked lens adjacent to the eye, due to moist, warm air from the body impinging on the lens to produce fogging.

Use of the standard protective goggles or eyeglasses with the integrated headgear will limit the utilization of optical equipment. The integrated headgear must not interfere with optical equipment user performance to any degree greater than evidenced by the combined use of the protective goggles with the standard face mask. The integrated headgear shall not interfere with the positioning of any optical equipment within its design axis nor with proper location with respect to the head and eyes during sighting tasks.

Under operating conditions during the use of optical equipment it shall be possible for the wearer to remove the protective goggles to accommodate any item of optical equipment. During this period of reduced thermal protection there shall be no loss of protection to any portion of the head, face or neck still enclosed by protective layers. It is desirable to incorporate some form of protection into the headgear design to preclude direct contact of the cold-soaked eyepiece with facial tissue.

Protective Mask Compatibility

Use of the M17A1 Protective Mask is required for respiratory protection against chemical agents during extreme cold weather. Although this mask may be winterized for use down to temperatures of -50°F the winterizing kit does not provide adequate protection against windchill; its use may well increase the danger of frostbite.

The requirement for donning the M17A1 Protective Mask may arise at any time and when the individual soldier is already wearing the integrated headgear. It is required that the integrated headgear not prevent the wearer from rapidly donning the M17A1 Protective Mask and achieving the maximum level of respiratory protection afforded under these conditions.

Under military doctrine, the donning of the M17A1 Protective Mask is accomplished as a two-handed operation and is to be accomplished during the breath-holding capability of the user (approximately eight seconds assuming the breath-holding starts at the end of an exhalation). To achieve protection the mask must seal against the face; it is unacceptable for any portion of the integrated headgear to prevent complete seal contact with the facial tissues or for any portion of the headgear to introduce a force against the seal or other parts of the mask which could reduce seal tension.

If it is necessary to remove any portion of the integrated headgear in order to don the M17A1 Protective Mask, the time for removal shall not significantly increase the user's time to achieve respiratory protection.

Modification of the M17A1 Protective Mask through the application of the M6A2 Protective Hood may be required. There are no requirements for removing any integrated headgear elements to ensure hood performance; however, if the hood is used with the integrated headgear, the headgear shall permit the M6A2 Protective Hood to seal at the neck.

Weapons Compatibility

The integrated cold weather headgear shall be compatible with each type of weapon used. Compatibility shall be determined through comparison with user performance during wear of the standard cold weather protective ensemble. The primary requirement in weapons compatibility is that the user be able to sight and fire within the same duration of time and accuracy as he can when wearing the headgear components of the standard uniform. Encumbrances of the integrated headgear which will impede head and neck movement or positioning within the weapon sighting axis are to be avoided. The integrated headgear shall not have loose materials or protuberances which can snag on weapon's components.

Communications Equipment Compatibility

Enclosure of the mouth and ears for thermal protection will most likely result in sound attenuation across the insulative barrier. Bulk added around the head will also prevent the positioning of some communications equipment for effective sound pickup and/or input in each of these areas.

The design of the integrated cold weather headgear must minimize the effect of these interactions and the headgear is required to perform with unmodified communications equipment. The incorporation of means for positioning of both microphones and earphones within the effective performance zones shall ensure that adequate thermal protection is maintained at all times and that a speech intelligibility of 70% (with electrically-aided communication) will be achieved at a noise level of 100 dBC overall.

MILITARY TASK AND ENVIRONMENT COMPATIBILITY

The integrated headgear shall be compatible with the performance of all military tasks typically performed by soldiers while wearing the cold weather protective uniform. These tasks range from combat tasks to general work tasks and survival and are to be performed throughout the range of environmental conditions (both natural and induced).

Body Motions

Restrictions of body motions during wear of the integrated headgear shall not exceed the degree of restrictions invoked by the cold-dry uniform. However, significant improvements are to be made in reducing head and neck motion restrictions evident from use of the winter hood. The integrated

headgear shall permit head rotation through a range of at least 180°. Head movement in the ventral direction and the total range from ventral to dorsal shall not be restricted to a degree greater than exists during wear of the standard cold weather uniform. According to Reference 11, the Arctic uniform reduces these head movements by an angular distance of 20° and 32°, respectively.

The integrated headgear shall not cause any restrictions of arm, shoulder or torso motions which are greater than that associated with the standard headgear.

Tactical Activities

During wear of the integrated headgear, the individual shall not be impeded in the performance of any tactical maneuver or operation. These activities shall include skiing and snowshoeing, parachuting, travel over both hard packed and loose snow, travel up and down hills, climbing over rocky or rough ground, mounting and dismounting from equipment, and climbing poles. The level of performance to be achieved with the integrated headgear is to equal or exceed that measured with the standard headgear.

Environmental Compatibility

In addition to providing thermal protection to the wearer, the integrated cold weather headgear must be compatible with both the natural and induced environment. It is to be durable under both wear and storage conditions.

Wind blast conditions (or gusts) in excess of the 35 mph protection criteria can develop under blizzard conditions and during parachuting. The headgear must be retained on the head and neck, without damage, under these conditions. Loosening of headgear components shall not occur for gusts up to 100 mph.

The individual soldier can be expected to move from extreme windchill conditions to relatively sheltered environments (eg. into sheltered equipment or command posts) which may be heated. The frequency of this transition from cold to warm to cold will introduce the problem of moisture deposition and ice formation.

Cold soaking of the materials to -65°F shall not prevent flexing or result in damage to the fibers even with ice infiltration. It shall also be possible to break ice loose from the materials without damage.

At higher temperatures for the cold environment (up to 40°F), components of the integrated headgear may be worn under wet conditions. These conditions may involve either falling rain or contact with other sources of water during the performance of any military task. The integrated cold weather headgear is required to protect the wearer from cold injury under these conditions and to continue its protective function after exposure to these conditions.

USER COMPATIBILITY AND ACCEPTANCE

User acceptance of the integrated cold weather headgear will depend upon the level of comfort provided, the facility with which the user can perform his job, and the degree to which he can rely on the headgear for protection. Any penalties perceived by the user, in comparison with the current headgear for the cold assembly, are to be avoided.

Thermal Comfort

The integrated cold weather headgear is to prevent tissue damage during exposure to the combined extremes of temperature and wind velocity. Under these conditions the wearer can be expected to be either inactive or active while generating considerable metabolic heat. Military doctrine (Reference 3) indicates that thermal comfort is considered to be cool rather than the perception of warmth.

Sensible perspiration is to be avoided. Thus, there is the requirement to provide a means for reducing the level of thermal insulation, provided by the complete assembly, by the removal of components or by increasing the degree of ventilation to compensate for increases in metabolic activity rates.

Moisture accumulation within the protective layers is to be prevented.

Size and Fit

The integrated headgear shall be designed in a minimum number of sizes (not to exceed three) to accommodate the military population. However, this requirement may be achieved by combining protective elements of different sizes as long as each discrete element does not require more than three sizes.

A significant advantage will be achieved if fewer than three sizes are required. The objective will be to achieve a single, adjustable size to accommodate the using population.

Table 1 describes the range of head, face and neck dimensions for the military population. Due to variations in anthropometric dimensions and overall shapes of heads, faces and necks, the headgear components must possess some degree of compliance to accommodate all people within each size range. This compliance may be effected through manual or elastic adjustments.

In the selection of materials and the design of components the tendency for many textiles to shrink must be considered. Any significant amount of shrinkage will have an adverse effect on size determination and the ability for the finished item to maintain its shape. This is particularly important in design approaches which integrate several materials having different shrinkage rates.

Donning and Doffing

The integrated headgear is to be capable of being donned and doffed by the user without assistance. The user shall be capable of ensuring an

Table 1. SAMPLE HEAD, NECK AND FACE DIMENSIONS RELATED TO DESIGN AND SIZING
OF INTEGRATED HEADGEAR FOR COLD WEATHER PROTECTION.

MEASUREMENT	(Source Reference 13)			(Source Reference 12)		
	PERCENTILE - Inches	5th	95th	DIFFERENCE Inches	PERCENTILE - Inches	DIFFERENCE Inches
Facial Length	4.31	4.31	5.17	0.86	-	-
Interpupillary Distance	2.15	2.15	2.67	0.52	-	-
Neck Circumference	13.50	13.50	16.10	2.60	-	-
Head Circumference	21.07	21.07	23.16	2.09	-	-
Bitracion-Min Frontal Arc	11.20	11.20	12.80	1.60	-	-
Bitracion-Menton Arc	11.80	11.80	13.70	1.90	-	-
Bitracion-Submandibular Arc	11.10	11.10	13.20	2.10	-	-
Bitracion-Subnasal Arc	10.50	10.50	12.20	1.70	-	-
Bitracion-Coronal Arc	13.00	13.00	14.80	1.80	-	-
Bitracion-Posterior Arc	9.30	9.30	13.00	3.70	-	-
Sagital Arc	-	-	-	-	14.10	16.00
Anterior Neck Length	-	-	-	-	2.30	4.40
Posterior Neck Length	-	-	-	-	2.70	4.70
						2.00

Note: Neck length dimensions are given for a neutral head position. Reference 14 presents the following data for head flexion: anterior neck length with maximum posterior flexion has a mean of 2.81 inches with a standard deviation of 0.43; posterior neck length with maximum anterior flexion has a mean of 2.41 inches with a standard deviation of 0.45.

accurate fit without the need for a mirror and shall not be able to don the gear in a manner that precludes achievement of the desired level of protection.

Donning and doffing shall be accomplished as a two-handed operation and shall be possible while the hands are protected with trigger-finger mitten inserts. The time to don and doff shall be less than the time to onset of thermal discomfort to the mittened hand when not protected by the outer Arctic shell.

The use of protective modules to achieve full thermal protection shall not require the removal and redonning of any previously donned module. The donning or doffing of each successive element shall be independent of other elements.

Similarly, the donning and doffing of the integrated headgear shall not require the removal of other clothing or equipment mounted on the wearer with the possible exception of the helmet and liner.

In order to achieve a comfortable and accurate fit, two forms of adjustment may be used. Gross adjustments which are intended to be semi-fixed may be used in prefitting each component to the wearer. Fine adjustments for controlling snugness are to be accomplished each time the headgear is donned and during wear.

Weight and Bulk

The headgear components of the total cold-dry protective uniform weigh 1.41 pounds. This weight shall not be exceeded by the integrated headgear. Bulk of the contemporary headgear is primarily the result of the winter hood with fur ruff. This bulk shall be reduced by the integrated headgear design.

Portability and Stowage

All elements of the integrated headgear are to be carried on the user even when not required for thermal protection. The method of stowage on the man shall provide for rapid access of each component on a selective basis; there shall be no need for unpackaging all of the components when only one component is required.

The method of stowage on the man shall protect the integrated headgear from damage and should be located to protect against cold soaking (i.e. when donned, the headgear should not be stiffened due to cold nor shall it introduce a cold stress).

Breathing Comfort

The integrated headgear shall not introduce any significant degree of breathing difficulty. There is no requirement to protect lung tissue

against damage due to air temperature; however, exposure of nasal tissues to temperatures lower than 30° F may result in tissue damage.

Enclosure of the nose and mouth will create a respiratory dead space. Breathing flow characteristics within this enclosed space shall not result in a carbon dioxide concentration of inhaled air that is greater than 0.5%.

Oronasal Access

Means shall be provided to permit the wearer to eat and drink or to smoke while wearing the integrated headgear. Gaining facial access for these purposes may require reduction of facial thermal protection during this transient period; however, the area of the face which is affected is to be minimized.

Nasal access must also be provided to permit nose blowing and inspection for frost bite. Other areas of the head, face and neck may also be susceptible to frost bite and provisions are to be made for ensuring that these areas can be inspected periodically. Provisions shall also be made for gaining access to frost bite areas in order to use hand warming.

Pressure Points

Wear of the integrated headgear shall not result in the application of localized pressures to any part of the head, face and neck which can result in either discomfort or blood flow restrictions. Often with the donning of clothing or equipment, and for short durations of use, the wearer may judge the item as fitting comfortably. After a period of use the wearer can begin to perceive discomfort and even pain. The headgear is to be designed to preclude this and to provide a means for readjustment during wear. However, any method for readjustment in terms of fitting comfort shall not affect the amount of ventilation by ambient air. Adjustments for controlling ventilation shall be independent and shall not result in changes of relative wearer comfort in terms of fit.

Use of the helmet over the integrated headgear shall not introduce additional pressures on the head which are not evident with the helmet alone.

Appearance

Acceptance of the integrated protective headgear by the users will be influenced by its appearance and the appearance of others wearing it. The user's acceptance cannot be established through quantitative means. Therefore, only generalized requirements can be established.

The integrated headgear should have an appearance of having a good fit. It should appear to be well fabricated and capable of taking rugged use. After the headgear has undergone several launderings or cleanings it should not appear to have lost its function as a protective garment nor shall it be more difficult to don and adjust.

The need for camouflage in the cold-dry environment has been established by military procedures; this entails the use of colors which have a low

contrast with the background. Use of the overwhite garment satisfies this requirement for a snow background. Olive green used in the components of the standard uniform satisfies this requirement for dark backgrounds and this approach shall be retained in the design of the integrated headgear.

Static Charge

Within the cold-dry environment the tendency for materials to develop a static charge is greatly enhanced. In addition to this being a safety hazard (eg. when working with fuels or other flammable materials) a static charge on the headgear will interact with other materials around the wearer. The design shall be such that adequate grounding is effected and that only materials which have a high resistance to static charge build-up (i.e. low electrical resistance) be employed.

User Maintainability

The integrated headgear will require periodic cleaning to ensure cleanliness and drying to prevent ice buildup during wear. Since elements of the headgear will be worn for relatively long periods of time in direct contact with the skin it is a requirement that cleaning can be accomplished as frequently as after each days wear (similar to the requirement for socks and underwear). This will be particularly necessary if perspiration soaking is not completely avoidable. However, not all of the components may be required to withstand the same frequency of cleaning.

It is required that the headgear components be launderable in the field using warm water and soap or detergents. Under field conditions this will involve hand-washing; however, a machine-washing capability is also required.

Drying is to be accomplished by convective and radiant means while hung to air dry. Machine-drying and body-heat-drying (i.e. when stowed within a sleeping bag or carried beneath the protective clothing and adjacent to the body) are also requirements.

Drying times should be rapid; therefore, it is a requirement to select materials which will dry rapidly under each of these conditions.

Biological Compatibility

Wear of the integrated headgear in contact with the skin will require that fabrication materials be selected from among those known to be biologically inert. This requirement includes the avoidance of material physical properties which are abrasive or otherwise irritating to the skin. Examples of materials wear problems which are to be avoided are as follows:

1. Tackiness or other properties which tend to irritate due to tissue adhesion.
2. Impermeable surfaces which permit salt build-up at the contact surface.
3. Odor of fabrication materials; also the development of odors due to use (eg. mildew).

Section IV

PROTOTYPE DEVELOPMENT

INITIAL PROTOTYPES

The four prototypes delivered on 29 March 1974 consisted of three elements: a cap, a face covering, and an integration piece designed to connect the cap to the field jacket or parka. The elements were made of largely elastic material in an attempt to produce a single-sized device. Two prototypes each of two designs were submitted.

The design identified as 0001 A is pictured in Figures 7 and 8. Design 0001 B is pictured in Figure 9. It is seen that the essential difference between the two designs is the mode of providing coverage for the facial region. Design 0001 A utilizes an adjustable half mask specifically developed for this ensemble, while design 0001 B takes advantage of a standard cold weather face mask developed by Synsis under a previous effort.

INSULATING CAP

The insulating cap, as shown in Figure 7, covers the crown, sides, back, of the head and the wearer's neck. The cap is similar in design and configurations to the existing standard insulating cap, but is fabricated of a laminated material composed of white helenca, 1/4-inch thick open-cell urethane foam, and white cotton jersey. The material is quite elastic, and the patterns have been sized to provide a device which appears to fit adequately on both the "small" and the "large" sizes of the Chemical Research and Development Laboratories head form series. Experience with small and large human subjects has been equally promising. The gaps at the sides of the face shown in the photograph are due to peculiarities in the shape of the manikin head and do not occur with human wearers.

The cap has hook and pile fastener tapes on the inner and outer surface of the flaps at the lower edge which can be used to secure the cap snugly under the chin and around the neck. Additional strips of pile material have been placed around the inner surface of the cap at the lower edge to form an attachment with the hook surface on the integration piece. Strips of pile material were used rather than one, continuous ring to minimize their effect on the stretchability of the basic hood fabric.

Strips of hook fastener tape are affixed to the sides of the hood on the 0001 A design, approximately at the position of the ears, to provide for attachment of the face covering device. An additional strip of hook material is used on the outer surface of the outermost neck closure flap to accommodate the attachment of the lower edge of the face covering device. Note that the glued seams and stapled attachments used for the prototypes were expedients for rapid development of prototype configurations, and were replaced by more durable and traditional attachment means in the final prototypes.

The cap for design 0001 B differs from the above description only in the absence of the hook material strips at the sides of the cap and at the

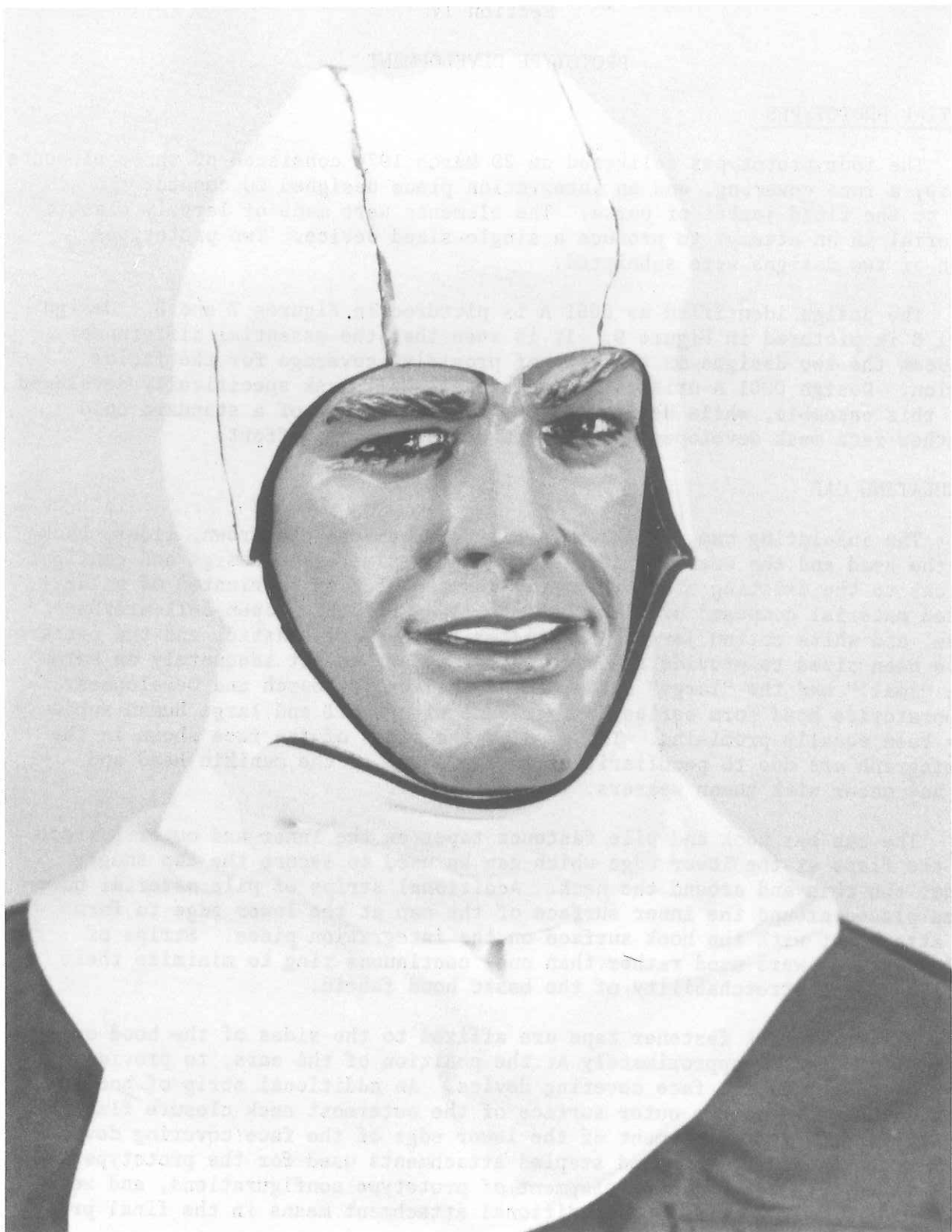


Figure 7. Insulating Cap and Integrating Collar for Initial Prototype Design 0001A or 0001B.

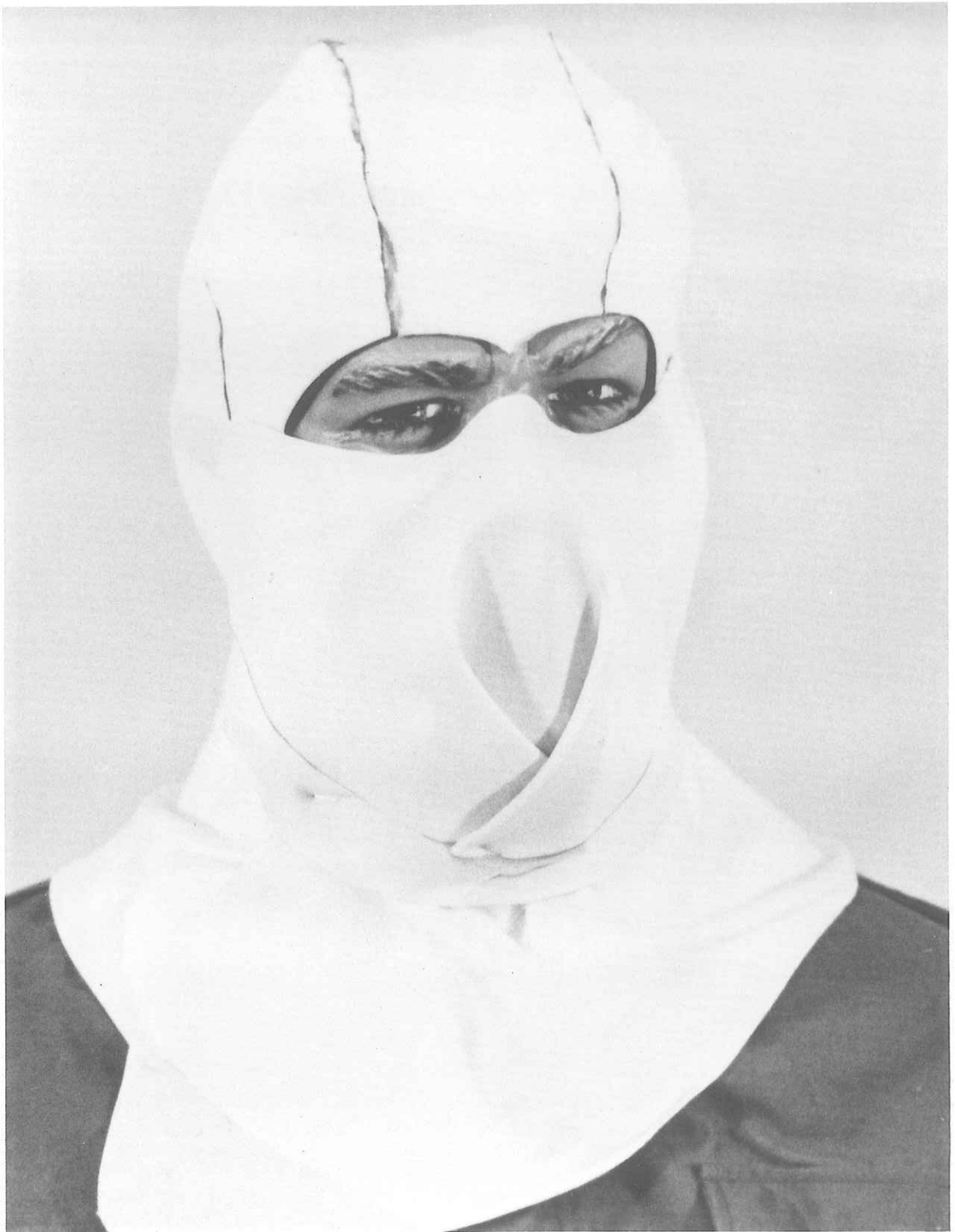


Figure 8. Complete Ensemble for Initial Prototype Design 0001A Including Adjustable, Half-Mask Face Covering.

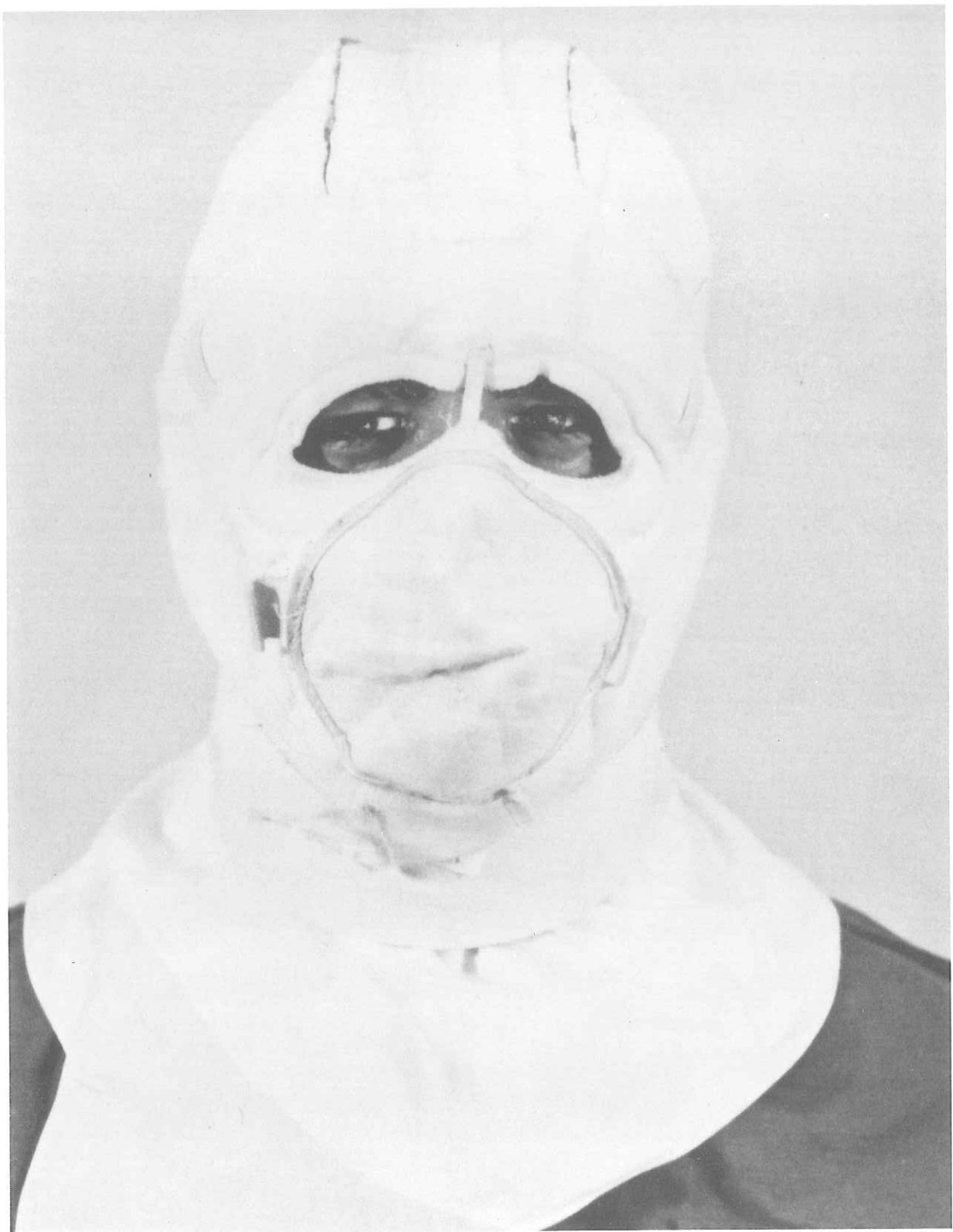


Figure 9. Complete Ensemble for Initial Prototype Design 0001B Using
New Standard Cold Weather Face Mask.

outer surface of the outer neck flap. In design 0001 B, the standard, Synsis-developed face mask is intended to be used in exactly its present condition; it is supplied with all the necessary straps and attachments for mounting on the wearer's head, over the insulating cap.

INTEGRATION COLLAR

The integration collar is patterned after the cape on the existing Hood with Fur Ruff, and is designed to integrate with the existing buttons, buttonholes, and snaps on both the field jacket and on the parka and to provide a surface in the area of the collar of both of these garments to which the insulating cap can attach. The integration collar has a flap which fits inside of the field coat or parka and buttons to existing buttons and snaps to a snap on the parka. Attached to this flap and overlapping and lying on the outside of the upstanding collar on the field coat and parka is a second flap having buttons on its inner surface which mate with buttonholes in the coat and parka.

The configuration of the integration collar is such that it naturally sheds rain and snow, and provides an effective barrier against penetrating wind which might pass between it and the jacket or parka. The models of this integration collar which were delivered do not have the pile fabric insulation exhibited by the standard Hood with Fur Ruff in this area, but the initial prototypes were intended to show configuration rather than detail finish. A hook and pile closure is provided at the front of the integration collar to provide complete closure of the neck of the jacket or parka, and, in addition, a ring of hook material is provided at the upper edge of the collar to mate with the corresponding pile material on the inner surface of the insulating cap.

FACE COVERING

The face covering for design 0001 A consists of a roughly semicircular piece of laminated material attached to an 0.020 inch thick aluminum stiffener. The aluminum stiffener is designed to be formed to the facial contour so that it passes over the bony ridge of the nose, under the eyes, and overlaps the sides of the insulating cap by approximately 1-1/4 inch on each side. The laminated fabric of nylon tricot bonded to 1/16-inch thick open-cell polyurethane foam is folded over the stiffener bar to provide a padded surface in contact with the skin. Rectangles of pile material are affixed to the outer ends of the assembly on the inner surface to mate with corresponding hook material on the sides of the insulating cap. When the face covering is first attached via the hook and pile fasteners at the sides of the insulating cap and is moulded to fit the facial contours over the nose and at the lower edge of the eyes, it hangs over the lower portion of the face very much like a veil.

To close the face covering up and thus provide protection for the lower face against cold, three steps are required: First, a strip of pile material attached to the lower edge of the "veil" is affixed to a corresponding piece

of hook material located on the outer surface of the outer flap of the neck closure for the insulating cap. Secondly, the excess material at the sides is gathered together in a fold at each side and folded toward the center where it is attached with appropriately located hook and pile fastener tape to yield a final configuration as shown in Figure 8.

The face covering design accommodates a wide range of variation in individual face lengths and face widths. The malleability of the stiffener strip and the adjustability inherent in the hook and pile attachments at the sides of the face permit achievement of very close conformance to facial contours and to the lower perimeter of the eyes. The method of attaching the lower edge of the covering and of removing excess slack tends to form a very adequate seal at the overlap between the face covering and the insulating cap, and to minimize the volume contained within the adjusted covering. Minimization of this volume is important in preventing the buildup of CO₂ in inhaled air.

The face covering for design 0001 B is the Synsis-developed cold weather facemask. The mask is used exactly as was originally intended, and is worn over the insulating cap as shown in Figure 9.

DISCUSSION AND PLANS FOR FINAL PROTOTYPES

The major deficiencies of the initial head covering prototypes were the bulkiness around the neck region and the consequent interference with head mobility. Changes contemplated for the final prototypes included a redesign of the interface between the insulating cap and the integrating collar, a switch to an olive green color, some material substitutions, and standardization of materials and attachment methods.

DISCUSSION

With the initial configuration, the insulating cap was attached to the integrating collar by lapping over its outer surface. However, due to the design of the field jacket and parka, the circumference of the outer surface of the collar is considerably greater than typical human neck circumferences. Lapping the hood over the outer circumference of the collar creates considerable bulk, and prevents the hood from fitting closely against the head. Additionally, due to the large radius to this interface, it requires large neck torques to stretch the hood material sufficiently to permit head rotation or neck extension or flexion.

As an alternative to the initial approach, it was proposed that the insulating cap be permitted to lie close to the surface of the head and neck, and that a "diaphragm" of very flexible material be attached to the outer surface of the cap, and to the edge of the integrating collar to provide protection against wind, rain, and blowing snow. Partial mock-ups of this approach were assembled, and the design seemed promising.

Since the ability of the insulating cap to fit a wide range of head sizes and shapes depends largely on its stretchiness, it is desirable that

the seams used to "make up" the device be stretchy in a lengthwise direction as well. A machine capable of producing a stitch with the desired characteristics was identified. Mr. E. Fredrick of Natick Laboratories. Mr. Fredrick noted, however, that the particular machine required to produce the desired stitch would probably not be capable of following the sharply curved seam lines incorporated in the initial insulating cap pattern. This dictated modification of the patterns to accommodate the seaming equipment.

A thermal analysis based on assumed tissue conductance of $2.85 \text{ BTU/hr/ft}^2/^{\circ}\text{F}$ and a polyurethane foam conductivity of $0.23 \text{ BTU in/hr/ft}^2/^{\circ}\text{F}$ yields the results shown in Figure 10. As indicated by the Figure, no single thickness of foam insulation will provide adequate protection (skin temperature above 70°F) at -65°F with wind (film coefficient = $3 \text{ BTU/hr/ft}^2/^{\circ}\text{F}$) and comfortable skin temperatures at 30°F with no wind. It appeared that it would be necessary to use the newly designed insulating cap in much the same fashion as has been typical for the existing insulating cap; in warmer temperature environments, the lower edge of the cap must be folded upward to expose more and more of the neck, ears, and back of the head. The 5/16-inch foam thickness appeared to be most appropriate for the sides and rear of the hood below the plane defined approximately by the headband of the field helmet. Above this plane, the 1/4-inch thickness foam was most appropriate; as long as the helmet is being worn, the film coefficient should not exceed 1 or 2 in this region, for most individuals there is sufficient hair in this region to make up for the loss of 1/16-inch of foam thickness, and it is desirable to maintain a thin head covering in this region to obviate the need for readjustment of the helmet suspension when the insulating cap is worn.

The 5/16-inch thick foam with bonded helenca and cotton jersey is sufficiently stiff that it was thought necessary to provide stitch lines to compress the laminate to ease folding in the cap into configurations compatible with mild temperature wear. The "fold lines" turned out not to be necessary.

During discussion with the Contract Project Officer during the last week of March, several new materials were identified for application to this project. Principal among these was a pile material made by Velcro Corporation which consists essentially of napped nylon tricot bonded to a 1/16-inch thick layer of polyurethane foam. The material had specific applications to the large areas of the insulating cap that needed to be covered. The pile material; the standard pile has no "give" and thus stiffens the insulating cap to an unacceptable degree. The new pile material exhibited considerable elongation along one dimension. A second application of the "Velcro" pile material was as a substitute for the initial nylon tricot/polyurethane foam laminate used for the 0001 A face covering. Use of the material for this application obviated the necessity to attach separate pieces of pile material to the assembly.

Another major change in materials was the change in material color from white to olive green. This change prevented the use of existing, standard helenca/urethane foam/cotton jersey laminate, but permitted the use of commonly available standard fabrics currently used for other items of U.S. Army clothing.

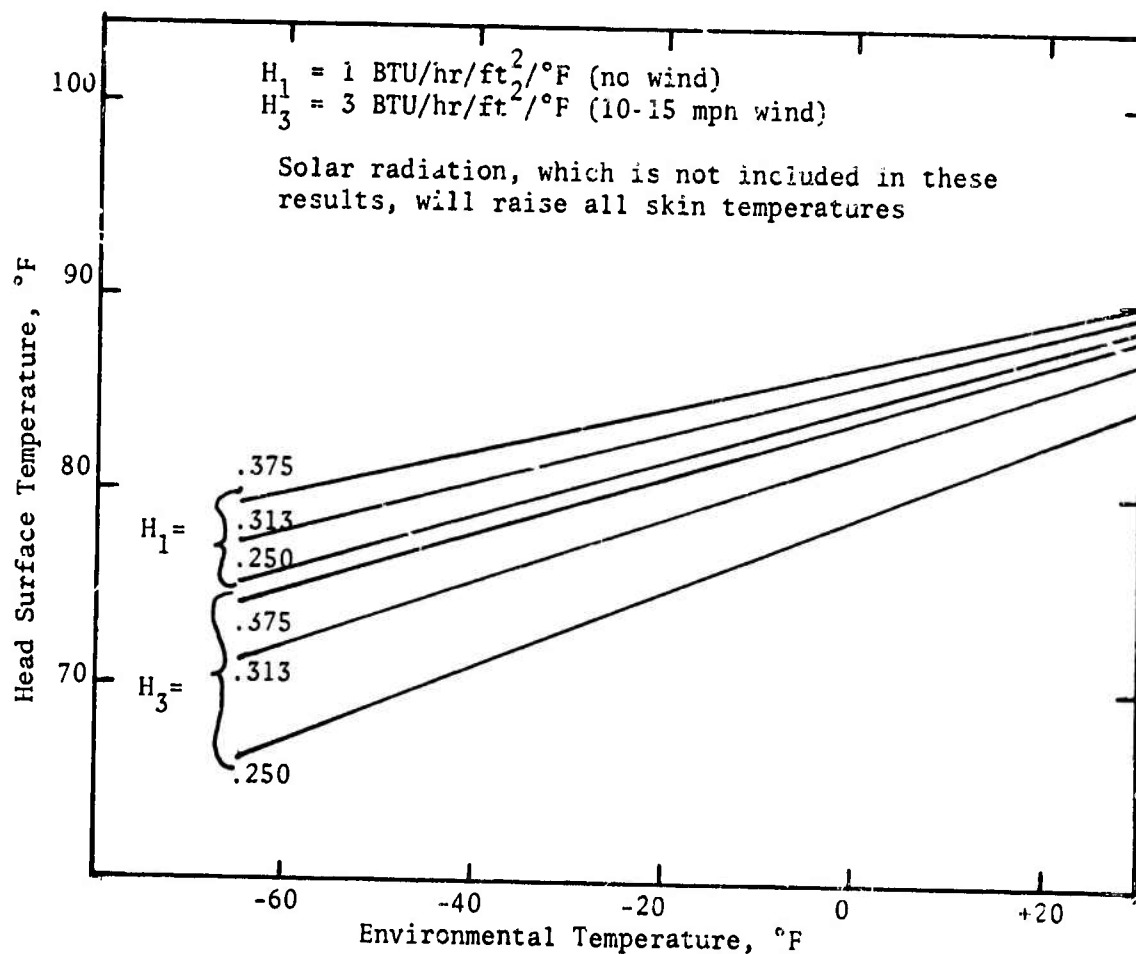


Figure 10. Head Surface Temperature Dependence on Environmental Temperature for Three Insulation (Urethane Foam) Thicknesses in Inches and Two External Film Coefficients.

PLANNED CONFIGURATION OF FINAL PROTOTYPE

Based on experience with the preprototypes, with the initial prototypes submitted to Natick Laboratories, and discussions held with the Contract Project Officer and other personnel at Natick Laboratories, a planned configuration for the final prototypes of the integrated cold weather ensemble was developed. The final prototypes were to consist of essentially the same three elements as the delivered prototypes: 1) an integrating collar, 2) an insulating cap, and 3) a face covering. It was planned to develop the insulating cap and integrating collar to be entirely compatible with the use of the existing Synsis-developed cold weather face mask but to continue with the development of the face covering for design 0001 A as defined previously.

Thread, polyester, cotton wrapped, ticket no. 70, 2 ply in accordance with MIL-T-43548A and Quarpel treated in accordance with the requirements for Class 3, Type II of MIL-T-3530E was used for all sewing.

Integrating Collar

The new integrating collar was designed so that the hook material to mate with the insulating cap lies flat against the outer surface of the upstanding collar on both the field jacket and the parka. The outer cape of the integrating collar which lies on the external surfaces of the jacket or parka was fabricated of the OG helenca/urethane foam/cotton jersey laminate, and safety stitched all around. The use of this material provided the required insulation and greatly simplified fabrication compared to the existing cape on the Hood with Fur Ruff. The inner flap of the initial integrating collar - the flap which fit inside of the jacket or parka - was eliminated. The closures on the front of the integrating collar utilized hook and pile fastener material.

Insulating Cap

Though the final insulating cap retained the essential configuration of the cap delivered to Natick Laboratories, a number of modifications of design and in fabrication technique were incorporated. The pattern of the cap was extensively modified to minimize the existence of sharp curves in the seam lines. This modification was required in order to ease the task of stitching the pieces together on the flat seamer machine (Seam Type FSa-1, Stitch Types 606 or 607 with 12 to 16 Stitches per inch (per Fed. Std. No. 751a, Stitches, Seams and Stitchings)).

The basic material for the cap was changed by substituting an olive green helenca for the outer covering and by using 1/4-inch foam for the upper portions of the cap and the 5/16-inch foam for the lower portions of the cap. All seaming and attachments were by sewing rather than by gluing and stapling as with the submitted prototypes. In addition, the entire periphery of the insulating cap was overedged with Stitching Type 504 with 8 to 10 Stitches per inch. A new product of Velcro Corporation, referred to as V22-90 Pile Fabric, was substituted for all applications previously requiring pile fastener tape.

A flap was added to the external surface of the insulating cap composed of a laminate of "Velcro" V22-90 material and olive green helenca. The flap, which had the pile material on its inner surface, served to integrate with the hook material on the outer surface of the integrating collar. Short strips of hook fastener material were provided around the lower edge of the insulating cap to secure the laminated flap in a position flat against the hood surface when integration with the field jacket or parka was not desired. All attachment of hook and pile fastener was by a Chain Stitch Type 301 with 8 to 10 Stitches per inch.

All hook fastener tape material used in the design was of the 65 mil hook configuration to maintain compatibility with the "Velcro" V22-90 pile material.

0001 A Face Covering

The material for the 0001 A design face covering was changed from the initial nylon tricot/urethane foam laminate to a laminate composed of "Velcro" V22-90 material bonded to olive green helenca. This new material was oriented so that the helenca is on the outer surface of the mask. The nose bridge stiffener design remained essentially unchanged, with the exception that it was attached by enclosing it within a pocket of nylon/cotton oxford cloth material which is stitched to the outer surface of the laminate. Additional work was done to arrive at a more optimum configuration for the facepiece pattern to improve its fit to range of face lengths, widths and contours. The face mask was overedged with Stitch Type 504 at 8 to 10 Stitches per inch.

PREPROTOTYPES

A number of partial models and preprototypes were fabricated based on the concepts originally presented in the proposal, and substantiated by the requirements report submitted early in the program. The basic concept had to do with upgrading the cold protection capabilities of the insulating cap, providing integration with the upper torso clothing, and providing a detachable face covering. The partial models or preprototypes described and pictured in the following paragraphs were fabricated in attempts to develop means of satisfying all of the requirements. The devices described have been assigned model numbers for convenience in discussion, but the numbering system in no way implies the sequence in which the devices were built nor progression towards the delivered items.

MODEL 1

Model 1 as pictured in Figure 11 was used to investigate means of integrating the hood with the torso clothing, and forms of removable face coverings. In the particular device shown, the integrating cape is a duplicate of the cape used on the Hood with Fur Ruff, and is permanently attached to the insulating cap. The detachable facemask is a slight modification of a commercially available disposable respirator made of polyurethane foam.

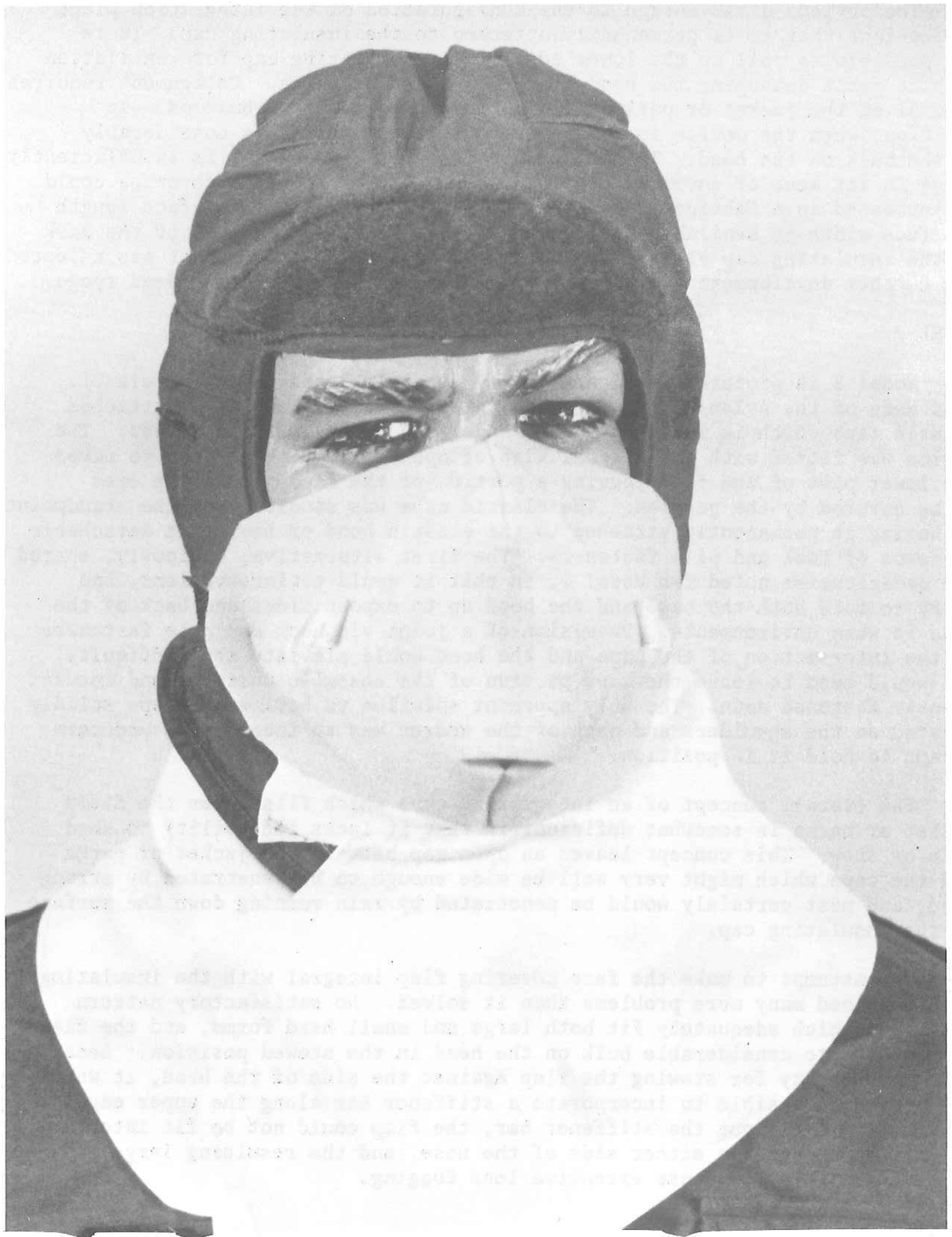


Figure 11. Preprototype Model 1 with Standard Insulating Cap, Integrating Collar, and Modified, Commercial Urethane Foam Respirator.

The obvious disadvantage to the configuration of the integration piece is the fact that it is permanently attached to the insulating cap. It is not possible to roll up the lower edge of the insulating cap for ventilation without first detaching the hood from the jacket or parka. Detachment requires removal of the jacket or parka and unbuttoning a number of buttons. In addition, when the device is rolled up, the cape contributes considerably to the bulk on the head. The detachable face mask, as shown, is insufficiently large in its area of coverage to protect the face. While the coverage could be increased in a fabricated device, and some adjustability for face length and face width is available through adjustment of the attachment of the mask to the insulating cap via the hook and pile fasteners, the concept was rejected for further development due to inherent bulk and large breathing dead space.

MODEL 2

Model 2 is pictured in Figure 12. This device consists of an elastic hood made of the nylon/urethane/cotton jersey material and has an attached elastic cape which is intended to fit under the parka or field jacket. The device was fitted with an integral flap of open-cell urethane foam to cover the lower part of the face leaving a portion of the face around the eyes to be covered by the goggles. The elastic cape was studied from the standpoint of having it permanently attached to the elastic hood or having it detachable by means of hook and pile fasteners. The first alternative, obviously, shared the deficiencies noted for Model 1, in that it would be inconvenient, and bulky to fold both the cape and the hood up to expose sides and back of the head in warm environments. Provision of a joint via hook and pile fasteners at the intersection of the cape and the hood would alleviate the difficulty, but would tend to leave the cape portion of the ensemble unstable and insufficiently fastened down. The only apparent solution to having the cape solidly located on the shoulders and neck of the wearer was to incorporate underarm straps to hold it in position.

The overall concept of an integrating cape which fits under the field jacket or parka is somewhat deficient in that it lacks the ability to shed rain or snow. This concept leaves an open gap between the jacket or parka and the cape which might very well be wide enough to be penetrated by strong wind, and most certainly would be penetrated by rain running down the surface of the insulating cap.

The attempt to make the face covering flap integral with the insulating hood produced many more problems than it solved. No satisfactory pattern was found which adequately fit both large and small head forms, and the flap contributed to considerable bulk on the head in the stowed position. Because of the necessity for stowing the flap against the side of the head, it was considered unfeasible to incorporate a stiffener bar along the upper edge of the flap. Without the stiffener bar, the flap could not be fit into the re-entrant corners on either side of the nose, and the resulting large gaps could be expected to cause extensive lens fogging.

MODEL 3

Model 3 (Figure 13) represented a combination of ideas from Model 1 and Model 2. The detachable facemask, however, is similar to the face mask

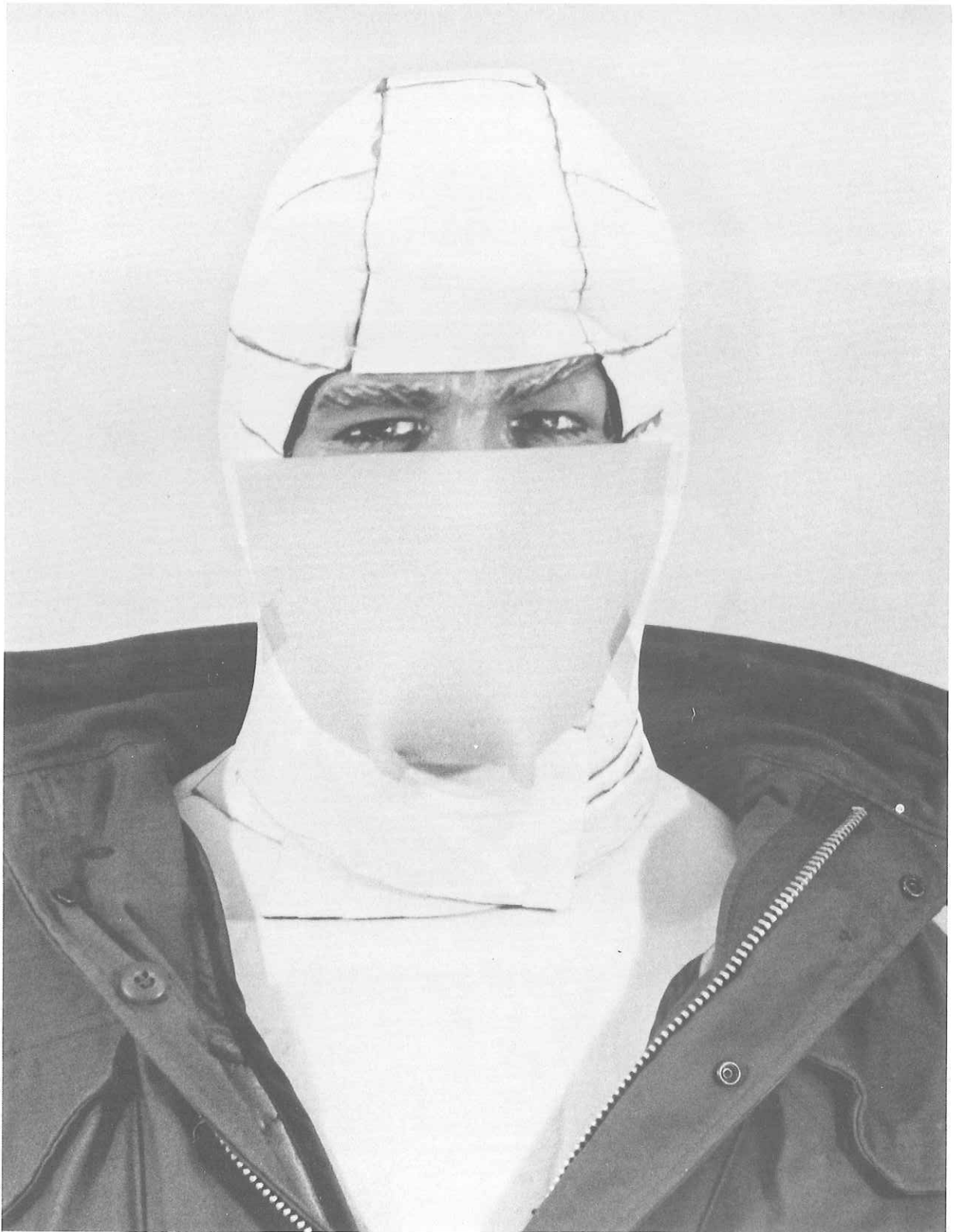


Figure 12. Preprototype Model 2 with Hood and Integrating Collar (Cape) of Hellenca/Urethane/Jersey Laminate, and Integral Urethane Face Covering.

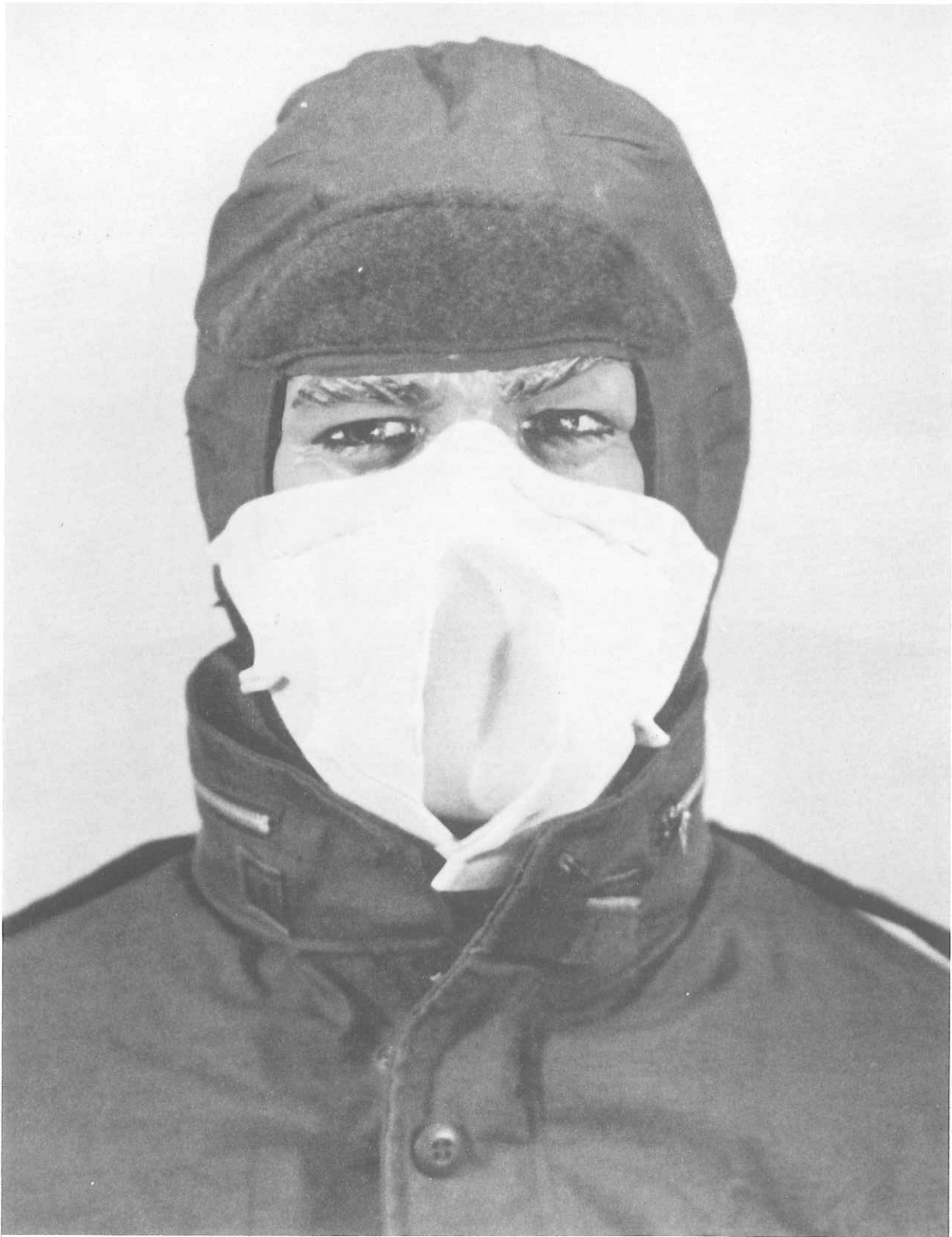


Figure 13. Preprototype Model 3 with Standard Insulating Cap, Adjustable, Half-Mask Face Covering, and Using Turtle-Neck Sweater (Under Jacket) as Integrating Collar.

included with the prototypes which were delivered. The use of a turtleneck sweater as an integration piece was based on the assumption that since such items already exist, it might be easier to modify them by the addition of hook and pile fasteners, than to fabricate an integrating cape from scratch. The idea was discarded when it was realized that a garment of knit construction which had sufficient insulating value to protect at the lower extremes of temperatures expected would represent considerable bulk, and would be uncomfortably warm under the field jacket or parka at moderate temperatures or during heavy work loads.

MODEL 4

The sole purpose of Model 4 was to attempt to obtain an insulating hood which had extraordinary stretch to it. It was felt that if a sufficiently stretchy hood could be fabricated, the entire range of head sizes and shapes could be fit with a single device.

The approach used in Model 4 of attempting to "shingle" a thin elastic hood with insulating material was not extremely successful. The hood was extremely bulky due to the necessity to overlap the insulation at all joints and no suitable means could be found for securing the overlaps against penetration by wind and/or rain.

OTHER STUDIES

Several other samples which are not pictured were partially assembled to further investigate the problem of integrating the insulating hood with the field jacket or parka. An attempt was made to form a detachable joint between the integrating cape of Model 1 and the elastic hood of Model 2 by providing hook and pile fasteners on the inner surface of the cape and on the outer surface of the lower edge of the hood. The result was reasonably neat and free of bulk, but left the opening edge of the joint facing upward where it could be penetrated by water or rain. It was eventually decided that for the prototypes which were to be delivered the hood would overlap the outer surface of the integrating cape to produce a rain shedding joint.

The detachable facemask shown in Model 3 was further developed and was submitted with the initial prototype as part of design 0001 A.

Section V

CONCLUSIONS AND RECOMMENDATIONS

The final version of the cold weather headwear ensemble developed under this program has been evaluated with respect to the requirements stated in Section III. Evaluations have consisted of informal wear trials to determine the compatibility of the ensemble with existing clothing and equipment, task performance, and user acceptance. Analytical evaluations have been made to project the protection performance of the ensemble. No empirical evaluations have been made under real or simulated conditions for which the ensemble is designed.

CONCLUSIONS

According to the analytical evaluations of the ensembles' protective capabilities, it will, when properly donned, provide sufficient protection at the lower extremes of environmental conditions defined by AR70-38 to maintain acceptable skin surface temperatures over the wearers' head region, and interact with the torso clothing in such a way that it will actually improve or at least not degrade the overall protection provided the wearer. The ensemble satisfies the other functional, physical, and operational requirements stipulated in Section III.

RECOMMENDATIONS

While the ensemble does appear to satisfy the requirements stipulated in Section III, several possible improvements were noted during the evaluation stage. These recommended improvements are noted in the following paragraphs:

HOOD

It appears that the cold weather protective hood can be improved from the standpoint of wearer acceptability and overall durability of the element.

Acceptability

It appears that the hood can be improved from an acceptability standpoint by reducing the width of the overlapping flaps used to retain the hood on the wearers head. The width reduction should be accomplished by removing material from the upper edge of these flaps so as to reduce and/or eliminate an interference between these edges and the under chin area of some wearers. This reduction in width of the overlap is accompanied by a loss in area of coverage provided by the hood but this loss can be compensated by wearing the face covering device.

Another modification to improve the utility and acceptability of the overall ensemble consists of incorporating pull tabs in the assembly to ease the task of detaching hook and pile fasteners when wearing cold weather hand gear. The additional pull tabs should be located at the lower front corners on the integration flap.

Durability

The ends of the flat seams on all segments of the hood (and the cape) are secured by a bartack in an attempt to prevent separation or ravelling of these seams. The bartacks appear not to provide sufficient holding power to prevent a small amount of separation from occurring at the ends of these seams. A possible alternative is the use of approximately 1/4 inch of zigzag stitching extending from the edge of the hood along the seam direction; the length of zigzag stitch used at the termination of each of the seams should be limited to avoid adversely affecting the stretchability of the overall hood.

CAPE

As currently used, the cape acts to restrict rotational head movement when the insulating hood is attached to it. This effect results from the fact that the cape is buttoned to the upstanding collar on the field jacket or parka, and because there is insufficient stretchability in the integrating flap on the hood to allow appreciable head rotation. A possible solution to this difficulty is to avoid attaching the cape to the parka or field jacket. If the cape is simply draped around the wearer's shoulders and closed at the front with the hook and pile attachment, and the integrating flap of the insulating hood is subsequently folded down to attach to the hook fastener tape on the cape, head rotation will cause the entire cape to rotate with respect to the torso clothing. The fact that the cape is fairly wide, and is contoured to fit the neck and shoulders of the wearer may provide a sufficient seal against penetrating winds. This approach must be evaluated under simulated or actual conditions of low environmental temperatures and winds.

FACE COVERING

No experience in cold environments has been accumulated with the use of the particular laminate of which the face covering is composed. Though difficulties are not anticipated, it is possible that the laminate may prove unsuitable for this application. This result would dictate a return to the approach used on the new standard face mask oronasal barrier; appropriate non-woven materials would have to be identified and substituted for the laminate used in the current prototype. The substitution would require that the pile fastener function be provided by strips of pile fastener material mechanically attached to the face covering.

Though the economics of the situation have not been investigated in detail, it is possible that some cost savings might be realized by the elimination of the present large piece of proprietary material incorporated in the face covering ("Velcro" V22-90). It may be cheaper to attach smaller pieces of this material or of nonproprietary pile fastener tape to the edge of some other material used to provide the insulating function of the face covering.

The current face covering device is removed rather easily by hooking the thumbs under the upper outer corners of the device and pulling outward and forward. This operation could be further improved by the incorporation at these locations of upstanding pull tabs which could be more easily grasped while wearing cold weather hand wear.

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Appendix A

DONNING INSTRUCTIONS

Donning of the cold weather headgear is accomplished without assistance and may be performed while wearing protective gloves and mittens. It is recommended that the procedure indicated below be followed.

GENERAL

The integrating cape may be placed on the field jacket or parka independent of whether the hood or face covering are worn. Once it is in place it can be considered as a portion of the torso clothing. The hood may be donned with or without the integrating collar being in place, and the collar can be added subsequent to donning the hood. The face covering device can only be attached to the hood after the latter has been donned by the wearer, though it may be removed and reattached to the hood without disturbing the positioning or adjustment of the latter.

ATTACHMENT OF INTEGRATION CAPE

The integration cape is to be attached to either the field jacket or to the parka; two sets of buttons are provided to accommodate existing buttonholes in either of the two pieces of upper torso clothing. Attachment is accomplished by first positioning the cape on top of the jacket so that the collar-like section with the hook material on the outer surface is adjacent to and on the outside of the upstanding collar on the field jacket or parka. Buttons are attached beginning at the right front corner of the collar by inserting the buttons on the integrating cape into the buttonholes on the outer surface of the field jacket or parka collar and progressing around the back until the last button has been attached on the left front corner. There are two sets of buttons; the first one of these sets is a single button at the right front corner of the collar, and this button is attached to the first buttonhole at the right front corner of the collar on either the field jacket or the parka. The appropriate button on the integrating cape is selected for the corresponding buttonhole on the jacket or the parka by identifying and attaching buttons on the cape which are closest to the buttonholes on the collar.

When the integrating cape has been attached to the field jacket or parka, either of these pieces of torso clothing may be worn as usual, with the exception that the hook and pile fastener on the integrating cape collar may be used to provide additional snugness for the neck closure of the jacket. This is accomplished by lapping the left hand extreme of the cape collar over the outside of the right hand extreme of the cape collar.

HOOD DONNING

To don the insulating hood, the following steps are to be performed sequentially:

1. Detach any hook and pile fastener which may have inadvertently become attached during storage or handling of the insulating hood. Position the hood with the crown portion downward and the opening facing upwards and backwards. Hold the hood as indicated in Figure 14.
2. Insert the forehead into the opening as shown in Figure 15 and rotate the hood body upwards and backwards until it is positioned on the head as shown in Figure 16.
3. Reach back and release the hook and pile attachment between the hood body and the integrating flap. Fold the flap into an upward-pointing position as shown in Figure 17.
4. Fold the right hand tongue of the hood across the throat to the left hand side of the neck as shown in Figure 18. Then cross the left hand tongue across the throat and attach to the hook material at the right hand side of the neck as shown in Figure 19.
5. Depending upon the joint desired at the interface between the torso clothing and the insulating hood, select one of the following:
 - 5a. Reclose the torso clothing at the neck over the outside of the basic hood body and pull the integrating flap of the hood down in a position to overlap the collar of the torso clothing and to attach to the hook material tabs at the front corners of the field jacket or parka as shown in Figure 20. The integrating flap may also be folded down in this position for attachment to the hook material on the outer surface of the collar of the integrating cape.
 - or
 - 5b. If the insulating hood has been lapped over the outside of the collar on the torso clothing, then the integrating flap may simply be returned to its original position and secured by means of the hook fastener on the hood.
 - or
 - 5c. If the torso clothing is to lap over the outside of the insulating hood, the integrating flap is returned to its original position and secured in place by means of the hook fastener material. The torso clothing is then returned to its original position around and lapping over the lower edge of the insulating hood as shown in Figure 21.
6. If ventilation of the insulating hood is required, then the lower edge of the hood may be folded upward by reversing the appropriate attachment steps as described above and folding the hood lower edge into the configuration as shown in Figure 22.

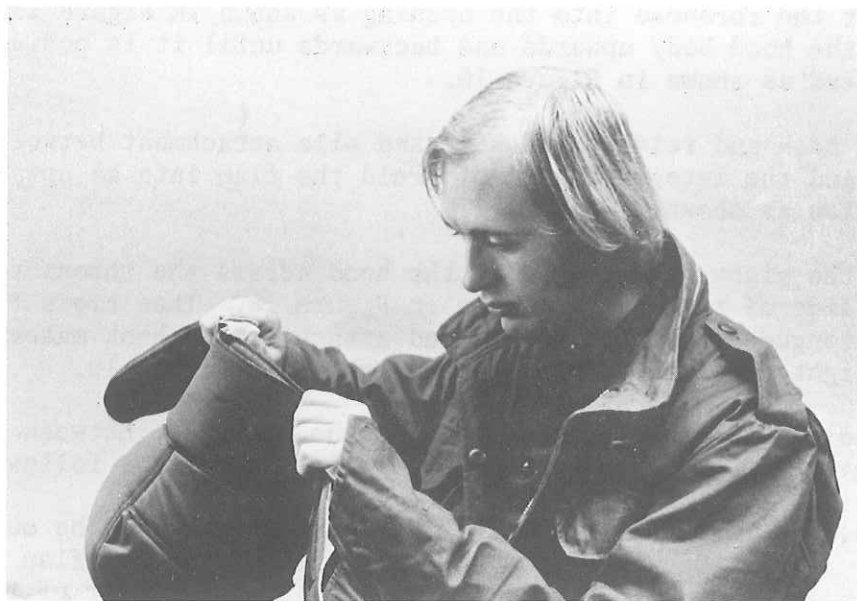


Figure 14.



Figure 15.
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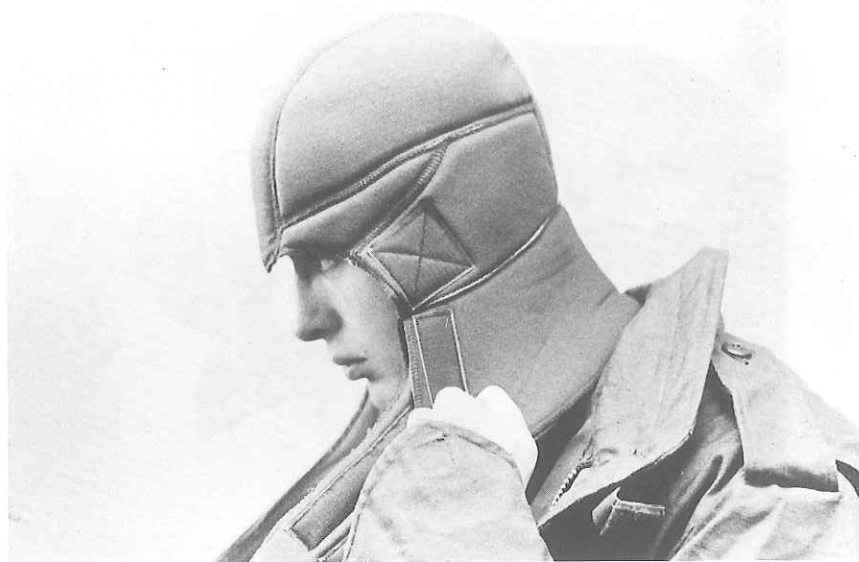


Figure 16.



Figure 17.
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Figure 18.



Figure 19.



Figure 21.



Figure 20.



Figure 22.



Figure 23.

7. Additional exposure of the neck and lower portions of the head may be achieved by taking an additional fold in the hood as shown in Figure 23. Either of the folding operations may be accomplished with or without the helmet in place as is the case with the standard insulating cap.

FACE COVERING ATTACHMENT

The face covering device can only be mounted on the insulating hood; it cannot be donned without the insulating hood being in place. The procedure for donning a face covering device and attaching it to the insulating hood is as described in the following sequential steps:

1. Center the face covering device laterally over the face and place its upper edge in contact with the bony ridge of the nose as shown in Figure 24.
2. Mold the malleable stiffener in the upper edge of the face covering against the face and around to the side to lap over the forward edge of the insulating hood as shown in Figure 25.
3. While holding the upper edge of the face covering device in position over the nose, stretch out the mask by pulling downward in the center and attach it to the insulating hood by swinging it into position as shown in Figure 26.
4. Fold out the excess material in the face covering as shown in Figure 27, and fold the flaps over one another and secure in position with the hook and pile fastener tapes as shown in Figure 28.
5. The face covering may be removed by grasping the rearward, upper corners where they overlap the hood and pulling outward and downward until all of the hook and pile fastener material has been detached.



Figure 24.



Figure 25.



Figure 26.

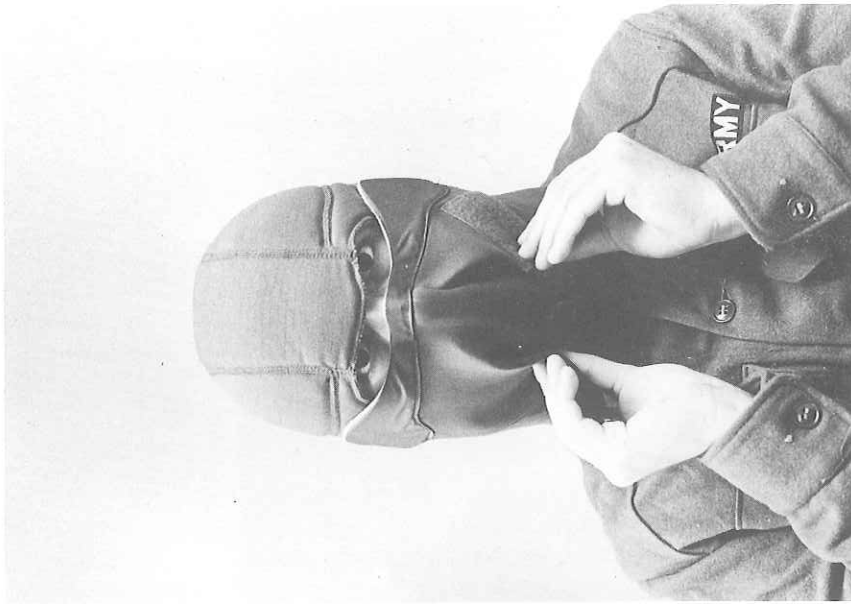


Figure 27.



Figure 28.

Appendix B

MATERIALS DESCRIPTIONS AND FABRICATION INSTRUCTIONS

Descriptions of the materials used in the fabrication of the cold weather headwear ensemble are presented below. A list of pattern parts and detailed cutting and fabrication steps are presented in Tables 2 and 3, respectively.

MATERIALS DESCRIPTIONS

- a. Helenca - Cloth, Knitted, Nylon, Tubular Stretch Type, Class I, 7 ± 0.5 oz/yd², OG 106 (MIL-C-43247A)
- b. Nyco Fabric - Cloth, Oxford, Cotton Warp, Nylon Filling, Quarpel Treated, OG 107, 5 oz/yd² (MIL-C-3924)
- c. Cotton Knit - Flat (Jersey) Stitch Knitted Cloth
- d. Foam - Foam, Polyurethane, 80% open cell, 1/4 inch and 5/16 inch thickness, Commercial Source
- e. Napped Nylon Tricot - Part Number V22-90 Pile Fabric, Velcro Corp., Manchester, New Hampshire 03103, or equivalent
- f. Hook and Pile Tape - Fastener Tape, Hook and Pile, Nylon, Type I, Class I (MIL-F-21840)
- g. Fabric Tape - Tape, Textile, Cotton OD 7, 5/8 inch wide (MIL-T-43566)
- h. Buttons - Button, Sewing Hole and Button, Staple (Plastic) Type II, Class D, Style 26, 30 line, Dull Finish, OG Shade BP (FED SPEC V-B-871)
- i. Thread - Thread Polyester, Cotton Wrapped, Ticket No. 70, 2 ply, Quarpel Treated (MIL-T-3530E)
- j. Aluminum Stiffener - Aluminum 1100, Plate and Sheet, 0 Temper, Aluminum Sheet, 0.020 inches thick (FED SPEC QQ-A-250/1)
- k. Laminates (flame or adhesive bonded):
 1. Helenca/5/16 inch foam/cotton jersey with face (wale) side of jersey in contact with foam.
 2. Helenca/1/4 inch foam/cotton jersey laminated as above.
 3. Helenca/foam-backed nylon tricot laminated with Helenca against foam surface.

PATTERN PARTS

The pattern parts to be provided for each cold weather headwear ensemble are indicated in Table 2. Parts not requiring patterns are described by their dimensions in Table 3.

CUTTING AND FABRICATION INSTRUCTIONS

Cutting and fabrication instructions are presented sequentially in Table 3, Manufacturing Operations Requirements data sheets.

Table 2

LIST OF PATTERN PARTS

<u>MATERIAL</u>	<u>PATTERN NOMENCLATURE</u>	<u>CUT PARTS</u>
5/16 foam, Hellenca, Cotton Jersey Laminate	* Hood side panel	2 - 1 L.H. 1 R.H.
1/4 foam, Hellenca, Cotton Jersey Laminate	* Upper hood side section	2-1 L.H. 1 R.H.
	* Hood center panel	1
	* Cape	2 - units
Napped nylon tricot, 1/16" foam, Hellenca Laminate	* Hood-to-cape integration	1
	* Face covering	1
Napped nylon tricot, 1/16" foam Hellenca Laminate	* Inner left flap hood closure	1
2" hook tape	Outer right hood flap closures	2 - 1 angular, 1 contoured
	Outer collar hook tape	1
	Face covering attachment on hood	2
2" pile tape	Inner left collar closure	1
	Outer face covering device	1
Nylon/Cotton fabric	Cape collar	2
	Nose-bridge pocket	2

* Patterns provide 1/4-inch trim-off for over-edging and flat seaming.

NOTE: Other parts not requiring patterns are described by their dimensions in cutting instructions of Table 3.

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Loop
1.	<u>Cutting.</u> a. Cut all parts of the Hood, Face Covering and Cape in strict accordance with patterns furnished, which show directional lines, notches and locating marks for assembly. b. Cut the 1-inch hook tapes as follows: (1) 6 inches long - cut two (2) for outer left hood flap cut one (1) for pull-tab closure face covering (2) 3-1/2 inches long - cut two (2) for outer edges of hood-to-cape integration c. Cut the 5/8-inch woven tape as follows: 4 inches long - cut one (1) for face covering pull-tab d. Cut the 2-inch hook tapes as follows: (1) 2 inch square - cut two (2) for face covering to hood attachment, just below side darts on hood (2) two (2) contoured pieces for outer right hood flap closure, (see patterns) (3) 28-3/4-inch long - cut one (1) for outer collar on cape (contoured edges) (see pattern)					

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Looper
2.	e. Cut the 2-inch pile tapes as follows: (1) 3-1/2 inches long - cut one (1) for closure on inner left collar, (contoured edge) (see pattern) (2) 3-1/4 inches long - cut one (1) for outer face covering closure					
	<u>Make Hood.</u>					
	a. Flat seam darts in hood side panels; start seam at opening of dart, close dart and continue stitching on up to edge of panel.	606 or 607	FSa-1	12-16	70	70
	b. Flat seam hood side panels to upper hood side sections.	606 or 607	FSa-1	12-16	70	70
	c. Flat seam hood center panel to completed hood sides	606 or 607	FSa-1	12-16	70	70
	d. Over-edge stitch around raw edges of hood; position pile fabric closure on inner left hood flap and secure with over-edge stitch.	503 or 504 or 602	EFd-1	8-10	70	70
	e. Bartaack the ends of all abutted seams and darts. (6 tacks.)	Bartaack		28 per Bartaack	70	70
	f. Stitch down loose edge of inner left hood flap (pile fabric) closure.	301		8-10	70	70
	g. Position the 1-inch hook tapes on outer left hood flap (see pattern.) Stitch on all four sides of each tape.	301		8-10	70	70

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Looper
3.	h. Position the 2-inch sq. hook tapes on hood side panels; not more than 1/4 inch below darts, and not more than 1/4 inch in from edge of hood. Stitch all four sides of each tape and cross stitch through center of each square.	301		8-10	70	70
	i. Position, angle cut and contoured 2-inch wide hook tapes on outer right hood flap, (see pattern.) Stitch all edges of tapes and center stitch in long direction.	301		8-10	70	70
	<u>Make Hood-to-Cape Integration.</u>					
	a. Over-edge stitch around hood-to-cape integration.	503 or 504 or 602	FFd-1	8-10	70	70
	b. Position the two 1-inch wide hook tapes on integration, (see pattern.) Stitch all four sides of each tape.	301		8-10	70	70
	c. Position hood-to-cape integration on hood; upper corner edges of integration should be attached not more than 1/8 inch below the 2-inch sq. hook tapes and not more than 1/8 inch from hood edge. Integration at center back hood should not be lower than 3 inches from the junction at the vertical upper hood section seam and the horizontal center hood panel seam. (see pattern.)	301		8-10	70	70
	d. Bartack edges of hood-to-cape integration at edges of hood; align bartack with top edge of integration and run it lengthwise over the integration-to-hood seam. (2 tacks.)	Bartack		28 per bartack	70	70

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Looper
4.	<u>Make Nose-Bridge Pocket for Face Covering.</u> a. Stitch bottom edge of nose-bridge pocket pieces together between notches with 1/4 inch seam. Turn pocket right-side out and stitch along outside of turned seam 1/8 inch from edge of pocket.	301		8-10	70	70
5.	<u>Insert Nose-Bridge Stiffener in Nose-Bridge Pocket.</u> a. Insert aluminum stiffener in pocket; push stiffener down into pocket against seam, pin upper opening of pocket, snugly securing stiffener in pocket.					
6.	<u>Make Face Covering.</u> a. Over-edge stitch around lower edge of face covering between notches. b. Match upper edge of nose-bridge stiffener pocket with upper edge of inner pile side of face covering. Stitch pocket onto face covering; (use 1/8 inch pressure foot on machine) run stitch up against stiffener in pocket, making sure that stiffener is firmly encased in pocket. c. Snip and trim bulk edges of pocket-to-face covering seam. d. Turn pocket to outer side of face covering and stitch down along the 1/8 inch outer pocket seam. Bartack lower outer corners of pocket to face covering at ends of 1/8 inch outer pocket seam. (2 tacks.)	503 or 504 or 602 301 301	EFd-1	8-10 8-10	70 70	70 70
		301 Bartack		8-10 28 per bartack	70 70	70 70

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Looper
7.	e. Position the 2-inch wide pile tape on outer side of face covering, (see pattern) stitch all four sides and center stitch in long direction.	301		8-10	70	70
	<u>Make Pull-Tab for Face Covering.</u>					
	a. Fold the 5/8-inch wide woven tape in half lengthwise. Take the two raw edges together and fold over 1/2 inch; bartack the 1/2 inch folded end of woven tape, with raw edges down, onto non-hook side end of tape, (2 tacks, crosswise not more than 3/8 inch apart.) Woven tape pull-tab loop should extend out from edge of hook tape not less than 3/4 inch and not more than 1 inch.	Bartack		28 per bartack	70	70
8.	b. Position pull-tab on face covering (hook side down) and stitch down raw end of hook tape, secure with a square 1-inch of stitching and a cross of stitching.	301		8-10	70	70
	<u>Make Cape.</u>					
	a. Flat seam cape units together.	606 or 607	FSa-1	12-16	70	70
	b. Over-edge stitch around cape raw edges.	503 or 504 or 602	EFd-1	8-10	70	70
	c. Bartack ends of abutted seam on cape. (2 tacks.)	Bartack		28 per bartack	70	70

No.	Manufacturing Operations Requirements Table 3	Stitch Type	Seam and Stitching Type	Stitches per Inch	Thread	
					Needle	Bobbin or Looper
9.	<u>Make Collar for Cape.</u>					
	a. Stitch the two Nyco collar pieces together with a 1/4 inch seam, leave a turn opening no more than 3 inches long at center bottom collar.	301		8-10	70	70
	b. Turn collar right-side out through the 3 inch opening, close opening with a 3 inch row of stitching not more than 1/8 inch from edge of bottom collar.	301		8-10	70	70
	c. Position buttons (see pattern) and attach to inner side of collar.	Button stitch			70	70
	d. Position 2-inch wide (x 3-1/2" long) contoured (see pattern) pile tape on inner left side of collar. Stitch all four sides.	301		8-10	70	70
10.	e. Position 2-inch wide (x 28-3/4" long) contoured (see pattern) hook tape on outer side of collar and stitch all edges.	301		8-10	70	70
	<u>Attach Collar to Cape.</u>					
	a. Stitch cape to lower outer edge of collar, (run stitch not more than 1/4 inch below finished edge of cape) over-lay cape edge on collar; edge of cape should lie not more than 1/4 inch below edge of hook tape, but should not over-lap at any point on the hook tape. Right end of collar should extend past edge of attached cape not more than 2-1/2 inches and not less than 2-1/4 inches.	301		8-10	70	70
	b. Bartack ends of cape-to-collar seam; place bartack crosswise over cape-to-collar seam, parallel to edge of cape and collar unit.	Bartack		28 per bartack	70	70