



CANADIAN POLICE RESEARCH CENTRE



CENTRE CANADIEN DE RECHERCHES POLICIERES

TM-18-93

Two-Piece Integrated Riot Suit

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TECHNICAL MEMORANDUM

Submitted by
Canadian Police Research Centre

December, 1993

NOTE: Further information
about this report can be
obtained by calling the
CPRC information number
(613) 998-6343

SUMMARY

At present, commonly issued protective apparel for police riot troop members consists of a modular mix of hockey or football padding that is worn under standard issue uniforms or coveralls. Such equipment is often cumbersome and uncomfortable. The true value of such equipment for protecting the upper body, knees, thighs, groin and shins in riot situations is also largely unproved. Law enforcement agencies require a protective suit for their crowd management teams that provides suitable protection, comfort and ease of use.

The purpose of this research project was to design and develop a two piece protective suit with integrated padding that is appropriate for the threat faced by Canadian riot troop members. Specifications for a suitable protective suit were established and a preproduction prototype suit was manufactured to meet this specification. This specification and resulting prototype has padding integrated in the jacket but not the trousers. Initial assessments of the prototype suit are favourable. The only difficulty encountered is the fact that this suit (and any other offering this degree of protection) is very hot to wear in a warm environment.

RÉSUMÉ

À l'heure actuelle, les vêtements de protection utilisés par les troupes anti-émeute de la police se composent essentiellement de protecteurs de hockey ou de football que les agents portent sous leur uniforme ou sous leur combinaison standard. Cet équipement est encombrant et peu confortable. De plus, il n'a pas été démontré que cet équipement fournissait aux membres des troupes anti-émeute une protection adéquate pour le haut du corps et au niveau des genoux, des cuisses, du bassin et des tibias. Les forces de l'ordre désiraient des vêtements de protection pouvant assurer aux équipes de contrôle des foules une protection adéquate tout en étant confortables et faciles à utiliser.

Ce projet portait sur la conception et la mise au point d'une combinaison deux-pièces avec rembourrage intégral pouvant assurer la protection des membres des troupes anti-émeute des forces policières canadiennes. On a défini les spécifications de ce vêtement de protection et confectionné un modèle de présérie conformes à ces spécifications. Le prototype retenu à la suite de ce projet est une combinaison deux-pièces comprenant une veste avec rembourrage intégré, et un pantalon porté par-dessus des protecteurs rembourrés facultatifs. Les premières évaluations du prototype ont été favorables. Le seul problème identifié avec cet équipement est le fait que la combinaison (comme tout autre vêtement offrant ce degré de protection) emprisonne la chaleur du corps et devient rapidement très chaude.

TWO-PIECE INTEGRATED RIOT TROOP SUIT

Operational Requirement:

At present, commonly issued protective apparel for police riot troop members consists of a modular mix of hockey or football padding that is worn under standard issue uniforms or coveralls. Such equipment is often cumbersome and uncomfortable. The true value of such equipment for protecting the upper body, knees, thighs, groin and shins in riot situations is also largely unproved. Law enforcement agencies require a protective suit for their crowd management teams that provides suitable protection, comfort and ease of use.

Project Objective:

The purpose of this research project was to design and develop a two piece protective suit with integrated padding that is appropriate for the threat faced by Canadian riot troop members.

Prototype Development:

The project was undertaken in two phases; the first being the development of a jacket and the second the trousers. The suit was designed to provide protection against direct blows, thrown objects and ricocheting projectiles as well as threats associated with penetrating or cutting devices. Fire retardancy was also required as protection from "Molotov cocktails".

The jacket was designed to take into account the range of body sizes it will have to accommodate as well as the need to interface with existing equipment. Lightness, comfort and flexibility were deemed important but not at the sacrifice of protection.

Early in the project it was determined that padding would be an integral part of the jacket but not for the trousers. Conventional modular padding would be used for protection below the wearers waist. The primary reason for using a jacket with integrated padding is that the user can don or remove the garment much more quickly. Consequently, a riot troop member can use a lesser degree of protection (e.g. shin and thigh protection and padded gloves) with conventional uniform garments when the threat from the crowd is minor. They can quickly upgrade their level of protection, with the donning of the protective jacket, if the need arises. Using integrated padding in the trousers would substantially increase the selling price of such a suit yet provide little additional benefit as members can wear modular lower body padding for extended periods with relative comfort,

The project began with identifying the garment needs of the RCMP Headquarters riot troops. Criteria were identified establishing sizing, color, interface with present equipment, comfort, items carried, cleaning, maintenance, life expectancy, weight, mobility, insignia, appearance and

performance criteria. Details on these design and performance criteria are found in **Appendix A - General Design and Performance Criteria.**

In developing the padding for the suit, it was critical that the padding be not only lightweight but that it offer the wearer the maximum protection required. In order to better understand the protection offered by various padding materials, a series of tests were undertaken. These tests were performed using equipment that measures transmitted forces and load distribution. These tests were performed on several samples of varying composition, thickness and densities. The samples were prepared with a high density foam laminated to the exterior of a low density foam. The sample is placed in such an orientation that the high density foam absorbs the blow first by distributing the load across the lower density foam. The low density foam then absorbs the remainder of the impact energy. Details on the dual layer padding that was selected for use is found in **Appendix C - Riot Suit Specifications - Padding.**

It is critical in crowd management situations that the officer be protected by a flame and chemical resistant material which also maintains its integrity in a variety of situations. In order to properly evaluate the exterior suit material two tests were devised. The first being a flammability test, where 10 ml of a toluene/iso-octane (gasoline) is poured onto the material. The material cannot sustain combustion after the point at which the fluid has been burned away. The second test is known as a tear strength test. This involved placing a hook through the material and applying a known load. The point at which the material gave way was the recorded as its ultimate tear strength. The chosen specification for the Exterior Shell Fabric is found at **Appendix B.**

Final Design:

After several iterations, two copies of the final prototype were created.

Appearance

The riot suit jacket is similar in appearance to the navy coloured RCMP patrol jacket. The colour matched trousers are a “combat” style with pockets at the upper and lower leg areas. Please refer to **Figure 1 - External View of Suit and Figure 2 - External View of Trousers.**

Materials

As a result of the testing and given the colour options, costs and availability of the different materials, the following materials and features were selected for use in the fabrication of the prototype suit.

Exterior Shell Features

The shell fabric chosen was "Vulkan" - 180 gm. and 370 gm. weight. The jacket has double-end zipper “Velcro” front overlap (in case of zipper failure). The jacket has a loose lower band designed to promote jacket return (no permanent “ride-up”). The jacket has no shoulder seams. The jacket has no sleeve cuffs (for improved glove interface) but does have a thumb loop (to keep the sleeves down). The jacket has back vent and front pleat to permit a full range of movement.

An exterior expandable pocket is available for a radio and a pocket is available in the interior for a water bottle. The trousers have a zipper and velcro closure for leg openings (for ease of doning or removal over boots).

Padding Units

The padding material consists of inserts of a dual layer foam laminate "LD70 + HD80". The jacket has a single padded unit covering upper back over shoulders over clavicles and covering down to lower ribs. This torso padding is securely affixed to the inside of the exterior shell. The upper arm and elbow/lower arm padded units are fitted in envelopes in "Spandex" sleeve liners. Forearm padding is trimable to fit the wearer. Please refer to **Figure 3** for a cut-away figure illustrating the interior padding. Padding coverage in the trousers is illustrated in **Figure 4**. The choice of lower body padding is optional. The RCMP use shinpads and a padded hockey girdle.

Jacket Lining

The torso of jacket is lined with "Coolmax" for comfort and perspiration absorption. The interior of the sleeves are lined with "Spandex" envelopes in order to retain the padded units in position.

Other Features

Staining and shrinkage tests were also conducted on a sample of "Vulkan" fabric. The sample was stained with eggs, dried overnight and then subjected to a normal machine wash and dry. The material washed clean and the overall shrinkage was less than 3%. All of garment (including padding) is machine washable. Cleaning Instructions are attached to this report as **Appendix F**.

Operational Evaluation:

Two copies of this final prototype suit were submitted to RCMP Headquarters tactical troops for evaluation. They had 20 troop members (from the Ottawa area) and 10 Tactical Troop Instructors (from across Canada) conduct evaluations of the product.

The evaluators preferred the heavier weight of vulcan fabric although there is little difference with durability and protection provided.

They found that the suit was very hot to wear in a warm environment; especially if the member is physically active. This is a very difficult (perhaps impossible) problem to solve. The very nature of the protection required demands materials that limit air movement in the garment and heat transfer away from the body.

Other than the problem with heat build-up, they found the suit to be very comfortable and presented a very professional appearance. While wearing the suit they felt a sense of confidence and security that they had an adequate level of physical protection available to their bodies.

Two members used the suit while participating in specialized tactical troop training in England. During part of this training, one was subjected to having flammable materials burning at his feet.

Conclusions and Recommendations:

- (1) If the crowd control unit is expected to be exposed to tear gas or toxic vapors while on the line and with little advance warning of their presence, a quick don type helmet/mask system is highly recommended
- (2) If the crowd control unit has advanced knowledge that it will be using tear gas or be exposed to other toxic vapors, conventional gas masks can be donned in advance of engagement. In such a scenario a quick don type helmet/mask system is of little advantage over conventional gas masks.
- (3) careful sizing of the helmet and mask is recommended in order to ensure that face seal integrity is maintained even under adverse conditions
- (4) careful selection and sizing of the gas mask be followed to ensure adequate nose seal in order to minimize internal fogging of the gas mask visor

This CPRC technology has been licensed to a private Canadian company. For additional information regarding further technical development and commercial availability, please contact:

Biokinetics and Associates Ltd.
2470 Don Reid Drive
Ottawa, Ontario K1H 8P5
telephone: 613-736-0384
facsimile: 613-736-0990

Appendix A

GENERAL DESIGN and PERFORMANCE CRITERIA

Size	A wide variety of male and female sizes are necessary to ensure proper fit of interior padding Suits would be individual issue
Colour	dark navy blue
Comfort	comfortable for 3-5 hours wear during “down-time” and 30 minutes “in-action” comfortable in temperatures range - 10°C to +25°C
Flexibility	Flexible for all riot situation activities, viz. <ul style="list-style-type: none">- shield use- running- walking over debris- operating shoulder to shoulder- recovery after fall- in push-pull rioters
Appearance	Consistent with RCMP garment styles Not overly aggressive appearance
Cleaning	Stain resistant Washable, using home washer and dryer, with no shrinkage or colour loss
Maintenance	Routine repair without reducing protective level
Life Expectancy	Minimum 5 years
Interface	Interface with existing equipment, specifically <ul style="list-style-type: none">-ballistic vest-riot helmet-gas mask-gloves-baton-riot shields-gas gun and firearms (for special support teams)

Fire retardant

Acid splash resistant

Direct impact resistance:

Low mass, high velocity (eg. sling shot golf balls)

High mass, low velocity (eg. ricocheting piece asphalt)

Appendix B

RIOT SUIT SPECIFICATIONS EXTERIOR SHELL FABRIC

FLAMMABILITY PERFORMANCE

Standard	Performance
BS 3119/3120	Pass on original and after 50 Industrial laundry cycles.
BS6249/5438 Part 1	Pass Index B on original and after 50 Industrial laundry cycles.
DIN 54336/66083 Class 8b	Pass Sb on original and after 50 Industrial laundry cycles.

PHYSICAL PERFORMANCE

	Characteristics	Test Method
Tensile	846 N - Warp 605 N - Filling	Can 2-4.2 method 9.2
Tear	42 N - warp 33 N - filling	Can 2-4.2 method 12.3
Pilling	4.5	Can 2-4.2 method 51.2
Shrinkage	-3.0%. - Warp -2.2% - Filling	AATC method 135-III-B 3 cycles

COLOUR PERFORMANCE

	Characteristics	Test Method
Colour Fastness to:		
Crocking:	4.5 - Dry 4.0 - Wet	Can 2-4.2 method 22
Light	L-5	Can 2-4.2 method 18.3
Laundering	4.5	15 Dupont
Perspiration	4.5 - Shade change 4.5 - Staining	Can 2-4.2 method 23

FABRIC SPECIFICATION

Fibre Content	65% Danufil CS 35% Conex Aramid
Finished Weight	320 grams/Mete? (9.4 osy)
Weave	Cross Twill
Minimum finished width including selvedge	150 cm (59 in)

Appendix C

RIOT SUIT SPECIFICATIONS INTERIOR PADDING MATERIALS

Plastazote HD Polyethylene Foam

Plastazote is a closed cell, cross-linked polyethylene foam

Property	Test Method	Units	Typical Value	
			HD80	HD115
Density	ASTM D3575-84	lb/ft ³		
skin/skin			5.0	7.2
cell/cell			4.5	6.2
Compression Strength 25% compression	ASTM D3575-84	PSI	85	130
Compression Set				
22 hrs 50% compression 73°F 24 hr recovery		% set	20	21
22 hrs 50% compression 73°F 24 hr recovery		% set	14	15
Tear Strength	ASTM D3575-84	lb/in	65	85
Horizontal Burning	FMVSS.302		Pass @ 0.2 in thickness and above	Pass @ 0.02 in thickness and above

Appendix D

CHEMICAL RESISTANCE RIOT SUIT SHELL FABRIC

Chemical	Concentration %	Temperature °C	Time Hours	Residual Strength %
Formic Acid	90	20	10	80
Ammonium hydroxide	10	20	10	100
White spirit	100	20	10	100
Benzene	100	20	10	100
Dimethyl formamide	100	20	10	100
Acetic acid	10	20	10	85
Ether	100	20	10	100
Ethyl alcohol	96	20	10	100
Glycerol	100	20	10	100
Sodium carbonate	10	20	10	100
Sodium hydroxide	10	20	10	85
Perchloro ethylene	100	60	100	100
Phenol	100	20	10	100
Prosphoric acid	10	20	10	80
Nitric acid	10	20	10	65
Hydrochloric acid	37	20	10	25 (viscose destroyed)
Sulphuric acid	10	20	10	25 (viscose destroyed)

Appendix E

Instructions for Use and Care

1. Pad Insertion

- (a) Open the front of the jacket.
- (b) Reach into one of the sleeves and locate the zipper in the upper sleeve.
- (c) Open the zipper completely.

1.1 Lower Arm Protection

- (a) Reach down, through the open zipper, in between the lining and the outer shell, grab a hold of the elastic strip and pull the sleeve out such that it is inside out.
- (b) Unfasten the Velcro® closures on each of the three elastic strips and locate the colour tab.
- (c) Place the lower arm protector over the colour tab with the arrow pointing towards the cuff.
- (d) Fasten the Velcro® closures.
- (e) Push the liner with the lower arm protection attached, back into the sleeve.

1.2 Shoulder Protection

- (a) Reach up, through the open zipper, in between the lining and the outer shell to the shoulder, pull down on the on the cloth pouch, far enough to have access to the zipper.
- (b) Open the zipper and insert a shoulder protector into the pouch, concave side up with the indicator tape up.
- (c) Close the zipper and replace the pouch into position.

1.3 Upper Arm Protection

- (a) While holding the upper arm protector by the snap tab, insert the pad through the zipper, and thread the tab through the shoulder opening/slit.
- (b) Snap the upper arm tab into place on the shoulder of the vest.
- (c) Close the zipper in the lining of the upper arm.

1.4 Chest Protection

- (a) Fasten the three snaps around the collar of the vest to the jacket.

Appendix E

2.0 Cleaning Instructions

2.1 Preparation for Washing

- (a) Open the zipper located in the upper sleeve.
- (b) Unfasten the snap at the shoulder.
- (c) Reach inside the open zipper and unfasten the Velcro® closure located on the bottom edge of the upper arm padding.
- (d) Remove the upper arm padding from the sleeve.
- (e) Reach up, through the open zipper, to the shoulder and remove the shoulder cap from the zippered pocket.
- (f) Reach down through the open zipper towards the cuff and remove the lower arm padding.
- (g) Re-fasten the Velcro® closures.
- (h) Close the zipper in the upper sleeve.
- (i) Unfasten the snaps around the collar of the vest.
- (j) Apply protective strips to the exposed Velcro®
- (k) Fasten the Velcro® closures on the sleeve cuffs, collar and pant cuffs.

2.2 Washing Instructions

- (a) Use detergent, **not** soap or soap powder.
- (b) Do not boil.
- (c) Use of hard water is not recommended.

2.3 Dry Cleaning Instructions

- (a) The garment may be dry cleaned but thorough rinsing is required to remove all traces of laundry residual products which would affect flame retardant properties.

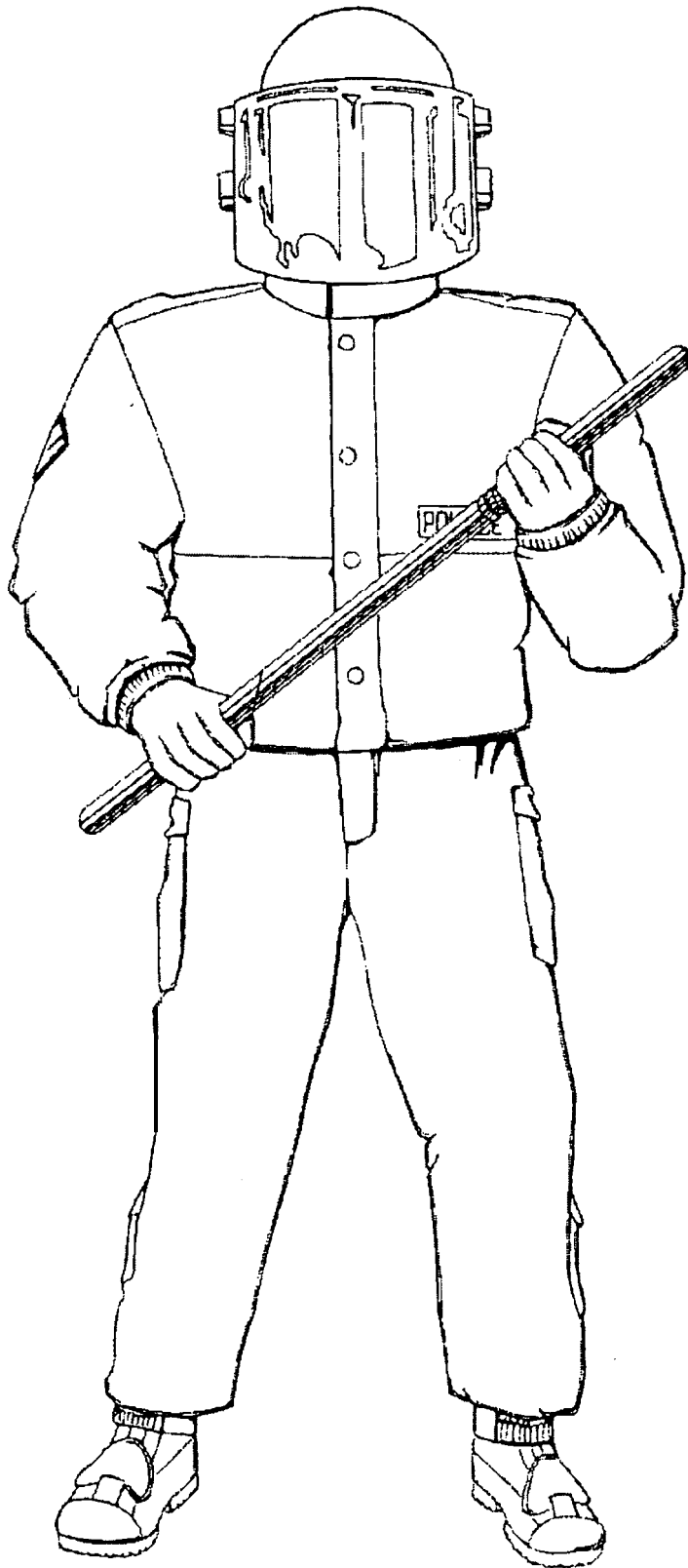


Figure 1

**External View of
Riot Troop Suit**

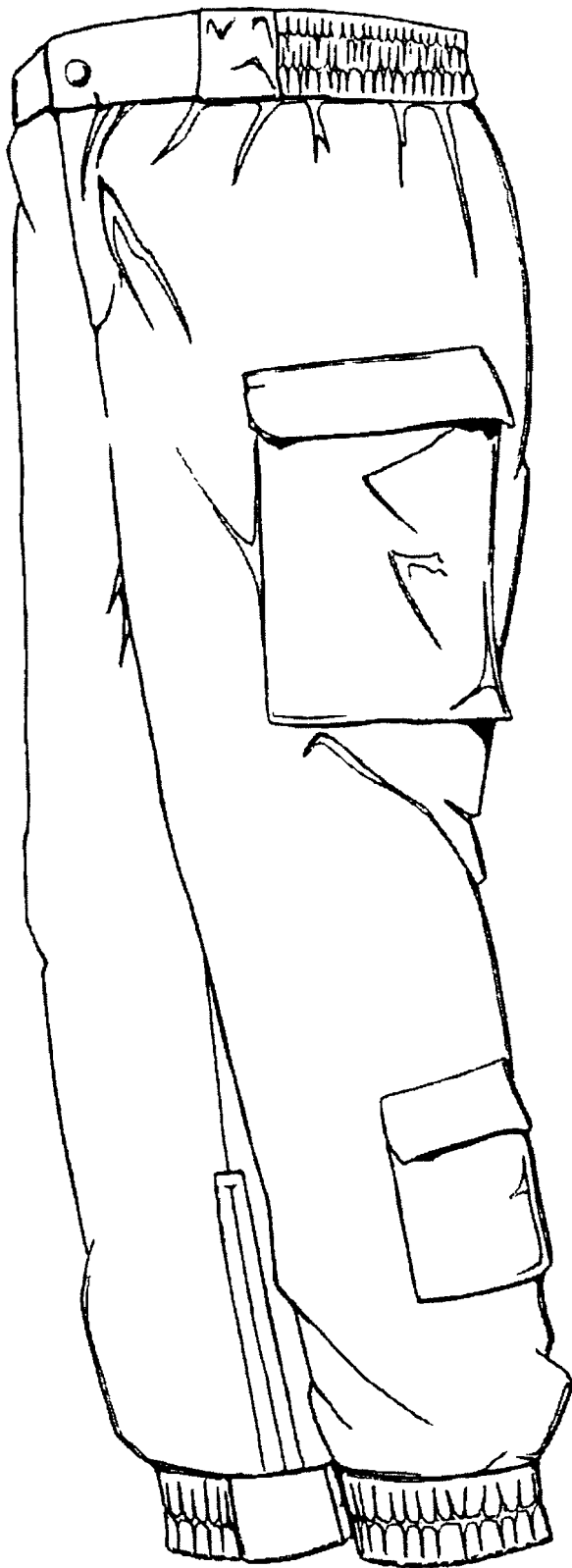


Figure 2

**External View of
Riot Troop Trousers**

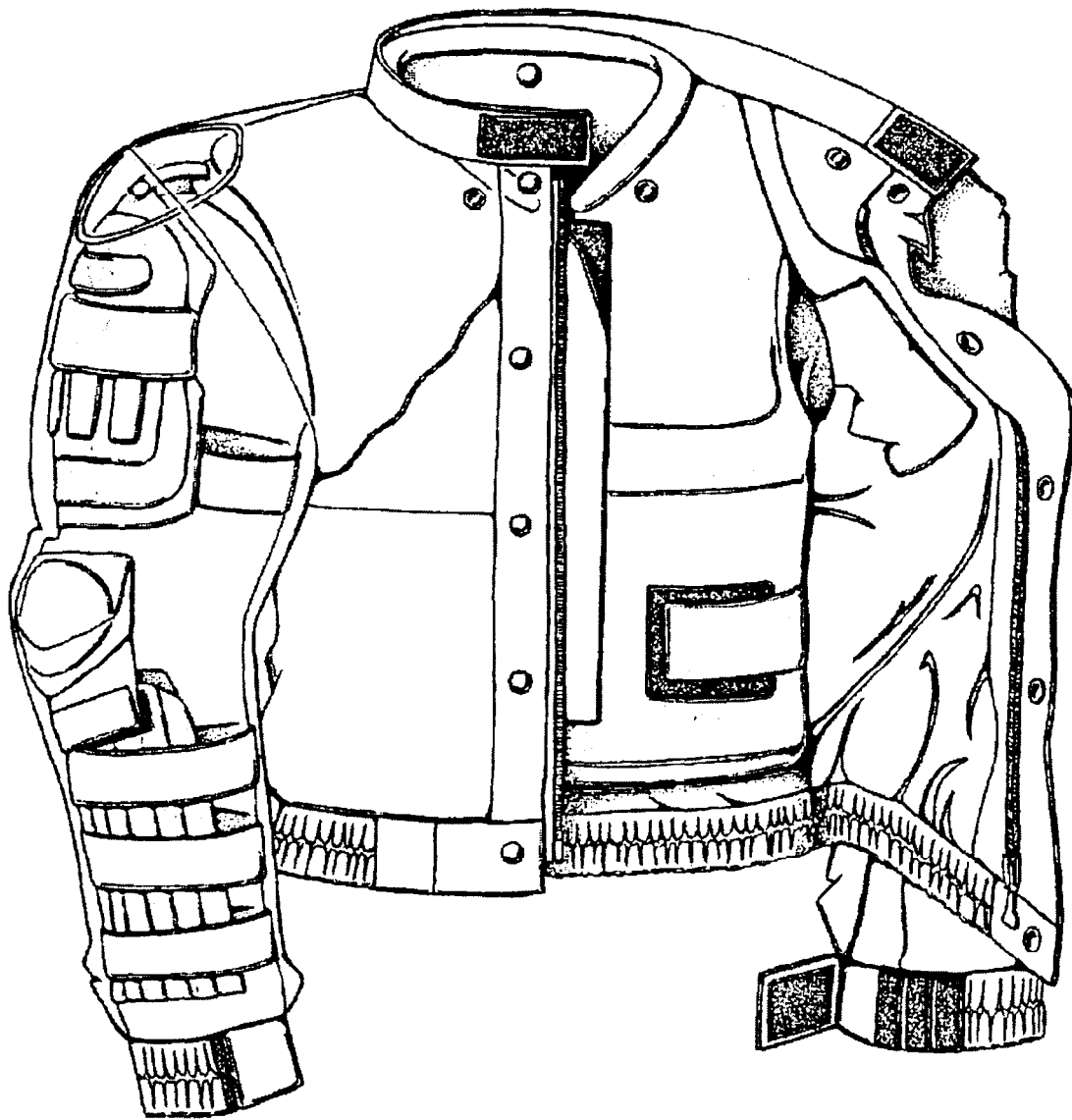


Figure 3

**Cut-away View of
Riot Troop Jacket**

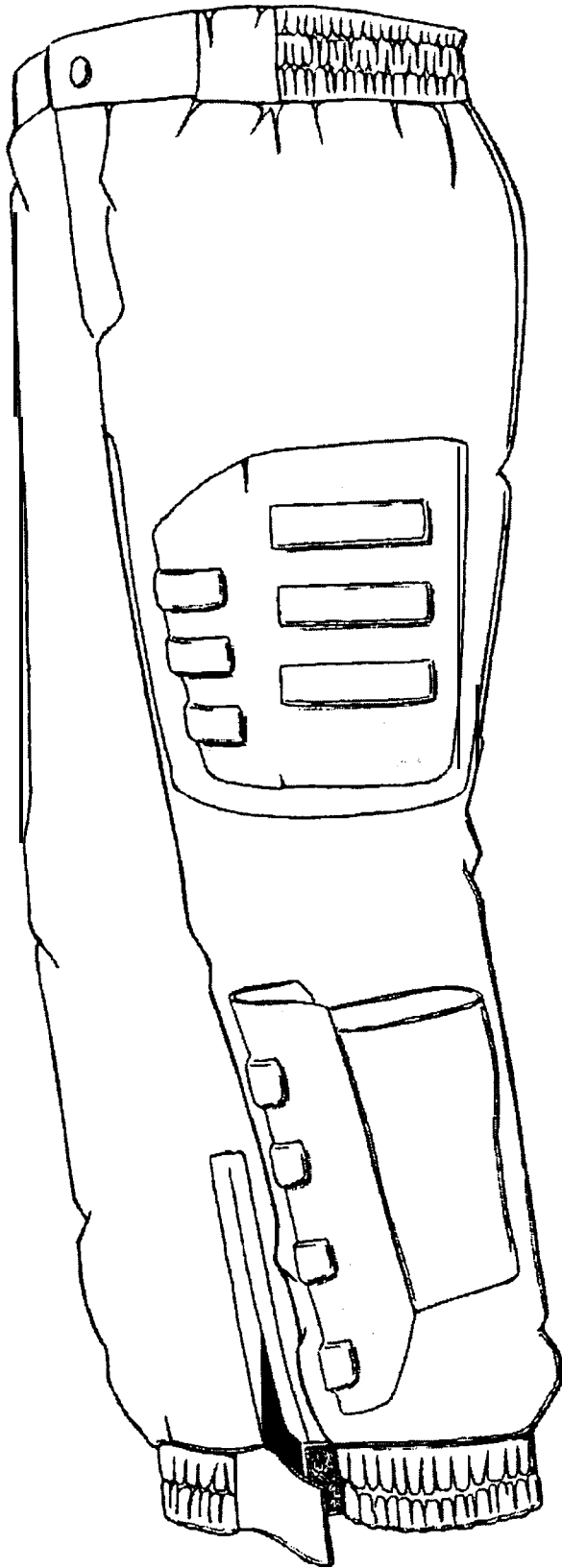


Figure 4

**Cut-away View of
Riot Troop Trousers**