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TECHNICAL REPORT NO. LWL-CR-30B73

PROTECTIVE GARMENTS FOR PUBLIC OFFICIALS

Final Report

by

NICHOLAS MONTANARELLI
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U. S. ARMY LAND WARFARE LABORATORY
Aberdeen Proving Ground, Maryland 21005

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ABSTRACT

This task has been a 12-month project to develop an inconspicuous, lightweight, external garment (top coat or sport coat) for use by public officials to defeat the .38 caliber special threat. Several promising protective materials were evaluated for their ballistic properties. The material known as PRD-49-IV was superior to all other materials tested, and it was then used to tailor an acceptable external garment. The ballistic penetration tests consisted of firing several types of ballistic projectiles with a threat severity equivalent to or less than that of the 0.38 caliber special at panels of candidate materials. The test conditions were compatible with National Bureau of Standards requirements. Blunt trauma effects were observed in animals wearing panels of protective material.

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FOREWORD

The joint study described in this report was conducted under LWL Task 30-B-73 for the Law Enforcement Assistance Administration of the U. S. Department of Justice, with funds provided by that agency. The LWL Task Officer, Mr. Nick Montanarelli, provided overall coordination of the project and technical assistance to the U. S. Army Bio-Medical Laboratory, Wound Ballistic Branch, Edgewood Arsenal, MD. Mr. Clarence Hawkins supervised the ballistic evaluations of candidate materials and directed material selection. MAJ Michael Goldfarb conducted the blunt trauma medical assessment. Successful completion of the project was due in large part to the cooperation, interest and high level of professional competence of the following individuals: Mr. George Shollenberger and Mr. Lester Shubin, Law Enforcement Assistance Administration; Dr. Thomas Gage, DuPont de Nemours & Co.; Dr. Roy Laible, U. S. Army Natick Laboratories; and Mr. Roy Metker and Mr. Russell Prather, Bio-Medical Laboratory, Edgewood Arsenal. We would also like to extend our appreciation to Mr. Carlyle Lilly and Dr. William Sacca, Medical Research Laboratory, Edgewood Arsenal, for their support of this program.

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SUMMARY

Introduction.

The problem of using most bullet-proof vests is the burden imposed on the wearer of the vest. They are often used in hot, humid situations, and the weight and tight fit of the protective vest limit the wearer's ability to perform normal tasks. The conspicuous appearance of an individual wearing a vest in public has created many problems. Many of the vests on the commercial market provide only limited protection to the groin and other vital areas of the body.

Because of these problems, the protective vest is only used when the individual has prior knowledge of impending danger. Most often, however, those individuals who have been attacked had no prior warning of the immediate threat, or were unable to secure proper protection in time to avert it. It has been determined within the scope of this program that it is feasible to fabricate a protective garment to resolve many of the problems currently associated with the use of protective vests.

Background.

Body armor has generally been developed by and for military and then applied to civilian use. It is heavy, bulky and conspicuous and often is not worn unless an immediate danger is foreseen. Military armor is of two general types: hard-faced armor (steel or ceramic plates) for stopping high-velocity missiles, and soft-material armor (nylons) for stopping fragments and low-velocity projectiles.

The civilian application of these protective armors has concentrated on preventing projectile penetration, but little substantive effort has been undertaken to assess blunt trauma effects on the body even when non-penetration is assured. Furthermore, an assessment of available gun and weapon injuries to law enforcement personnel indicates a threat no worse than that presented by the .38 caliber police special occurs approximately 85 to 90 percent of the time.

This information on threat severity, coupled with the development of new and stronger synthetic fibers by the textile industry, suggests the possibility of developing lightweight, inconspicuous, and relatively inexpensive garments that might satisfy the protective needs of public officials.

Objective.

The objective of this task was to develop a protective outer garment (overcoat, suit jacket or sport coat) to prevent penetration of a caliber .38 or smaller bore low-velocity bullet fired from a handgun at close range and to minimize any associated blunt trauma. Garments were designed to be relatively inconspicuous, inexpensive and of little burden to the wearer.

Conclusions.

1. Of all the protective materials tested, DuPont PRD-49-IV (Fiber B) is the most suitable fabric for the required protective garment, on the basis of strength-to-weight ratio, ability to absorb bullet impact energy, ease of tailoring and cost.

2. The number of layers (plies) of PRD-49-IV used in a protective garment depends in part on individual needs and/or the amount of blunt trauma that may be acceptable. Penetration from low velocity, small caliber handguns is provided by as few as four plies. Limited protection against larger caliber/high velocity projectiles would be provided by ten plies. For the present garment requirement, five plies provide the specified level of protection; five plies of the material can readily be tailored and are suitable with respect to weight and appearance.

3. A protective garment fabricated with five plies of PRD-49-IV will prevent penetration of low velocity bullets fired at close range from caliber .22 and caliber .38 handguns (800 fps).

4. A garment tailored with five plies of PRD-49-IV allows freedom of movement to perform normal functions, and is not conspicuously different in appearance from a conventional garment of similar type.

5. Several layers of PRD-49-IV will defeat the thrust and slash of most commonly used types of knife and razor (see Appendix A).

6. Heat stress is minimized in the outer garment configuration because the comparatively loose fit allows air circulation under the garment.

7. Trauma data from animal tests need to be related to human trauma victims. Techniques to do this are being developed.

MATERIALS AND TEST CRITERIA

Survey of Materials.

The U. S. Army Textile Research Section, Fiber and Fabric R&D Branch, Natick Laboratories, Massachusetts, provided technical direction in the selection of ballistic materials to be used in the development of the protective garment. Additional information on protective vests and materials resulted from a survey of the following armor and material manufacturers:

DuPont de Nemours & Company
Burlington Industries
Union Carbide Corporation
Twentieth Century Body Armor
Rolls-Royce
Imperial
Transcon
Federal Spooner
Second Chance
Protective Materials (AVCO)
Fabric Development, Inc.
American Safety
Goodyear Aerospace Corporation
Battelle Memorial Institute
Institut de Medecine Legale (Dr. Jan Weinberger)
Franklin Institute Research Laboratories.

From this investigation the following materials were selected for testing:

Hi-Tenacity Nylon, DuPont
Hi-Tenacity Rayon, DuPont
Hi-Tenacity Dacron, DuPont
Hi-Tenacity PRD-49-IV (Fiber B), DuPont*
Hi-Tenacity Fiber B, DuPont
Hi-Tenacity Thornel Graphite Yarn, Union Carbide
Hi-Tenacity Panex Graphite Yarn, Union Carbide & Stackpole, Inc.
Hi-Tenacity X-P (Marlex), Phillips 66
Hi-Tenacity X-55, Monsanto
Standard Nylon, DuPont
Nylon Felt, DuPont
Monsanto X-500 Felt, Monsanto.

Test Criteria for Materials.

1. Weight-to-strength ratio: Light in weight but strong enough to defeat penetration of the bullet.

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*The material referred to as PRD-49-IV has been redesignated by the manufacturer as Fiber B.

2. Flexible or non-rigid: Fabric-type material that would allow wearer freedom of movement.

3. Inexpensive in cost: Adaptable in the future for law enforcement applications and procurement.

4. Good ballistic qualities: Able to absorb bullet energy in defeating it.

5. Tailoring: Tailored so as to provide good fit and styling in order to reduce appearance as armor.

Using these criteria, test results showed that PRD-49-IV is superior to the other materials tested (Appendix B, Tables 1 through 5). Several different weights and material styles of PRD-49-IV were selected and tested on animals to evaluate their use as protective materials. Standard ballistic nylon was used as a control material for comparison because of its wide use in body armor and because of the information available on its ballistic characteristics.

The DuPont de Nemours Co. provided ballistic test results on both nylon and PRD materials which agree with the data obtained from the tests performed at Edgewood Arsenal's Wound Ballistic Laboratory.

TEST PROCEDURES AND RESULTS

Ballistic Evaluation.

Ballistic evaluation of several materials was performed at various areal densities in an attempt to select the most adequate material to be incorporated into an inconspicuous outer garment. These materials are listed in Table 1 of Appendix B. After ballistic evaluations were performed, several of the more promising materials were tested on animals to collect blunt trauma data. It may be possible to predict lethality or serious injury from non-penetrating abdominal and thoracic impacts by measuring:

1. Arterial and venous pO_2 (blood gas).
2. Lung weight to body weight ratio.
3. Correlation with gross pathology.
4. Deformation of chest wall areas.

A total of 33 animals fitted with various materials were tested for the purpose of making medical determinations (see Table 2 of Appendix B). For autopsy results of animal tests, see Appendix E.

The data for ballistic evaluations of candidate materials are found in Tables 3 through 5 in Appendix B. It should be noted that a 24-inch barrel was used to fire the .22 caliber bullets in these tests. It would have been somewhat more realistic to use a 4-inch barrel, since a 4-inch .22 caliber barrel is the threat to be contended with (a longer barrel provides longer burning time and greater bullet velocity). Limited tests with a .22 caliber handgun firing rounds with a velocity of 800 to 900 fps were performed to determine the number of plies required to prevent penetration.

Table 3 shows only penetration or non-penetration. Depth of penetration was not determined. Additional data concerning penetration and deformation of projectiles impacting on the various materials will be obtained in a proposed follow-on program (see Appendix C, Figures 11, 12 and 13).

Selection or ranking of materials was based on consideration of the following factors:

1. Ballistic properties of a material. These properties indicate the probable effectiveness of a material at various areal densities against different threats.

2. The nature and degree of damage incurred by animals protected by various weights of material. The most appropriate material is that which minimizes trauma to the animal.

3. Blood gas concentration in test animals following impact trauma. Partial pressure of O_2 and CO_2 in the blood may be related to the degree of trauma produced by a blunt impact on an animal and hence may indicate the level of protection provided by a given material.

4. Energy absorption and/or dissipation. These parameters are a function of a material's physical properties and configuration (see Appendix C, Figure 14).

Upon completion of the ballistic evaluations, it was found that two PRD materials offered comparable protection on a weight-for-weight basis. These materials were PRD-49 TL-105-27A and PRD-49 TL-105-26. Both materials were 400 denier, plain woven, but differed in yarn twist. In order to segregate the better of the two materials, limited testing was conducted using experimental animals to determine arterial blood O_2 partial pressure (ApO_2) and venous blood O_2 partial pressure (VpO_2). The results of these tests indicate that PRD TL-105-26 gives more protection against non-penetrating impacts than does TL-105-27A (see Figure 1, Appendix D). These tests were conducted using the materials on a weight-for-weight basis. To confirm the validity of the results as a basis for making final selection of material, 9 mm parabellum bullets were fired against most of the materials employed in the .38 caliber tests. The PRD TL-105-26 was the only material that defeated the 9 mm parabellum bullet (see Table 6, Appendix B).

Animal Tests.

Following ballistic evaluation, which resulted in the selection of 400 denier TL-105-26 as a promising candidate material, it was necessary to determine the areal density or number of layers of the material to be used. Many materials can defeat the .38 caliber bullet at 800 fps. However, the results of the animal tests show that tissue and organ damage may occur even at high areal densities of some materials. Because of the requirement for a lightweight protective garment, the material to be used must be effective at a low areal density. Several tests with animals fitted with 10-ply PRD TL-105-26 were conducted. The data from these tests combined with blood gas data (Appendix D) suggest that if a human is shot in the chest with a .38 caliber bullet at 800 fps while wearing a 10-ply garment of PRD TL-105-26, he may incur minor chest trauma that will probably not require surgery. Chance of death would be negligible. Impact over the liver and spleen, however, could result in injuries serious enough to result in surgery, though probability of death is low.

Previous ballistic tests showed that five plies of PRD TL-105-26 would defeat the .38 caliber bullet at 800 fps and limited tests showed it would also defeat the .22 caliber handgun bullet at 800 fps. Three animal tests were conducted using five plies of PRD-105-26. As expected, some lung and tissue damage did occur but no lethalities or serious wounds were found. It must be stressed that only a small number of animals has been tested, and that no significant human correlation can be made to verify the protection level on a man wearing 5-ply PRD TL-105-26. More testing is urgently required to confirm the level of protection afforded by 5-ply PRD TL-105-26.

Figures 1 through 5, Appendix C, show tissue and organ damage from blunt trauma for three material configurations. Figures 1 and 2 show damage to the animal fitted with 12-ply ballistic nylon. This 12-ply nylon is presently incorporated into a commercial protective vest. Figures 3 and 4 show damage to the animal fitted with 5 plies of TL-105-26. It is apparent that 5 plies of the PRD material are about as effective as 12 plies of ballistic nylon. On a weight-for-weight basis the 12-ply nylon is 1.17 lb/ft^2 while the 5-ply PRD TL-105-26 is only .40 lb/ft^2. In a protective coat, size 42, the 12-ply nylon would weigh approximately 8 to 10 pounds while the 5-ply PRD TL-105-26 would weigh only 3 to 4 pounds. Figure 5 shows lung damage to an animal fitted with 12 plies of PRD TL-105-26. The damage is less severe than either of the others illustrated. These examples illustrate that by increasing the number of layers of PRD, the tissue and organ damage will be reduced, but also by increasing the number of layers, the weight of the garment could become impracticable for wear.

Much interest has been expressed in a comprehensive study of blunt trauma as related to protective garments. Figure 6, Appendix C, illustrates a proposed method for an investigation of blunt trauma effects as a function of protective materials, including extrapolation of animal data to humans. The methodology would establish a rational basis for predicting how a human might react to certain types of blunt trauma. A program has been initiated to develop several measurements of thoracic trauma in animals plus an attempt to extrapolate the data to humans. A description of the proposed methodology for performing this study is found in Appendix D.

PROTECTIVE GARMENT FABRICATION

Material.

Having established PRD-49-IV (Fiber B) as the best material to be used in the protective garments, it was then necessary to determine whether the material could be tailored into a relatively inconspicuous garment. In order to demonstrate that the material is suitable for handling, cutting and sewing, a sport jacket was fabricated with 5 layers of PRD on the right side and 10 layers on the left side. No protective material was used in the sleeves of the jacket in order to allow more surface area for body heat exchange. The PRD material was concealed in the garment as a filler.

Tailoring.

No problems were encountered in the garment fabrication using heavy duty cutting and sewing equipment. It has been suggested that future garments should be fabricated from their inception with protective material rather than to buy a garment and add the protective material as a filler. This in toto procedure would provide better fit and style to the garment.

Evaluation.

Evaluation of the prototype garment indicated that the 10-ply portion of the jacket was conspicuous and bulky. The 5-ply portion of the jacket was inconspicuous and allowed the wearer excellent freedom of movement (Figure 8). Ten plies of material, although unsuitable for a sport jacket, might be used in a cold weather coat as a liner.

Additional Protection.

To protect the large area directly exposed below the neck when wearing a sport jacket or suit vest, a dickey can be provided that is made of at least 5-ply PRD material and worn beneath the shirt.

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USER REQUIREMENTS

As this study progressed it became clear that a single type of protective garment will not meet every potential user need. It appeared appropriate to canvas potential users and other concerned organizations to determine what degree of protection may be necessary for various operational uses. Implicit in such a determination is an estimation of the amount of body injury that is acceptable or can be tolerated in a given situation.

Input was received from the following organizations:

Federal Bureau of Investigation
U. S. Secret Service, Department of the Treasury
National Bureau of Standards
MITRE Corporation
USAMC Natick Laboratories
Bureau of Narcotics and Dangerous Drugs
Department of State, Agency for International Development
New York City Police Department
International Association of Chiefs of Police
US Army Standardization Group, UK
US Army Material Research Center
US Naval Research Laboratory
US Marine Corps Development and Education Command
US Naval Warfare Laboratory
Naval Explosive Ordnance Disposal Facility.

The information that was received indicated that a variety of garment types must be considered for protective uses (Figure 7). The number of plies of PRD TL-105-26 will vary depending on the type of garment and the damage level that is acceptable to a particular user. In general, the following medical criteria appear valid as a basis for determining desirable protective garment parameters:

a. Should prevent penetration by the bullet into the chest or abdomen.

b. Any blunt trauma effects requiring surgical repair should have a mortality risk of 10 percent or less.

c. An adult male wearing the garment should be able to walk from the site of a shooting after being hit in the chest or abdomen by a bullet of specified caliber or weight and velocity. It is assumed that he will receive medical attention within one hour.

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APPENDIX A

PROTECTIVE MATERIAL SPECIFICATIONS FOR PRD-49-IV (FIBER B)

Style No. Fabric Development FUSL #1
Du Pont TL 105-26

Warp 400 Denier, 267 filiments, 2 ply, 4 twist per inch, Z direction for both longitudinal and filling.

Weave Plain

Ends/inch 33 ± 2

Picks/inch 33 ± 2

Weight in ounces/square yard 7.45 ± 0.25 ounces

After fabric is woven, it is scoured, rinsed and dried.

Width 38.25 inches

Thickness Approximately .015 inch

Current cost Approximately $10-15/pound for 400 denier.

PHYSICAL PROPERTIES OF PRD-49 (FIBER B) YARN

Density	1.45 g/cc	40% lower than glass and boron, and slightly lower than graphite.
Tensile Strength	400,000 psi	substantially above conventional organic fibers and equivalent to most high performance reinforcing fibers.
Specific Tensile	8×10^6 in.	highest of any commercially available reinforcing fiber.
Modulus	19×10^6 psi	twice that of glass fibers.
Specific Modulus	3.5×10^8 in.	between that of the high modulus graphites and boron and that of glass fibers.

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Chemical Resistance	Good	highly resistant to organic solvents, fuels, and lubricants.
Textile Processibility	Excellent	can be readily woven on conventional fabric looms.
		yarns retain 90% of their tensile strength after weaving.
		can be easily handled on conventional filament winding equipment.
Flammability Characteristics	Excellent	inherently flame resistant. Self-extinguishing when flame source is removed. Does not melt.
Temperature Resistance	Excellent	no degradation of yarn properties in short term exposures up to temperatures of 500°F.

APPENDIX B

MATERIAL TEST RESULTS

TABLE 1

MATERIALS TESTED AGAINST THE 0.38 CALIBER 158 GRAIN LEAD BULLET AT APPROXIMATELY 800 FT/SEC.

Material	Areal Density Per Ply	12-Ply Nylon Equivalent
Std. Ballistic Nylon	1.6 oz/ft^2	12-ply, 1.17 lb/ft^2
PRD 49-IV TL 105-20	0.352 oz/ft^2	52-ply, 1.14 lb/ft^2
PRD 49-IV TL 105-27A	1.58 oz/ft^2	12-ply, 1.11 lb/ft^2
PRD 49-IV TL 105-26	0.81 oz/ft^2	23-ply, 1.17 lb/ft^2
Fiber B TL 152-628	1.093 oz/ft^2	17-ply, 1.16 lb/ft^2
High Density Ballistic Nylon	0.9 oz/ft^2	20-ply, 1.13 lb/ft^2
Nylon Felt	Total A.D. 0.701 lb/ft^2	6-ply, 0.70 lb/ft^2
PRD 49-IV Needle punched felt (9-ply)	Total A.D. 2.2 oz/ft^2	
Monsanto Experimental Fiber X500 Type III	1.46 oz/ft^2	13-ply, 1.18 lb/ft^2

TABLE 2

CALIBER 0.38 SPECIAL VS CANDIDATE ARMOR ON ANIMALS

Material	Animal No.	Vel M/Sec	Vel Ft/Sec
Armor - 12 Ply Davis	21597	238	781
12 Ply Davis	Dummy	239	784
Nylon - 12 Ply Davis	21598	248	814
Nylon - 12 Ply Davis	21603	232	761
Nylon - 12 Ply Davis	21604	235	771
Nylon - 12 Ply Davis	21609	224	735
Nylon - 12 Ply	21625	243	797
Police Vest All Nylon	21583	225	738
Std Nylon, 7 Ply	21596	236	774
Ballistic Nylon - 7 Ply	21619	242	794
105-20-52 Ply AD 1.14 lb/ft^2	21617	240	787
105-20-40 Ply	21595	240	787
152-628-17 Ply AD 1.16 lb/ft^2	21615	244	801
105-27A-12 Ply AD 1.11 lb/ft^2	21616	237	778
105-27A-12 Ply	21627	242	794
105-27A-10 Ply	21631	249	817
105-26-10 Ply	21641	241	791
105-26-10 Ply	21642	242	794

TABLE 2 (Continued)

Material	Animal No.	Vel M/Sec	Vel Ft/Sec
105-26-23 Ply AD 1.17 lb/ft^2	21618	246	807
105-26-23 Ply	21624	242	794
105-26-18 Ply	21626	248	814
105-26-15 Ply	21628	243	797
105-26-10 Ply - 8.10 oz/ft^2	21622	240	787
105-26-10 Ply	21633	235	771
105-26-10 Ply	21633	247	810
105-26-10 Ply	21634	242	794
105-26-10 Ply	21634	242	794
105-26-10 Ply	21637	234	768
105-26-9 Ply	21629	243	797
105-26-9 Ply	21630	243	797
105-26-5 Ply + 1 Felt	21632	249	817
105-26-5 Ply - 4.05 oz/ft^2	21620	246	807
105-26-5 Ply + 1 thickness Felt ERD 49	21621	242	794
No Armor	21636	239	784

TABLE 3

CALIBER 0.38 SPECIAL VS CANDIDATE MATERIAL

MATERIAL	VEL M/SEC	VEL FT/SEC	COMPLETE PENETRATION	PARTIAL PENETRATION	RESULTS
Police Vest All Nylon	224	735		PP	Bullet severely deformed. Stopped at 3d ply nylon.
40 Ply TL 105-20	235	771		PP	Bounced off 1st ply dented gelatin.
15 Ply TL 105-20	240	787		PP	Pulverized paper torn between sample, dented gel.
P-5363-66-TL 105-26	249	817		PP	Pulverized paper torn between sample, dented gel.
Std Nylon, 7 Ply	237	778		PP	Pulverized paper torn between sample, dented gel.
High Tenacity Nylon, 11 Ply	252	827		PP	Pulverized paper torn between sample, dented gel.
105-20-10 Ply - DuPont	242	794		PP	
105-20-7 Ply - DuPont	247	810		PP	Bounced off 1st ply, deformation broke thru last ply.
105-20-1 Ply - DuPont	249	817	CP		
105-20-3 Ply - DuPont	237	778	CP		
105-20-7 Ply - DuPont	244	801		PP	Bounced off 1st ply, deformation broke thru last ply.

TABLE 3 (Continued)

MATERIAL	VEL M/SEC	VEL FT/SEC	COMPLETE PENETRATION	PARTIAL PENETRATION	RESULTS
105-27A-6 Ply - DuPont	244	801		PP	Bounced off front ply.
105-27A-3 Ply - DuPont	250	820		PP	Bounced off front ply.
105-27A-2 Ply - DuPont	248	814	CP		Bullet in gelatin 2.0 cm.
105-26-9 Ply - DuPont	248	814		PP	Bounced off.
105-26-6 Ply - DuPont	248	814		PP	Bounced off.
105-26-3 Ply - DuPont	255	837		PP	Bounced off.
105-26-2 Ply - DuPont	248	814	CP		Perforated gelatin.
105-26-3 Ply - DuPont	242	748		PP	Bounced off.
Ballistic Nylon - 3 Ply	247	810	CP		Perforated gelatin.
Ballistic Nylon - 4 Ply	252	827	CP		Perforated gelatin.
Ballistic Nylon - 6 Ply	247	810	CP		Perforated gelatin.
High Tenacity Nylon - 4 Ply	242	794	CP		Perforated gelatin.
High Tenacity Nylon - 6 Ply	245	804	CP		Perforated gelatin.
High Tenacity Nylon - 8 Ply	244	801	CP		Perforated gelatin.
PRD 49 IV Felt - 1 Ply	242	794	CP		Thru 1st thickness gel block nearly thru 2d thickness
Needle Punch Felt	251	823	CP		Thru gelatin block.
XP-13.2 oz/ft^2	251	823		PP	Missile in sample.
Monsanto X500 - 4 Ply	251	823	CP		Thru gelatin.

TABLE 3 (Continued)

MATERIAL	VEL M/SEC	VEL FT/SEC	COMPLETE PENETRATION	PARTIAL PENETRATION	RESULTS
Monsanto X500 - 8 Ply	247	810	CP		Thru gelatin.
Monsanto X500 - 12 Ply	238	780	CP		Missile in gelatin block.
Monsanto X500 - 12 Ply	303	994	CP		Missile perforated 2 gelatin blocks.
Monsanto X500 - 12 Ply	208	683		PP	Missile bounced off 2d ply. Missile between 1st & 2d ply.
Monsanto X500 - 12 Ply	226	741		PP	Missile perforated 6 plies. Stopped at 7th ply.
Monsanto X500 - 12 Ply	227	745		PP	Missile perforated 6 plies. Stopped at 7th ply.
Monsanto X500 - 12 Ply	251	823		PP	Missile perforated 4 plies. Embedded in 5th Ply
Monsanto X500 - 12 Ply	259	850	CP		Missile perforated sample. Missile in gelatin block.
105-26-10 Ply - DuPont	240	787		PP	Bounced off.
105-26-10 Ply - DuPont	238	780		PP	Bounced off.
105-26-10 Ply - DuPont	240	787		PP	Bounced off.

TABLE 4

CALIBER 0.22 L.R. BULLET VS VARIOUS ARMOR MATERIALS - GELATIN BACKED
GUN: 24" BARREL

Material	Rnd	Velocity	Results
6-Ply TL 105-26	1	1073 ft/sec	*PP-Missile in 3d ply
	2	1086 ft/sec	PP-Missile in 3d ply
	3	1093 ft/sec	PP-Missile in 3d ply
	4	1093 ft/sec	PP-Missile in 3d ply
	5	1099 ft/sec	PP-Missile in 3d ply
	6	1122 ft/sec	**CP-Missile thru material & gelatin
8-Ply TL 105-26	7	1096 ft/sec	PP-Missile in 6th ply
	8	1178 ft/sec	PP-Missile in 6th ply
	9	1227 ft/sec	CP-Missile thru material & gelatin
	10	1247 ft/sec	PP-Missile in 5th ply
	11	1260 ft/sec	CP-Missile thru material & gelatin
10-Ply TL 105-26	12	1168 ft/sec	PP-Missile in 4th ply
	13	1168 ft/sec	PP-Missile in 4th ply
	14	1168 ft/sec	PP-Missile in 5th ply
	15	1191 ft/sec	PP-Missile in 4th ply
	16	1191 ft/sec	PP-Missile in 5th ply
	17	1200 ft/sec	PP-Missile in 5th ply
	18	1207 ft/sec	PP-Missile in 4th ply
	19	1207 ft/sec	PP-Missile in 4th ply
	20	1207 ft/sec	PP-Missile in 4th ply
	21	1211 ft/sec	PP-Missile in 4th ply
	22	1214 ft/sec	PP-Missile in 5th ply
	23	1217 ft/sec	PP-Missile in 5th ply
	24	1217 ft/sec	PP-Missile in 4th ply
	25	1230 ft/sec	PP-Missile in 6th ply
	26	1234 ft/sec	PP-Missile in 5th ply
	27	1247 ft/sec	PP-Missile in 4th ply
	28	1253 ft/sec	PP-Missile in 5th ply
	29	1266 ft/sec	PP-Missile in 5th ply
10-Ply TL 105-27A	30	1237 ft/sec	PP-Missile in 4th ply
	31	1247 ft/sec	PP-Missile in 3d ply
	32	1257 ft/sec	PP-Missile in 6th ply
	33	1230 ft/sec	PP-Missile in 5th ply
	34	1240 ft/sec	PP-Missile in 6th ply

TABLE 4 (Continued)

Material	Rnd	Velocity	Results
8-Ply TL 105-27A	35	1201 ft/sec	PP-Missile in 3d ply
	36	1266 ft/sec	PP-Missile in 5th ply
	37	1211 ft/sec	PP-Missile in 4th ply
	38	1214 ft/sec	PP-Missile in 4th ply
	39	1217 ft/sec	CP-3 plies folded downward after missile traversed sample.
	40	1240 ft/sec	CP.
	41	1227 ft/sec	PP-Missile in 5th ply
	42	1214 ft/sec	PP-Missile in 4th ply
	43	1243 ft/sec	PP-Missile in 4th ply.

*PP - Partial penetration.
**CP - Complete penetration.

TABLE 5

CALIBER 0.22 L.R. BULLET VS VARIOUS COMPOSITES OF MATERIALS ON 20% GELATIN BACKED

Materials	Rnd	Velocity Ft/Sec	Results
6-Ply TL-105-26 + 3-Ply TL-105-20	1	1286	*CP.
	2	1079	**PP-Missile in 4th ply of -26.
	3	1283	CP.
	4	1010	PP-Missile in 3d ply -26.
6-Ply TL-105-26 + 5-Ply TL-105-20	5	1247	CP.
	6	1083	PP-Missile in 5th ply - 26.
	7	1243	CP.
6-Ply TL-105-26 + 7-Ply TL-105-20	8	1247	PP-Missile in 6th ply of -26.
	9	1250	PP- Missile in 6th ply of -26.
	10	1217	PP- Missile in 6th ply of -26.
	11	1217	PP- Missile in 6th ply of -26.
6-Ply Monsanto X-500 + 3-Ply TL-105-20	12	1220	CP.
	13	1119	CP.
	14	1086	CP.
6-Ply Monsanto X-500 + 7-Ply TL-105-20	15	1083	PP- Missile in 1st layer of 20.
	16	1214	CP.

* - PP - Partial penetration. ** - CP - Complete penetration.

TABLE 6

9 MM PARABELLUM VS. VARIOUS MATERIALS

	MATERIALS AND AREAL DENSITY	VELOCITY FT/SEC	RESULTS
1.	X-P Film, Flexible 13.2 oz/ft^2	1099	* PP - Back of Material Begins Deliminating, Missile in Sample.
2.	PRD-TL-105-26 23 Ply 1.17 lb/ft^2	[illegible]	PP - Missile Perforates 12 Ply.
3.	PRD-TL-105-26 18 Ply	1132	** CP - Missile Perforates Sample and 7" Gelatin Block.
4.	PRD-TL-105-26 15 Ply	1099	CP - Same as above.
5.	Standard Ballistic Nylon 12 Ply 1.17 lb/ft^2	1102	CP - Missile Perforates Sample and 7" Gelatin Block Behind.
6.	Standard Ballistic Nylon 20 Ply	1112	CP - Same as above.
7.	PRD-TL-105-27A 17 Ply	1099	PP - Missile Perforates 6 Ply.
8.	PRD-TL-105-27A 8 Ply	1119	CP - Missile Perforates Sample and 7" Gelatin Block.
9.	PRD-TL-105-27A	1237	CP - Same as above.
10.	PRD-TL-105-26	1250	PP - Missile Perforates 6 Ply.
11.	PRD-TL-105-26	1220	PP - Missile Perforates 7 Ply.

*PP - Partial penetration. **CP - Complete penetration.

APPENDIX C

PHOTOGRAPHS AND ILLUSTRATIONS

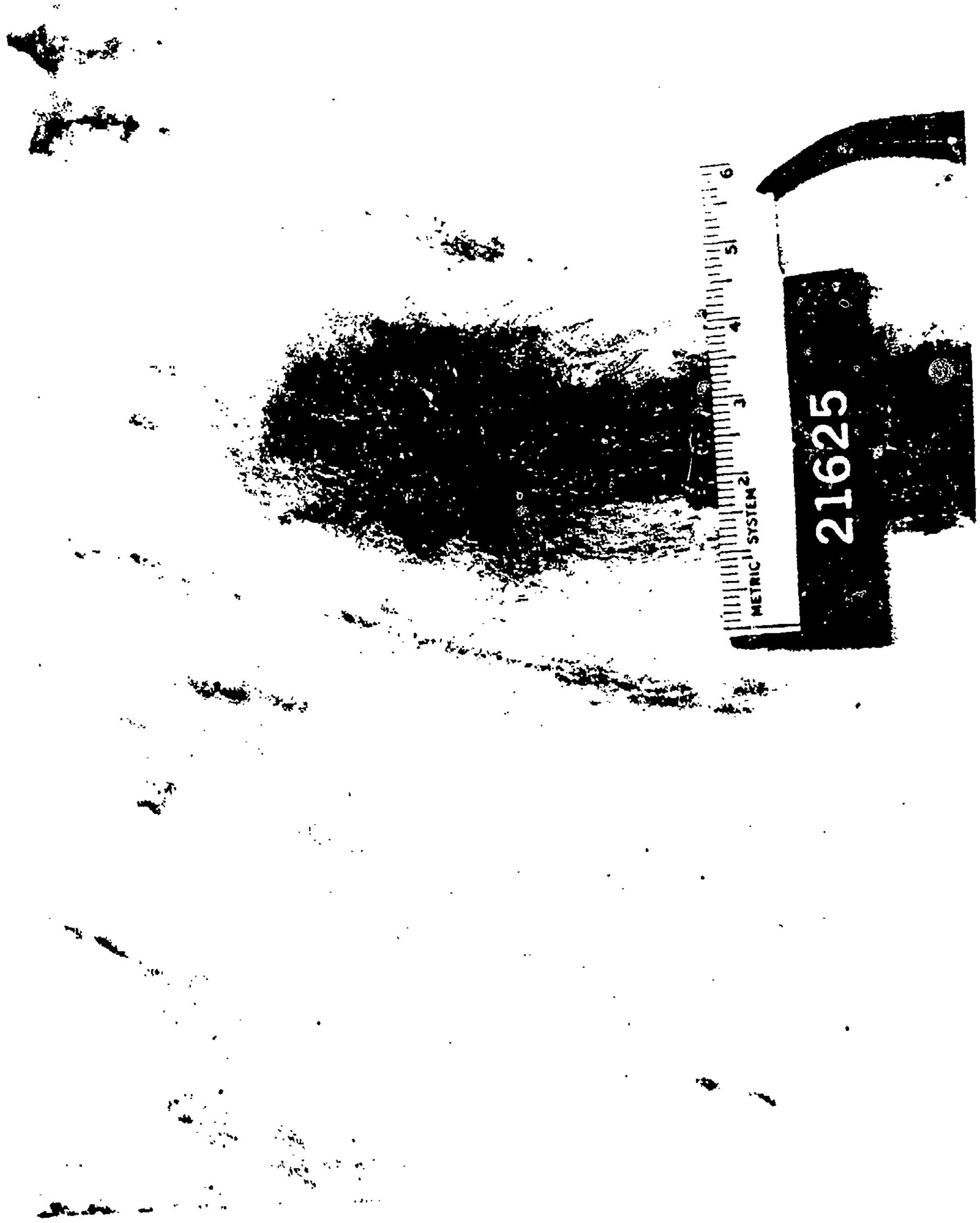

FIGURE 1. Laceration on skin surface - 12 ply ballistic nylon versus .38 caliber bullet.

FIGURE 2. Lung damage from blunt trauma, 12 ply ballistic nylon versus .38 caliber bullet.

FIGURE 3. Laceration on skin surface - 5 ply PRD-105-26 versus .38 caliber bullet.

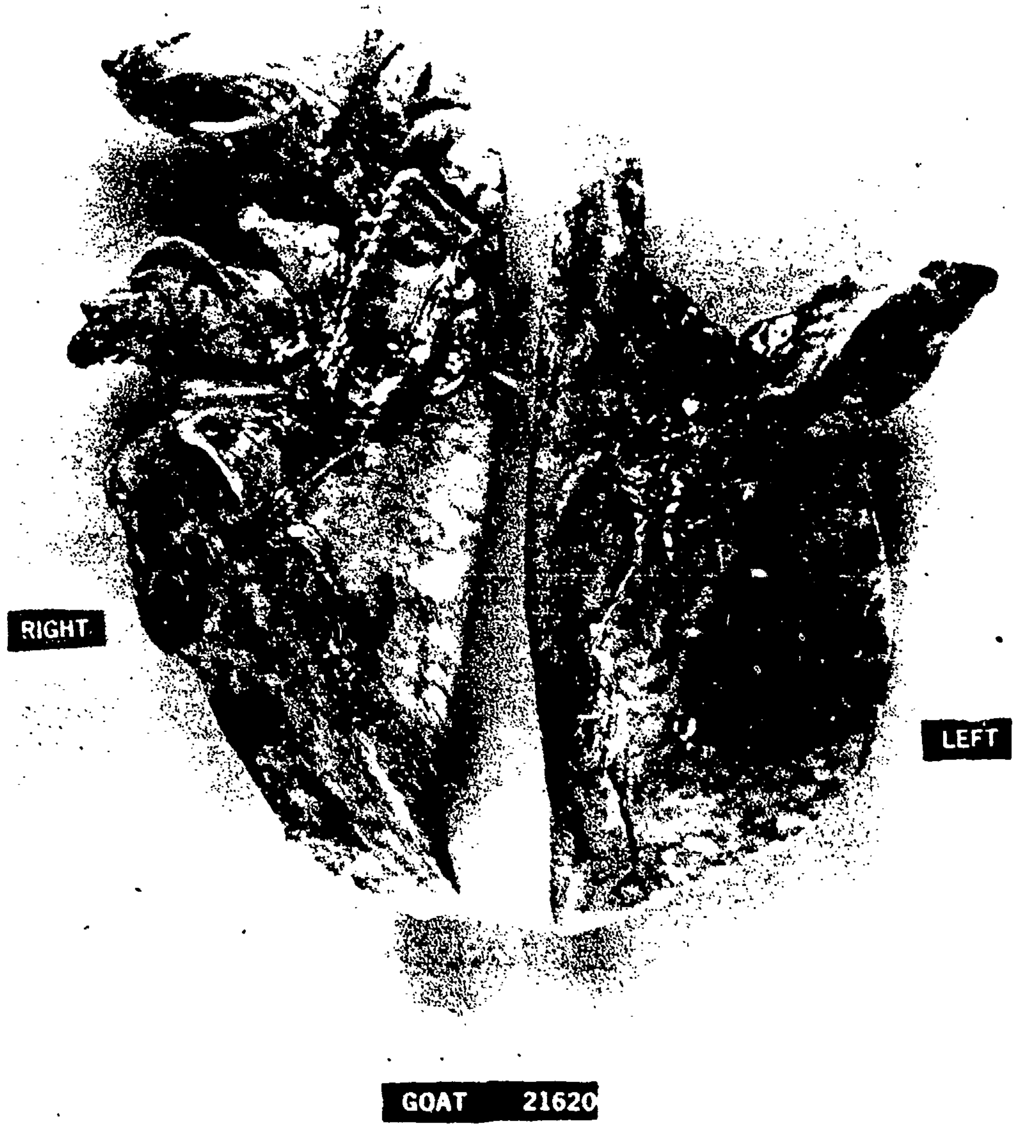

FIGURE 4. Lung damage from blunt trauma - 5 ply PRD-105-26 versus .38 caliber bullet.

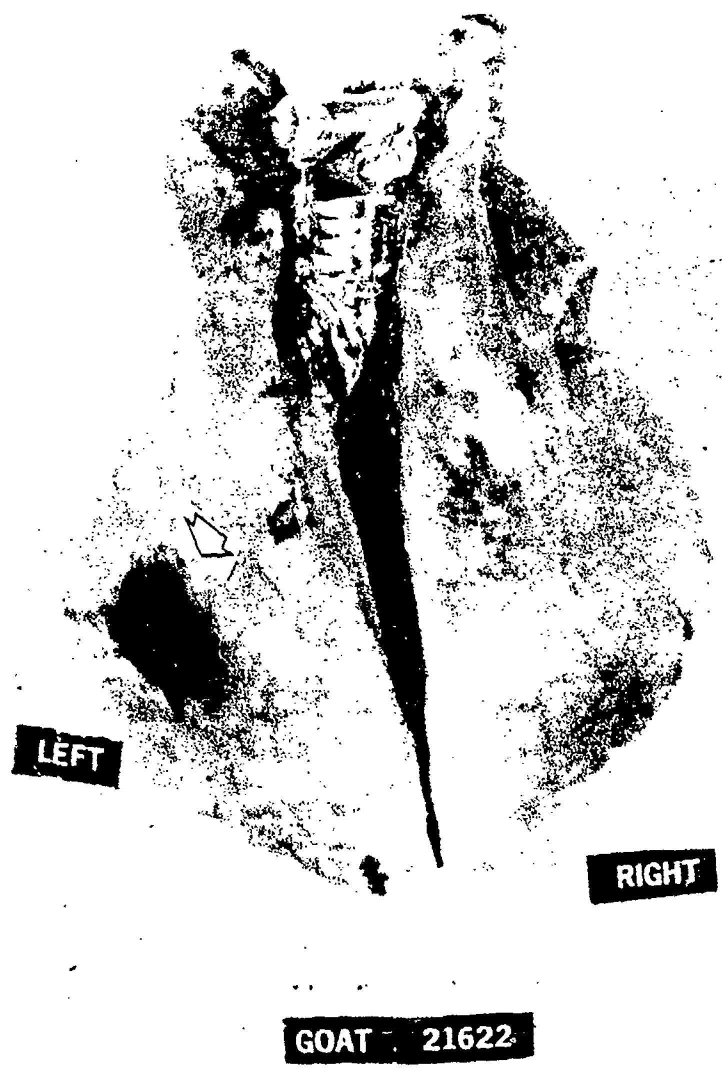

FIGURE 5. Lung damage from blunt trauma - 10 ply PRD-105-26 versus .38 caliber bullet.

BLUNT TRAUMA THORACIC AND ABDONIMAL ASSESSMENT PLAN
WITH REGARD TO BULLET PROOF MATERIALS

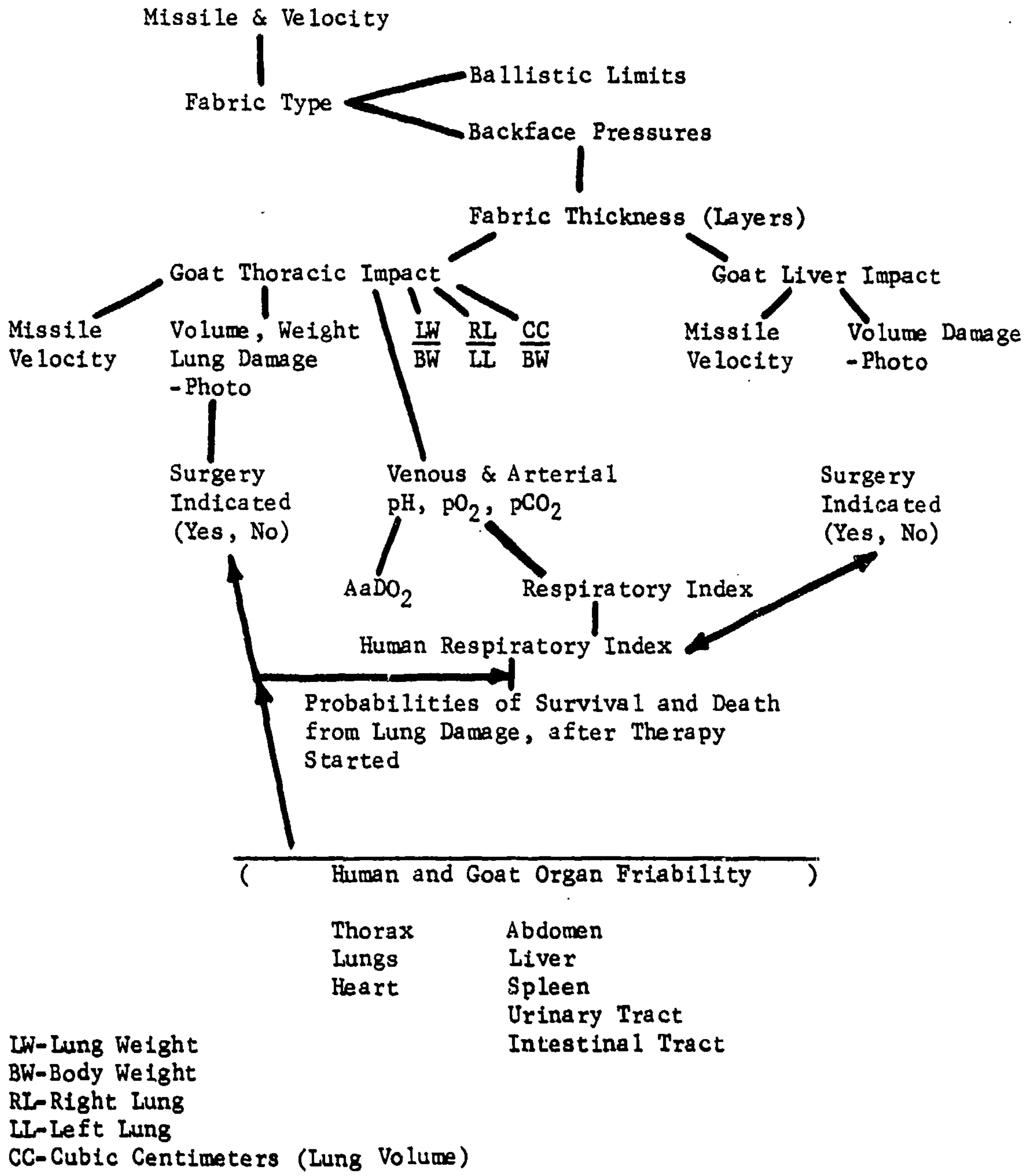

FIGURE 6. Scheme for an Investigation of Blunt Trauma Effects as a Function of Protective Materials.

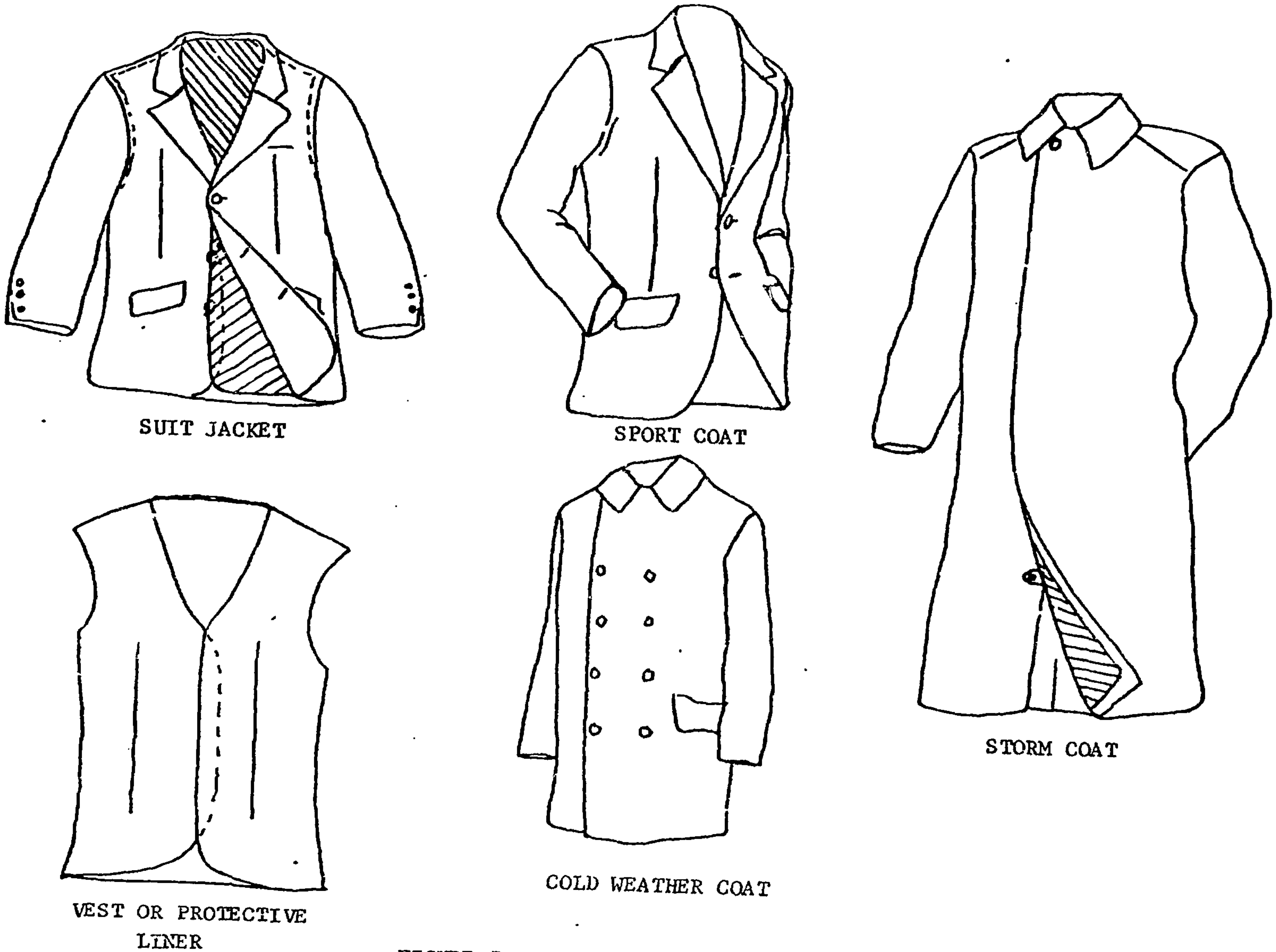

FIGURE 7. Examples of Protective Garments.

FIGURE 8. Prototype Protective Jacket Shown on Right Compared with Standard Military Armored Vest on Left.

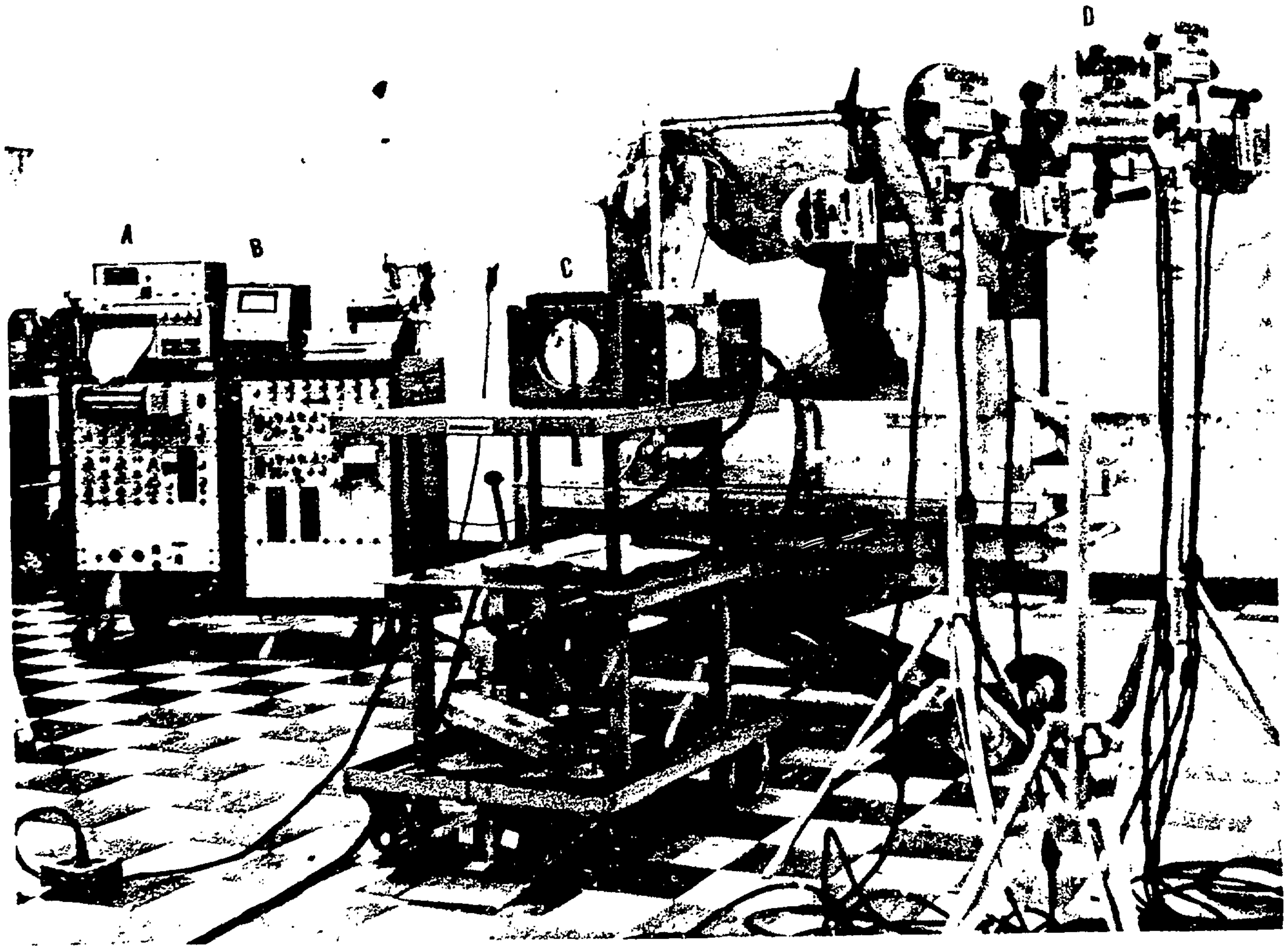

FIGURE 9. Range set-up for testing of blunt impact effects on experimental animal: A. EKG machine; B. Recorder for impact pressures; C. Velocity screens; D. Lights for high speed photography.

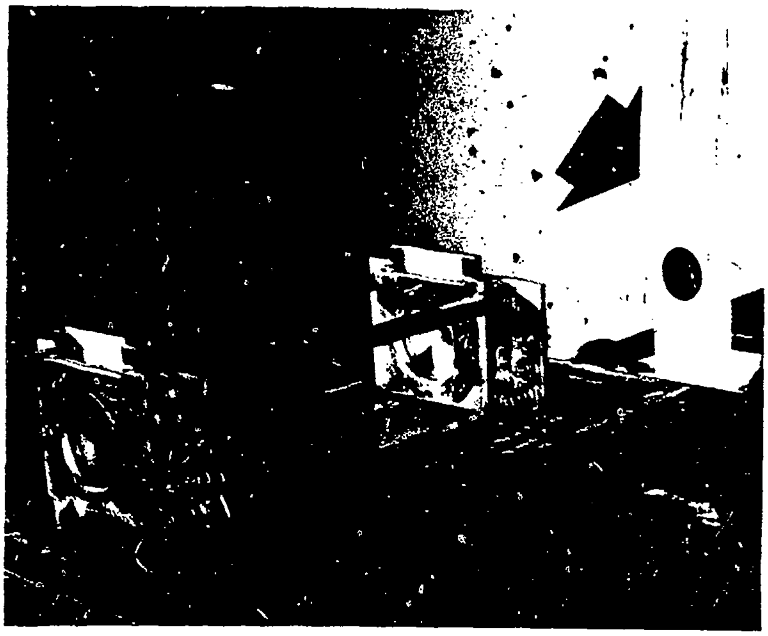

FIGURE 10. The Arrow Points to the Mounting Device for a Pressure Transducer. The Device is Placed Directly Lehind the Armor.

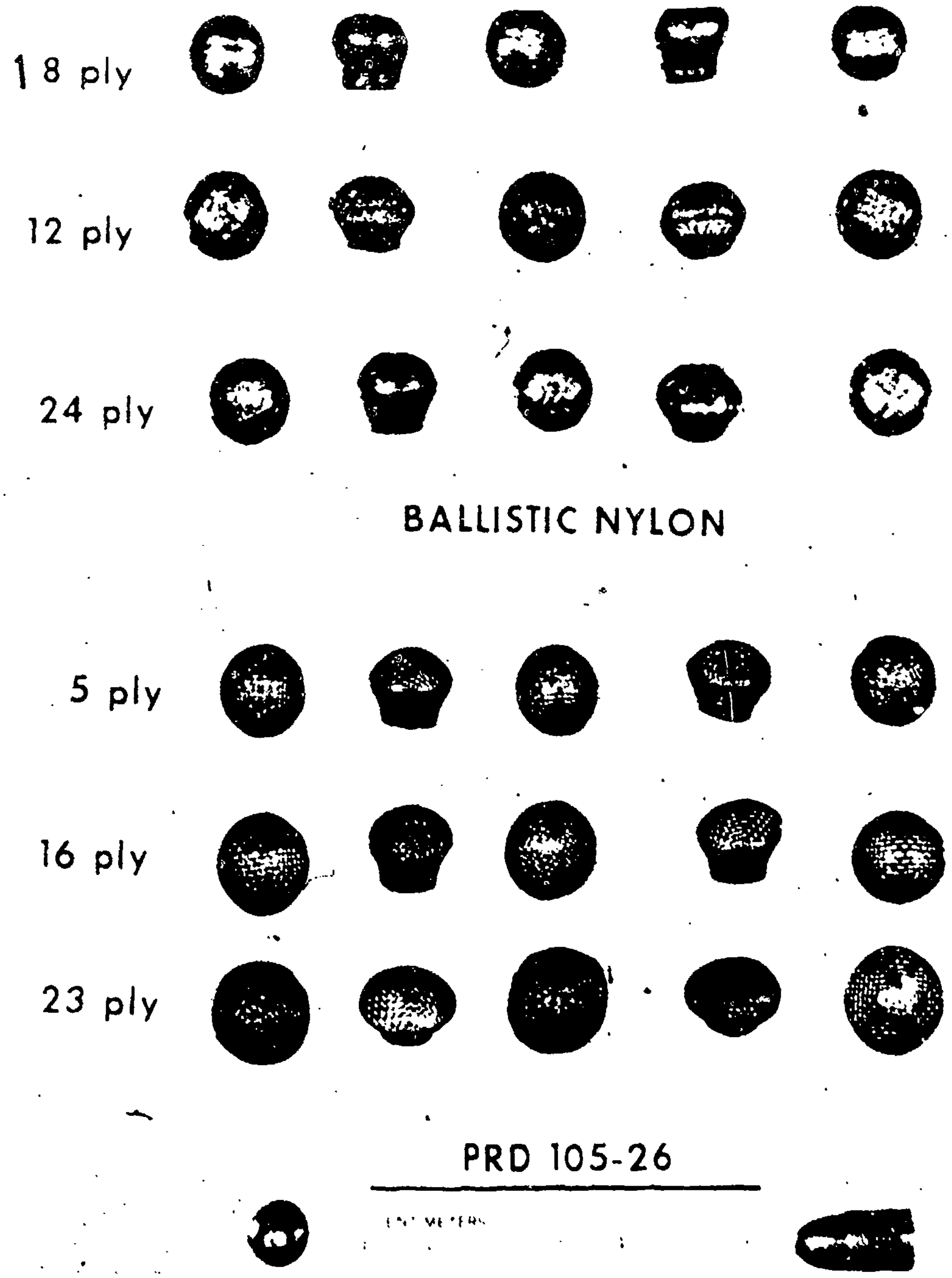

FIGURE 11. .38 Caliber Bullet Deformation After Impact with Armor Materials at Various Areal Densities. All Impacts at Approximately 800 FPS.

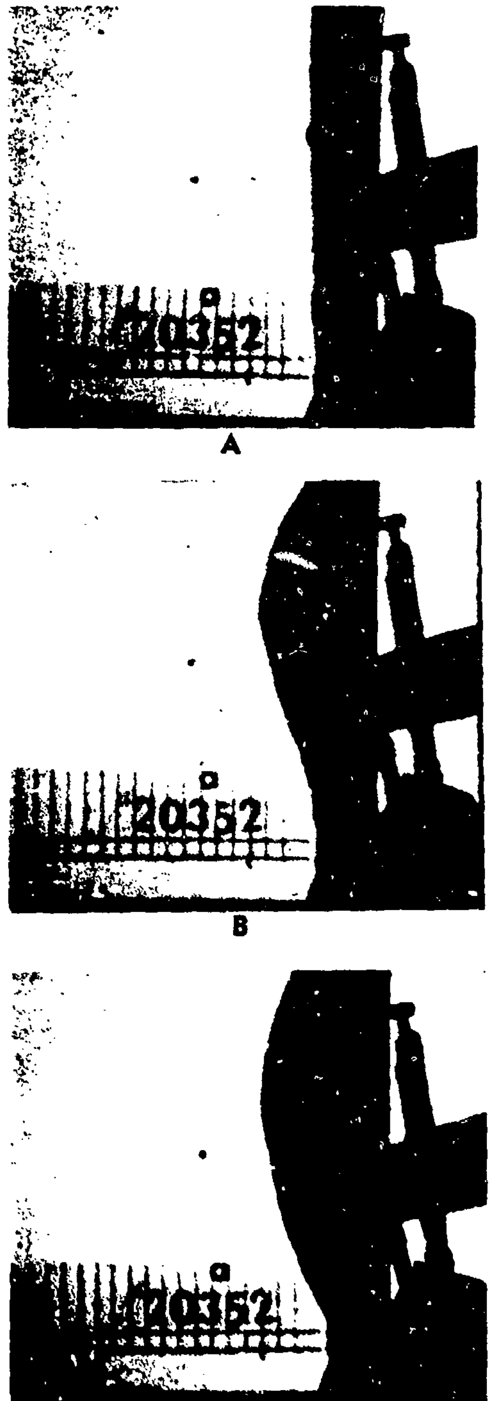

FIGURE 12. Transient Deformation of 12-Ply Ballistic Nylon, in Air, Impacted with the .38 Caliber Bullet at 775 FPS: A. 0.32 cm, B. 2.87 cm, C. 3.44 cm (Maximum Deformation).

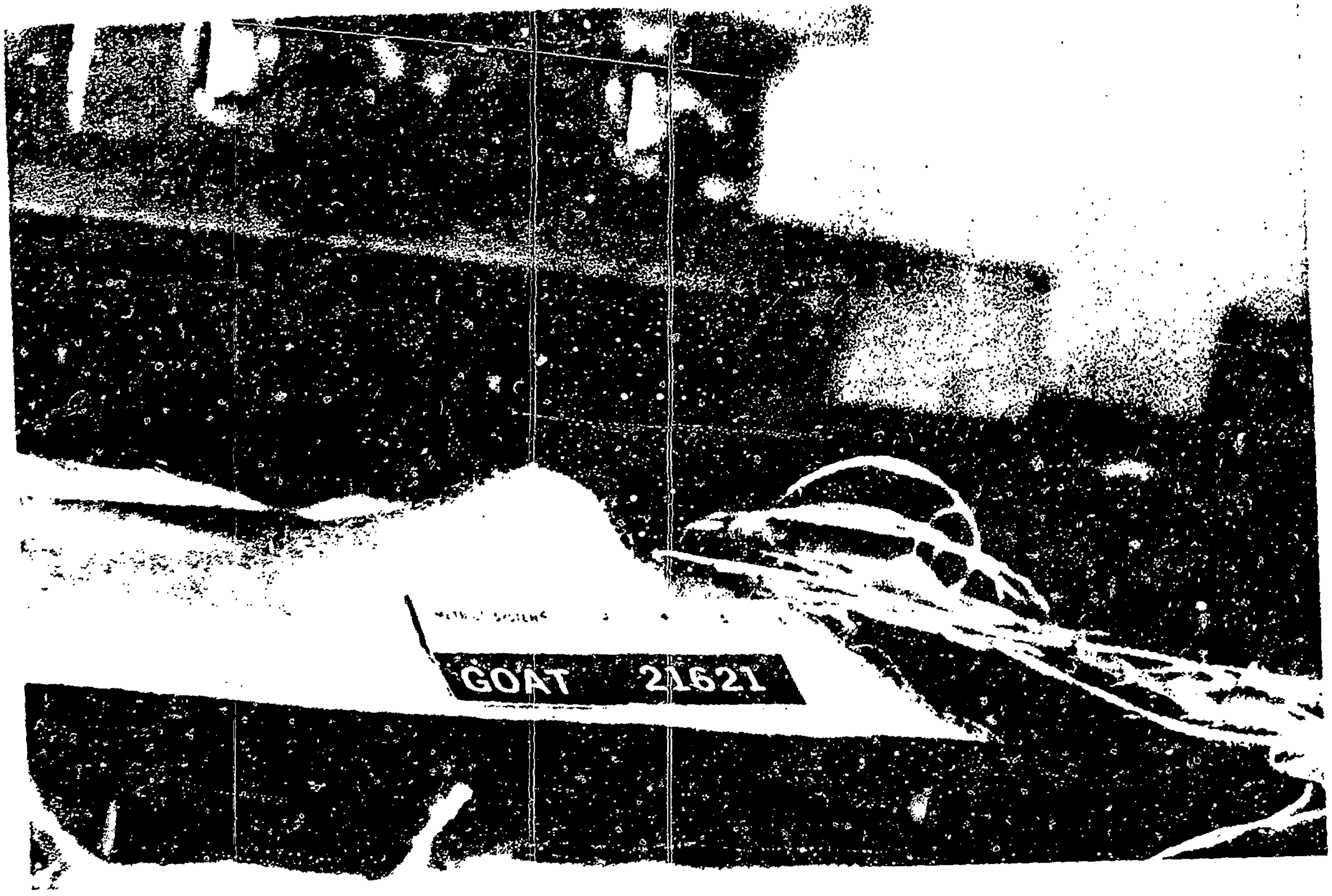

FIGURE 13. Permanent Deformation of PRD-49 Felt. Felt was Behind 5-Ply, PRD 49 TL-105-26. Impacted by .38 Caliber Bullet at 794 FPS.

FIGURE 14. .38 Caliber Bullet Embedded in 5-Ply PRD-49 TL-105-26. Impact Velocity 807 FPS.

APPENDIX D

GOAT THORACIC STUDIES AND HUMAN CORRELATION STUDY

In order to compare traumatized goats with traumatized humans, a cooperative study was undertaken with the University of Maryland Shock Trauma Unit. Patients had arterial blood gases drawn in addition to other tests, at least four times a day. Arterial blood gases assist the clinician in respiratory management. These measurements allow the physician to change the mode of oxygenation or the percent of oxygen inspired and also help determine when a patient has no further need of respiratory support. One index incorporating blood gases is the alveolar - arterial oxygen difference divided by the partial pressure of oxygen in arterial blood ($P(A\text{-}aDO_2)/PaO_2$). This measurement will be referred to as the respiratory index or R.I., and reflects pulmonary shunting. Pulmonary shunting is associated with lung contusion (the typical lung injury noted in the above photographs). Pulmonary shunting here refers to that portion of the lung that is being perfused but not ventilated such as pulmonary contusion or atelectasis.

$$R.I. = \frac{P(A\text{-}aDO_2)}{PaO_2} = \frac{[(BP-47)\,F_IO_2 - PaCO_2] - PaO_2}{PaO_2}$$

BP = barometric pressure

47 = water vapor pressure

F_IO_2 = percent oxygen inspired by patient

$PaCO_2$ = partial pressure of carbon dioxide in arterial blood

PaO_2 = partial pressure of oxygen in arterial blood.

In human as well as the goat the normal R.I. is 0.0 to 0.6. When a human reaches about 2, he must be placed on a respirator, inhaling more than 20 percent oxygen, in order to support respiration and keep him adequately oxygenated. When the ratio exceeds 5 or 6, the patient has a severe respirator deficit, and his chances for survival are poor.

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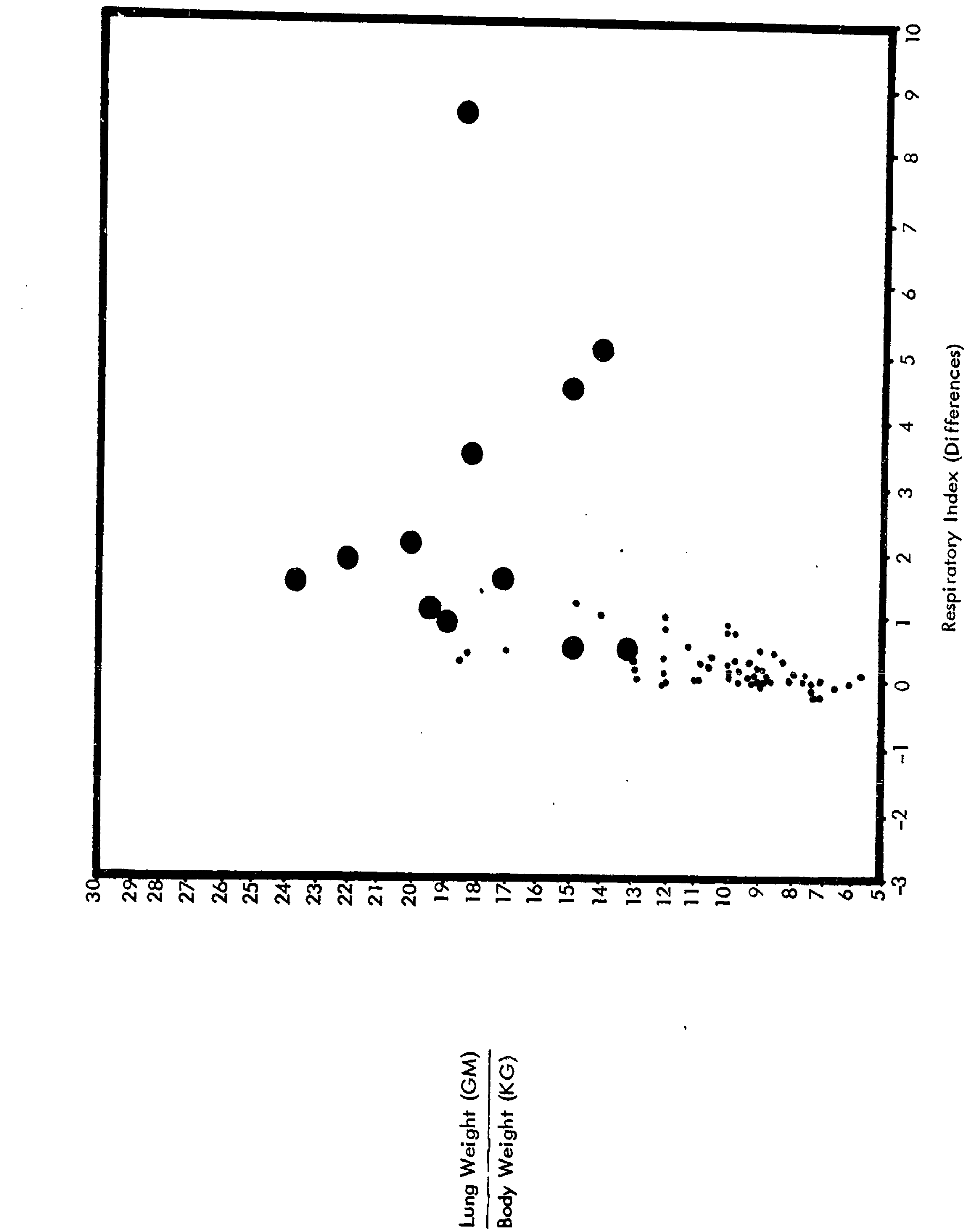
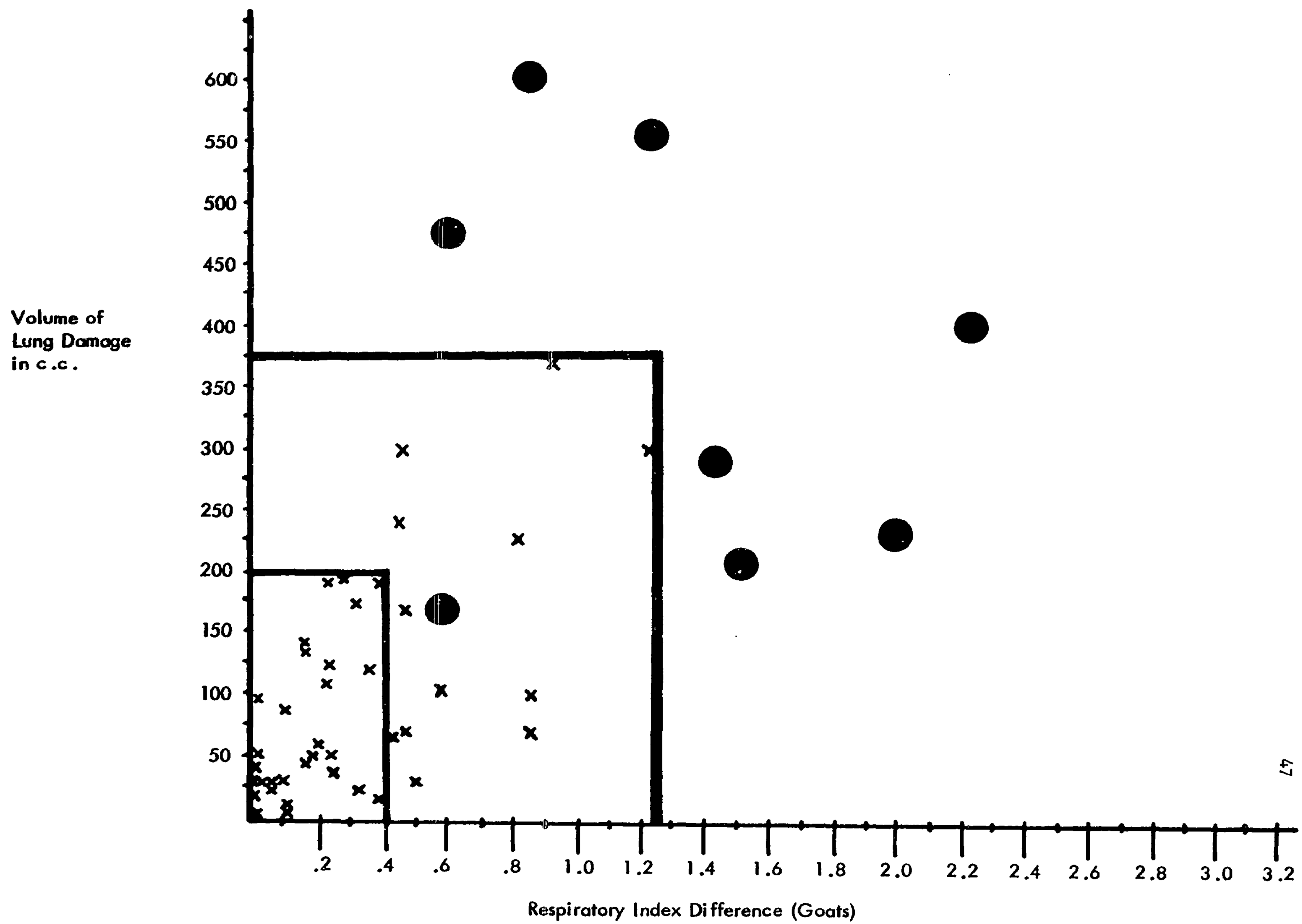
At the shock trauma unit there were 177 consecutively intubated patients studied. These patients were in the unit at least two days. The probability of death with an R.I. of 0 to 2 was 12 percent; with an R.I. over six, the probability of survival was 12 percent. It should be stressed, however, that out of 22 patients that died with an R.I. under four, there were 16 who died from brain injury, and six that died from sepsis and/or cardiac arrythmias. No patient with an R.I. under four died primarily from lung injury.

The data from the patients then permit certain predictions with regard to different R.I.'s in goats. The following data refer to goats that have had blunt thoracic trauma. Before every impact, two control blood samples were drawn. Post impact samples were drawn at 5, 10, 15, 20, and 30 minutes. The control R.I. was subtracted from the post trauma R.I. to give the R.I. difference, noted on the graph. Note that the normal value for humans and goats is similar. On Figure 1 the large black dots indicate the animals that die. All had a LW/BW ratio above 13 and an R.I. of at least 0.58 above control (pre-trauma R.I.). No animal that lived was above 12. It is important to realize that no goat was treated in any experiment. The animals that died within four minutes after impact, had an average R.I. difference of 3.14. Goats that died within 10 to 120 minutes had an average R.I. difference of 0.89.

The animals that survived at least 24 hours had an R.I. difference (increase) averaging 0.28. An increase of at least 0.2 above control (0.3) was associated with 0 to 100 cc of contused lung. There were also animals that had a lower post trauma R.I. than their control value. These negative R.I. differences represent cases where there also was no associated lung damage.

In three preliminary experiments, the goat was wearing a 10-ply PRD vest over one-half of the thorax, and was then shot in the lateral chest with a 0.38 caliber bullet at 792 fps. No layers of PRD were penetrated. The goats had an average R.I. difference of 0.15. This means that the goat lung damage is well within the treatable range, in terms of humans assessment and a human adult would probably incur not more than this damage. An animal may have a single rib fracture and this also is a possibility in the human. The same lung damage had occurred where there was rib fracture. No goat died with an R.I. difference below 0.58 in any blunt trauma direct impact, or bullet-proof vest experiment. If a human were to have lung damage resulting in an R.I. under 1, his chance of dying would probably be negligible according to data trends. It should be emphasized that the human chest wall is thicker than the goat, and this will offer the human more protection than the goat. In addition, the same amount of damage in the goat and the human would actually represent a smaller percent in the human since human lungs are larger than the goat's. Another important ballistic fact is represented by the velocity decay curves. Lung damage occurs from 770 fps and above. Very minimal damage (under 3 cc of contused lung) occurs at 760 fps. The velocity decay curve indicates that if the muzzle velocity is 800 fps, 50 yards away the velocity is 760 fps. The risk of incurring chest injury 50 yards away, therefore, is negligible. The hand-loaded gun used in the laboratory, imparts more velocity than the average gun "on the street". Testing of street weapons reveals an average muzzle velocity of about 750 fps, so that the risk of chest trauma should be, as mentioned earlier, negligible, wearing 10-ply PRD.


Lung Weight (GM)
Body Weight (KG)
Respiratory Index (Differences)
30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5
-3 -2 -1 0 1 2 3 4 5 6 7 8 9 10


Volume of
Lung Damage
in c.c.
600
550
500
450
400
350
300
250
200
150
100
50
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
Respiratory Index Difference (Goats)

APPENDIX E

AUTOPSY REPORTS

NOTE: These are not the total reports of all animals tested, but the representative results of various materials tested.

23 Ply 105-26 Vel. 807 ft/sec Wt. 35.8 kg

50

Animal Dissection Data

Prosector C. LILLY Animal Number 21618

Date and Time of Dissection 8Feb73- 0935 Date and Time of Death 8Feb73 - 0930

Internal Blood Loss cc. ____________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	5.0 x 6.0	0.4	Contused area on skin.
* INNER SURFACE OF SKIN	10.0 x 5.0		Contused area on inner surface.
SUBCUT MUSCLE	6.5 x 4.5	0.5	Contused area on subcutaneous muscle. Missile impacted at the base of the left scapula.
* MUSCLE INTER-COSTAL INNER-SPACE	2.0 x 1.0	0.3	Missile impacted between 7th & 8th left rib. Bruise in 8th innerspace.
* LT LUNG	6.0 x 1.9 5.5 x 3.5 11.5 5.4	lateral 3.0 medial	Solidified blood in contused area. Old pneumonia in lungs adhered to rib cage.
RIBS	----------	-----------	Normal
HEART	----------	-----------	Normal

SMUEA Form 1 (OT)
1 Nov 68

5 Ply 105-26   Vel. 807 ft/sec   Wt. 31.8 kg

Animal Dissection Data

Prosector J. F. MILLER   Animal Number 21620

Date and Time of Dissection 28Feb73 - 0900   Date and Time of Death 28Feb73 - 0835

Internal Blood Loss cc. ____________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* LEFT SIDE SKIN	1.7 x 3.9	0.4	
SUBCUT MUSCLE	2.0 x 2.5	0.1	
FAT	2.0	0.2	
* MUSCLE	1.3 x 3.0	1.8	Comminuted fracture with 4 or more fragments (see pictures).
* 7TH LEFT RIB	1.0 x 1.3	0.6	This rib had a compound.
DIAPH LOBE LEFT LUNG	6.5 x 7.5	1.0 to 4.9 thickness	Bruise is full thickness.
* INSITU	0.2 x 0.4	0.2	Defect.
* L & R LUNG			There is no free blood in left or right pleural cavity.
HEART			Heart appears grossly normal and shows no trauma or no endocardial peteachiation.
RT LUNG			There is no contusion (bruise) on right lung. There are areas of aspirated blood throughout lung with clotted blood in the trachea and bronchials.

SMUEA Form 1 (OT)
1 Nov 68

5 Ply + 1 thickness felt 105-26 Vel. 794 ft/sec Wt. 32.3 kg

Animal Dissection Data

Prosector C. LILLY Animal Number 21621

Date and Time of Dissection 1Mar73 - 0930 Date and Time of Death 1Mar73 - 0830

Internal Blood Loss cc. ____________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	1.8 x 1.5	0.3	Defect in skin.
* MEDIAL ASPECT OF SKIN	6.5 x 6.0		Bruised area around defect.
* CUTANEOUS MUSCLE	6.0 x 4.5	0.2	Bruised area around defect in muscle.
* DEFECT	1.0 x 0.9		Hole in muscle.
* FAT	3.0 x 1.2	0.6	Defect (hole) in fat.
* LATISSIMUS DORSI MUSCLE	1.1 x 0.6	0.5	Defect (hole) in muscle.
* LT RIBS	---------	---	Normal.
* DIAPHRAGMATIC LOBE LT LUNG	3.2 x 3.2	3.0	Bruised area on diaphragmatic lobe of left lung. The bruise covers the entire thickness of the lung.

SMUEA Form 1 (OT)
1 Nov 68

12 Ply 105-26 Vel. 790 ft/sec Wt. 34.0 kg

Animal Dissection Data

Prosector C. LILLY Animal Number 21622

Date and Time of Dissection 1Mar73 - 1030 Date and Time of Death 1Mar73 - 0845

Internal Blood Loss cc.

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	1.8 x 1.2	0.3	Defect (hole) in skin.
* CUTANEOUS MUSCLE	1.5 x 1.2	0.2	Defect (hole) in muscle.
* FAT	1.4 x 1.0	0.3	Defect (hole) fat.
* LATISSIMUS DORSI MUSCLE	1.5 x 1.0	0.3	Defect (hole) in muscle.
* MUSCLE ON SCAPULA	0.5 x 0.4	0.9	Bruise at ventral border of scapula.
* INTERCOSTAL MUSCLE BE-TWEEN 7TH & 8TH LT RIB	1.6 x 0.6	0.3	Bruise between 7th and 1t rib
* DIAPHRAGMATIC LOBE LT LUNG	2.8 x 3.9	3.0	Circular bruise on diaphragmatic lobe of left lung.

SMUEA Form 1 (OT)
1 Nov 68

23 Ply 105-26   Vel. 794 ft/sec   Wt. 32.6 kg

54

Animal Dissection Data

Prosector THOENIG   Animal Number 21624

Date and Time of Dissection 15Mar73 - 1030   Date and Time of Death 15Mar73 - 0840

Internal Blood Loss cc. ____________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	1.8	3.0	Dark hemorrhagic area. Ovoid shape.
* SQ	1.8	3.0	Hemorrhagic lesion on fascia.
MUSCLES			No lesions.
RIBS			No lesions.
* LEFT LUNG	3.0		Hemorrhagic lesion - 3 cm. diameter along posterior border of diaphragmatic lobe.
LEFT LUNG POST BORDER OF DIAPHRAGMATIC LOBE			Lesions throughout (complete thickness) 4.0 cm. diameter.
RT LUNG			No gross lesions.

SMUEA Form 1 (OT)
1 Nov 68

12 Ply Nylon Vel. 798 ft/sec Wt. 40.4 kg

Animal Dissection Data

Prosector J. F. MILLER Animal Number 21625

Date and Time of Dissection 15Mar73 - 0925 Date and Time of Death 15Mar73

Internal Blood Loss cc. ______________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	2.0 x 3.3	0.4	Left lung weighs 215.0 gm.
SUB CUT. M	1.2 x 2.8	0.1	Right lung weighs 358.0 gm.
FAT	1.0 x 3.0	0.2	Total 573.0 gms
* MUSCLE	1.2 x 3.0	0.5	
* (MUSCLE SCAPULA)	1.5 x 1.5	0.1	Hemorrhagic area 1/3 of which is in fascia over bone of scapula. The remainder over muscle.
		(1.3)	Thickness of muscle is 1.3 cm.
MUSCLE OVER RIB CAGE		(0.2)	Thickness of muscle - no evidence of trauma.
* RIB CAGE FASCIA	(2.0 x 3.0)	< 0.1	(Missile)? area was over the 6th intercostal area causing minimal peteakiation in a 2.0 x 3.0 cm area
RIB CAGE		1.0	Thick No free blood in left pleural cavity. There are other small areas of hemorrhage including (envolving) approx. 1/3 of cardiac lobe.
* LEFT LUNG DIAPHRAGMATIC LOBE	4.8 x 6.0	3.4	Part of this hemorrhagic area is full thickness.
HEART			No evidence of external or internal trauma.
* RT LUNG * X SECTION			Shows areas of aspirated blood and p.m changes.

SMUEA Form 1 (OT)
1 Nov 68

9 Ply 105-26 Vel. 797 ft/sec Wt. 53.4 kg

Animal Dissection Data

Prosector C. LILLY Animal Number 21629

Date and Time of Dissection ______ Date and Time of Death 21Mar73 - 0840

Internal Blood Loss cc. ______

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
EXT. SKIN	2.0	1.5	Circular wound. There is a minimal amount of hemorrhage in the area. Subcutaneous tissue minimally involved externally.
SUBCUTANEOUS	2.0	2.0	Bruise.
SUBCUTANEOUS FAT	2.0	2.0	Wound in fat down to muscular layer.
MUSCLE	---	---	NSL.
RIB CAGE			Ext. NSL.
LUNGS			Int. NSL.
LUNGS LEFT WEIGHT			191
LUNGS RIGHT WEIGHT			318

SMUEA Form 1 (OT)
1 Nov 68

9 Ply 105-26 + 1 Ply Felt   Vel. 817 ft/sec   Wt. 54.4 Kg

Animal Dissection Data

Prosector J. HARDISTY   Animal Number 21630

Date and Time of Dissection 22Mar73 - 1000   Date and Time of Death 22Mar73 - 0800

Internal Blood Loss cc.__________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
SKIN	Slit	1.0	Slit hole, moderate amt of hemorrhage. Around the hole the skin is elevated in a 7 cm dia.
DERMIS	7 cm x	8	Rectangular bruise and edema 2 cm depth
SUBCUTANEOUS	3 cm x	3	Bruise Penetrating wound 1.0 cm in dia. 1 cm deep.
MUSCLE		?	NSL.
RIB CAGE		?	NSL.
LUNG (L)			Wt 160 gram Small (2) areas of focal hemorrhage 1.0 cm dia in ventral apical and diaphragmatic lobes.
LUNG (R)			Ventral anterior portion of lung hemmorhagic approx. 1/3 of art lobe Wt 241 gram Poss. related

SMUEA Form 1 (OT)
1 Nov 68

5 Ply 105-26 + 1 Ply felt   Vel. 817 ft/sec   Wt. 52.8 kg

58

Animal Dissection Data

Prosector J. THOMPSON   Animal Number 21632

Date and Time of Dissection 22Mar73 - 0910   Date and Time of Death 22Mar73 - 0820

Internal Blood Loss cc. ______________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
* SKIN	4.0 x 3.5	0.4	Oval shaped, hemorr. wd. laceration with ragged edges.
* SUBCUT.	1.0 x 1.0	0.2	Bloody discoloration with petechial Bruises - measures 7.0 x 6.5 cms of inner surface of skin. Oval shape.
* FAT	2.5 x 2.0	1.0	
LATISS. DORSI M.		1.2	No bruises or damage.
			No significant lesion on ribs.
* LEFT LUNG 290 GMS		3.0	Contusion or hemorrh. area on diaphragmatic lobe - 3.5 cms from edge. Bruise meas. 4.4 x 3.1 cms.
* RIGHT LUNG 240 GMS		2.9	Trauma related markings - from ribs. #1 (Edge of border) measures (a) 1.2 x 1.5 cms (b) 0.8 x 0.4 cms #2 1.8 x 0.9 cms #3 0.8 x 0.9 cms

SMUEA Form 1 (OT)
1 Nov 68

1st Ply PRD 49 TL-105-26 0.38 Special Vel. 810 ft/sec Wt. 45.2 kg

Animal Dissection Data

Prosector C. LILLY Animal Number 21633

Date and Time of Dissection 2May73 Date and Time of Death 2May73 - 0835

Internal Blood Loss cc.______

* Photograph taken LIVER

Tissue	Diam. cm	Length cm	Remarks
SKIN SUBCUT. MUSC.	1,0 x 1.0	0.7	Laceration through and through.
FAT AND MUSC.	1.7 x 2.5	1.0	Lac. through and through.
10TH INTER-COSTAL INNER SPACE AND 11 TH RIB	0.8 x 1.9	0.5	Missile struck the 11th rib and 10th inter-costal inner space. Transverse fracture of the 11th rib.
DIAPHRAGM	1.0 x 1.0	0.3	Lac. of diaphragm under the 11th rib.
LIVER	6.0 x 5.0	2.0 x 5.0	

SMUEA Form 1 (OT)
1 Nov 68

60 | 0.38 Special | PRD 10 Ply

Animal Dissection Data

Prosector ______________ Animal Number 21633

Date and Time of Dissection 2May73 Date and Time of Death 2May73 - 0835

Internal Blood Loss cc. ______________

* Photograph taken LUNG LEFT

Tissue	Diam. cm	Length cm	Remarks
SKIN SUBCUT FAT AND MUSC	1.0 x 1.0	1.0	Lac. on skin.
FAT	0.5 x 0.5	0.3	Lac. in fat
MUSC.	---------	1.0	No damage to muscle. Missile impacted between 7 and 8th rib.
RIBS	---------	0.6	No damage.
LT. LUNG DIAPHRAGMATIC LOBE	5.5 x 2.5	0.4	Contusion of the ventral border of the diaphragmatic Lobe left lung.

SMUEA Form 1 (OT)
1 Nov 68

10 Ply PRD 49 TL-105-26 Vel. 794 ft/sec Wt. 46.0 kg

Animal Dissection Data

Prosector J. THOENIG Animal Number 21634

Date and Time of Dissection 2May73 - 0900 Date and Time of Death 2May73 - 0845

Internal Blood Loss cc. ______________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
RT BODY WALL EXTERNAL-SKIN	3.0 cm A.P. 1.8 cm V.D.	0.7	Wound or laceration irregular in at line completely thru outer cutaneous tissue penetrating to depth of 0.7 cm.
INTERNAL-SKIN	4.0 cm A.P. 4.0 cm V.D.	0.7	Hemorrhage around laceration has irregular borders 4.0 cm diameter - opening has diameter of ~2.5 cm.
SQ TISSUE	3.5 cm A.P. 3.0 cm V.D.	0.6	Contusion - penetration to 0.6 cm level and laceration.
MUSCLES	.5 cm A.P. 2.5 cm V.D.	3.0	Penetration to intercostal muscles with laceration to rib.
RIBS			Rib #10 fractured transversely area of hemorrhage underlying fascia 7.0 cm V. D. 4.8 cm A..P.
RT LUNG	8.0 cm V.D. 2.5 cm A.P.	1.0 cm	Hemorrhage on diaphragmatic lobe-lateral 8.0 cm and long posterior border 2.5 cm A.P.
DIAPHRAGM			Contused and bruised
LIVER	4.0 x 0.5	2.5 x 2.0	Fracture of liver 4.5 cm long in V.D. direction - clot on outer surface
LEFT BODY WALL -SKIN	3.0 cm A.P. 2.5 cm V.D. 0.4 cm thick	0.4 cm	Laceration over area of ribs 6 & 7
EXTERNAL INTERNAL	4.0 cm A.P. 3.0 cm V.D.	0.4 cm	Contusion on inner side of skin penetration of SQ & muscle to depth of 1.0 cm with that being 10. cm in diameter.
RIBS		3.2 cm depth of penetration	Contusion of musculature over rib 7 on external surface - inner surface no damage
LEFT LUNG	2.0 cm V.D. 1.5 cm A.P. depth 0.7 cm	0.7	hemorrhage on ventral border of cardiac lobe

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10 Ply PRD 49 TL-105-26 Vel. 794 ft/sec Wt. 46.0 kg

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Animal Dissection Data

Prosector J. THOENIG Animal Number 21634

Date and Time of Dissection 2May73 - 0900 Date and Time of Death 2May73 - 0845

Internal Blood Loss cc. ________________

* Photograph taken

Tissue	Diam. cm	Length cm	Remarks
LEFT LUNG	3.5 cm V.D. 4.0 cm A.P. 0.8	0.8	Hemorrhage on posteria surface of diaphragmatic lobe

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