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16. Abstract

A pilot study was performed to evaluate use of the HSRI high-speed cineradiographic system for study of aortic trauma mechanisms. The thoraxes of anesthetized New Zealand white rabbits were impacted by a dropped accelerometer-instrumented, 1.5 kg mass from a height of 2.44 meters. Velocity and force data were obtained from the instrumented impacting mass. High-speed cineradiographs at approximately 1000 frames per second showed thoracic skeletal deformation and heart, diaphragm, and liver displacements. No radiopaque contrast medium was used in this preliminary investigation. Post-impact autopsy revealed rib fracture, localized hemorrhaging, and aortic transection. On the basis of film obtained, this method has potential for the study of internal organ injury mechanisms.

17. Key Words
Aortic trauma mechanisms,
High-speed Cineradiography
New Zealand White Rabbit

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UM HSRI-77-53

Feasibility of Investigating the Mechanisms of Aortic Trauma Using High-Speed Cineradiography

A Pilot Study

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Final Report for Period

May 15, 1977 through August 31, 1977

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PURPOSE

Automobile accidents often produce thoracic impacts severe enough to cause life-threatening trauma to the large vessels of the vascular system, such as the aorta. A reduction of these traumas might be achieved if the injury mechanisms involved could be verified. The numerous injury mechanism hypotheses that have been proposed lack substantive evidence from impact observation. However, an improved high-speed cineradiographic system recently developed at HSRI (1)* is designed to record biomechanical impacts at 1000 frames per second and offers an important approach to injury mechanism investigation.

The technical questions addressed by this pilot study include:

1. Is it feasible to modify the HSRI high-speed cineradiographic system for looking at small mammalian thoraxes and to obtain high-speed movies of impacts to New Zealand white rabbit thoraxes which produce severe aortic trauma?
2. Based on the impact movies and autopsy results, is it feasible to study the mechanisms of aortic trauma using the HSRI system?
3. What recommendations is it possible to make regarding future investigations of this nature?

The purpose of this report is to describe the methodology used to evaluate the HSRI high-speed cineradiographic system, to present test results obtained, to discuss the results, to summarize what is learned, and to make recommendations concerning the system in any future studies.

CONCLUSIONS

1). The HSRI high-speed cineradiographic system can be, and is now, modified for use with small mammalian thoraxes.

2). High-speed cineradiographic movies (1000 fps) have been obtained of impacts to anesthetized New Zealand white rabbit thoraxes where the aortic tear injury level was approached.

*Numbers in parentheses indicate references.

3). The aortic injury level was found to be a force in the range of 300 to 400 Newtons for New Zealand white rabbits.

4). The high-speed x-ray movies of the impacts show the skeletal system, diaphragm, and liver well. The heart-lung complex is detectable as a shadowy area if no contrast medium is used.

5). Based on this pilot study, the HSRI high-speed cineradiographic system is a feasible method of investigating intra-thoracic injury mechanisms if further developmental work is pursued.

1. INTRODUCTION

Impact trauma to the vascular system within the human thorax is often life-threatening and, therefore, is the subject of considerable study and hypothesizing relative to possible injury mechanisms. Lacking, however, are impact trauma observations adequate for validation of a composite injury mechanism theory. The recently developed HSRI high-speed cineradiographic system is designed to aid investigations of biomechanical impacts and required evaluation for use in observing impact trauma to animal models with sufficient detail to provide aortic injury mechanism evidence. This evaluation constitutes a pilot study for aortic injury mechanism investigation using the system.

In this pilot study, high-speed cineradiographic movies were taken of several anesthetized rabbit thoraxes being impacted with forces that produce severe intrathoracic trauma such as aortic tears, crushed livers, and hemothoraxes. The rabbits were autopsied and the observed injuries noted in relation to what can be seen in the movies. The x-ray system parameters of voltage, current, time, filtration, target placement and pulsing were examined along with the necessity and possibilities of radiopaque targeting (2).

The following discussion of the methodology lists the objectives of the test procedure, describes the drop tower test fixture and x-ray system, gives the animal protocol used, and details the test procedure. The results discussion explains what data were taken, how they were analyzed, and presents a table of instrumentation data, a table of autopsy findings, and a recreated segment of the high-speed x-ray movie. The discussion also summarizes findings about the feasibility of aortic injury mechanism investigation using the HSRI system and recommendations regarding further similar use of the system.

2. Methodology

2.1 Test Objectives - The objectives of the test procedure were as follows:

2.1.1 Impact the thorax of an anesthetized New Zealand white rabbit midsagittally between the manubrium and xiphoid with a range of forces sufficient to cause severe intrathoracic trauma such as aortic ruptures and crushed livers.

2.1.2 Instrument the impacting mass to obtain the applied force, acceleration, velocity, and duration of impact.

2.1.3 Obtain high-speed cineradiographic movies (approximately 1000 fps) of the impact with the HSRI system.

2.1.4 Measure the chest deflection with x-ray targeting or otherwise.

2.1.5 Autopsy the traumatized rabbit at the culmination of each test and record observed injuries.

2.1.6 Review the instrumentation results, x-ray movies and autopsy findings. Reiterate with feedback.

2.2 Equipment

2.2.1 Drop Tower Impact Fixture - As no test fixture existed at HSRI for controlled impact of small mammal thoraxes with an appropriate resulting injury level, the design, fabrication, assembly and testing of a drop tower impact fixture was necessary. The drop tower consists of basically four substructures: upright structural square tube stock, cylindrical rail, impactor, and rabbit supporting station as shown in Figure 1. The upright structural square tube stock is 38.1 mm square and has a continuous length of 4.57m from a perpendicular base to brackets bolted to the ceiling beams. At mid-length, two horizontal stabilizing struts were bolted between the upright and the wall. The cylindrical rail consists of cylindrical steel stock bolted to aluminum "T" stock which is, in turn, bolted to the upright. The cylindrical stock is 38.1 mm in diameter. The impactor is a 127 mm-long, 76 mm-diameter thin-walled aluminum tube

Figure 1 - Experimental Test Set-up

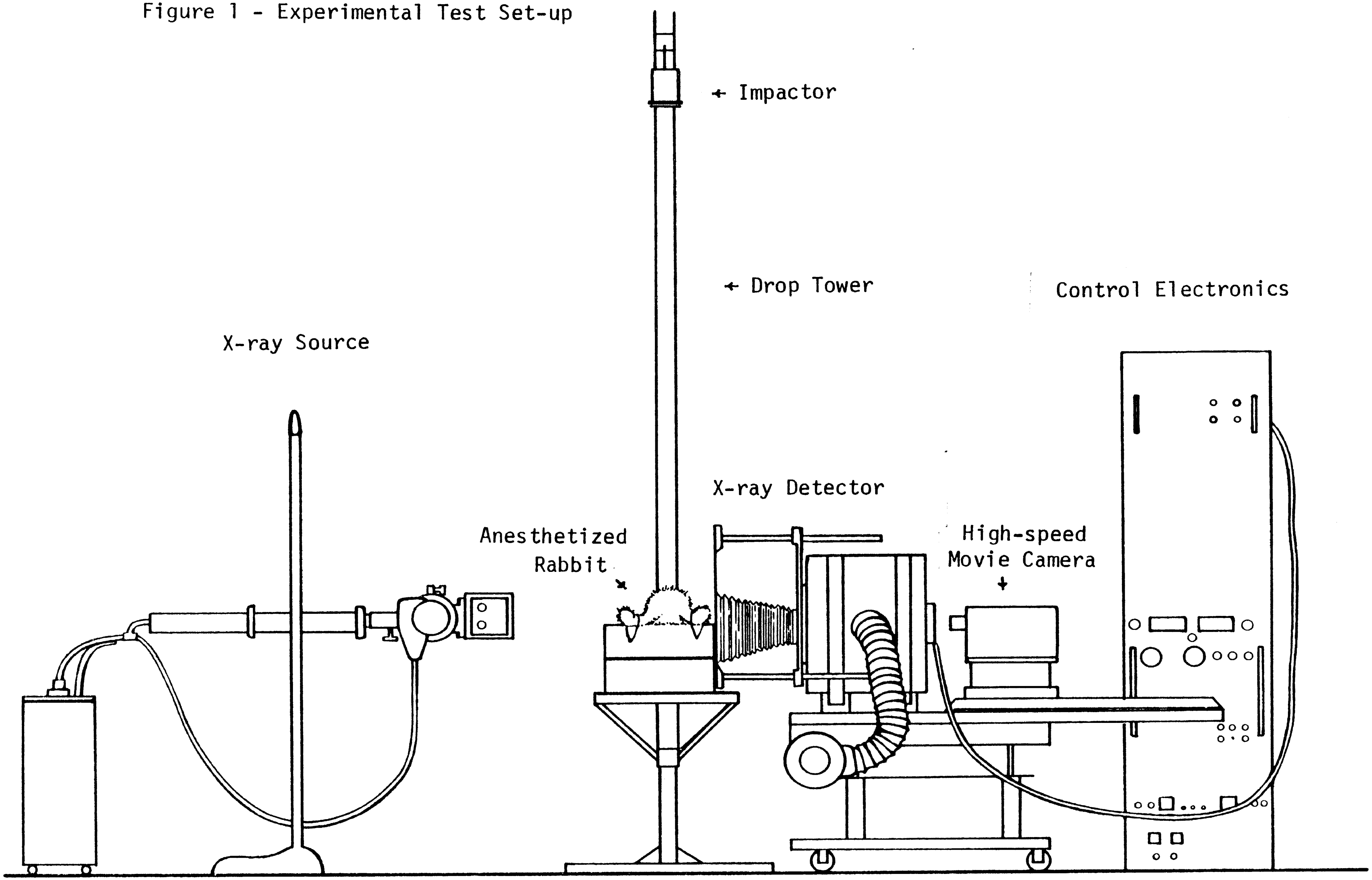
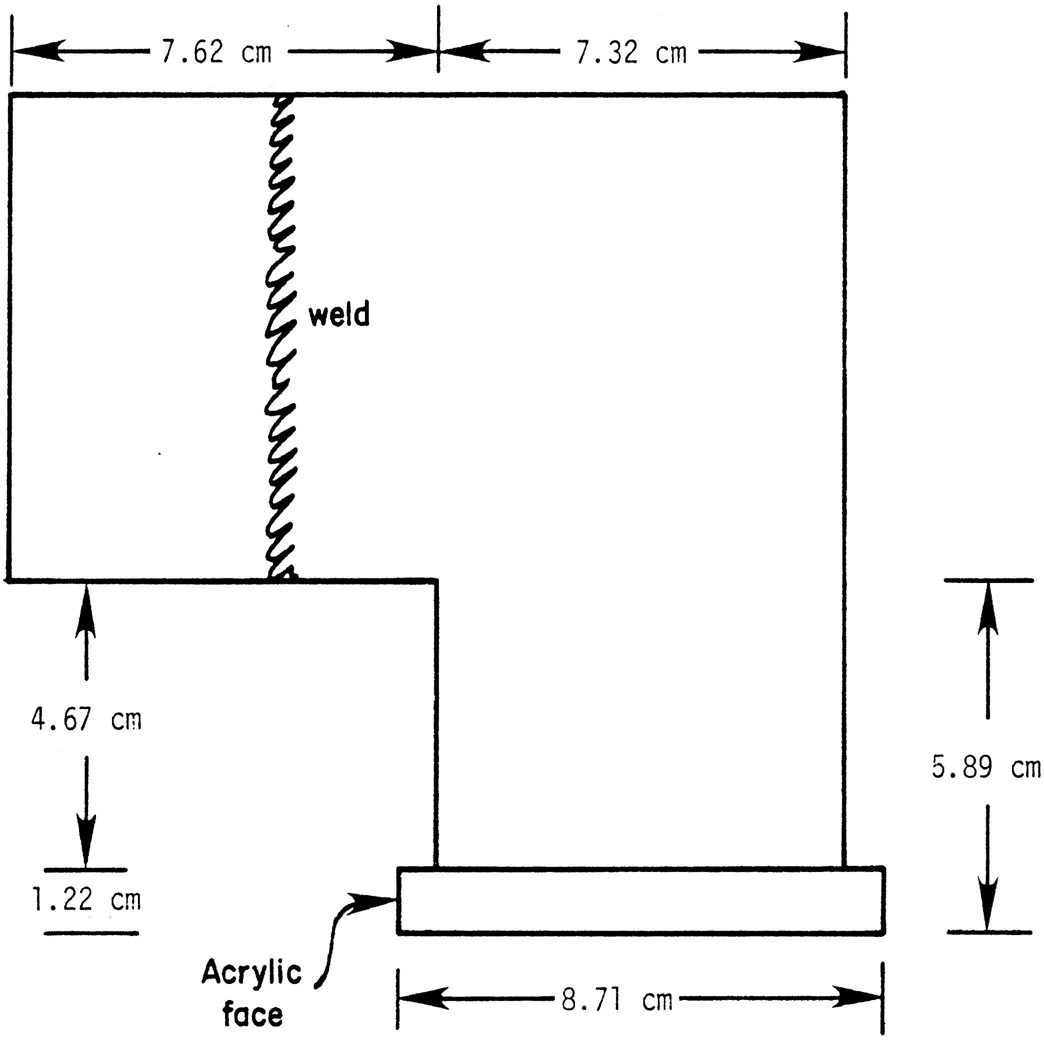


Figure 2. Impactor Details



which has had its side longitudinally cut, flared out and welded to a 76 mm O.D., 38.1 mm I.D. bearing race as shown in Figure 2. The entire impactor has a mass of 1.15 kg and an acrylic plastic face of 87.1 mm diameter. The rabbit supporting station is a 0.46 m square of angle iron (fitted with 12.7 mm plywood) welded to a slide fit piece of square tube stock bolted to the upright. The station is further supported by two angle iron struts welded at 45° between the station and another piece of slide fit tube stock (See Appendix A).

The accelerometer instrumented impactor is raised to the desired height and released by a solenoid. A small bracket with two magnetic pick-up probes located on it one inch apart is attached to the rail so that the impactor causes the magnetic probes to produce spikes on the tape record. Velocity is later determined using the tape record time history. A metal stop is attached to the bottom end of the rail and is padded as desired to control the deceleration pulse.

With the test initiation, the solenoid releases the impactor which slides down the rail and impacts the restrained rabbit. The first magnetic velocity probe also triggers the high-speed cineradiographic system. The rabbit height and impactor stop padding control the chest deflection.

See test set-up illustrations in Appendix A.

2.2.2 The HSRI High-Speed Cineradiographic System

This system consists of a Photosonics 1B high-speed, 16-mm motion-picture camera which views a 2-inch diameter output phosphor of a high-gain, four-stage, magnetically focussed image intensifier tube, gated on and off synchronously with shutter pulses from the motion-picture camera. A lens optically couples the input photocathode of the image intensifier tube to x-ray images produced on a fluorescent screen by a smoothed direct-current x-ray generator. Smoothing of the full-wave rectified x-ray output is accomplished by placing a pair of high-voltage capacitors in parallel with the x-ray tube. The degree of ripple, or unsmoothness, of the x-ray output is directly proportional to x-ray tube current and inversely proportional to anode potential. At best, ripple in this system is approximately 8% of peak output. In applications which require rather low kilovoltage, particularly when no contrast medium is used, such as in this experiment, ripple can become as large as 30%. Ripple frequency occurs at the same frequency as full-wave rectification, 120 Hz, so over a period of 8 milliseconds, or one cycle, density variation on resulting eight frames of motion picture film can be as large as 50%. However, even with this density variation on the film, it is still possible to discern changes in contrast boundaries caused by the impact event, and this was done in this experiment.

An important feature of this system is its capability of variation of screen size in the x-ray field because the screen is imaged by a lens onto the image tube. This is similar to a zoom-type optical system, although a suitable single zoom lens is not yet available for this system. In this experiment a close-up lens was attached to the image intensifier objective lens to give a 4-inch diameter field in which to radiograph a small mammalian heart, aortic arch, and other close-by anatomical structures of interest.

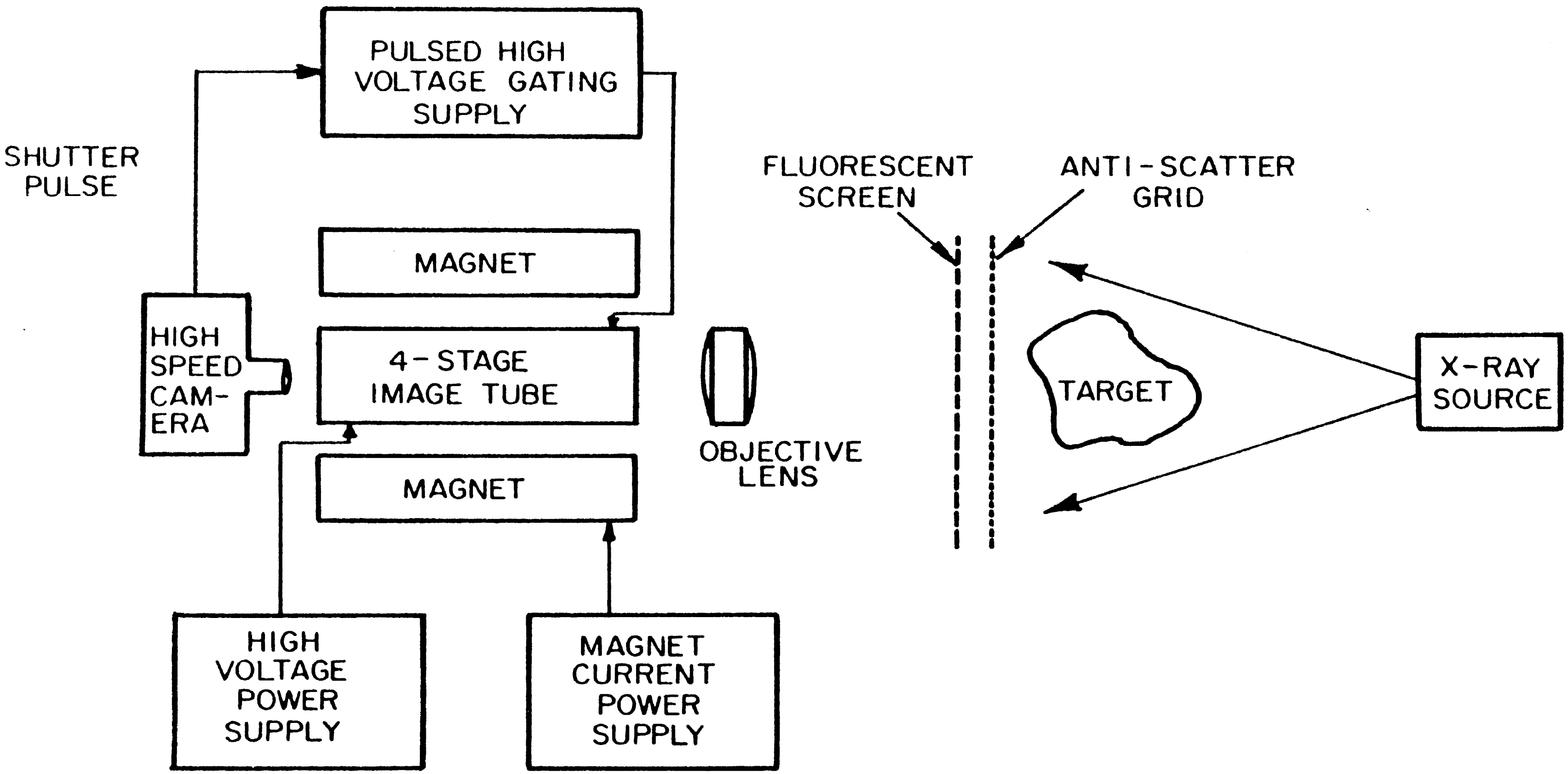


Figure 3. Schematic Diagram of the High-speed Cineradiographic System.

2.3 Animal Protocol

2.3.1 Animal Type: New Zealand white rabbits, weighing 2 to 3.6 kg, were used in this study.

2.3.2 Housing: All rabbits were stored at the AAALAC accredited HSRI animal facility.

2.3.3 Care: All rabbits were handled and cared for in a manner commensurate with the guidelines set by the U of M Animal Use Committee and the AAALAC.

2.3.4 Anesthesia: Sodium pentobarbitol (30 mg/kg) was administered by trained personnel either by I.V. or I.P. methods. The appropriate depth of anesthesia was maintained throughout the testing period.

2.3.5 Surgery: Surgery was limited to one attempt at inserting a radiopaque supply catheter into the right axillary artery.

2.3.6 Euthanasia: After each test, the animal was euthanized with an overdose of sodium pentobarbitol.

2.4 Test Procedure

2.4.1 Day before: Focus x-ray system, weigh rabbit, start fasting rabbit, and confirm surgery procedure.

2.4.2 Obtain rabbit: Remove a previously fasted rabbit (12 to 18 hours) from its cage to the surgical preparation area.

2.4.3 Anesthetize rabbit: Administer an injection of sodium pentobarbitol, 30 mg/kg, using a catheter in the ear vein or I.P. (whichever is necessary).

2.4.4 Check out impact system: While the rabbit is achieving an appropriate depth of anesthesia, verify that the recording equipment and x-ray system are stable, the high-speed movie camera is loaded and functioning properly, the impactor release mechanism, velocity probes and accelerometer are functioning properly.

2.4.5 Prepare rabbit: Attach any x-ray targeting and in one case investigate surgical procedures for inserting a catheter into the right axillary artery as a means of contrast medium introduction.

2.4.6 Position rabbit: Transport rabbit from surgical facilities to the test fixture and restrain rabbit in proper test position. Record pertinent positioning dimensions.

2.4.7 Final check: Verify that all equipment and personnel are ready. Final zero.

2.4.8 Impact the rabbit: Initiate test and note any problems.

2.4.9 Examine rabbit: Check the rabbit's respiration, heart beat, post-test position, appearance, and palpate for gross injuries.

2.4.10 Euthanize rabbit: Administer an overdose of sodium pentobarbitol intravenously or by direct injection into the heart muscle. Verify termination.

2.4.11 Autopsy rabbit: Carefully autopsy each impacted rabbit and record injuries. Give special attention to the aorta, thoracic wall, pulmonary arteries, and liver.

2.4.12 Film: Examine the processed high-speed movies for evaluation of method and system.

3. TEST RESULTS

3.1 Data Obtained. Basic data were obtained for each test as presented in Table 2 and Appendix A.

3.1.1 Acceleration of the impactor was taken by a Setra 111 uniaxial accelerometer attached to the rear surface of the impactor face plate.

3.1.2 Velocity at a known distance from the stop plate was taken with two magnetic pick-up probes one inch apart.

3.1.3 A high-speed cineradiographic movie (~1000 fps) was taken with the HSRI system and a Photosonics 1-B high-speed movie camera.

3.1.4 Rabbit position relative to the impactor stop was recorded.

3.1.5 Autopsy findings were recorded for each rabbit and are presented in Table 2. A set of 35mm color slides accompanies this report. These slides show injuries observed in the first and second impacted rabbits.

3.2 Data Analysis This section presents how each type of data was analyzed.

3.2.1 Instrumentation Results A list of the calculated results and how they were calculated follows:

3.2.1.1 Velocity calculated for impact:

$V_p = D_p/\Delta T_p$

V_p = average velocity at probes

D_p = distance between probes (2.54 cm)

ΔT_p = time between velocity probe spikes on tape

$V_i = V_p + gT_v$

V_i = velocity at start of impact

g = acceleration of gravity

T_v = time between last velocity probe strike and beginning of deceleration

$V_e^2 = V_i^2 + 2AD_i$

V_e = velocity at end of impact **but before stop contact**

A = assumed average deceleration of impact

D_i = distance between first rabbit thorax contact and stop contact (Appendix A)

3.2.1.2 Impact duration BCS*:

$T_i = (V_i - V_e)/A$

T_i = duration of impact BCS

*BCS = before contacting stop

If the assumed value of A produced improbable values of V_e, the value was iterated upon.

3.2.1.3 Average acceleration BCS: The acceleration trace was examined over the T_i impact duration and an average value determined.

3.2.1.4 Peak acceleration BCS: The acceleration trace is examined for the peak value during the T_i impact period.

3.2.1.5 Average force BCS: The average force is the determined average acceleration BCS multiplied by the impactor mass.

3.2.1.6 Peak force BCS: The peak force is the determined peak acceleration BCS multiplied by the impactor mass.

3.2.1.7 Impact duration total: The acceleration trace is examined for beginning of rebound.

3.2.1.8 Thorax deflection BCS: The thorax deflection BCS is determined before the test by the position of the rabbit relative to the impactor stop.

3.2.1.9 Thorax deflection total: The total thorax deflection is the sum of the deflection BCS and the deflection allowed by compression of the padding on the impactor stop. The compression of the padding is determined by post-test calculations using load deflection curves for the padding materials (3).

3.2.1.10 Percent thorax deflection: Percent thorax deflection is defined as the thorax deflection total divided by the pre-test measured thorax depth and multiplied by 100%.

3.2.2 Autopsy Results: Careful autopsy of each impacted rabbit thorax and abdomen was performed immediately after euthanasia. Particular attention was given to the aorta. After examining the total injury summary for each rabbit, the result was classified with a system similar to the American Association for Automotive Medicine's Abbreviated Injury Scale (AIS) (4). Representative important slides were taken.

3.2.3 High-speed Cineradiographs: Seeing details of the impact in a high-speed cineradiograph is often difficult for the trained eye as well as the untrained eye. For this reason, a method of recreating the movie using ink drawings was performed in this pilot study. Selected frames were projected on white paper; tracings were made of what could be seen of the rabbit thorax as it was deformed, and then finalized in a sequence of ink drawings. Rabbit anatomy texts (5), (6) were used as guides. This is an inherently subjective procedure; therefore, effort was made to prevent overzealous additions. The actual movie accompanies this report.

Certain features of the recreated movie sequence represent important features of the actual movie. First, lines on the sequence represent major density variations such as a rib or liver or heart-lung complex. Second, the absence of the ribs and spine in later rebound frames indicates that so much contrast was lost that the piece could no longer be detected. This loss of contrast is the result of the increased x-ray absorbtion path length during impact compression. Finally, as indicated in the first frame, the organ motions and deformations of the liver-diaphragm, sternum, ribs, heart-lung complex, and thalmus region appear as changes in the shape and location of the outlines.

3.3 Data The instrumentation, autopsy, and movie data follow.

3.3.1 Table 1 - Impact Instrumentation Results

Test Number	77G001	77G002	77G003	77G004
Velocity Calculated For Impact($\frac{m}{s}$)	V_i = 6.8±2% V_e = Bottomed Out	V_i = 6.7±2% V_e = 5.4±2%	V_i = 6.84±2% V_e = 6.07±2%	V_i = 6.62±2% V_e = 5.60±2%
Average Force BCS* (N)	563±5%	377±5%	217±5%	253±5%
Peak Force BCS* (N)	1180±5%	563±5%	231±5%	310±5%
Average Acceleration BCS* (m/s^2)	490±5%	327±5%	189±5%	221±5%
Peak Acceleration BCS* (m/s^2)	1030±5%	490±5%	201±5%	270±5%
Impact Duration BCS* (ms)	17±5%	4.7±5%	3.9±5%	4.2±5%
Impact Duration Total (ms)	17±5%	11±5%	13±5%	16±5%
Thorax Deflection BCS* (cm)	6.78±2%	2.54±2%	2.54±2%	2.54±2%
Thorax Deflection Total (cm)	7.33±4%	3.0±4%	4.37±4%	4.37±4%
% Thorax Deflection	90%±5%	41%±5%	57%±5%	54%±4%†

*BCS ≡ Before Contacting Stop

V_i ≡ Velocity at contact of rabbit thorax

V_e ≡ Velocity just prior to contacting stop

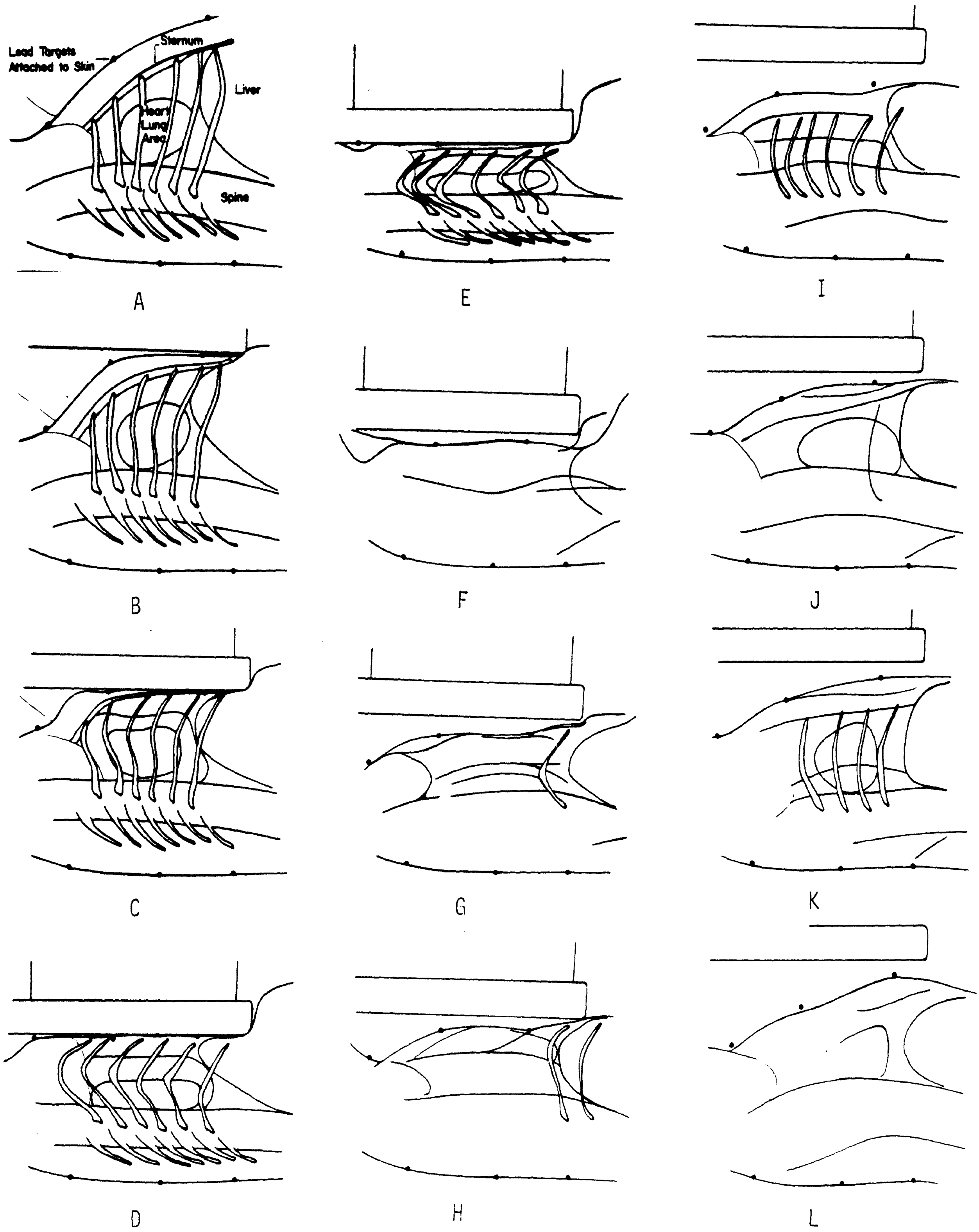
NA ≡ Not Applicable

† ≡ Film analysis determined

3.3.2 Table 2 - Autopsy Findings

Test No.	Area	Damage
77G001	Ribs	Right 1 to 6 fractured near sternum; Left 4 to 8 fractured near spine; Hemorrhage at fractures.
	Lungs	Hemothorax (20-25 cc); Right & Lung hematomas.
	Pericardium	Ruptured and torn near fractured ribs at spine.
	Aorta	Punctured mildly by fractured ribs at spine. Tear on dorsal interior of aorta between left subclavian and carotid arteries.
	Liver	Hematoma, crush of ventral surface of left lobule and near gall bladder.
	Other	Right ventricle tearing with hemorrhaging.
	Estimated AIS	6
77G002	Ribs	Right 3 to 7 and Left 3 to 8 fractured at intercostal junction.
	Lungs	Large contusion on ventral surfaces of all lobes. Large hemorrhage of ruptured Right pulmonary artery.
	Pericardium	Hemorrhaged around dorsal areas.
	Aorta	Circumferencial tear of posterior wall of aorta across from left subclavian; left subclavian torn circumferencially and longitudinally near junction to aorta.
	Estimated AIS	6
77G003	Ribs	Right 2 to 6, Left 2 to 6 fractured with hemorrhaging on Right 2, 5 & 6, Left 3 to 6.
	Lungs	Spotty hematoma on ventral surface of all lobes.
	Estimated AIS	3 or 4
77G004	Ribs	Right 2 to 8, Left 2 to 5 fractured near sternum. Right 2 to 6, Left 2 to 6 fractured near spine, hemorrhaging at each fracture.
	Lungs	Spotty hematoma on ventral lobe surfaces.
	Other	Hypothalmus vessels - small spotty hemorrhaging
	Estimated AIS	4

3.3.3 Figure 4 - Recreated Motion Picture Sequence



4. SUMMARY

4.1 What Was Done

4.1.1 One rabbit served to check out the rabbit handling and positioning, and was terminated.

4.1.2 One rabbit served to establish the proper x-ray system parameters and was terminated.

4.1.3 Rabbit test 77G001 was a very severe impact. No x-ray movies were obtained because of triggering problems.

4.1.4 Rabbit test 77G002 was a severe impact. X-ray movies were obtained, but extreme ripple problems and a negative processing provided unacceptable film. Rabbit expired 15 minutes prior to test.

4.1.5 Rabbit test 77G003 was an impact which did not produce aortic trauma. X-ray system functioned properly, but the high-speed movie camera did not function.

4.1.6 Rabbit test 77G004 was an impact which did not produce aortic trauma. Good x-ray movies were obtained of the impact.

4.2 Findings

4.2.1 The HSRI high-speed cineradiographic system is capable of obtaining 1000 fps movies of impacts to small mammalian thoraxes.

4.2.2 The obtainable movies, without contrast medium, show the skeletal system, diaphragm and liver quite well. The image of the heart-lung complex is an area whose boundaries have sufficient contrast to permit detection.

4.2.3 Organ movement shows up well but techniques of contrast medium injection and x-ray targeting need to be developed and refined.

4.2.4 The rabbit's small size makes surgery and organ observation difficult.

4.2.5 A force level of 300 to 400 N is capable of producing aortic tears, pulmonary artery ruptures and crushed livers in rabbits impacted as described in this paper.

4.2.6 The x-ray absorption path length increases with impact compression. A method of compensating for this "blacking-out" of the image needs development.

4.2.7 It seems feasible to use the HSRI x-ray system to study aortic trauma mechanisms.

4.3 Recommendations

4.3.1 Contrast medium introduction and targeting techniques need to be developed if the motion of the heart is to be observed.

4.3.2 Allow for the compression of the tissue by utilizing maximum kilovoltages and appropriate filtration.

4.3.3 An increase in the subject size would be helpful.

5.0 REFERENCES

(1) M. Bender et al., "A High-speed Cineradiographic Technique for Biomechanical Impact," SAE 760800, Proceedings of the Twentieth Stapp Car Crash Conference, Society of Automotive Engineers, Inc., Warrendale, Pa., 1976.

(2) S. Shatsky et al., "Traumatic Distortions of the Primate Head and Chest: Correlation of Biomechanical, Radiological and Pathological Data," SAE 730978, Proceedings of the Eighteenth Stapp Car Crash Conference, Society of Automotive Engineers, Inc., Warrendale, Pa., 1973.

(3) J. Melvin et al., "Compression of Cellular Plastics at High Strain Rates," Journal of Cellular Plastics, Vol.7, No.2, Mar./Apr., 1971.

(4) Joint Committee on Injury Scaling; The Abbreviated Injury Scale (AIS), 1976 Revised Ed., American Association for Automotive Medicine, Morton Grove, Illinois, 1976.

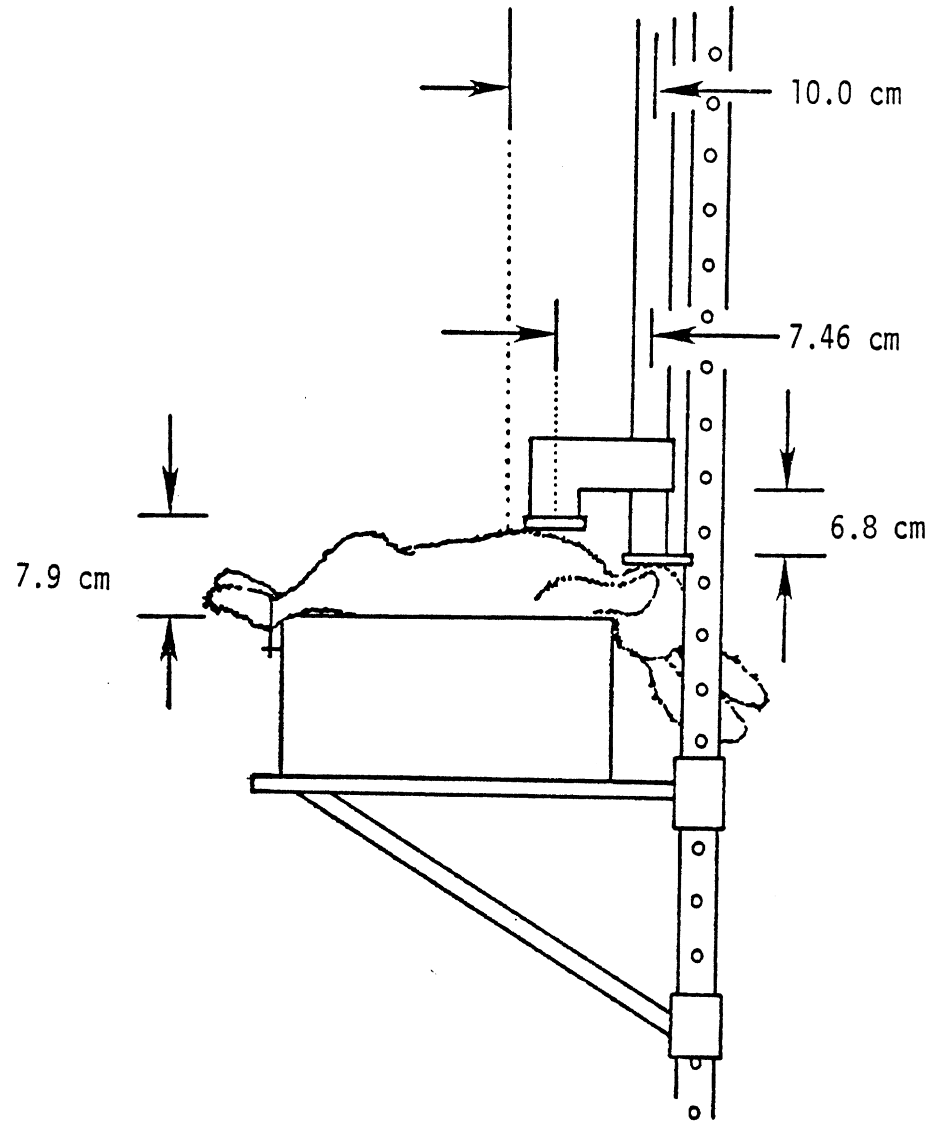
(5) C. A. McLaughlin, Laboratory Anatomy of the Rabbit, William C. Brown Company Publishers, Dubuque, Iowa, 1970.

(6) E. H. Craigie, Practical Anatomy of the Rabbit, The University of Toronto Press, Toronto, 1948.

Appendix A

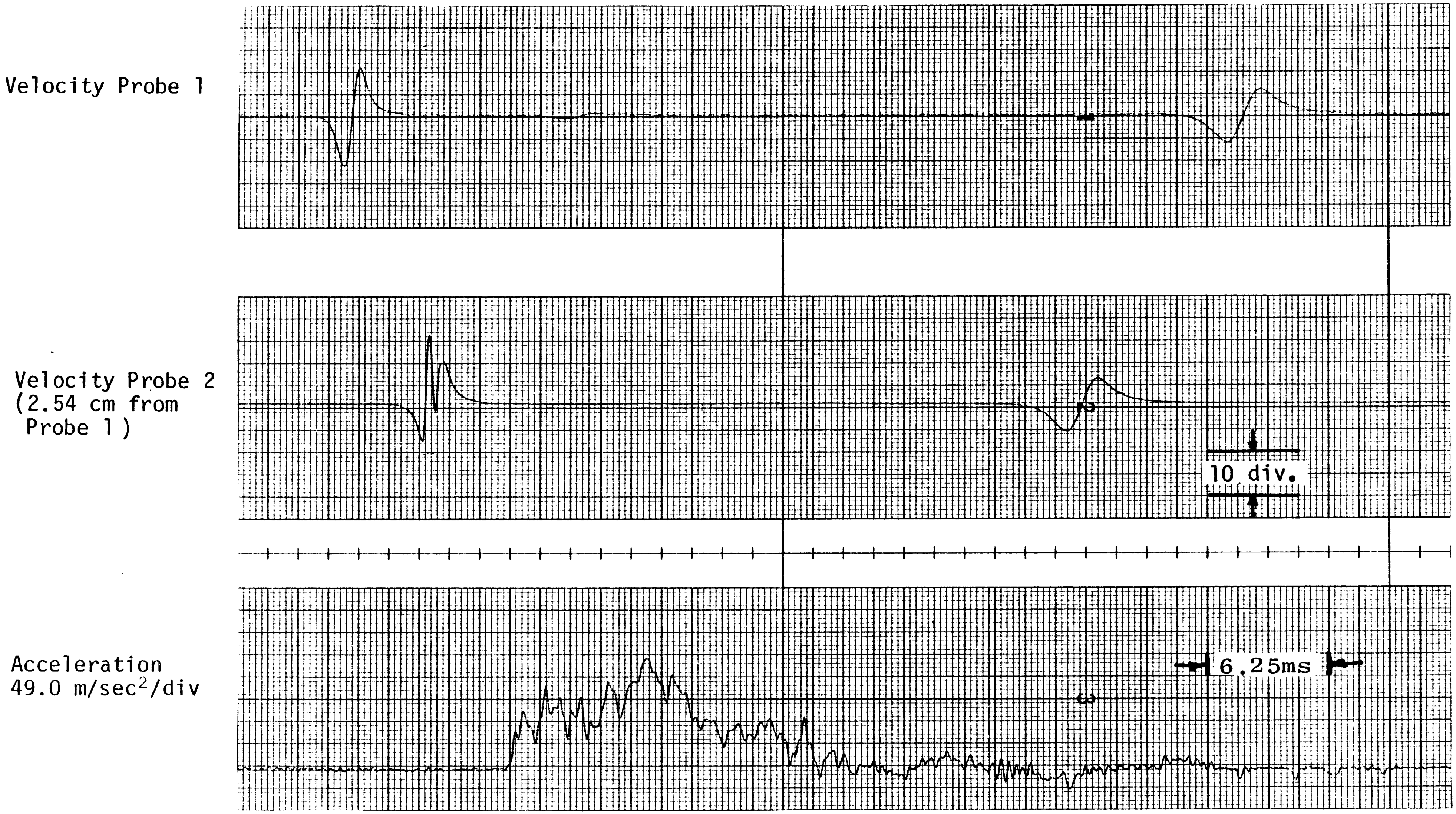
Test Data

Test No. 77G001



Test Description: Achieved a 1cm left of midsagittal impact at approximately the seventh intercostal junction where the impactor bottomed out on the spine. Drop height was 2.44 meters, and the metal stop had a 0.5 cm ensolite pad on it.

Test No. 77G001 Instrumentation Traces



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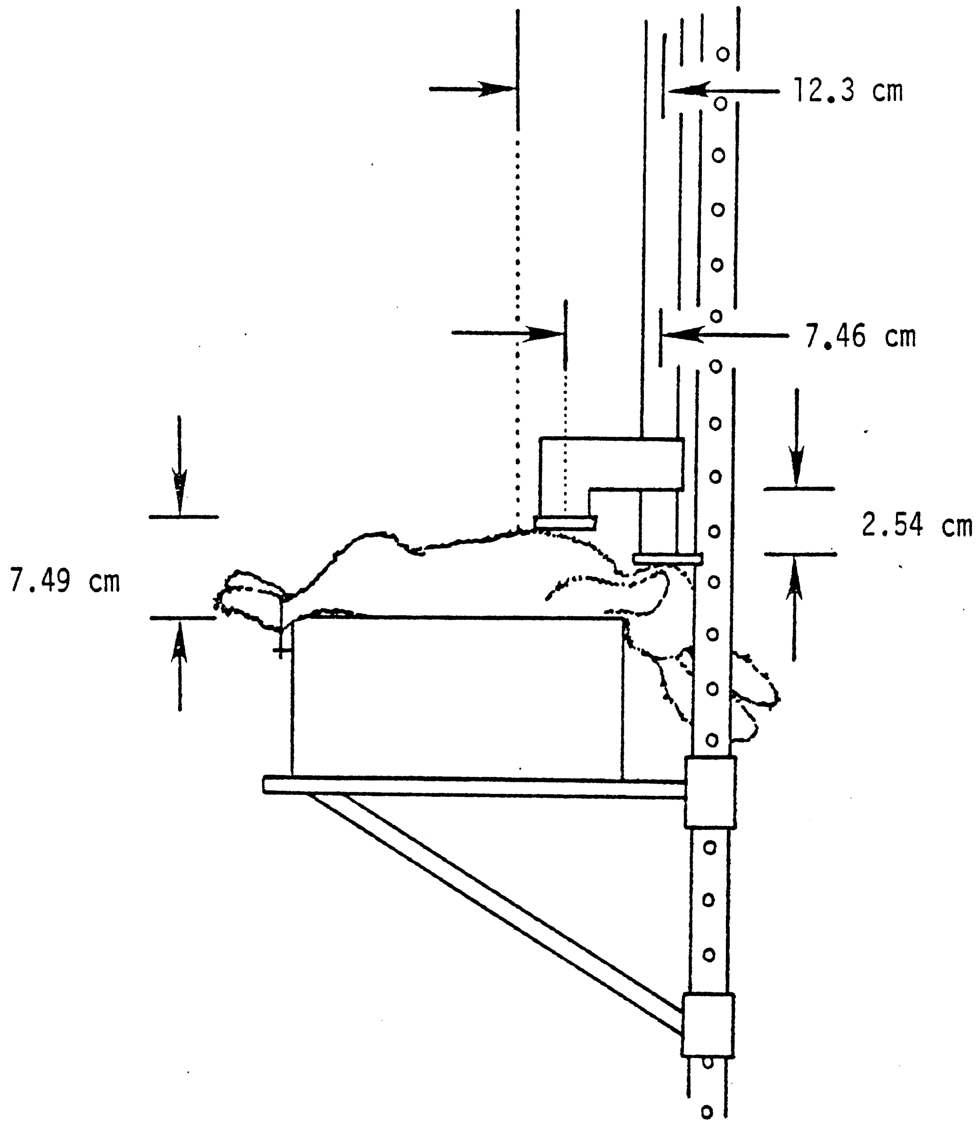
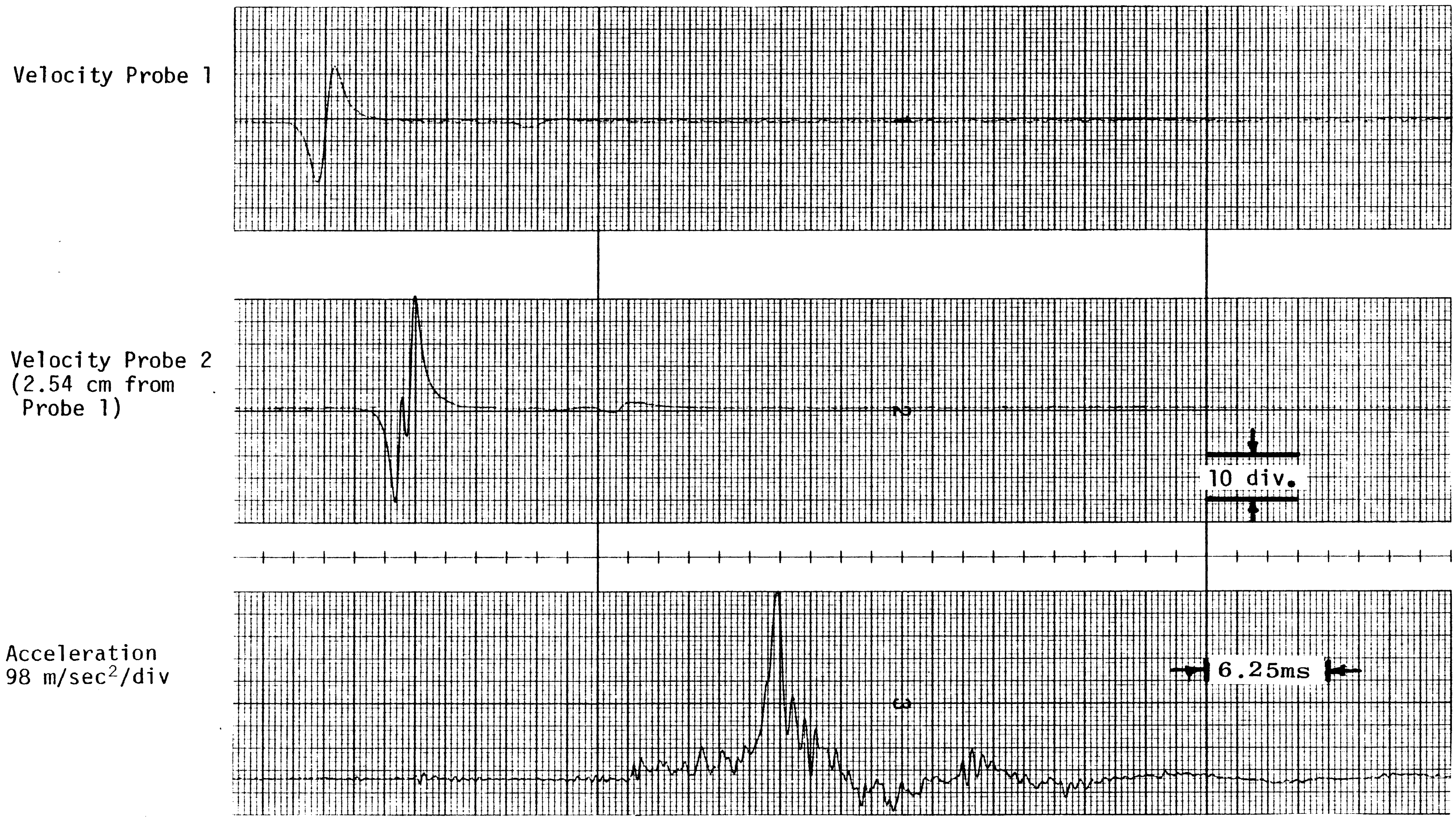
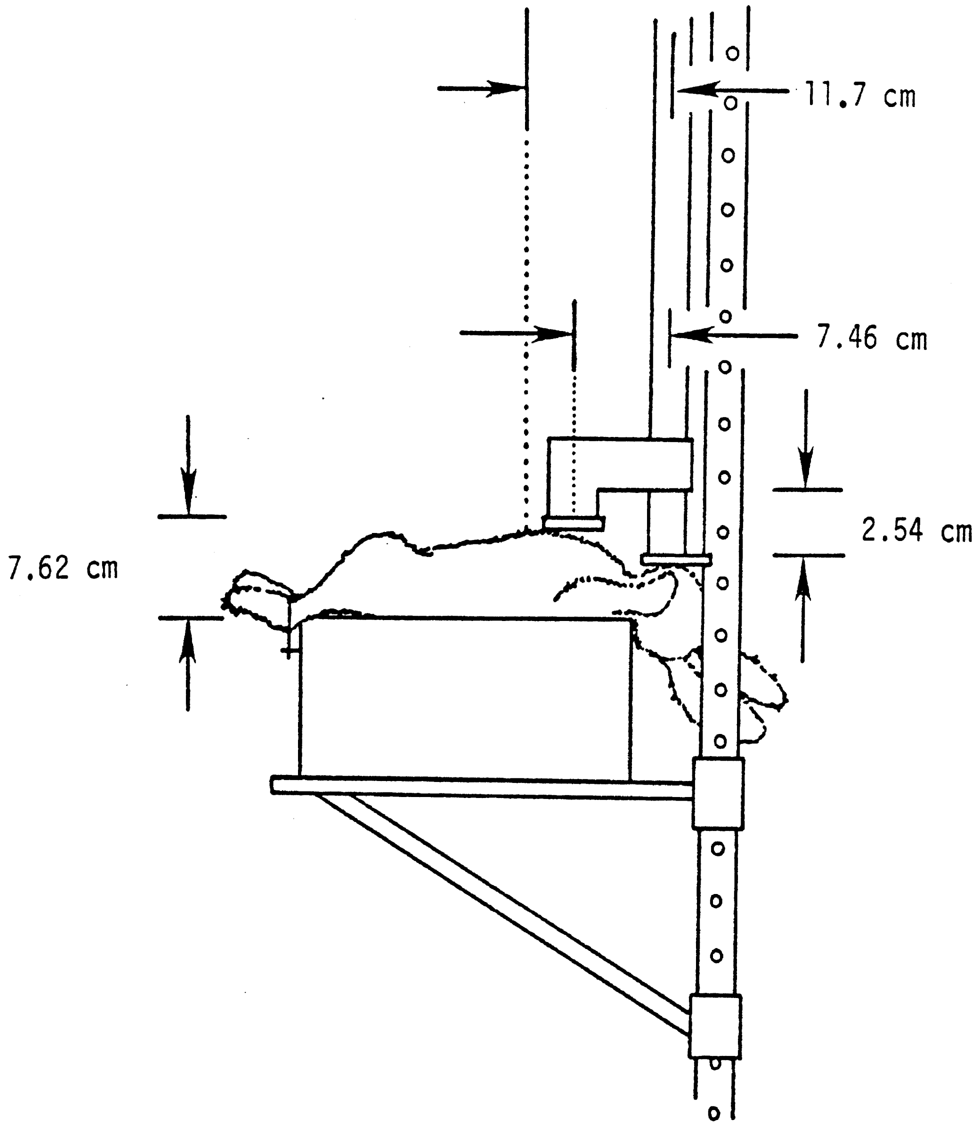


Test Description: Achieved midsagittal impact at approximately fourth intercostal junction. Drop height was approximately 2.44 meters, and the metal stop had a 0.5 cm ensolite pad on it. Rabbit expired 15 minutes before the impact.

Test No. 77G002 Instrumentation Traces

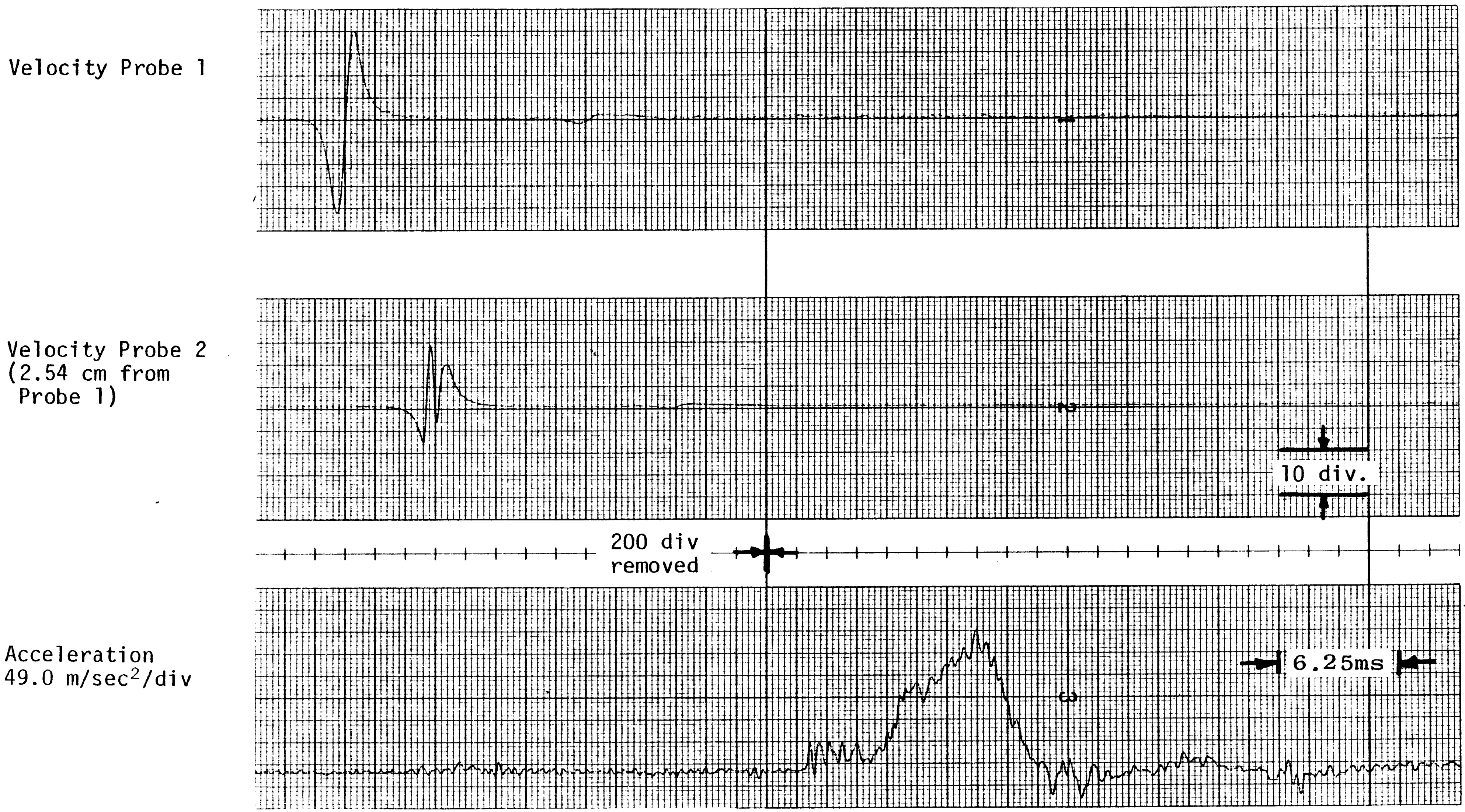


Test No. 77G003

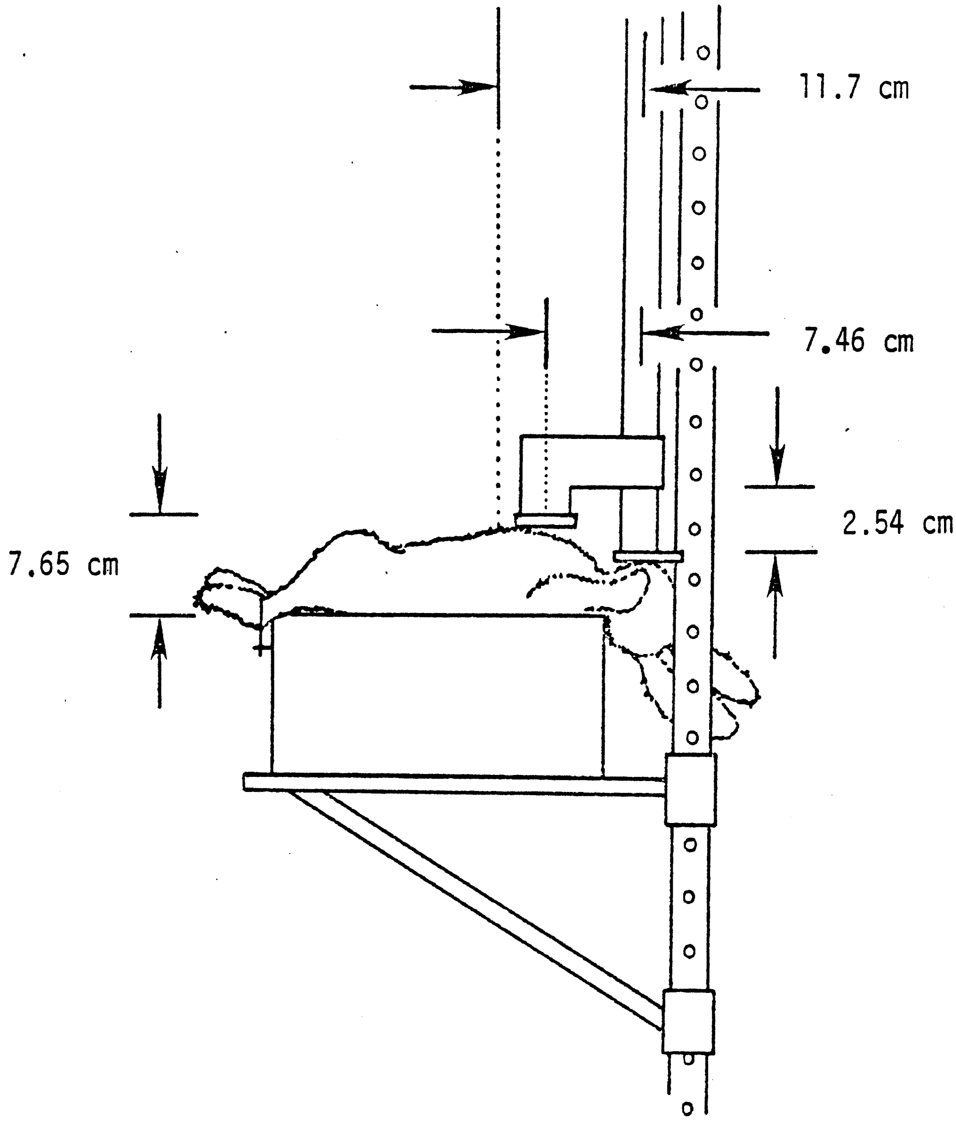


Test Description: Achieved midsagittal impact at approximately sixth intercostal junction. Drop height was approximately 2.44 meters, and the metal stop had a 0.5 cm ensolite pad and a styro-foam piece covering it. Lead targets marked the sternum and spine.

Test No. 77G003 Instrumentation Traces

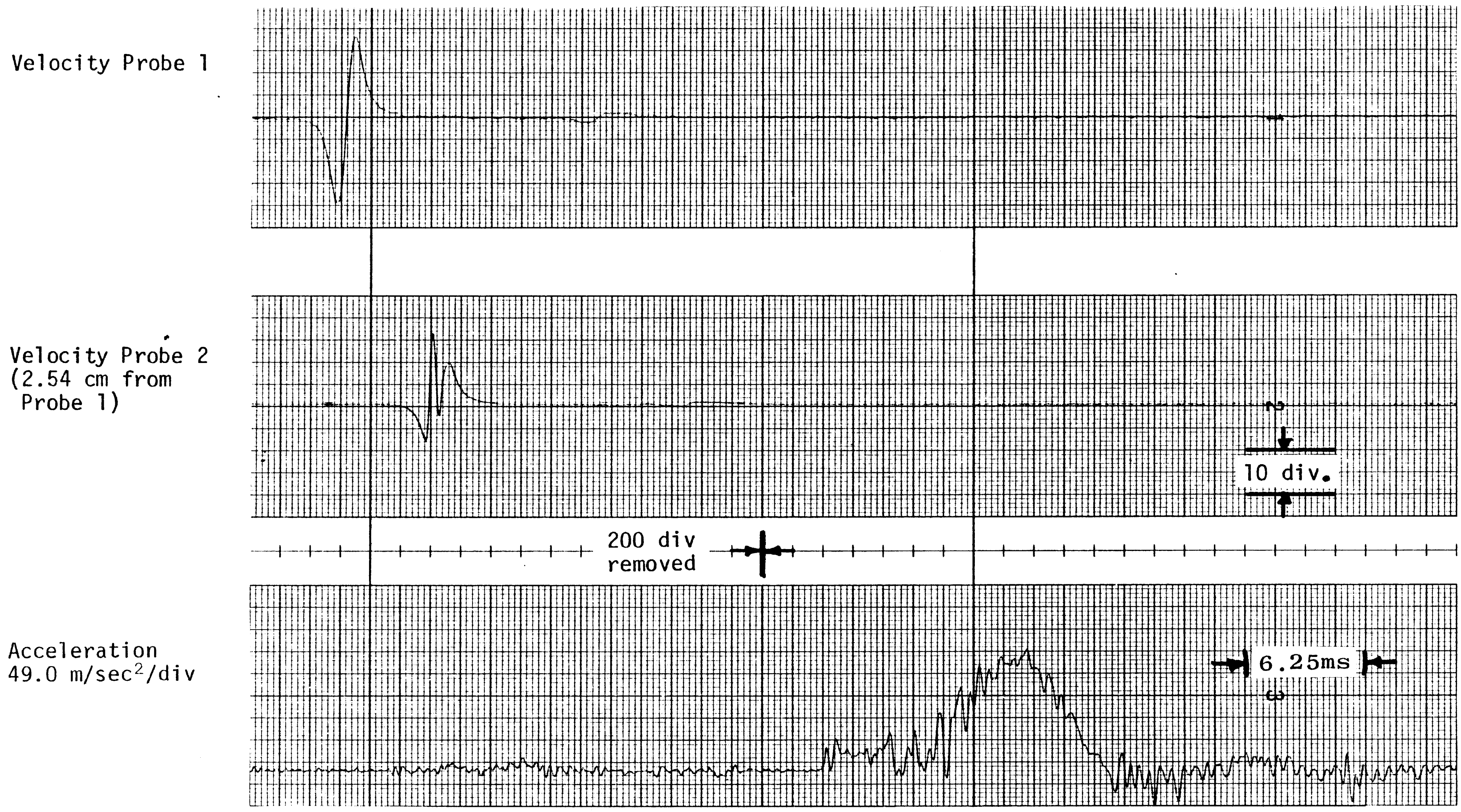


Test No. 77G004



Test Description: Achieved 1.5 cm right of midsagittal impact at approximately the sixth intercostal junction. Drop height was 2.44 meters and the metal stop had a 0.5 cm ensolite pad and a 2.54 cm-thick styrofoam piece covering it. Lead targets marked the sternum and spine.

Test No. 77G004   Instrumentation Traces



Appendix B

Animal Protocol
Details

General Motors Corporation
Animal Research Committee
Form No. 75/2

1. TITLE OF PROJECT:

Pilot Study - Mechanisms of Aortic Trauma

2. Project Period: From June 1977 To September 1977

3. Applicant Institution: University of Michigan

   Organizational Unit or Department Biomechanics Dept, Highway Safety Research Institute, University of Michigan

   Address where research will be performed (street, city, state, zip)

   Huron Parkway and Baxter Roads, Ann Arbor, MI 48109

4. Principal Investigator (Name, professional degrees, job title)

   D. C. Viano, Ph.D., J. W. Melvin, Ph.D. and Marvin Kirsch, M.D.

   (Postal address & telephone number) University of Michigan, Ann Arbor, Michigan, HSRI, 48109, (313) 763-3462.

5. Person directly in charge of animal care (Name, professional degrees, job title - if same as P.I., so state) Dr. R. L. Stalnaker, Ph.D. (Biomechanics) HSRI

   (Postal address & telephone number) same as above

6. Special qualifications in laboratory animal care of person named in item 5 13 years of experience with Laboratory animal care.

   Weekly hours present in location named under item 3 full time

7. Animal care staff and qualifications: Thomas Tann, Research Assistant II. Has worked with the animals for two years.

8. If you employ a consulting veterinarian, give name and qualifications

   Howard G. Rush, D.V.M., Instructor in Laboratory Animal Medicine, Diplomate, American College of Laboratory Animal Medicine

   Extent of availability under consulting agreement on call

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9. Species and strain(s) involved in this experiment Rabbit (Oryctolagus cuniculus) New Zealand White

Total No. of animals to be purchased 25 Age 4-8 mths. Sex Mixed

Maximum weight of animal 2 to 3.6 Kg

Identify vendor (firm name, address) Langshaw Farms, Route No. 1 Box 256, Augusta, MI 49012

10. Does your institution have an animal care committee? YES [X] NO [ ]

Is your institution approved by the American Association for Accreditation of Laboratory Animal Care (AAALAC)?

YES [X] NO [ ] If no: Not applied [ ] * / Applied and pending [ ] / Applied and rejected [ ] *

*If either of these boxes are checked, state reason ______

11. Animal housing No. of rooms 2

Size (sq.ft.) of each: 346^2 80^2 ft.

Floor surfaces Sealed concrete

Wall surfaces Sealed cinder blocks

Window area -- Direction --

Heat thermostatically controlled yes

Air conditioned yes

12. Size of cages 16"w x 23"d x 13"Hi No. animals per cage 1

No. cages per rack 12 No. of racks per room 1

Max. No. of animals at any one time 12

13. Describe feeding, watering, and sanitation schedules (including weekend care, if any) Teklad Rabbit Ration fed ad lib; water ad lib (bottles filled daily, 2 bottles/cage; clean bottles weekly) pans pulled and litter changed 2 to 3 times per week. Cages washed once per week. Dr. R. L. Stalnaker will feed animals on weekends.

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14. Describe experimental procedures involving the animals (quarantine, handling, surgery, postoperative care, euthanasia, assurance of death)

See attached animal protocol

15. Describe all medication planned in the experiment (prophylactic, therapeutic, analgesic, anesthetic). State mode of administration, dosage, and schedule

Anesthetic: Probarbitol (Na pentobarbital, 40 mg/Kg, IV)

Euthanasia sol probarbitol (110 mg/Kg, IV)

If necessary and applicable procaine penicillin G IM (45,000 u/Kg daily) for ten days as treatment for Pasteurellosis.

16. If the experiment involves stress or pain to the animal, explain.

No, animal under anesthetic for entire period.

Appendix C

Slide Catalog

Slide Catalog

Slide No.1 - Thorax surface with skin and muscles reflected. Test 77G001

Slide No.2 - Traumatized contents of right pleural cavity. Test 77G001

Slide No.3 - Hematoma, crush of liver. Test 77G001

Slide No.4 - Hematoma and hemorrhaging along left side of spine. Test 77G001

Slide No.5 - Hematoma on surface of descending aorta. Test 77G001

Slide No.6 - Punctures of aorta by fractured ribs. Test 77G001

Slide No.7 - Large contusion on lung. Test 77G002

Slide No.8 - Tears in aorta and subclavian artery. Test 77G002