

UM - HSRI-77-25

FEMUR IMPACT STUDY

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FINAL REPORT
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16. Abstract Data was generated to better study the mechanism of femur fracture. Thirteen human knee impacts were conducted with and without flesh on the femur. Strain gages and pelvic accelerometers were used in most tests. High speed movies were taken of all tests to give an over-view of the femur kinematics.					
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INTRODUCTION

The objective of these tests was to generate data which could be used to study the mechanism of femur fracture. Thirteen human knee impacts were conducted on six cadavers. Twelve femurs were defleshed for testing and one was tested with the flesh intact. Strain gages were mounted at approximately the mid-shaft of the femur in ten knee impacts. A triaxial accelerometer pack was mounted to a bar rigidly attached to the posterior-superior iliac spine. Side and overhead high-speed motion pictures (3000 and 1000 fps respectively) were taken of each test.

METHOD

Cadaver Preparation. The cadavers were sanitarily prepared by sealing off all body openings. The cadaver's upper torso was suited with the top of a vinyl sweat suit, and the head and hands were covered and sealed. The flesh on the right and left femurs was removed. The skin flaps on the superior end of the femurs were sutured closed. The bottom of a vinyl sweat suit, with the legs cut off, was placed on the cadaver and the legs of the suit wrapped around the femur shaft and sealed off to stop any resultant leaking from the removal of the flesh. The quadriceps tendon was cut on the superior end. All of the ligaments of the knee were left intact. Only the muscle was removed from around the femur and the patellar surface.

Strain Gaging. The mid-shaft region of each femur was cleaned of all soft tissue. The regions to be gaged were scraped clean and sanded smooth with 320 grit wet abrasive paper, while flushing with 99% ethyl alcohol. Final cleaning and drying was done with gauze sponges and alcohol. Three uniaxial Micro-Measurements type EA-13-250BG-120 strain gages were applied. These gages were placed along the axis of the femur at the following locations:

1. Anterior Mid-shaft
2. Lateral Midshaft
3. Medial Midshaft

The gages and cable relief tabs were bonded to the femurs with Micro-Measurements M-Bond 100 (Methy-2-Cyanoacrylate) adhesive. The cables were secured to the femur by nylon cable ties, so as not to be loaded during impact. The gages were checked out for continuity and the location of each strain gage was recorded before the cadaver was moved to the impact area.

Pelvic Accelerometer Mount. A fixture for mounting a triaxial accelerometer pack was rigidly attached to the posterior-superior iliac spines. The orientation of the accelerometer pack relative to the body was measured and recorded.

Impact. The cadaver was taken from the preparation room to the impact room. A Ferno-Washington head traction harness was placed on the cadaver's head and fixed to an overhead hoist by a six-foot section of rope. The cadaver was seated on a balanced wooden block, and the legs supported on the inferior-posterior surface of the femur by a half-inch diameter steel rod supported at the ends. The cadaver was positioned so the femur was along the axis of the impactor with the lower leg pulled back so the patella was lined up along the femur axis. The cadaver's upper torso was tipped back so that the overhead camera would have a clear view of the top of the femurs.

Each strain gage was connected to a Honeywell Accudata 120 through an Accudata 105 for the signal conditioning. The triaxial acceleration package was mounted to the pelvis back mount. The accelerometers (Endevco Model 2264-2000) were connected to the Honeywell Accudata 120 and 105 the same as used for the strain gages. The orientation of the accelerometer package in the laboratory coordinate system was measured and recorded. Along with the impactor force, acceleration, and velocity, the camera synchronization flash signal, femur strains and pelvis accelerations were recorded on a Honeywell 7600 FM tape recorder.

Two high-speed motion picture cameras were used to record the test. A Hycam (3000 fps) was used to record the impact from the side while a Photosonics (1000 fps) recorded it from above.

The impacts were conducted using a pneumatically operated testing machine specifically constructed for impact studies. The machine consists of an air reservoir and a ground and honed cylinder with two carefully fitted pistons. The transfer piston, which is propelled by compressed air through the cylinder from the air reservoir chamber, transfers its momentum to the impact piston. A striker surface with an inertia-compensated load cell is attached to the impact piston. This piston is allowed to travel up to ten inches and then its motion is arrested by an inversion tube which absorbs the remaining kinetic energy of the piston. The desired impactor stroke can be precisely controlled by the initial positioning of the impact piston with respect to the inversion tube. The impactor velocity is controlled by reservoir pressure and the ratio of the masses of the transfer and impact pistons. The load cell is a Kistler 904A piezoelectric load washer with a Kistler 805A piezoelectric accelerometer mounted internally for inertially compensating the load cell for the striker mass between the load cell and the impact surface. The impact-piston and load-cell striker assembly for all these tests weighed 22.25 pounds. The striker used was six inches in diameter and was surfaced with various types of padding. The following filter characteristics were used:

1. Force - Class 1000
2. Strains - Class 1000
3. Pelvis Accelerations - Class 180

Gross Autopsy. The gross autopsies were conducted in the autopsy laboratory, specially equipped for dissection. Careful anatomical dissection of the pelvis and knee was performed to allow discrete identification of all injuries. When gross trauma was found, it was photographically recorded, using a specially modified Pentax camera with a closeup lens, to provide a permanent record of the injury. When strain gages were used, a photograph was made of the cross-sectional area of the femur at the gage for strain analysis.

The femurs were characterized by a set of measurements made at the autopsy. The femur's length was measured and divided into four equal lengths. The diameter in the anterior-posterior and in the lateral-medial directions at each quarter length, as well as the circumference, was measured and recorded.

Samples of the condyles and of the head of the femur were taken for microscopic examination. Bone samples were also taken and stored for future chemical analysis.

RESULTS

A data package was made up for each test, and is given in the appendix. This data package consists of the following information:

1. A word description of the test
2. Set-up photographs
 - A. Lateral view
 - B. Rear view
3. Knee impact data sheets
 - A. Force and strain time histories
 - B. Force and pelvic acceleration time histories
4. Accelerometer pack location and orientation
5. Strain gage locations
6. Autopsy photographs
 - A. Femur overall view
 - B. Cross-section of femur at the strain gage site
7. Knee impact autopsy summaries
 - A. Anterior aspect
 - B. Posterior aspect
8. Post Impact Bone Measurements

All of the test data was recorded unfiltered on FM tape for future analysis. An overall summary of the test data is given in Table 1.

CONCLUSIONS

The test procedures used in this study generated test data which were good for studying the failure mechanisms of the femur under axial loading. The flesh could be removed from the femur while still maintaining the knee joint complex in a normal state. The strain gage mounting techniques resulted in good bonding of the gages to the bone both during and subsequent to the tests. The overhead camera frame rate of 1000 fps was found to be too low for this type of test.

TABLE 1. TEST SUMMARY

TEST NO.	IMPACT TYPE	IMPACT		AUTOPSY
		VELOCITY m/s (fps)	FORCE N (lb)	
77Q001 Rt.	Rigid	140.4 (42.8)	13456 (3025)	The midshaft was fractured. The patella was shattered.
77Q002 Lt.	Rigid	142.1 (43.3)	15235 (3425)	The midshaft and patella were fractured.
77Q003 Lt.	Rigid	113.5 (34.6)	13345 (3000)	The midshaft and neck of the femur were fractured. The patella was shattered.
77Q004 Rt.	Rigid	114.5 (34.9)	13345 (3000)	The midshaft and neck of the femur were fractured. The patella was shattered.
77Q005 Rt.	Ensolite 1 in. No flesh	134.8 (41.1)	16014 (3600)	Comminuted fractures of the condyles were produced. No patellar damage.
77Q006 Lt.	Ensolite 1 in. No flesh	138.8 (42.3)	15346 (3450)	Comminuted fractures of the condyles were produced. No patellar damage.
77Q007 Lt.	Rigid	143.7 (43.8)	25800 (5800)	The midshaft was fractured. The patella was shattered.
77Q008 Rt.	Rigid	136.2 (41.5)	28469 (6400)	The midshaft was fractured. The patella was shattered.
77Q009 Rt.	2 in. Hexcel, 1/4 cell Ensolite 1 in. No flesh	134.5 (41.0)	5338 (1200)	No injuries.
77Q010 Lt.	2 in. Hexcel, 3/16 cell Ensolite 1 in. No flesh.	133.5 (40.7)	14012 (3150)	No injuries.
77Q011 Rt.	2 in. Hexcel, 3/16 cell Ensolite 1 in. No flesh.	135.2 (41.2)	13789 (3100)	No injuries.
77Q012 Rt.	2 in. Hexcel, 3/16 cell Ensolite 1 in. No flesh.	121.1 (36.9)	8674 (1950)	There was a supracondylar fracture. No patellar damage. Apparent osteoporosis.
77Q013 Lt.	2 in. Hexcel, 3/16 cell Ensolite 1 in. No flesh.	128.9 (39.3)	9341 (2100)	The condyles and the midshaft were fractured. No patellar damage. Apparent osteoporosis.

DATA SUMMARIES

APPENDIX I

TABLE 2. Characteristics of Cadavers Used in Knee Impact Tests

Run Number	Cadaver Number	Sex	Age (yrs)	Weight (kg.)	Height (cm.)	Cause of Death
77Q001	20690	F	54	99.6	169.5	Breast Cancer
77Q002	20690					
77Q003	20693	F	51	75.6	153.1	Cardiac Arrhythmia
77Q004	20693					
77Q005	20698	M	74	89.7	165.6	Myocardial Infarction
77Q006	20698					
77Q007	20709	M	73	69.9	171.9	Unknown Chronic Obstruction of Pulmonary Arteries
77Q008	20709					
77Q009	20703	M	61	53.2	182.5	Respiratory Failure
77Q010	20703					
77Q011	20703					
77Q012	20711	M	65	61.8	159.4	Acute Myocardial Infarction
77Q013	20711					

TEST SPECIFICATION

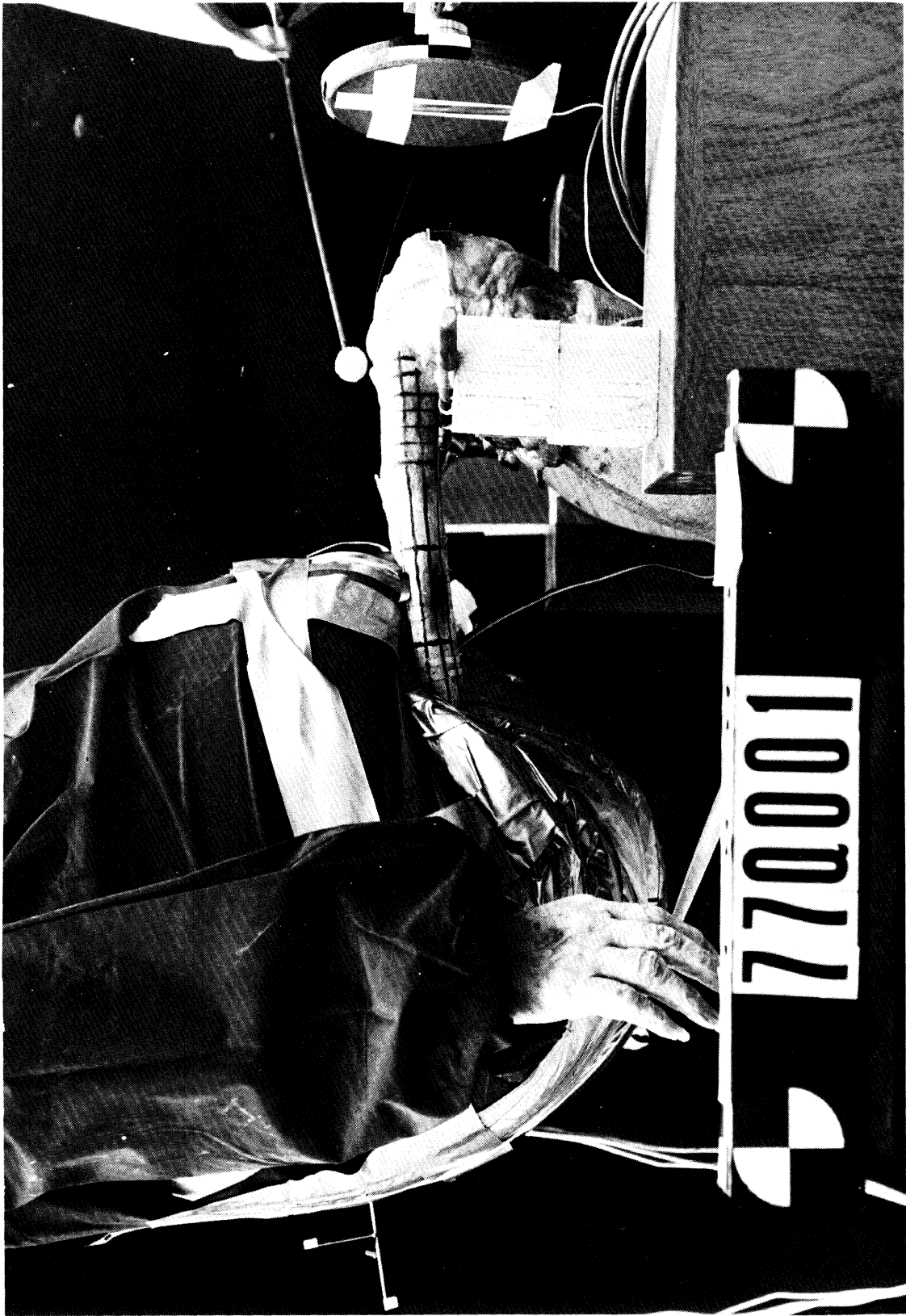
TEST NO. 77Q001 Rt.

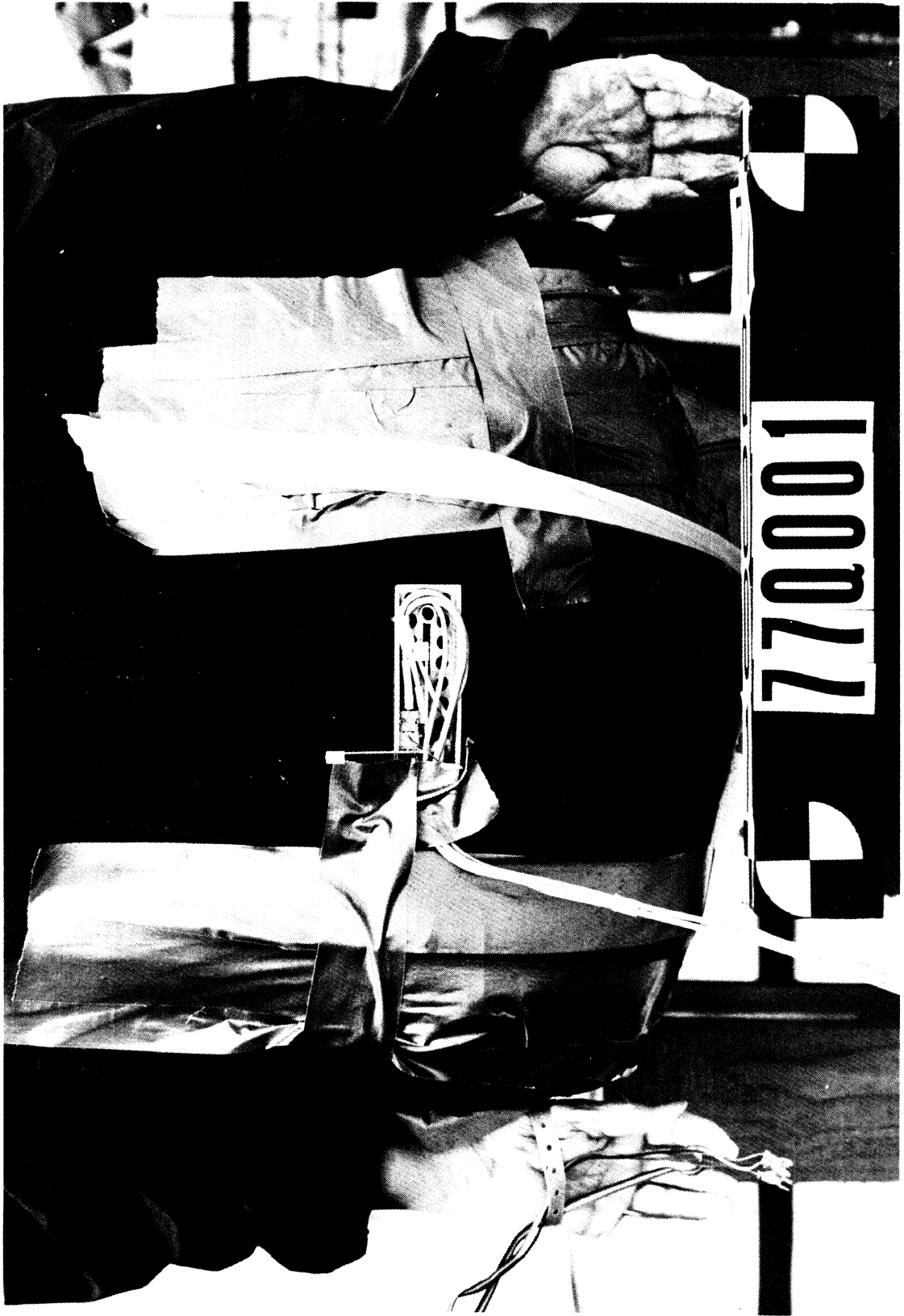
IMPACT VELOCITY 42.8 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: This test was conducted as outlined in the text. The
femur was left exposed in the air seven hours with no care taken
to prevent drying.

The midshaft was fractured and the patella was shattered.

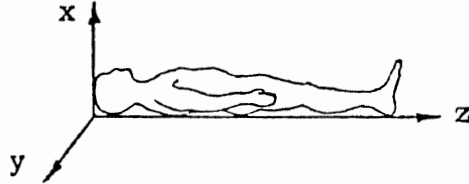




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q001-2
 Cadaver Number 20690
 Date 3-1-77

ANATOMICAL COORDINATE SYSTEM



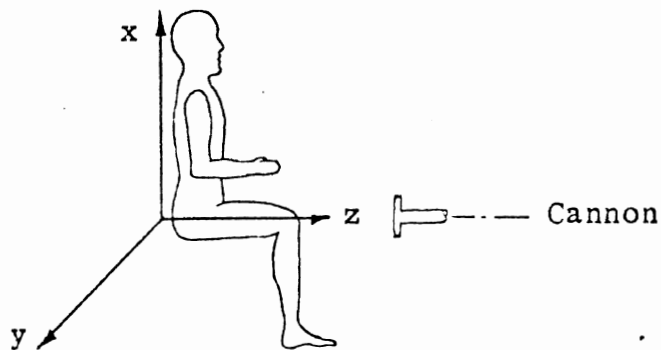
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	73.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	-5°	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

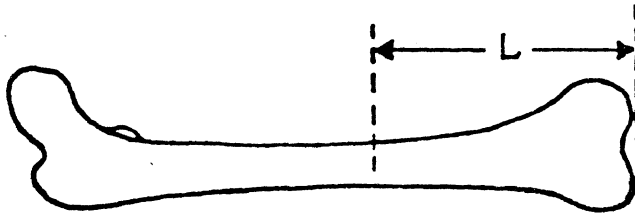
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q001	+5°	-2°	+7°
Lt. Lg 77Q002	+8°	-5°	+7°

STRAIN GAGE LOCATIONS

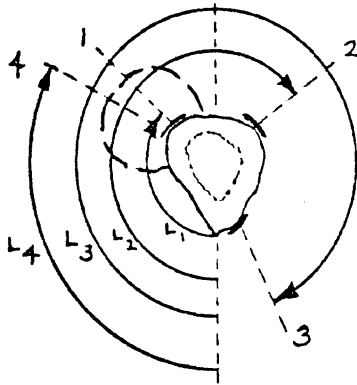
Run Numbers 77Q001-2
 Cadaver Number 20690
 Date 3-1-77

Photos of Cross Section at Strain Gages? Yes No

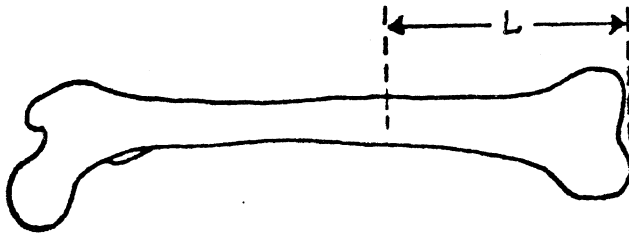
Right Leg 77Q001



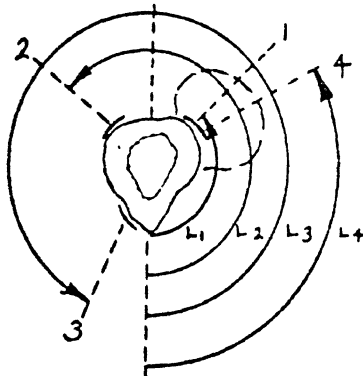
- L 18.7 cm
- L₁ 3.0 cm
- L₂ 5.6 cm
- L₃ 8.5 cm
- L₄ 1.7 cm



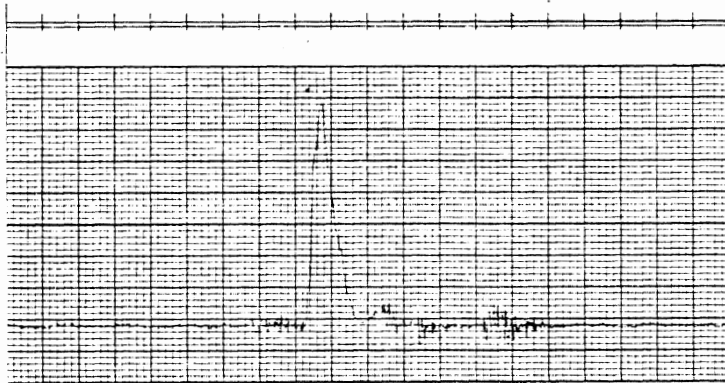
Left Leg 77Q002



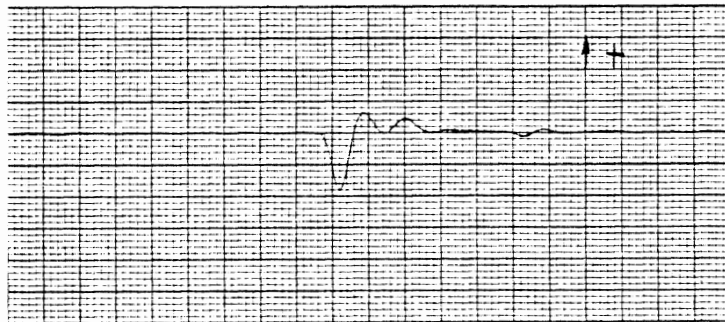
- L 17.4 cm
- L₁ 2.6 cm
- L₂ 5.1 cm
- L₃ 7.8 cm
- L₄ 1.8 cm



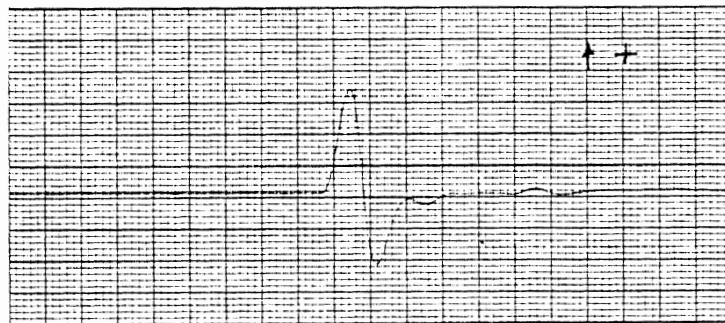
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



Pelvic Acceleration *
P-A
42.2 G's/Division
Filtered 300 Hz.



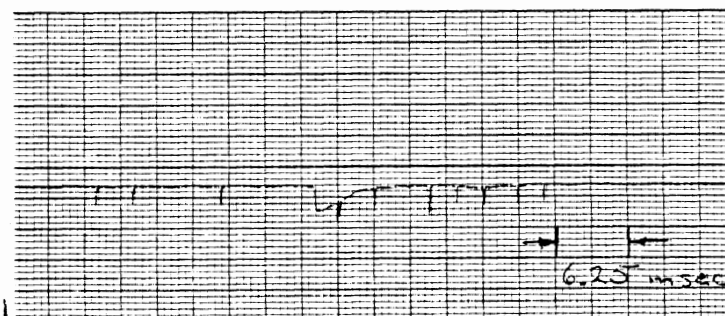
Pelvic Acceleration *
R-L
46.55 G's/Division
Filtered 300 Hz.



Pelvic Acceleration *
S-I
21.3 G's/Division
Filtered 300 Hz.

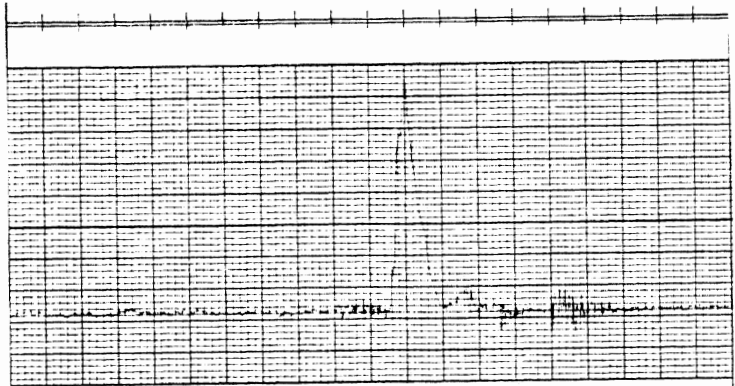


Strobe (T₀)

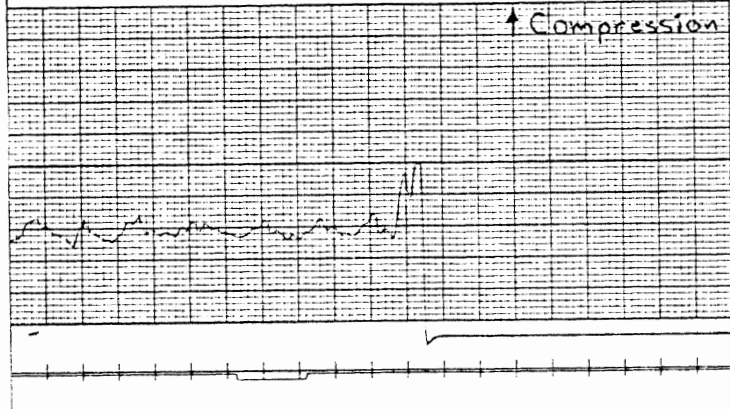


* Linear Range Exceeded

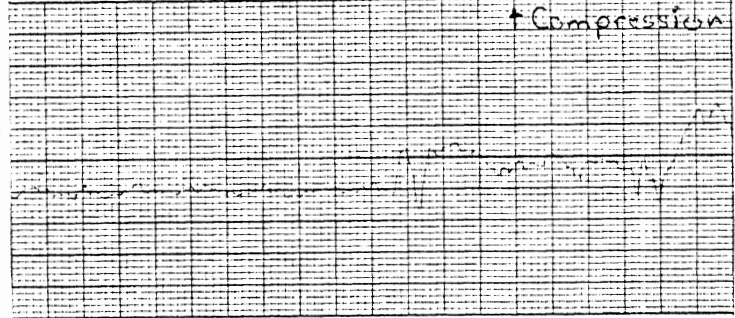
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



Femur Strain
Top (1)
1830.4 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Side (2)
1927.2 micro in./in./Div.
Filtered 1650 Hz.

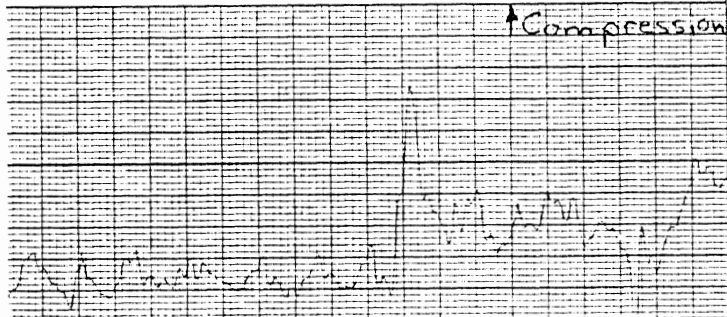


Gould Inc., Instrument Systems Division

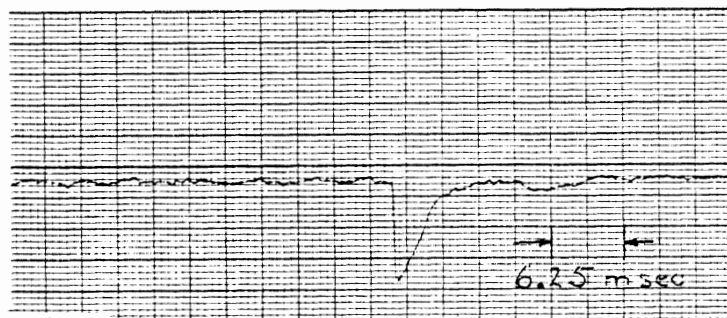
Cleveland, Ohio

Printed in U.S.A.

Femur Strain
Bottom (3)
1902. micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



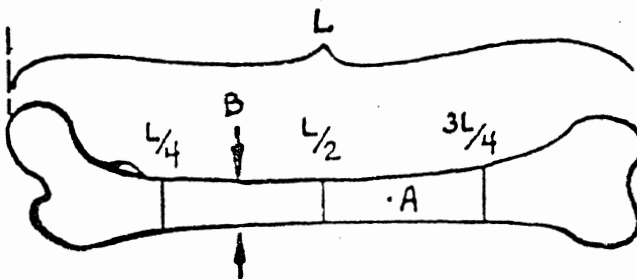
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q001-2

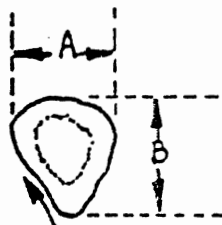
Cadaver Number 20690

Date 3-1-77

Right Leg 77Q001



L 42.3 cm



cross-section

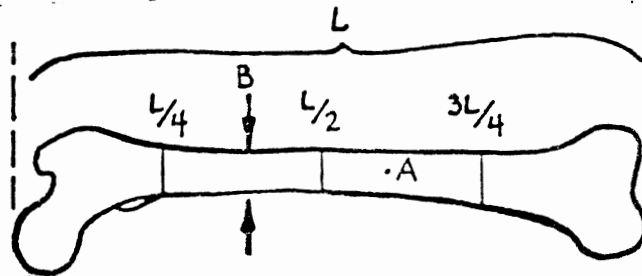
C = circumference

	A cm	B cm	C cm
L/4	2.8	3.4	10.1
L/2	2.8	3.4	9.9
3L/4	2.9	3.2	9.7

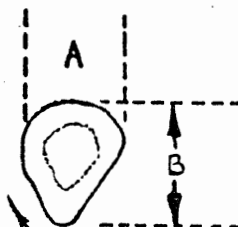
Weight of removed Anatomical Material (Rt.) 5.43 kg.

Weight of removed Femur (Rt.) 0.760 kg.

Left Leg 77Q002



L 42.2 cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4	3.3	3.3	10.2
L/2	3.0	3.3	10.2
3L/4	2.8	3.3	9.8

Weight of removed Anatomical Material (Lt.) 6.10 kg.

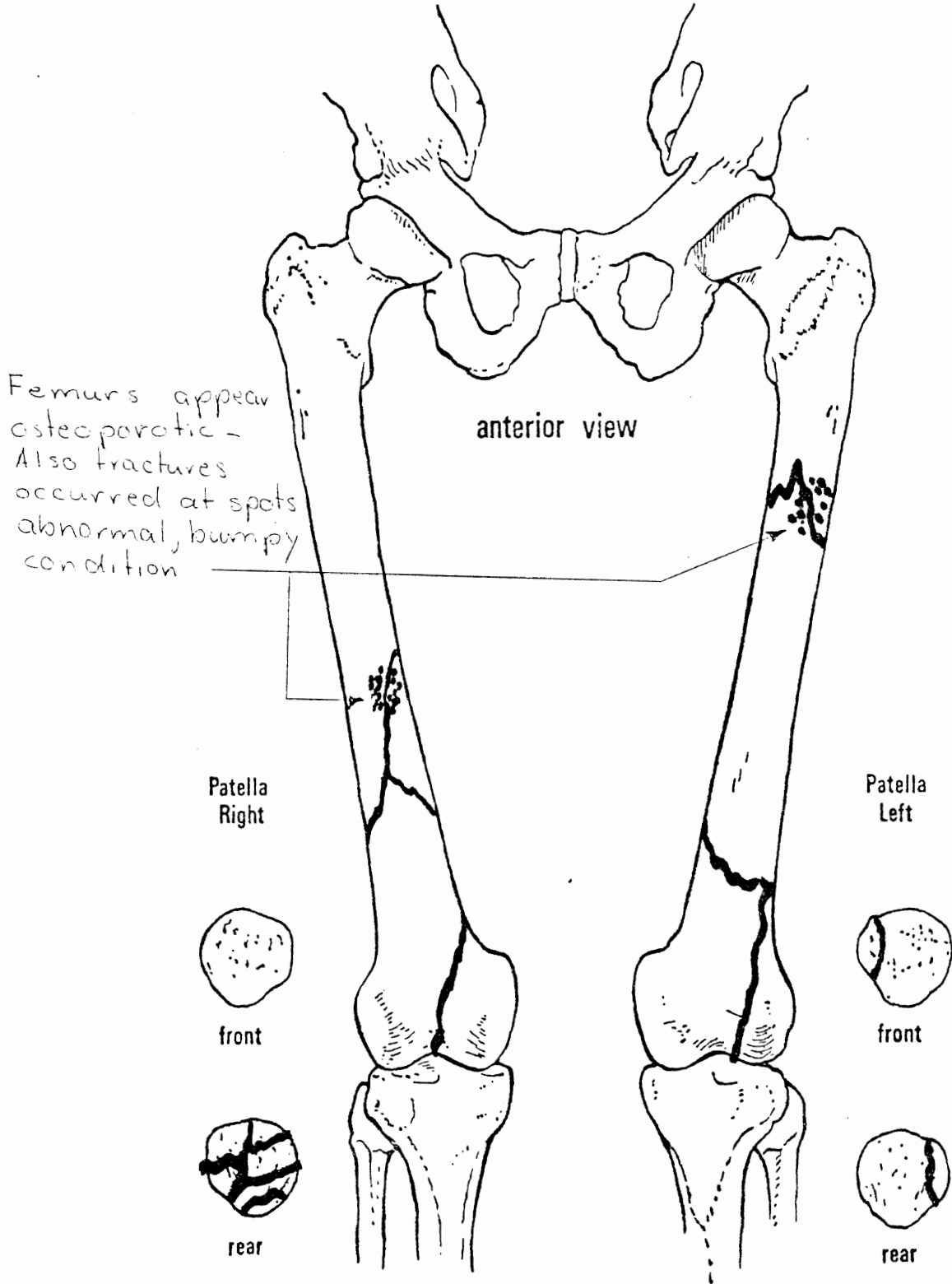
Weight of removed Femur (Lt.) 0.732 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77QCG1-2

CADAVER NO. 20690

DATE 3-1-77

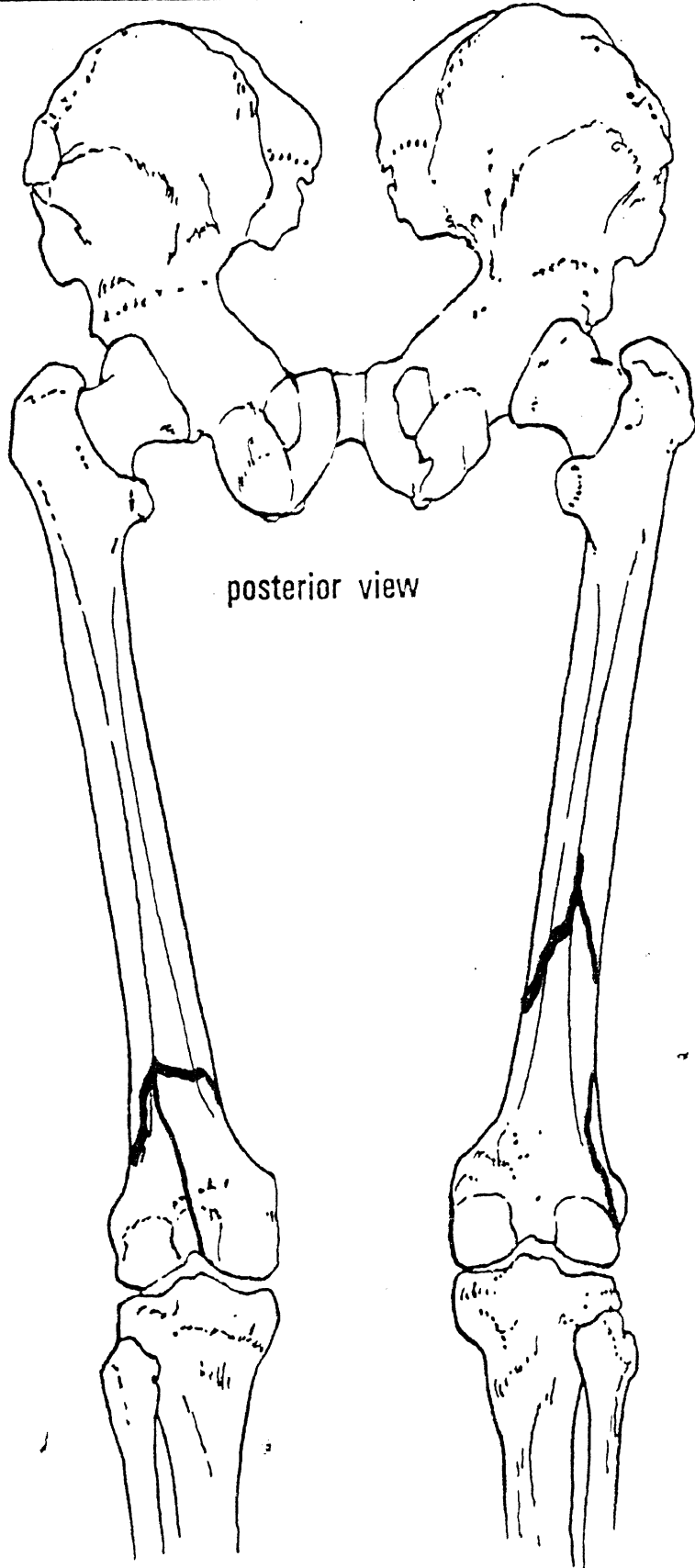


KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77QCC1-2

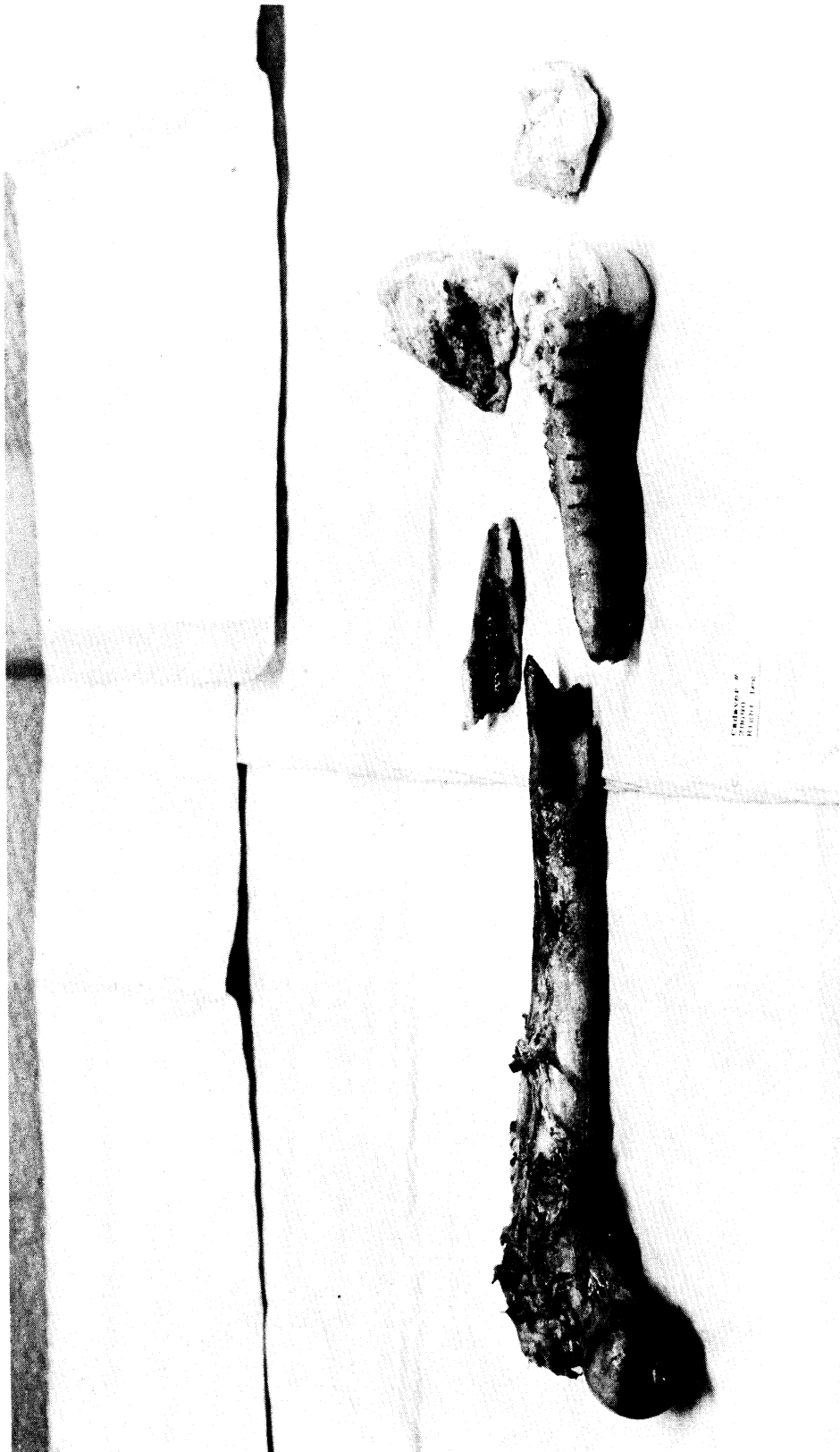
CADAVER NO. 20690

DATE 3-1-77

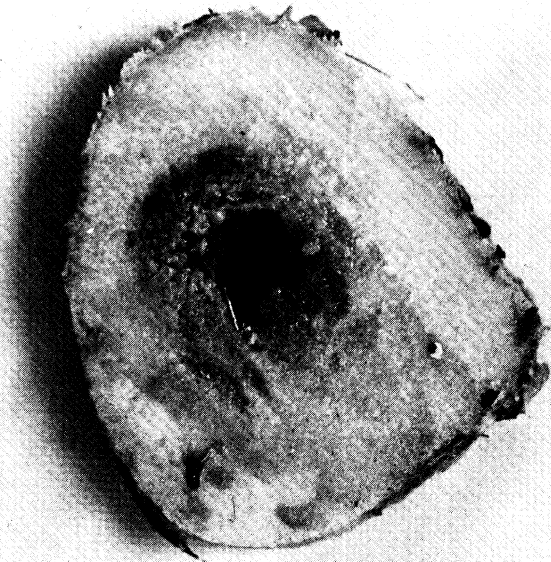




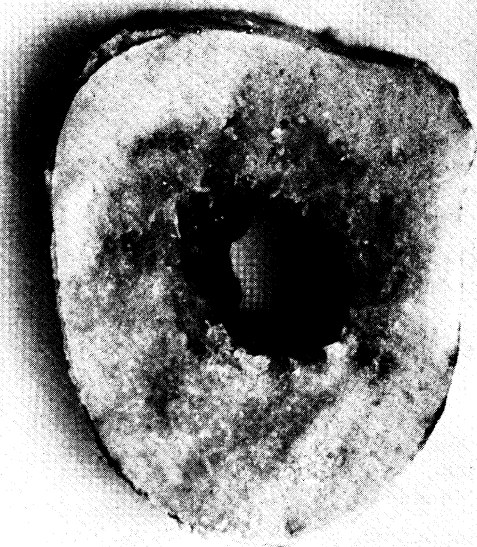
A-13



A-14



Cadaver #
20690
Right Leg



Cadaver #
20690
Left Leg

TEST SPECIFICATION

TEST NO. 77Q002 Lt.

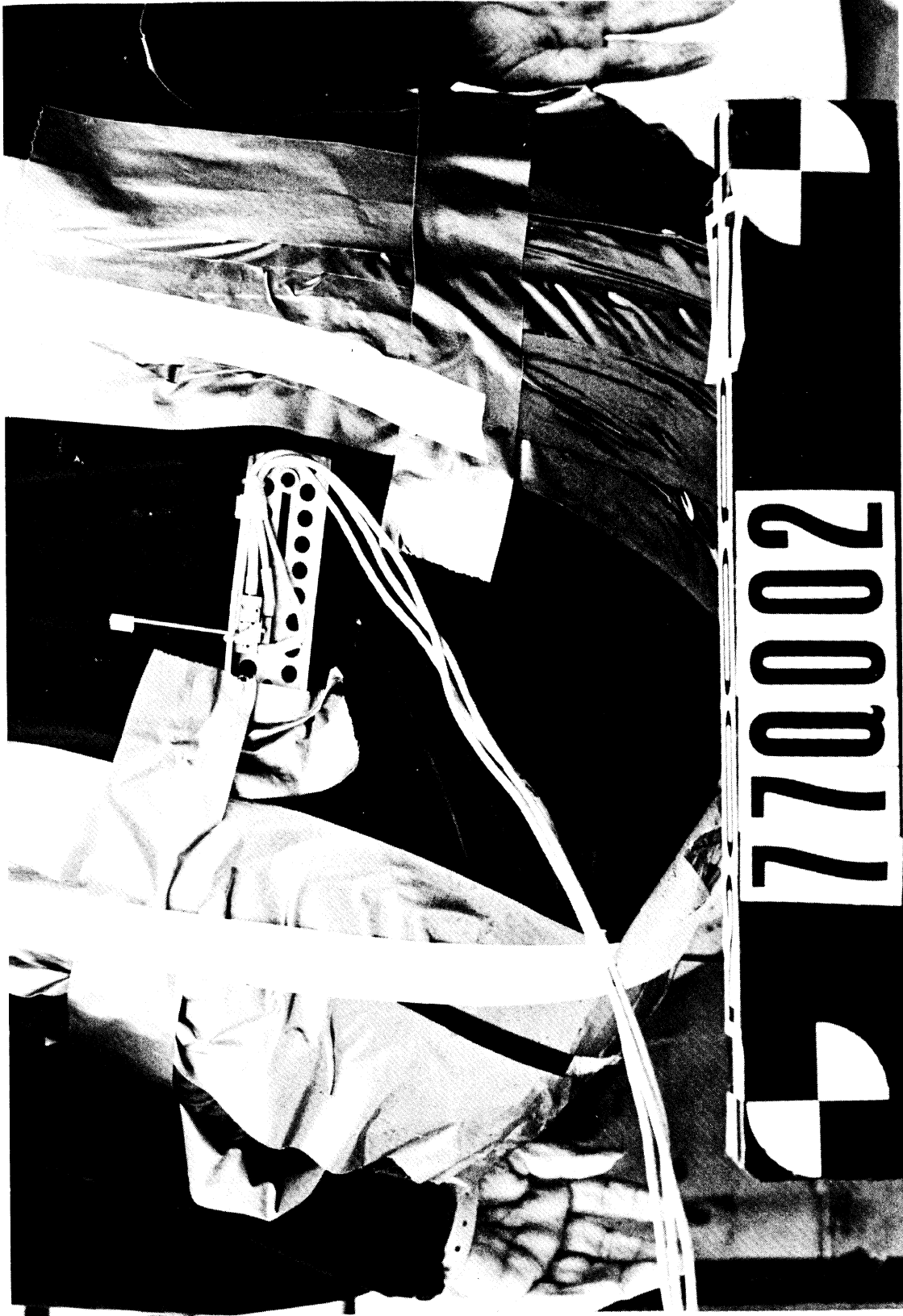
IMPACT VELOCITY 43.3 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: Same as 77Q001

The midshaft and patella were fractured.

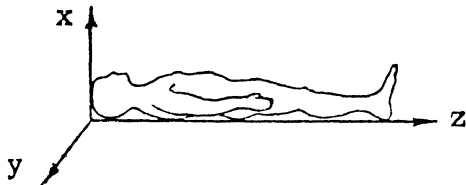




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q001-2
 Cadaver Number 20690
 Date 3-1-77

ANATOMICAL COORDINATE SYSTEM



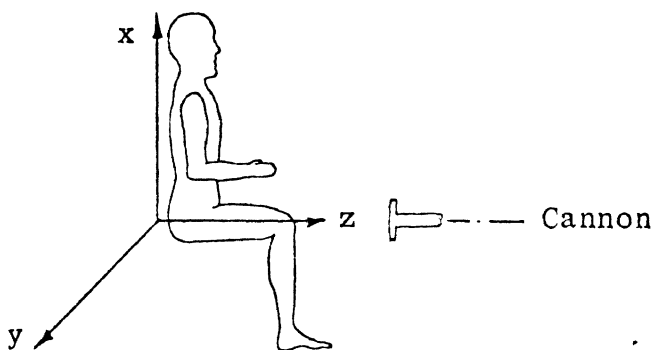
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	73.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	-5°	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

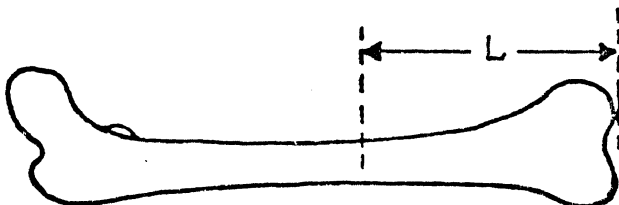
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt.Lg 77Q001	+5°	-2°	+7°
Lt.Lg 77Q002	+8°	-5°	+7°

STRAIN GAGE LOCATIONS

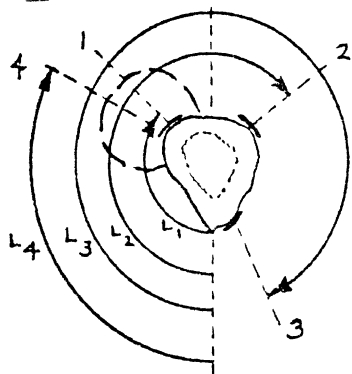
Run Numbers 77Q001-2
 Cadaver Number 20690
 Date 3-1-77

Photos of Cross Section at Strain Gages? Yes No

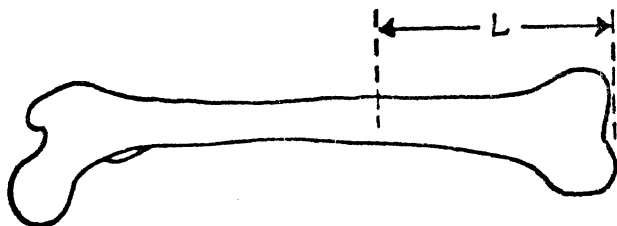
Right Leg 77Q001



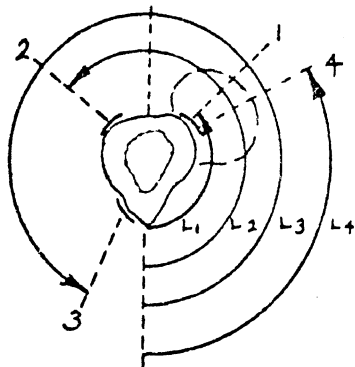
L 18.7 cm
 L₁ 3.0 cm
 L₂ 5.6 cm
 L₃ 8.5 cm
 L₄ 1.7 cm



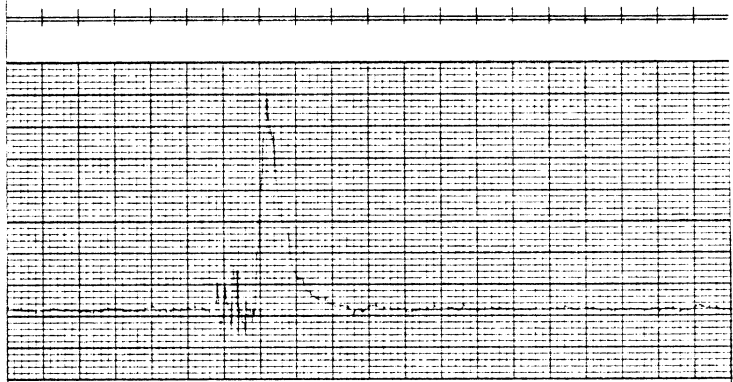
Left Leg 77Q002



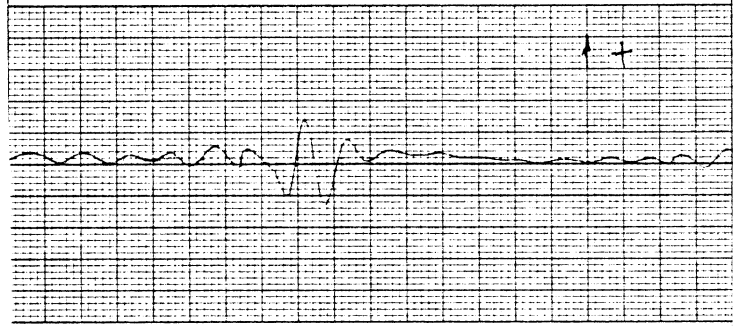
L 17.4 cm
 L₁ 2.6 cm
 L₂ 5.1 cm
 L₃ 7.8 cm
 L₄ 1.8 cm



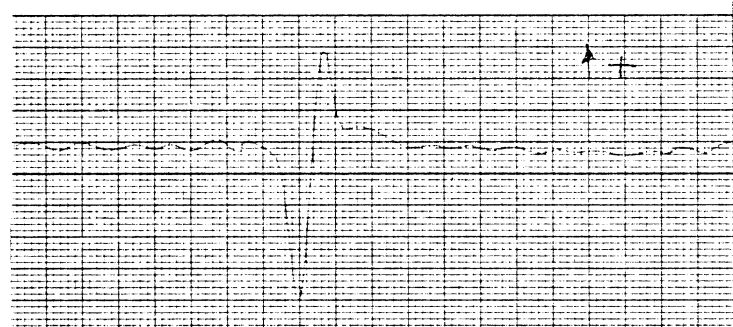
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



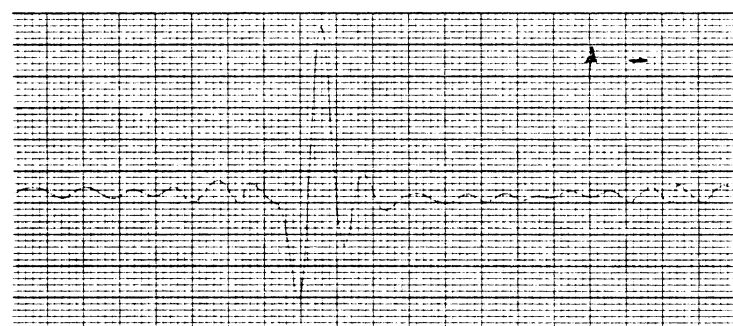
Pelvic Acceleration
P-A
21.1 G's/Division
Filtered 300 Hz.



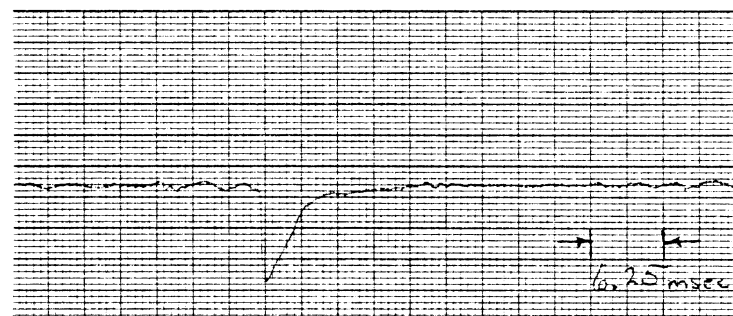
Pelvic Acceleration
R-L
18.6 G's/Division
Filtered 300 Hz.



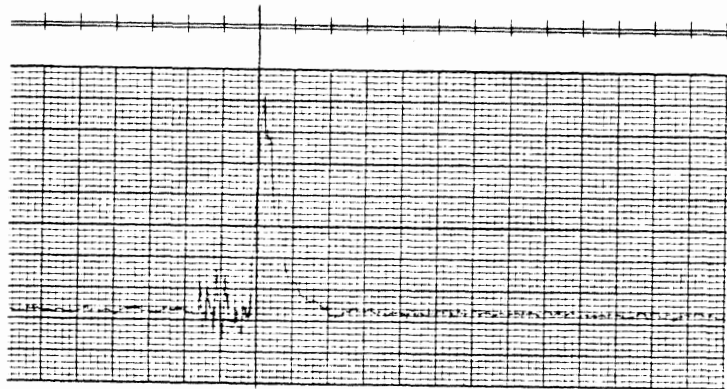
Pelvic Acceleration
S-I
21.3 G's/Division
Filtered 300 Hz.



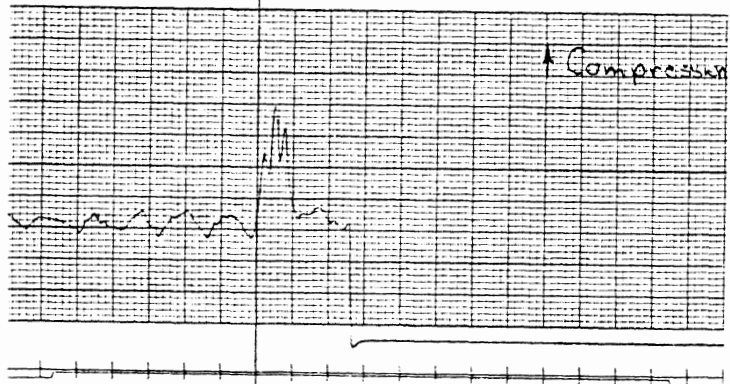
Strobe (T₀)



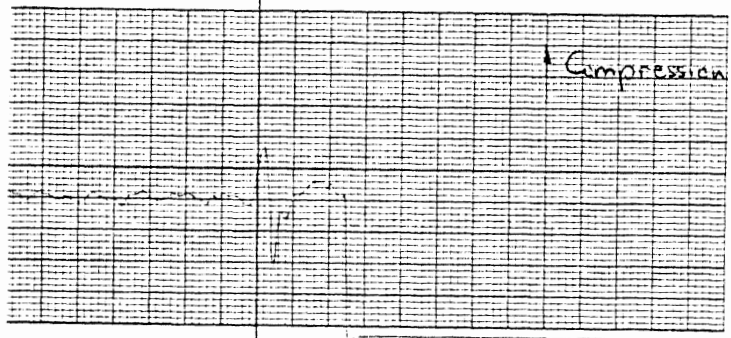
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



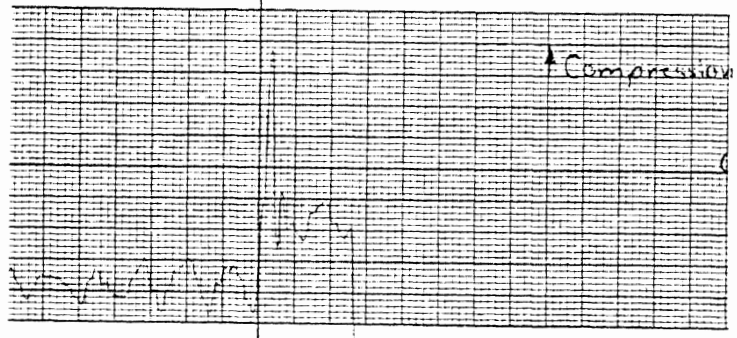
Femur Strain
Top (1)
949.4 micro in./in./Div.
Filtered 1650 Hz.



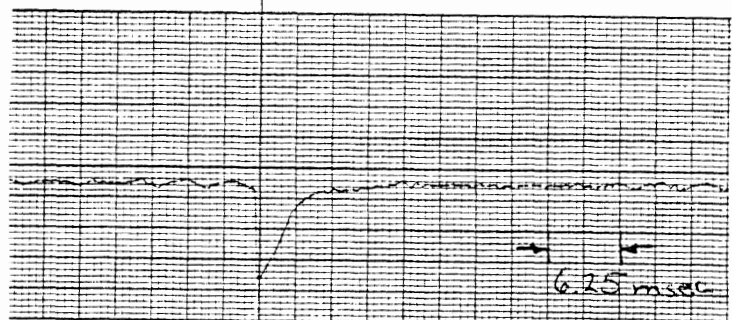
Femur Strain
Side (2)
963.6 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Bottom (3)
457.6 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



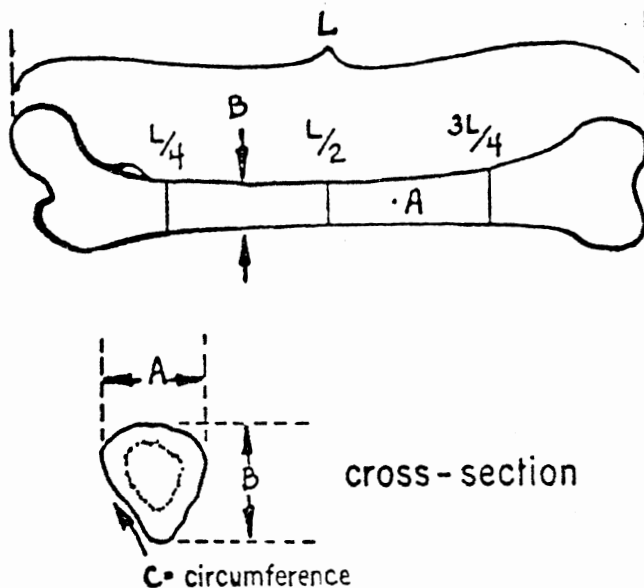
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q001-2

Cadaver Number 20690

Date 3-1-77

Right Leg 77Q001



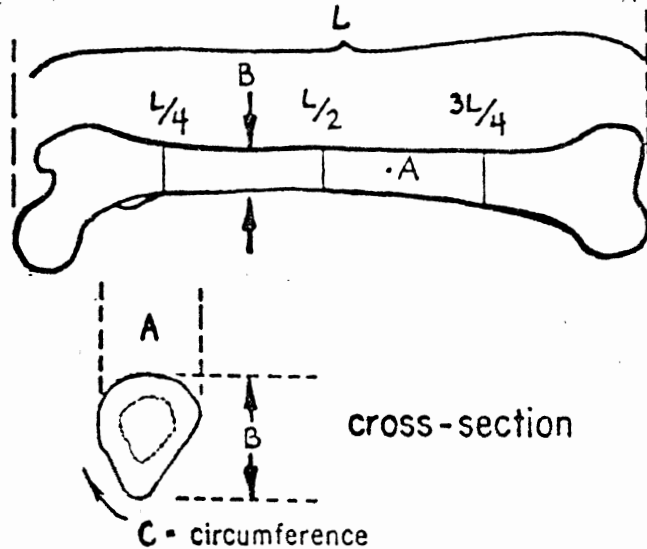
L 42.3 cm

	A cm	B cm	C cm
L/4	2.8	3.4	10.1
L/2	2.8	3.4	9.9
3L/4	2.9	3.2	9.7

Weight of removed Anatomical Material (Rt.) 5.426 kg.

Weight of removed Femur (Rt.) 0.760 kg.

Left Leg 77Q002



L 42.2 cm

	A cm	B cm	C cm
L/4	3.3	3.3	10.2
L/2	3.0	3.3	10.2
3L/4	2.8	3.3	9.8

Weight of removed Anatomical Material (Lt.) 6.10 kg.

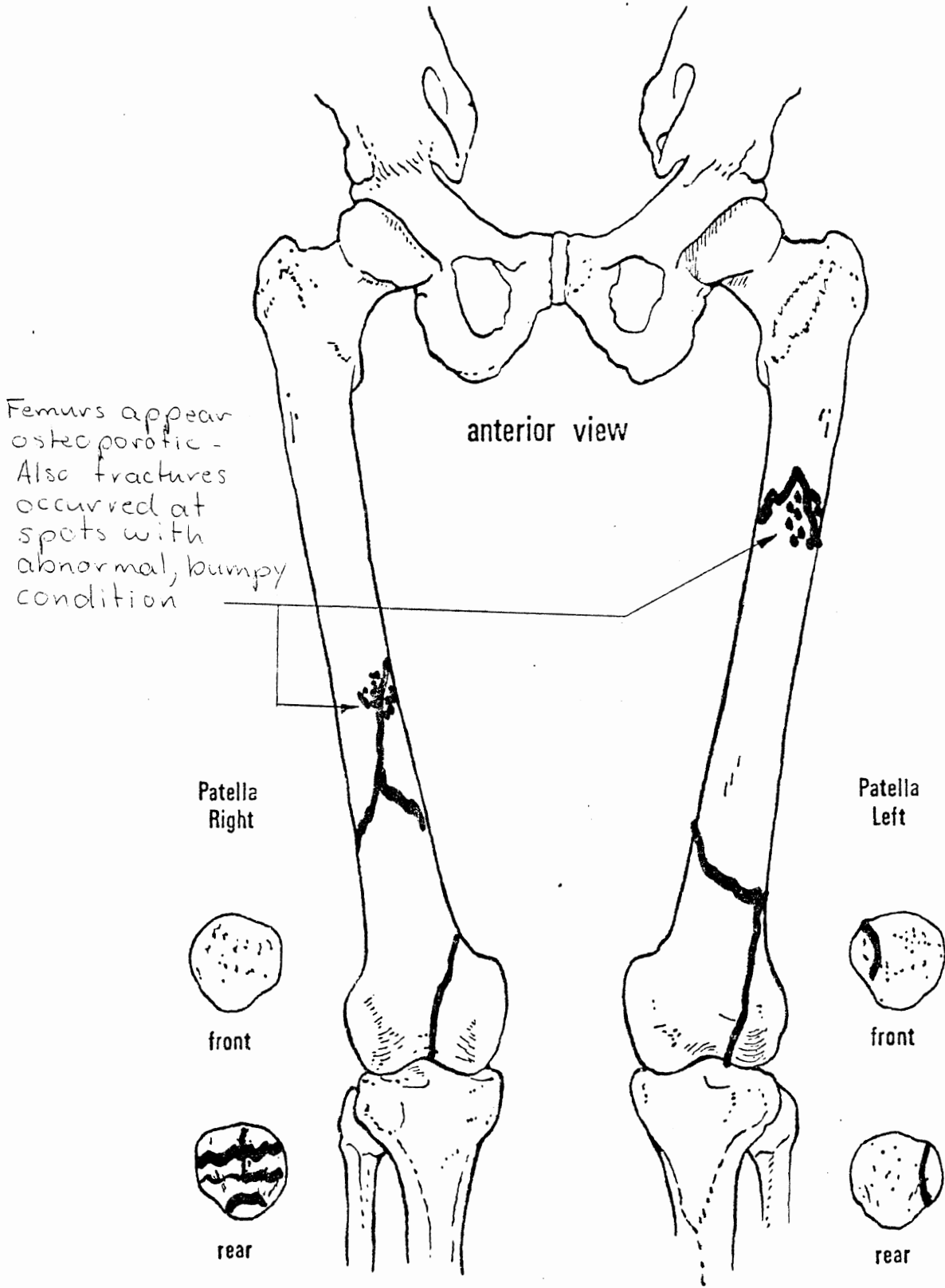
Weight of removed Femur (Lt.) 0.732 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 770001-2

CADAVER NO. 20690

DATE 3-1-77

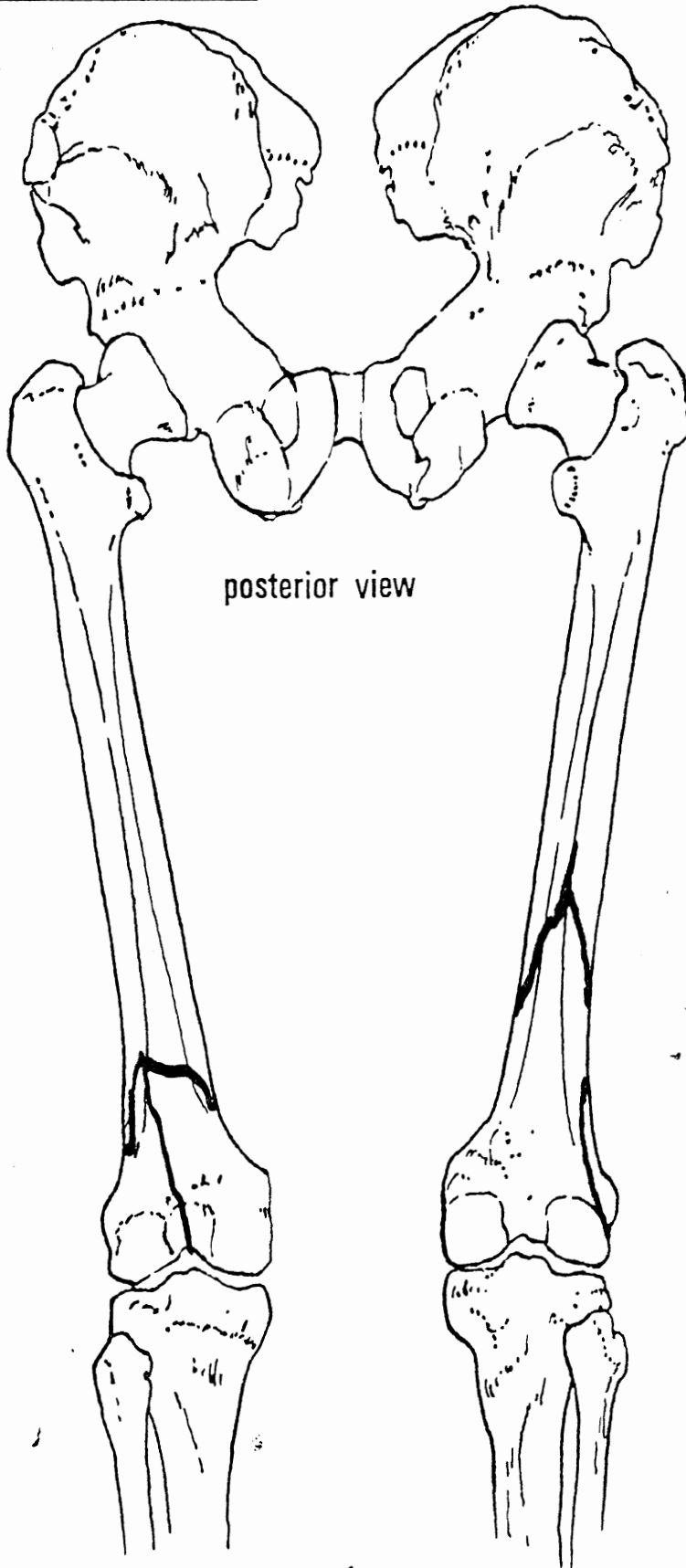


KNEE IMPACT AUTOPSY SUMMARY

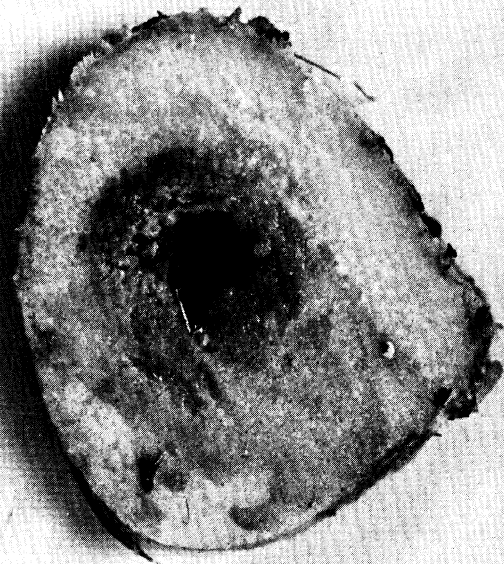
TEST NO. 77Q001-2

CADAVER NO. 20690

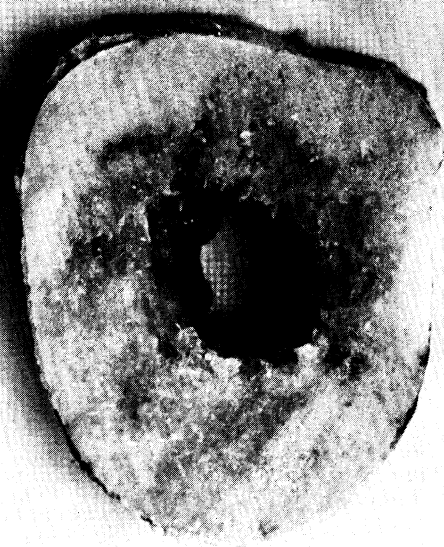
DATE 3-1-77







Cadaver #
20690
Right Leg



Cadaver #
20690
Left Leg

TEST SPECIFICATION

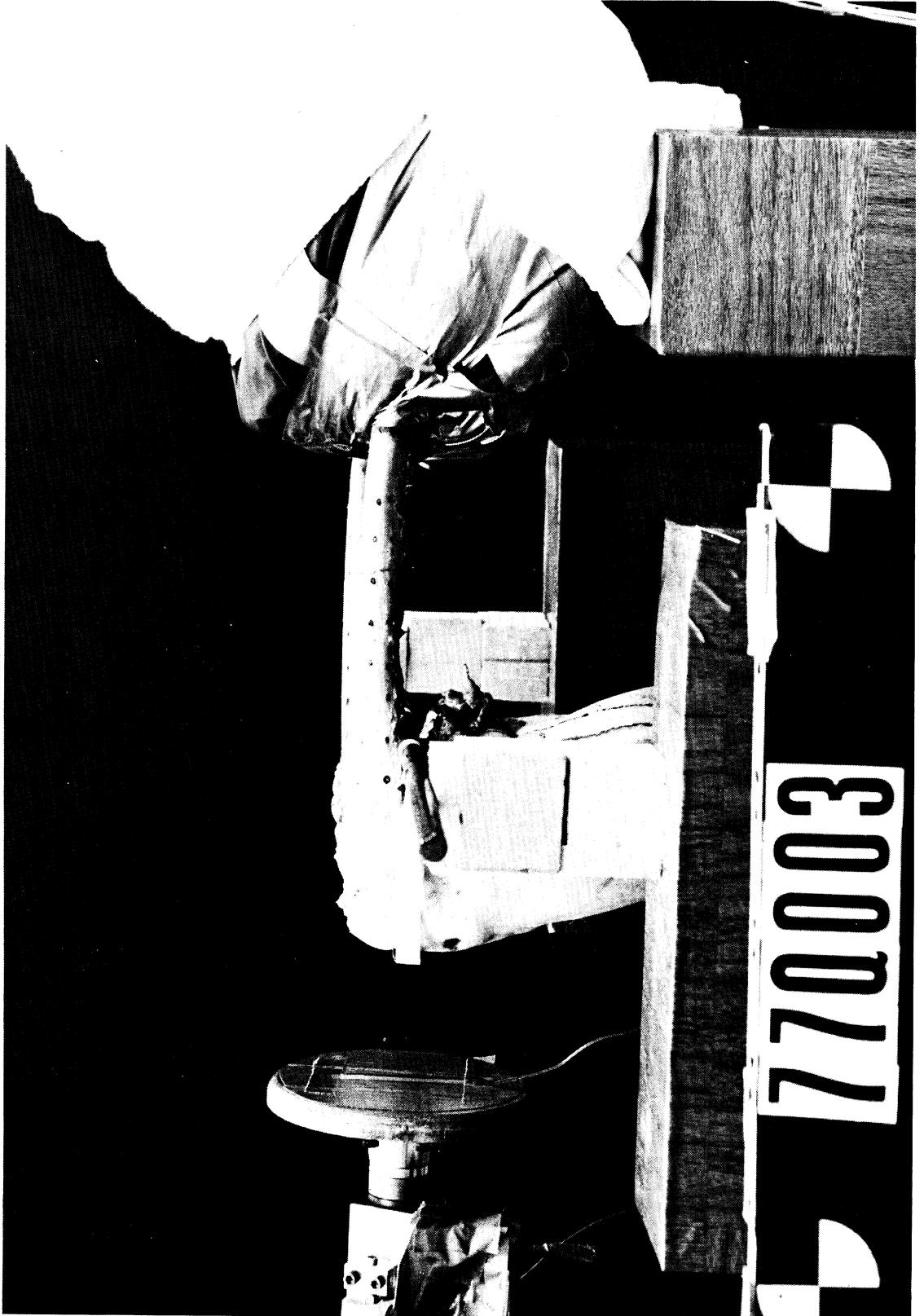
TEST NO. 77Q003 Lt.

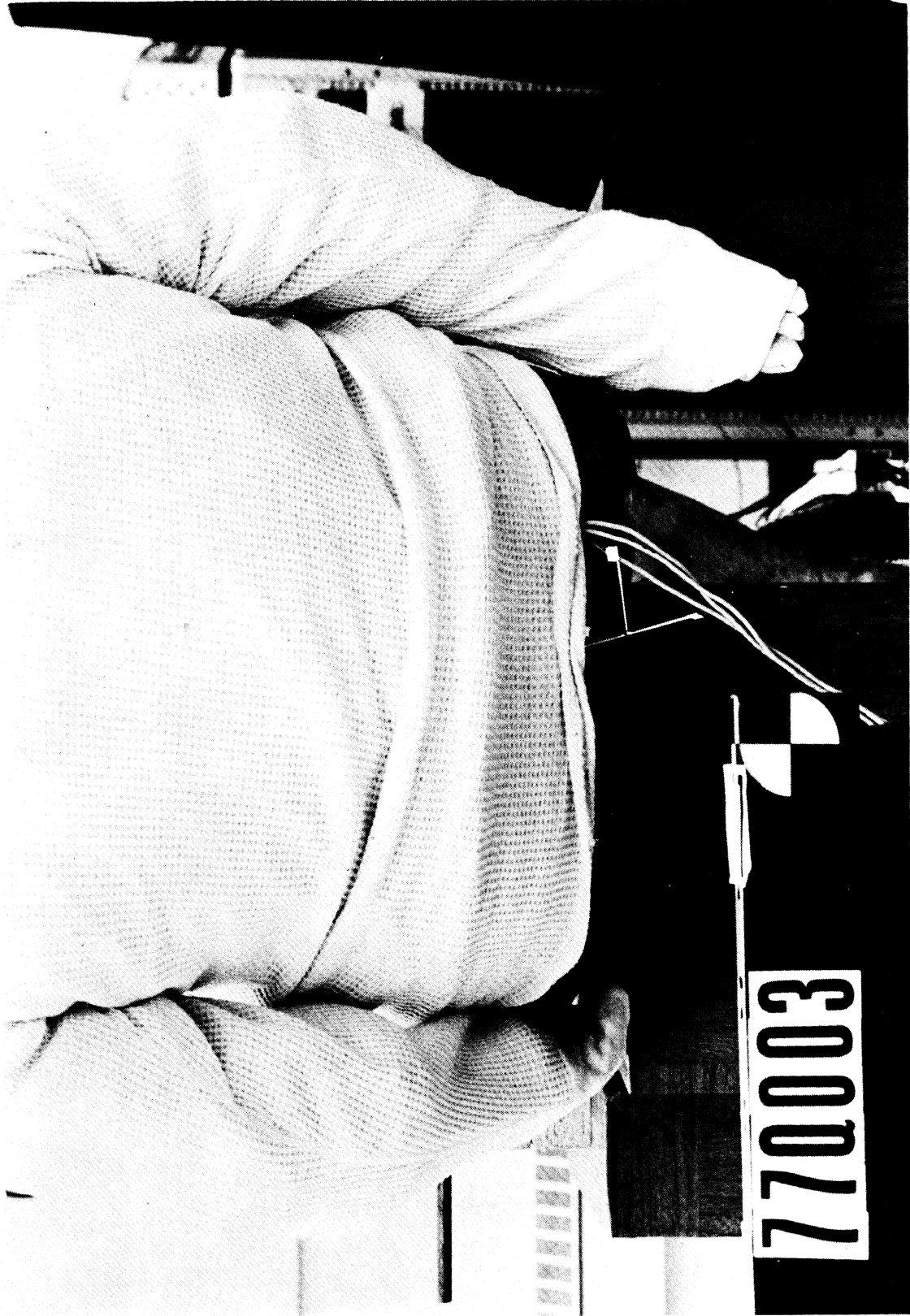
IMPACT VELOCITY 34.6 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: No strain gages were used in this test because it was
assumed that the femurs in tests 77Q001 and 77Q002 dried out while
the gages were being put on. The femur was coated with vaseline
as soon as the muscle was removed, so as to prevent drying.

The midshaft and neck of the femur were fractured. The patella
was shattered.

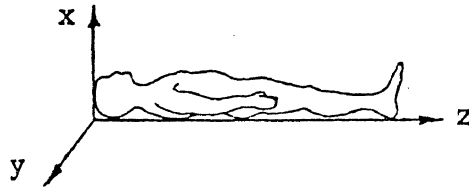




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q003-4
 Cadaver Number 20693
 Date 3-4-77

ANATOMICAL COORDINATE SYSTEM



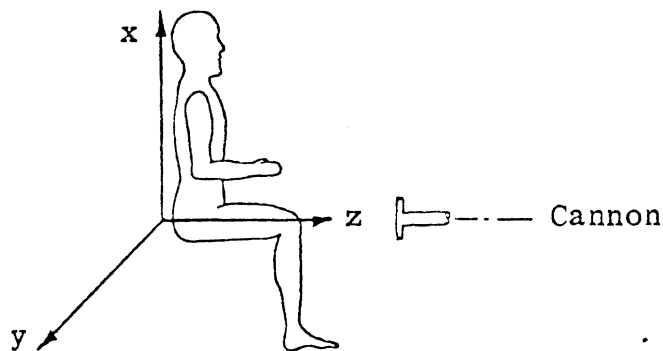
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	62.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	0	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q004	-20°	+40°	-6°
Lt. Lg 77Q003	-3°	+50°	-5°

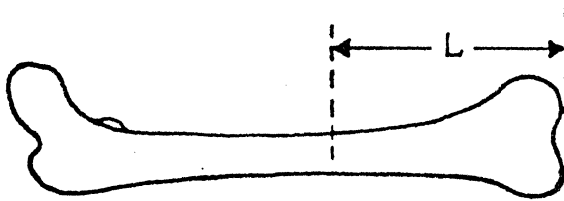
STRAIN GAGE LOCATIONS

Run Numbers 77Q003-4
 Cadaver Number 20693
 Date 3-7-77

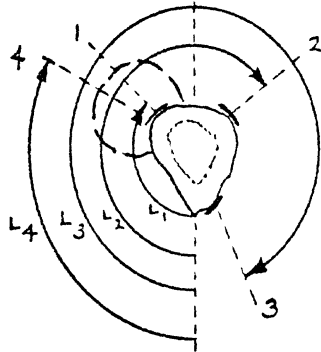
Photos of Cross Section at Strain Gages? Yes No

→ No Gages

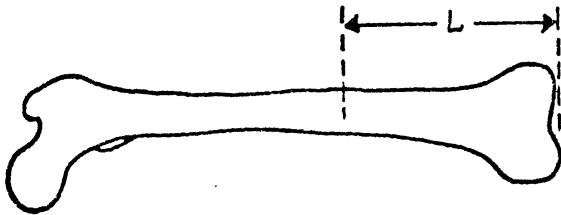
Right Leg 77Q004



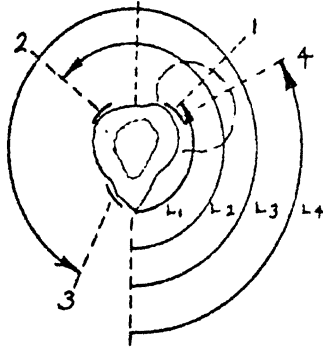
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ _____ cm



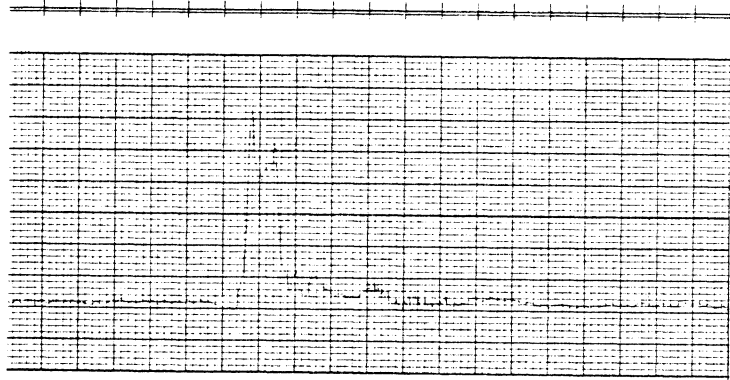
Left Leg 77Q003



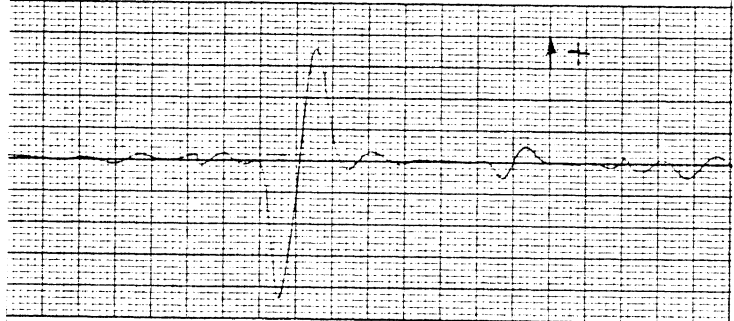
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ _____ cm



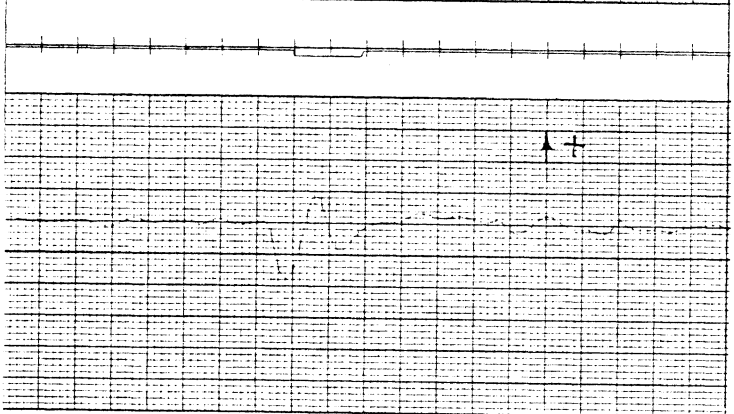
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



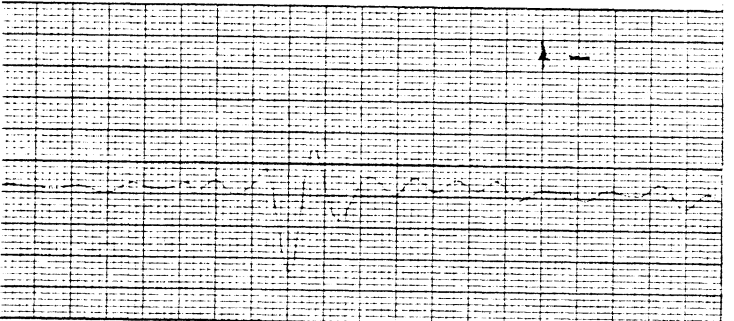
Pelvic Acceleration
P-A
21.1 G's/Division
Filtered 300 Hz.



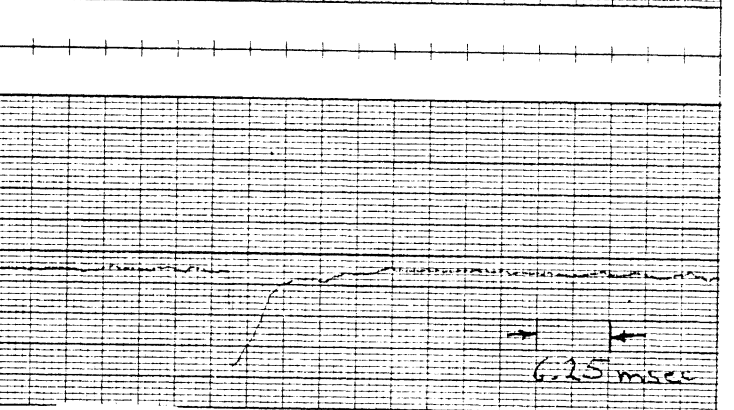
Pelvic Acceleration
R-L
18.6 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
21.3 G's/Division
Filtered 300 Hz.



Strobe (T₀)



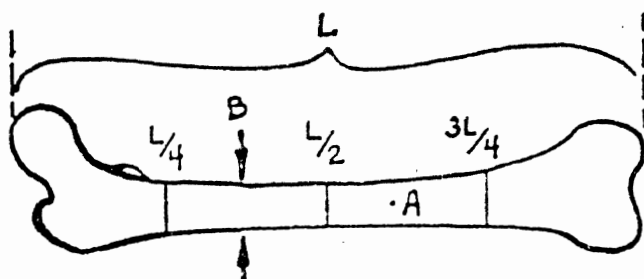
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q003-4

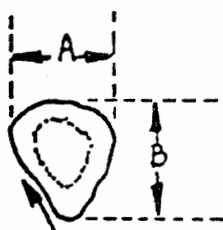
Cadaver Number 20693

Date 3-7-77

Right Leg 77Q004



L 41.9 cm



cross-section

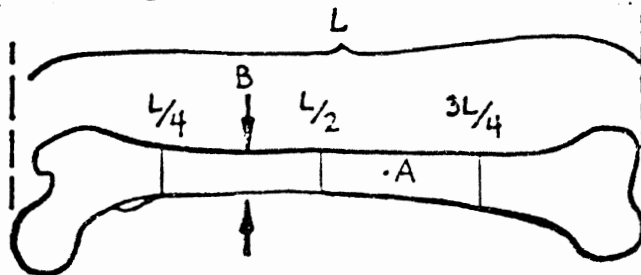
C = circumference

	A cm	B cm	C cm
L/4	2.3	2.8	8.5
L/2	2.8	2.3	8.3
3L/4	2.6	2.8	9.0

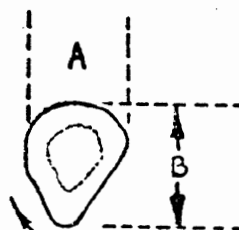
Weight of removed Anatomical Material (Rt.) 3.86 kg.

Weight of removed Femur (Rt.) 0.578 kg.

Left Leg 77Q003



L 42.0 cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4	2.3	2.8	8.5
L/2	2.6	2.4	7.9
3L/4	2.4	2.9	8.8

Weight of removed Anatomical Material (Lt.) 3.70 kg.

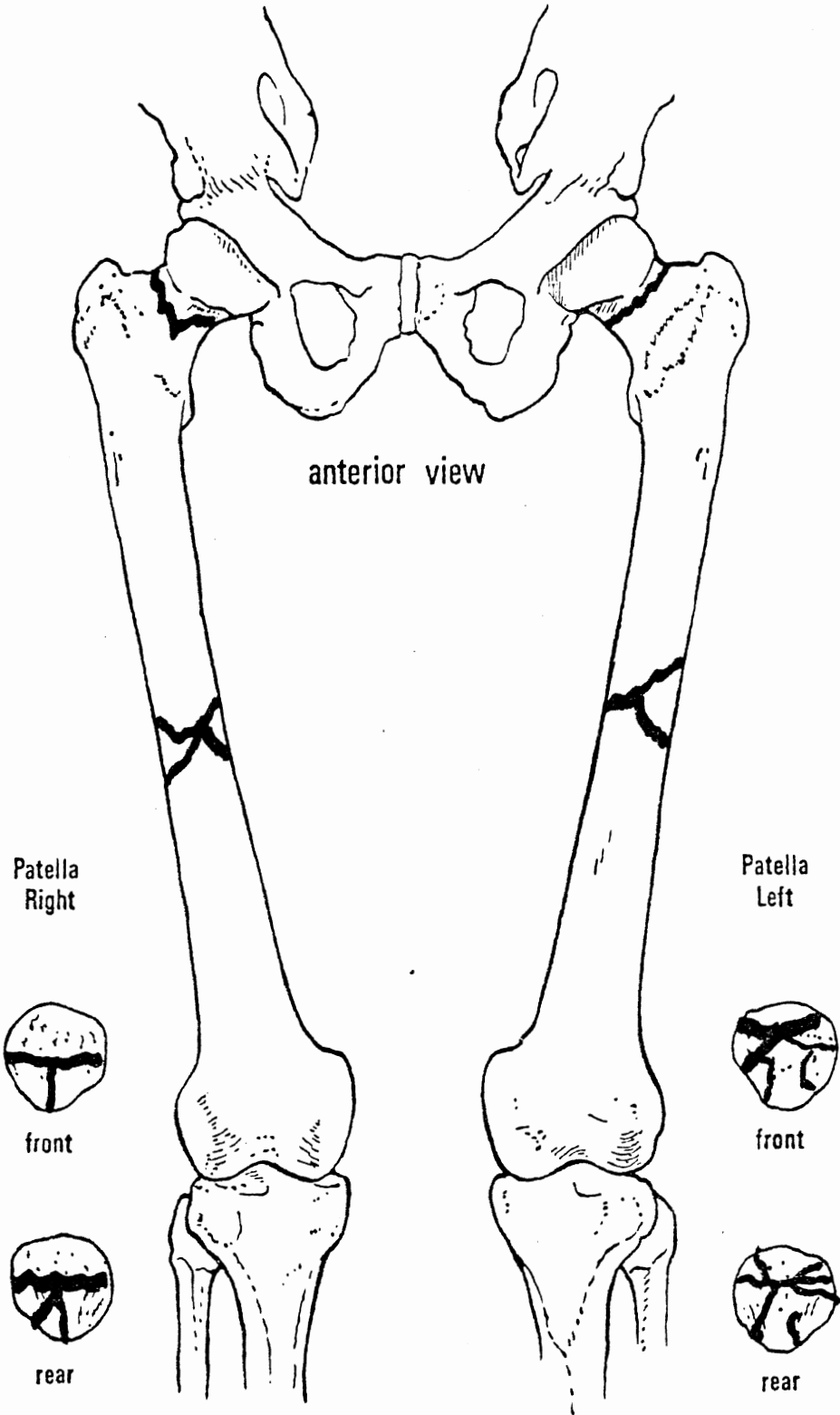
Weight of removed Femur (Lt.) 0.568 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q003-4

CADAVER NO. 20693

DATE 3-8-77

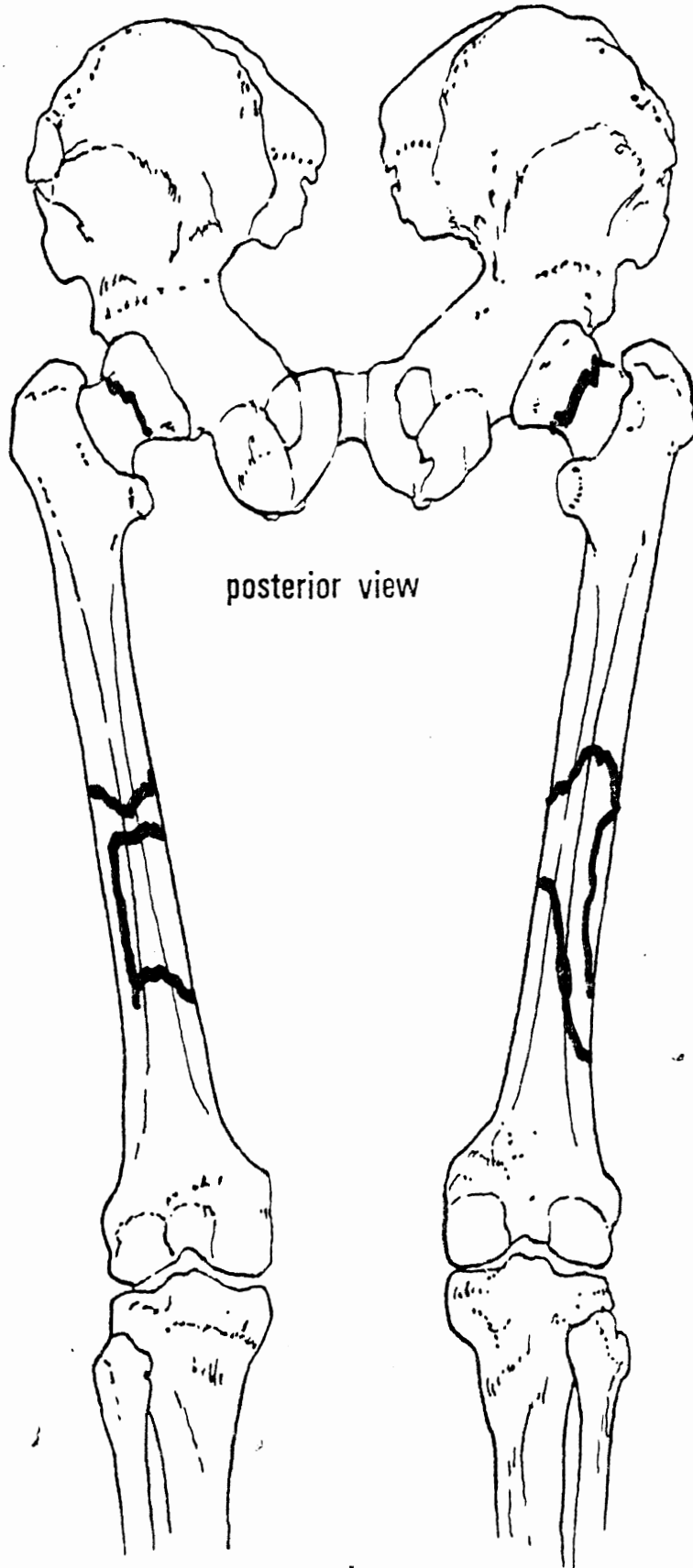


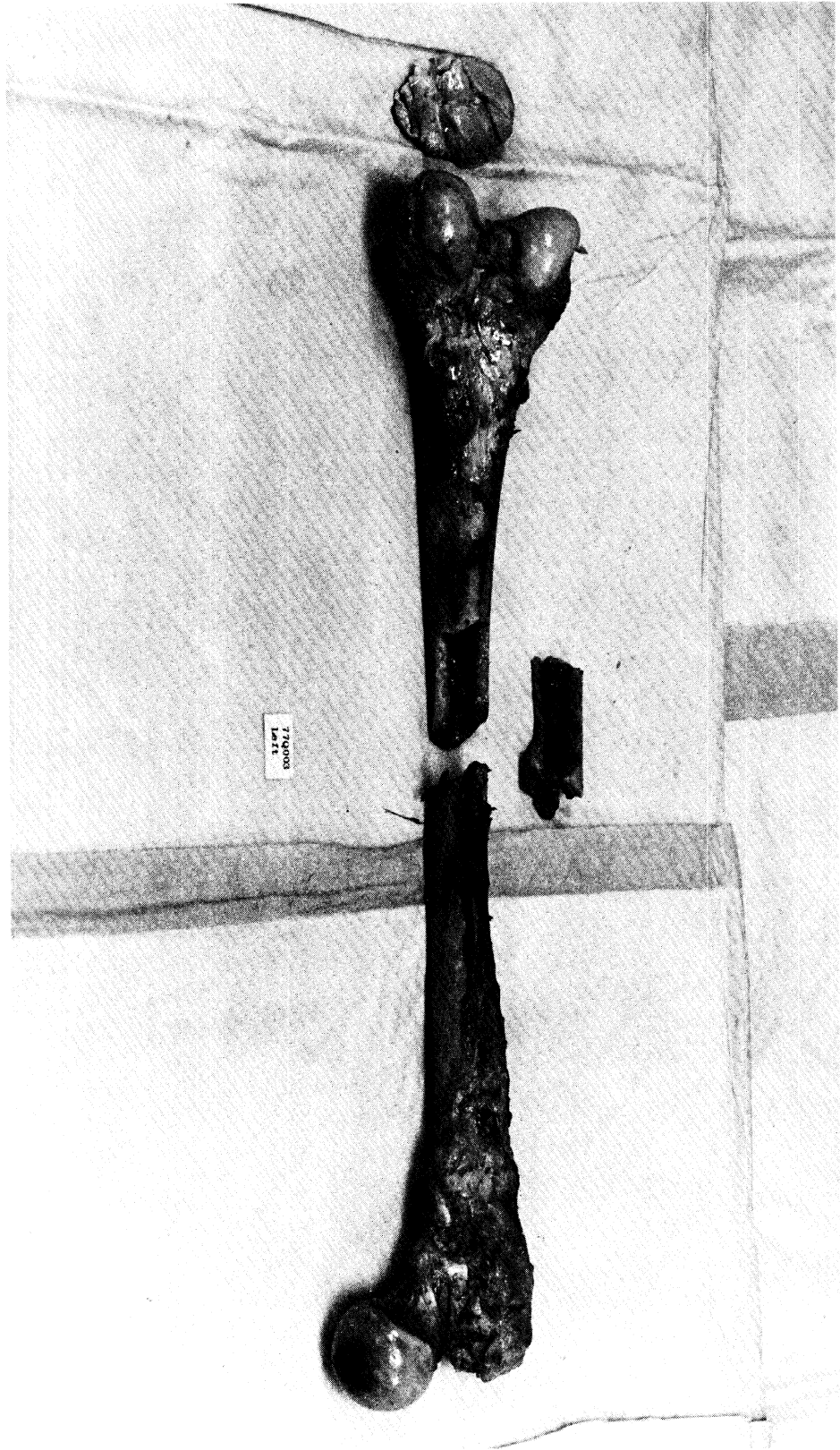
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q003-4

CADAVER NO. 20693

DATE 3-8-77





A-37

TEST SPECIFICATION

TEST NO. 77Q004 Rt

IMPACT VELOCITY 34.9 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: Same as 77Q003

The midshaft and neck of the femur were fractured. The patella was
shattered.

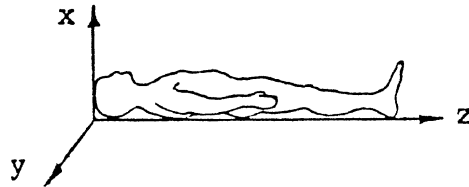




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q003-4
 Cadaver Number 20693
 Date 3-4-77

ANATOMICAL COORDINATE SYSTEM



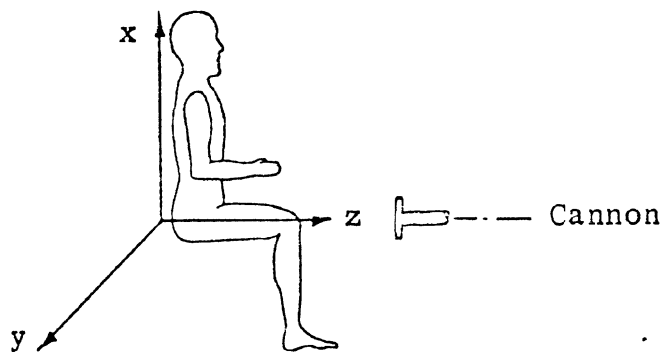
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
C	C	62.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	0	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt.Lg 77Q004	-20°	+ 40°	-6°
Lt.Lg 77Q003	-3°	+ 50°	-5°

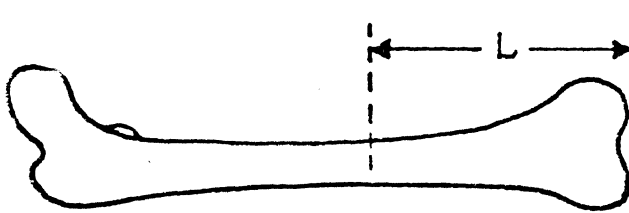
STRAIN GAGE LOCATIONS

Run Numbers 77Q003-4
Cadaver Number 20693
Date 3-7-77

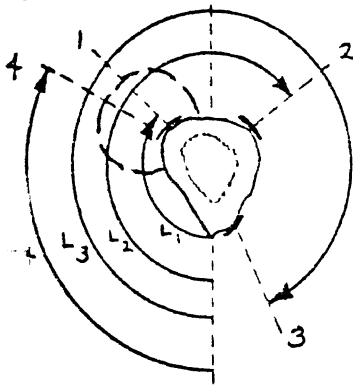
Photos of Cross Section at Strain Gages? Yes No

→ No Gages

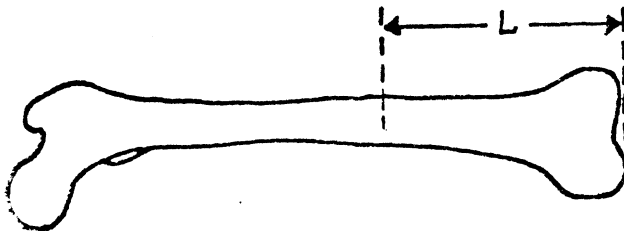
Right Leg 77Q004



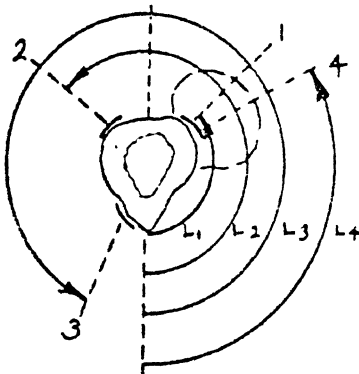
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ _____ cm



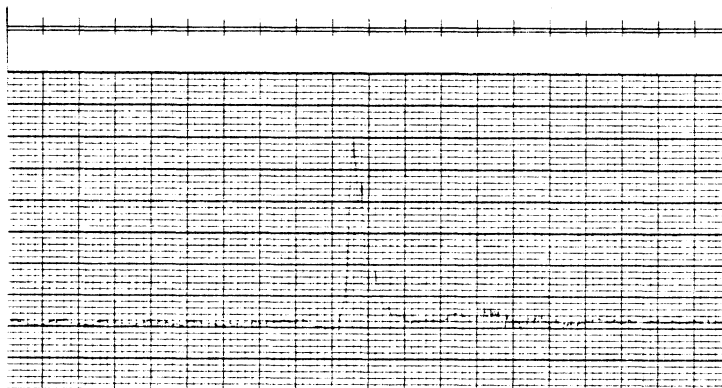
Left Leg 77Q003



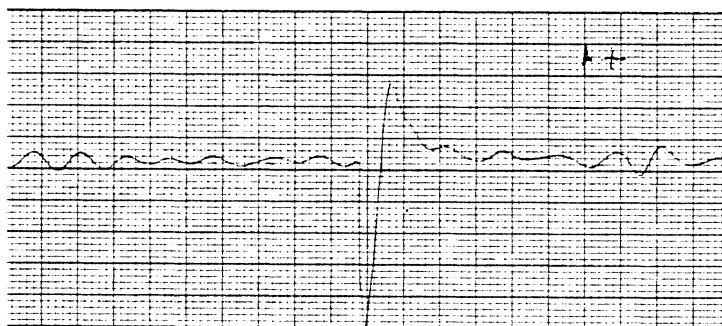
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ _____ cm



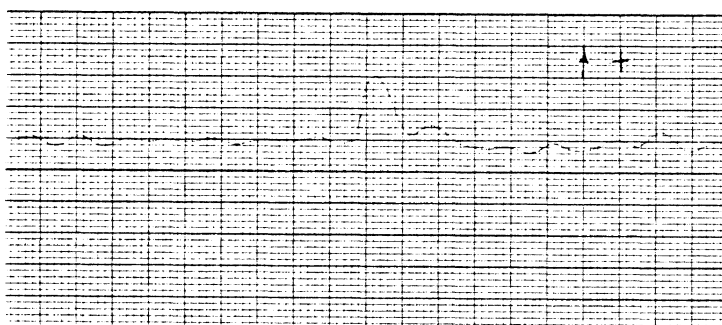
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



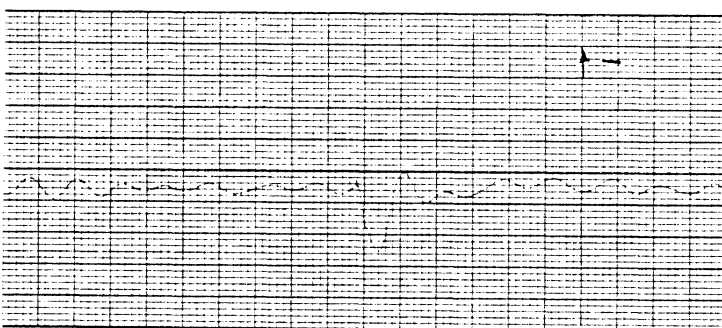
Pelvic Acceleration
P-A
21.7 G's/Division
Filtered 300 Hz.



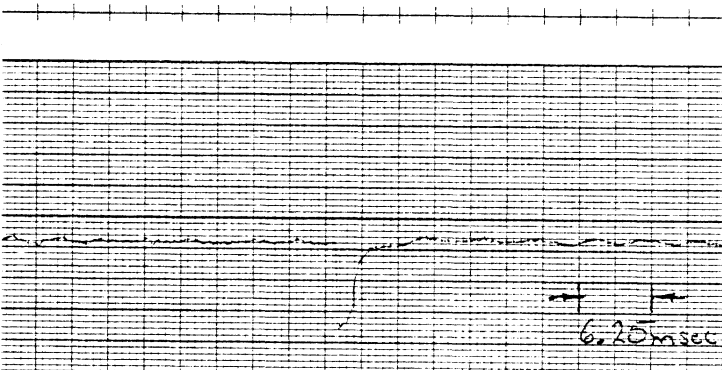
Pelvic Acceleration
R-L
18.6 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
21.3 G's/Division
Filtered 300 Hz.



Strobe (T₀)



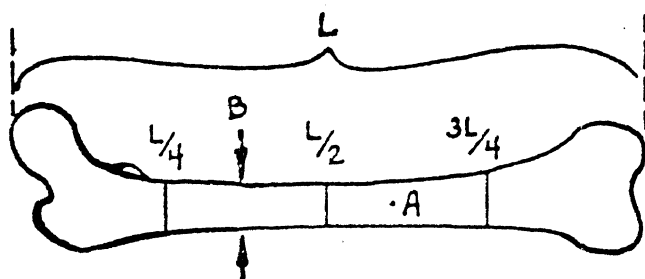
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q003-4

Cadaver Number 20693

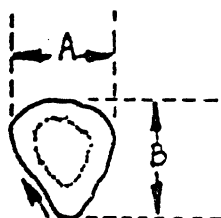
Date 3-7-77

Right Leg 77Q004



L 41.9 cm

	A cm	B cm	C cm
L/4	2.3	2.8	8.5
L/2	2.8	2.3	8.3
3L/4	2.6	2.8	9.0



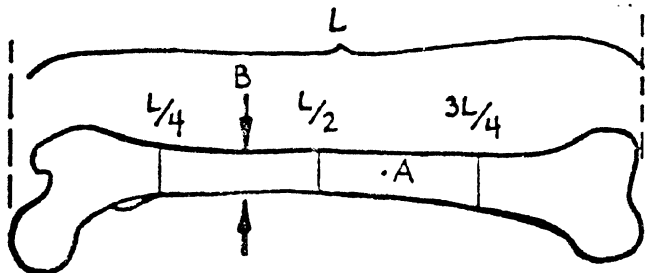
cross-section

C = circumference

Weight of removed Anatomical Material (Rt.) 3.86 kg.

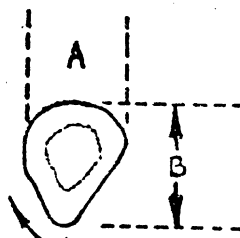
Weight of removed Femur (Rt.) 0.578 kg.

Left Leg 77Q003



L 42.0 cm

	A cm	B cm	C cm
L/4	2.3	2.8	8.5
L/2	2.6	2.4	7.9
3L/4	2.4	2.9	8.8



cross-section

C = circumference

Weight of removed Anatomical Material (Lt.) 3.70 kg.

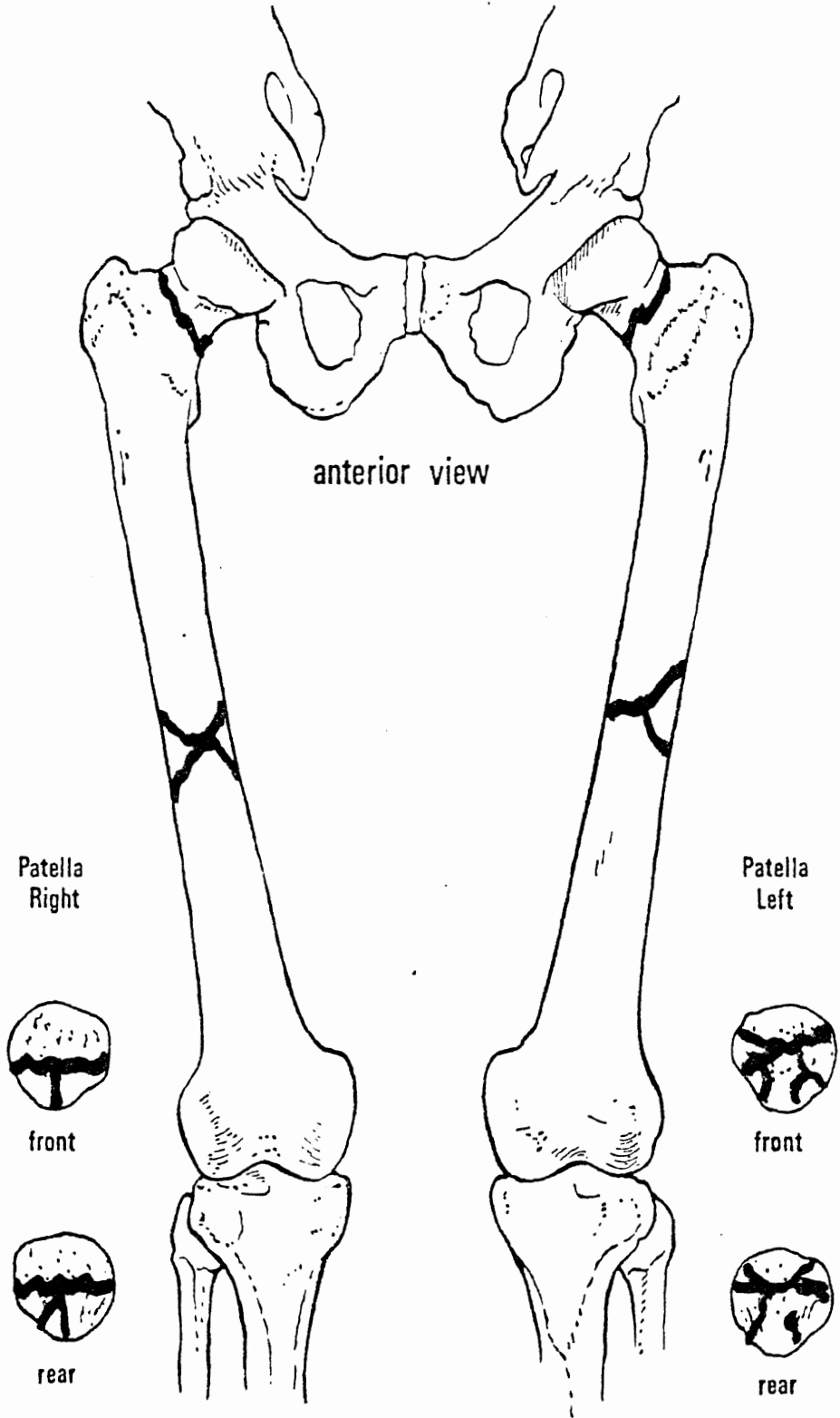
Weight of removed Femur (Lt.) 0.568 kg.

KNEE IMPACT AUTOPTSY SUMMARY

TEST NO. 77C003-4

CADAVER NO. 20693

DATE 3-8-77

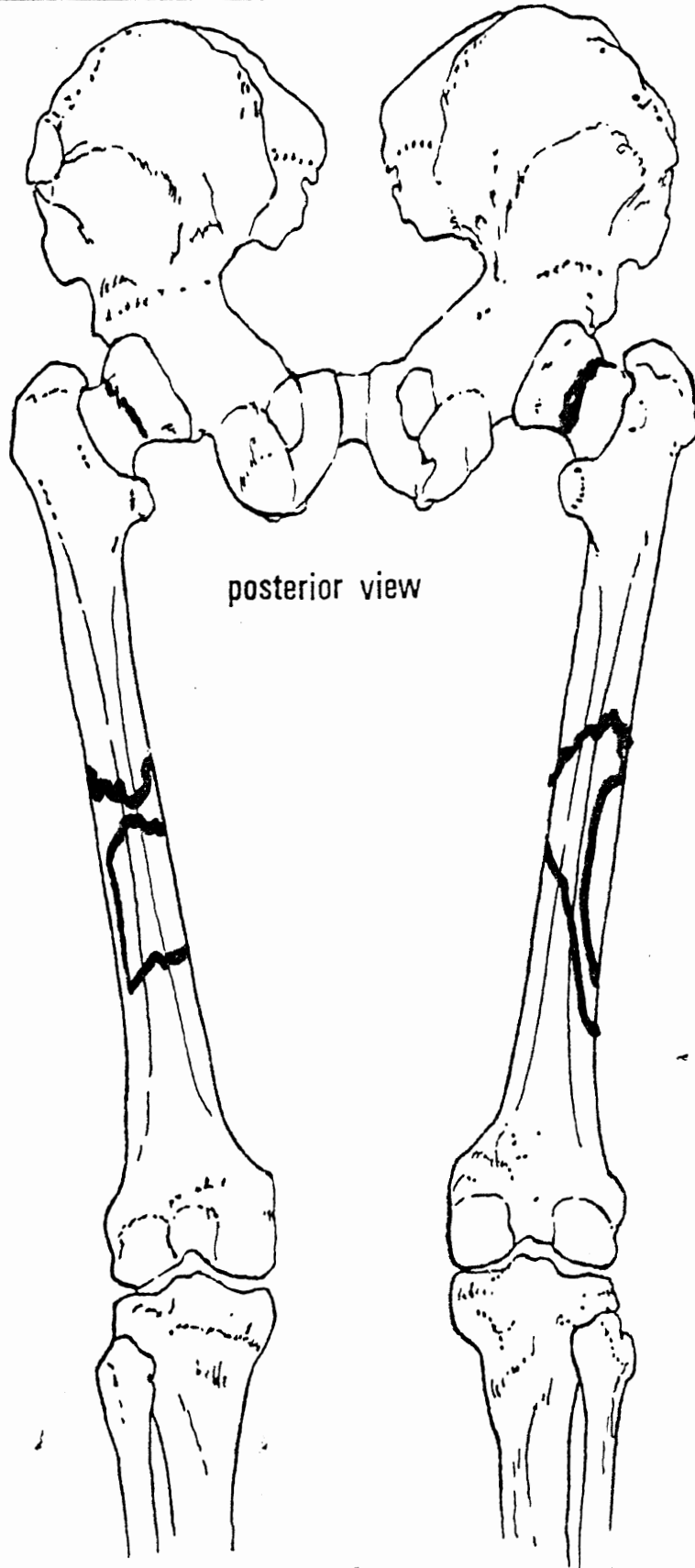


KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77QC03-4

CADAVER NO. 20693

DATE 3-8-77





A-47

TEST SPECIFICATION

TEST NO. 77Q005 Rt.

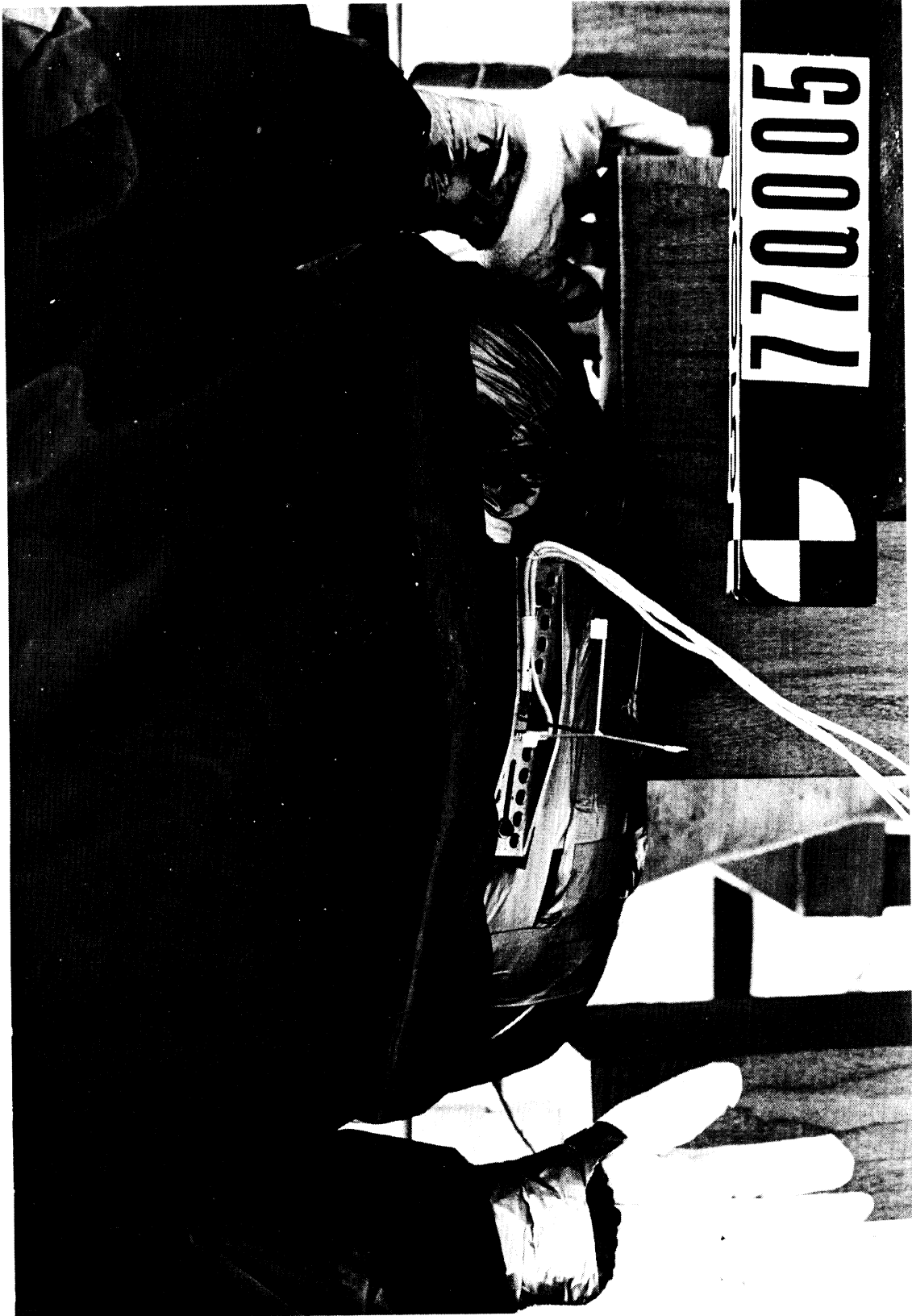
IMPACT VELOCITY 41.1 fps

TYPE OF PADDING Ensolute 1 in.

TEST DESCRIPTION: This test was conducted as outlined in the text,
but great care was taken to keep the femur from drying out. Vaseline
and wet sponges were used to keep the bone moist.

Comminuted fractures of the condyles were produced. There was no
patella damage.

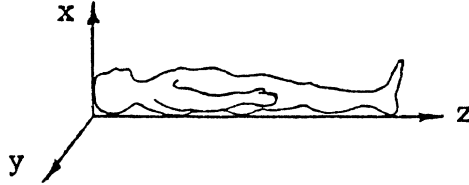




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q005-6
 Cadaver Number 20698
 Date 3-17-77

ANATOMICAL COORDINATE SYSTEM



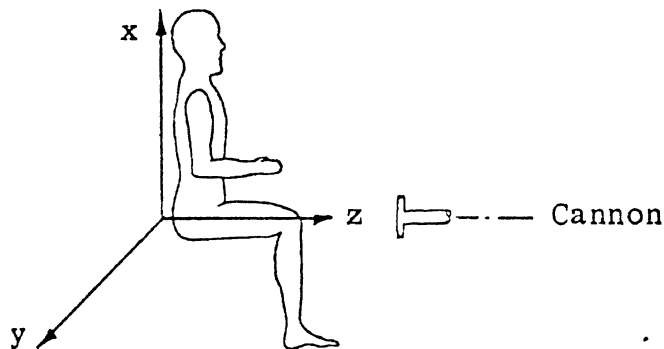
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	77.1 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
+ 2°	+ 3.0°	- 3°

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

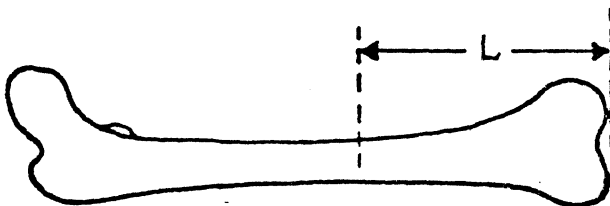
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q005	+ 9°	+ 40°	+ 5°
Lt. Lg 77Q006	+ 11°	+ 27°	+ 20°

STRAIN GAGE LOCATIONS

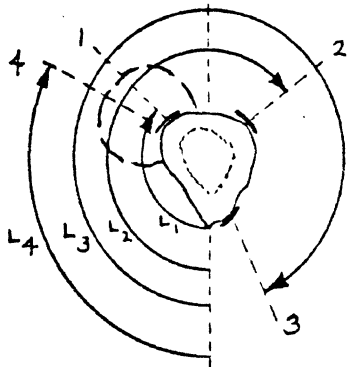
Run Numbers 77Q005-6
 Cadaver Number 20698
 Date 3-17-77

Photos of Cross Section at Strain Gages? Yes No

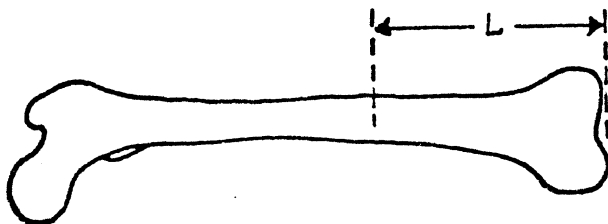
Right Leg 77Q005



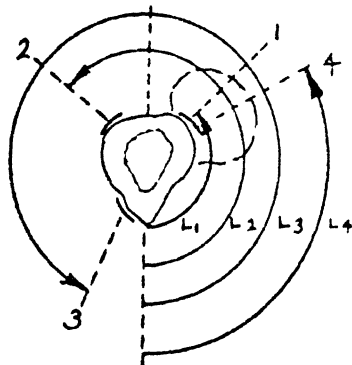
- L 21.5 cm
- L₁ 3.0 cm
- L₂ 5.7 cm
- L₃ 7.4 cm
- L₄ 2.9 cm



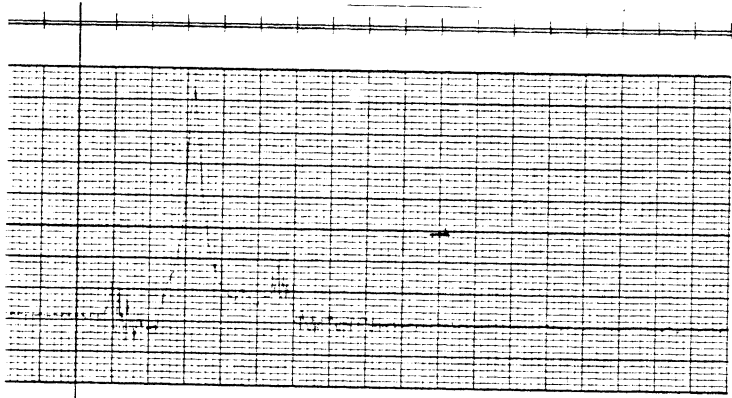
Left Leg 77Q006



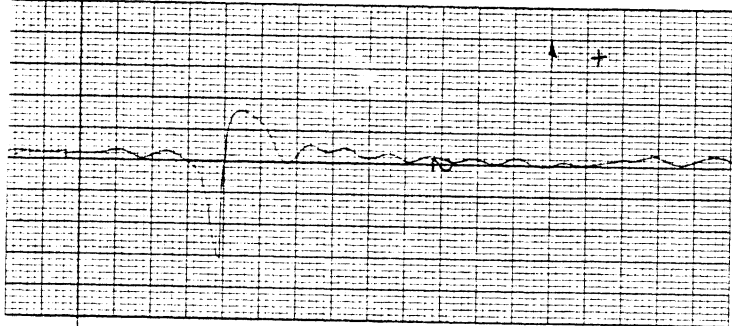
- L 21.5 cm
- L₁ 4.0 cm
- L₂ 6.0 cm
- L₃ 7.7 cm
- L₄ 2.9 cm



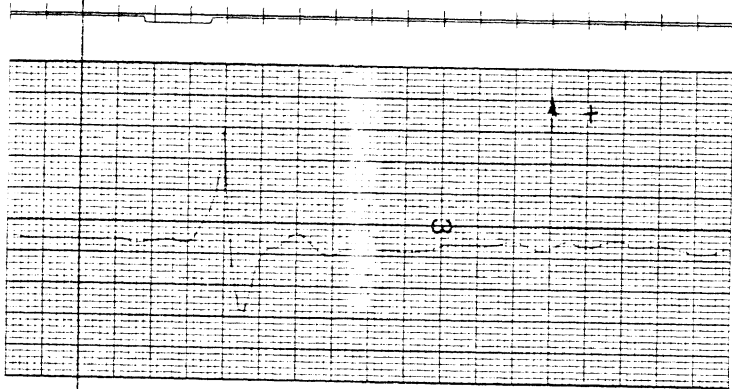
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



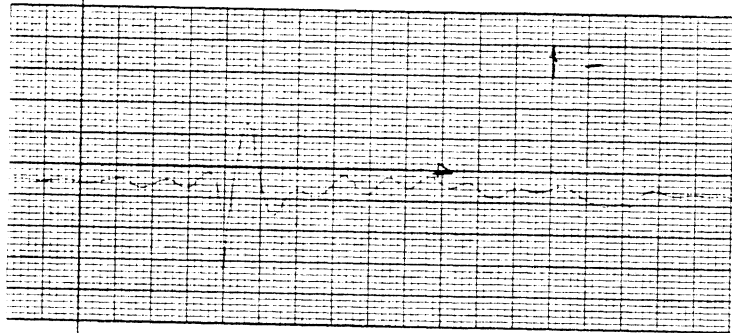
Pelvic Acceleration
P-A
21.1 G's/Division
Filtered 300 Hz.



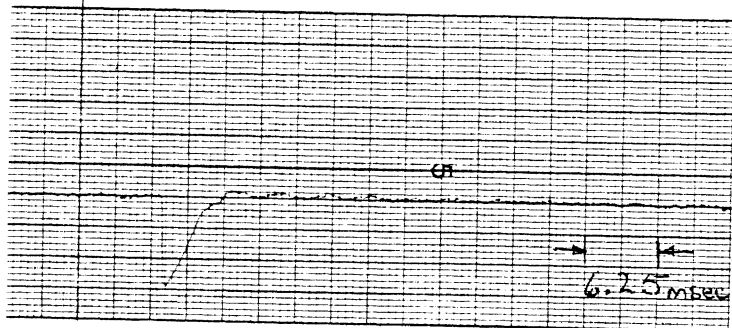
Pelvic Acceleration
R-L
18.6 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
21.3 G's/Division
Filtered 300 Hz.



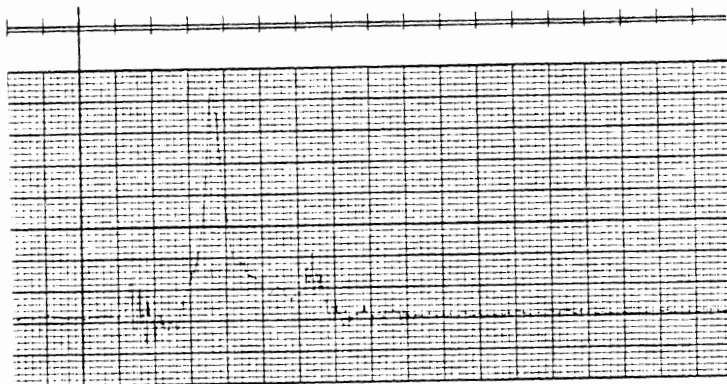
Strobe (T₀)



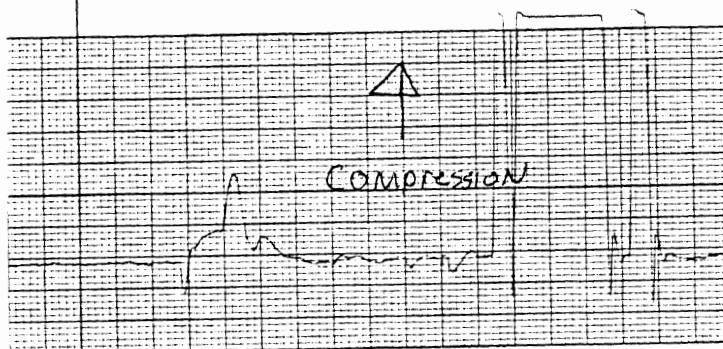
Test No. 77Q005 Rt.

KNEE IMPACT DATA SUMMARY

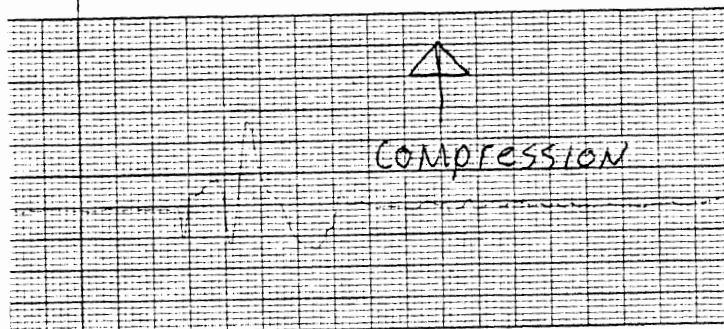
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



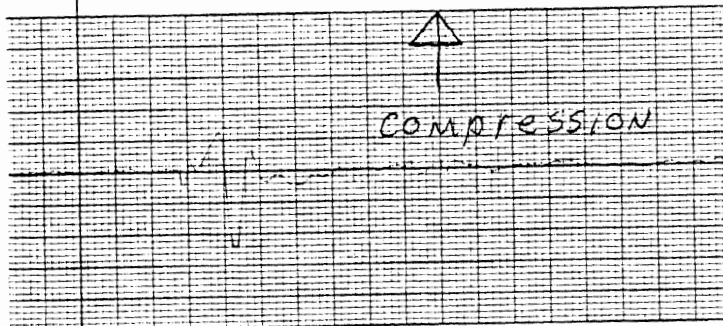
Femur Strain
Top (1)
2359.5 micro in./in./Div.
Filtered 1650 Hz.



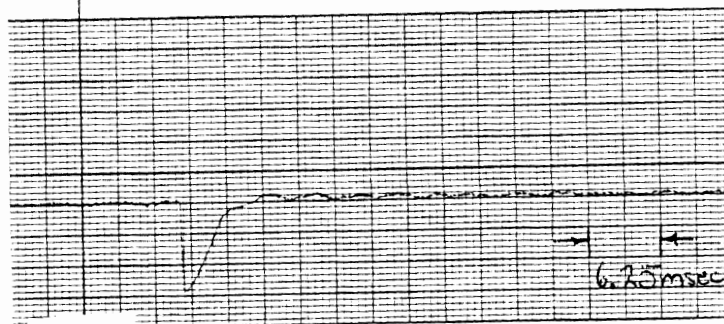
Femur Strain
Side (2)
2311 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Bottom (3)
2338.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



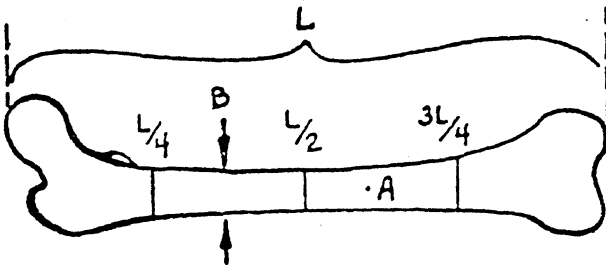
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q005-6

Cadaver Number 20698

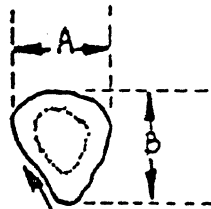
Date 3-17-77

Right Leg 77Q005



L 44.0 cm

	A cm	B cm	C cm
L/4	2.9	3.2	9.4
L/2	2.6	2.8	9.2
3L/4	3.1	2.8	9.8



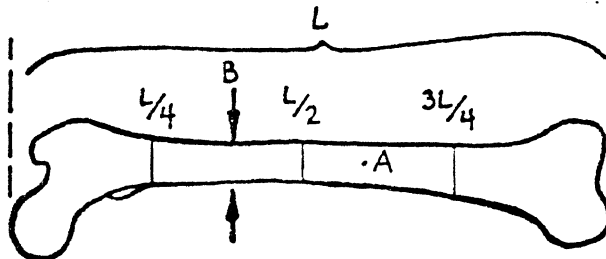
cross-section

C = circumference

Weight of removed Anatomical Material (Rt.) 3.59 kg.

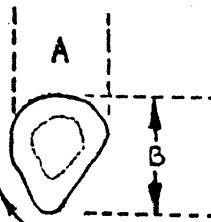
Weight of removed Femur (Rt.) 0.703 kg.

Left Leg 77Q006



L 43.9 cm

	A cm	B cm	C cm
L/4	3.0	3.2	9.5
L/2	2.8	2.7	9.1
3L/4	3.3	2.9	10.4



cross-section

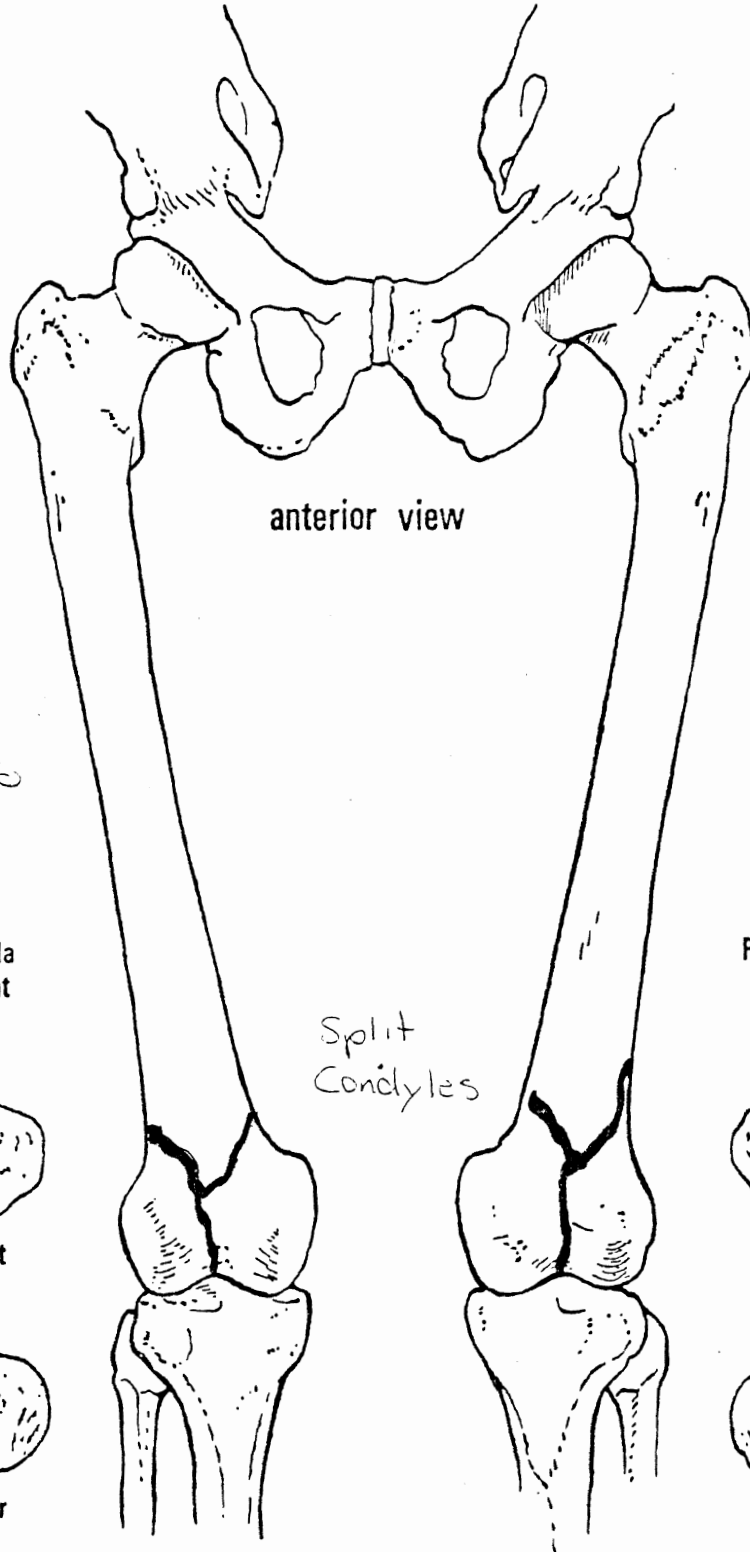
C = circumference

Weight of removed Anatomical Material (Lt.) 3.59 kg.

Weight of removed Femur (Lt.) 0.682 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q005-G
CADAVER NO. 20698
DATE 3-17-77



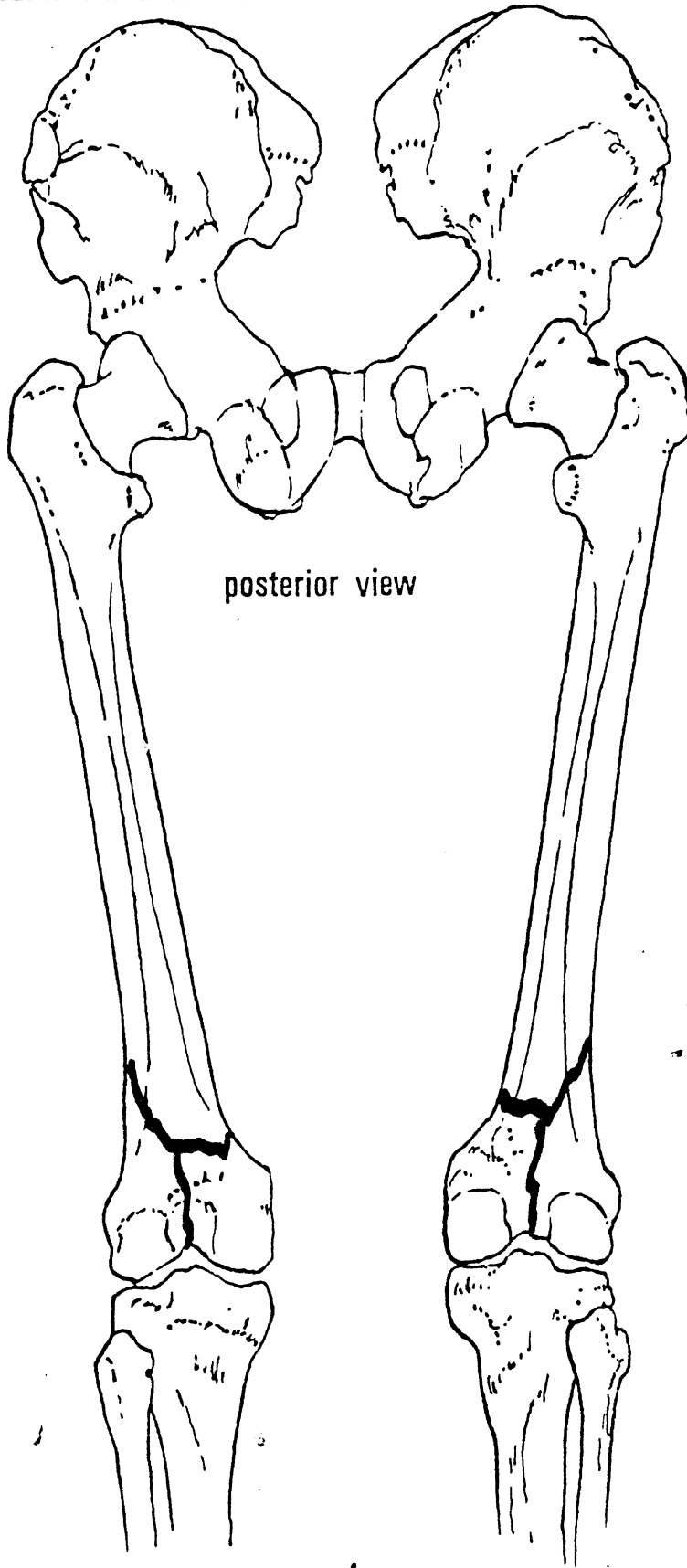
No Damage To
Patellas

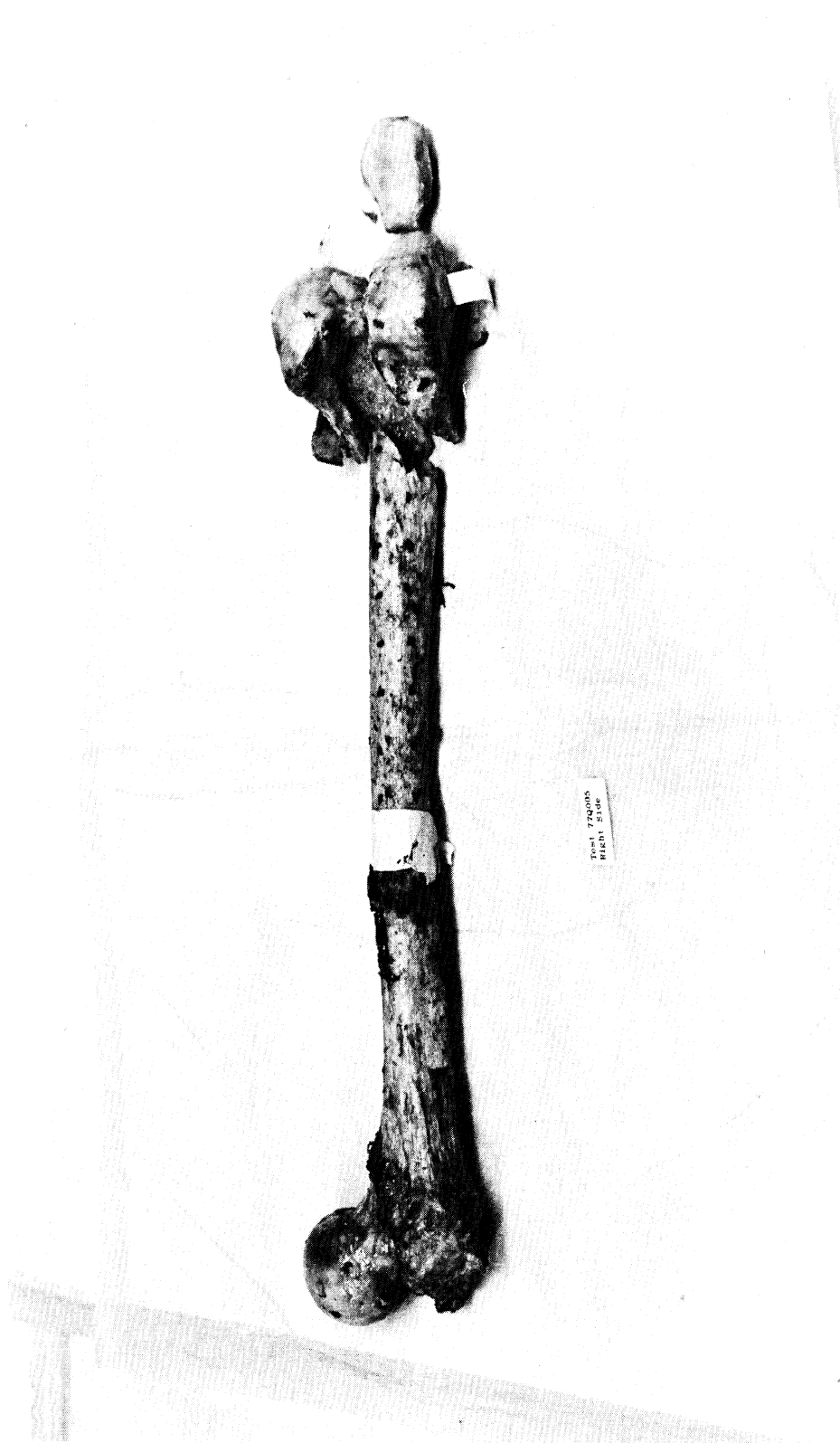
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q005-6

CADAVER NO. 20698

DATE 3-17-77

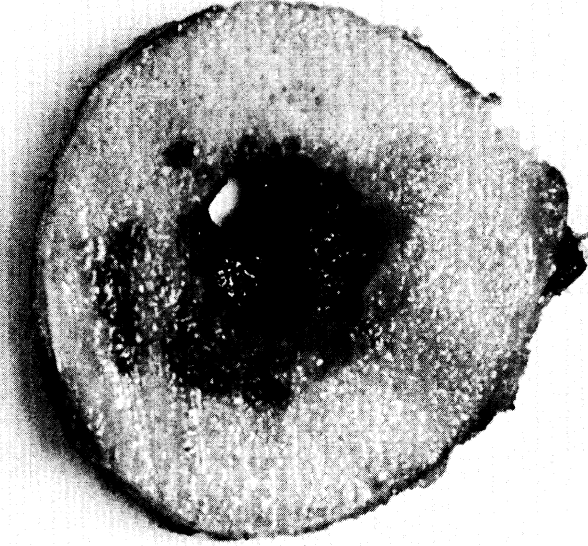




Post 72805
RICHY 5106

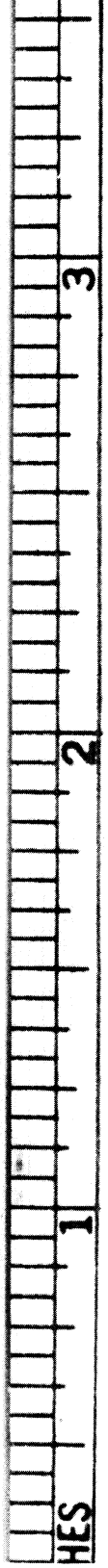
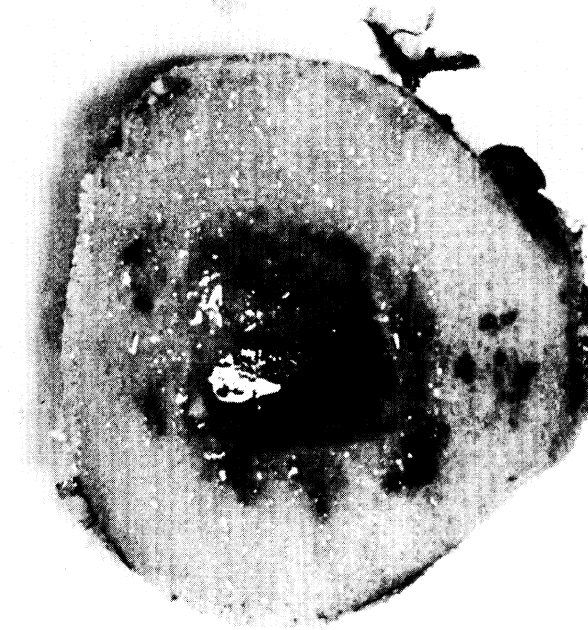
77Q005

Right



77Q006

Left



TEST SPECIFICATION

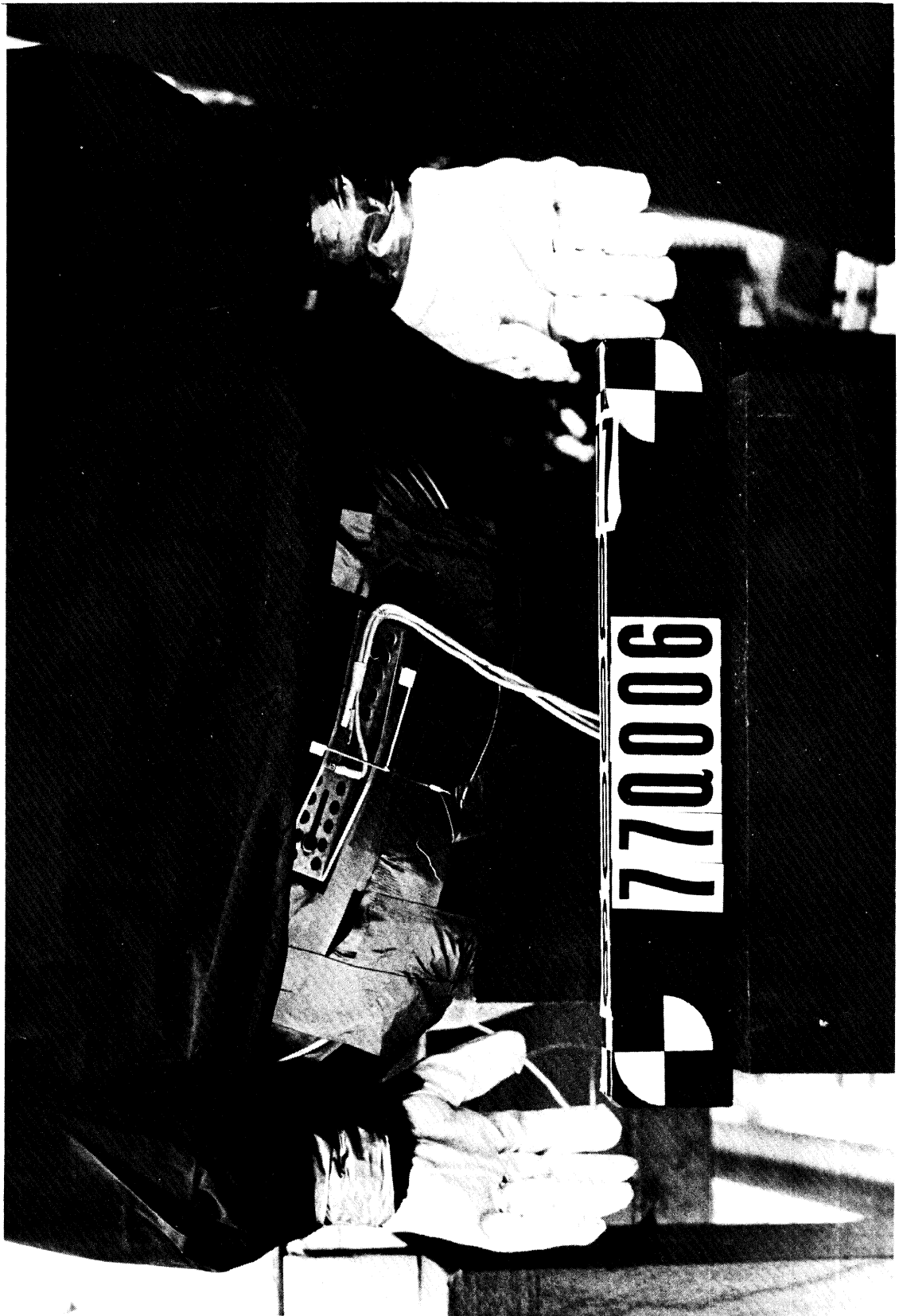
TEST NO. 77Q006 Lt.

IMPACT VELOCITY 42.3 fps fps

TYPE OF PADDING Ensolite 1 in.

TEST DESCRIPTION: Same as 77Q005

Comminuted fractures of the condyles were produced. There were no
patella damage.

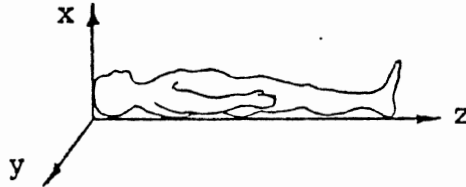




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q005-6
 Cadaver Number 20698
 Date 3-17-77

ANATOMICAL COORDINATE SYSTEM



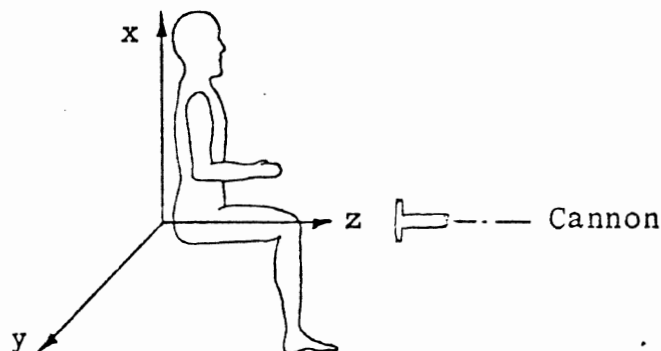
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	77.1 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
+ 2°	+ 3°	- 3°

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

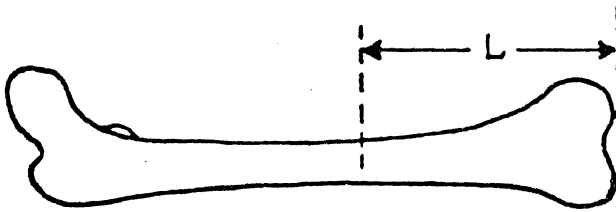
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q005	+ 9°	+ 40°	+ 5°
Lt. Lg 77Q006	+ 11°	+ 27°	+ 20°

STRAIN GAGE LOCATIONS

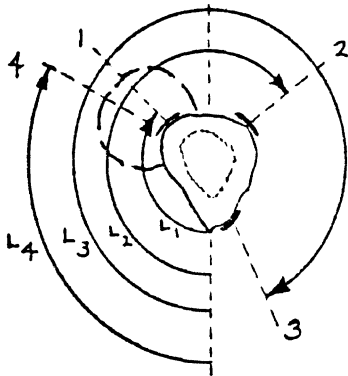
Run Numbers 77QCC5-6
 Cadaver Number 20698
 Date 3-17-77

Photos of Cross Section at Strain Gages? Yes No

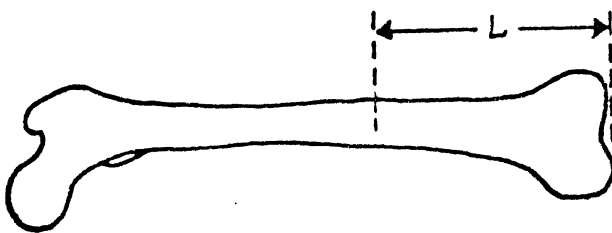
Right Leg 77Q005



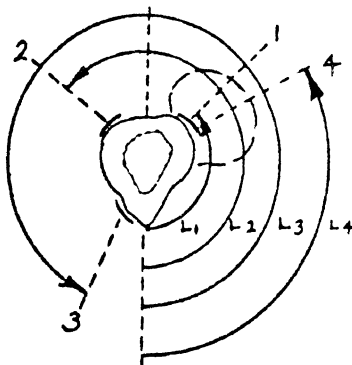
L 21.5 cm
 L₁ 3.0 cm
 L₂ 5.7 cm
 L₃ 7.4 cm
 L₄ 2.9 cm



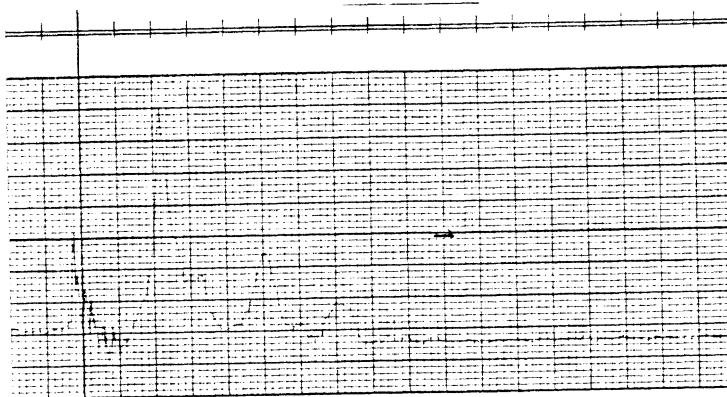
Left Leg 77Q006



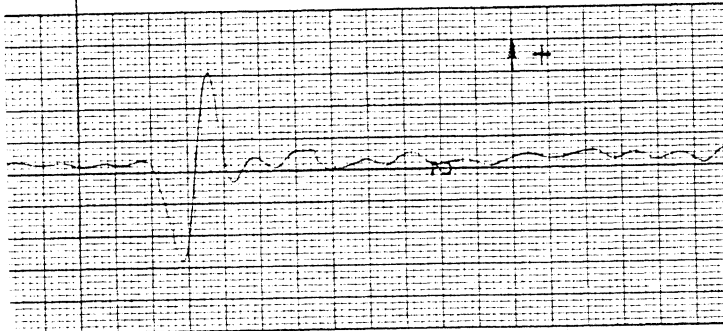
L 21.5 cm
 L₁ 4.0 cm
 L₂ 6.0 cm
 L₃ 7.7 cm
 L₄ 2.9 cm



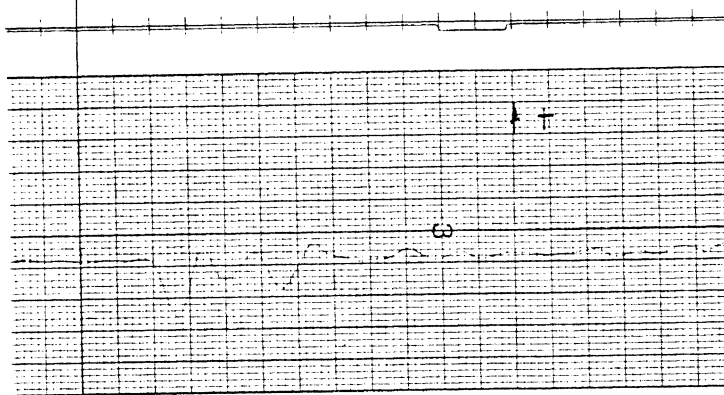
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



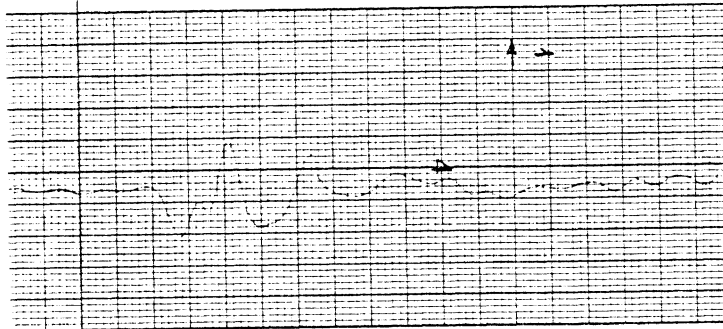
Pelvic Acceleration
P-A
21.1 G's/Division
Filtered 300 Hz.



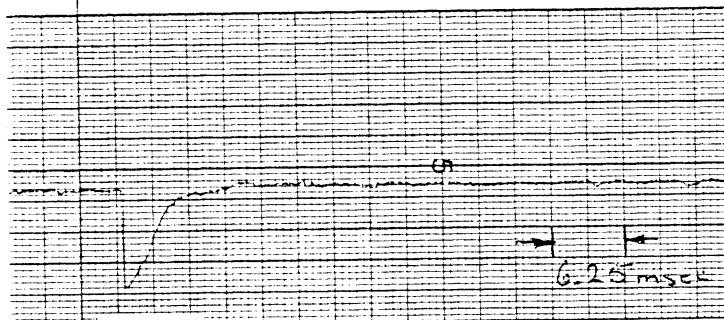
Pelvic Acceleration
R-L
18.6 G's/Division
Filtered 300 Hz.



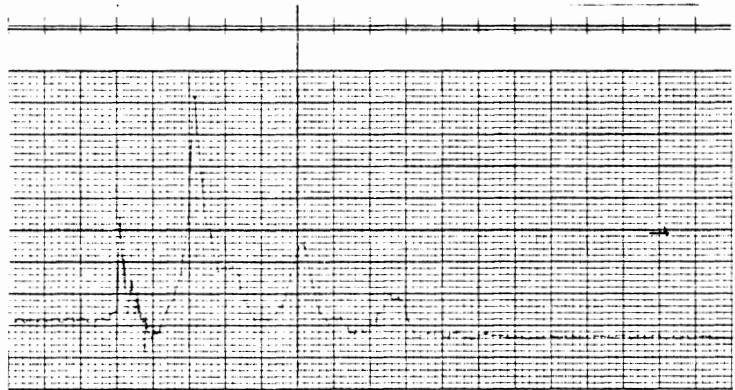
Pelvic Acceleration
S-I
21.3 G's/Division
Filtered 300 Hz.



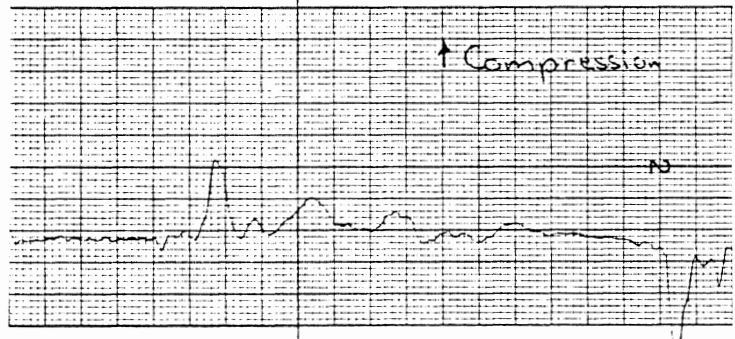
Strobe (T_0)



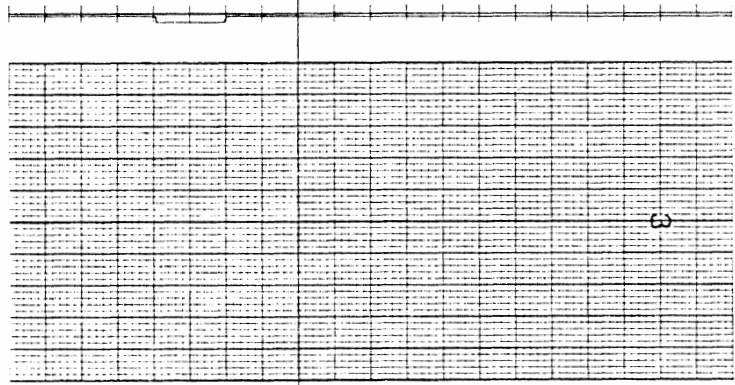
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



Femur Strain
Top (1)
4719 micro in./in./Div.
Filtered 1650 Hz.



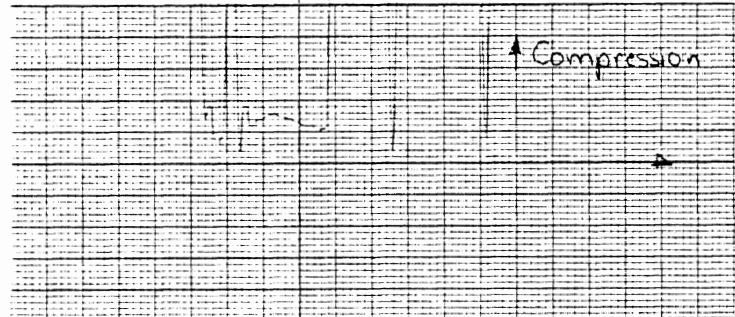
Femur Strain
Side (2)
4622 micro in./in./Div.
Filtered 1650 Hz.



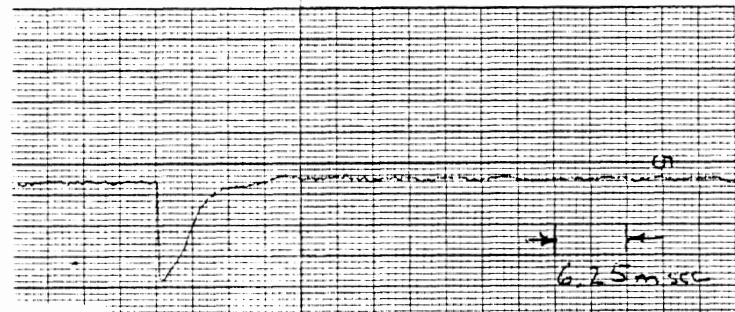
ems Division

inUSA

Femur Strain
Bottom (3)
4677 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



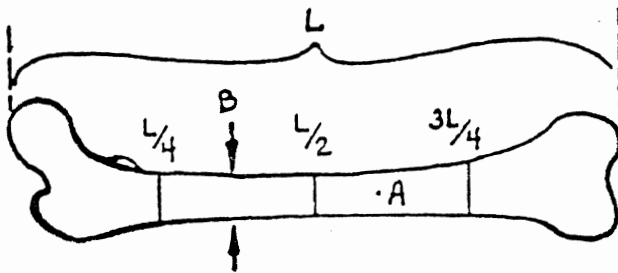
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q005-6

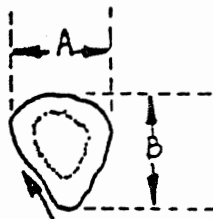
Cadaver Number 20698

Date 3-18-77

Right Leg 77Q005



L 44.0 cm



cross-section

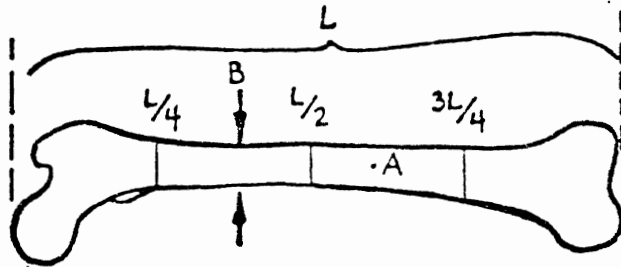
C = circumference

	A cm	B cm	C cm
L/4	2.9	3.2	9.4
L/2	2.6	2.8	9.2
3L/4	3.1	2.8	9.8

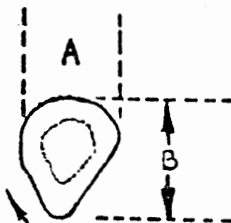
Weight of removed Anatomical Material (Rt.) 3.59 kg.

Weight of removed Femur (Rt.) 0.703 kg.

Left Leg 77Q006



L 43.9 cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4	3.0	3.2	9.5
L/2	2.8	2.7	9.1
3L/4	3.3	2.9	10.4

Weight of removed Anatomical Material (Lt.) 3.59 kg.

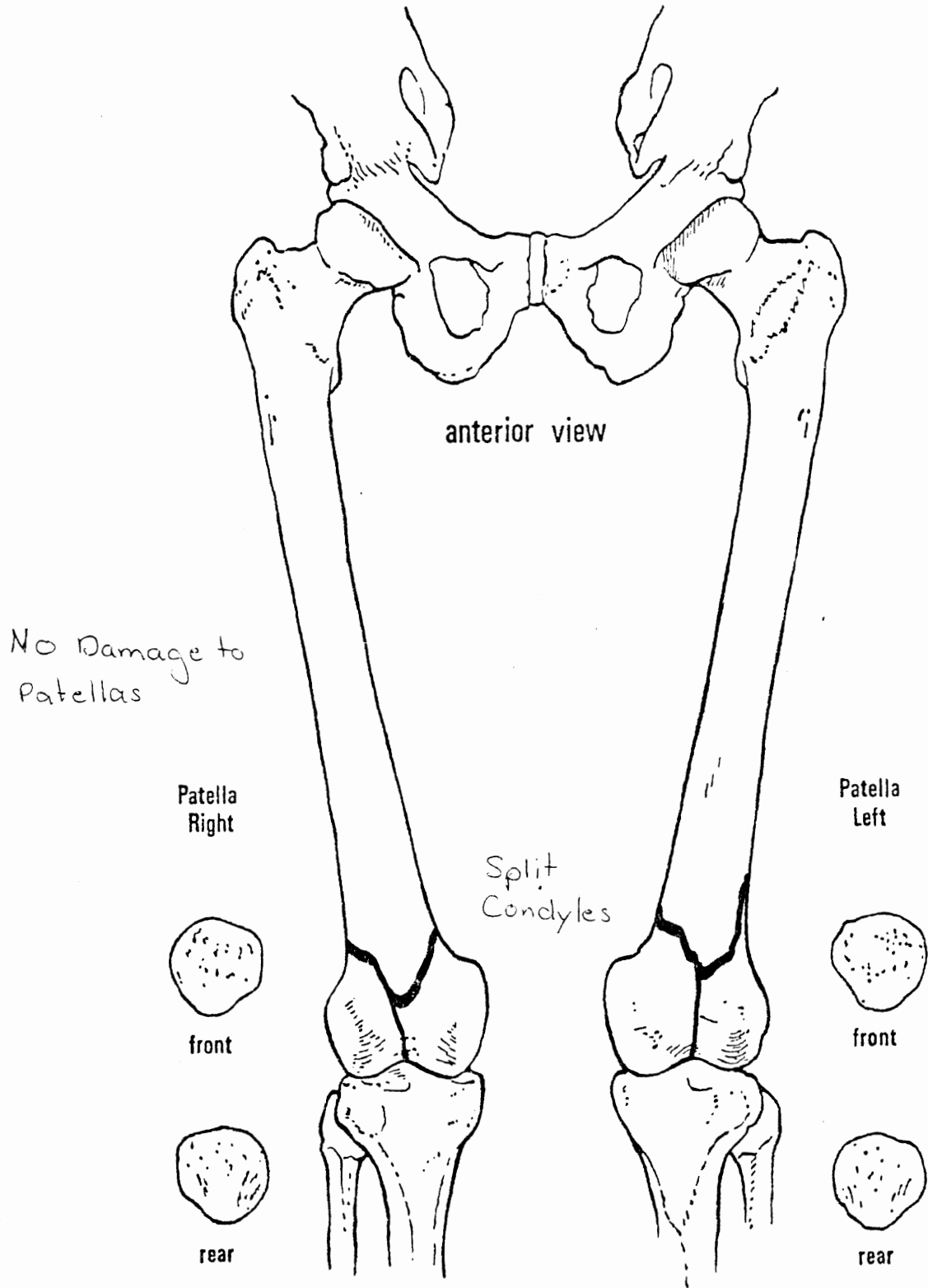
Weight of removed Femur (Lt.) 0.682 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q005-6

CADAVER NO. 20698

DATE 3-17-77

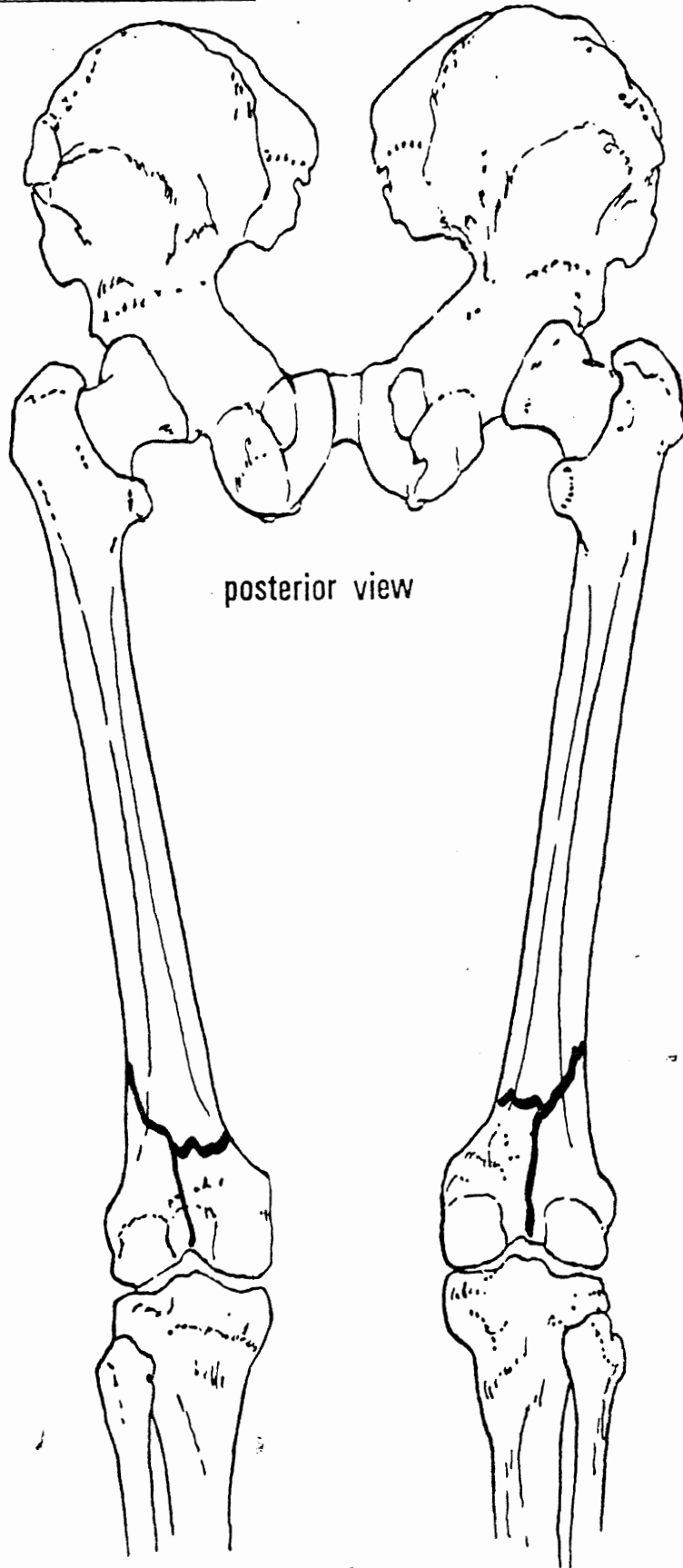


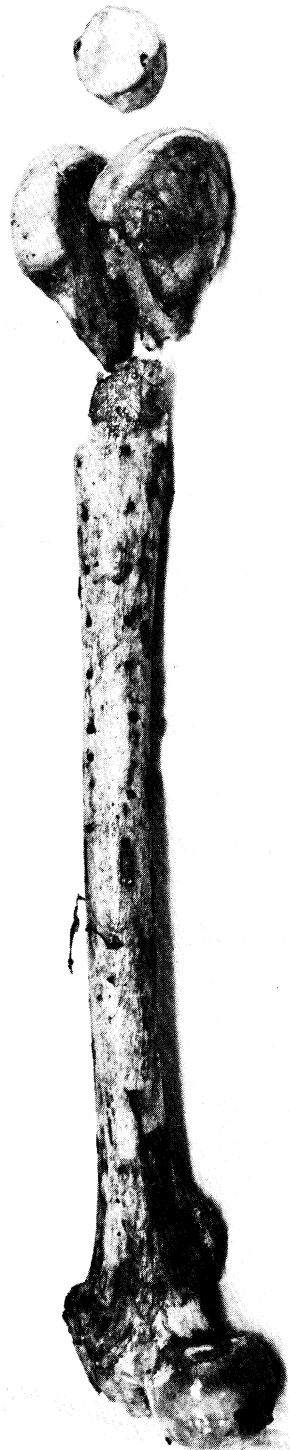
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q005-6

CADAVER NO. 20698

DATE 3-17-77

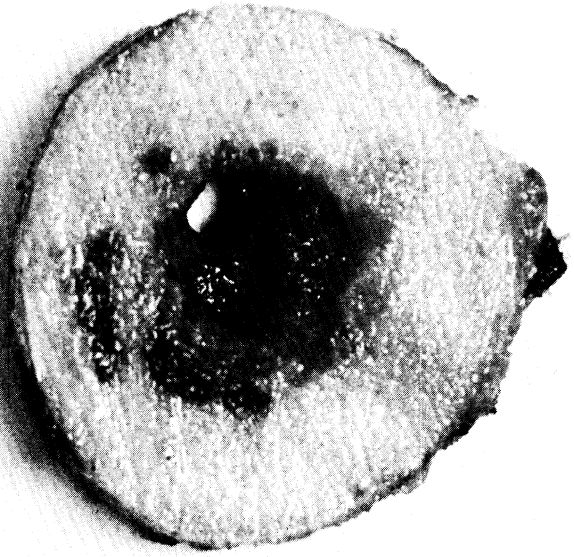




A-70

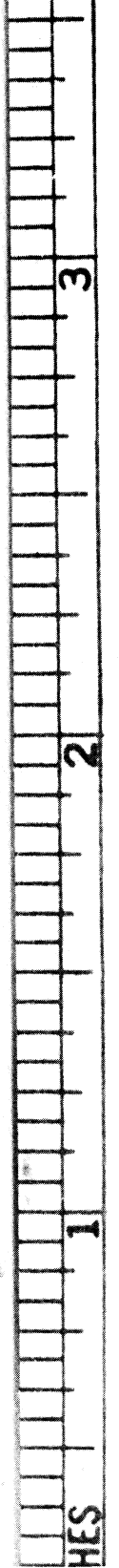
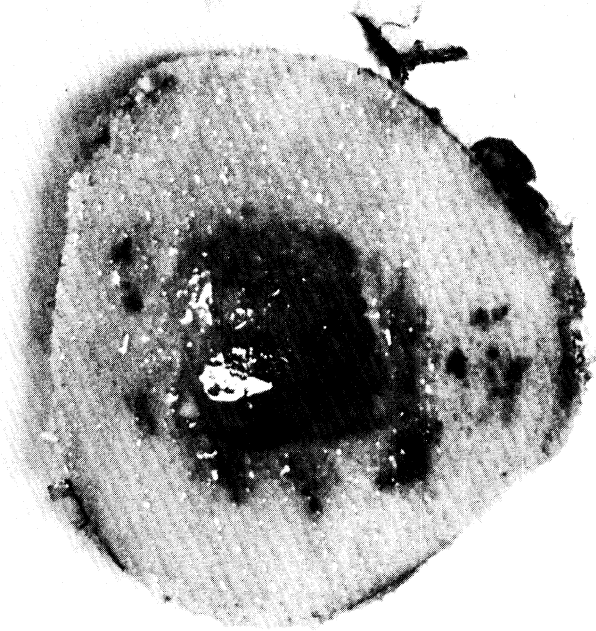
77Q005

Right



77Q006

Left



TEST SPECIFICATION

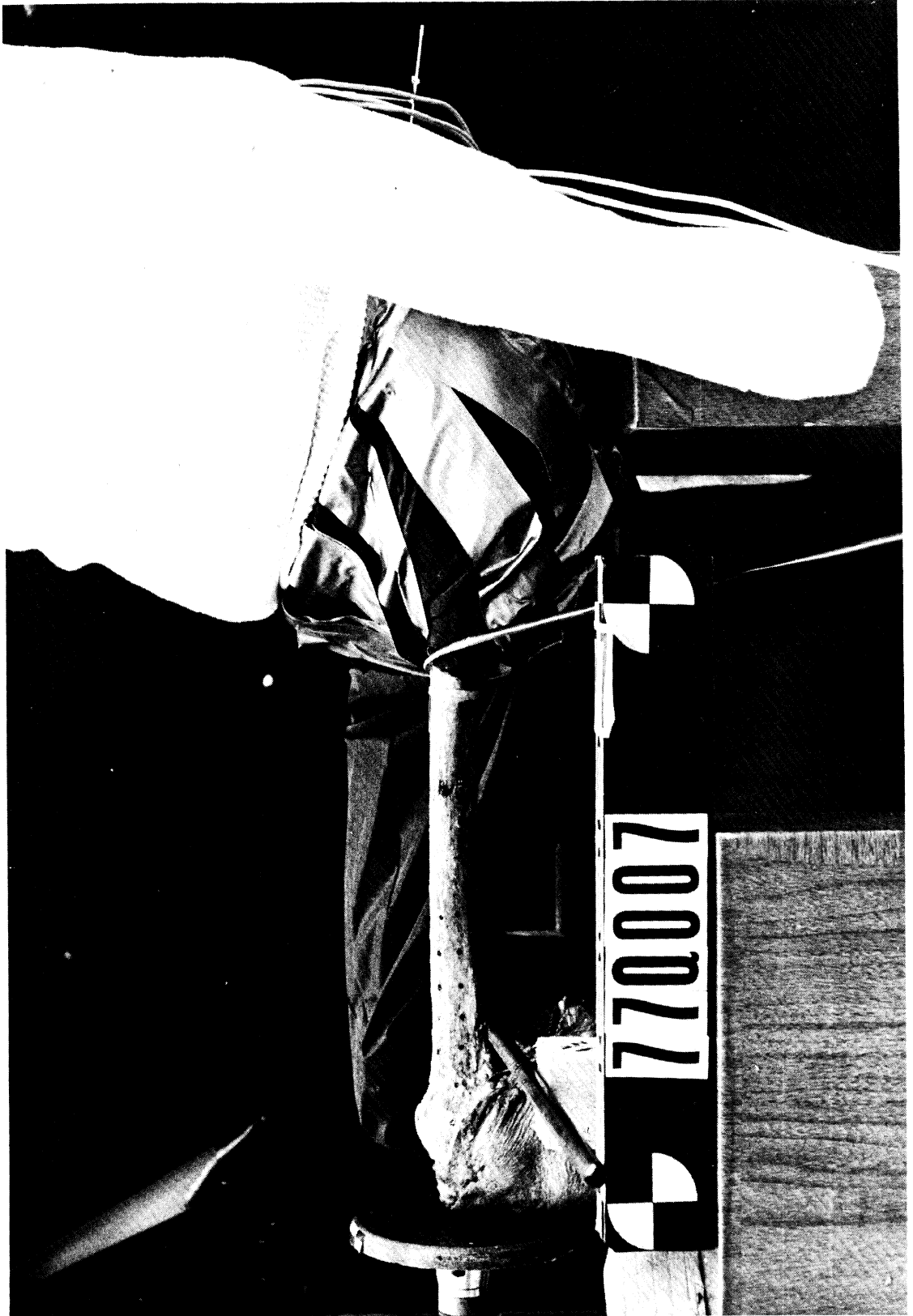
TEST NO. 77Q007 Lt.

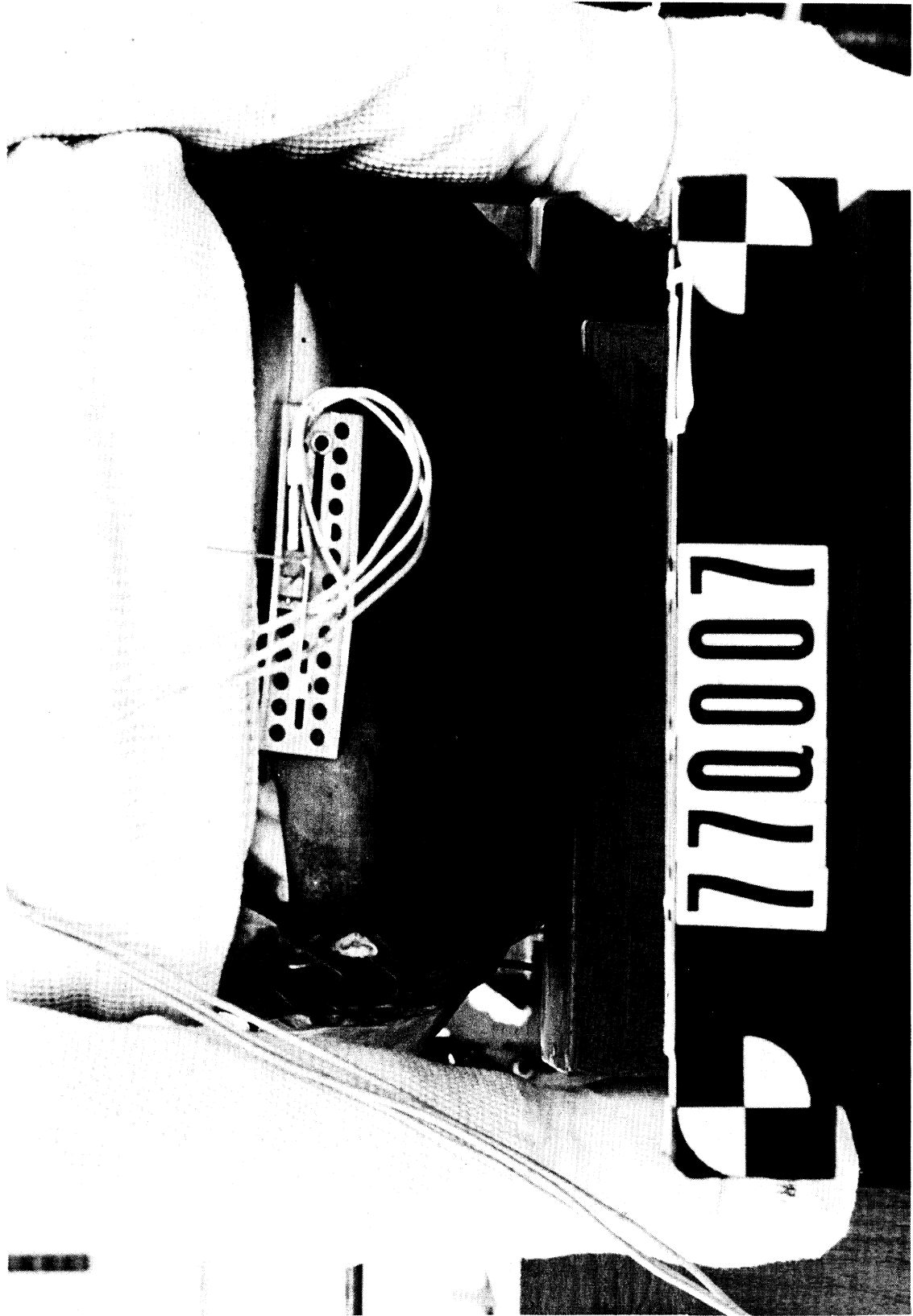
IMPACT VELOCITY 43.8 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: Tests seven and eight were performed to determine the effect of drying, flesh removal, and possible osteoporotic conditions on femur response. Cadaver 20709 was judged to be of good quality for this test. The left leg was prepared as in 77Q005. If it fractured mid-shaft and was shown not to be osteoporotic, then the right leg which had not undergone preparation, was to be tested in the identical manner. If the condyles failed, then the right leg was to be prepared as the left and run in a padded test.

The midshaft was fractured and the patella was shattered.

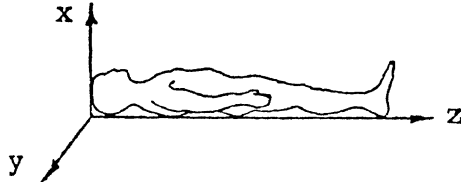




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q007-8
 Cadaver Number 20709
 Date 3-22-77

ANATOMICAL COORDINATE SYSTEM



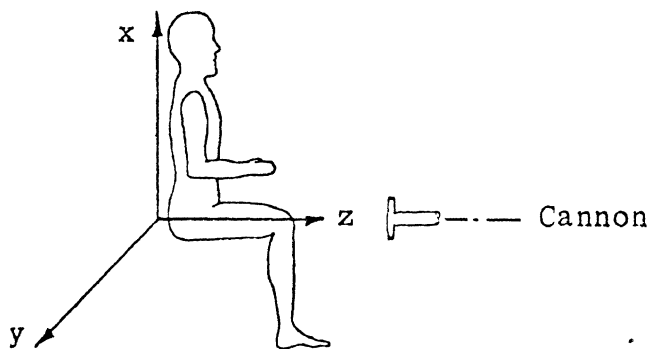
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	70.4 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
-3°	-5°	-4°

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

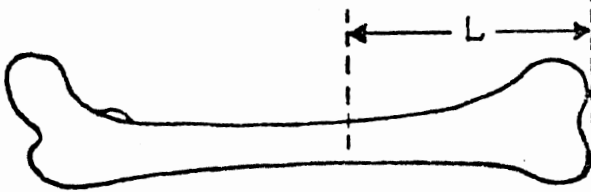
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt.Lg 77Q008	-6°	+9°	-2°
Lt.Lg 007	-5°	+8°	+7°

STRAIN GAGE LOCATIONS

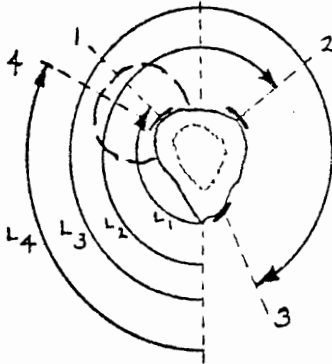
Run Numbers 77Q007-8
 Cadaver Number 20709
 Date 3-22-77

Photos of Cross Section at Strain Gages? Yes No

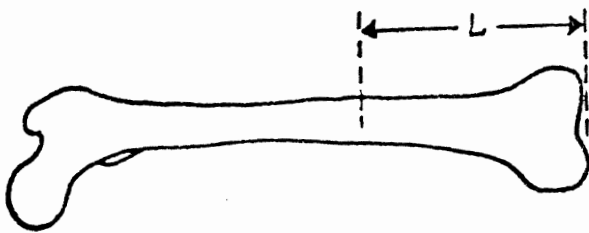
Right Leg 77Q008 No Gages



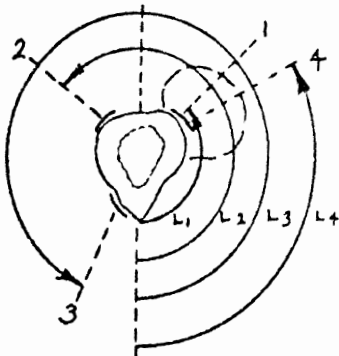
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ 2.3 cm



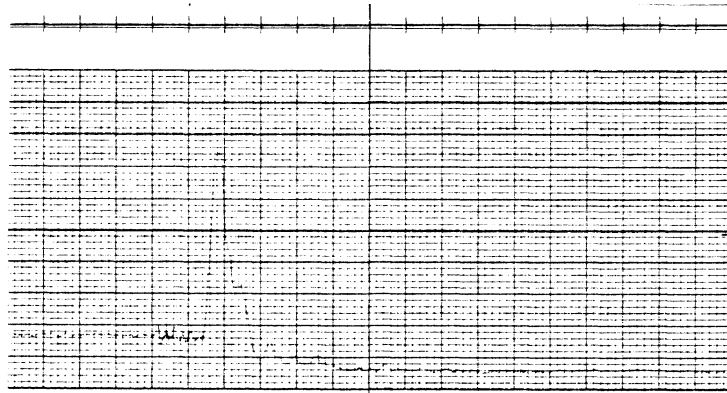
Left Leg 77Q007



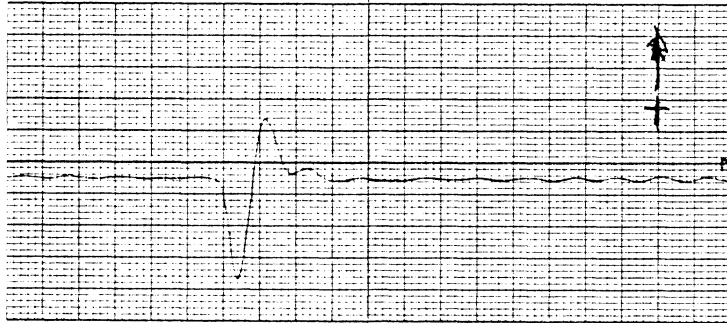
- L 23 cm
- L₁ 3.4 cm
- L₂ 5.0 cm
- L₃ 7.2 cm
- L₄ 2.2 cm



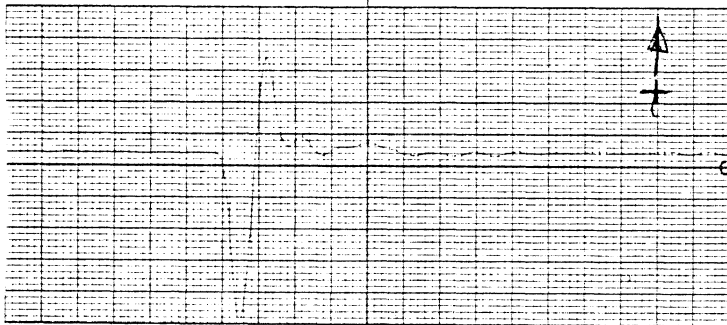
Compensated Force
1000 lbs./Division
Filtered 1650 Hz.



Pelvic Acceleration
P-A
52.75 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



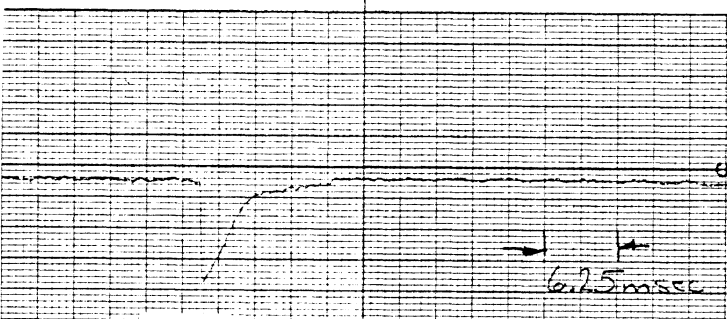
ent Systems Division

Printed in USA

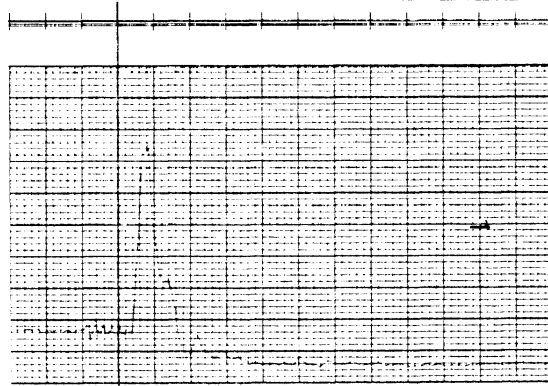
Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



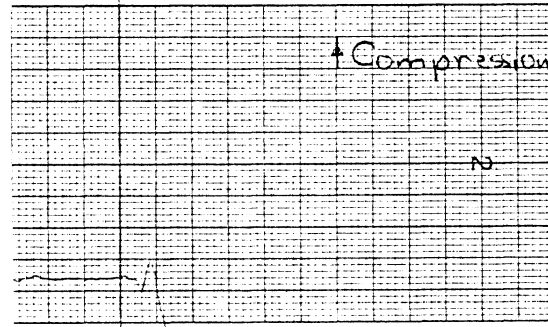
Strobe (T₀)



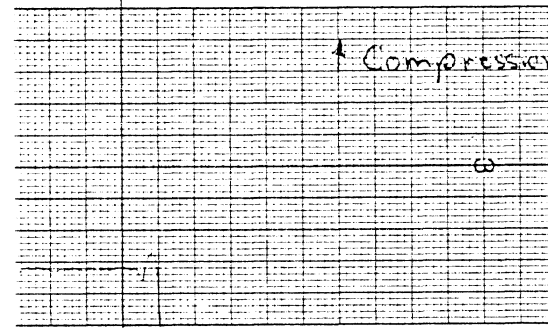
Compensated Force
1000 lbs./Division
Filtered 1650 Hz.



Femur Strain
Top (1)
2338 micro in./in./Div.
Filtered 1650 Hz.

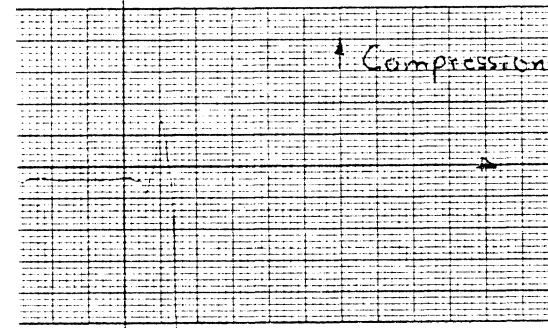


Femur Strain
Side (2)
2338 micro in./in./Div.
Filtered 1650 Hz.

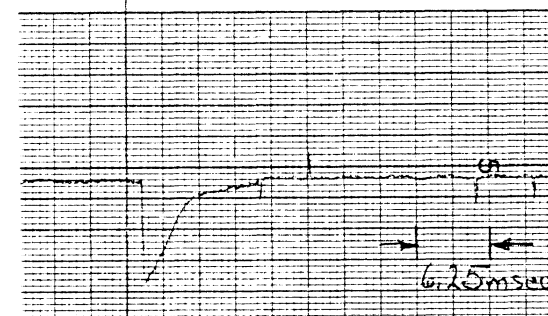


BRUSH ACCUCHA

Femur Strain
Bottom (3)
2338 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



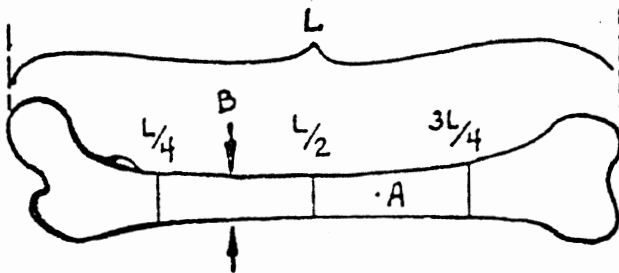
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q007-8

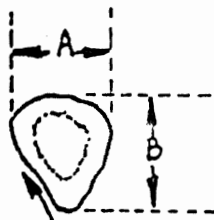
Cadaver Number 20709

Date 3-22-77

Right Leg 77Q008



L 49.2 cm



cross-section

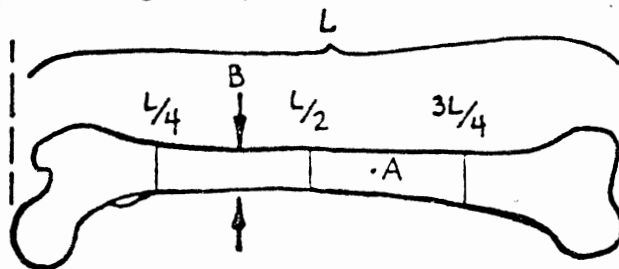
C = circumference

	A cm	B cm	C cm
L/4	3.4	3.1	10.4
L/2	3.1	3.2	10.3
3L/4	3.5	3.1	10.5

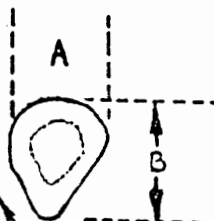
Weight of removed Anatomical Material (Rt.) 3.99 kg.

Weight of removed Femur (Rt.) 0.959 kg.

Left Leg 77Q007



L 49.6 cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4	3.5	3.1	10.5
L/2	3.1	3.2	10.3
3L/4	3.6	3.1	10.8

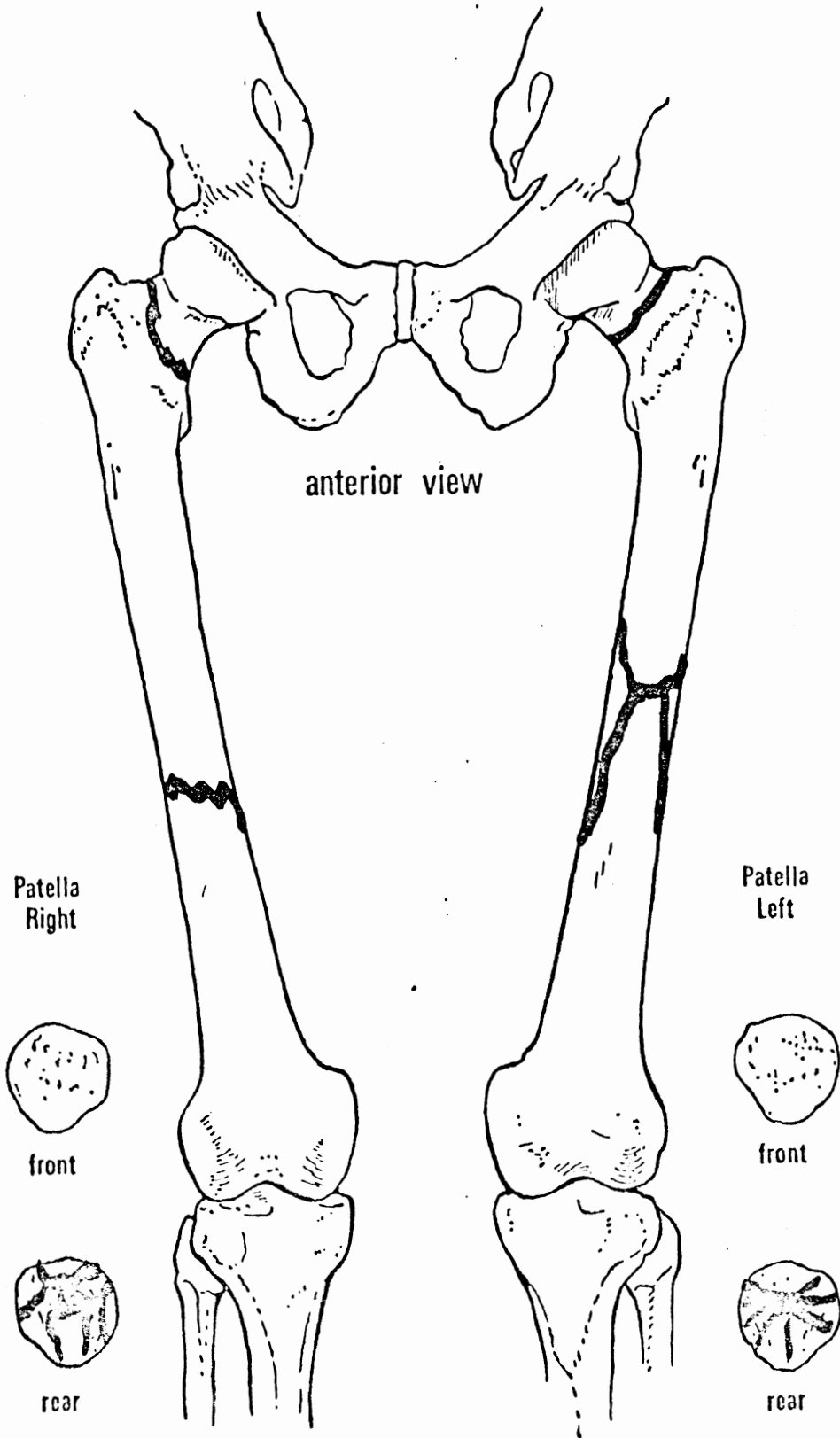
Weight of removed Anatomical Material (Lt.) 3.92 kg.

Weight of removed Femur (Lt.) 0.966 kg.

TEST NO. 77CC07-8

CADAVER NO. 20709

DATE 3-23-77



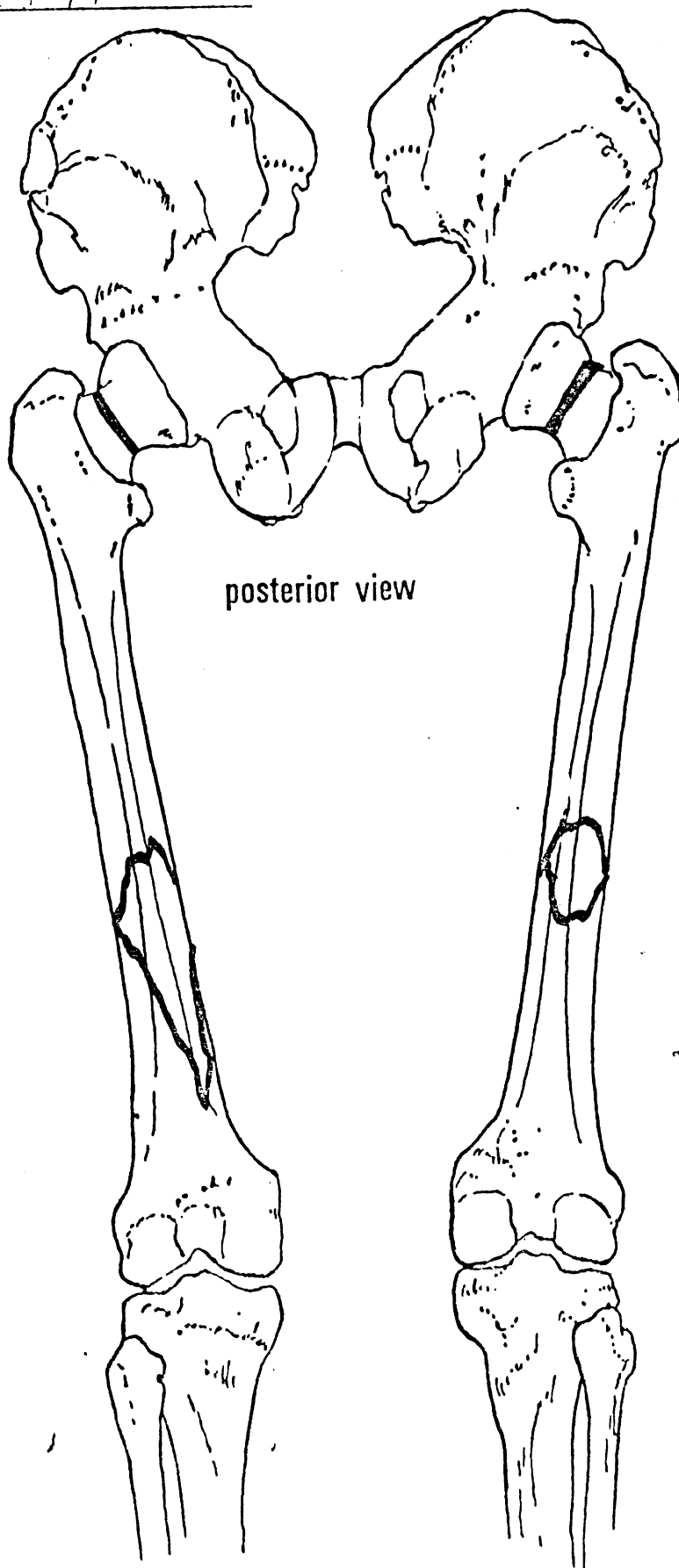
KNEE IMPACT AUTOPSY SUMMARY

corrected version
4-12-78

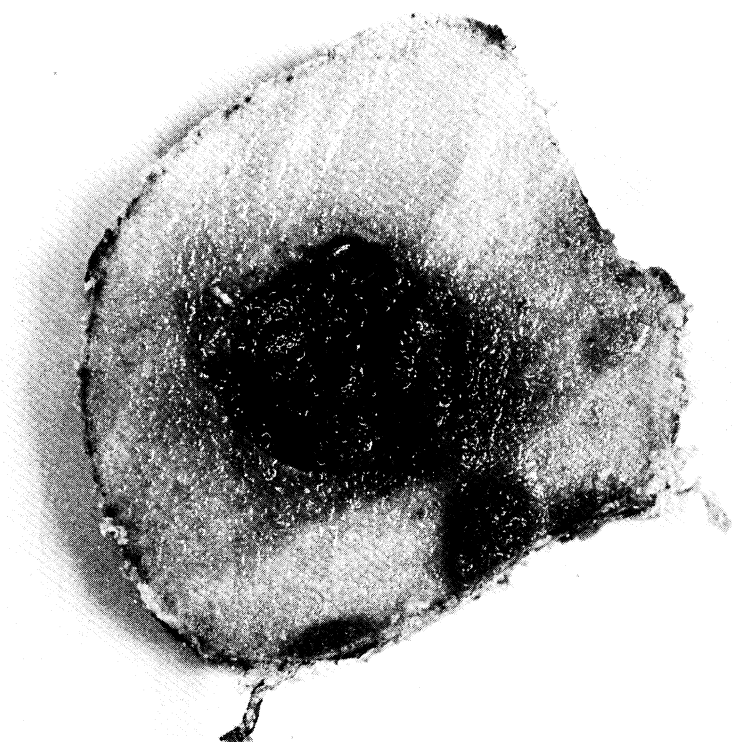
TEST NO. 77Q007-8

CADAVER NO. 20709

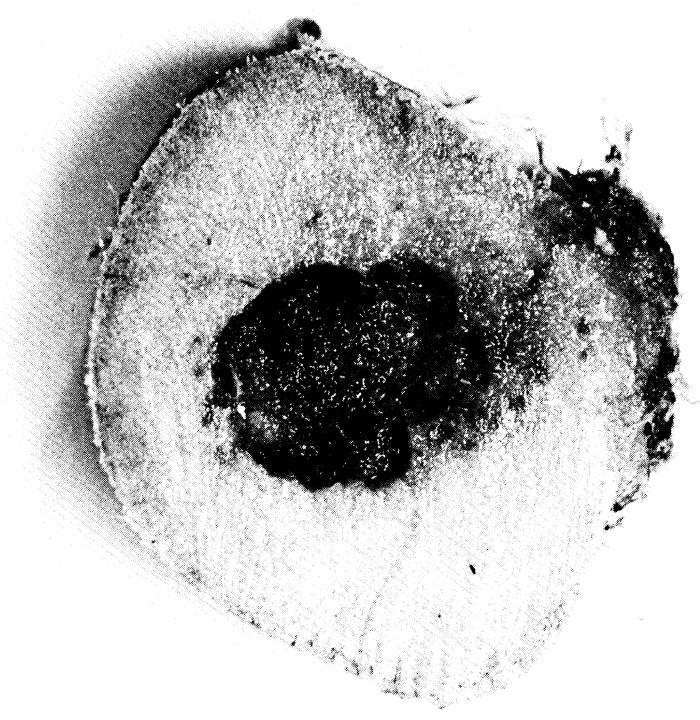
DATE 3-23-77







77Q008
Right



77Q007
Left

TEST SPECIFICATION

TEST NO. 77Q008 Rt.

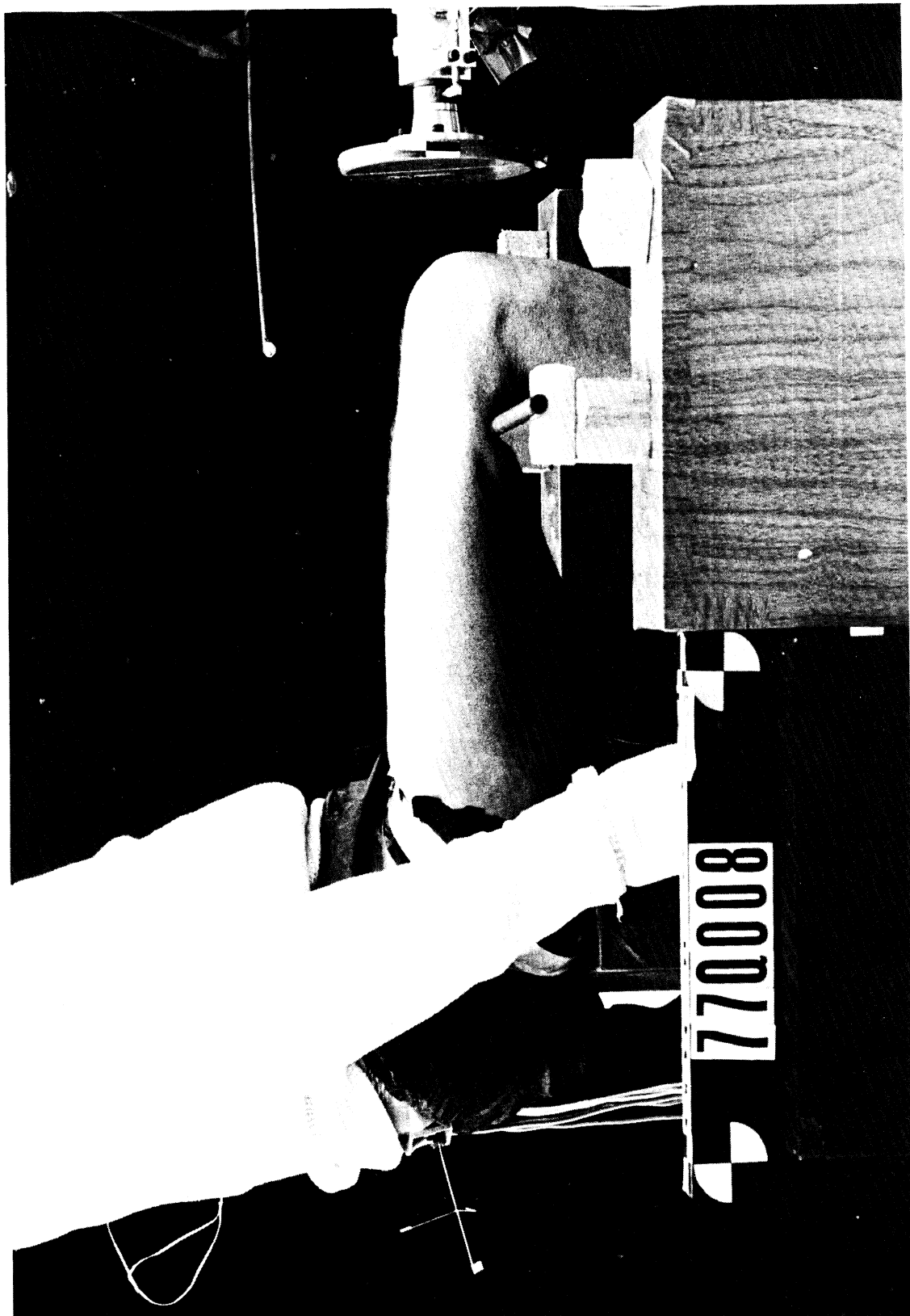
IMPACT VELOCITY 41.5 fps

TYPE OF PADDING Rigid

TEST DESCRIPTION: This test was run with the flesh left on the leg;

all else remained the same as run 77Q001.

The midshaft was fractured and the patella was shattered.

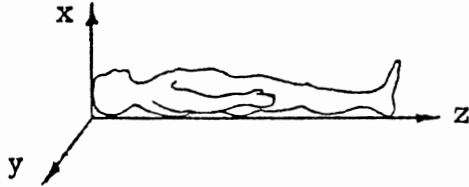




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q007-8
 Cadaver Number 20709
 Date 3-22-77

ANATOMICAL COORDINATE SYSTEM



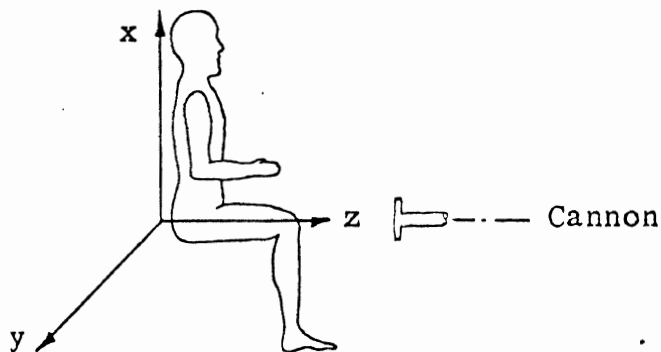
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	70.4 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
-3°	-5°	-4°

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

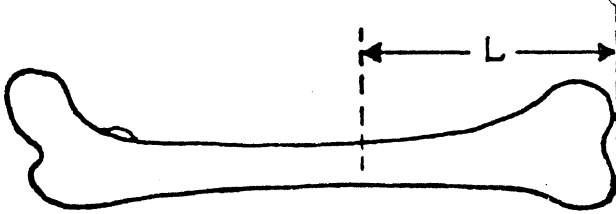
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q008	-6°	$+9^{\circ}$	-2°
Lt. Lg 77Q007	-5°	$+8^{\circ}$	$+7^{\circ}$

STRAIN GAGE LOCATIONS

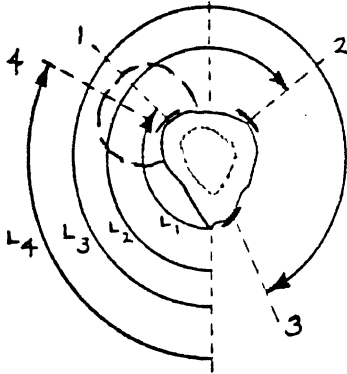
Run Numbers 77Q007-8
 Cadaver Number 20709
 Date 3-22-77

Photos of Cross Section at Strain Gages? Yes No

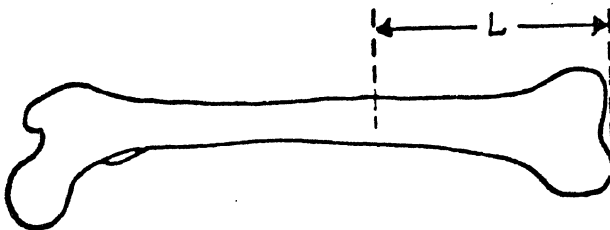
Right Leg 77Q008 No Gages



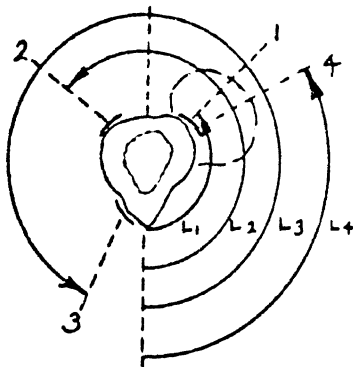
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ 2.3 cm



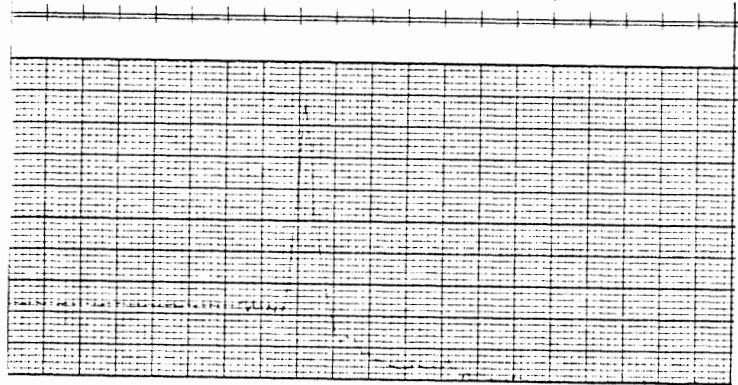
Left Leg 77Q007



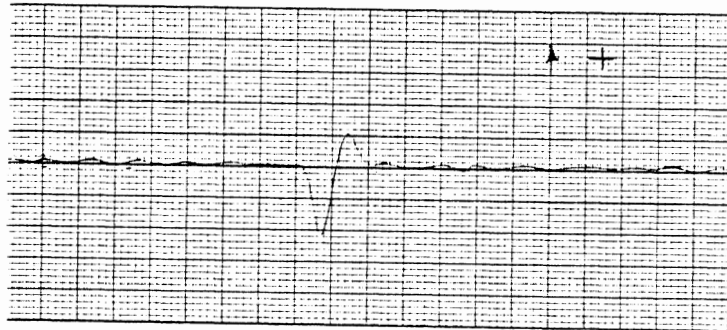
- L 2.3 cm
- L₁ 3.4 cm
- L₂ 5.0 cm
- L₃ 7.2 cm
- L₄ 2.2 cm



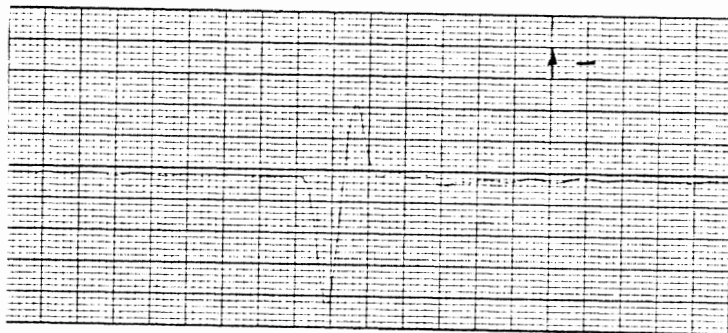
Compensated Force
/000 lbs./Division
Filtered 1650 Hz.



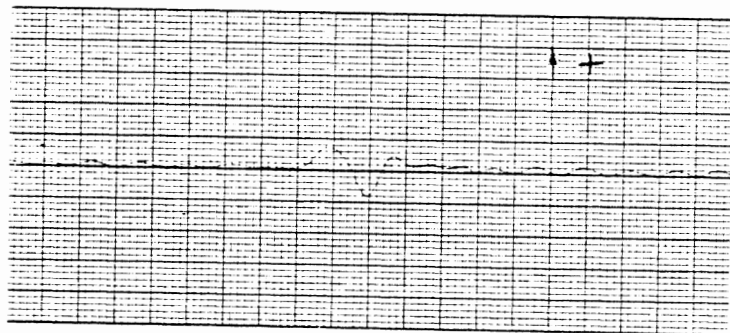
Pelvic Acceleration
P-A
52.75 G's/Division
Filtered 300 Hz.



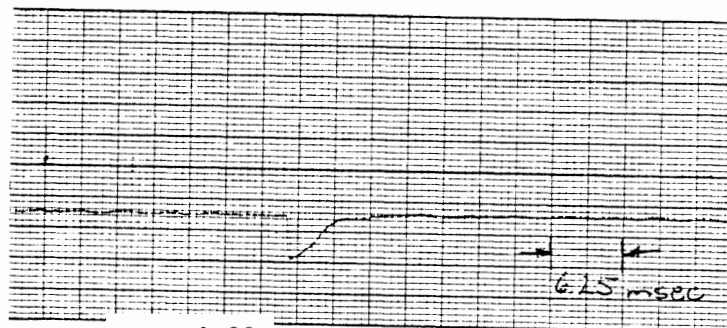
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



Strobe (T₀)



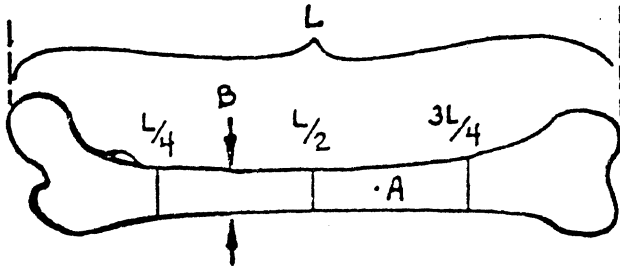
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q007-8

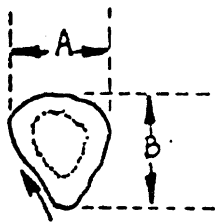
Cadaver Number 20709

Date 3-22-77

Right Leg 77Q008



L 49.2 cm



cross-section

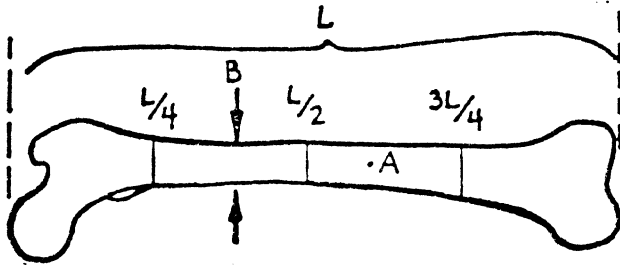
C = circumference

	A cm	B cm	C cm
L/4	3.4	3.1	10.4
L/2	3.1	3.2	10.3
3L/4	3.5	3.1	10.5

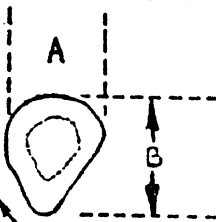
Weight of removed Anatomical Material (Rt.) 3.99 kg.

Weight of removed Femur (Rt.) 0.959 kg.

Left Leg 77Q007



L 49.6 cm



cross-section

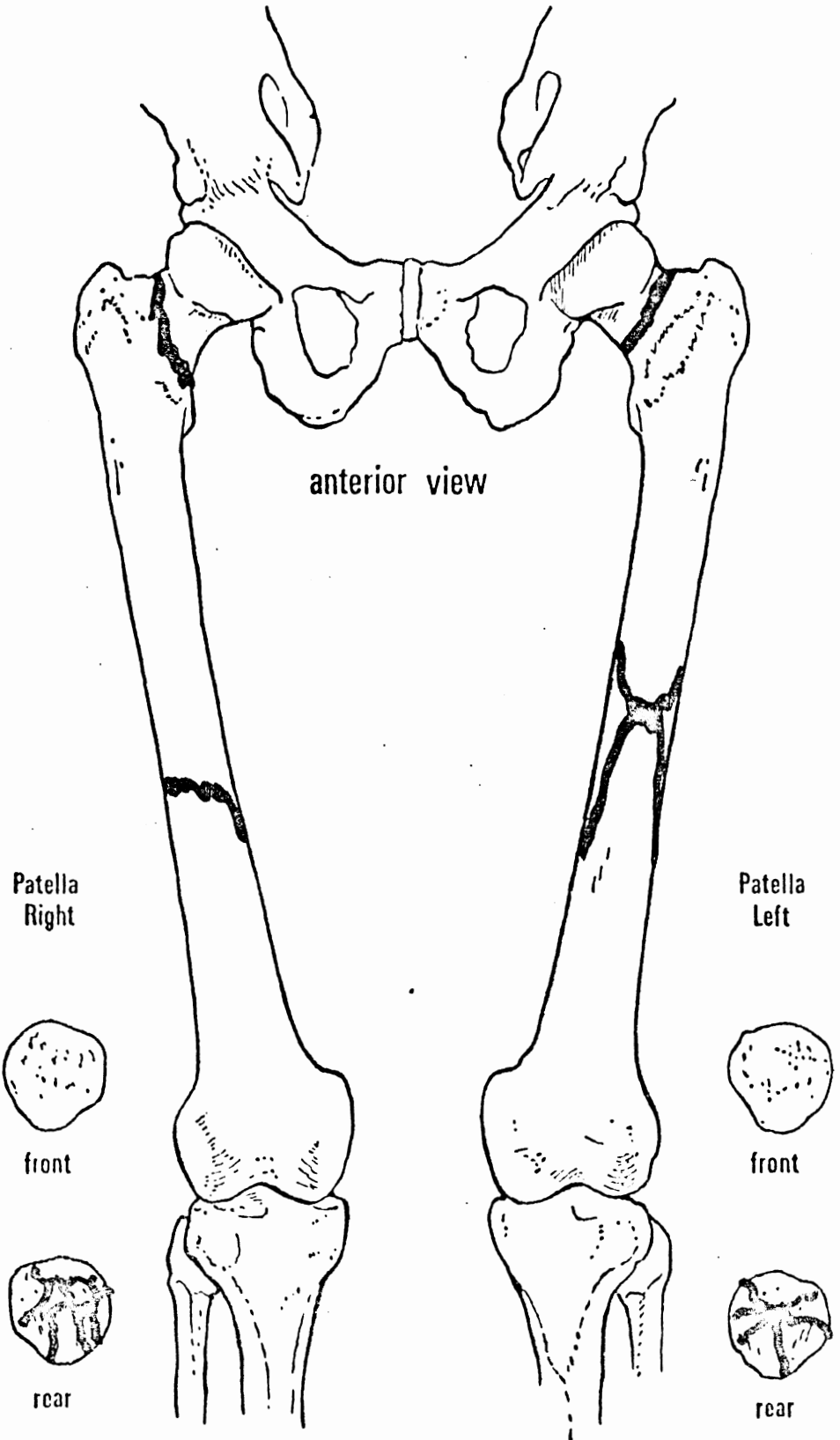
C = circumference

	A cm	B cm	C cm
L/4	3.5	3.1	10.5
L/2	3.1	3.2	10.3
3L/4	3.6	3.1	10.8

Weight of removed Anatomical Material (Lt.) 3.92 kg.

Weight of removed Femur (Lt.) 0.966 kg.

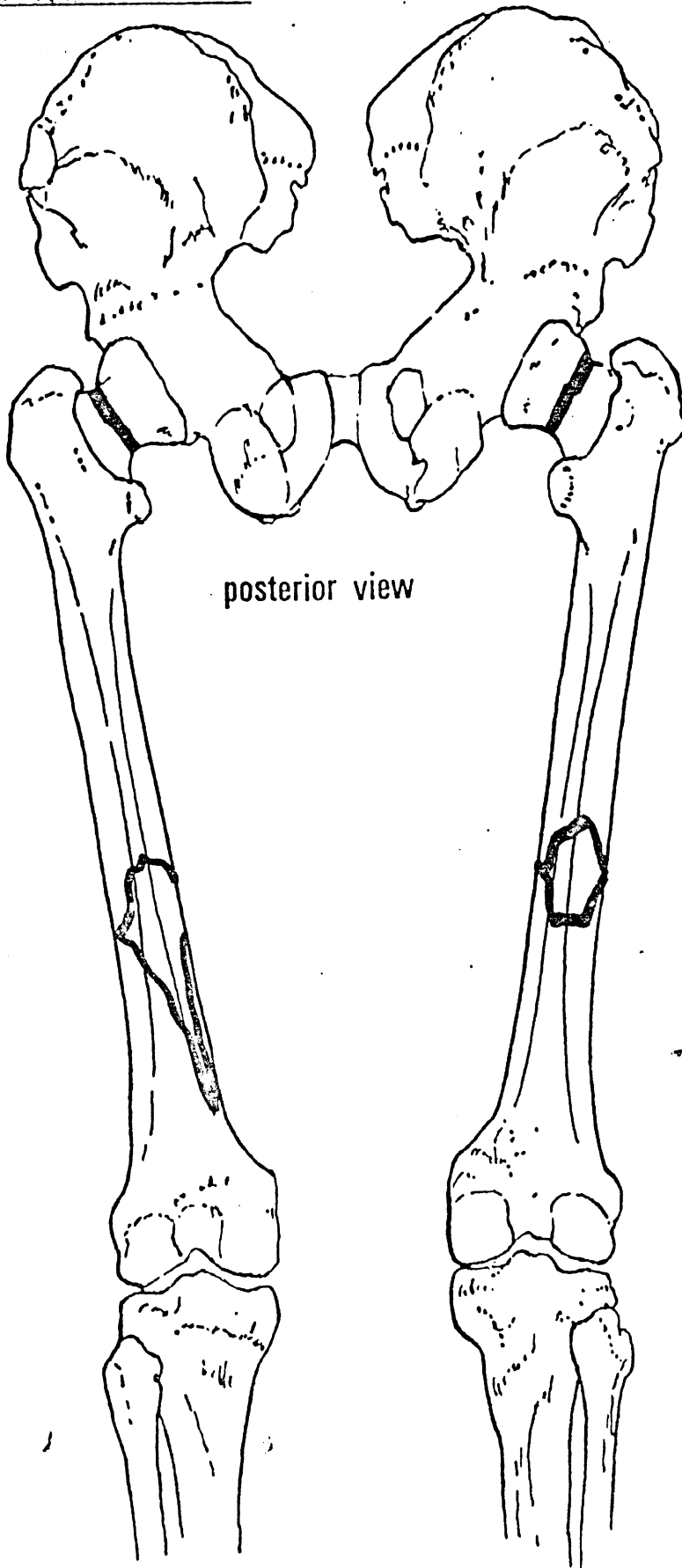
TEST NO. 77G007-8
CADAVER NO. 20707
DATE 3-23-77

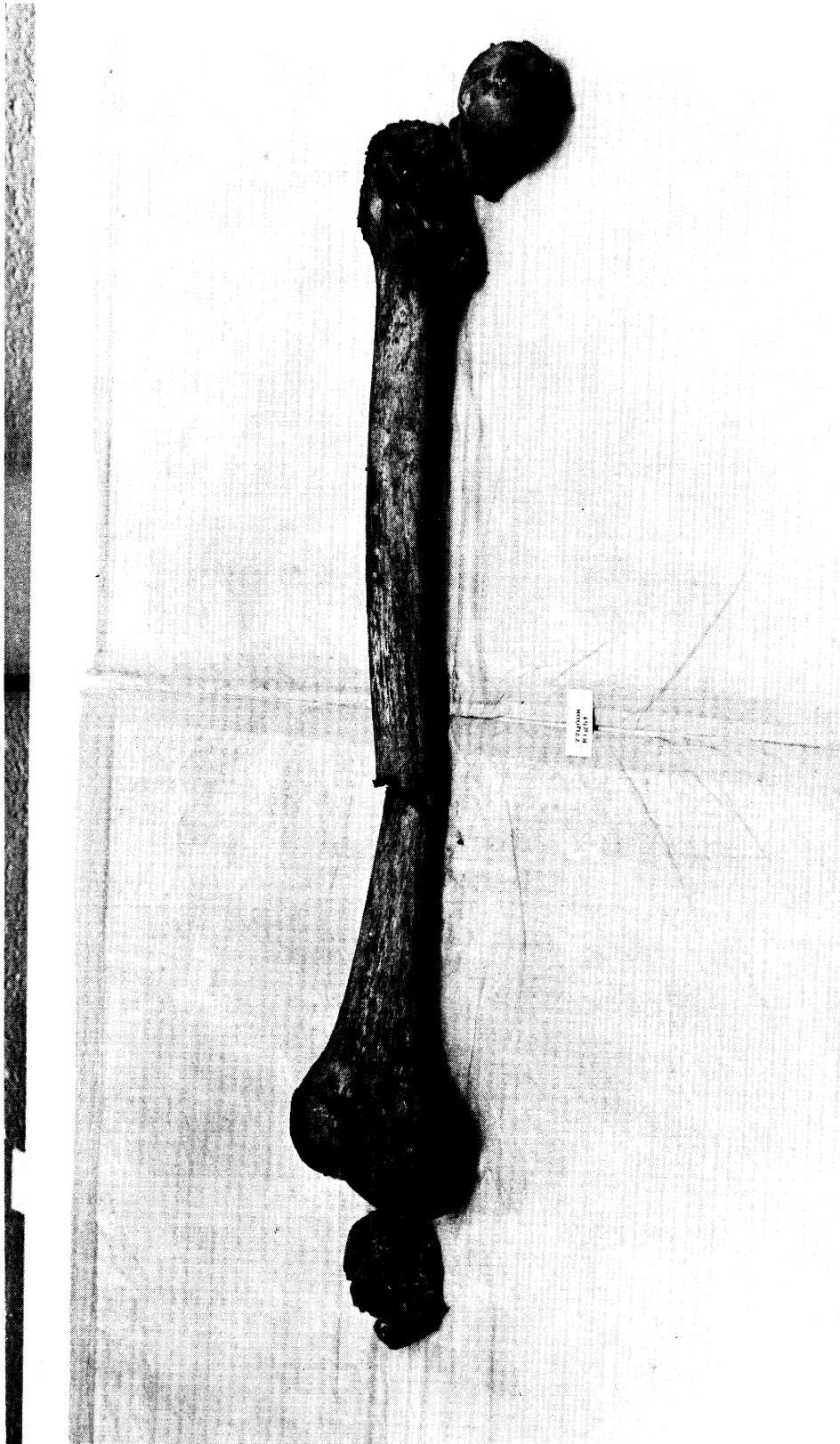


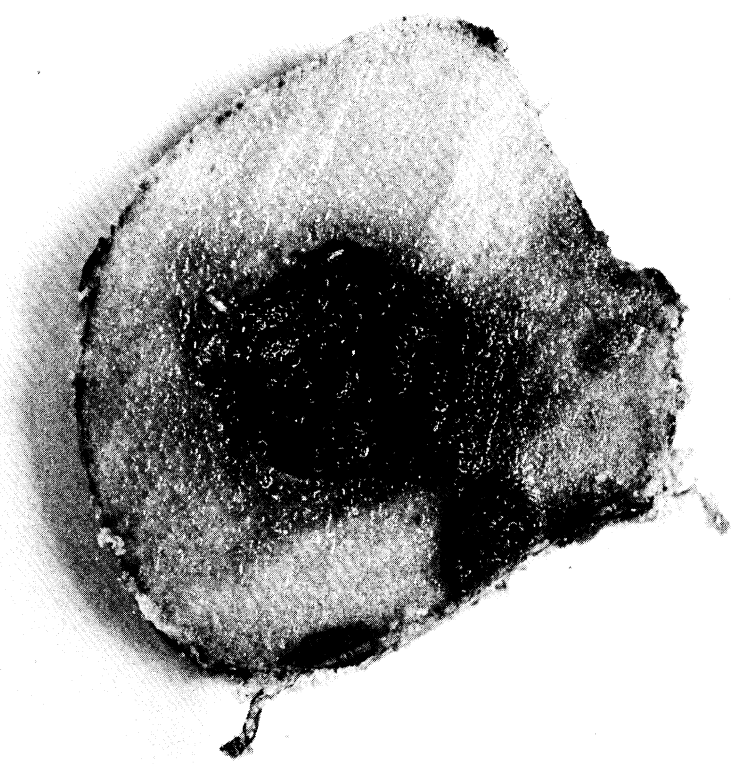
TEST NO. 770007-8

CADAVER NO. 20709

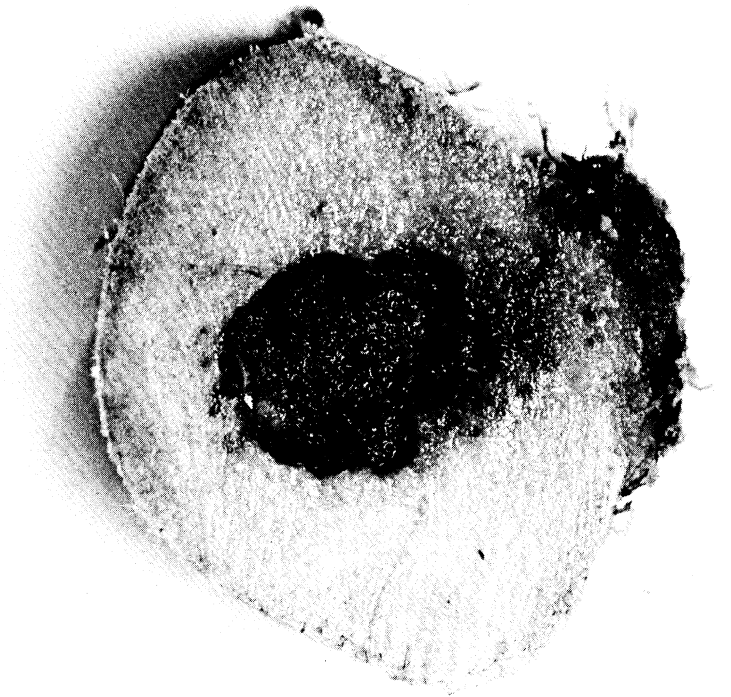
DATE 3-23-77







77Q008
Right



77Q007
Left

TEST SPECIFICATION

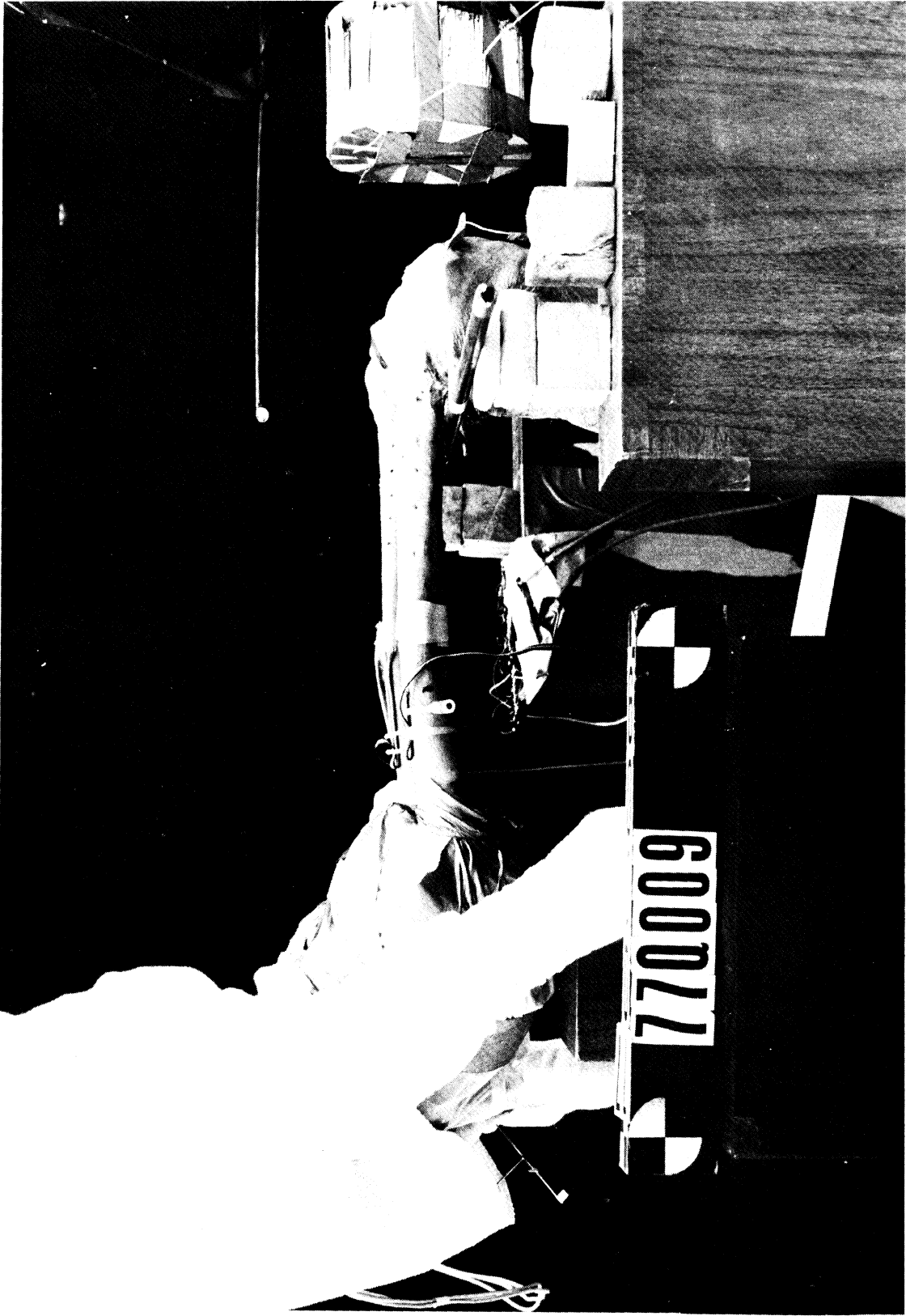
TEST NO. 77Q009 Rt.

IMPACT VELOCITY 41.0 fps

TYPE OF PADDING 2 in. Hexcel, 1/4 cell; ensolite 1 in.

TEST DESCRIPTION: Same as Test 77Q005

There were no injuries.

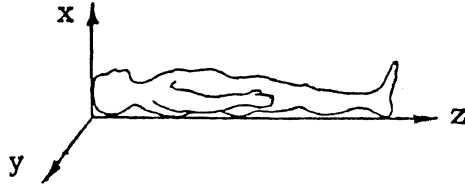




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q009-11
 Cadaver Number 207C3
 Date 3-28-77

ANATOMICAL COORDINATE SYSTEM



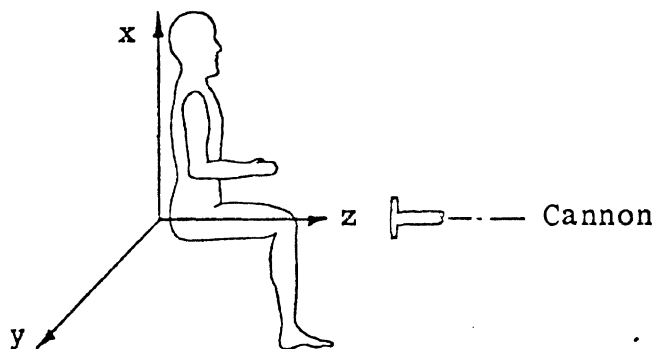
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	81.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
+4°	-3°	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

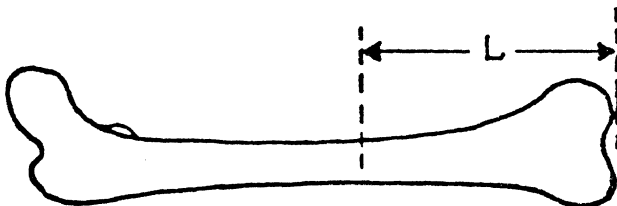
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt.Lg 77Q009	+18°	+38°	0
Lt.Lg 77Q010	+18°	+32°	-2°

STRAIN GAGE LOCATIONS

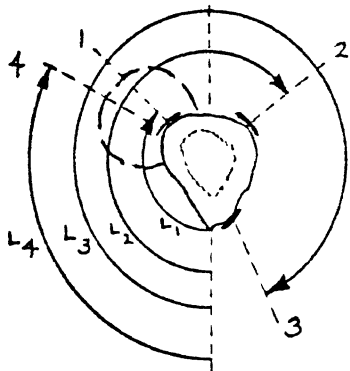
Run Numbers 77Q009-11
 Cadaver Number 20703
 Date 3-28-77

Photos of Cross Section at Strain Gages? Yes No

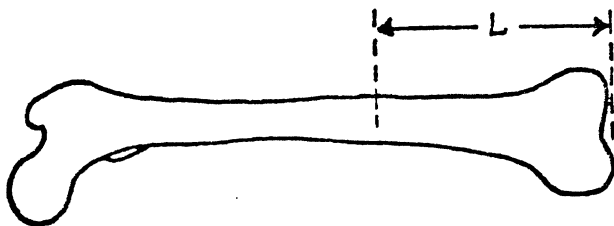
Right Leg 77Q009



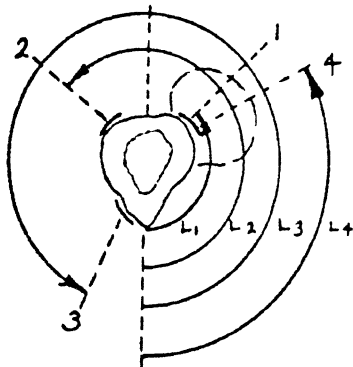
L 24 cm
 L₁ 3.3 cm
 L₂ 6.7 cm
 L₃ 10.0 cm
 L₄ 2.3 cm



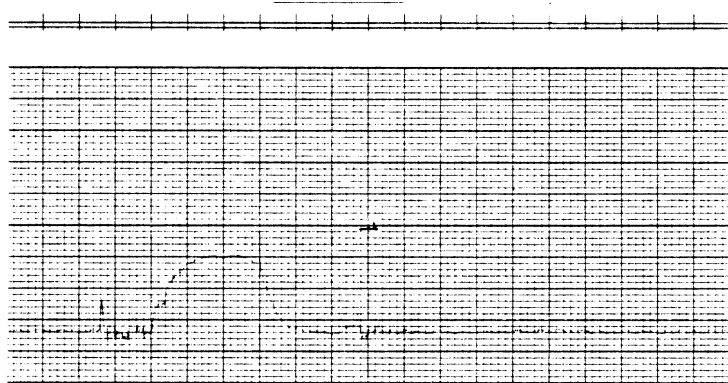
Left Leg 77Q010



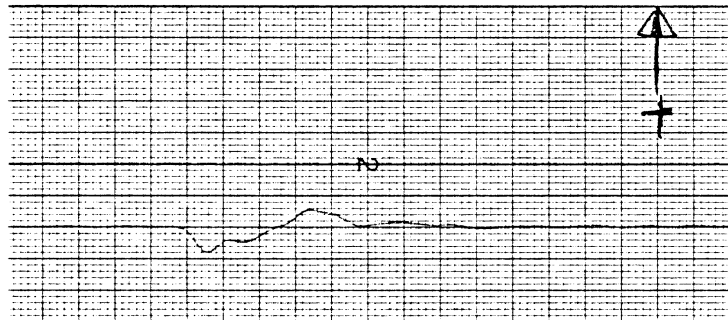
L 20 cm
 L₁ 3.2 cm
 L₂ 6.2 cm
 L₃ 10.0 cm
 L₄ 2.4 cm



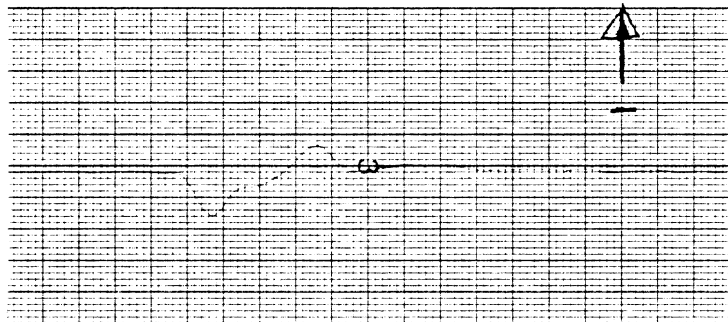
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



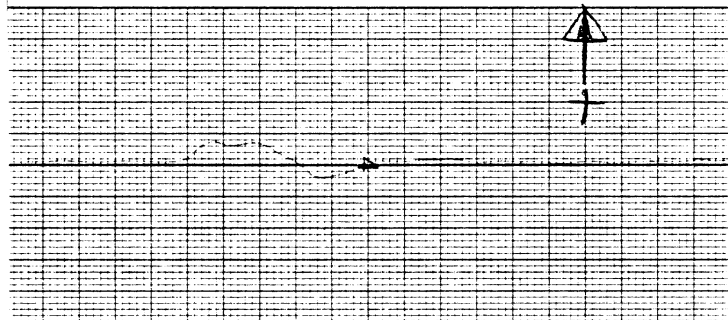
Pelvic Acceleration
P-A
52.78 G's/Division
Filtered 300 Hz.



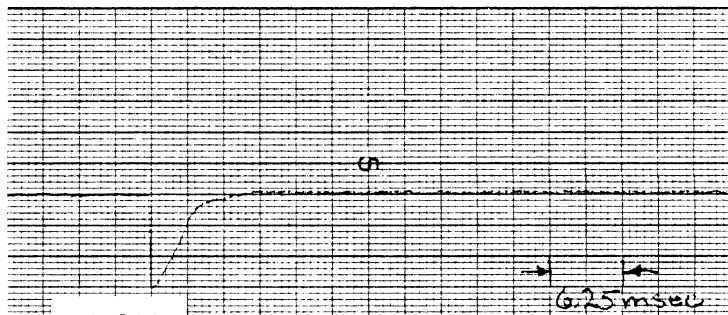
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



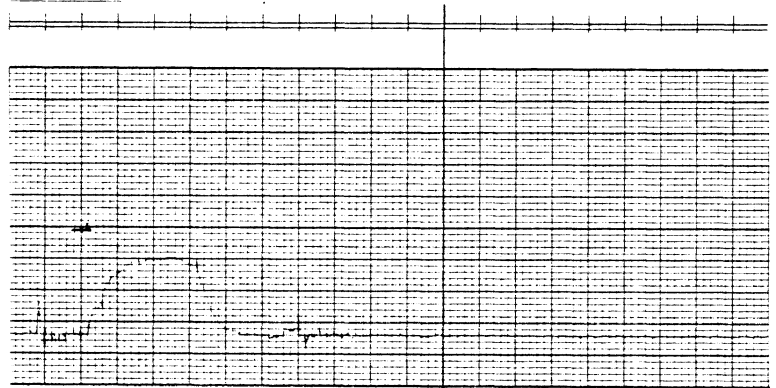
Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



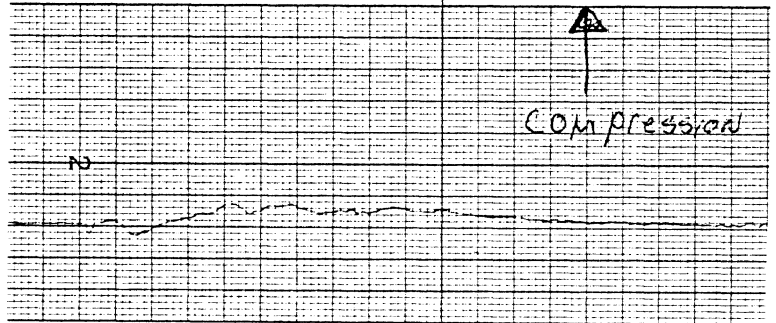
Strobe (T₀)



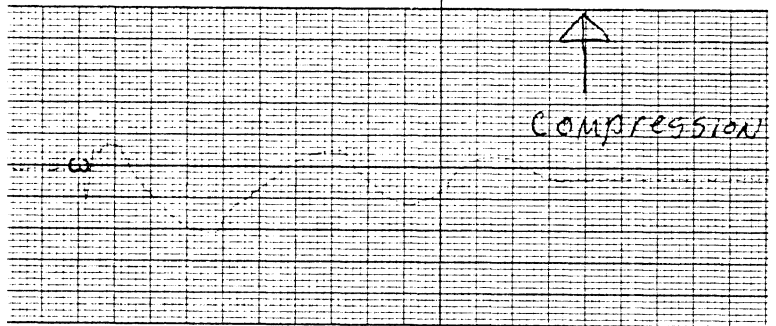
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



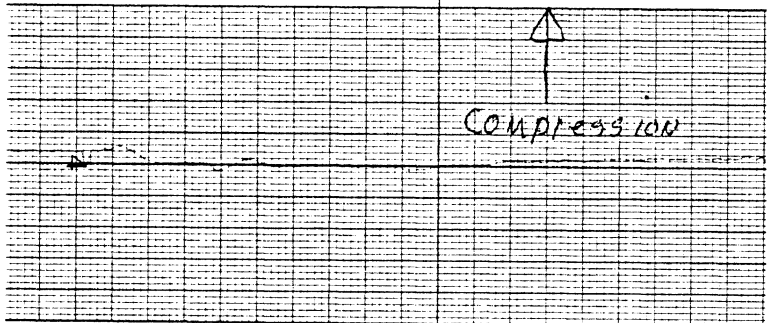
Femur Strain
Top (1)
2338 micro in./in./Div.
Filtered 1650 Hz.



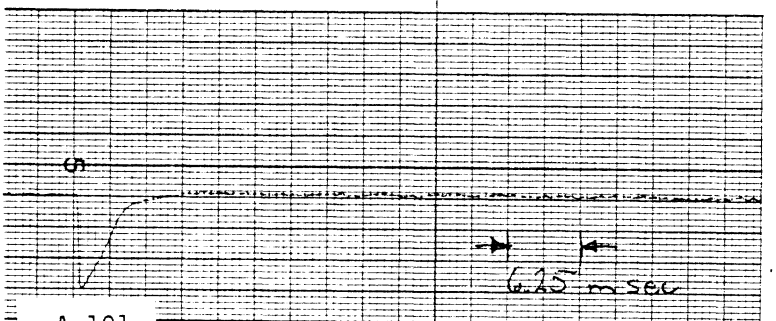
Femur Strain
Side (2)
2338 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Bottom (3)
2450.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



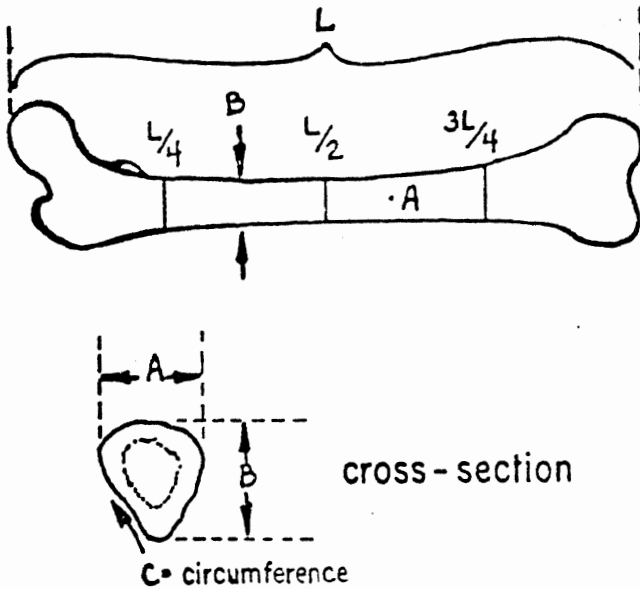
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q009-11

Cadaver Number 20703

Date 3-29-77

Right Leg 77Q009



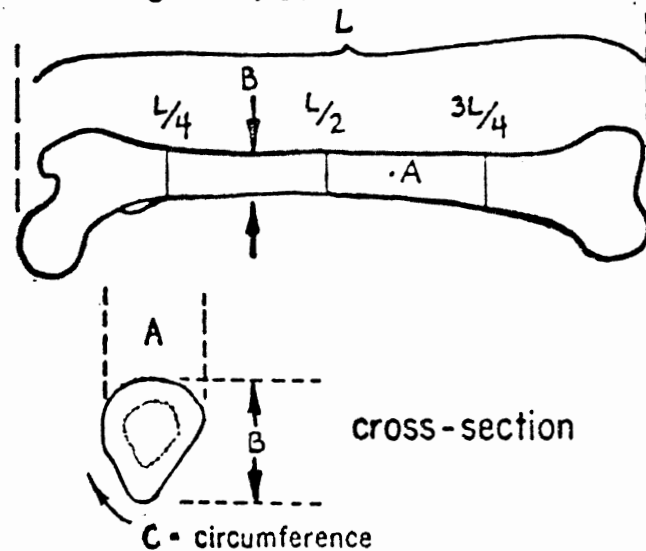
L 51.4 cm

	A cm	B cm	C cm
L/4	3.4	3.8	12
L/2	3.2	3.7	11.5
3L/4	4.2	3.5	12.9

Weight of removed Anatomical Material (Rt.) 2.29 kg.

Weight of removed Femur (Rt.) 1.14 kg.

Left Leg 77Q010



L 51.2 cm

	A cm	B cm	C cm
L/4	3.6	3.8	12.3
L/2	3.4	3.9?	12.9?
3L/4	4.3	3.5	12.7

Abnormal
Bump

Weight of removed Anatomical Material (Lt.) 2.33 kg.

Weight of removed Femur (Lt.) 1.18 kg.

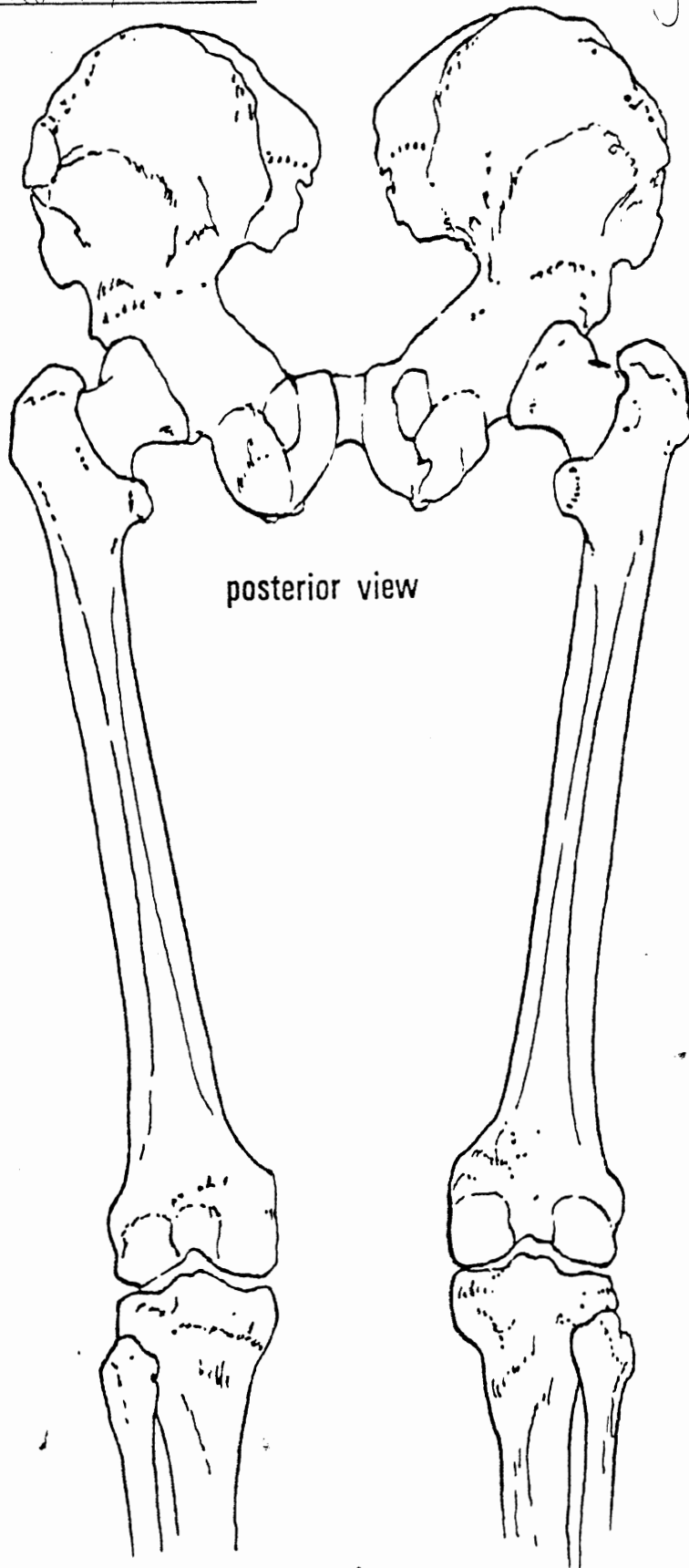
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77000 9-11

CADAVER NO. 20703

DATE 3-28-77

No Damage



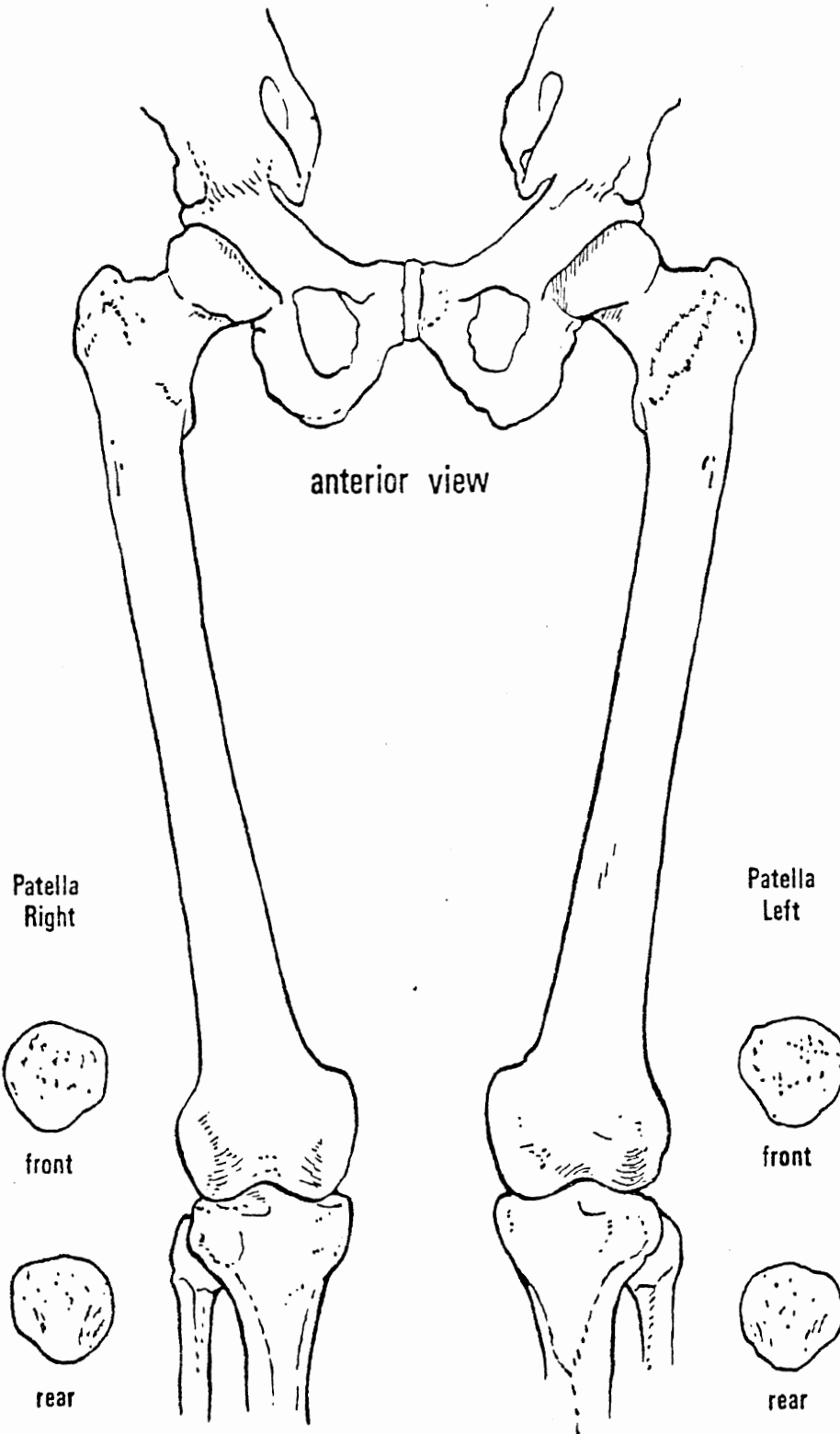
KNEE IMPACT AUTOPSY SUMMARY

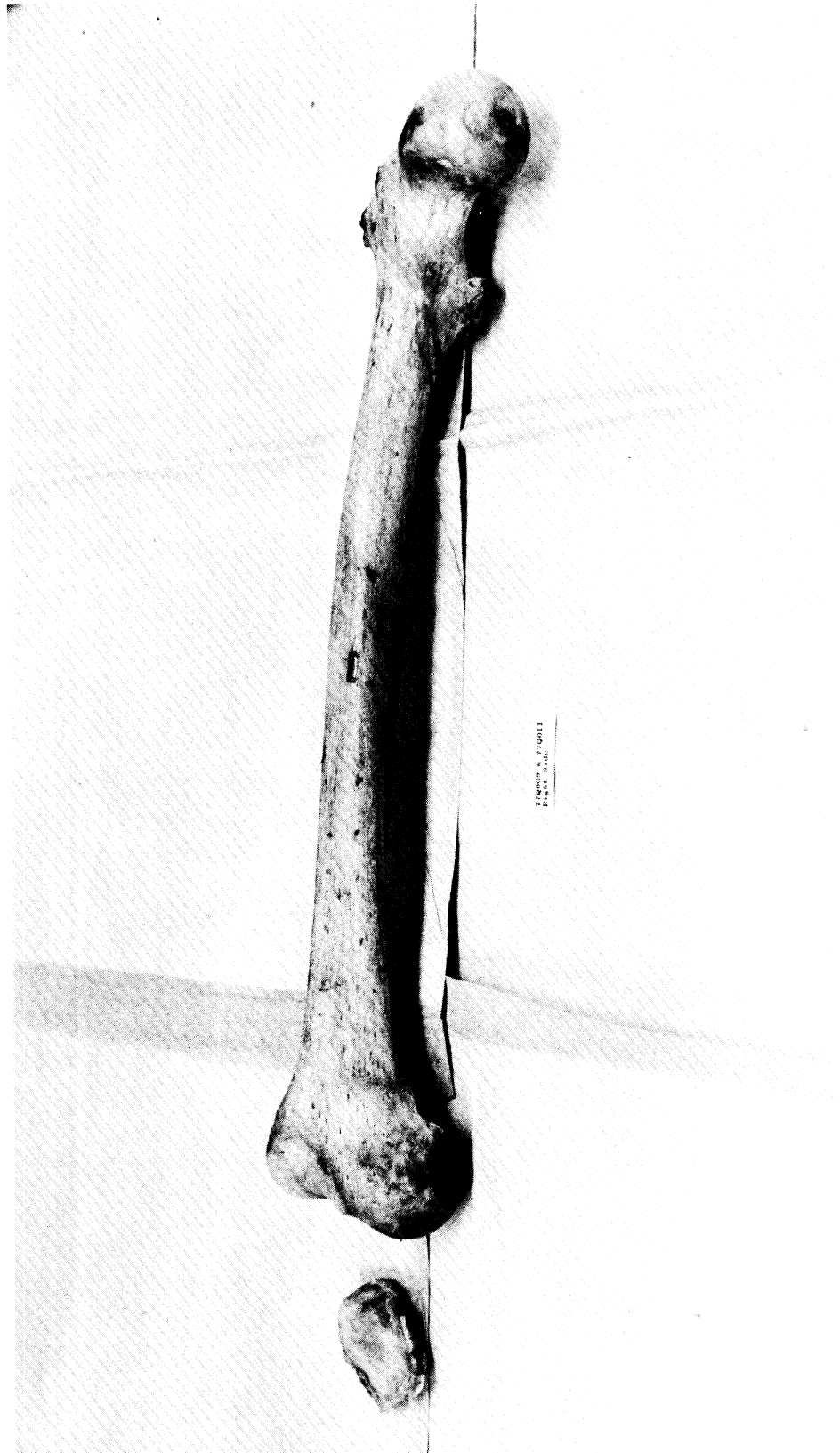
TEST NO. 77Q009-11

CADAVER NO. 20703

DATE 3-28-77

No Damage





A-105

TEST SPECIFICATION

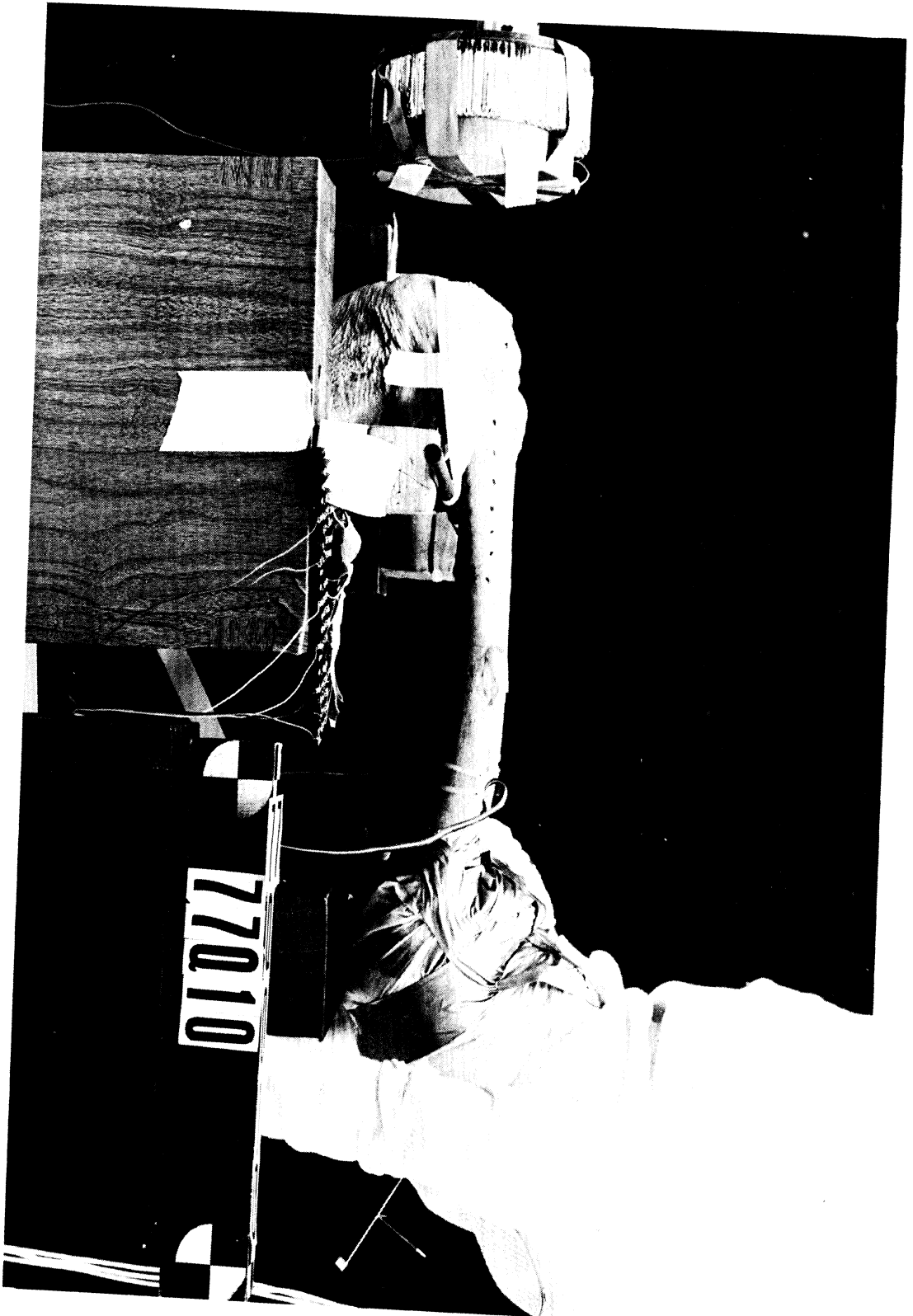
TEST NO. 77Q010 Lt.

IMPACT VELOCITY 40.7 fps

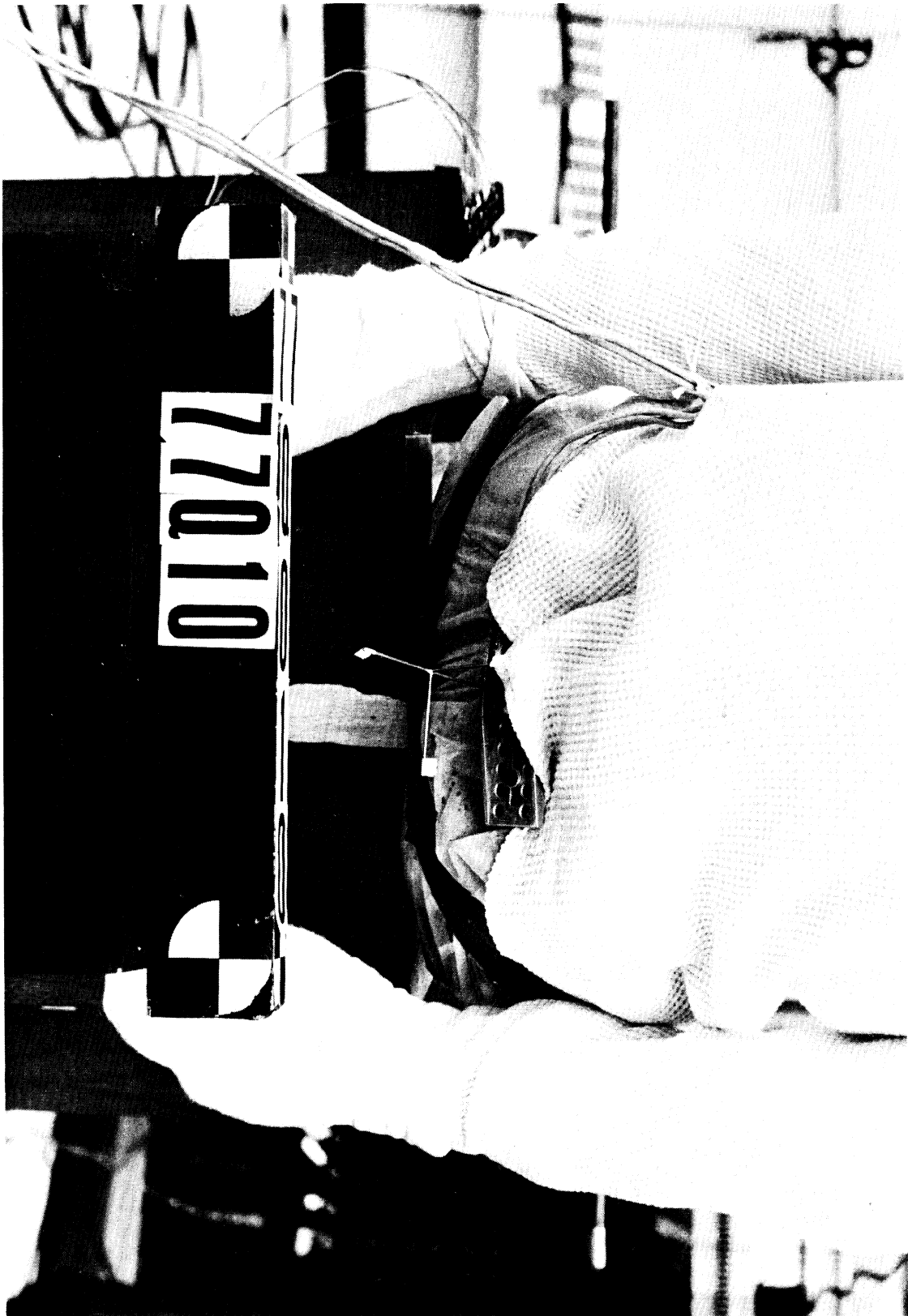
TYPE OF PADDING 2 in. Hexcel, 3/16 cell; Ensolite 1 in.

TEST DESCRIPTION: Same as Test 77Q005

There were no injuries.



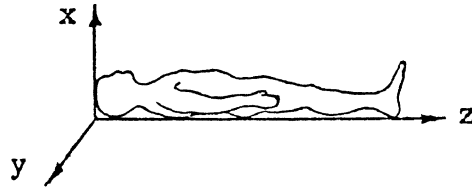
A-107



ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q009-11
 Cadaver Number 20703
 Date 3-28-77

ANATOMICAL COORDINATE SYSTEM



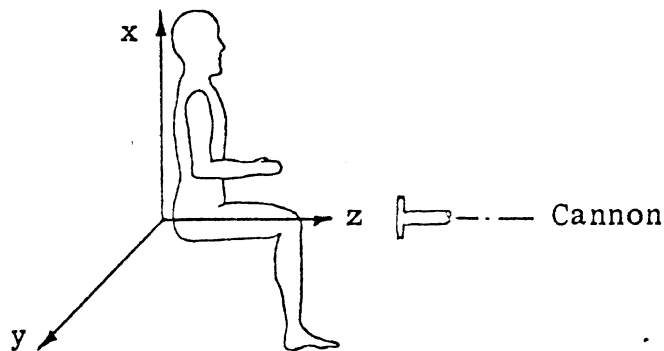
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	81.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
+ 4°	- 3°	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

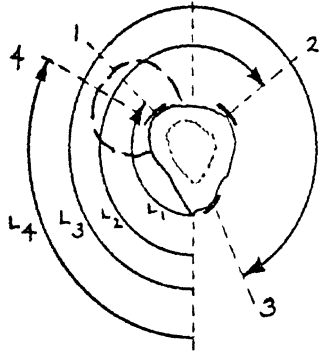
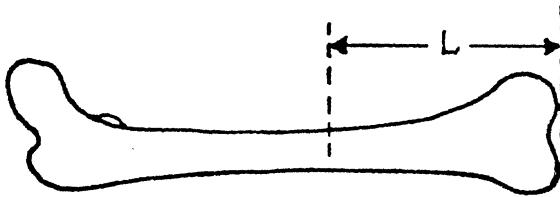
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q009	+ 18°	+ 38°	0
Lt. Lg 77Q010	+ 18°	+ 32°	- 2°

STRAIN GAGE LOCATIONS

Run Numbers 77Q009-11
 Cadaver Number 20703
 Date 3-29-77

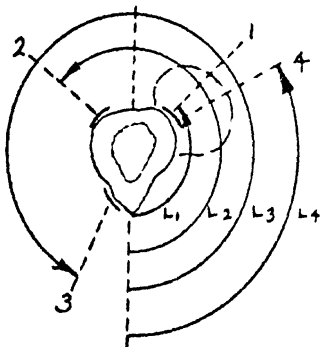
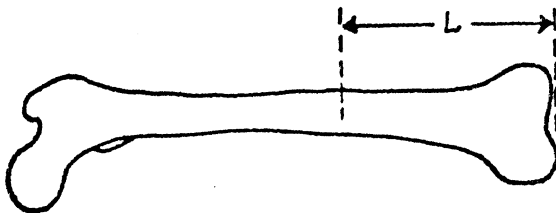
Photos of Cross Section at Strain Gages? Yes No ✓

Right Leg 77Q009



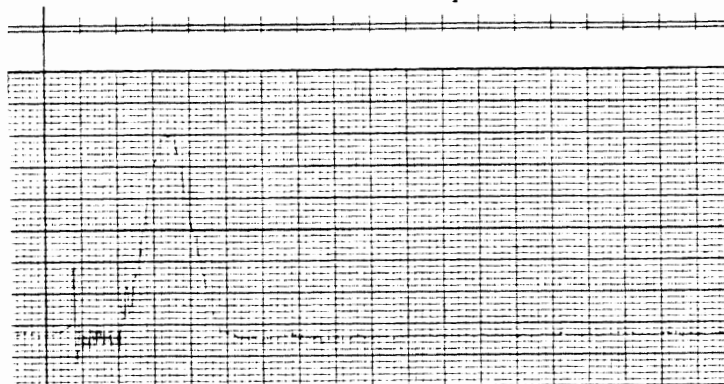
L 24 cm
 L₁ 3.3 cm
 L₂ 6.7 cm
 L₃ 10.0 cm
 L₄ 2.3 cm

Left Leg 77Q010

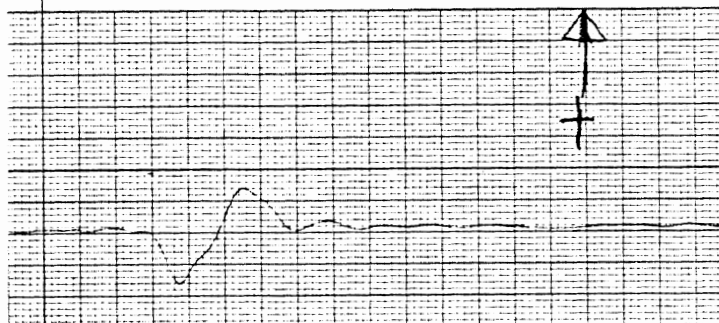


L 20 cm
 L₁ 3.2 cm
 L₂ 6.2 cm
 L₃ 10.0 cm
 L₄ 2.4 cm

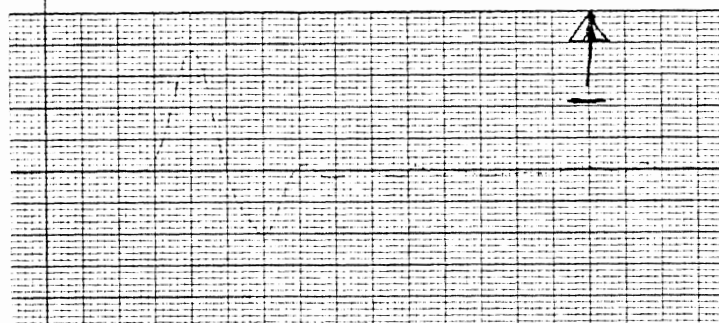
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



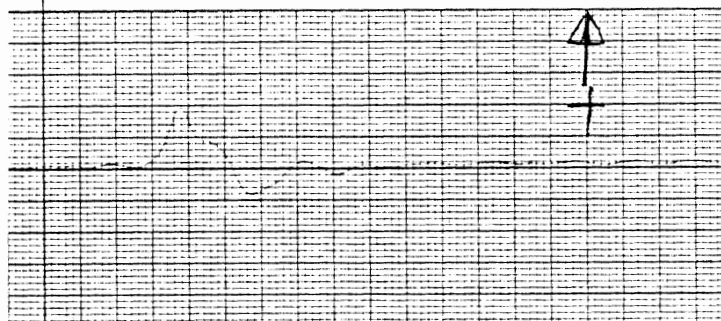
Pelvic Acceleration
P-A
52.75 G's/Division
Filtered 300 Hz.



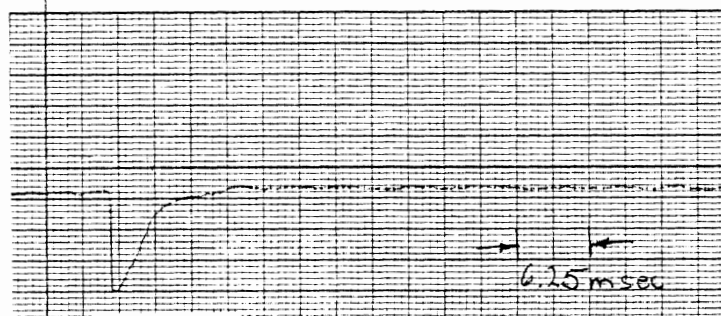
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



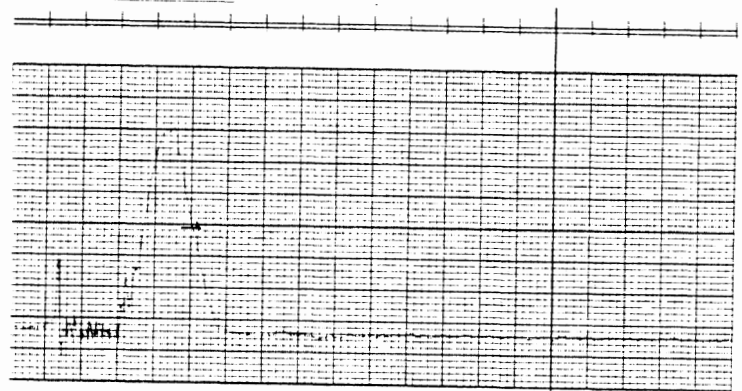
Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



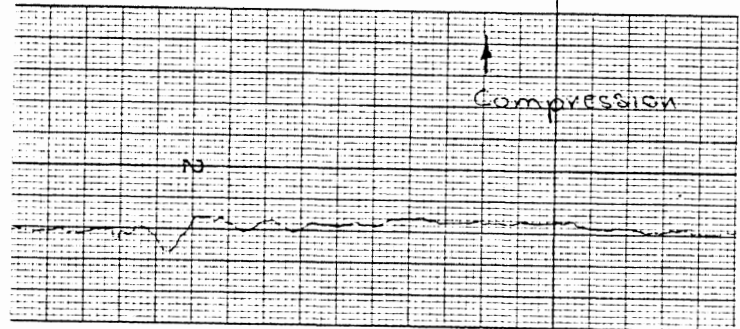
Strobe (T₀)



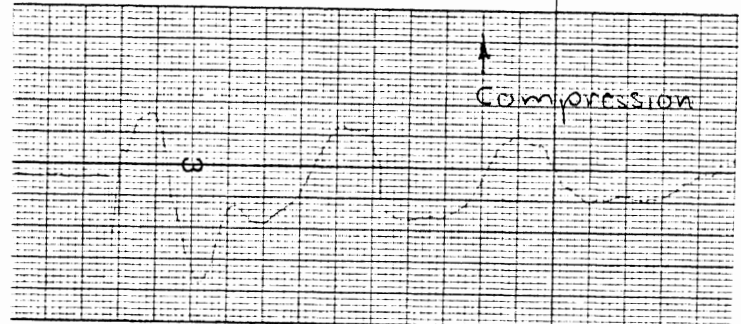
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



Femur Strain
Top (1)
2338 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Side (2)
2338 micro in./in./Div.
Filtered 1650 Hz.

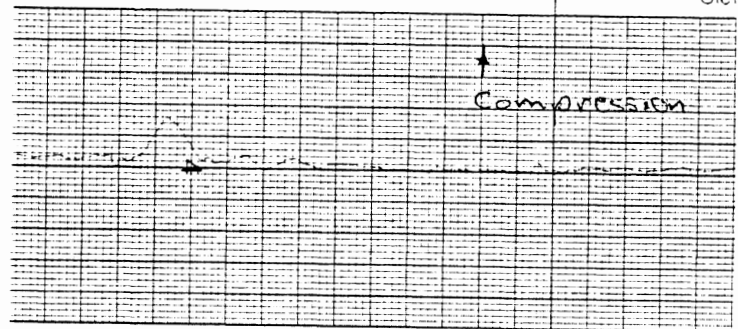


BRUSH ACCUCHART

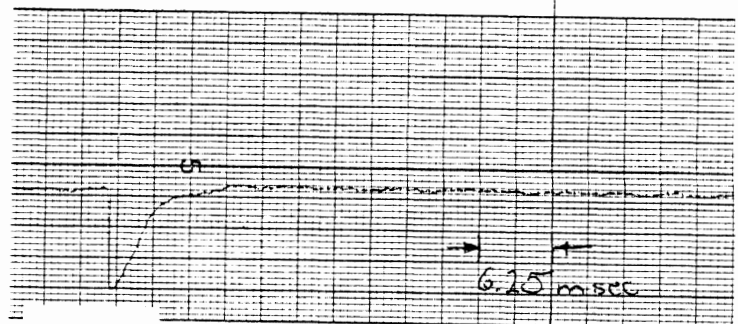
G

Clev

Femur Strain
Bottom (3)
2450.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



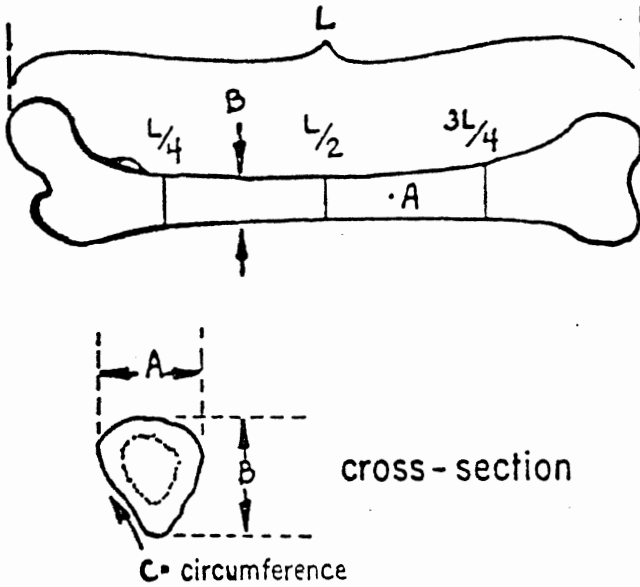
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q009-11

Cadaver Number 20703

Date 3-29-77

Right Leg 77Q009



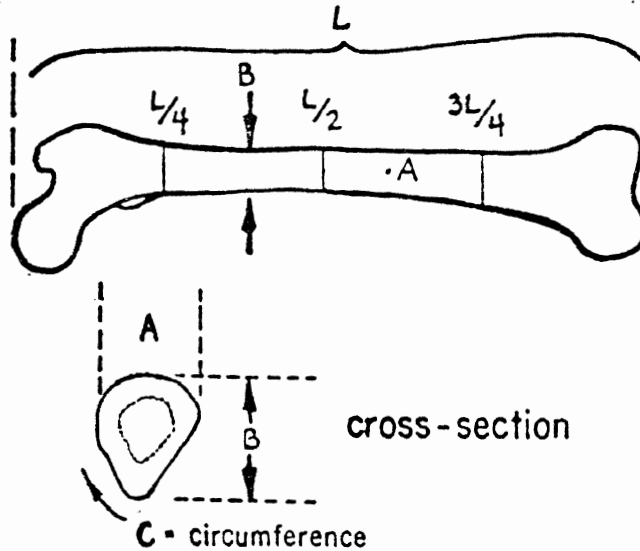
L 51.4 cm

	A cm	B cm	C cm
L/4	3.4	3.8	12
L/2	3.2	3.7	11.5
3L/4	4.2	3.5	12.9

Weight of removed Anatomical Material (Rt.) 2.29 kg.

Weight of removed Femur (Rt.) 1.14 kg.

Left Leg 77Q010



L 51.2 cm

	A cm	B cm	C cm
L/4	3.6	3.8	12.3
L/2	3.4	3.9 [?]	12.9 [?]
3L/4	4.3	3.5	12.7

Abnormal
Bump

Weight of removed Anatomical Material (Lt.) 2.33 kg.

Weight of removed Femur (Lt.) 1.18 kg.

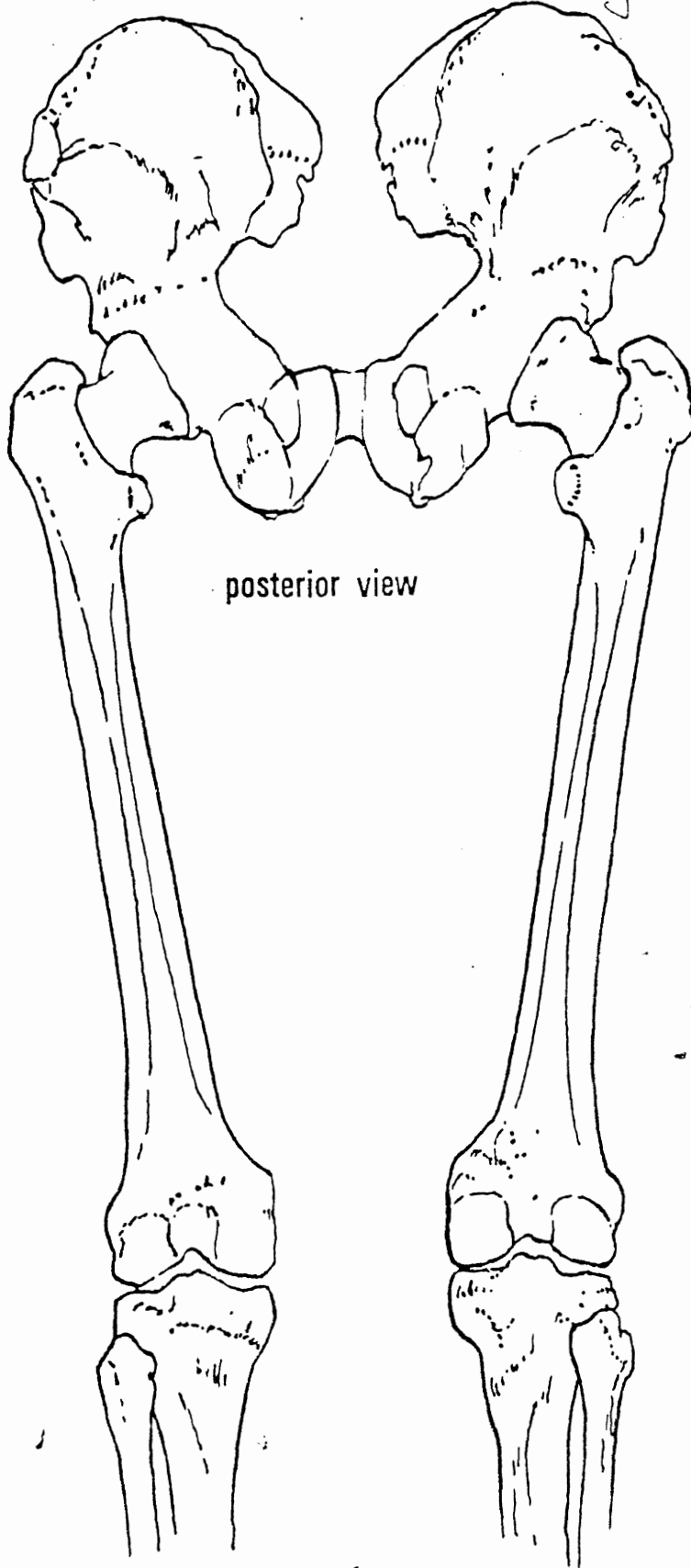
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q010

CADAVER NO. 20703

DATE 3-28-77

No Damage



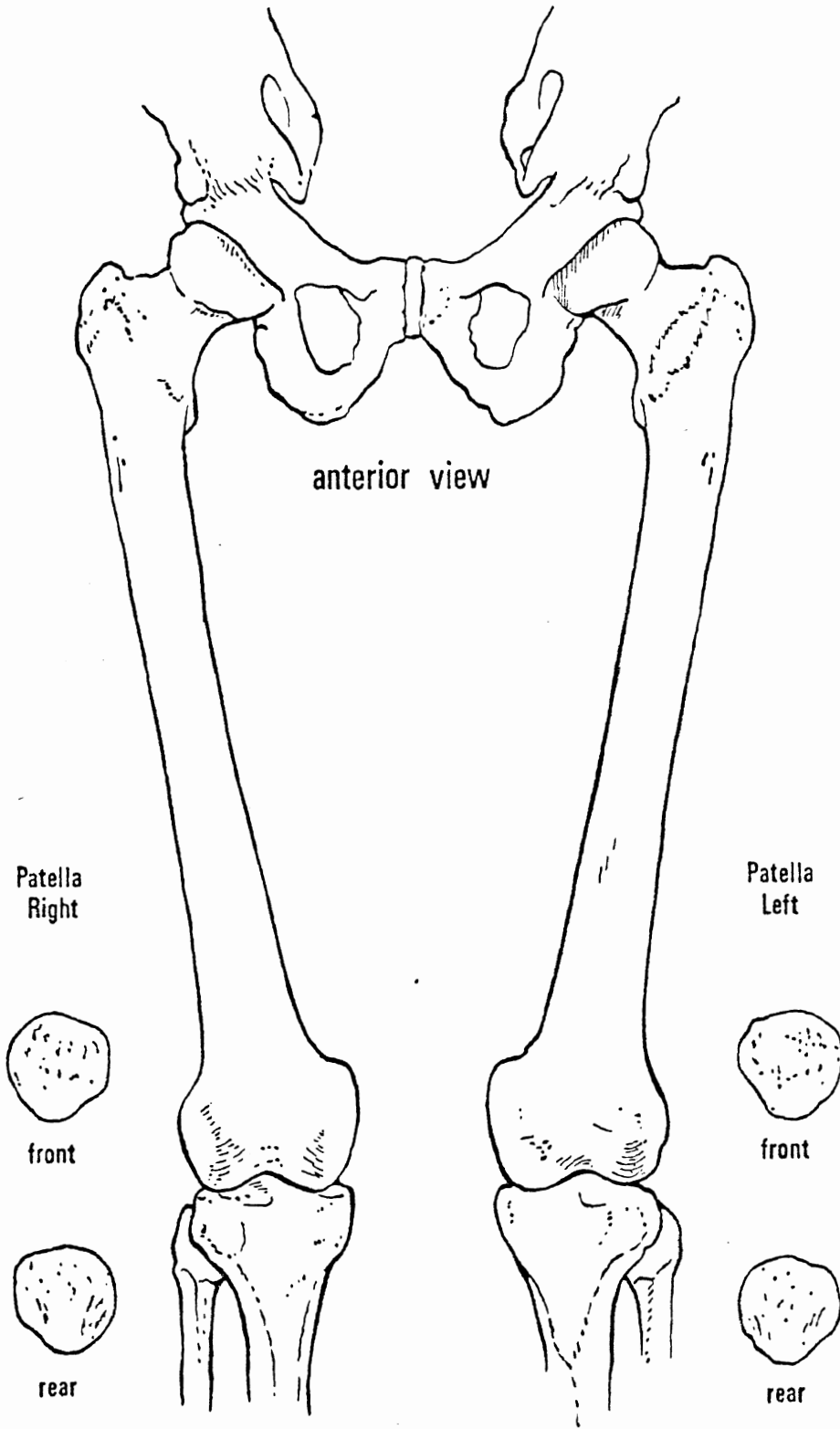
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 779010

CADAVER NO. 20703

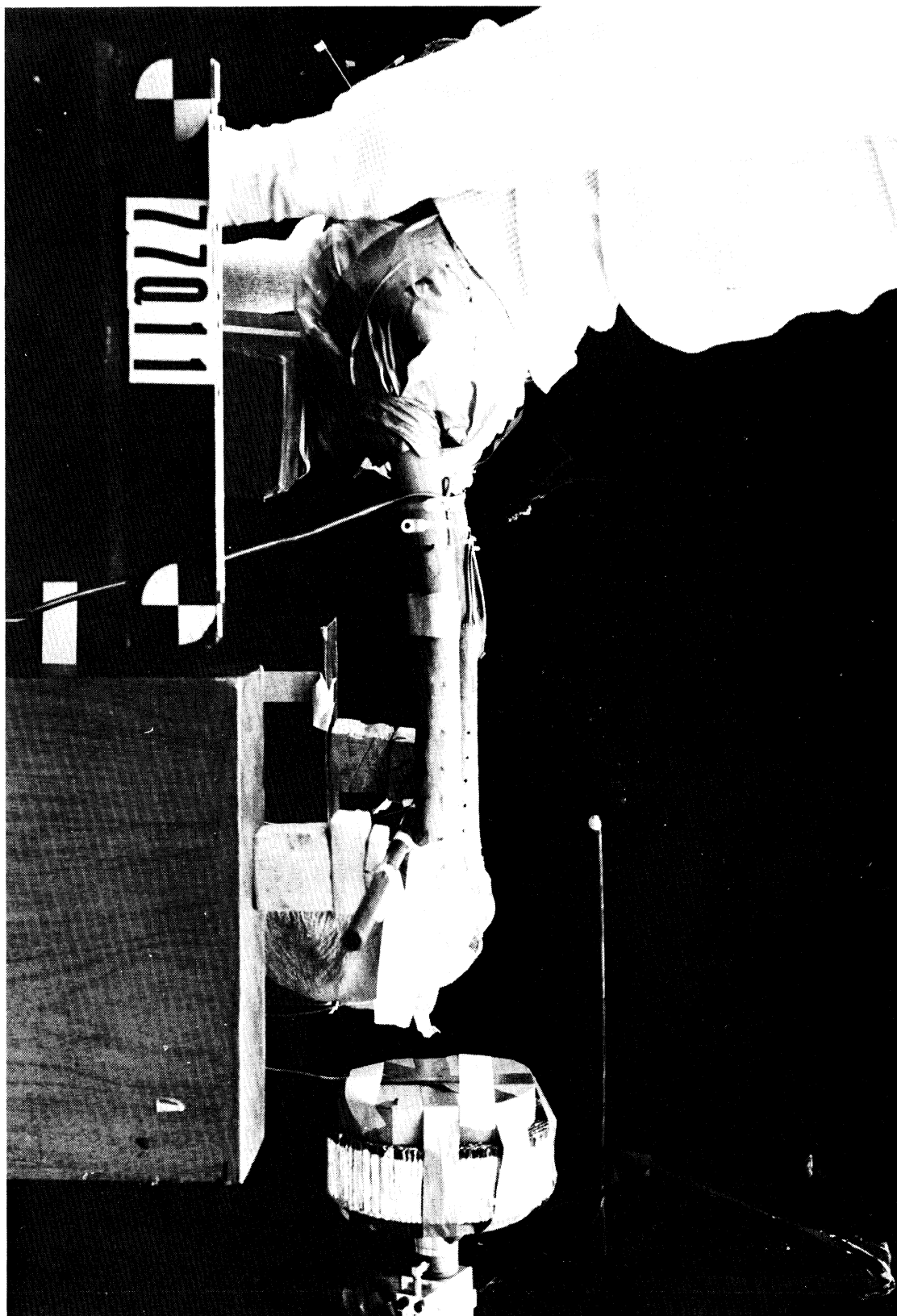
DATE 3-28-77

No Damage





A-116

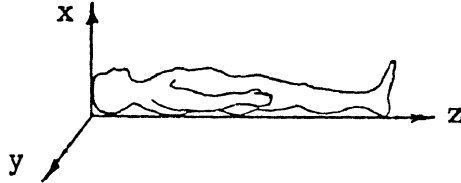




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 770011
 Cadaver Number 20703
 Date 3-28-77

ANATOMICAL COORDINATE SYSTEM



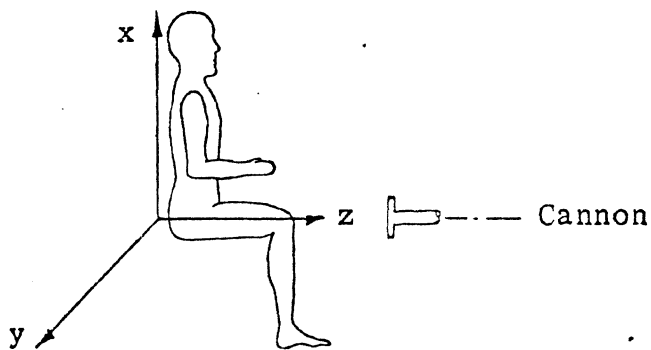
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	81.0 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
+4°	-3°	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

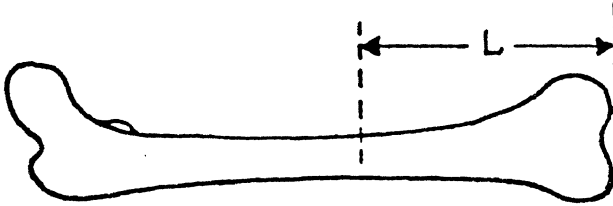
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 770011	+20°	-35°	-2°
Lt. Lg			

STRAIN GAGE LOCATIONS

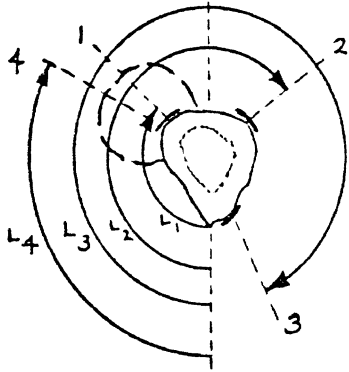
Run Numbers 77Q009-11
 Cadaver Number 20703
 Date 3-28-77

Photos of Cross Section at Strain Gages? Yes No

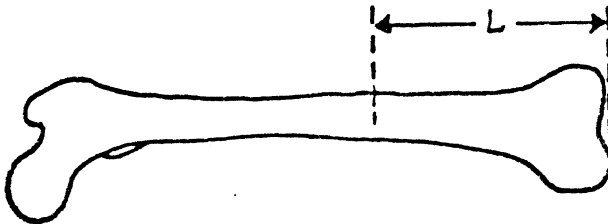
Right Leg 77Q011



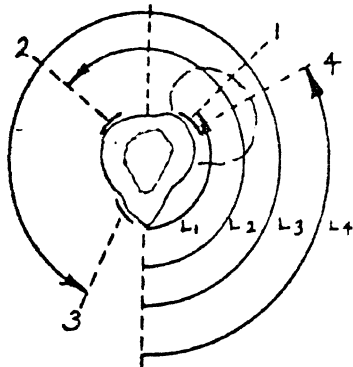
- L 24 cm
- L₁ 3.3 cm
- L₂ 6.7 cm
- L₃ 10.0 cm
- L₄ 2.3 cm



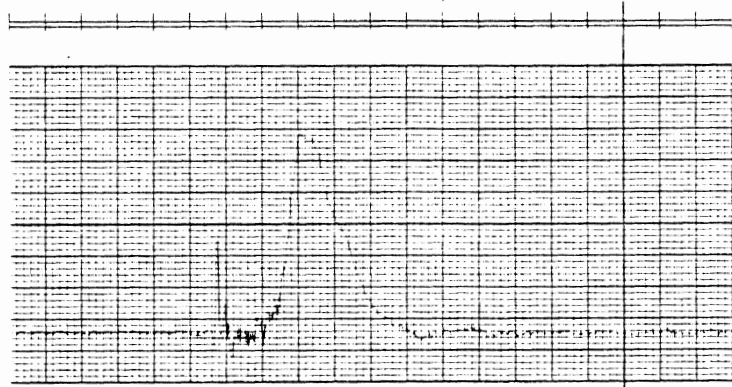
Left Leg 77Q



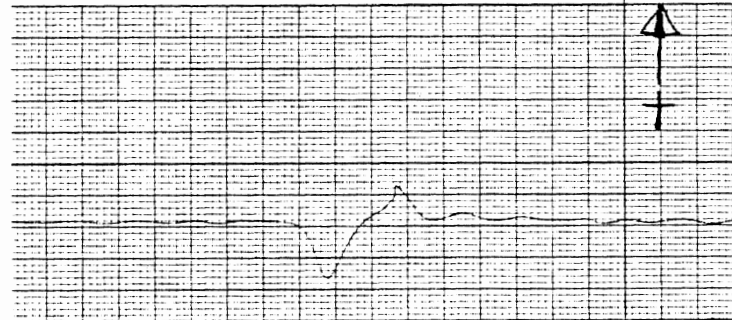
- L _____ cm
- L₁ _____ cm
- L₂ _____ cm
- L₃ _____ cm
- L₄ _____ cm



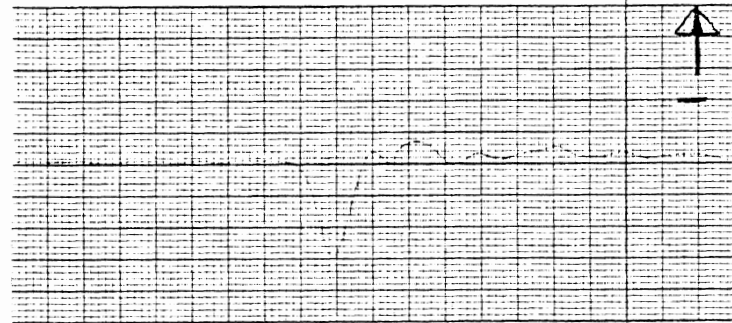
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



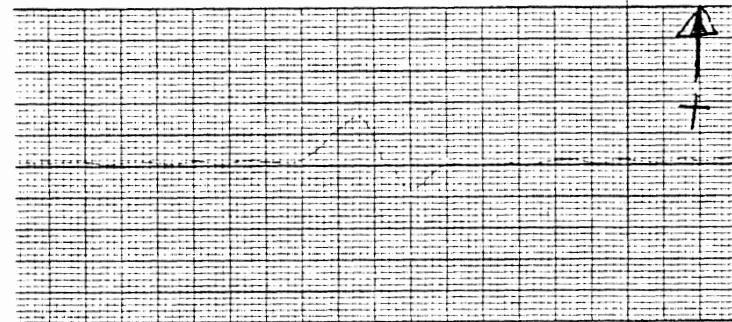
Pelvic Acceleration
P-A
52.78 G's/Division
Filtered 300 Hz.



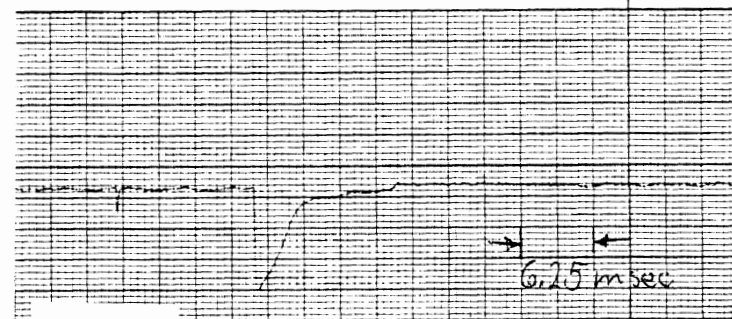
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



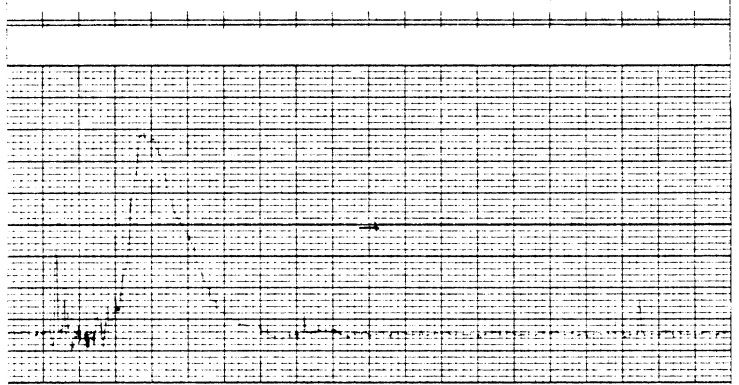
Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



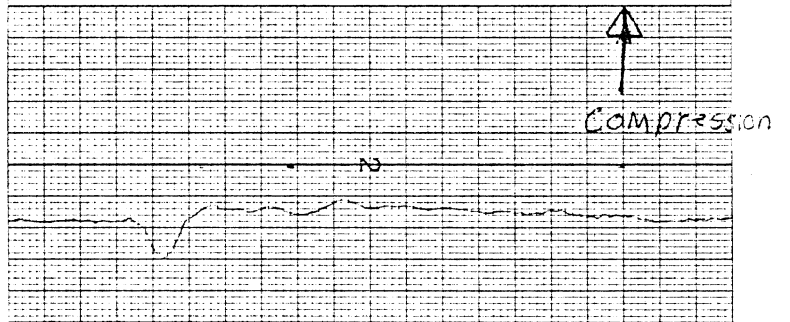
Strobe (T₀)



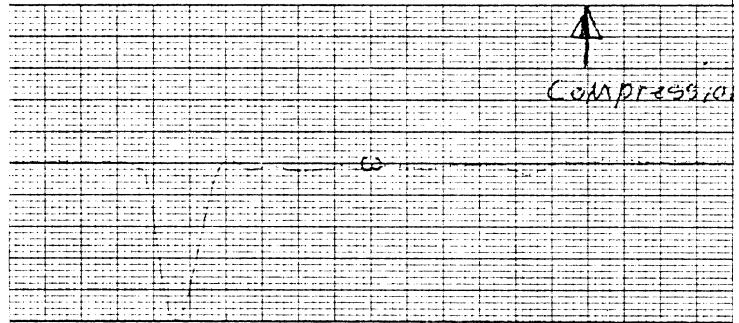
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



Femur Strain
Top (1)
2450.5 micro in./in./Div.
Filtered 1650 Hz.

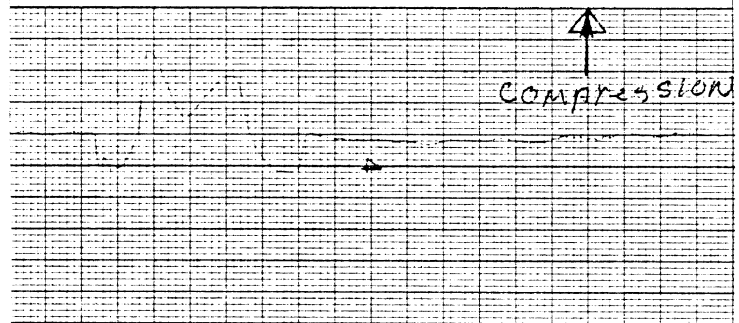


Femur Strain
Side (2)
2484.5 micro in./in./Div.
Filtered 1650 Hz.

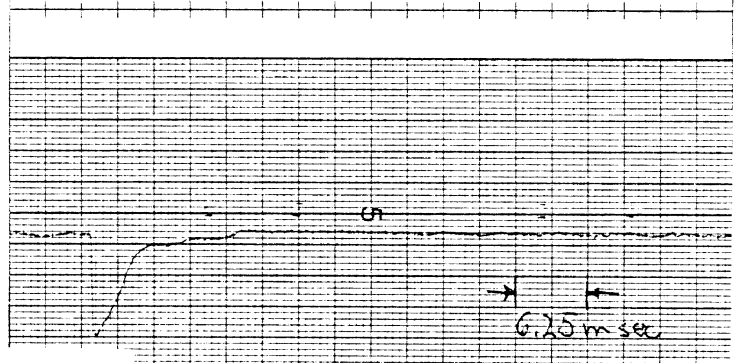


BRUSH ACCUCHART

Femur Strain
Bottom (3)
2450.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



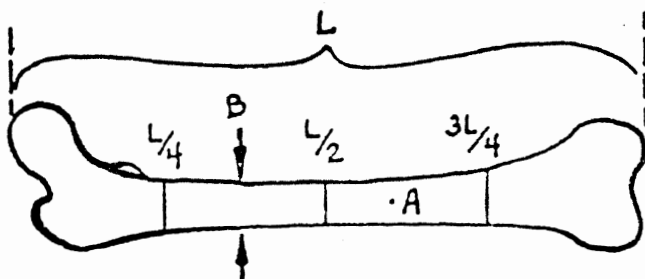
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q009-11

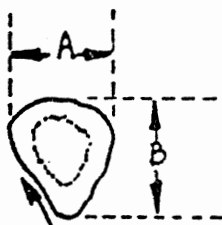
Cadaver Number 20703

Date 3-29-77

Right Leg 77Q011



L 51.4 cm



cross-section

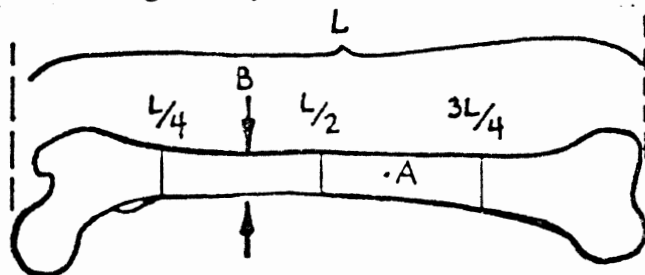
C = circumference

	A cm	B cm	C cm
L/4	3.4	3.8	12
L/2	3.2	3.7	11.5
3L/4	4.2	3.5	12.9

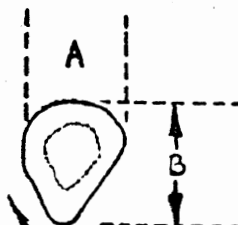
Weight of removed Anatomical Material (Rt.) 2.29 kg.

Weight of removed Femur (Rt.) 1.14 kg.

Left Leg 77Q



L _____ cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4			
L/2			
3L/4			

Weight of removed Anatomical Material (Lt.) _____ kg.

Weight of removed Femur (Lt.) _____ kg.

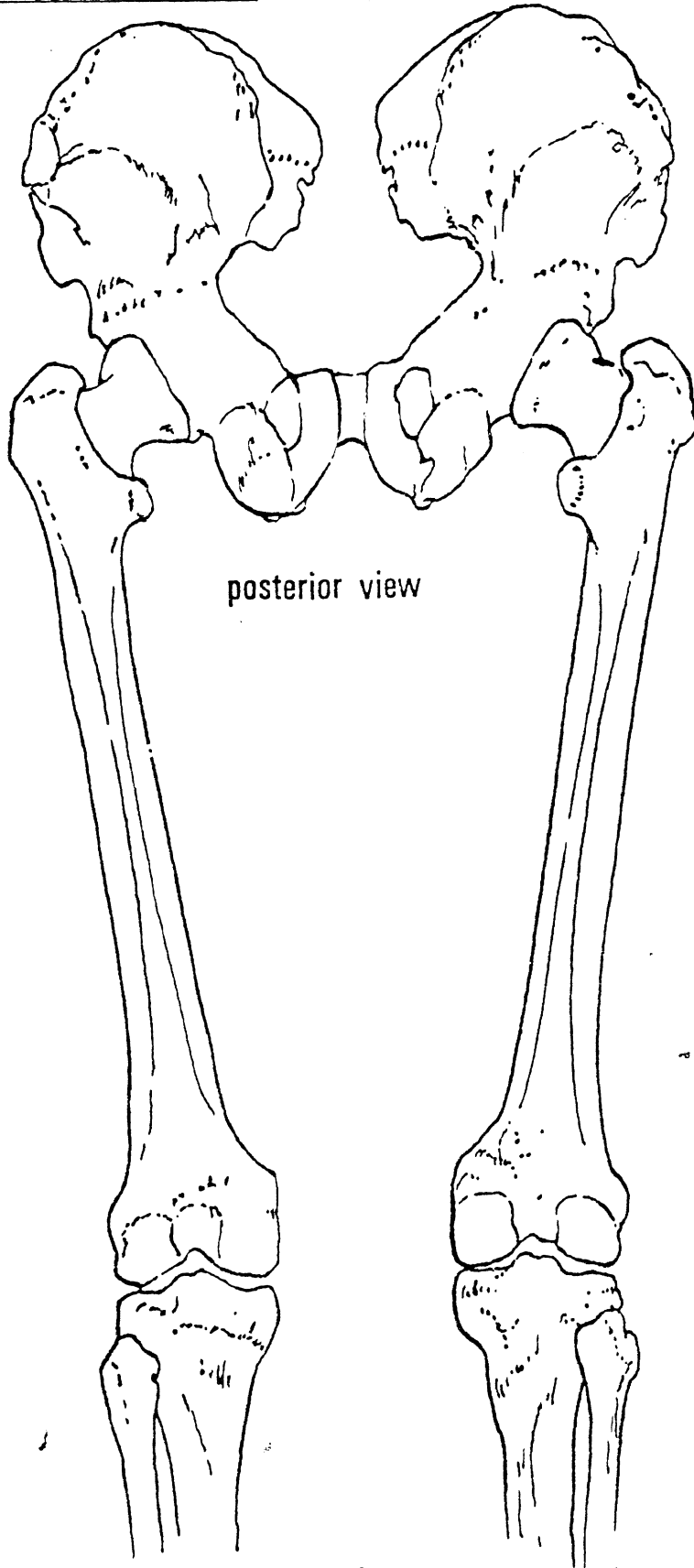
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 770009-11

CADAVER NO. 20703

DATE 3-28-77

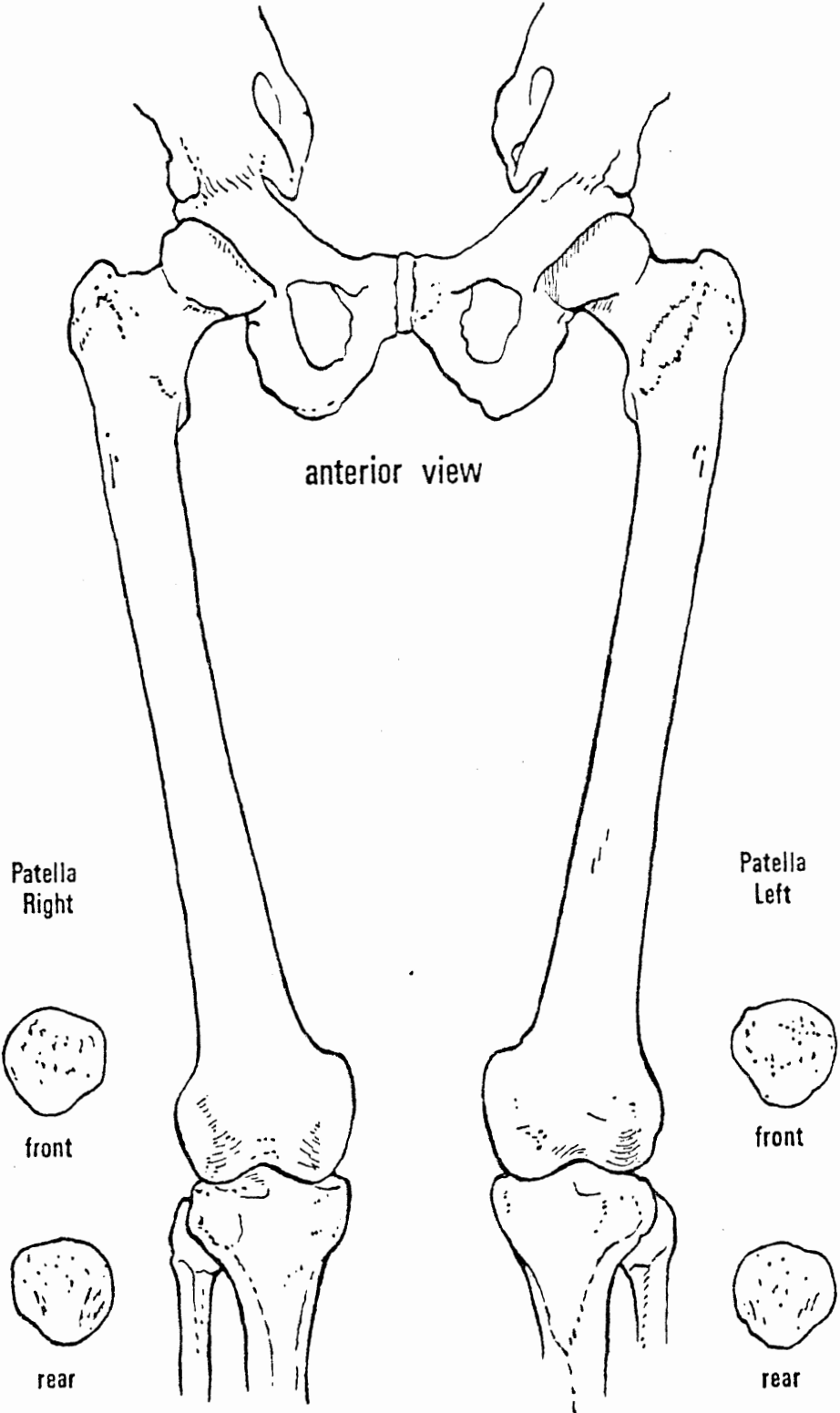
No Damage

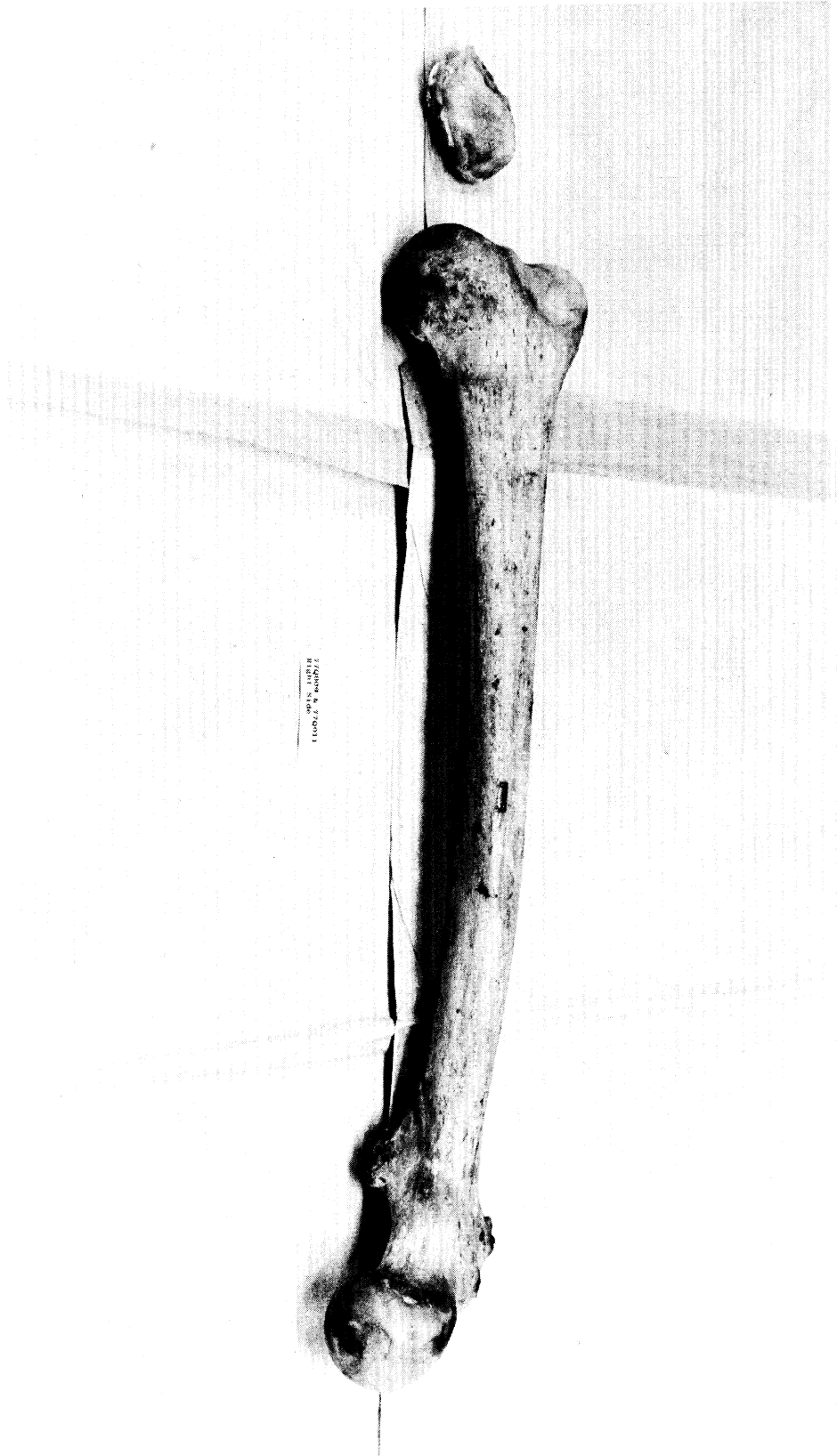


KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 770009-11
CADAVER NO. 20703
DATE 3-28-77

No Damage





220004, N. 270011
H. 1000, 1000

TEST SPECIFICATION

TEST NO. 77Q012 Rt.

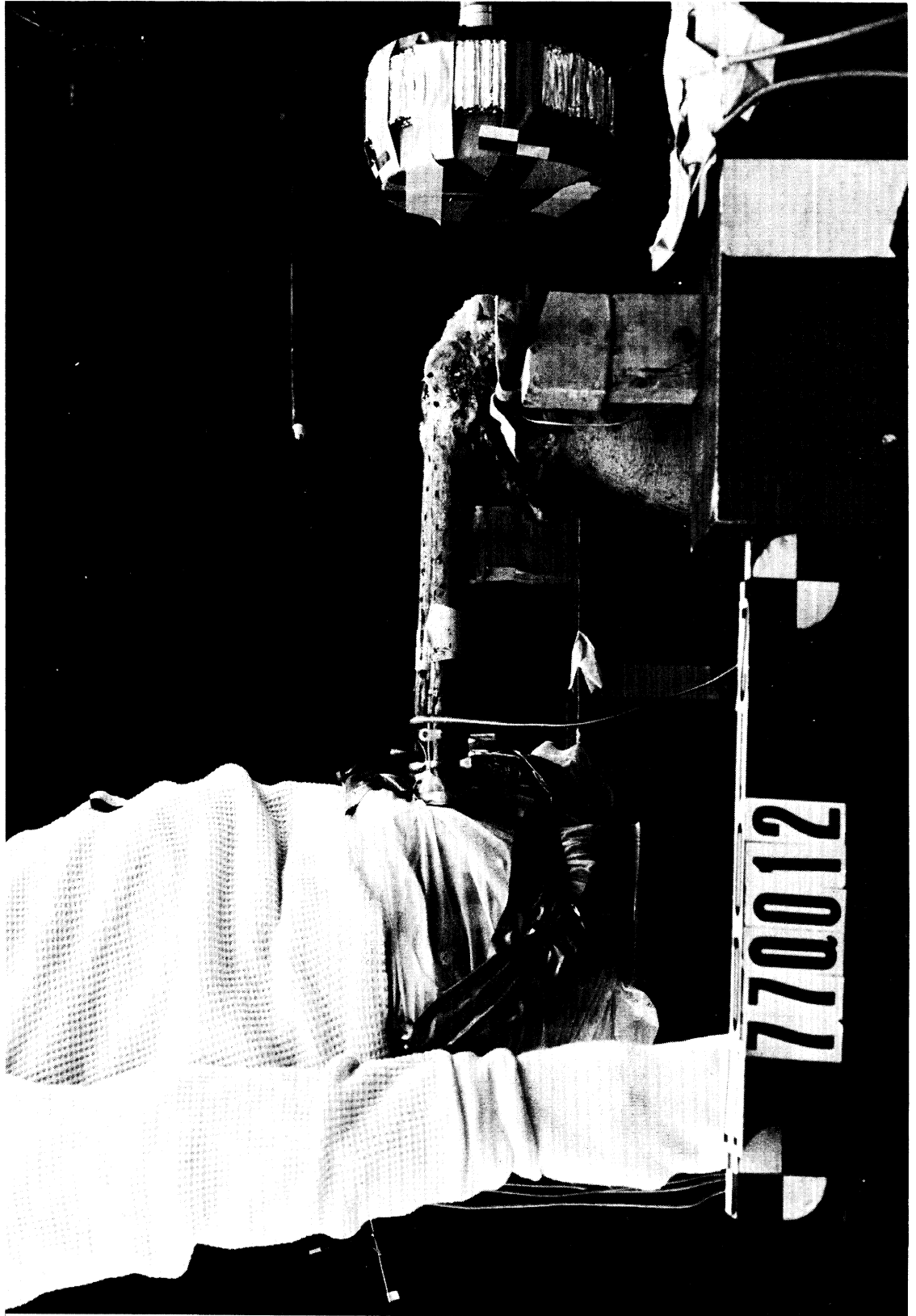
IMPACT VELOCITY 36.9 fps

TYPE OF PADDING 2 in Hexcel, 3/16 cell; Ensolite 1 in.

TEST DESCRIPTION: Same as Test 77Q005

There was a supracondylar fracture, but the patella wasn't damaged.

Apparent osteoporosis.

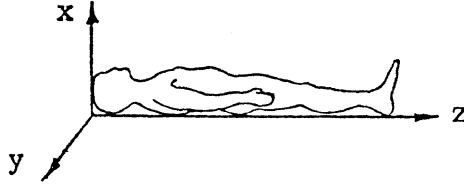




ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77QC12-13
 Cadaver Number 20711
 Date 3-30-77

ANATOMICAL COORDINATE SYSTEM



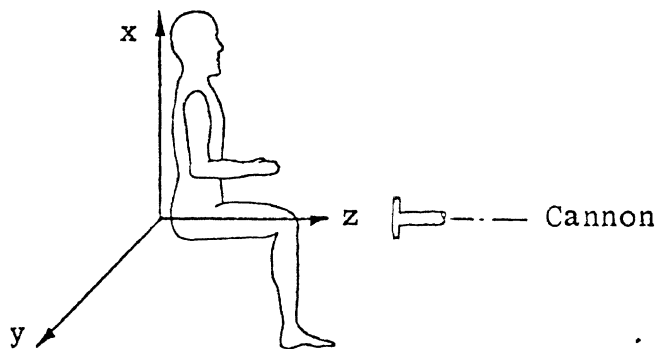
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	72.2cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	0	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

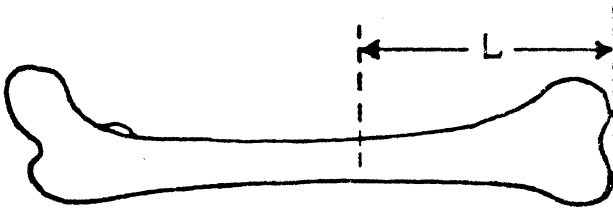
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77QC12	+5°	+15°	0
Lt. Lg 77QC13	+10°	+5°	0

STRAIN GAGE LOCATIONS

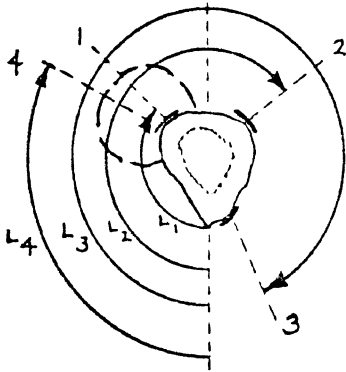
Run Numbers 77Q012-13
 Cadaver Number 20711
 Date 3-30-77

Photos of Cross Section at Strain Gages? Yes Lt., No Rt.

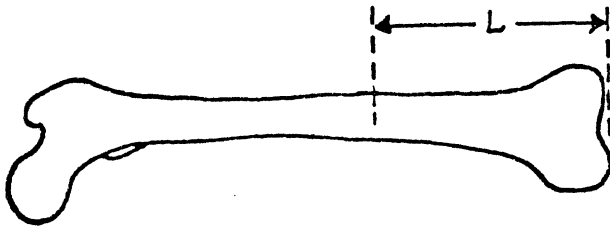
Right Leg 77Q012



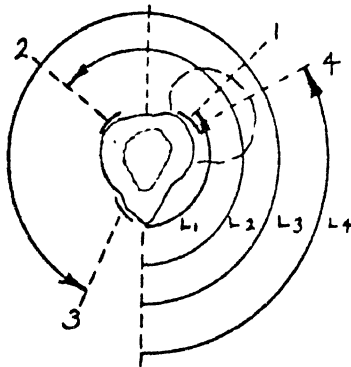
- L 20 cm
- L₁ 3.1 cm
- L₂ 4.7 cm
- L₃ 6.8 cm
- L₄ 2.4 cm



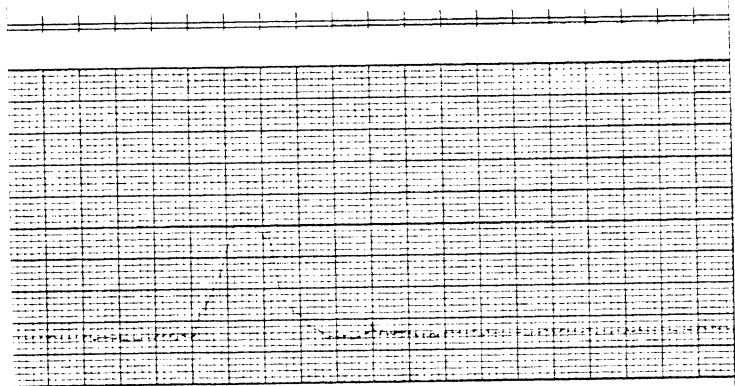
Left Leg 77Q013



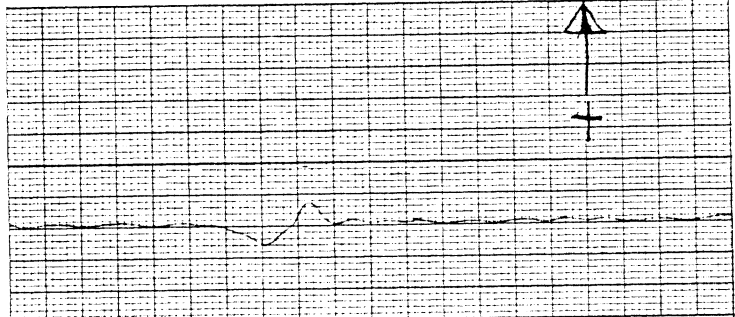
- L 20 cm
- L₁ 3.2 cm
- L₂ 4.2 cm
- L₃ 5.8 cm
- L₄ 2.5 cm



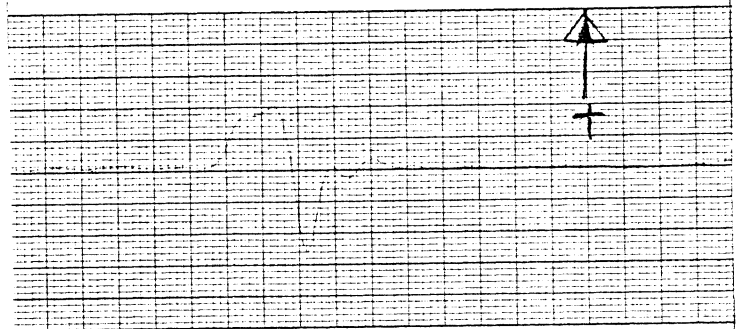
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



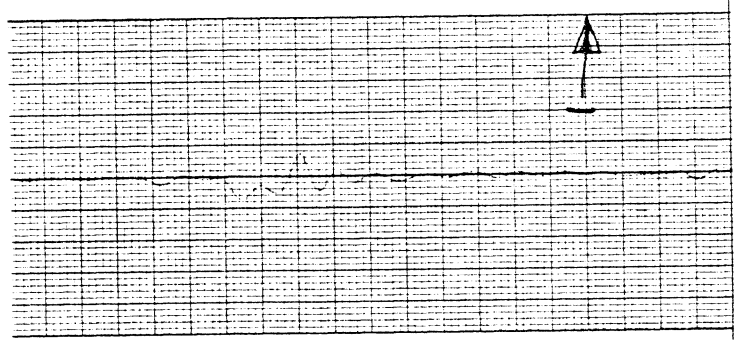
Pelvic Acceleration
P-A
52.78 G's/Division
Filtered 300 Hz.



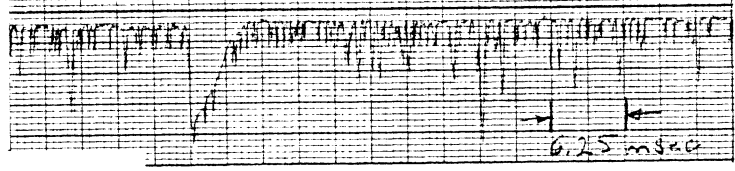
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



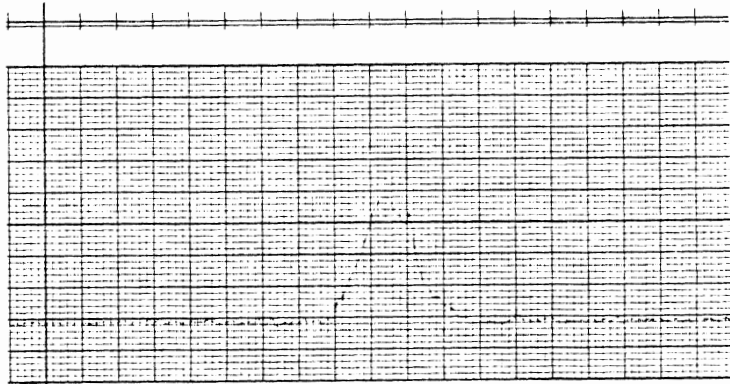
Strobe (T₀)



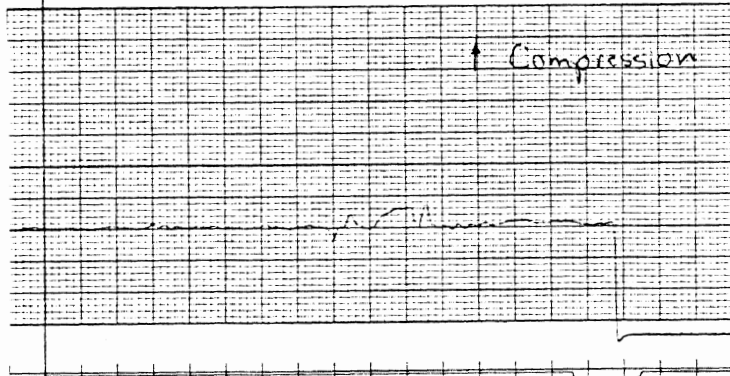
Test No. 77Q 012 R+

KNEE IMPACT DATA SUMMARY

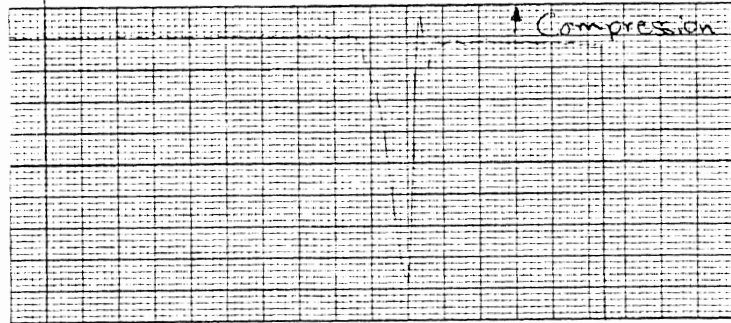
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



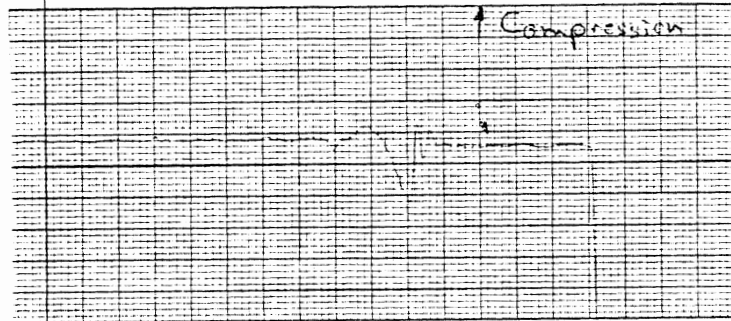
Femur Strain
Top (1)
2338 micro in./in./Div.
Filtered 1650 Hz.



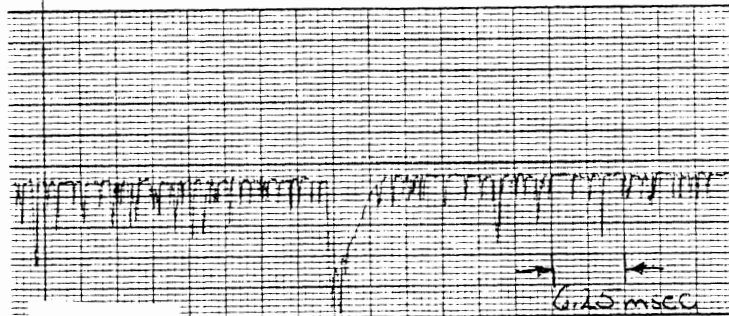
Femur Strain
Side (2)
2338 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Bottom (3)
2460.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



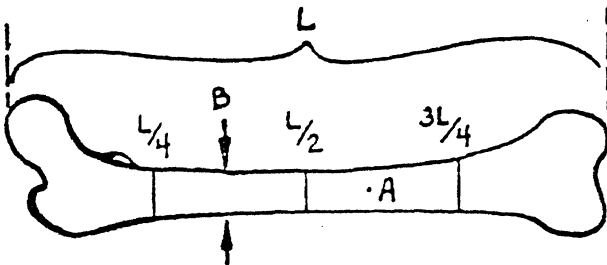
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q012-13

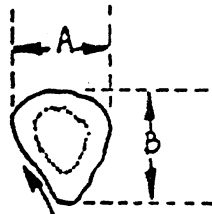
Cadaver Number 20711

Date 3-30-77

Right Leg 77Q012



L 44 cm



cross-section

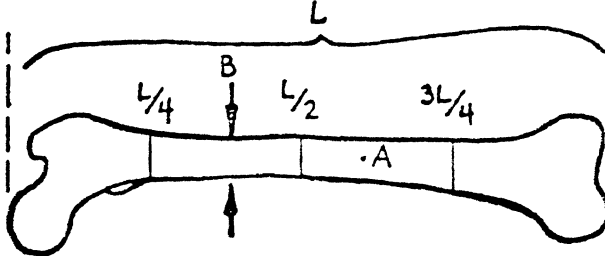
C = circumference

	A cm	B cm	C cm
L/4	2.8	2.7	9.8
L/2	2.6	2.5	8.8
3L/4	3.2	2.6	9.9

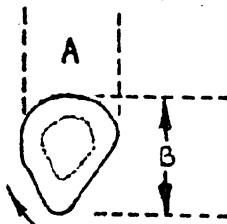
Weight of removed Anatomical Material (Rt.) 3.92 kg.

Weight of removed Femur (Rt.) 0.589 kg.

Left Leg 77Q013



L 43.6 cm



cross-section

C = circumference

	A cm	B cm	C cm
L/4	2.8	2.8	9.8
L/2	2.6	2.6	8.5
3L/4	Bone Reconstruction	Bone Broken	Beyond Reconstruction

Weight of removed Anatomical Material (Lt.) 3.69 kg.

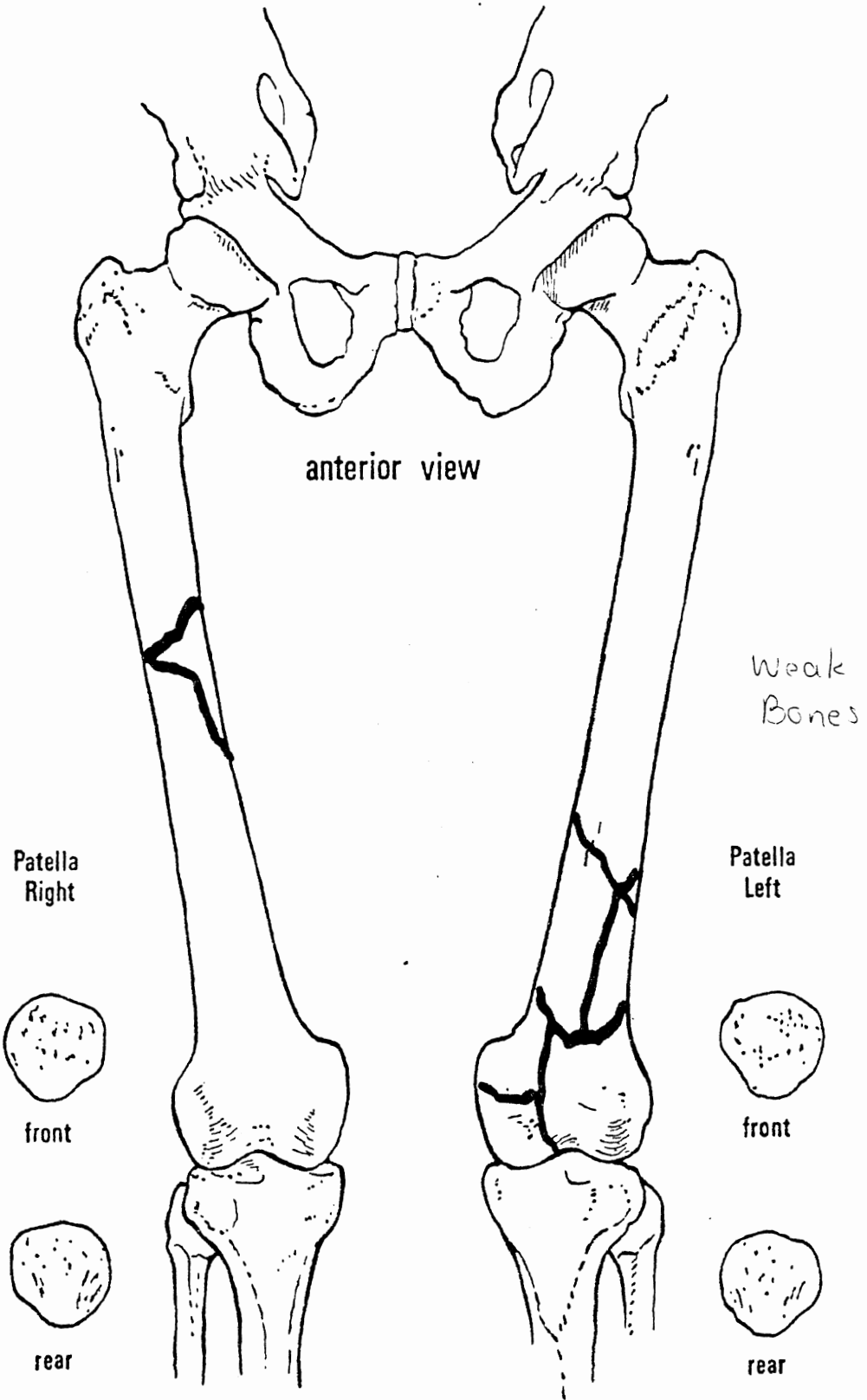
Weight of removed Femur (Lt.) 0.582 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q012-13

CADAVER NO. 20711

DATE 3-30-77

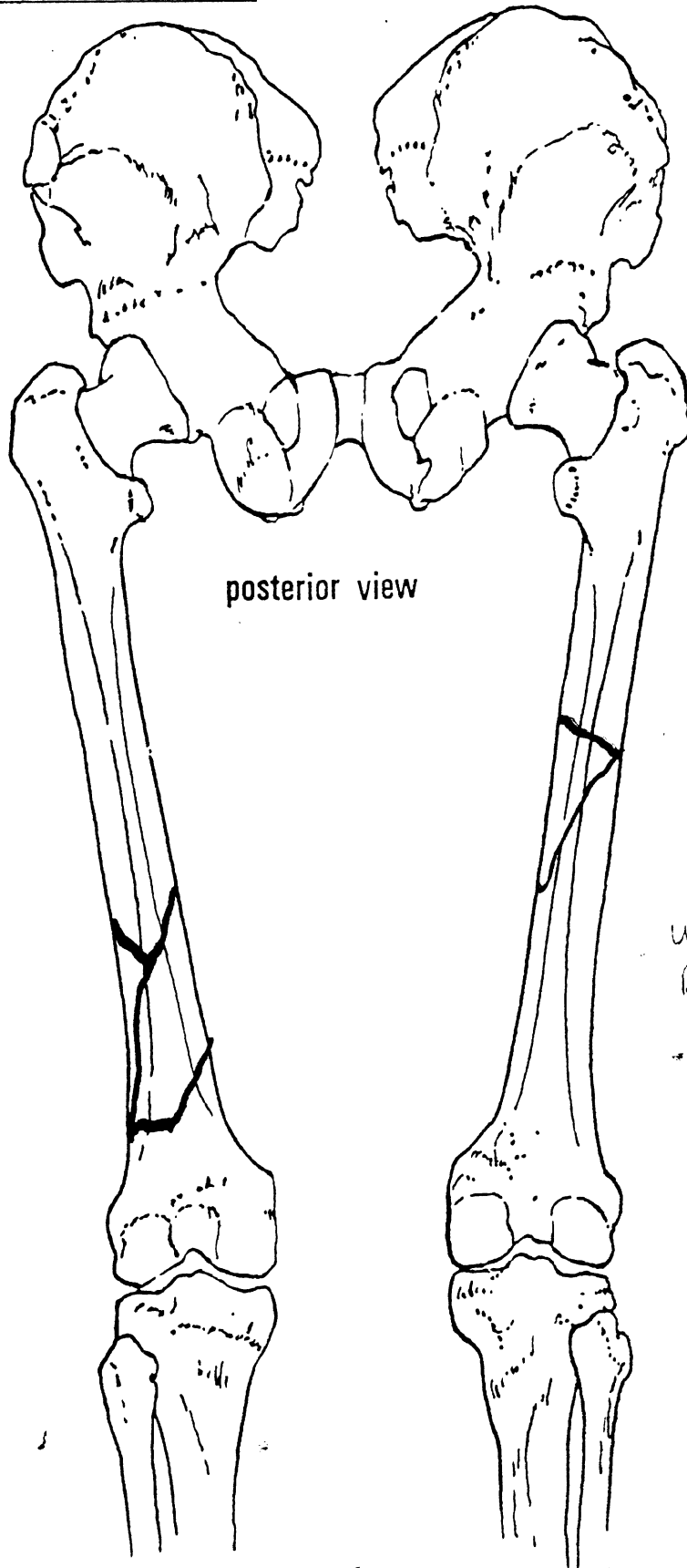


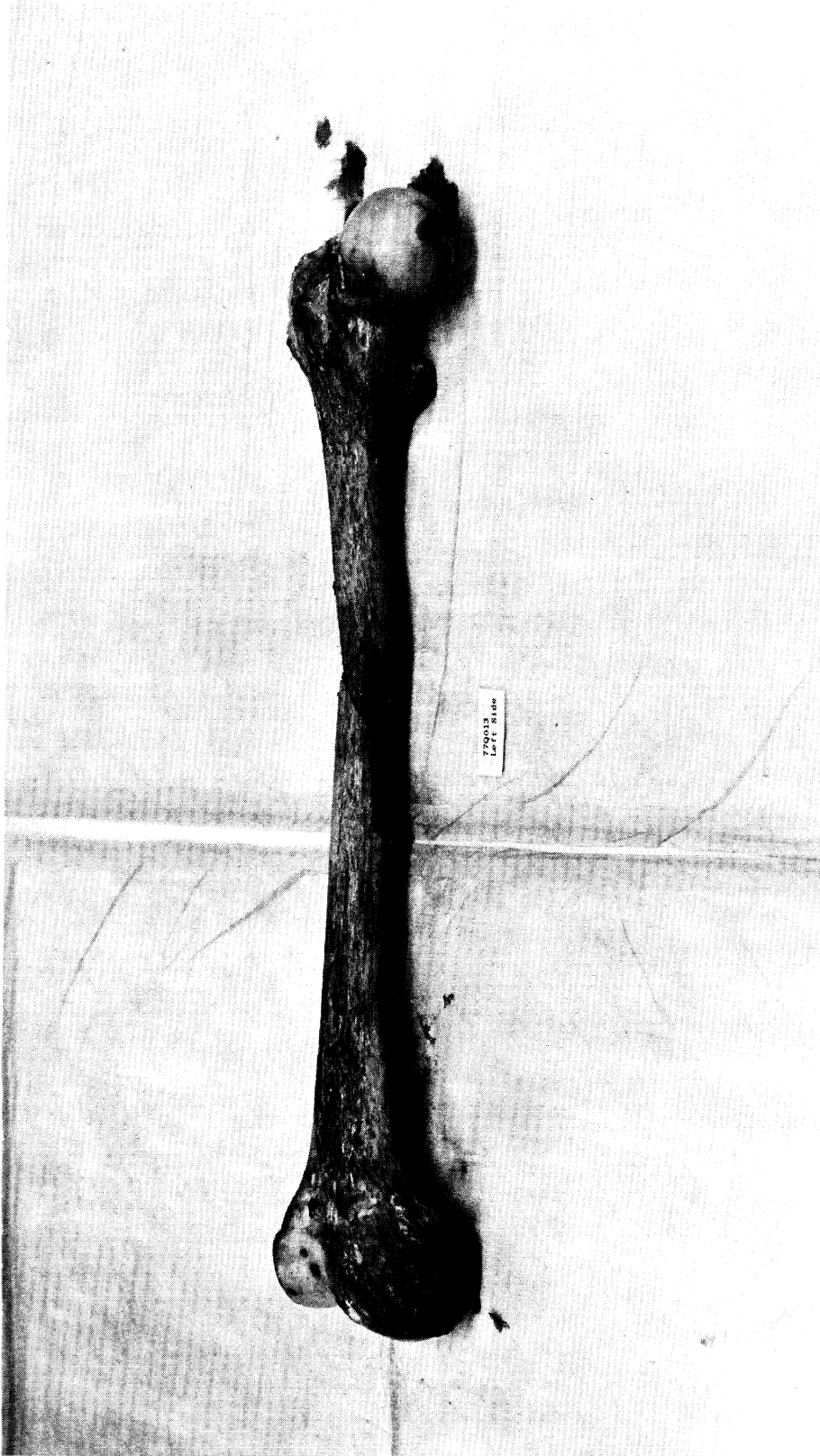
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q012-13

CADAVER NO. 20711

DATE 3-30-77





A-138



77Q013

Left Side



77Q012

Right Side



TEST SPECIFICATION

TEST NO. 77Q013 Lt.

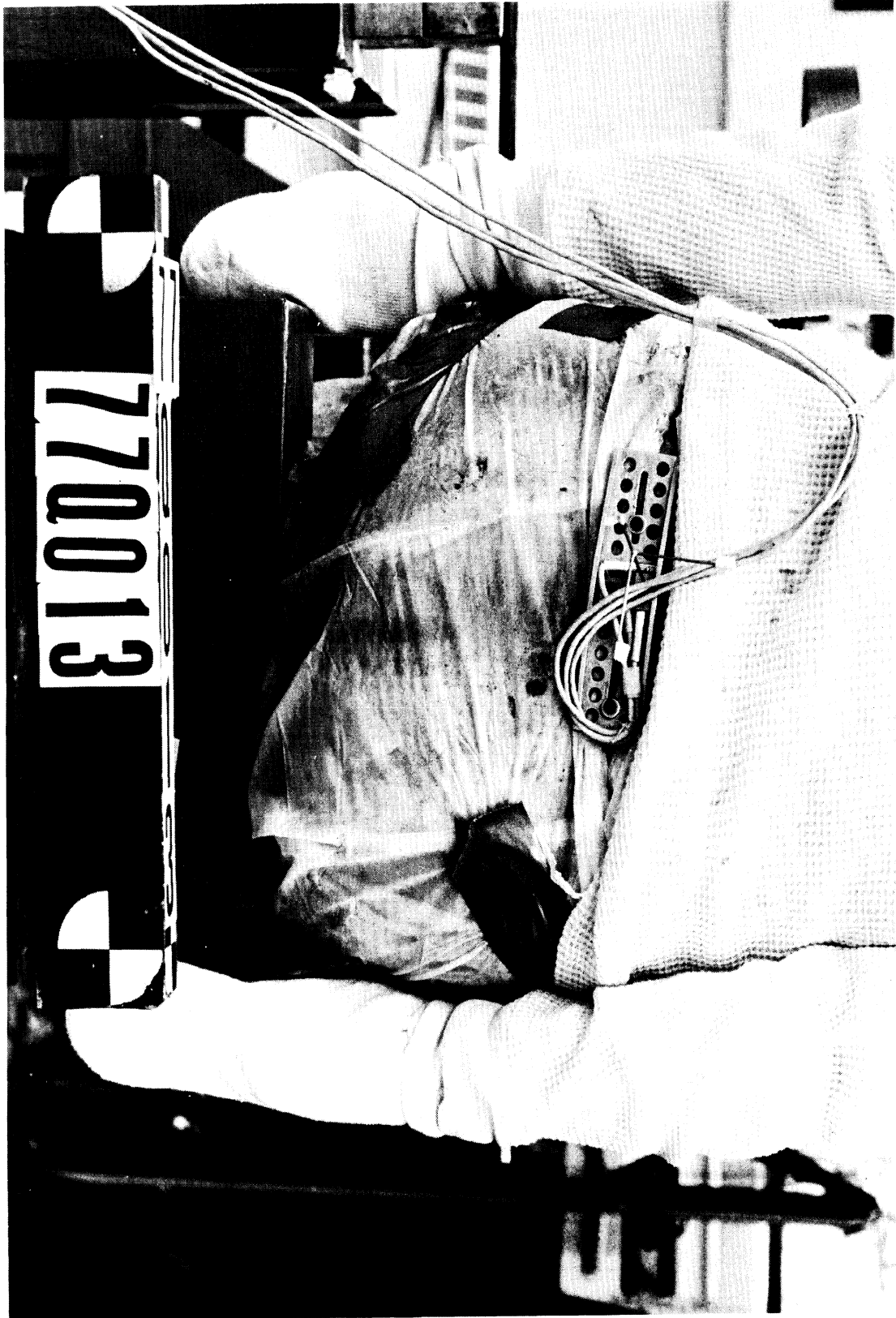
IMPACT VELOCITY 39.3 fps

TYPE OF PADDING 2 in. Hexcel, 3/16 cell; Ensolite 1 in.

TEST DESCRIPTION: Same as Test 77Q005

The condyles and midshaft were fractured, but the patella wasn't
damaged. Apparent osteoporosis.





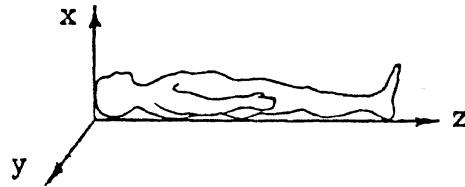
ACCELEROMETER PACK LOCATION AND ORIENTATION

Test Numbers 77Q012-13

Cadaver Number 20711

Date 3-30-77

ANATOMICAL COORDINATE SYSTEM



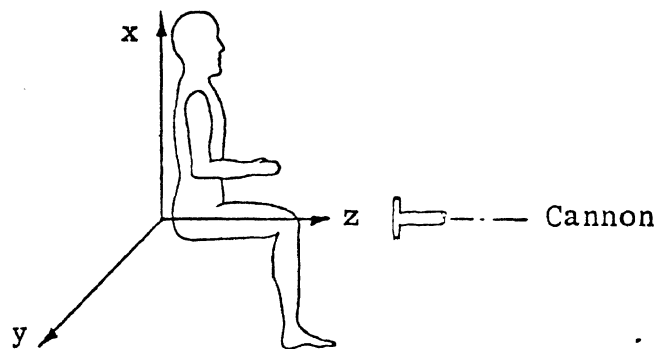
Accelerometer Pack Location (Anatomical Coordinate System)

Distance From y-z Plane (x)	Distance From Midsagittal x-z Plane (y)	Distance From x-y Plane At Vertex (z)
0	0	72.2 cm

Accelerometer Pack Orientation (Anatomical Coordinate System)

Angle About x-axis	Angle About y-axis	Angle About z-axis
0	0	0

LABORATORY COORDINATE SYSTEM



Accelerometer Pack Orientation (Laboratory Coordinate System)

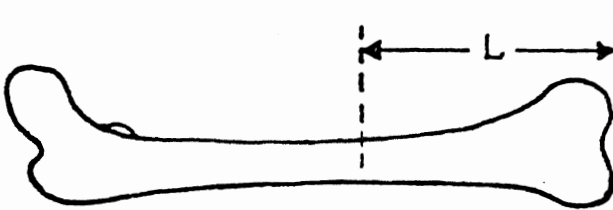
Test	Angle About x-axis	Angle About y-axis	Angle About z-axis
Rt. Lg 77Q012	+5°	+15°	0
Lt. Lg 77Q013	+10°	+5°	0

STRAIN GAGE LOCATIONS

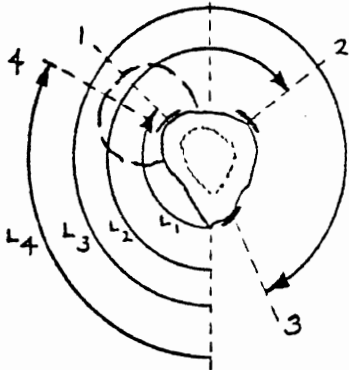
Run Numbers 77Q012-13
 Cadaver Number 20711
 Date 3-30-77

Photos of Cross Section at Strain Gages? Yes Lt., No Rt.

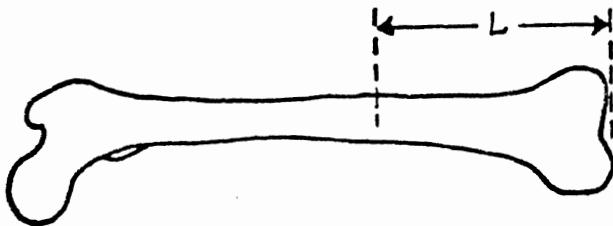
Right Leg 77Q012



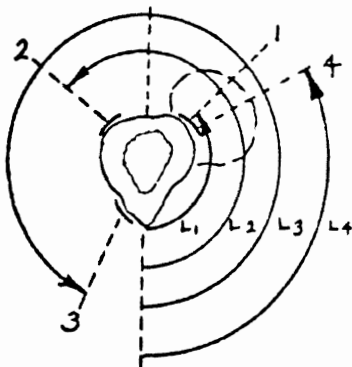
L 20 cm
 L₁ 3.1 cm
 L₂ 4.7 cm
 L₃ 6.8 cm
 L₄ 2.4 cm



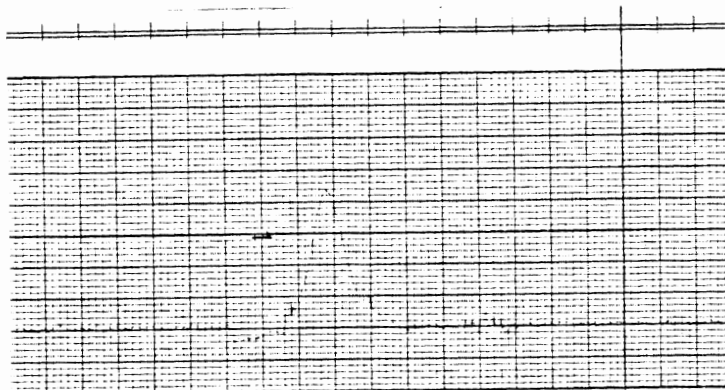
Left Leg 77Q013



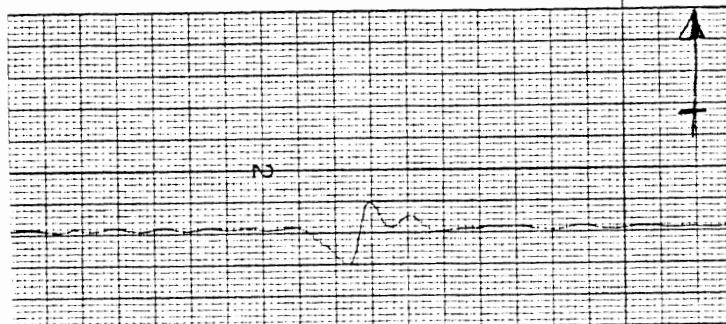
L 20 cm
 L₁ 3.2 cm
 L₂ 4.2 cm
 L₃ 5.8 cm
 L₄ 2.5 cm



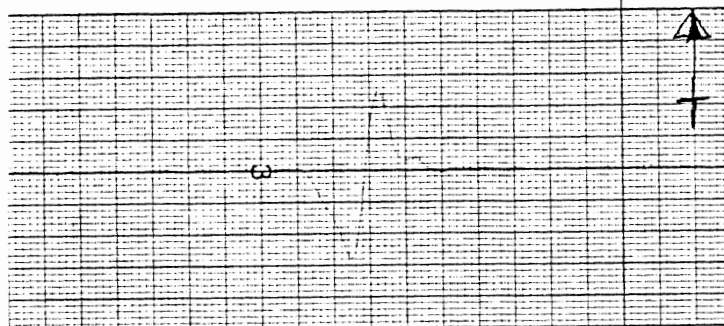
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



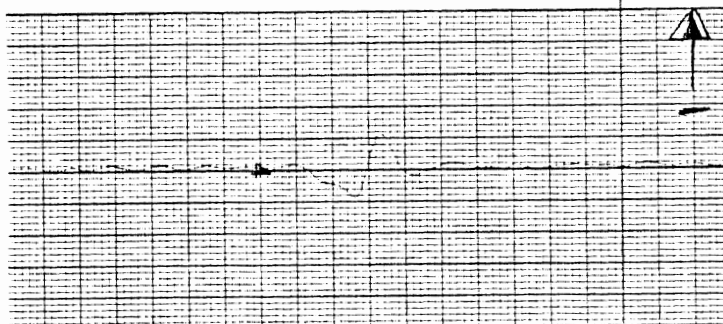
Pelvic Acceleration
P-A
52.78 G's/Division
Filtered 300 Hz.



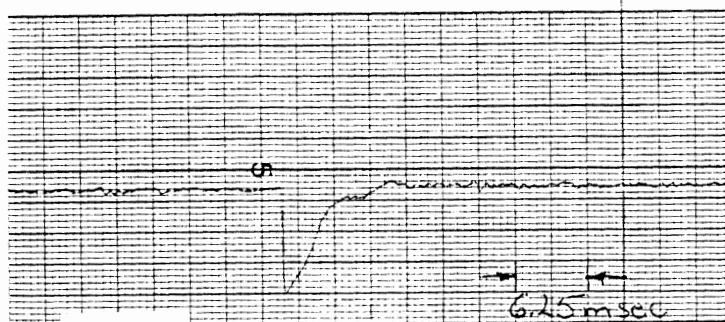
Pelvic Acceleration
R-L
42.75 G's/Division
Filtered 300 Hz.



Pelvic Acceleration
S-I
53.25 G's/Division
Filtered 300 Hz.



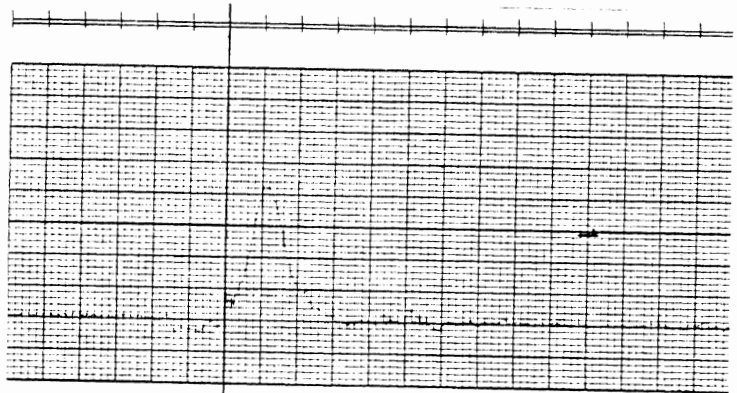
Strobe (T₀)



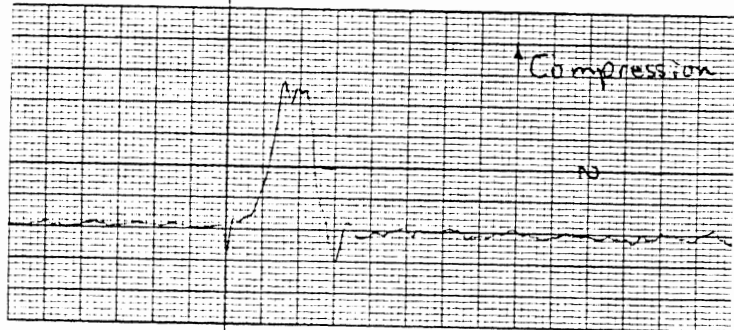
Test No. 77Q013LT,

KNEE IMPACT DATA SUMMARY

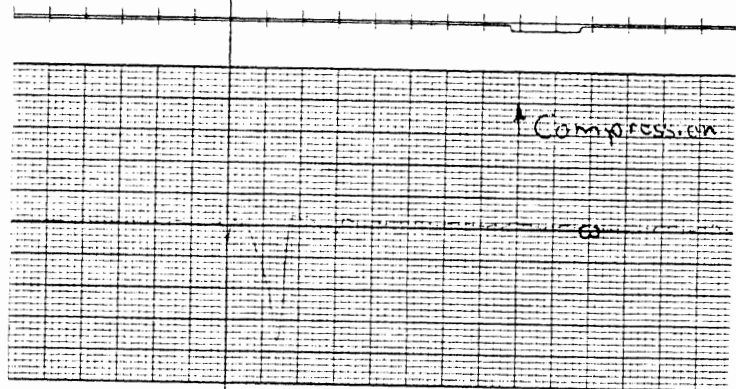
Compensated Force
500 lbs./Division
Filtered 1650 Hz.



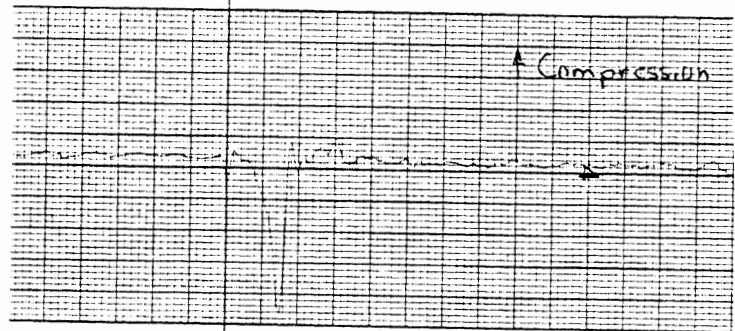
Femur Strain
Top (1)
2450.5 micro in./in./Div.
Filtered 1650 Hz.



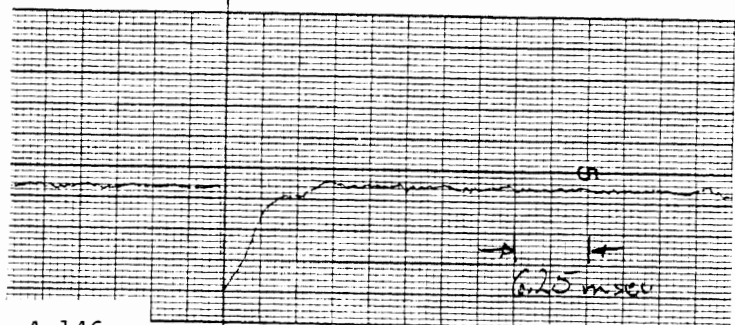
Femur Strain
Side (2)
2484.5 micro in./in./Div.
Filtered 1650 Hz.



Femur Strain
Bottom (3)
2450.5 micro in./in./Div.
Filtered 1650 Hz.



Strobe (T₀)



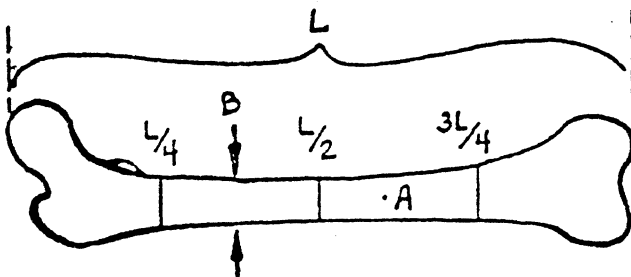
POST IMPACT BONE MEASUREMENTS

Run Numbers 77Q012-13

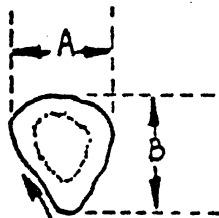
Cadaver Number 20711

Date 3-30-77

Right Leg 77Q012



L 44 cm



cross-section

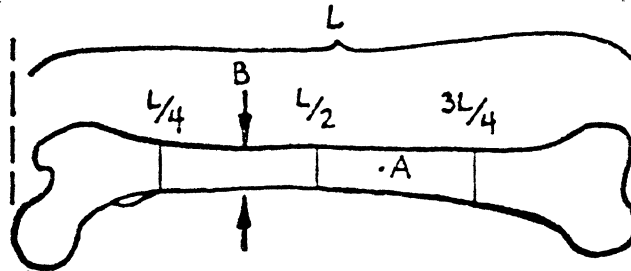
C = circumference

	A cm	B cm	C cm
L/4	2.8	2.7	9.8
L/2	2.6	2.5	8.8
3L/4	3.2	2.6	9.9

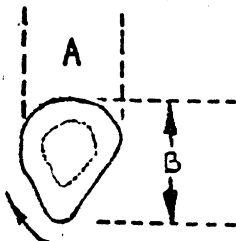
Weight of removed Anatomical Material (Rt.) 3.92 kg.

Weight of removed Femur (Rt.) 0.589 kg.

Left Leg 77Q013



L 43.6 cm



cross-section

C = circumference

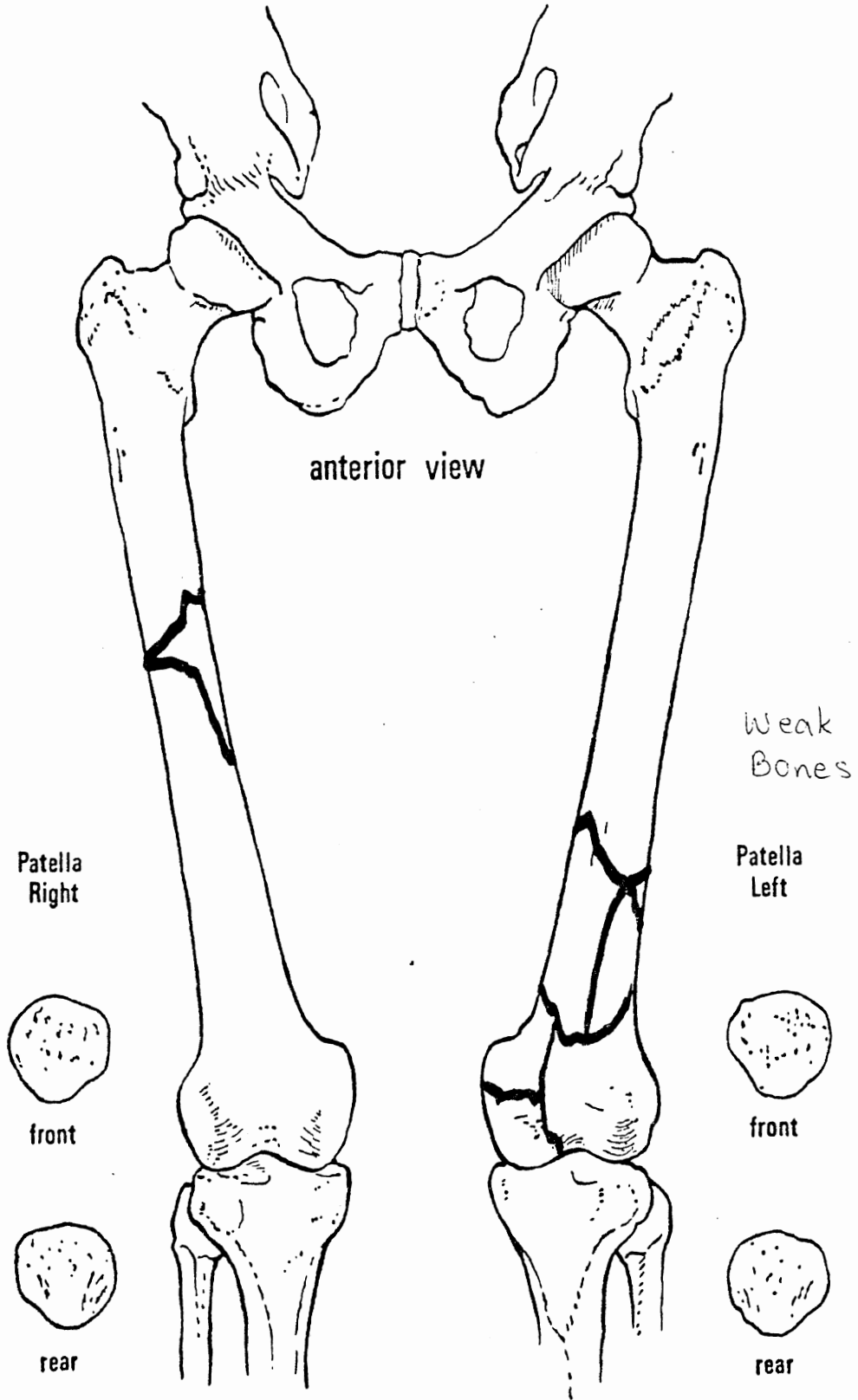
	A cm	B cm	C cm
L/4	2.8	2.8	9.8
L/2	2.6	2.6	8.5
3L/4	Bone Reconstruction	Broken	Beyond Reconstruction

Weight of removed Anatomical Material (Lt.) 3.69 kg.

Weight of removed Femur (Lt.) 0.582 kg.

KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q012-13
CADAVER NO. 20711
DATE 3-30-77

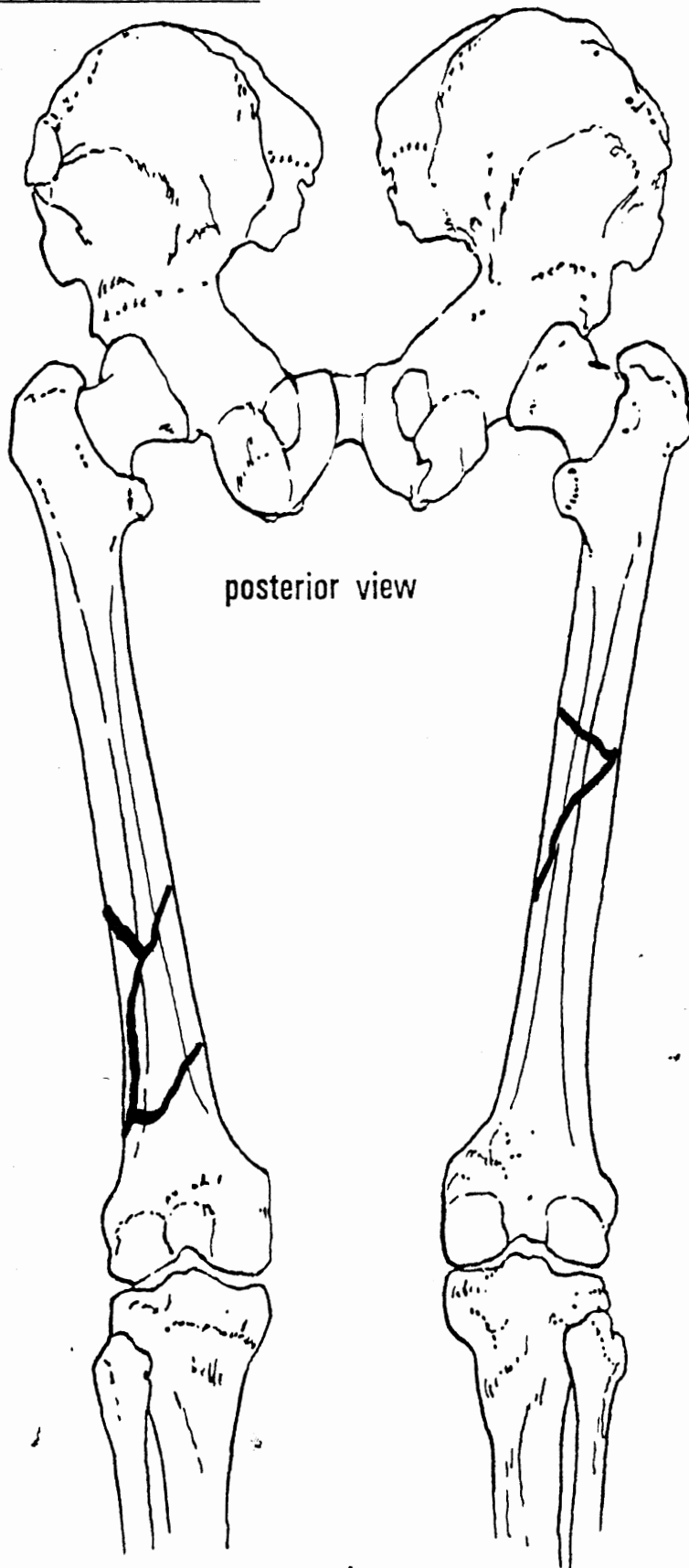


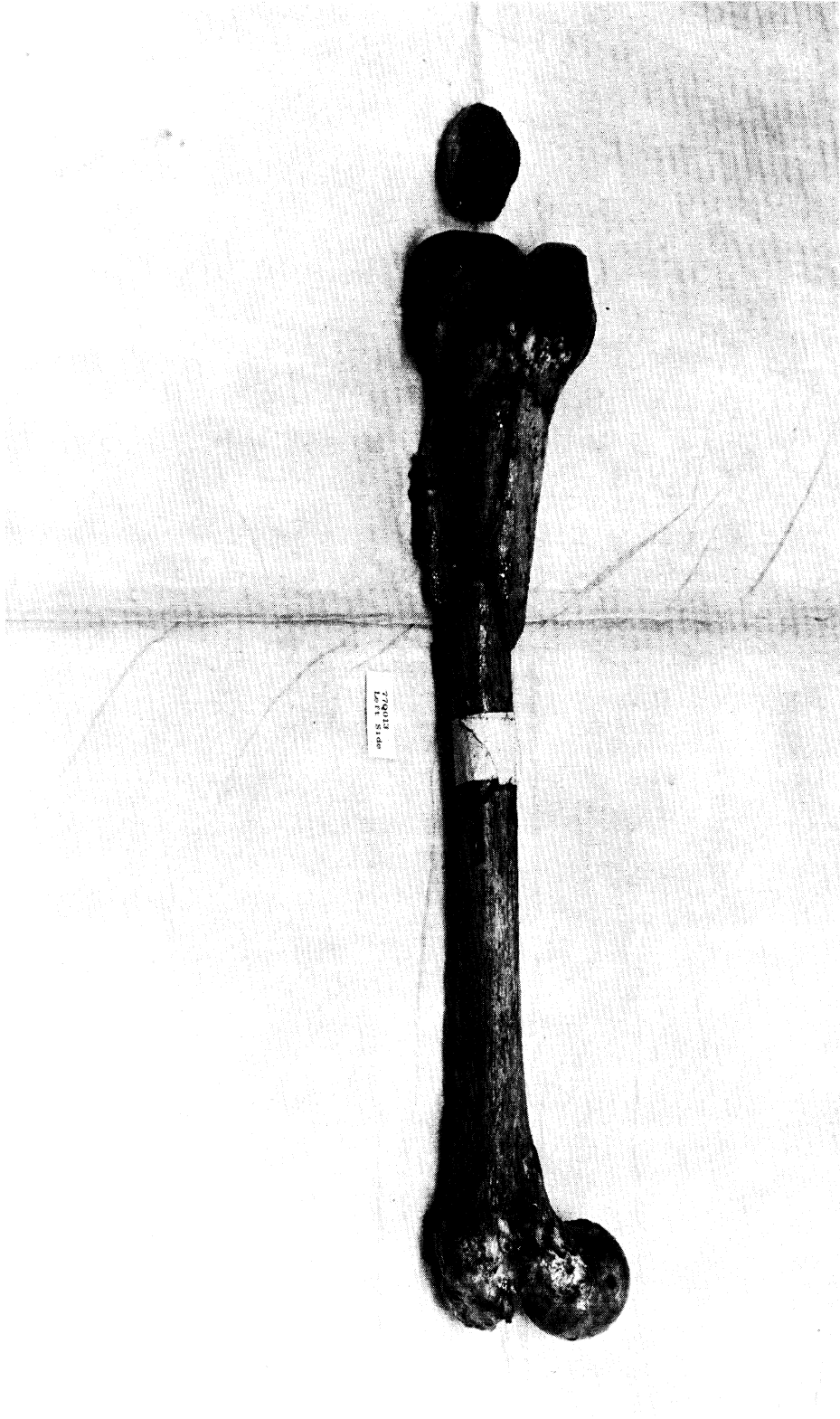
KNEE IMPACT AUTOPSY SUMMARY

TEST NO. 77Q012-13

CADAVER NO. 20711

DATE 3-30-77





A-150



77Q012

Right Side



77Q013

Left Side

