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CAR CRASH TESTS

J. H. McElhaney
D. H. Robbins
A. W. Henke
V. L. Roberts

Highway Safety Research Institute
The University of Michigan
Ann Arbor, Michigan 48105

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16. Abstract

Four 1966 Ford Galaxy 4-door sedans were crashed. The steering columns were removed to provide similar seating geometry for the right and left passengers. Two 50th percentile dummies rode in the front seat and a 3-year old child dummy rode in the back. The left front passenger was restrained with a standard 4-point lap belt and upper torso restraint system, while the right front passenger was restrained with a styrofoam knee block and an inflatable restraint system (airbag). The purpose of these tests was to compare car crash results with sled test results. The comparison was poor and these tests indicate that great care must be taken in the extrapolation of sled tests to predict injury reduction potential of candidate restraint systems in automobiles.

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1.0 INTRODUCTION

This report describes a series of 4 car crash experiments carried out as a final phase of Contract FH-11-6962 with the National Highway Traffic Safety Administration. The purpose of these tests was to provide data to allow a comparison between the sled testing results obtained on the HSRI impact sled and actual car crashes. To this end, four 1966 Ford Galaxies were crashed utilizing restraint system configurations that were identical to those used on sled tests described in previous reports on this contract (i.e., BioM-71-2). These sled tests were performed with a 1966 Ford Galaxy buck. A series of 126 frontal and 22 1/2° oblique tests were performed on various restraint systems, including inflatable occupant restraint systems (IORS) and standard lap and upper torso belt systems.

The major difference between sled tests and actual, but contrived, car crashes is the deceleration pulse. For head-on frontal crashes that are essentially one dimensional in terms of vehicle or sled deceleration, mathematical models can well predict these differences (see, for example, HSRI report number Bio M-71-4 on the above contract). An oblique sled test is still one dimensional in terms of the sled phase, but an oblique car crash involves 3 components of linear deceleration and 3 components of angular deceleration. Therefore, the question, "How well do sled tests predict the results of actual car crashes?" is both important and timely.

2.0 INSTRUMENTATION AND TEST PROTOCOL

2.1 CAR CRASH FACILITY

A car crash test facility has recently been constructed by The University of Michigan Highway Safety Research Institute. Design of this facility was initiated after a careful study, including site visits of seven other facilities both in the U.S. and abroad. The facility is located on the Willow Run Airport property. The facility is secured with an eight-foot chain-link fence and is accessible only from private roads (Figure 1). A 670-foot paved flat roadway approach to the barrier has been provided (Figure 2). A continuous cable and gasoline-drive winch, similar to that used by General Motors at their car crash facility, is used as the main drive (Figure 3). The maximum speed is 90 mph, limited by the bearings on the guide trolley. The maximum payload is at least 8000#. A large stationary abort brake of the industrial disk and caliper type is provided. Attachment to the vehicle is through a one-half inch diameter steel cable and a maximum deceleration of 3 G's is attainable (Figure 4). Provision for operating fixed and movable barriers and poles has been included. The cable drive direction may easily be reversed so that roll-over and car-to-car crashes at velocities higher than those that could be accommodated in front of the barrier can be performed. A large catch field has been provided for this purpose.

Instrumentation is housed in a large van which can be located appropriately for the test configuration. Currently, 42 channels of FM tape recording and 28 channels of visicorder are provided. Data is transmitted to the instrumentation van via umbilical cords. High speed camera coverage (nominally 1000 fps) includes side, oblique, overhead and undercarriage. For the undercarriage view, an 8' x 8' x 8' deep camera pit has been constructed immediately in front of the barrier. Both on-board and fixed camera coverage is routinely provided.

2.2 INSTRUMENTATION SPECIFICATIONS

2.2.1 TRANSDUCERS. The following transducers were used:

1. Kistler Piezotron Model 818 Accelerometer (Dummy Heads)

   Type: Piezoelectric with integral impedance converter
   Range: ±250 G
   Sensitivity: 10 mv/g
   Freq. Response: 1 to 5000 Hz (±5%)
   Resonant Freq.: 30,000 Hz

2. Setra Model 104 (Dummy Chests)

   Type: Capacitance with integral impedance converter
   Range: ±500 G
   Sensitivity: 10 mv/g
   Freq. Response: 0 to 7000 Hz (±3%)
   Resonant Freq.: 7000 Hz
   Damping: 0.7 of critical-gas damped

3. Statham Model A69TC-100-350 Accelerometer (Vehicle)

   Type: Temperature compensated, unbonded strain gage
   Range: ±100 G
   Natural Freq.: 1800 Hz
   Damping: 0.7 (±0.1) of critical at room temperature

4. Lebow Model 3371 Belt Load Cell

   Type: Strain gage
   Range: 3500 pounds, with 50% overload capacity
   Sensitivity: 2.2906 mv/V/3500 pounds

2.2.2 SIGNAL CONDITIONERS. The following signal conditioners were used:

1. Honeywell Model 120 D. C. Amplifier

   Type: Solid state, direct coupled, wideband differential
   Gain: 10 - 1000
   D.C. Gain Linearity: better than ±0.2% of full scale
   D.C. Gain Accuracy, Calibrated Gain Ranges: better than ±0.5%
   Freq. Response: ±2% D.C. to 10 KHz
   Used with Piezotron Accelerometer

2. Honeywell Model 105 Bridge Balance (Gage Control) Unit

   Type: Same as above
   Freq. Response: ± D.C. to 10 KHz within ±0.5%
   Used with Lebow Belt Load Cells

3. Setra Model SCM Amplifier

   Type: Solid state, direct coupled, wideband differential
   Gain: 0 - 5
   D.C. Gain Linearity: better than ± 0.2% of full scale
   D.C. Gain Accuracy: better than ± 0.5%
   Freq. Response: ±2% D.C. to 20 KHz
   Used with Setra Accelerometer

2.2.3 RECORDERS. The following recorders were used:

1. Honeywell Model 1612 Visicorder Light-Beam Oscillograph

   Galvanometer response:

   M-3300 (15 channels): ±5%, 0 to 2000 Hz
   M-1650 (4 channels): ±5%, 0 to 1000 Hz
   M-1000 (1 channel): ±5%, 0 to 600 Hz

2. Honeywell Model 7600 F.M. Tape Recorder/Reproducer

   Tape Speeds: 1 7/8 to 120 ips

   Freq. Response: $\pm$1.0 db 0 - 5000 Hz (at recording speed used - 30 ips)

   Harmonic Distortion: 1.2%

3. CEC Model VR-3300 F.M. Tape Recorder

   Tape Speeds: 1 7/8 to 60 ips

   Freq. Response: $\pm$0.5 db 0 - 10000 Hz (at recording speed used - 30 ips)

   Harmonic Distortion: 1.5%

2.3 CALIBRATION PROCEDURES

Transducers: The calibration sensitivities of the transducers are checked to insure that there has been no appreciable deviation from manufacturers specified sensitivity.

1. Kistler Piezotron Model 818 Accelerometers.

   The sensitivities of these piezoelectric accelerometers, which are used in the crash test dummies, are checked with a Kistler Model 894K Shock Calibration System. This system compares, on peak-reading voltohmmeters, the output of the test accelerometer and an NBS-traceable load cell onto which the accelerometer is dropped. Accuracy of the load cell and associated peak meters is checked against a NBS-traceable standard accelerometer prior to calibration of the test accelerometers.

2. Statham Model A69TC Accelerometer

   This strain-gage accelerometer, used to monitor sled deceleration, is calibrated by comparing its output with that of an NBS-traceable standard accelerometer. The two accelerometers are mounted piggy-back on a common carrier block and impacted. Their outputs are displayed, via the sled umbilical and the signal conditioning system, on the oscillograph. The excitation voltage of the Statham is adjusted until its output agrees with the standard accelerometer. This excitation voltage becomes the standard for subsequent use of the accelerometer.

3. Setra Model 104 Accelerometer.

Same as Item 2.

4. Lebow Seat-Belt Load Cells.

Calibration sensitivity of these load cells is checked by applying a known load to a length of seat-belt material on which the cell is mounted. The output signal is compared with that obtained when a shunt resistor is paralleled with one leg of the transducer's bridge. The resistor value is that which has been specified by the manufacturer to produce a transducer output equal to the output produced by a known load.

2.4 INSTRUMENTATION CHANNELS

The following channels were instrumented with appropriate transducers, signal conditioners and recorded on FM tape recorders during the car crash:

Channels	
1-3	Tri-Axial Head Accelerometer Dummy No. 1 (50% male, standard belt)
4-6	Tri-Axial Chest Accelerometer Dummy No. 1
7-10	Seat Belt Load Cells Dummy No. 1
11-13	Right Vehicle Tri-Axial Accelerometer
14	Timing Pulses and Contact Switch
15-17	Tri-Axial Head Accelerometer Dummy No. 2 (50% male, IORS)
18-20	Tri-Axial Chest Accelerometer Dummy No. 2
21	AP Head Accelerometer Dummy No. 3 (3-year-old)
22	Sl Head Accelerometer Dummy No. 3

Channels	
23	AP Chest Accelerometer, Dummy No. 3
24	Sl Chest Accelerometer, Dummy No. 3
25-27	Left Vehicle Tri-Axial Accelerometer
28	Timing Pulses and Contact Switches

2.5 TEST METHODS

The following test matrix was used:

Test Number	Speed MPH		Barrier Type
	Programmed	Actual	
B3	30.5	30.36	Flat Frontal
B4	30.5	30.36	Flat Frontal
B5	30.5	30.38	22 1/2° Oblique
B6	40.5	40.47	Flat Frontal

All cars were 1966 Ford Galaxy 4-door sedans except B6 which was a 4-door hardtop. Test B3 and B4 were identical to provide a preliminary check of reproducibility. Three anthropometric dummies were used in each test. The right front and left front passengers were 50 percentile #850 Sierra anthropometric dummies with the new 1050 pelvis and General Motors rubber necks. The steering wheel, shaft, brake, and accelerator pedals were removed so that the driver side and front passenger side of the vehicle presented the same geometry. A standard 4-point lap and upper torso belt restraint system was used on the left, or driver's, side while an inflating occupant restraint system (IORS) supplied by Eaton Corporation was used on the right front passenger side. This IORS utilized a 10 cubic foot bag inflated by compressed gas. A styrofoam block was installed on the right side to catch the dummy's knees and prevent submarining. A standard 3-year-old Sierra child dummy rode in the back seat restrained either with a Ford Tot Guard or an American Safety Engineering Child Safety Seat. Inflation of the IORS was initiated by contact switches on the front bumper of the car in order to provide comparison with recent IORS sled tests with similar contact switches (Figure 5).

This experimental design allowed a direct comparison of the three restraint systems employed, in addition to providing data directly comparable to sled tests. For a complete discussion of the sled tests referred to subsequently in this report the reader is referred to:

1 - HSRI Report No. Bio M-71-2, "Studies of Inflating Restraint Systems"

2 - HSRI Report No. Bio M-71-8, "Integrated Seat Restraint Systems"

2.6 VEHICLE SPEED MEASUREMENT

The vehicle impact velocity was determined photometrically and as a check the longitudinal impact velocity was determined from a speed trap consisting of two tape switches placed in front of the barrier, 5 feet apart. A digital electronic counter with an accuracy of ± 1 microsecond was switched on by the first switch when the vehicle wheel passed over the switch and switched off by the second switch. The photometric analysis compared quite well with the speed trap data and, since it yielded a complete velocity profile, was used in the analysis reported here.

2.7 CAR PREPARATION

The aim of the car preparation was to reproduce as nearly as possible the sled test configuration with which comparisons were to be made. A 1966 Ford Galaxy buck was used in these sled tests. Therefore, the doors and roof were removed from the vehicles to be crashed. Reinforcing members were added to the roof and door frames to provide essentially the same stiffness and mass as was removed. A simulated mesh door was provided that was open enough for film coverage. This simulation provided essentially the same boundary conditions for the air bag as a car door with the window down. The front seat was reinforced and welded in place as in the sled tests. The steering wheel, column, and pedals were removed to provide the same interior geometry for both front passengers. Two tri-axial accelerometers were installed just behind the front seat on the floor, one on the right side of the car and one on the left (Figure 6). An umbilical cord patch panel and outrigger were installed in the trunk (Figures 7 and 11). Figures 8 through 10 show the typical test setup.

3.0 RESULTS

3.1 SUMMARY

The speed control and drive winch performed exceptionally in their first series of tests. Speed control was well within acceptable tolerances. The instrumentation and recording devices worked well and all data was obtained for the first three tests of the series. In the fourth test, the piezotron accelerometers (dummy heads) failed to function properly, probably due to a heavy thunder shower that had previously wet the umbilicord and junction box. This type of accelerometer is notoriously sensitive to small impedance changes in the conditioner wiring. Due to this experience, these accelerometers are being replaced with Setra capacitance type transducers which are much more reliable under car crash conditions. Fortunately, it was possible to obtain the dummy head accelerations through photometric analysis. This technique has been significantly extended by researchers at HSRI (refer to HSRI Report Bio M-71-5, "Door Crashworthiness Criteria").

Table 1 presents a comparison of peak accelerations for the left and right front passengers with IORS and standard belt restraints.

Table 2 presents a comparison of peak belt loads for the car crashes or representative sled tests.

3.2 ANALYZED DATA

The recorded data, consisting of tri-axial accelerometer signals, was played back at a reduced speed 1/16 of the recording speed. These signals were filtered according to SAE-J211 recommended practice and then entered

TABLE 1

COMPARISON OF PEAK ACCELERATIONS

TEST NUMBER	TEST TYPE	NOMINAL SPEED (mph)	IORS 50% Dummy Head Accelerations (g's)				IORS 50% Dummy Chest Accelerations (g's)				STANDARD BELTS 50% Dummy Head Accelerations (g's)				STANDARD BELTS 50% Dummy Chest Accelerations - (g's)			
			S-I	L-R	A-P	RES	S-I	L-R	A-P	RES	S-I	L-R	A-P	RES	S-I	L-R	A-P	RES
B3	Barrier, Frontal	30	41	10	40	43	12	10	42	43	95	50	43	110	10	70	22	72
B4	Barrier, Frontal	30	30	9	23	32	12	18	44	45	65	37	40	76	13	11	51	52
B5	Barrier, Oblique	30	28	15	14	51	17	7	26	27	72	62	40	95	24	8	38	39
B6	Barrier, Frontal	40	12*	33*	49*	51*	35	13	55	64	18*	9*	82*	83*	42	25	63	63
A323	Sled, Frontal	30	14	55	85	125	18	42	112	120	-	-	-	-	-	-	-	-
A402	Sled, Frontal	30	-	-	-	-	-	-	-	-	92	30	15	100	14	27	45	103
A292	Sled, Frontal	30	20	18	23	39	8	10	33	37	-	-	-	-	-	-	-	-
A309	Sled, Frontal	40	49	10	26	57	17	-	42	46	-	-	-	-	-	-	-	-
A220	Sled, Oblique	30	20	15	15	23	20	25	30	39	-	-	-	-	-	-	-	-
A246	Sled, Frontal	30	-	-	-	-	-	-	-	-	60	10	59	77	15	20	40	46

*Obtained through photometric analysis

TABLE 2

COMPARISON OF PEAK BELT LOADS

TEST NUMBER	TEST TYPE	NOMINAL SPEED (mph)	LOAD (lbs) LAP BELT LEFT	LOAD (lbs) LAP BELT RIGHT	LOAD (lbs) SHOULDER BELT LEFT
B3	Barrier, Frontal	30	1275	1550	1975
B4	Barrier, Frontal	30	1350	1675	1950
B5	Barrier, Oblique	30	1325	1750	2175
B6	Barrier, Frontal	40	4000	1950	2690
A323	Sled, Frontal	30	-	-	-
A402	Sled, Frontal	30	1625	-	-
A292	Sled, Frontal	30	-	-	-
A309	Sled, Frontal	40	-	-	-
A220	Sled, Oblique	30	-	-	-
A246	Sled, Frontal	30	1410	1150	1760

into an analog computer to compute the vector resultant and severity index. Recording of these computed quantities was done on a Brush Model 206 recorder. The slower speed playback insured that the recorder was capable of responding to signals well above the cutoff frequency of the filters. Summary Data Sheets 1 through 9 show these computations for the car crash tests B3, B4, B5 and B6. In addition, typical sled test data analyzed in the same way is presented. Summary Data Sheets 10 through 14 show the belt loads for these car crash tests, along with a typical belt load time history for a sled test.

3.3 PHOTOMETRIC ANALYSIS

HSRI has pioneered in the development of advanced methods of analyzing high speed movie data. Fortunately, it was possible to bring this technology to work and obtain the head accelerations that were lost in test B6. The films for car crash B6 were analyzed on a Vanguard film analyzer and computer cards punched with the head displacement data. Differentiation and smoothing routines were used to obtain the linear and angular displacement, velocity and acceleration of the heads. In addition, the displacement, velocity and acceleration of the vehicle were determined. Figures 22 through 27 show the results of these analyses.

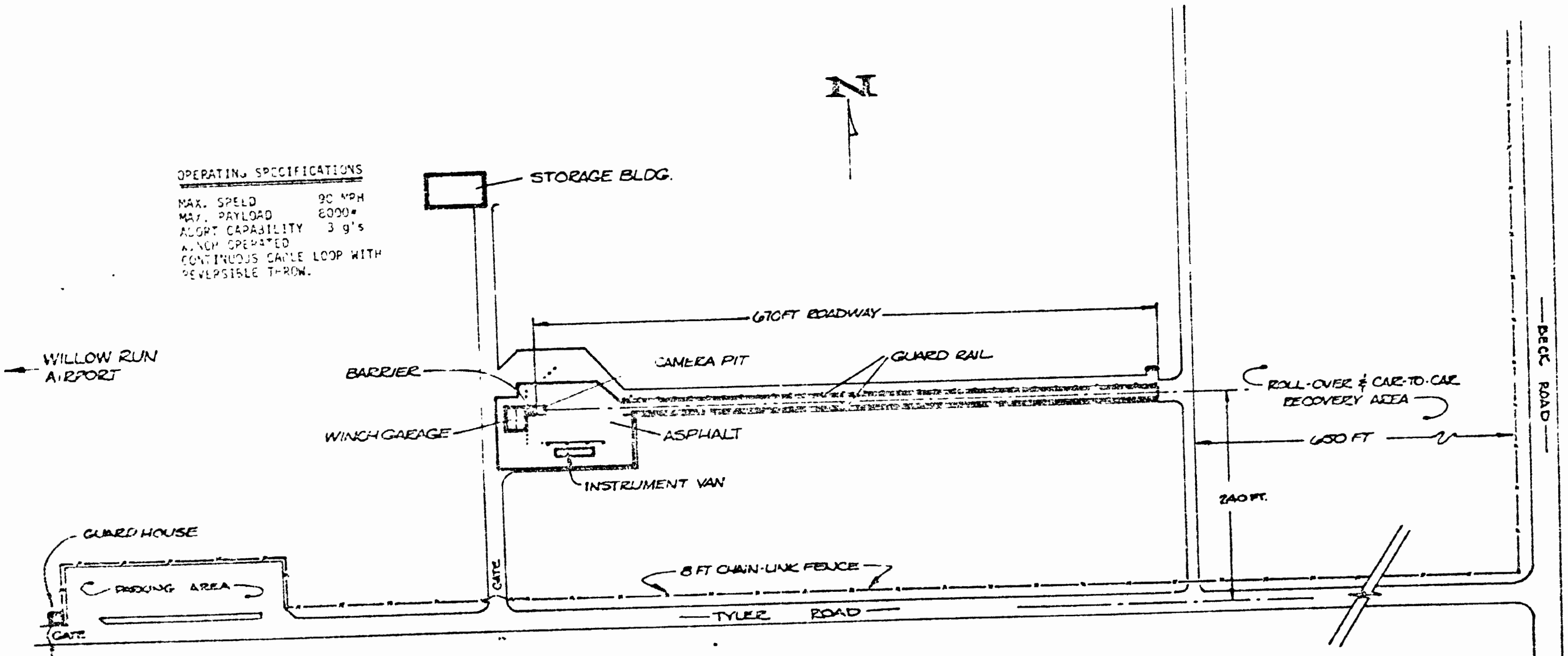
4.0 DISCUSSION

While it is impossible to draw statistically meaningful conclusions from four data points, the results of these tests indicate that severe difficulties exist in extrapolating even gross sled test results to actual car crash situations. These problems go far beyond the effects of different crash pulse shapes. They include the unrepeatability of dummy joint settings and positions and the so-called ringing of the dummies' head and chest to which the accelerometers are attached, which leads to vastly different acceleration signals. The dummy heads used in this test series had a natural frequency of 960 Hertz and a very low damping constant. This frequency is within the bandwidth of the data as presented. Thus, the head accelerometer outputs are quite dependent on local conditions that are essentially uncontrolable with the currently available dummies. A large amount of data is currently being examined at HSRI with the aim of carefully documenting the unrepeatable nature of sled and car crash testing. This will be reported at some future date as it is outside the provisions of this contract. Tests B2 and B3 were virtually identical in all major respects. The same model cars were crashed at virtually identical speeds. The same type of restraints were used, the same dummies and instrumentation were used, yet the recorded accelerometer traces supposedly indicative of the injury reducing potential of the restraint systems were very different.

However, dummy displacement time histories for the two similar car crashes and comparable sled tests were quite similar as determined photometrically. But photometric analysis is equivalent to filtering the data. For the 1000 frames per second rates used in these tests, photometric analysis of the type developed at HSRI is equivalent to filtering with a 20 Hertz first order filter. It is for this reason that the head accelerations for test B6 which were determined photometrically are not directly comparable with the head data for the other tests since this data was filtered with a 1650 Hertz first order filter. Great care must therefore be exercised in using accelerometer data to predict the injury reducing potential of automotive occupant restraint systems.

There is one important aspect of these tests that bears emphasis. No child seat test data is presented. This is because the rear seat back and the rear seat cushion repeatedly came loose in the crash. This extra loading on the ASE seat and the Ford Tot Guard caused structural failure of the child seat structures (Figure 21). The child dummy experienced severe loading due to this very real problem. It is too much to expect a child seat to restrain the child occupant and the adult seat as well.

5.0 FIGURES



H.S.R.I. CAR CRASH TEST FACILITY - Univ. of Michigan

Figuro no. 1

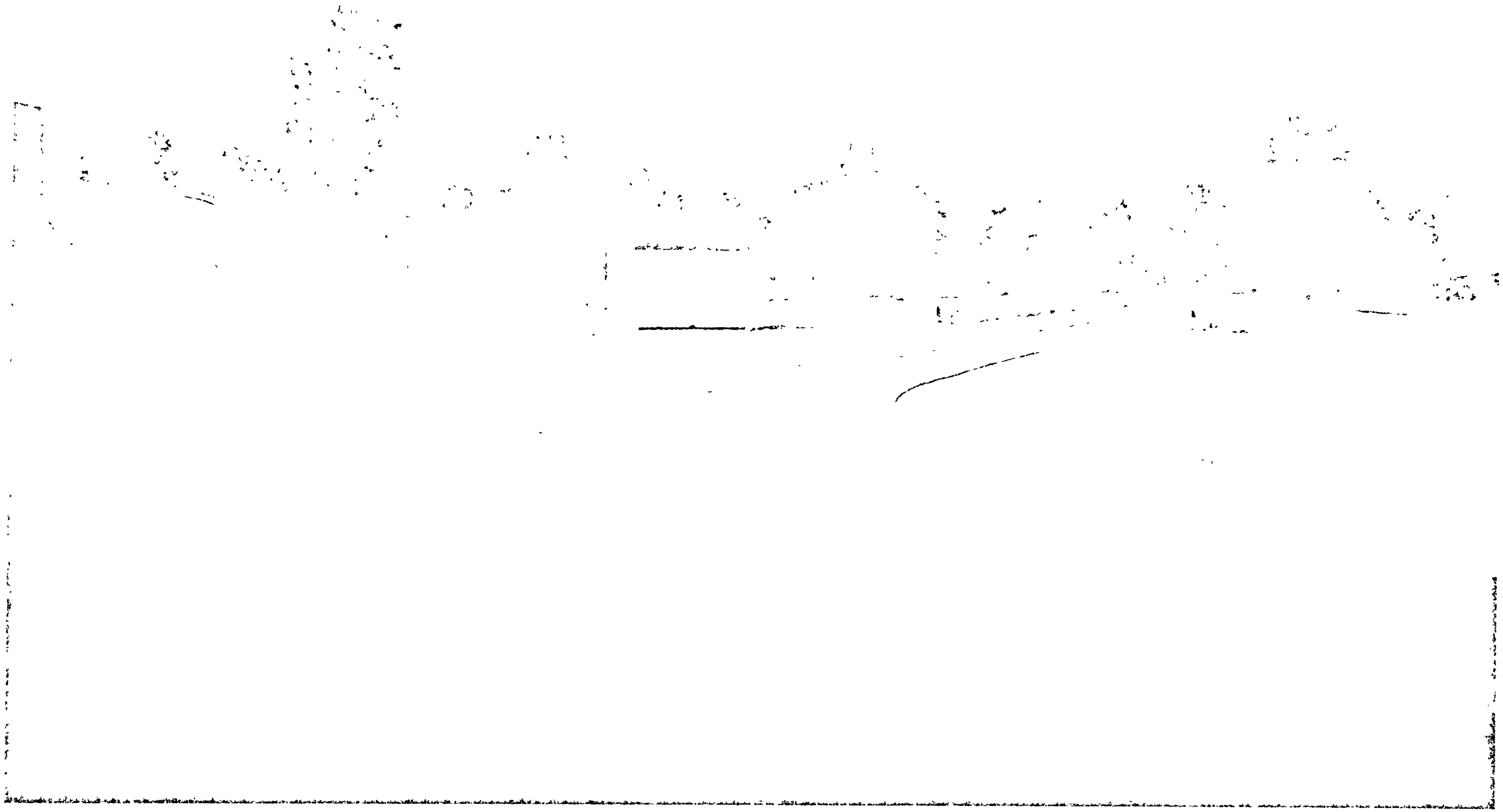


FIGURE 2. OVERALL VIEW OF HSRI CAR CRASH TEST FACILITY

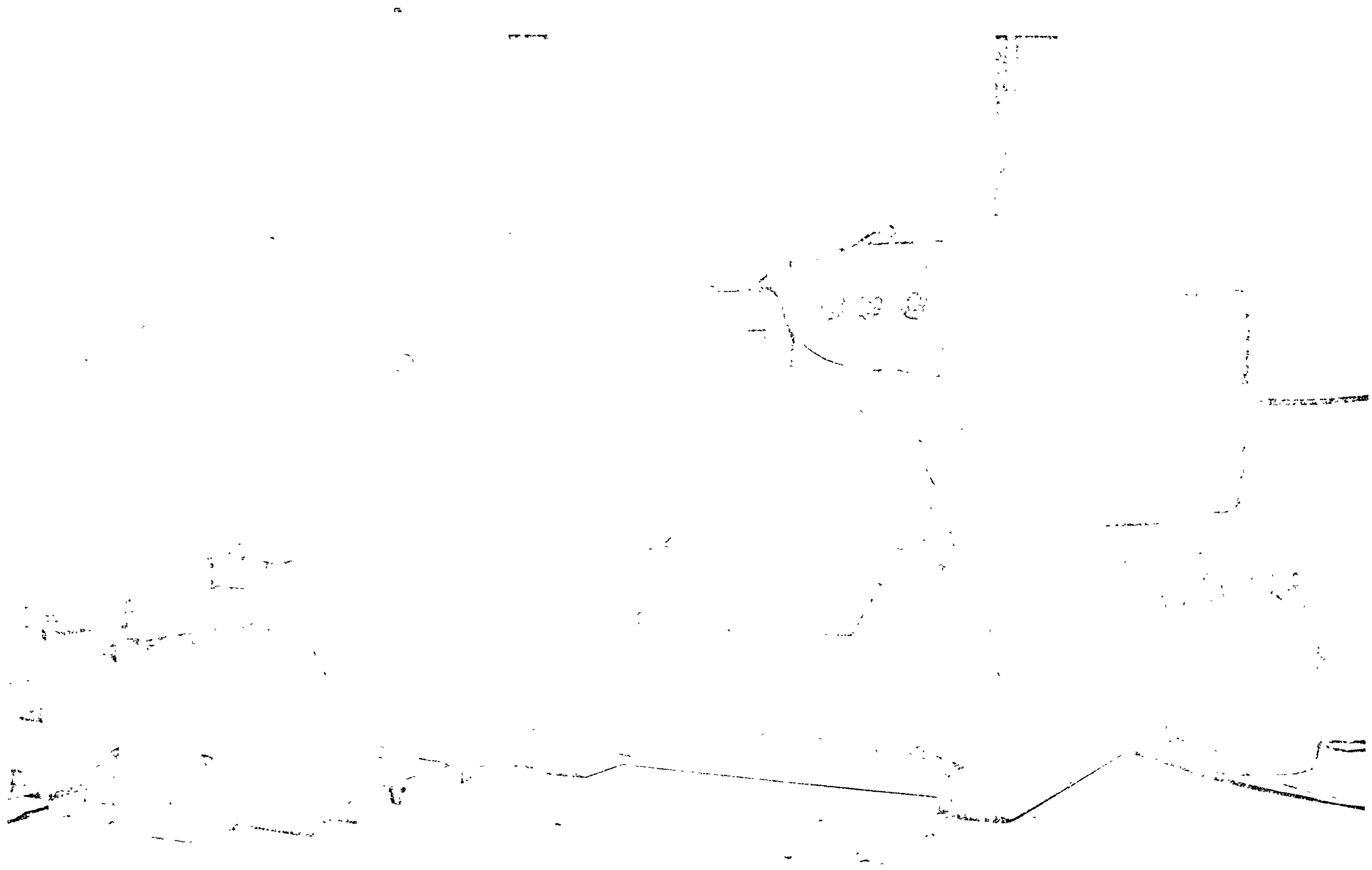


FIGURE 3. WINCH DRIVE ASSEMBLY

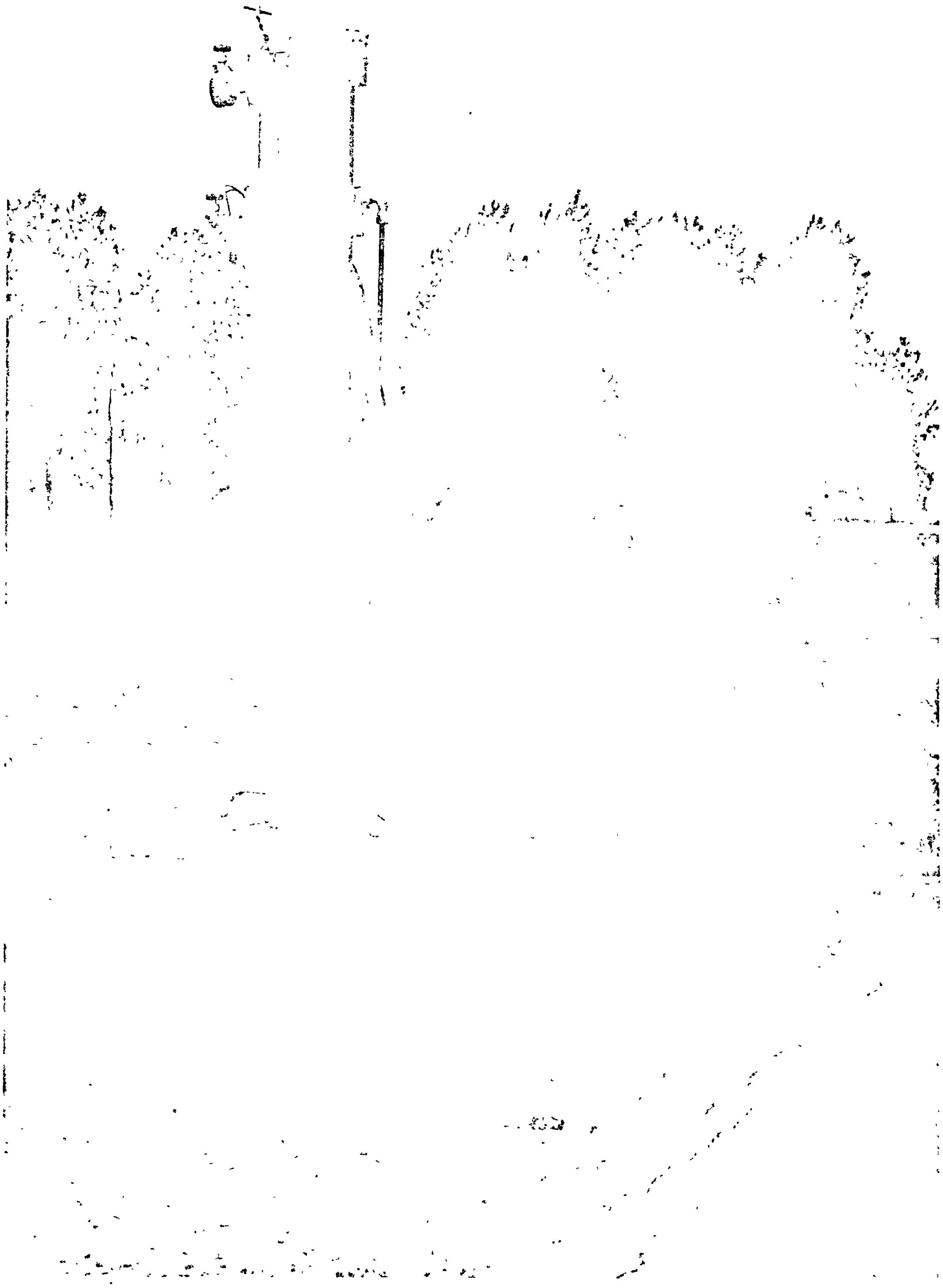


FIGURE 4. ABORT BRAKE

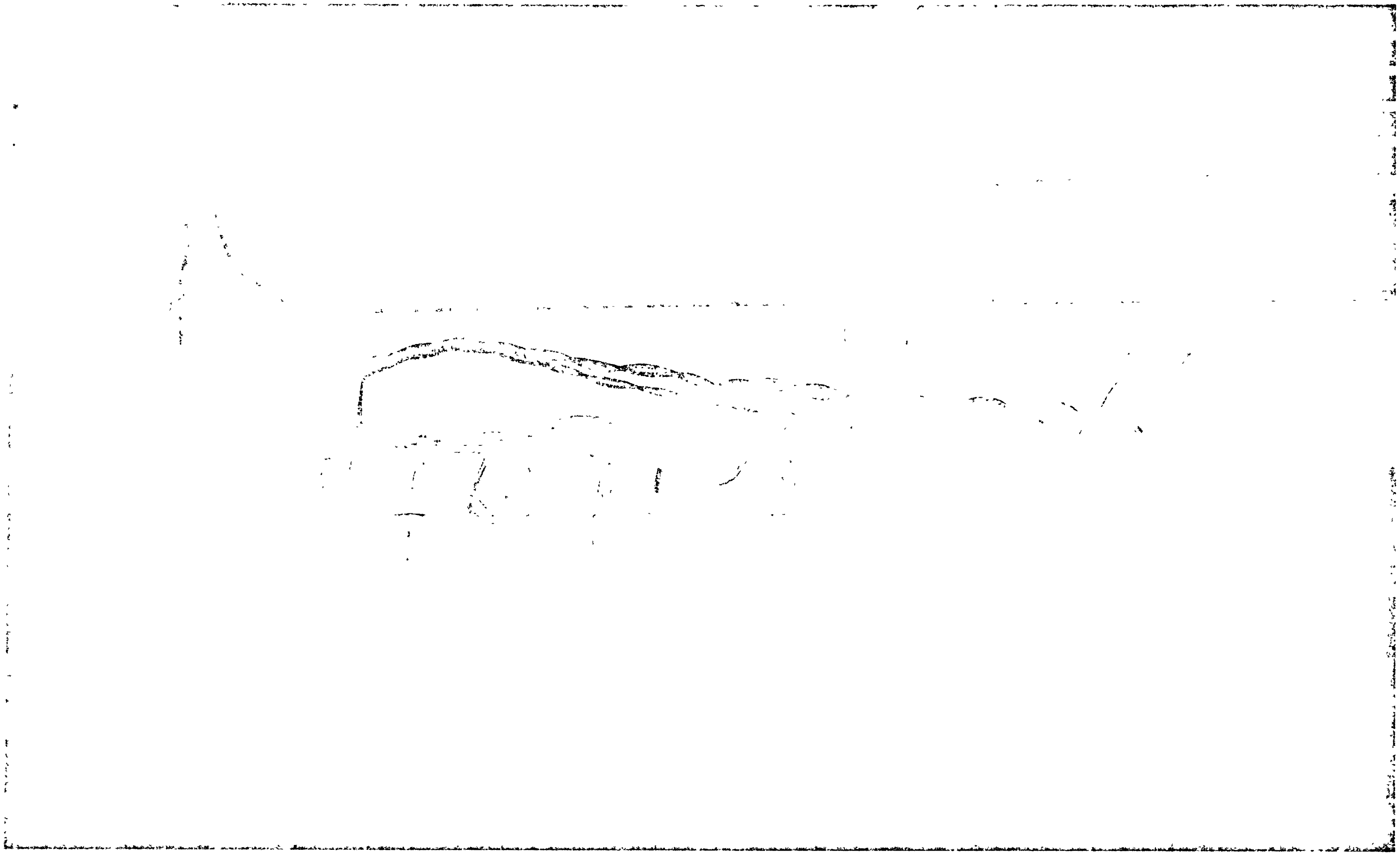


FIGURE 5. BUMPER CRASH SENSOR

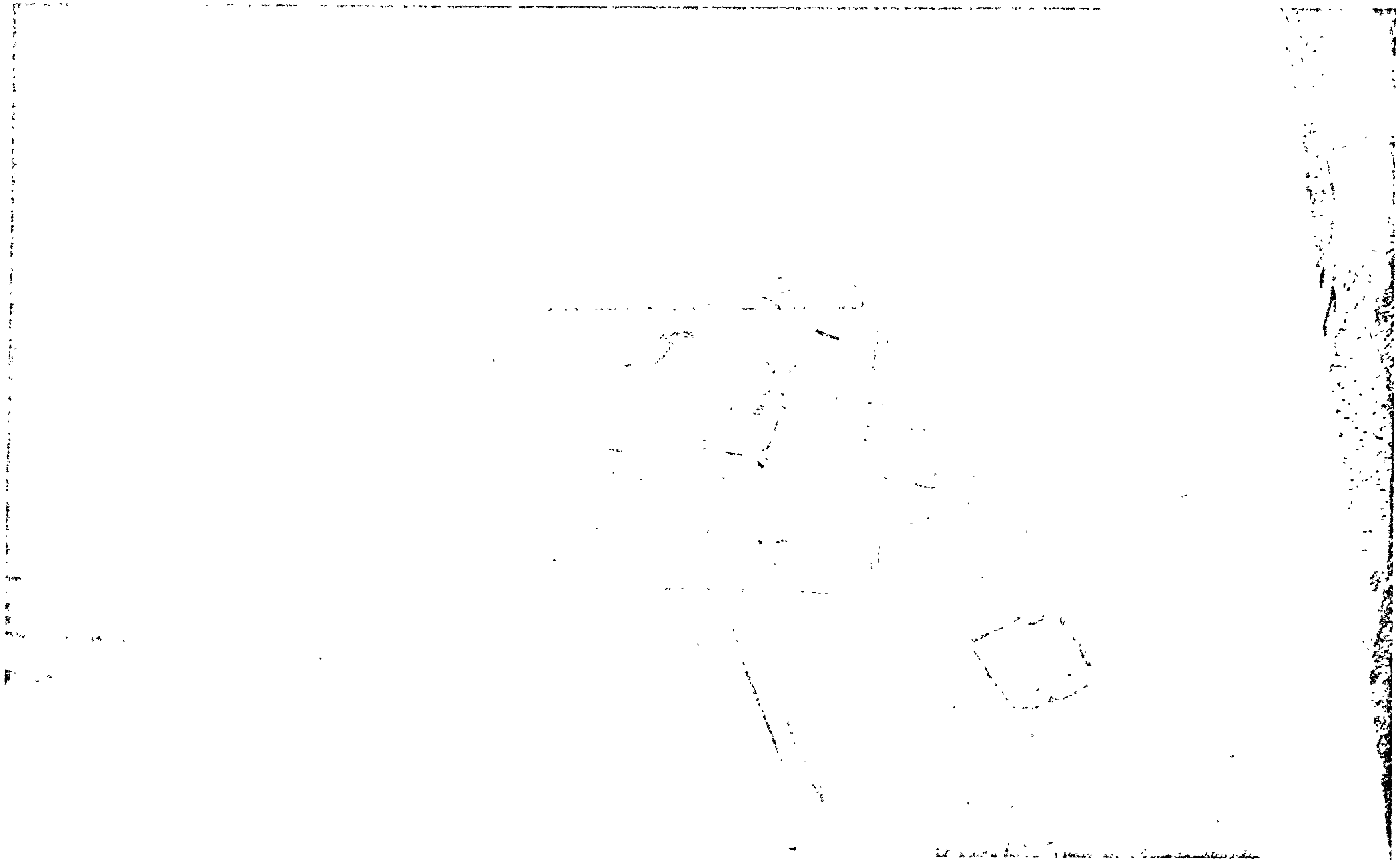


FIGURE 6. TRIAXIAL ACCELEROMETER FLOOR MOUNT

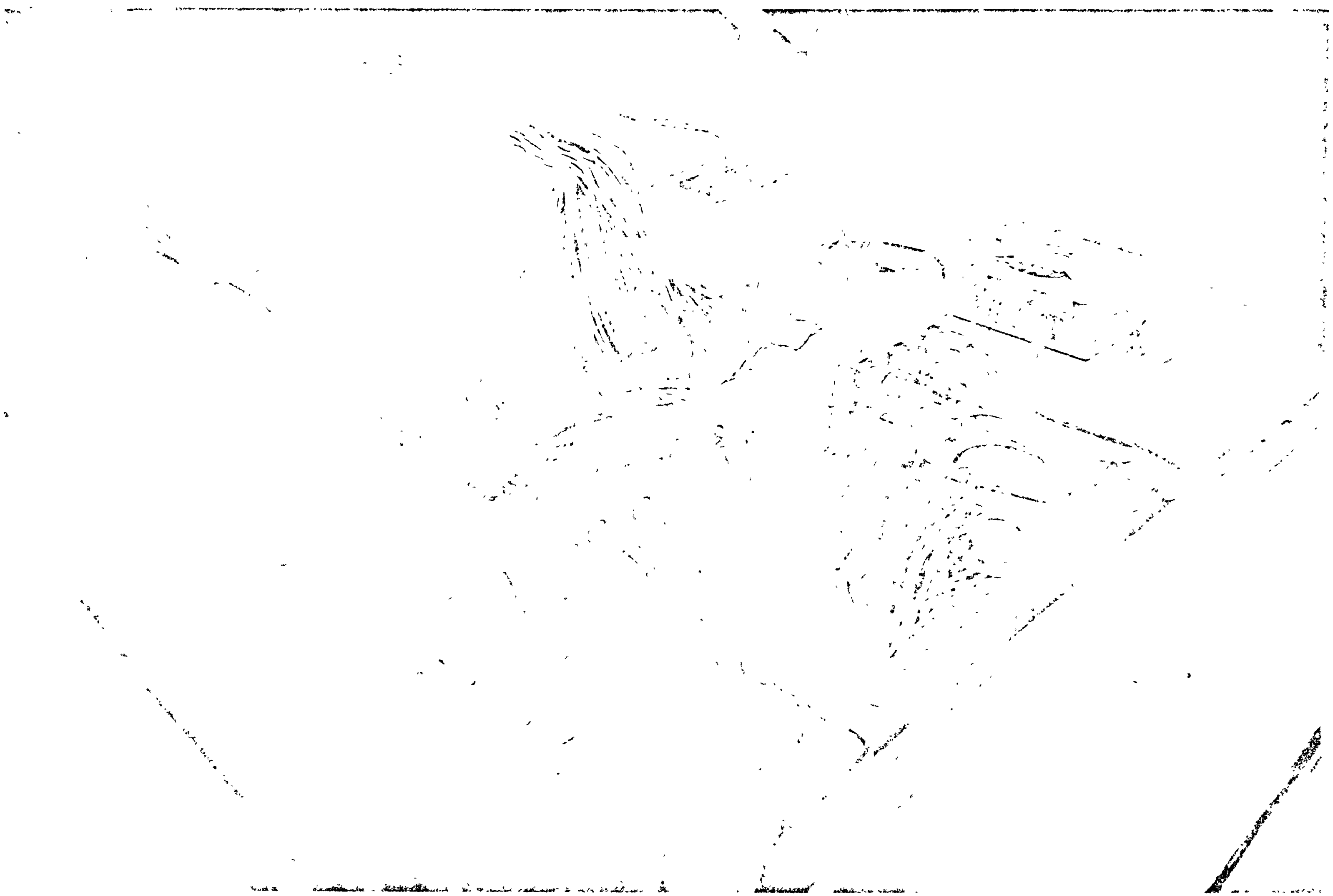


FIGURE 7. UMBILICAL CORD PATCH PANEL

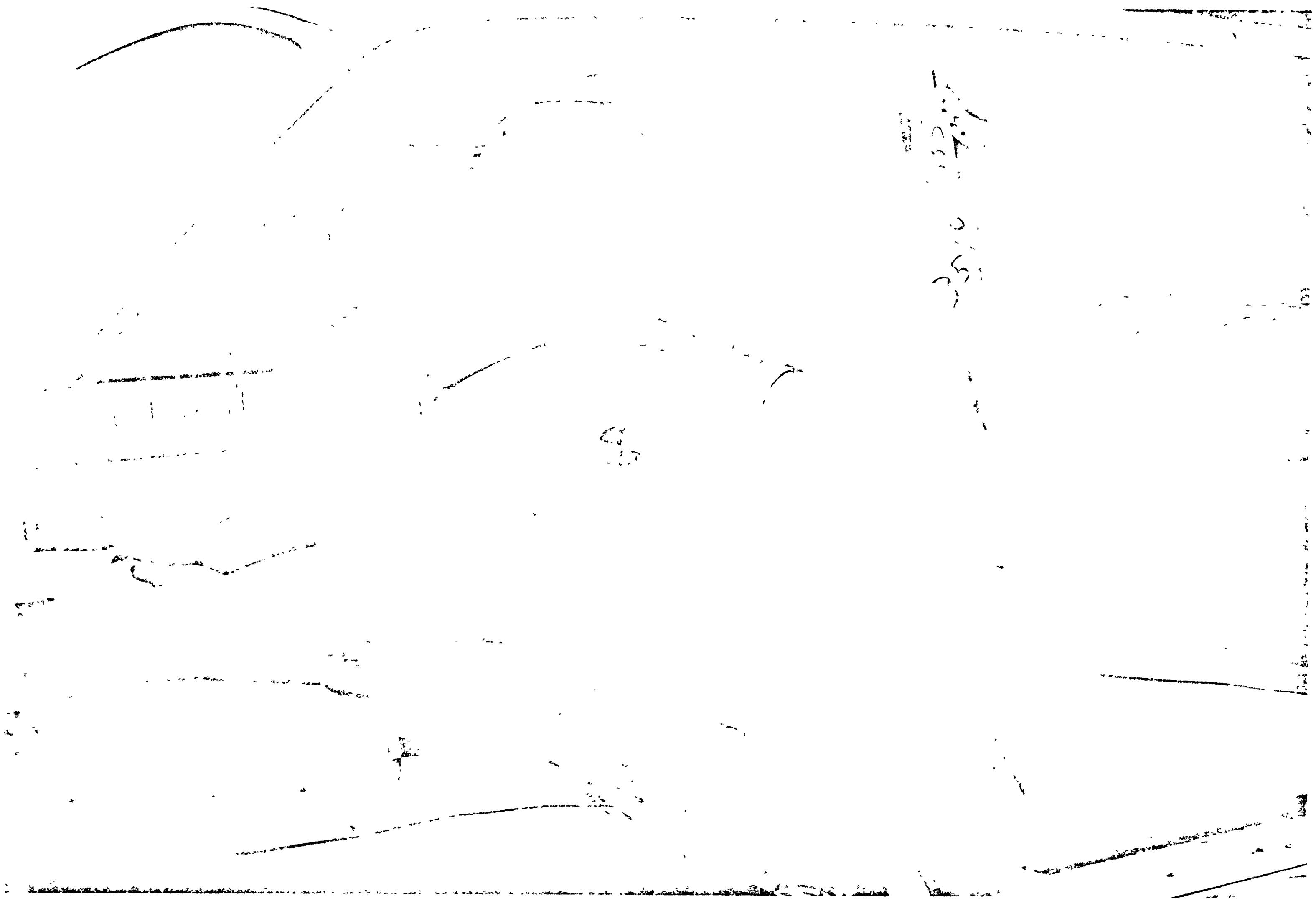


FIGURE 8. TYPICAL DUMMY CONFIGURATION

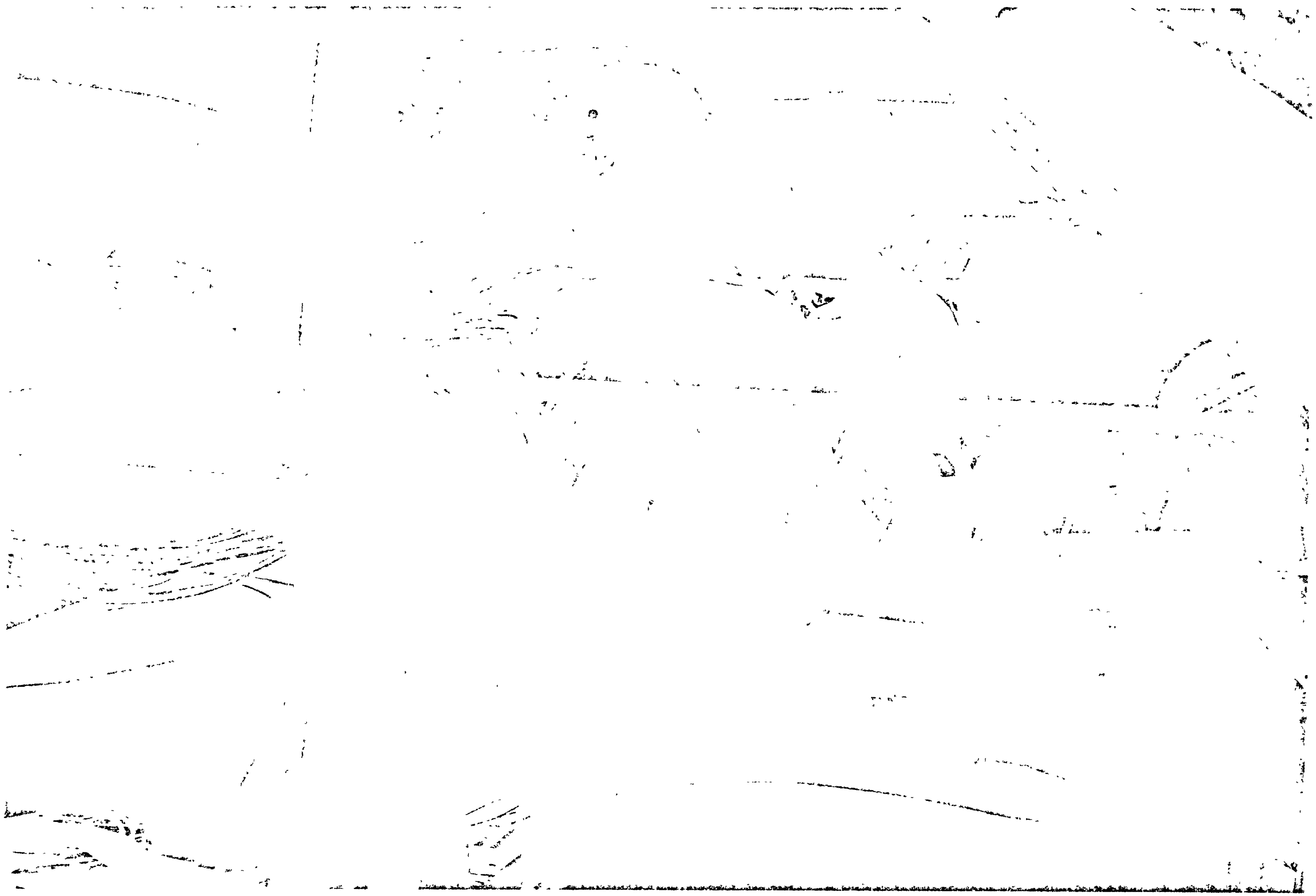


FIGURE 9. TYPICAL DUMMY CONFIGURATION

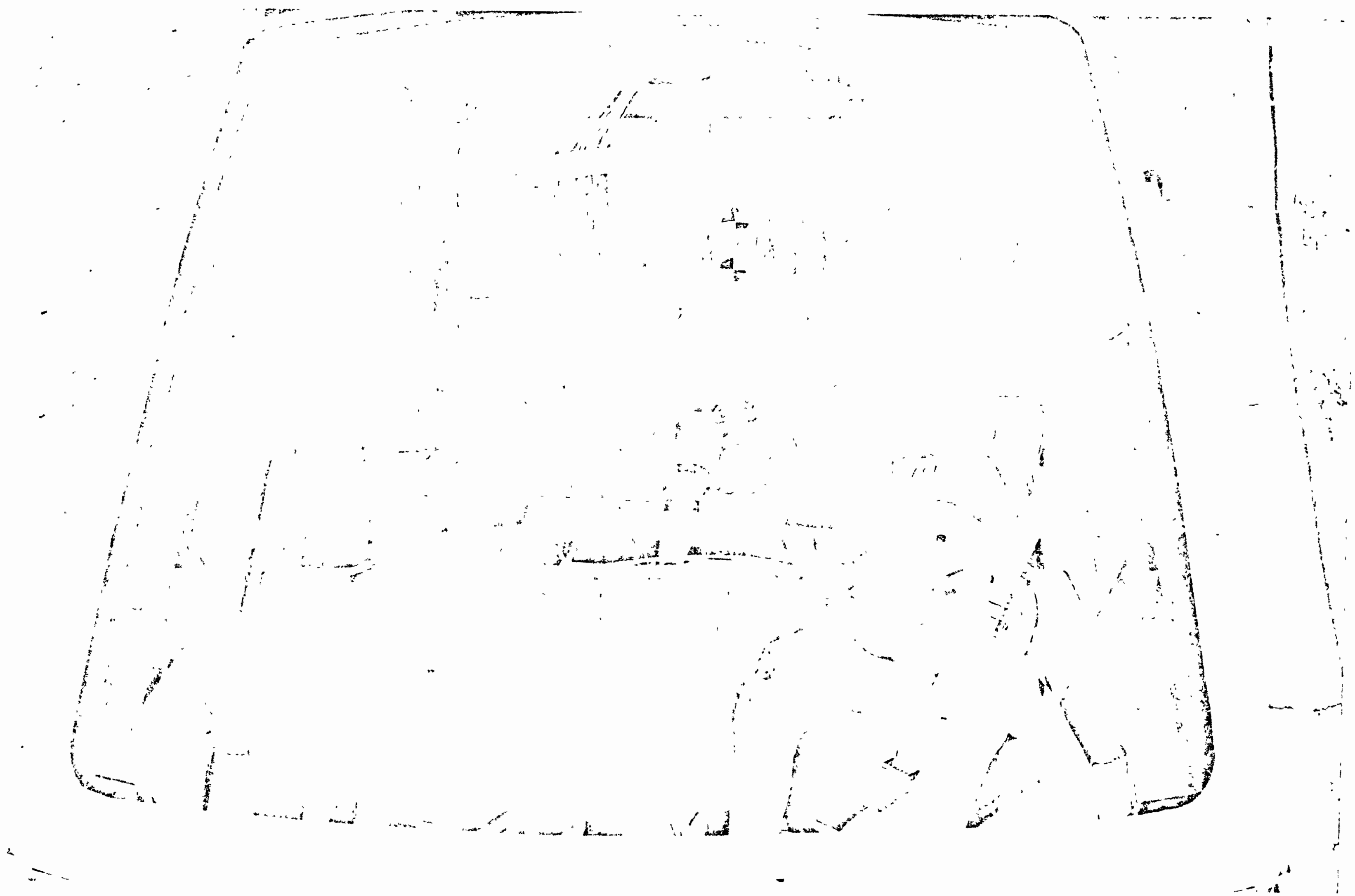


FIGURE 10. TYPICAL DUMMY CONFIGURATION.

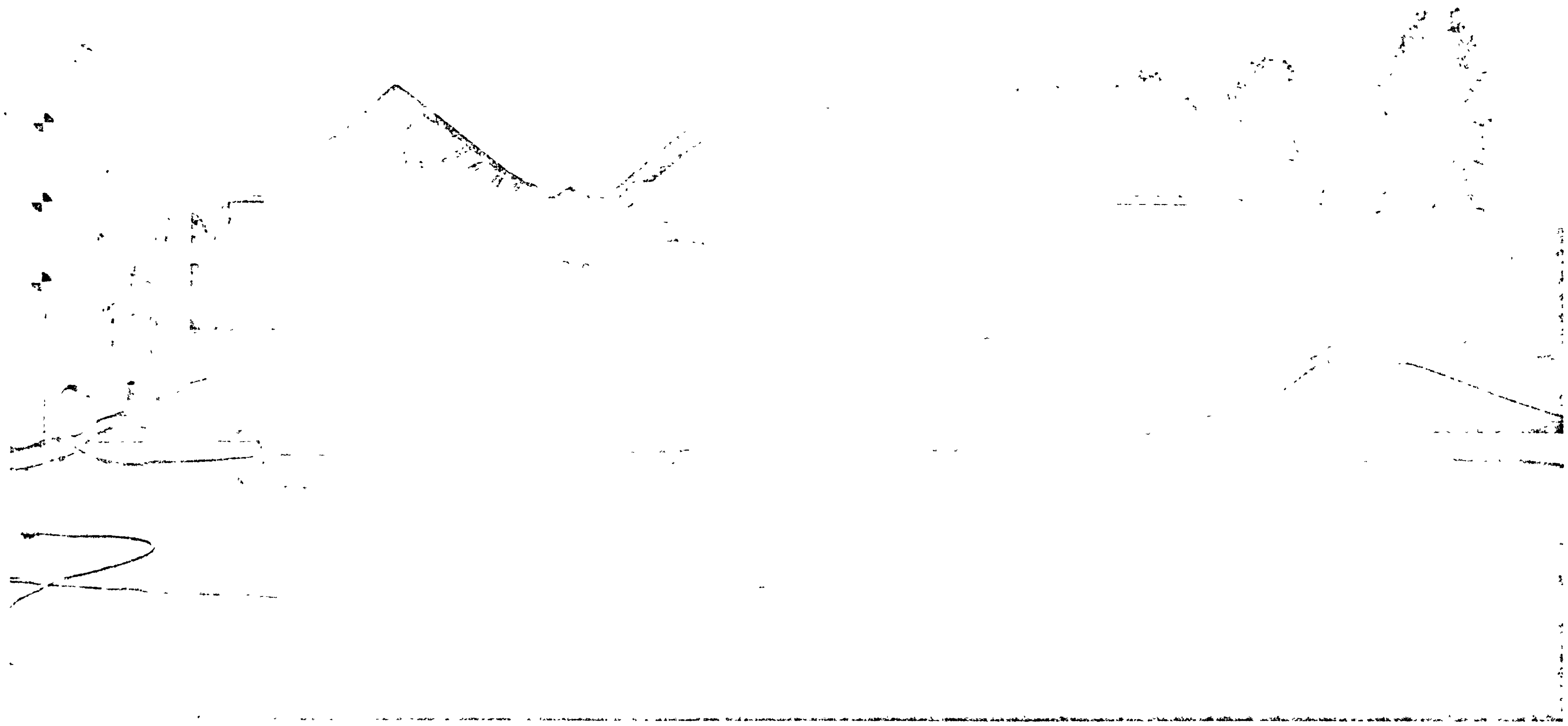


FIGURE 11. CONFIGURATION AFTER TEST B3

FIGURE 12. CONFIGURATION AFTER TEST B4

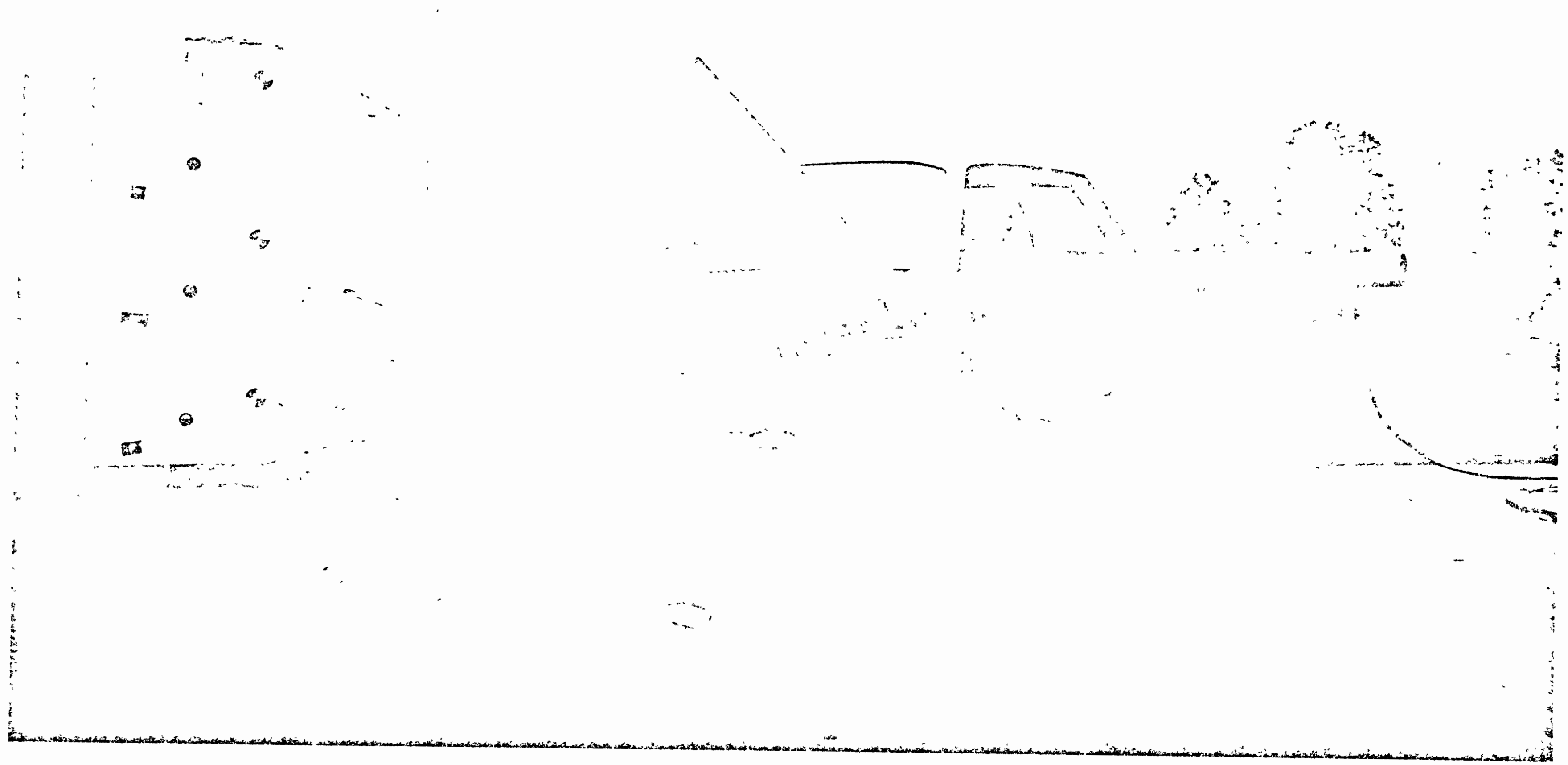


FIGURE 13. CONFIGURATION AFTER TEST B5

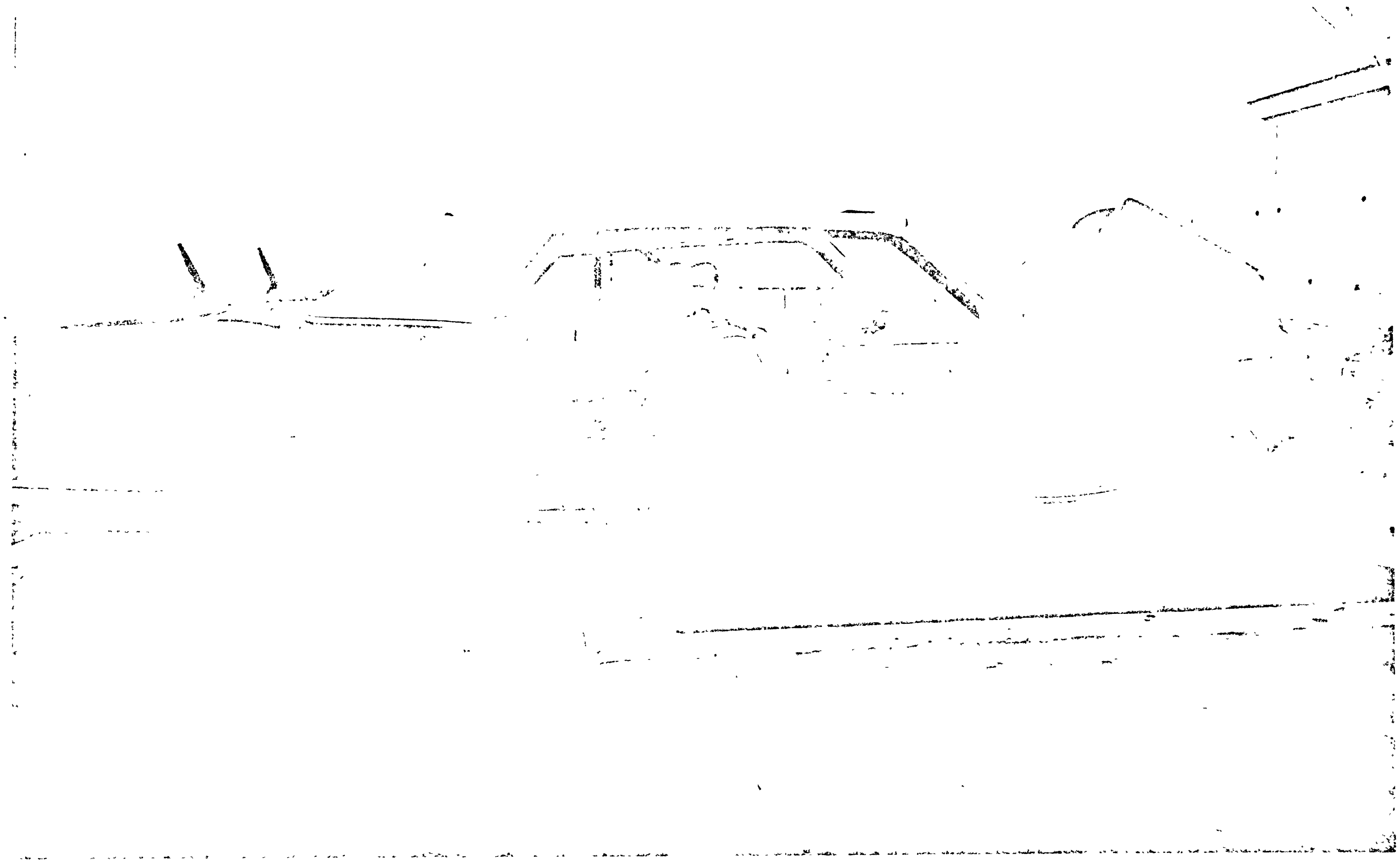


FIGURE 14. CONFIGURATION AFTER TEST B6

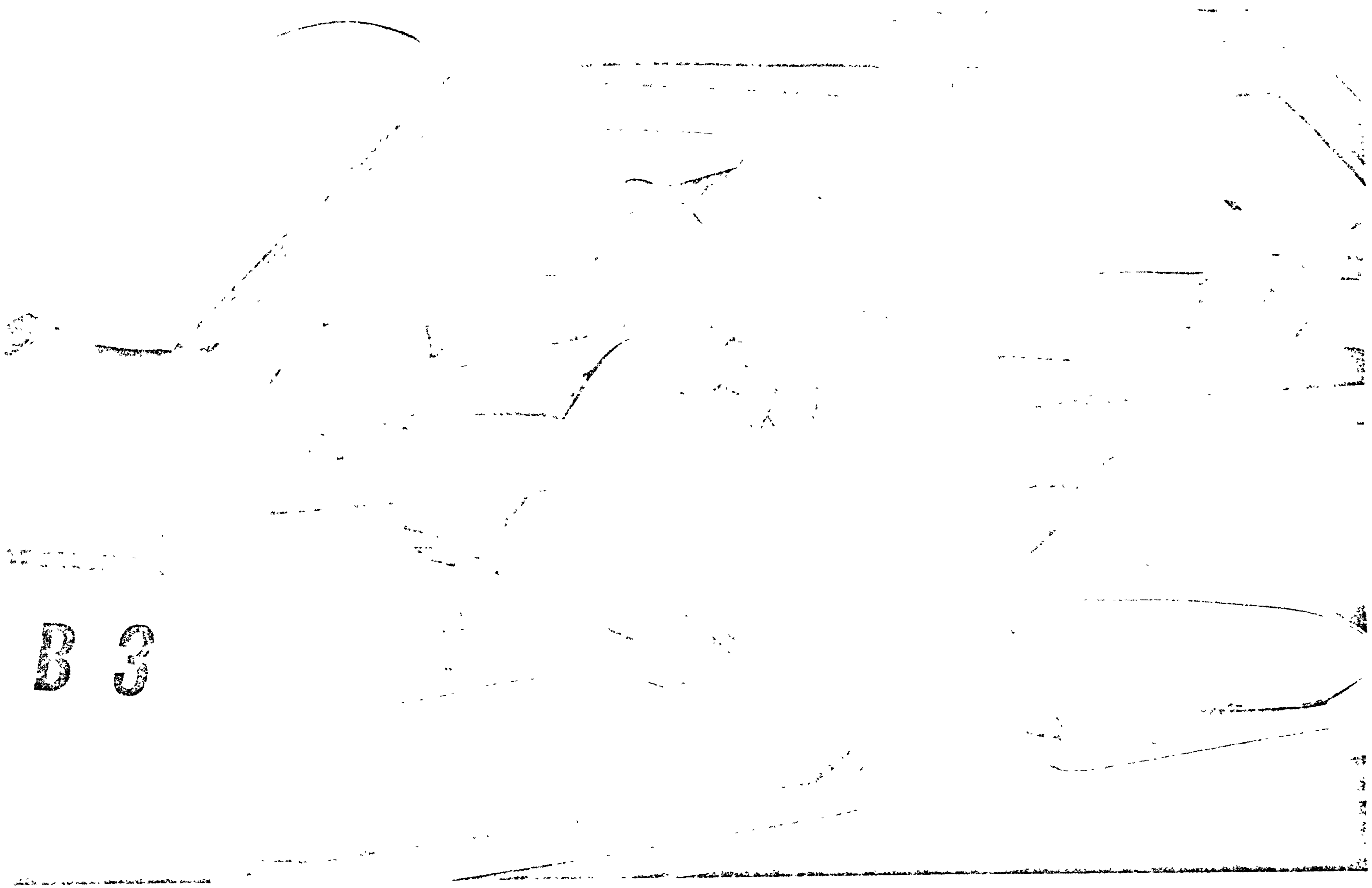


FIGURE 15. CONFIGURATION AFTER TEST B3

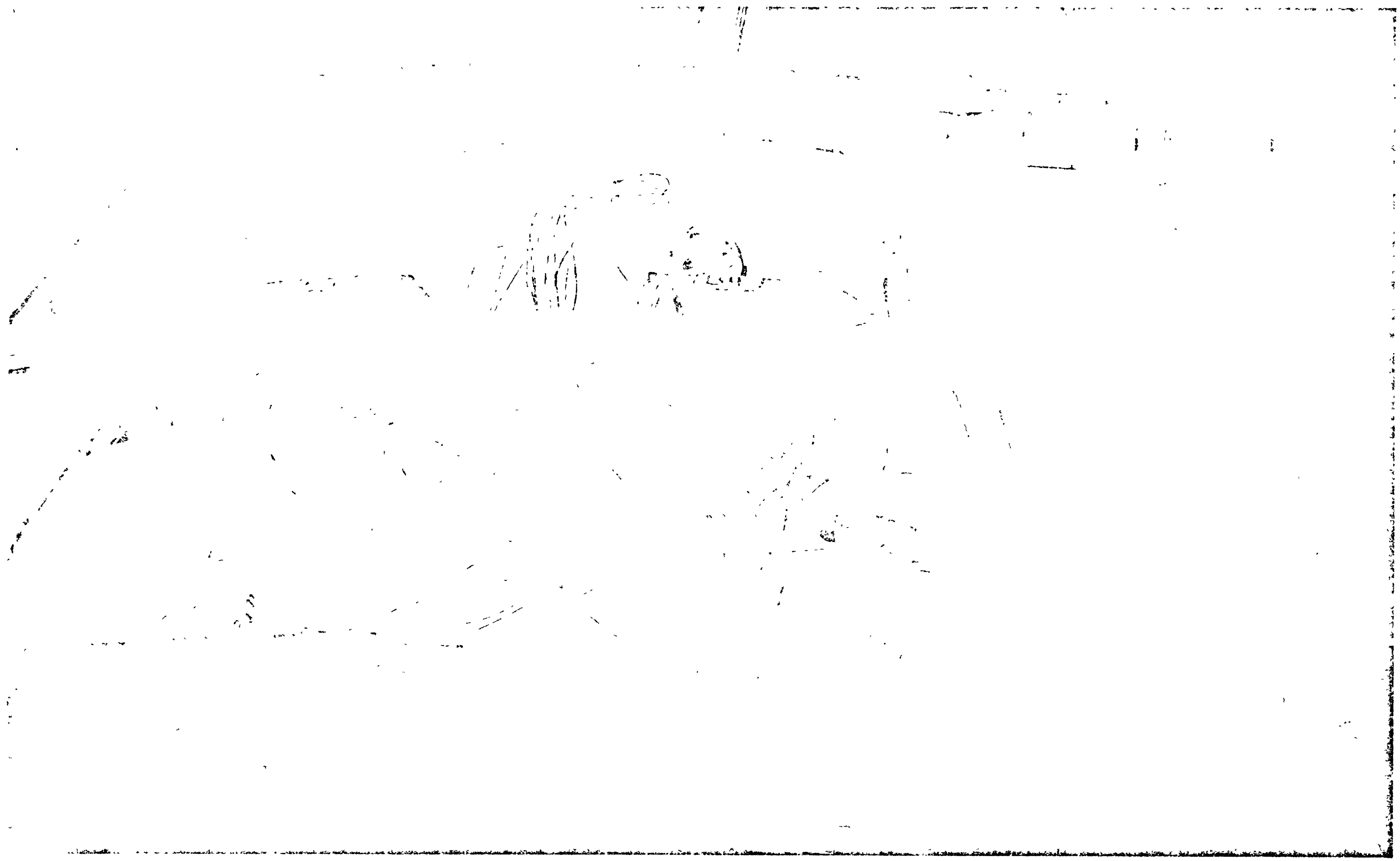


FIGURE 16. CONFIGURATION AFTER TEST B4

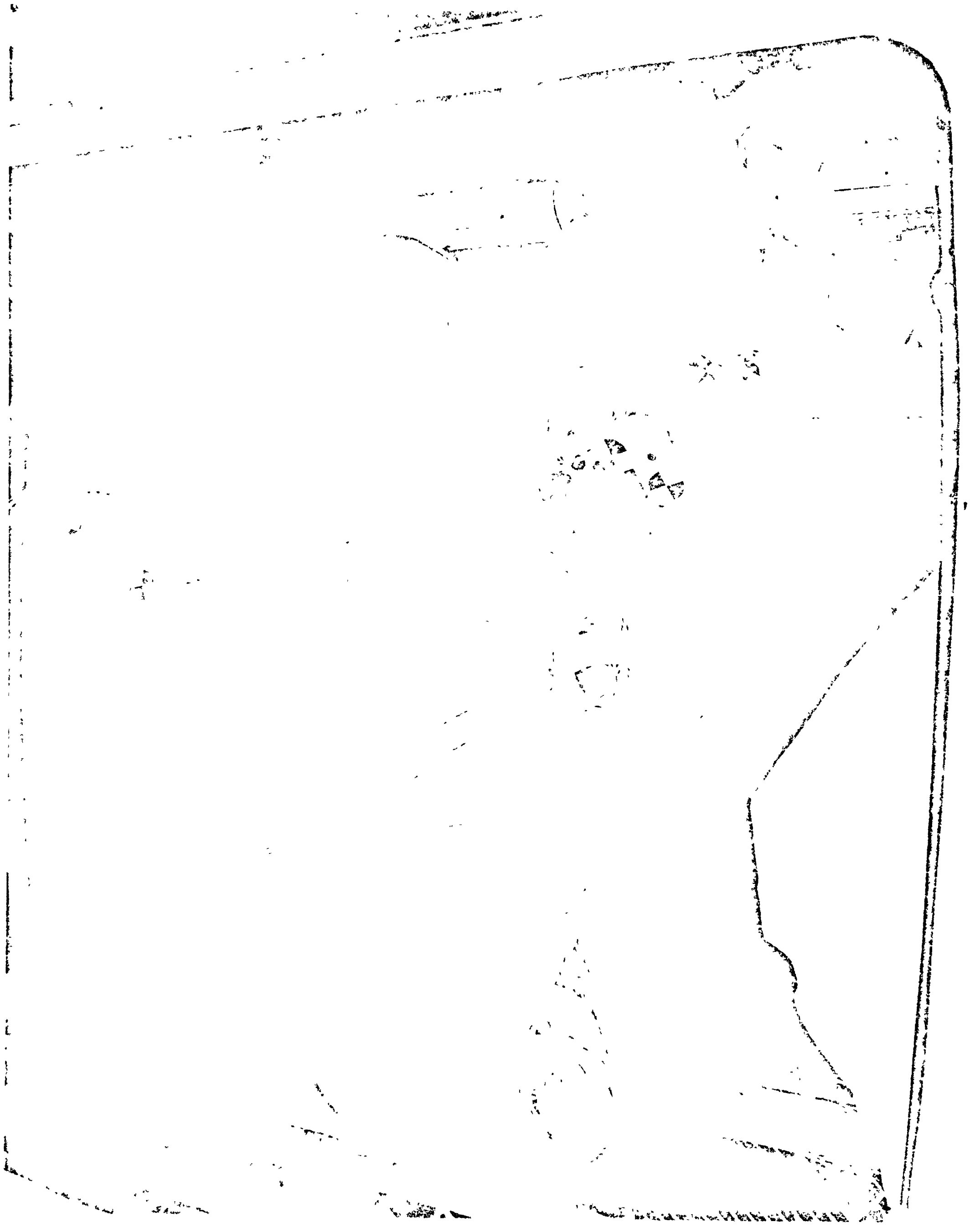


FIGURE 17. CONFIGURATION AFTER TEST B5

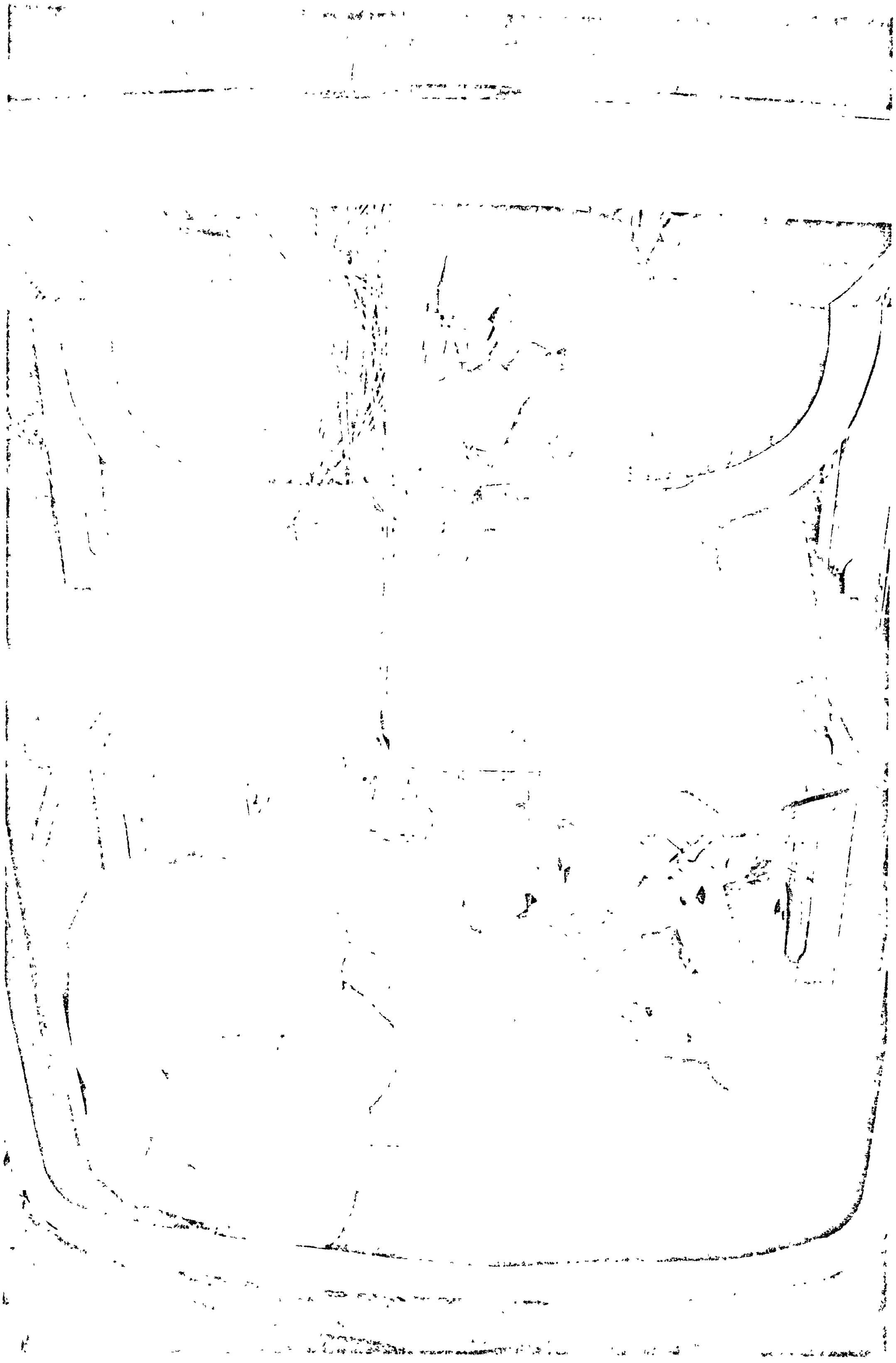


FIGURE 18. CONFIGURATION AFTER TEST B6

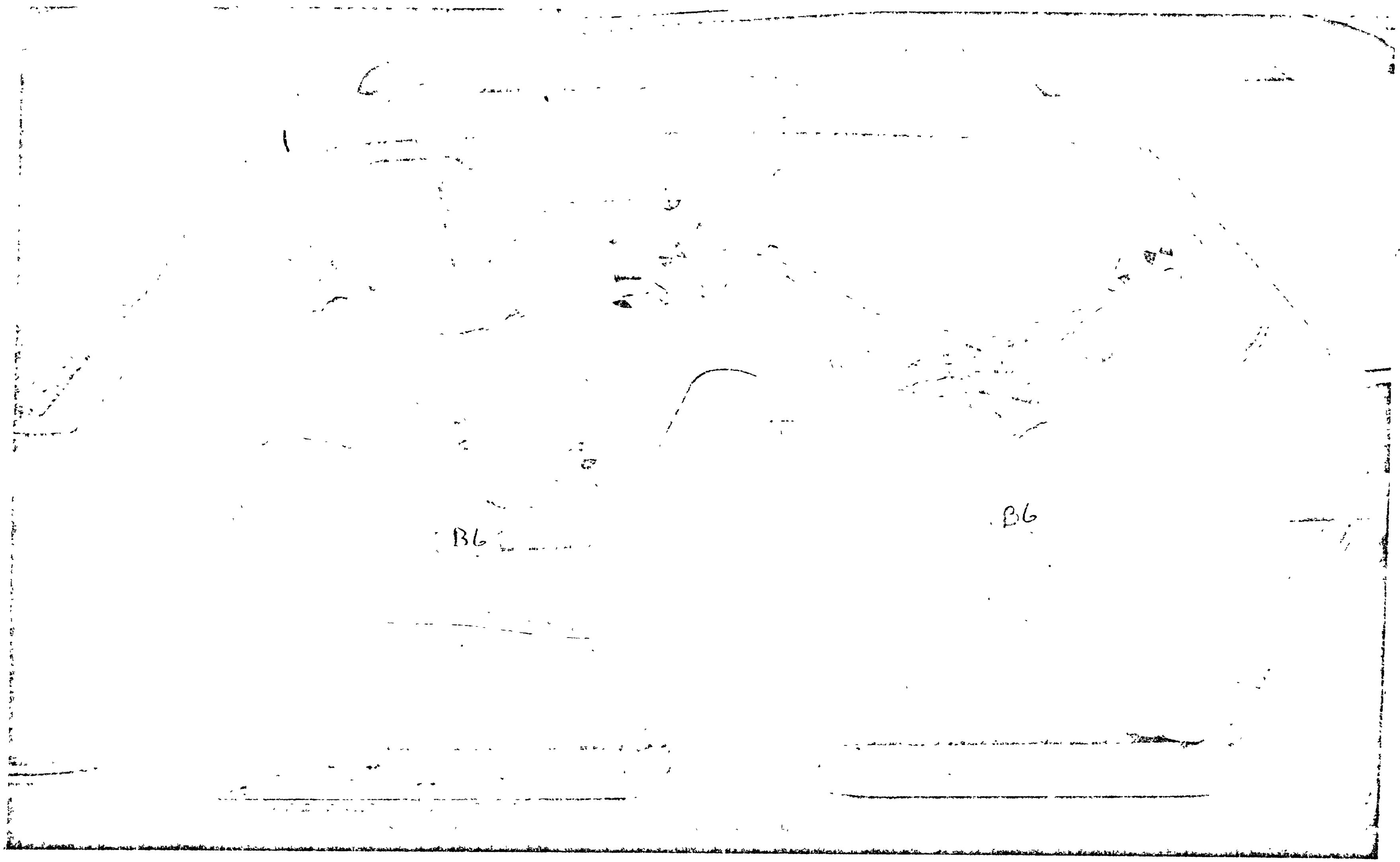


FIGURE 19. CONFIGURATION AFTER TEST B6

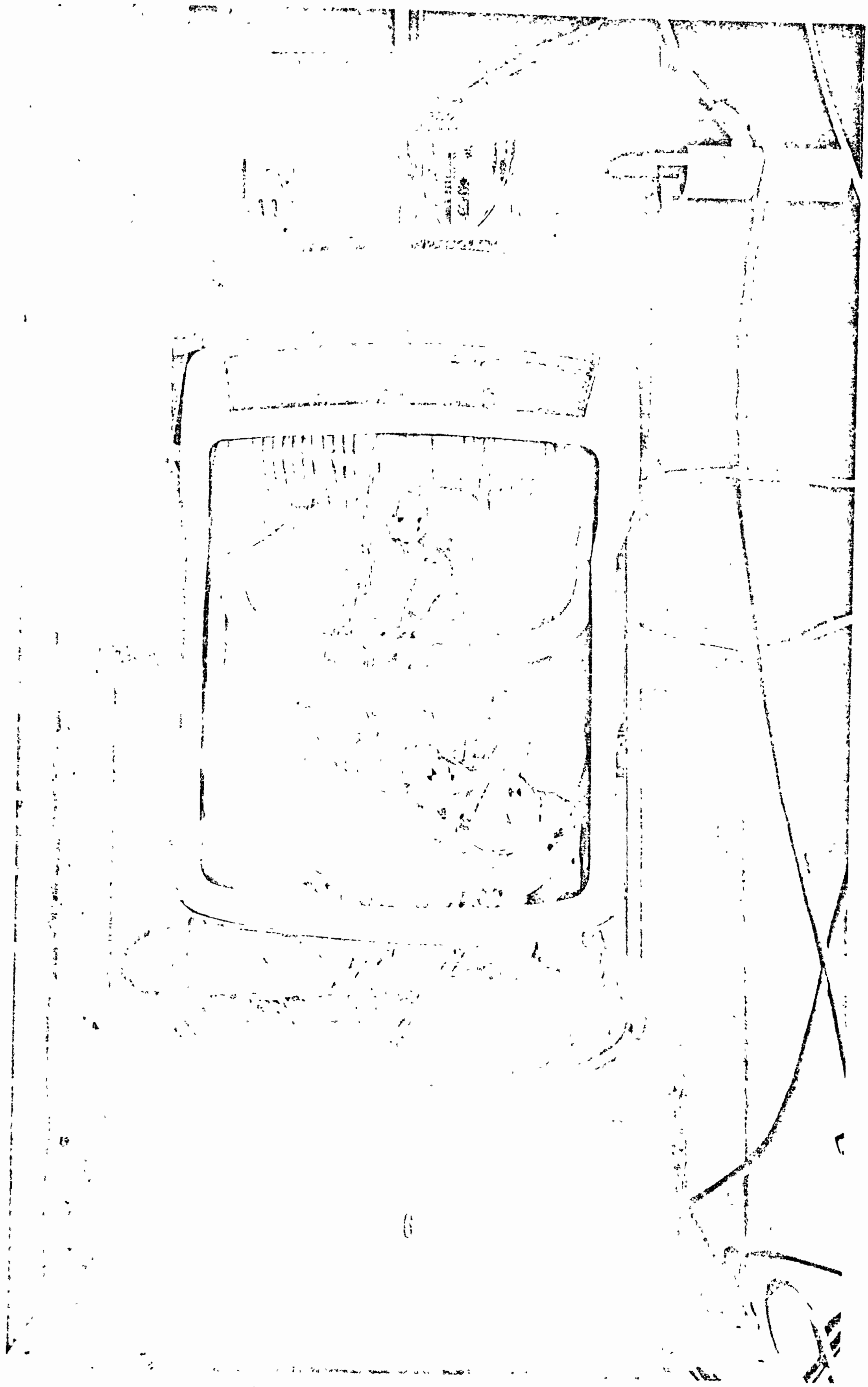


FIGURE 20. CONFIGURATION AFTER TEST B6

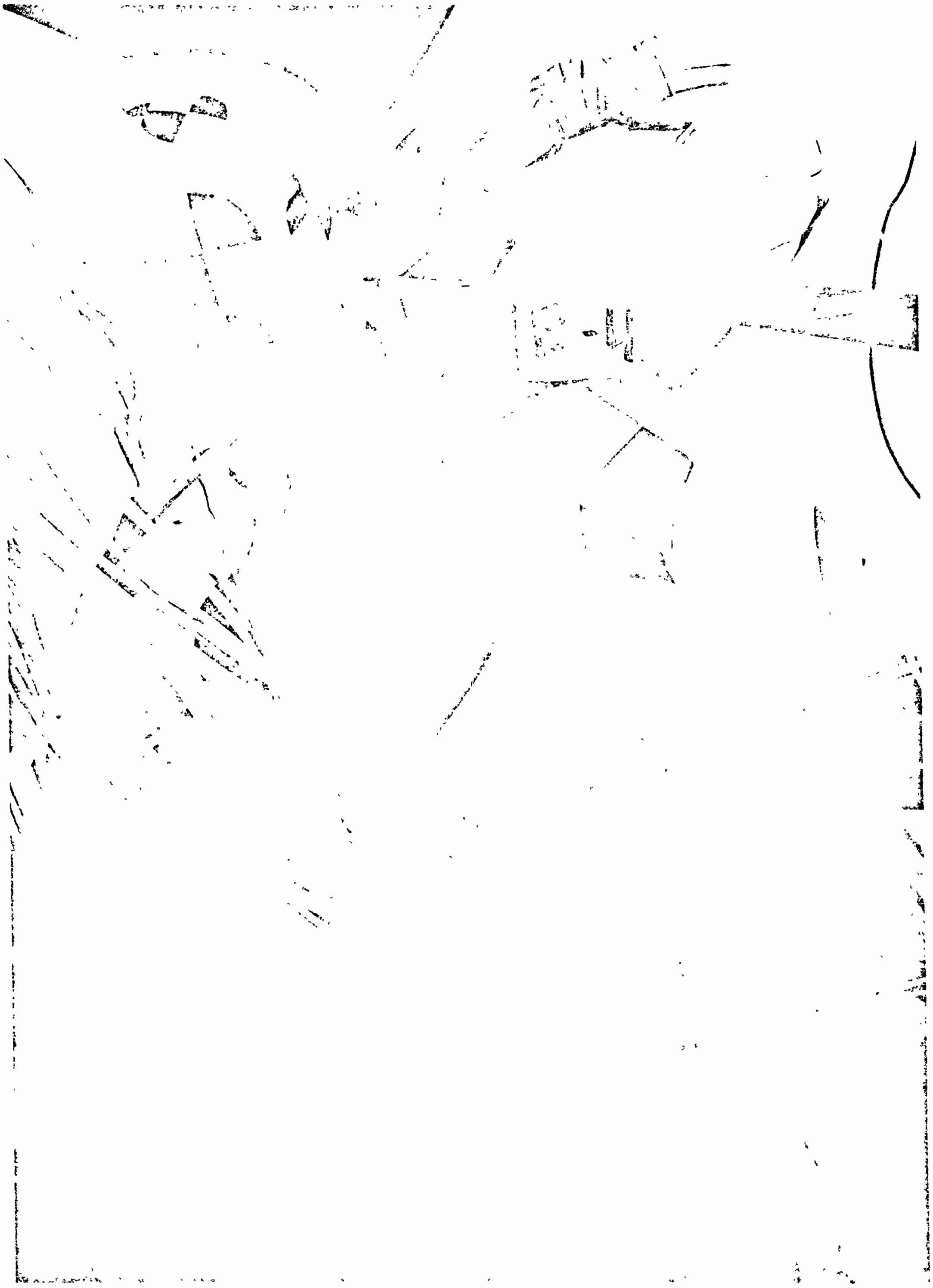
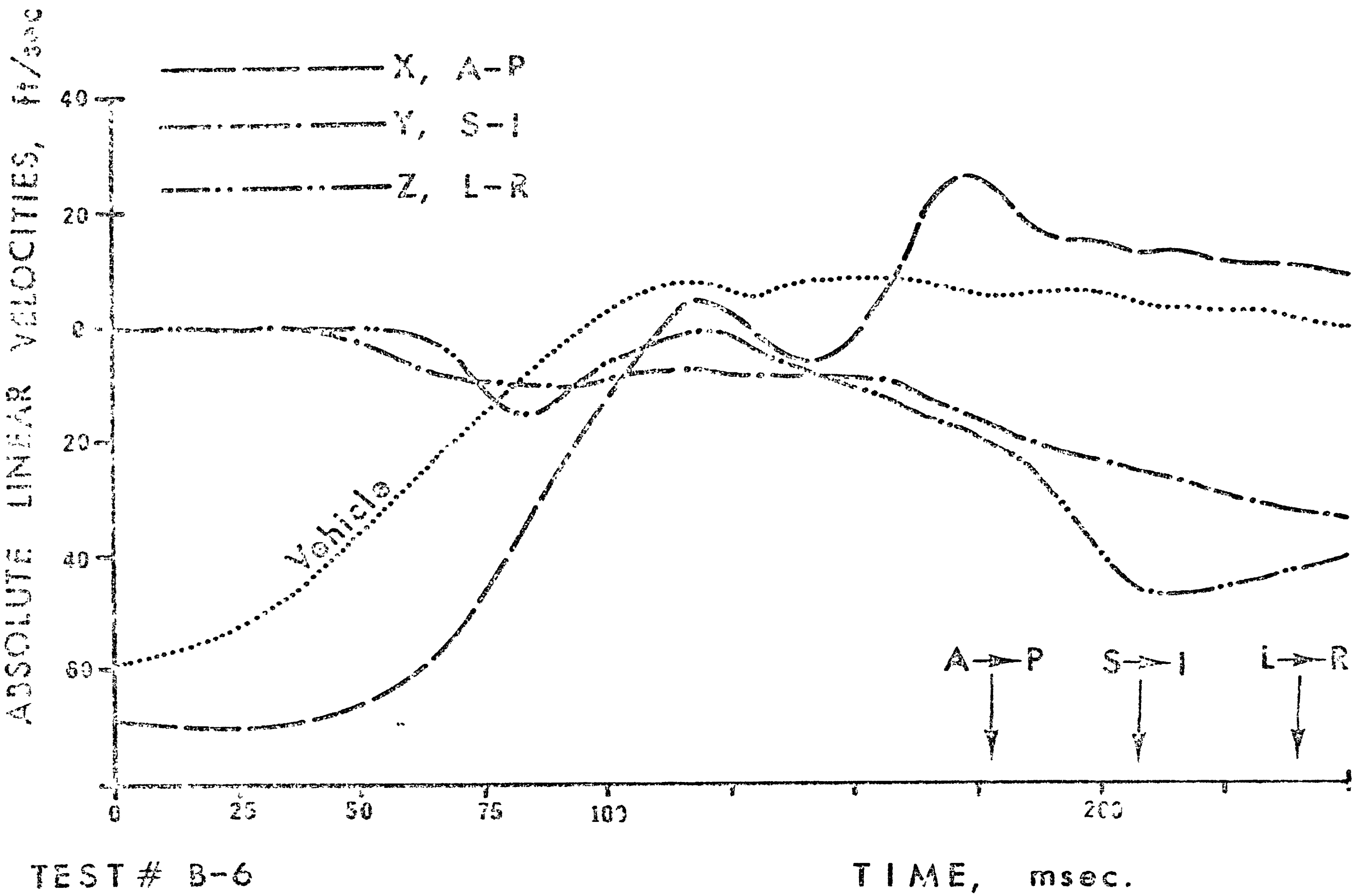


FIGURE 21. FORD TOT GUARD AFTER TEST



TEST # B-6

FIGURE 22. IORS PASSENGER HEAD MOTION

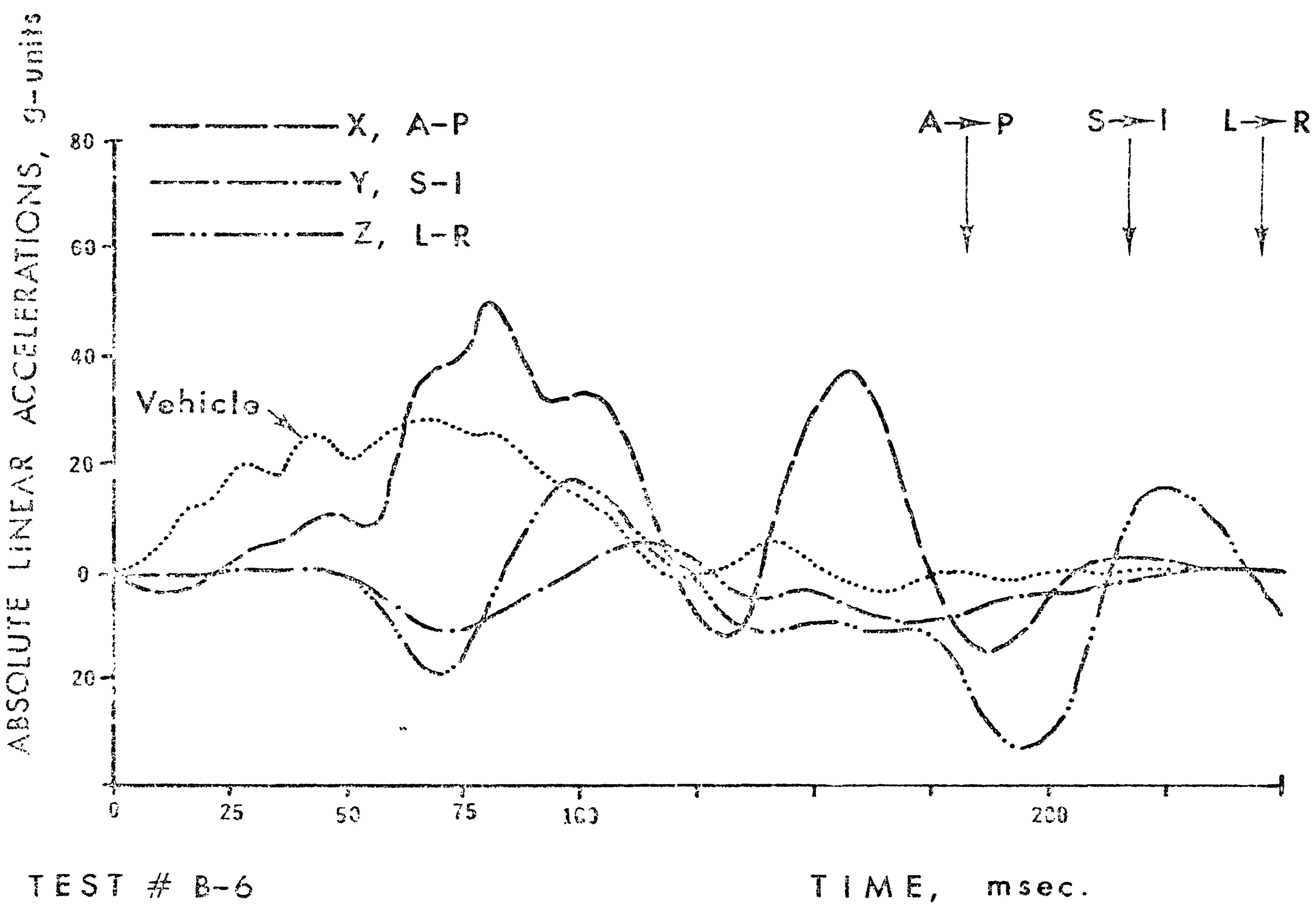
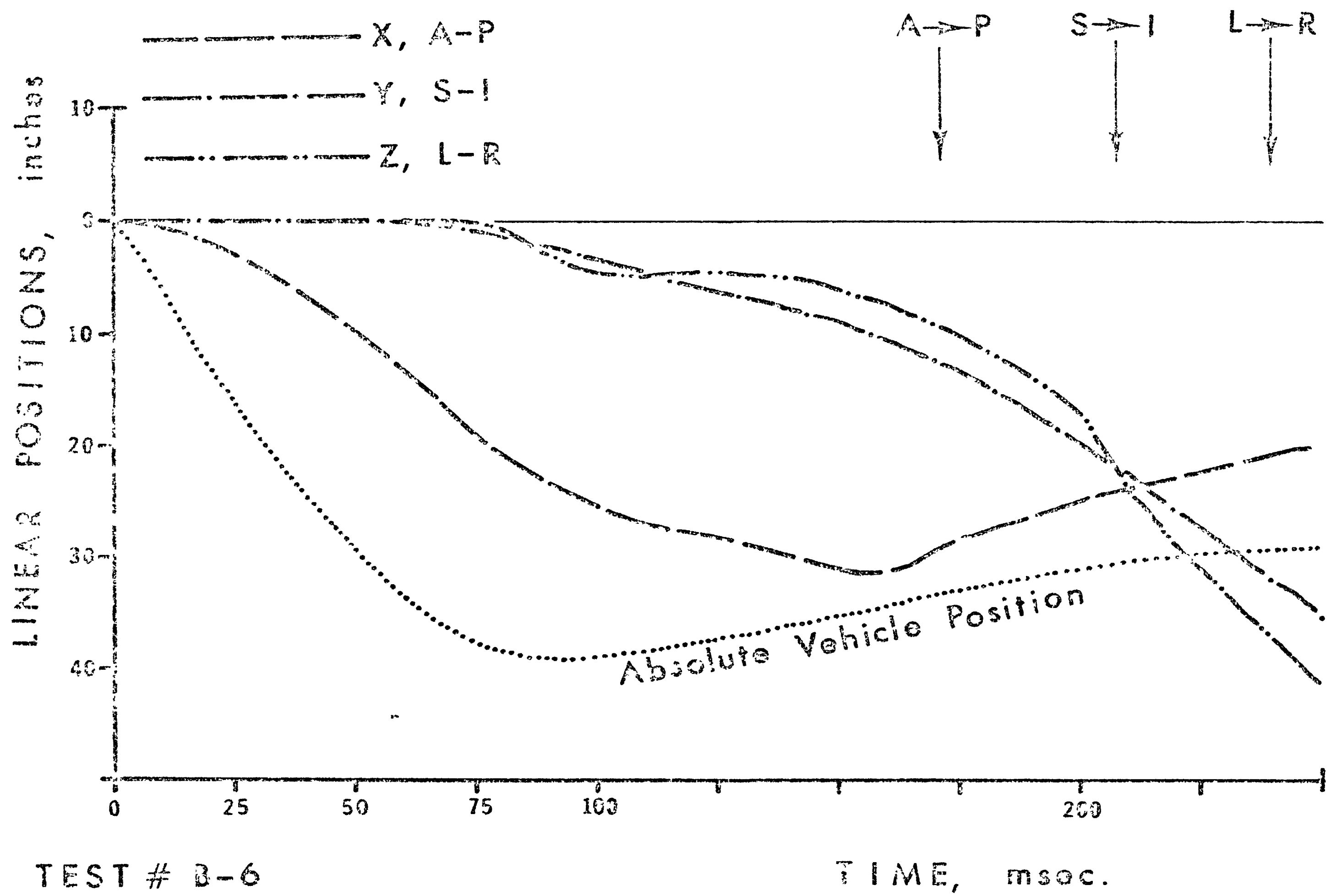
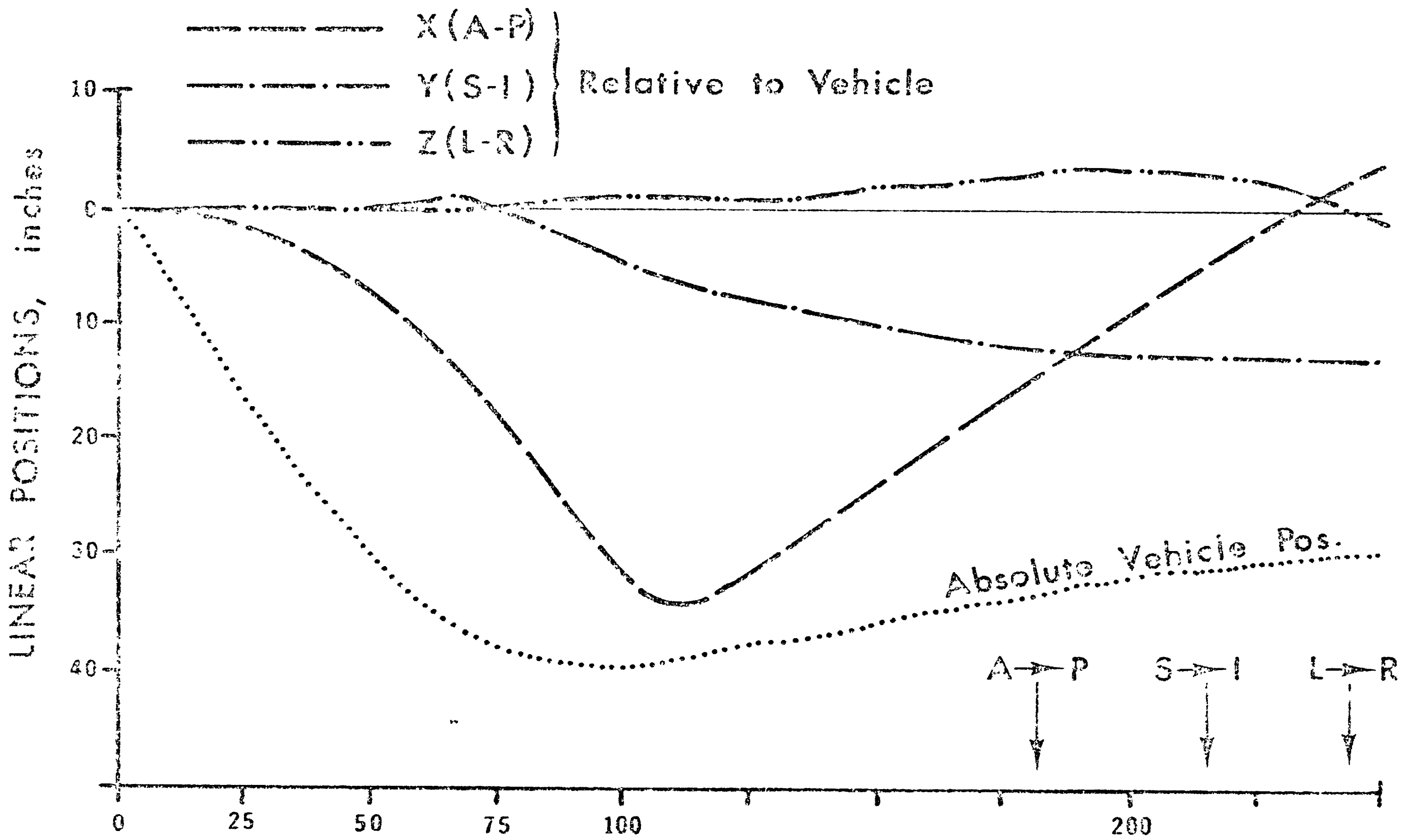


FIGURE 23. IORS PASSENGER HEAD MOTION



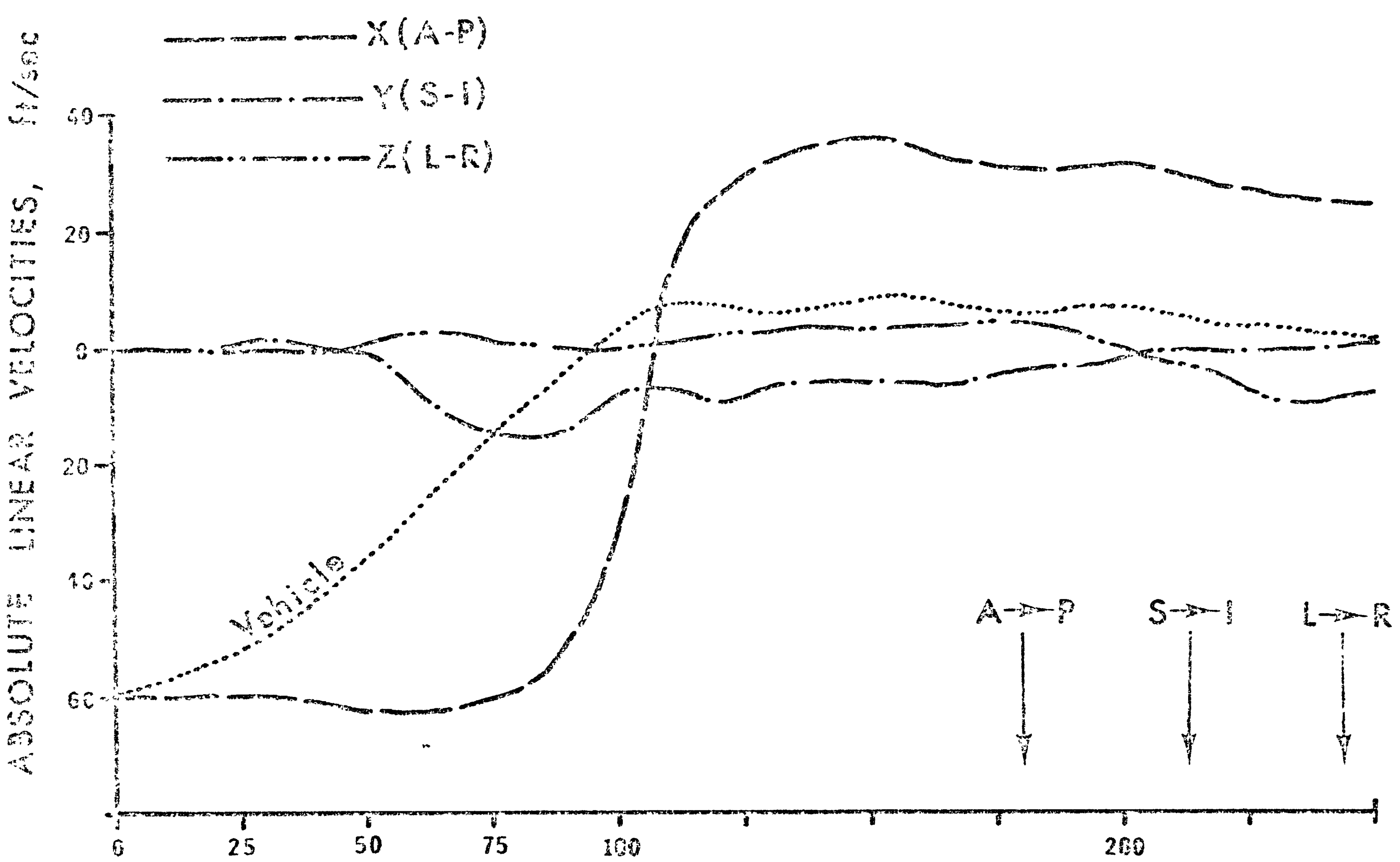
TEST # B-6

FIGURE 24. IORS PASSENGER HEAD MOTION



TEST # B-6

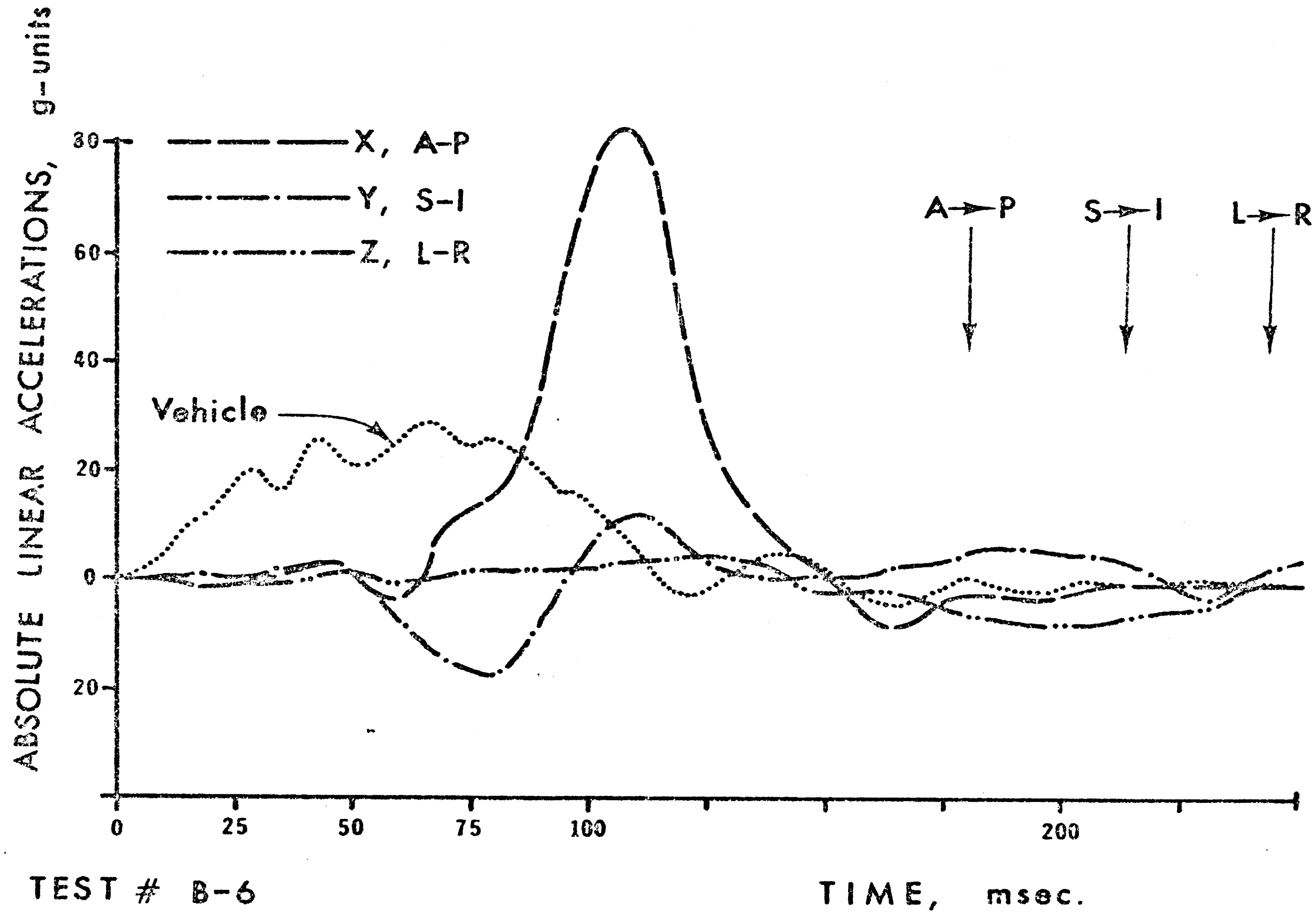
FIGURE 25. BELTED PASSENGER HEAD MOTION



TEST # B-6

TIME, msec.

FIGURE 26. BELTED PASSENGER HEAD MOTION



TEST # B-6

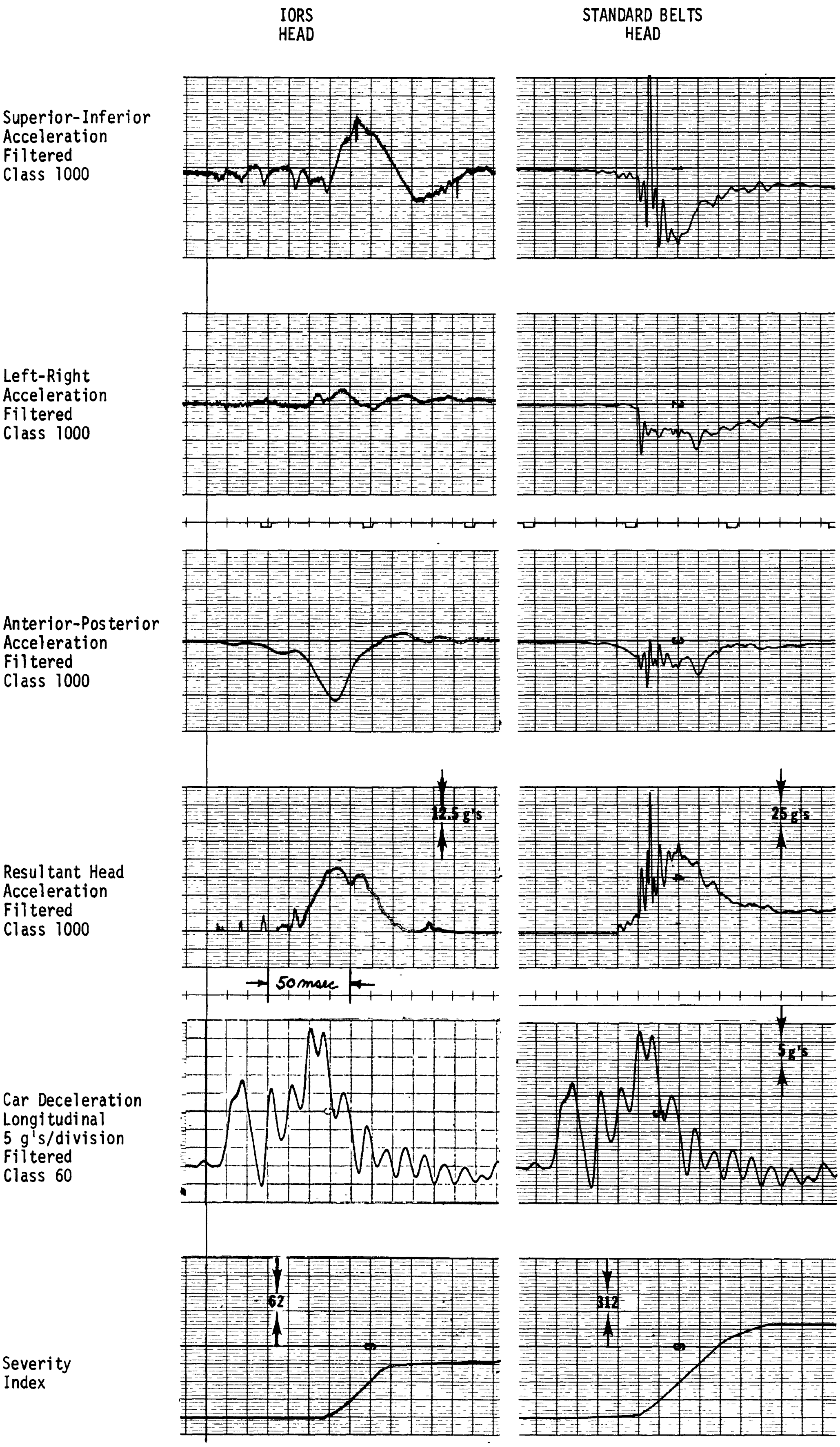
FIGURE 27. BELTED PASSENGER HEAD MOTION

6.0 SUMMARY DATA SHEETS

Impact Velocity 30.30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 1
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B3
Dummy 50%



Impact Velocity 30.36 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 2
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B4
Dummy 50%

IORS HEAD | STANDARD BELTS HEAD

Superior-Inferior Acceleration Filtered Class 1000

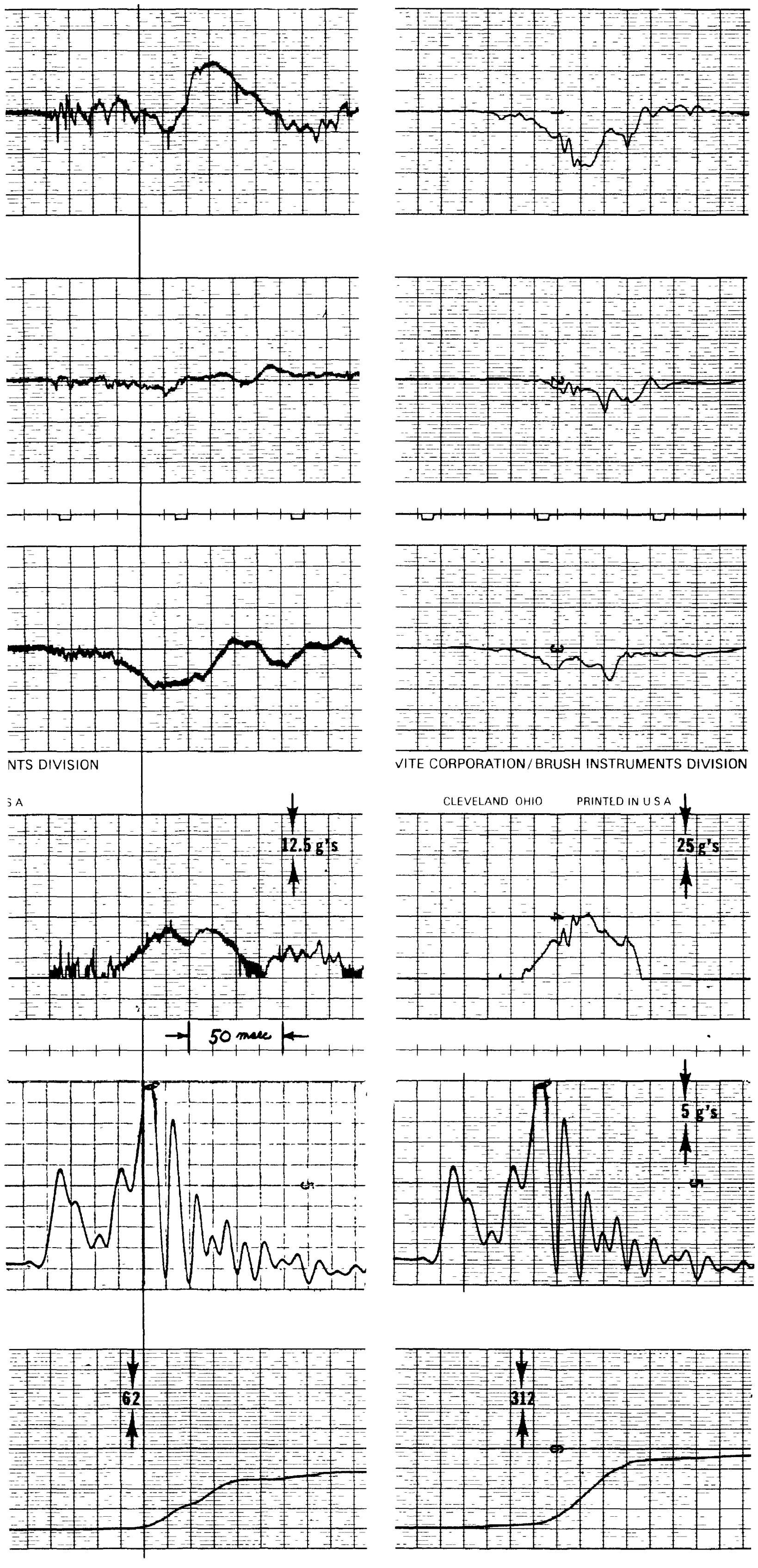
Left-Right Acceleration Filtered Class 1000

Anterior-Posterior Acceleration Filtered Class 1000

Resultant Head Acceleration Filtered Class 1000

Car Deceleration Longitudinal 5 g's/division Filtered Class 60

Severity Index

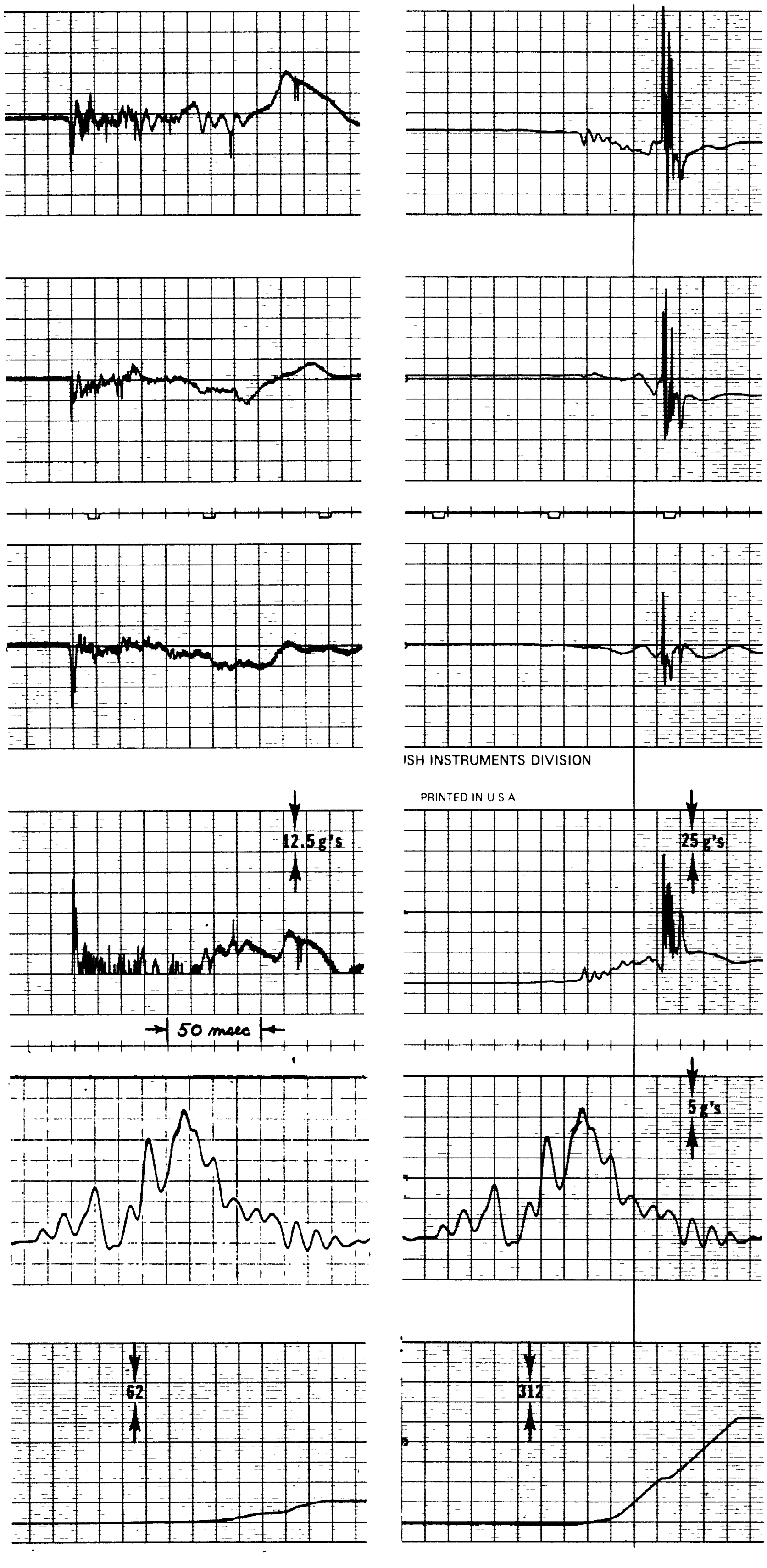


Impact Velocity 30.38 mph
Barrier Type 22.5° Oblique

SUMMARY DATA SHEET 3
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B5
Dummy 50%

	IORS HEAD	STANDARD BELTS HEAD
Superior-Inferior Acceleration Filtered Class 1000		
Left-Right Acceleration Filtered Class 1000		
Anterior-Posterior Acceleration Filtered Class 1000		
Resultant Head Acceleration Filtered Class 1000		
Car Deceleration Longitudinal 5 g's/division Filtered Class 60		
Severity Index		

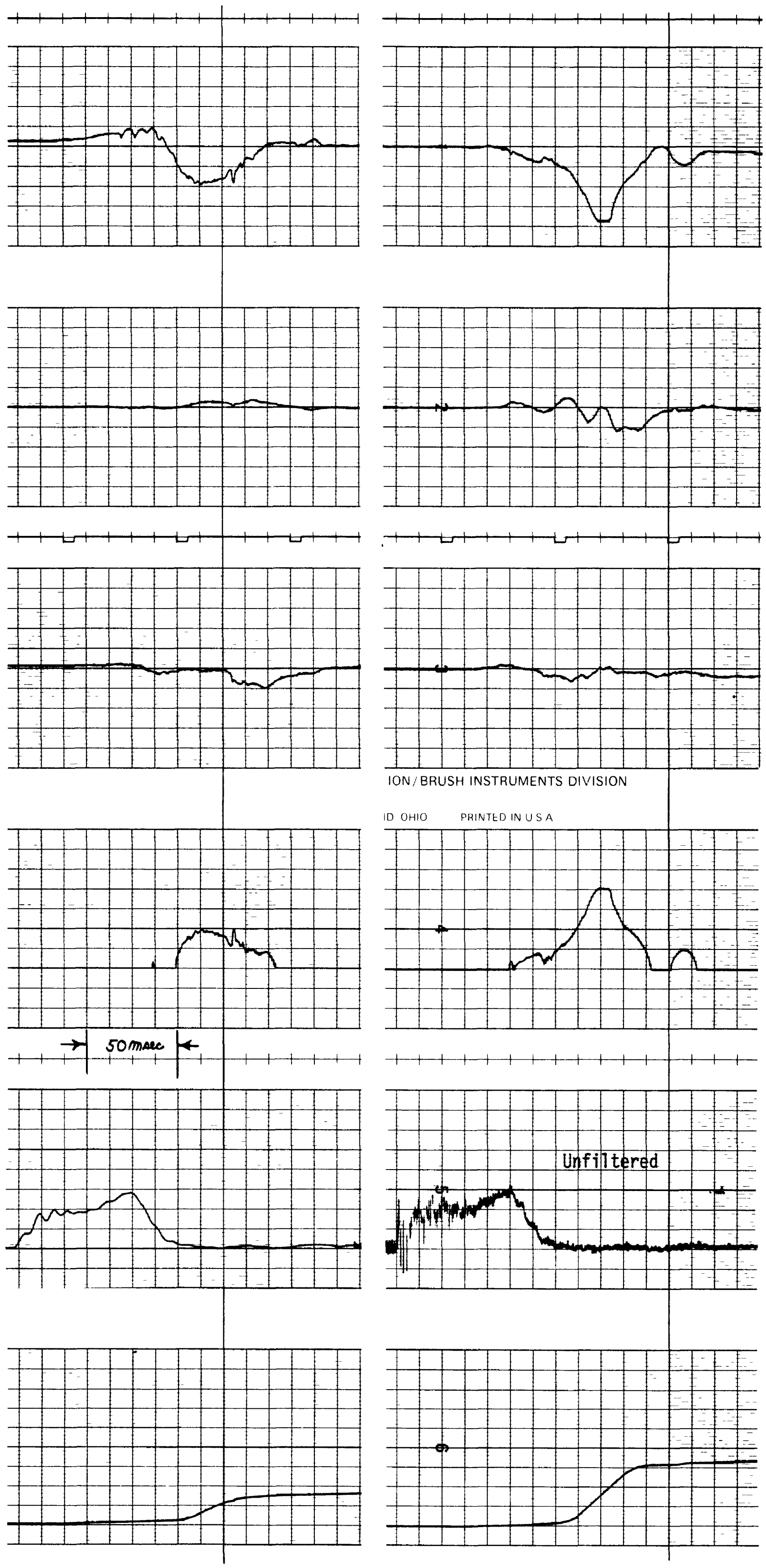


Impact Velocity 30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 4
HSRI SLED TEST
THE UNIVERSITY OF MICHIGAN

Test No. A-407

	STANDARD BELTS HEAD 50% Dummy	STANDARD BELTS HEAD 95% Dummy
Superior-Inferior Acceleration 25 g's/division Filtered Class 1000		
Left-Right Acceleration 25 g's/division Filtered Class 1000		
Anterior-Posterior Acceleration 25 g's/division Filtered Class 1000		
Resultant Head Acceleration 25 g's/division Filtered Class 1000		
Sled Pulse 10 g's/division Filtered Class 60		
Severity Index 312.5/division		

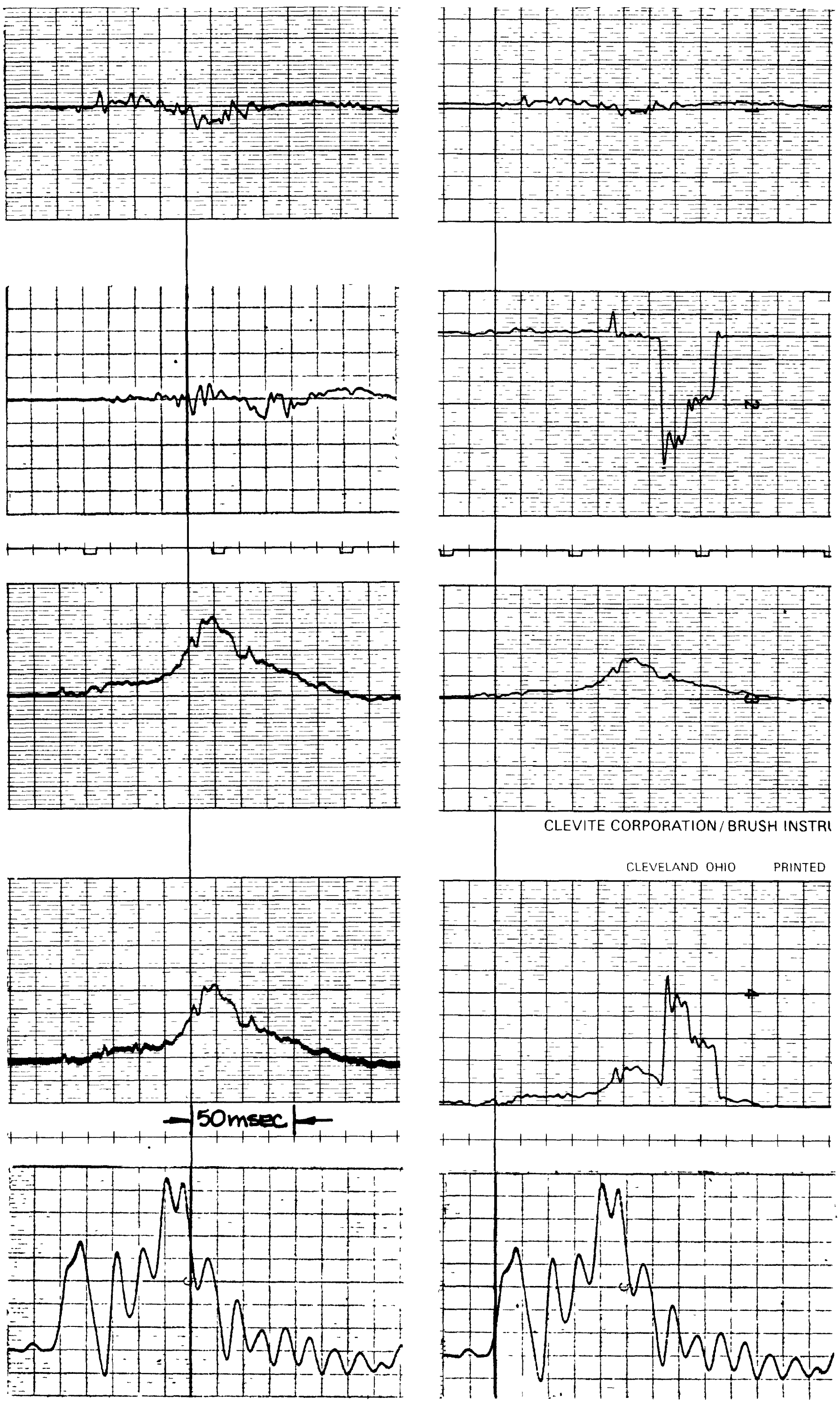


Impact Velocity 30.30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 5
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B3
Dummy 50%

IORS CHEST | STANDARD BELTS CHEST



Superior-Inferior Acceleration 12.5 g's/division Filtered Class 180

Left-Right Acceleration 12.5 g's/division Filtered Class 180

Anterior-Posterior Acceleration 12.5 g's/division Filtered Class 180

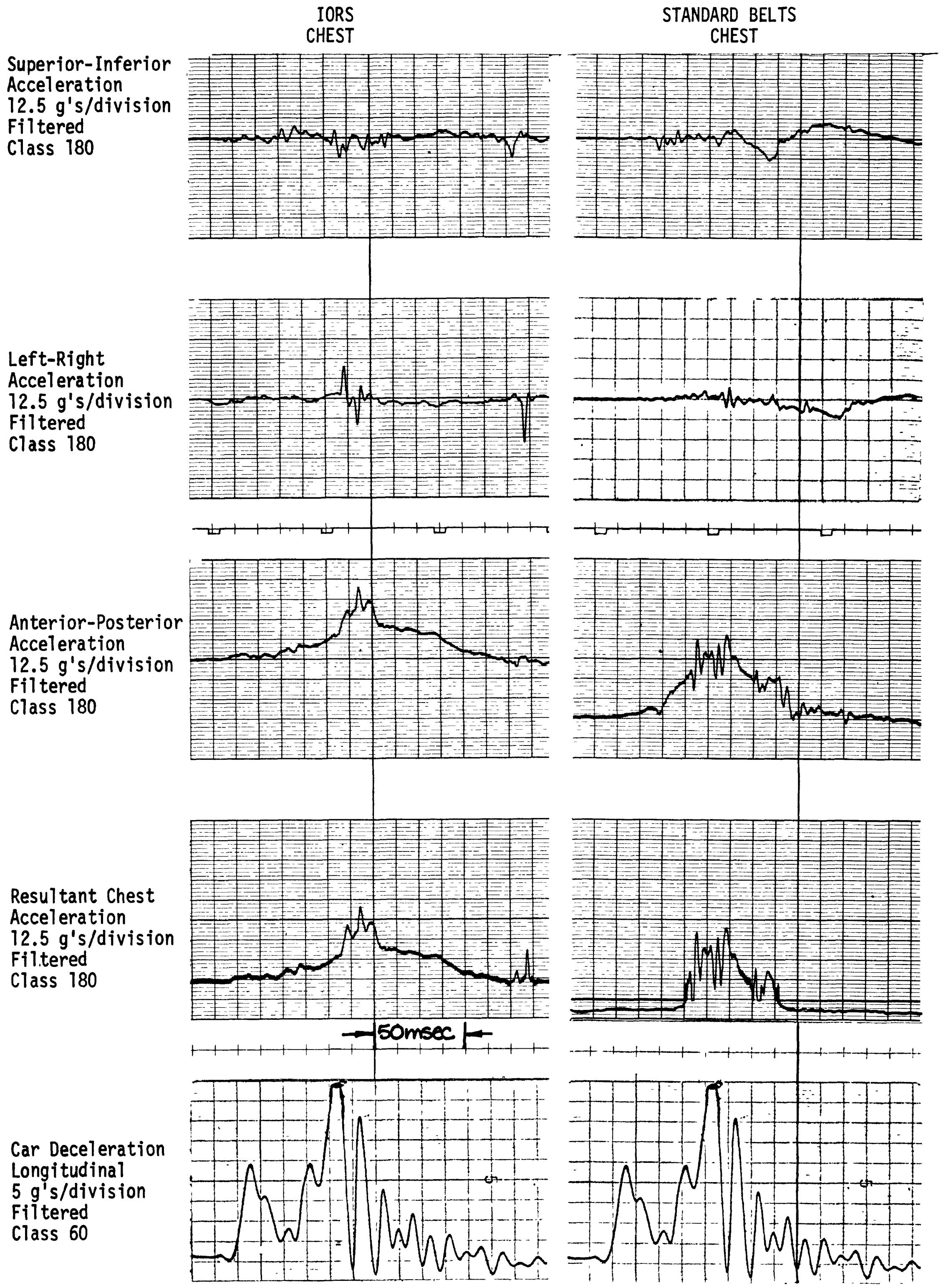
Resultant Chest Acceleration 12.5 g's/division Filtered Class 180

Car Deceleration Longitudinal 5 g's/division Filtered Class 60

Impact Velocity 30.36 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 6
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B4
Dummy 50%

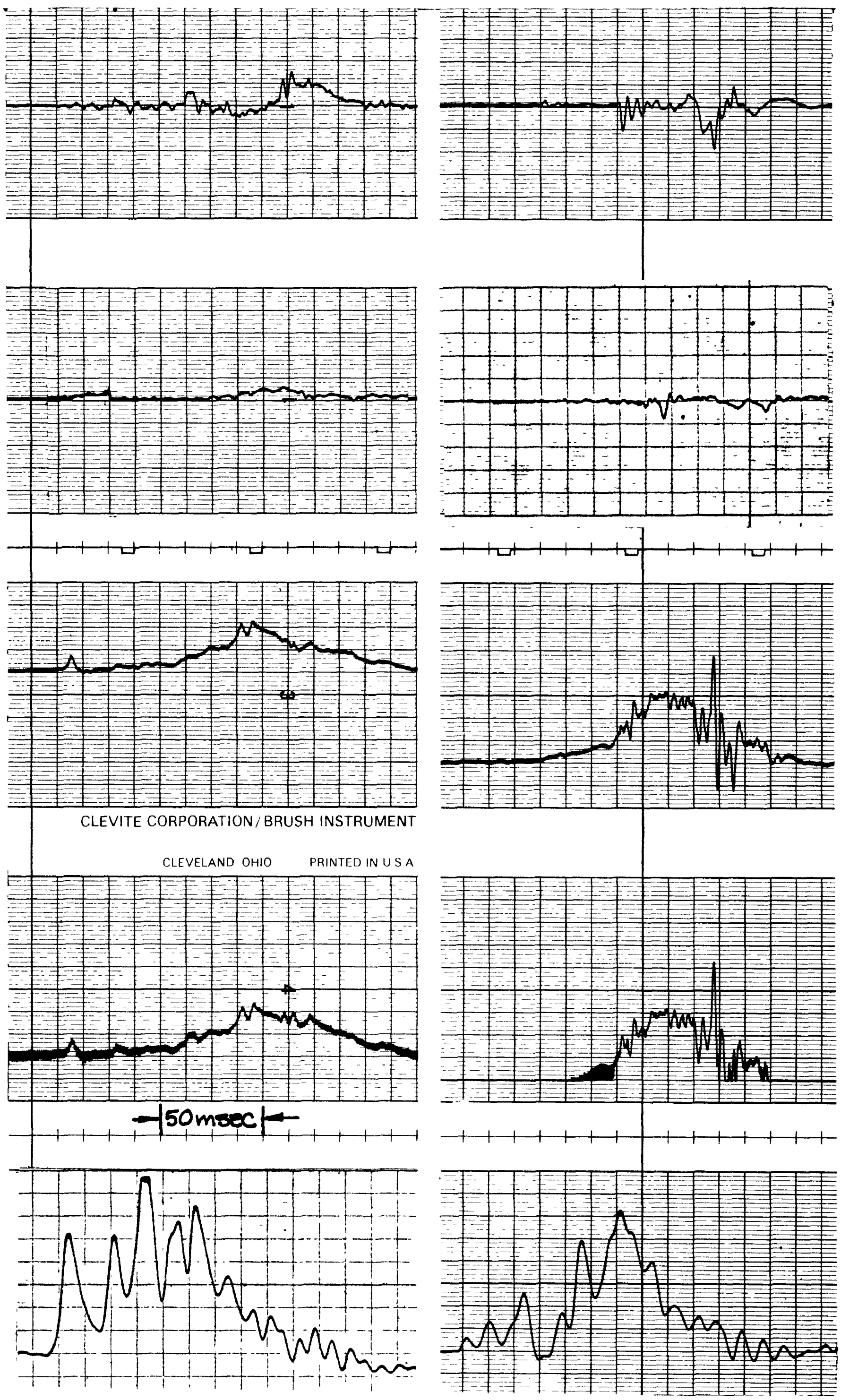


Impact Velocity 30.38 mph
Barrier Type 22.5° Oblique

SUMMARY DATA SHEET 7
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B5
Dummy 50%

	IORS CHEST	STANDARD BELTS CHEST
Superior-Inferior Acceleration 12.5 g's/division Filtered Class 180		
Left-Right Acceleration 12.5 g's/division Filtered Class 180		
Anterior-Posterior Acceleration 12.5 g's/division Filtered Class 180		
Resultant Chest Acceleration 12.5 g's/division Filtered Class 180		
Car Deceleration Longitudinal 5 g's/division Filtered Class 60		



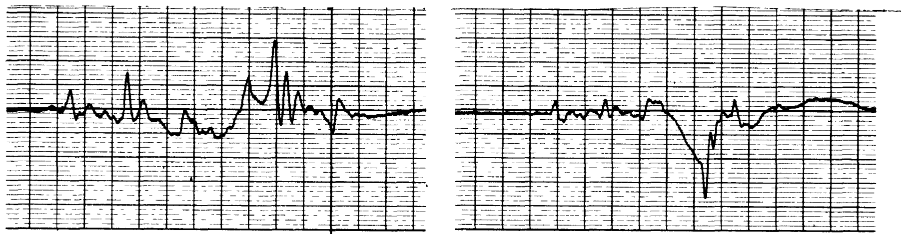
Impact Velocity 40.47 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 8
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

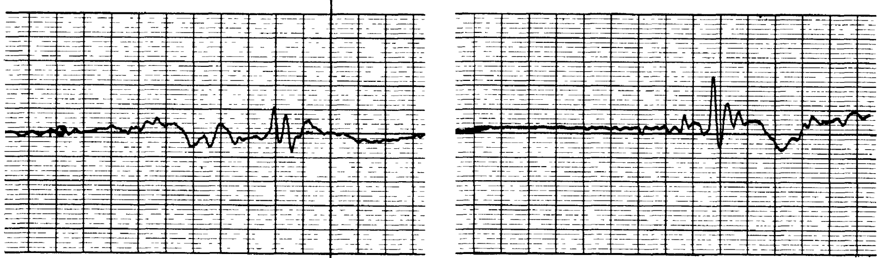
Test No. B6
Dummy 50%

IORS CHEST | STANDARD BELTS CHEST

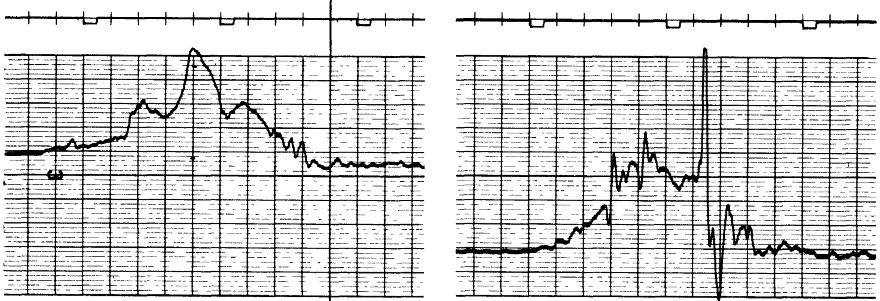
Superior-Inferior Acceleration
12.5 g's/division
Filtered
Class 180



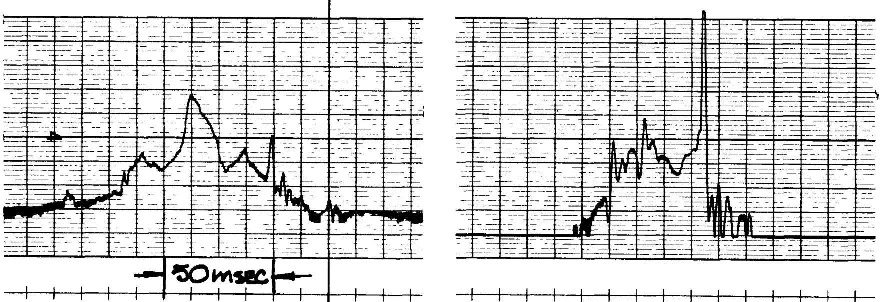
Left-Right Acceleration
12.5 g's/division
Filtered
Class 180



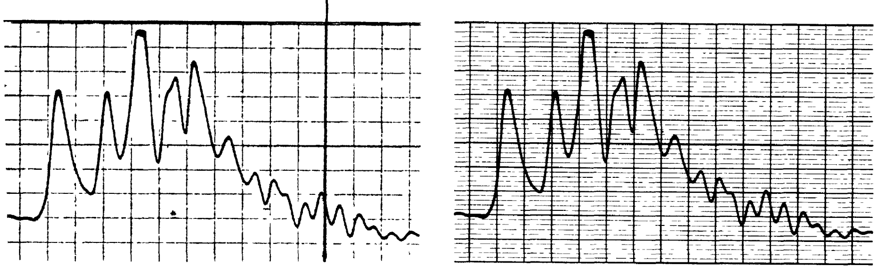
Anterior-Posterior Acceleration
12.5 g's/division
Filtered
Class 180



Resultant Chest Acceleration
12.5 g's/division
Filtered
Class 180



Car Deceleration Longitudinal
5 g's/division
Filtered
Class 60



Impact Velocity 30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 9
HSRI SLED TEST
THE UNIVERSITY OF MICHIGAN

Test No. A323
Dummy 50%

STANDARD BELTS HEAD | STANDARD BELTS CHEST

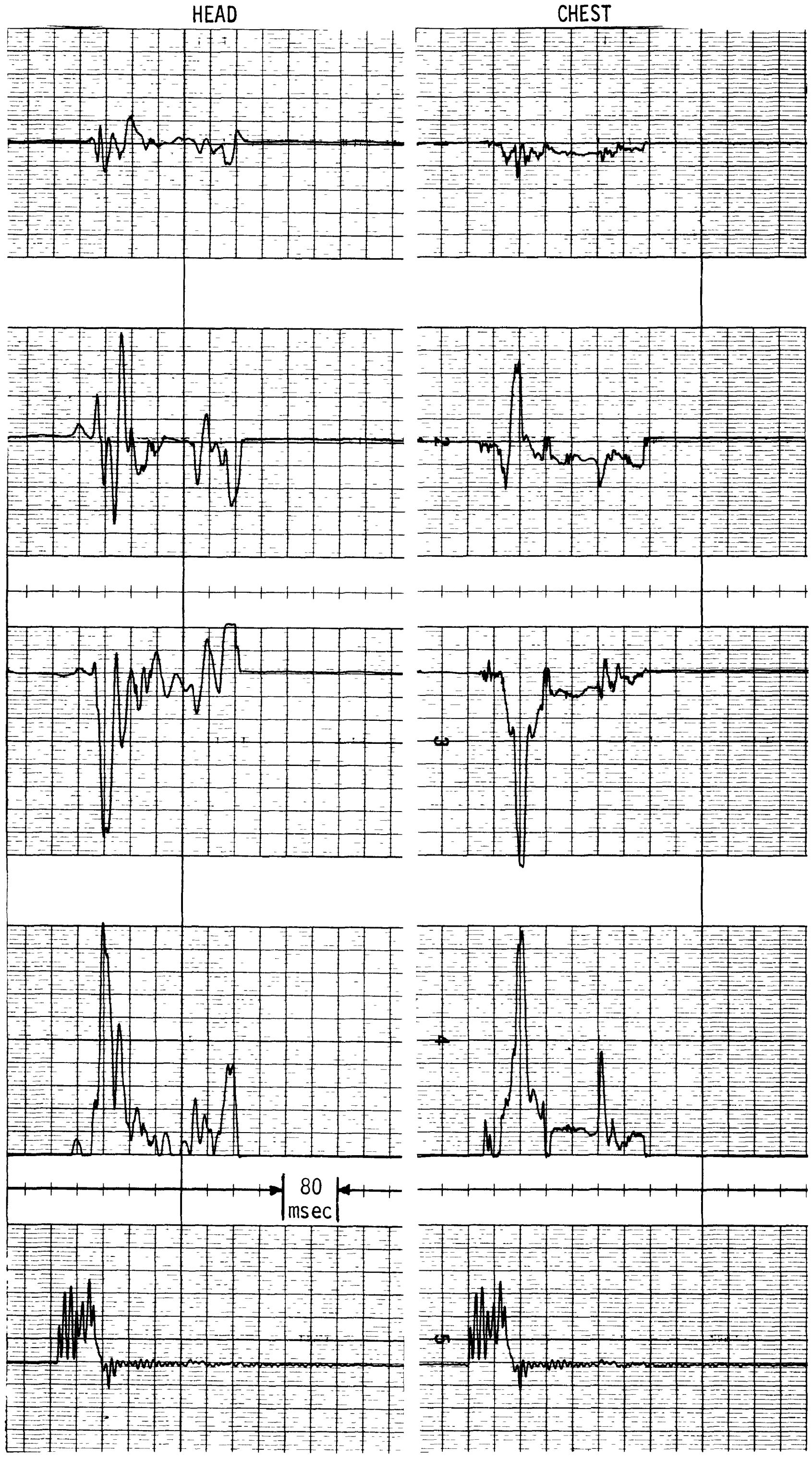
Superior-Inferior Acceleration 12.5 g's/division Filtered Class 180

Left-Right Acceleration 12.5 g's/division Filtered Class 180

Anterior-Posterior Acceleration 12.5 g's/division Filtered Class 180

Resultant Acceleration 12.5 g's/division Filtered Class 180

Sled Pulse 10 g's/division Unfiltered

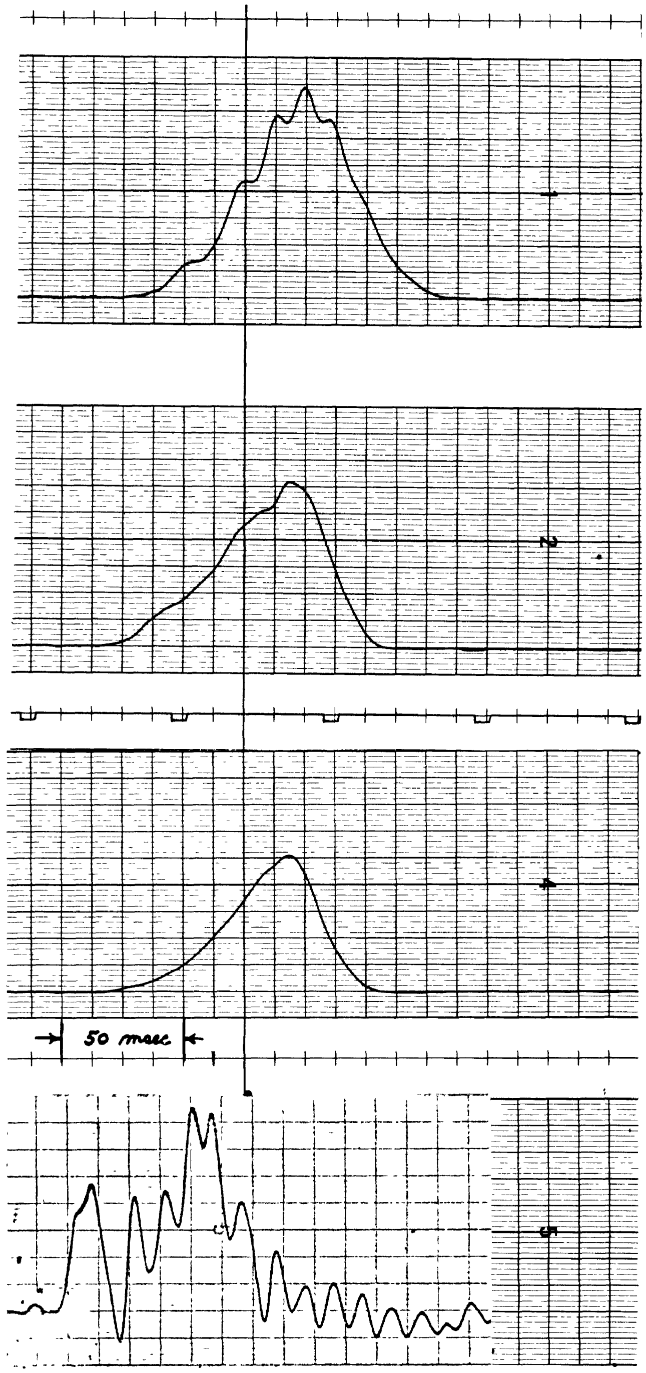


Impact Velocity 30.30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 10
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B3
Dummy 50%

BELT LOADS



Left Shoulder Belt
250 pounds/division
Filtered
Class 60

Right Lap Belt
250 pounds/division
Filtered
Class 60

Left Lap Belt
250 pounds/division
Filtered
Class 60

Car Pulse
5 g's/division
Filtered
Class 60

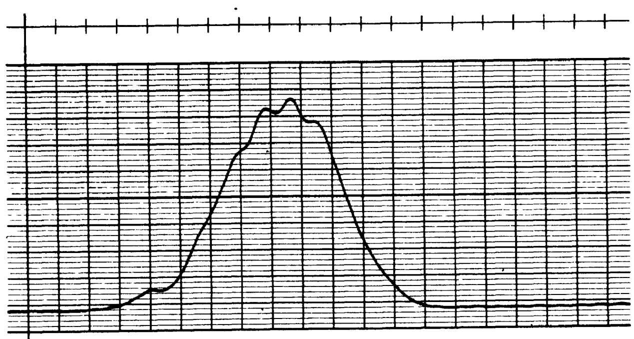
Impact Velocity 30.36 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 11
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

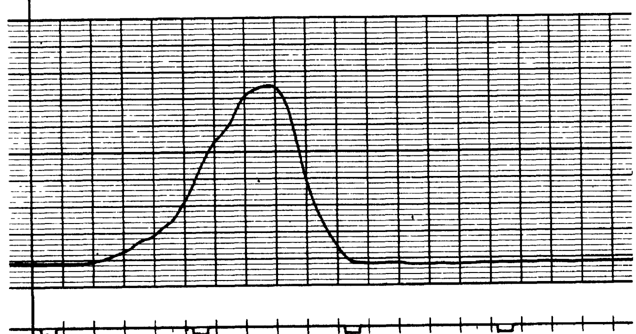
Test No. B4
Dummy 50%

BELT LOADS

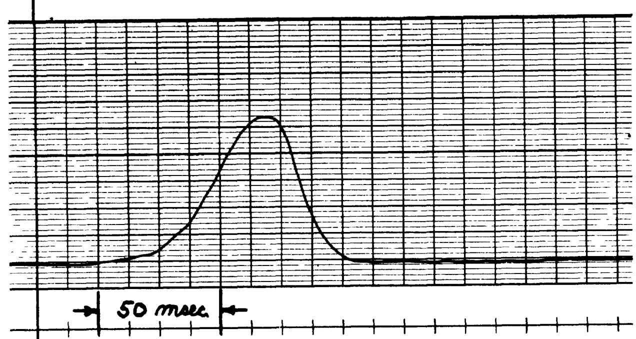
Left Shoulder Belt
250 pounds/division
Filtered
Class 60



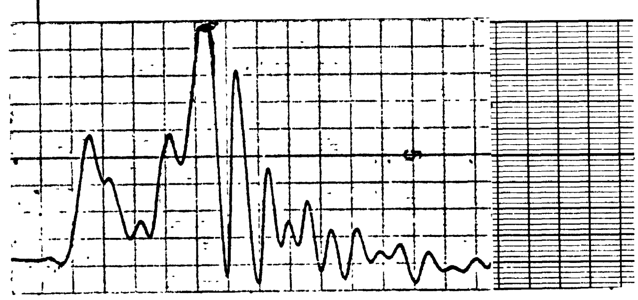
Right Lap Belt
250 pounds/division
Filtered
Class 60



Left Lap Belt
250 pounds/division
Filtered
Class 60



Car Pulse
5 g's/division
Filtered
Class 60



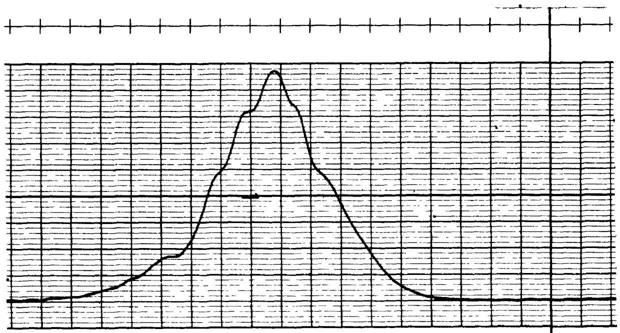
Impact Velocity 30.38 mph
Barrier Type 22.5° Oblique

SUMMARY DATA SHEET 12
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

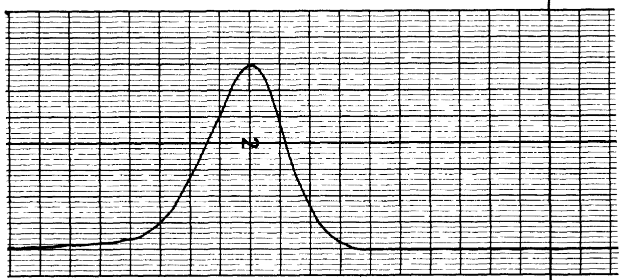
Test No. B5
Dummy 50%

BELT LOADS

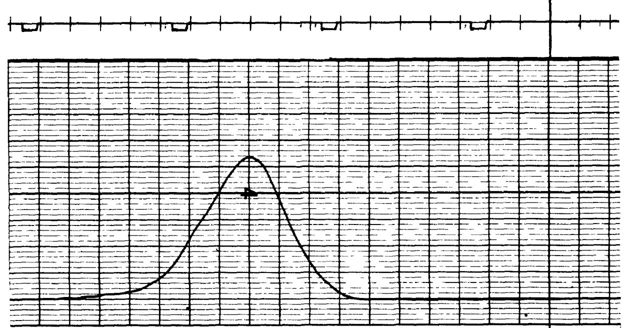
Left Shoulder Belt
250 pounds/division
Filtered
Class 60



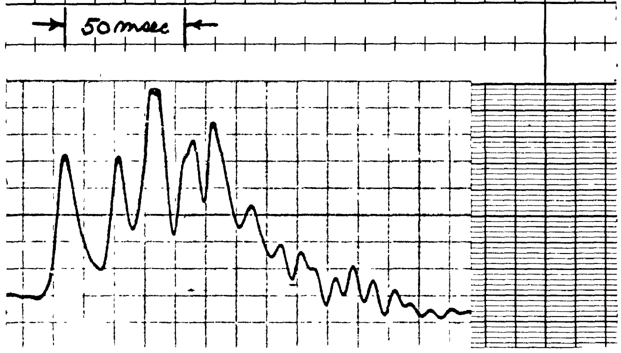
Right Lap Belt
250 pounds/division
Filtered
Class 60



Left Lap Belt
250 pounds/division
Filtered
Class 60



Car Pulse
5 g's/division
Filtered
Class 60



Impact Velocity 40.47 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 13
HSRI CAR CRASH FACILITY
THE UNIVERSITY OF MICHIGAN

Test No. B6
Dummy 50%

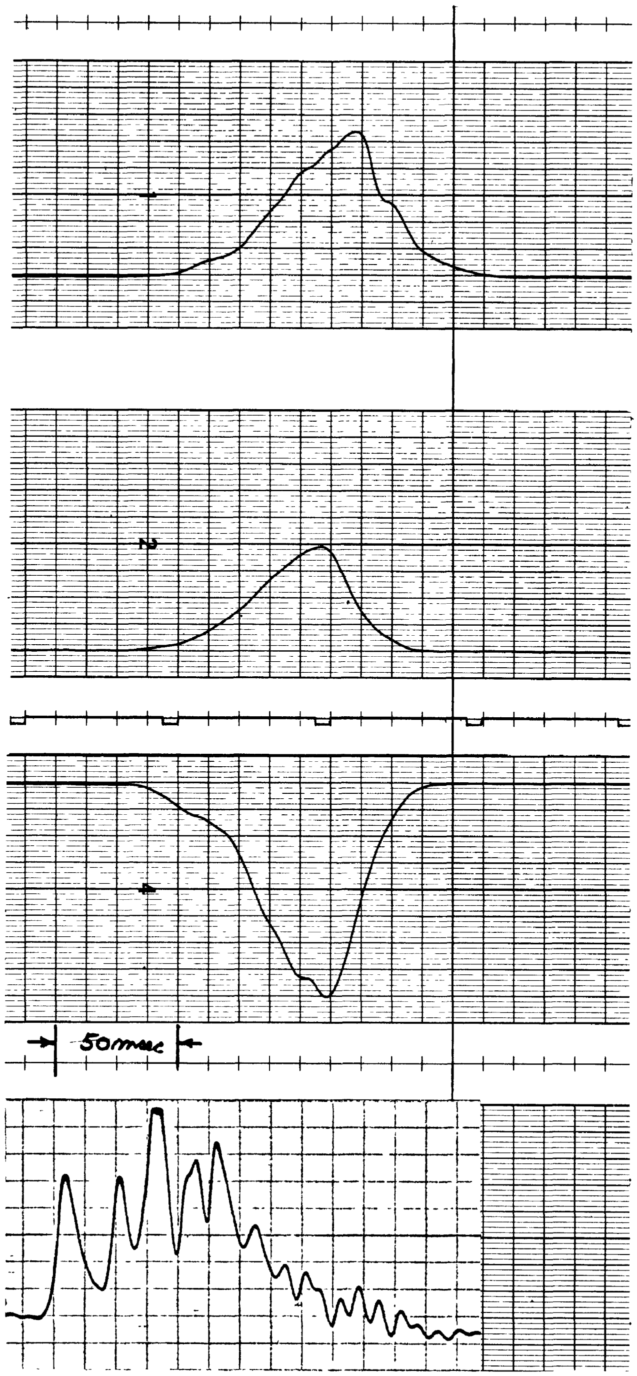
BELT LOADS

Left Shoulder Belt
500 pounds/division
Filtered
Class 60

Right Lap Belt
500 pounds/division
Filtered
Class 60

Left Lap Belt
500 pounds/division
Filtered
Class 60

Car Pulse
5 g's/division
Filtered
Class 60



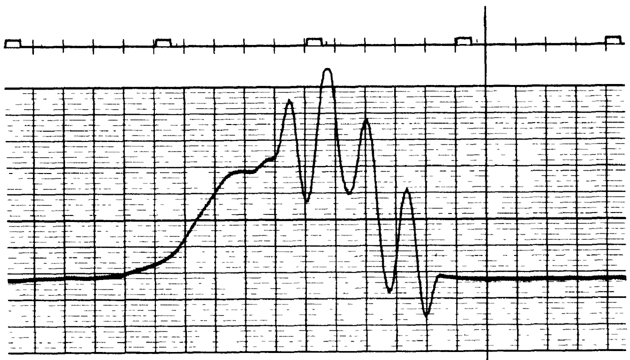
Impact Velocity 30 mph
Barrier Type Flat Frontal

SUMMARY DATA SHEET 14
HSRI SLED TEST
THE UNIVERSITY OF MICHIGAN

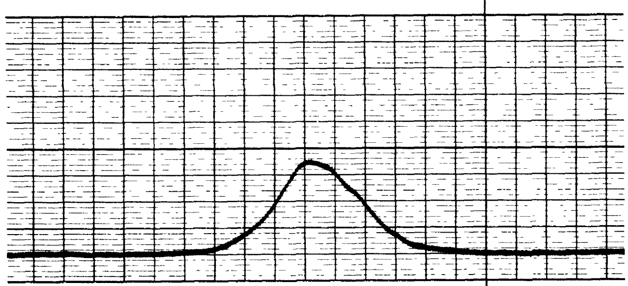
Test No. A402
Dummy 50%

BELT LOADS

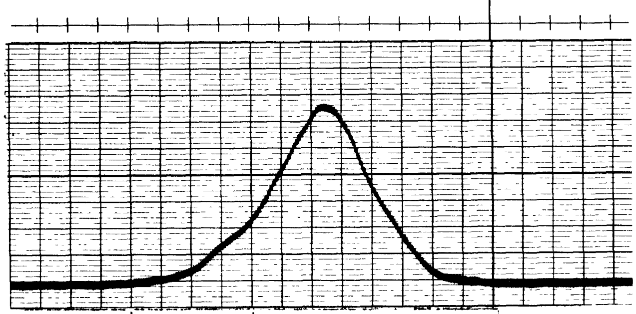
Left Shoulder Belt
250 pounds/division
Filtered
Class 60



Right Lap Belt
250 pounds/division
Filtered
Class 60



Left Lap Belt
250 pounds/division
Filtered
Class 60



Sled Pulse
10g's/division
Filtered
Class 60