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BASIC RESEARCH IN CRASHWORTHINESS II --- LOW SPEED IMPACT TESTS OF MODIFIED VEHICLES

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16. Abstract
A series of twelve low speed frontal impact tests were performed with ten structurally modified automobiles, that consisted of seven impacts into an S.A.E. flat barrier and five impacts into a fixed pole obstacle. The vehicle sizes ranged from subcompacts to large luxury-type vehicles. Impact velocities were within a range of 5 MPH to 11 MPH. The purpose of these tests was to determine if there were any significant differences in occupant responses between the modified vehicles and conventional cars. Unrestrained instrumented anthropometric dummies were on-board each test vehicle in the right front passenger seat. In two particular tests, an additional dummy was placed in the driver's seat position. Passenger compartment accelerations are presented along with accelerations recorded in the head, chest and pelvic areas of the dummies. The primary conclusion of the investigation is that there are essentially no differences in occupant accelerations between passengers of the modified and the conventional vehicles. Dummy response data were also compared briefly with human tolerance criteria which showed all of the occupant data to be below the presently established limits for serious injury.

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FOREWORD

This interim technical report presents the results of a series of low speed impact tests where structurally modified vehicles were impacted into both S.A.E. flat and pole rigid barriers. The tests were performed to provide information on the low speed crash characteristics of modified vehicles. This report is submitted in partial fulfillment of a program of research conducted by the Calspan Corporation for the National Highway Traffic Safety Administration under Contract No. FH-11-7622. Contract Manager for this project is Mr. Glenn Brammeier of NHTSA.

The opinions and findings expressed in this publication are those of the author and not necessarily those of the National Highway Traffic Safety Administration.

This report has been reviewed and is approved by:

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PREFACE

This report is one of a series of interim reports describing the research efforts being conducted under the "Basic Research in Crashworthiness II" program. These interim reports represent the effort and conclusions in a particular area associated with the overall crashworthiness program. While the conclusions may not be final and the data presented may not be all of the data to be collected in the particular area being reported, it is felt that these reports may be useful in:

(1) providing timely data for use by others interested and working in the problem area,

(2) providing a focus for the objectives of the overall program, and

(3) providing a convenient means for presentation of the program results in a measured fashion rather than in a voluminous final report.

It is anticipated that the final report will present any additional pertinent data collected and fully integrate these interim reports with the overall program objectives and conclusions. In the meantime, a brief discussion of the program objectives and the overall scope of the effort is presented to provide perspective for these interim reports.

The objective of this research program is to obtain experimental and analytical data that will establish the feasibility of designing automobile structures to dissipate energy at a controlled rate during collisions and prevent intrusion into the passenger compartment. The problem has been attacked from three separate and initially distinct aspects, namely,

- to determine structural performance characteristics of current automobiles through a wide range of test conditions, i. e., vehicle size, impact speed, impact conditions, etc. (so-called base line tests),

- to consider structural modifications required of the front of a vehicle to improve its structural performance in frontal impacts,

- to consider structural modifications required of the side elements (i. e., doors, door pillars, roof) of the vehicle to improve its structural performance in side impacts.

Each of these areas have involved a concern for the performance of unmodified and modified vehicles in impact situations with

- fixed pole and flat barriers, and

- in vehicle to vehicle impacts, including impacts between two unmodified vehicles, two fully modified vehicles and one unmodified and one modified vehicle.

The effort also encompasses a concern for the impact behavior between vehicles of

- different weight classifications,

- different structural characteristics, i. e., frame-compartment type vs. unitized type, and

- different impact conditions, namely compatibility in front/side impacts.

The modifications are not restricted to the vehicle exterior. A task concerned with desirable interior modifications, e.g., steering columns, piggyback testing of advanced restraint systems, interior modifications (padding, seats, etc.) is also a part of the program. A natural outgrowth of the overall concern for improving the crashworthiness of the vehicle is the concern for the production feasibility of the recommended structural design modifications made for full size automobiles. A separate task addresses itself to this aspect of the crashworthiness program.

Finally, a substantial analytical treatment of the problem of a frame-compartment type of automobile impacting a rigid obstacle is under development. The objective of the effort is to allow prediction and hence evaluation of the behavior of frame type structures.

Conclusion of the program is anticipated by April 1973.

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- Data Reduction

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SUMMARY

Four size classes of automobiles, including subcompacts to large luxury vehicles, were structurally modified to improve their high speed crash performance. Ten of these vehicles (namely 3 subcompacts, 2 compacts, 4 standard size and 1 large size sedan) were tested in frontal impacts with either S. A. E. flat or pole rigid barrier, within a speed range between 5 mph and 11 mph. These tests were conducted to determine if there were any significant differences in occupant responses between the modified vehicles and conventional cars. The results of the modified vehicle tests are presented in this report, along with several comparisons of these data with those from similar conventional vehicle tests.

Instrumented, unrestrained anthropometric dummies were used in the right front passenger seats of all the vehicles. In two particular tests, an additional dummy was placed in the driver seat position. Passenger compartment accelerations are presented along with the accelerations recorded in the head, chest, and pelvic areas of the dummies. Occupant responses of the modified and the conventional vehicles are also compared. In addition, acceleration data from the occupants are compared with human tolerance criteria.

The primary conclusion of the investigation is that there are essentially no differences in occupant acceleration between occupants of the modified and the conventional vehicles. Also, the data from the two driver position dummies of the modified cars fell well within the envelope of the right front passenger data, indicating the two seat positions were comparable with regard to acceleration exposure.

It was also observed that the size variations of the various modified vehicles produced no consistent differences in occupant responses. Furthermore, the barrier and pole impact tests exhibited about the same occupant behavior.

A comparison of dummy responses with human tolerance criteria showed all of the accelerations to be below the presently established limits for serious injuries.

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1. INTRODUCTION

The primary objective of the Basic Research in Crashworthiness II Program is to develop automobile structural configurations that provide occupant protection during extremely severe high speed collisions. To provide for adequate energy management, the frame members and forward sections of a number of conventional vehicles were redesigned and strengthened. In the event of low speed impacts of these modified vehicles against rigid obstacles, the passenger compartments will generally sustain somewhat higher deceleration levels than those experienced by conventional automobiles. It was the objective of this investigation to determine the effect a somewhat higher compartment deceleration level might have on acceleration response of unrestrained occupants* during such low speed collisions. The determination of absolute injury levels of the passengers was not a primary concern of these tests, although some comparisons are made between the dummy data and human tolerance criteria.

Both modified and standard vehicles were tested in this effort in order to obtain direct comparisons between the two types. Also, to allow for a valid assessment of the front structural effects, the same interior padding and geometry were generally maintained in both types of vehicles. No additional padding was used in the compartments other than the conventional configurations. The only exceptions were in the knee impact areas where

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* Occupants were unrestrained because this is expected to be the situation during low speed collisions if passive restraint systems are installed in the modified vehicles.

several of the modified vehicles required small knee pads around the lower rigid structure which supported the air bag systems (the air bag restraints were used for the high speed impact tests). Low speed impact velocities, for this work, were in the range of 5 to 11 mph.

For the initial tests of standard type vehicles, conventional automobiles were selected and subjected to low speed barrier and pole impacts. These results are used as base line data for comparions with the modified vehicle data. Following these initial tests, the conventional vehicles were then dismantled and structurally modified for the high speed crashes. Before subjecting these vehicles to the high speed crash tests, however, each was tested at low speed in order to obtain comparable data to those of the conventional vehicles. The low speed tests of the modified vehicles generally produced insignificant "dents" in the front bumpers and, in most cases, no visible damage at all. This report presents the results of the modified vehicle impact tests against flat and pole barriers and compares these data with the previously tested standard vehicle data*.

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* The low speed base line data were published in Reference 1 and also in the Appendix of this report for those data that were not previously published.

2. TEST METHODOLOGY

2.1 Test Conditions

The four types of modified vehicles tested were: (1) sub-compacts in a weight range of 2000-2700 lbs., (2) compacts in a weight range of 2700-3200 lbs., (3) standard size in a weight range of 3800-4300 lbs., and (4) large size in a weight range above 4300 lbs. Not all of the cars were tested against both a pole and a flat barrier, but a representative number were tested against each obstacle.

Table 2-1 presents information on these tests. The first three vehicles in the table are sub-compacts and were basically modified 1971 Chevrolet Vega 2300 sedans. The Mod. 2G and Mod. 2H1 vehicles are classified as compacts and were modified Chevrolet II Novas. The three Mod. 1D series vehicles were standard size, modified 1969 Ford sedans. The last test shown was a luxury size, modified 1968 Buick Electra. All tests were frontal right angle impacts and in the pole obstacle cases, impacts were at the center of the front bumper.

The anthropometric dummies employed were male Sierra 50th percentile, Model 292-850, weighing approximately 165 lbs. In a number of instances only the right front seat position was occupied, but some cars contained two and one test, the Mod. 6 Vega, contained three dummies, two in the front seats and one in the right rear seat. Each dummy was unrestrained and positioned in a natural seated position as shown in Figure 2-1. The front seats were set at the approximate mid-position of the available travel range. Dummy joints were set to friction levels somewhat higher than the general 1 g setting.

Table 2-1
TEST CONDITIONS

VEHICLE	TEST NO	TEST WEIGHT (lbs)	IMPACT VELOCITY (MPH)	OBSTACLE	TEST DATE	PUBLISHED TEST DATA LOCATION
MOD. 6 ('71 VEGA 2300)	50	2800.	5.1	POLE BARRIER	2/23/72	PROGRESS RPT. 21, ATTACHMENT NO. 1
MOD. 8 ('71 VEGA 2300)	78A	2580.	8.0	S.A.E. BARRIER	10/19/72	APPENDIX OF THIS REPORT
MOD. 9 ('71 VEGA 2300)	80A	2380.	8.3	S.A.E. BARRIER	11/20/72	APPENDIX OF THIS REPORT
MOD. 2G ('68 CHEV II NOVA)	22A	3370.	6.7	POLE BARRIER	6/22/71	CAL. RPT. NO. YB-2987-V-2
MOD. 2H1 ('68 CHEV II NOVA)	40B 40C	3400. 3400.	10.8 6.8	S.A.E. BARRIER POLE BARRIER	10/22/71 10/22/71	CAL. RPT. NO. YB-2987-V-2 CAL. RPT. NO. YB-2987-V-2
MOD. 1D1 ('69 FORD SEDAN)	33A	4010.	5.5	SAE. BARRIER	9/23/71	PROGRESS RPT. 16, ATTACHMENT NO. 1
MOD. 1D2 ('69 FORD SEDAN)	53C	4150.	8.1	SAE. BARRIER	3/7/72	PROGRESS RPT. 23, ATTACHMENT NO. 4
MOD. 1D3 ('69 FORD SEDAN)	64B	4720.	8.2	SAE. BARRIER	6/2/72	PROGRESS RPT. 27, ATTACHMENT NO. 1
MOD. 1D5A ('69 FORD SEDAN)	75A 75D	4350. 4350.	8.0 7.9	SAE. BARRIER POLE BARRIER	9/18/72 9/22/72	APPENDIX OF THIS REPORT APPENDIX OF THIS REPORT
MOD. 1F ('68 BUICK ELECTRA 225)	38	4435	7.3	POLE BARRIER	10/14/71	APPENDIX OF THIS REPORT

LEFT FRONT SEAT

RIGHT FRONT SEAT

Figure 2-1 DUMMY TYPICAL PRE-TEST POSITIONS

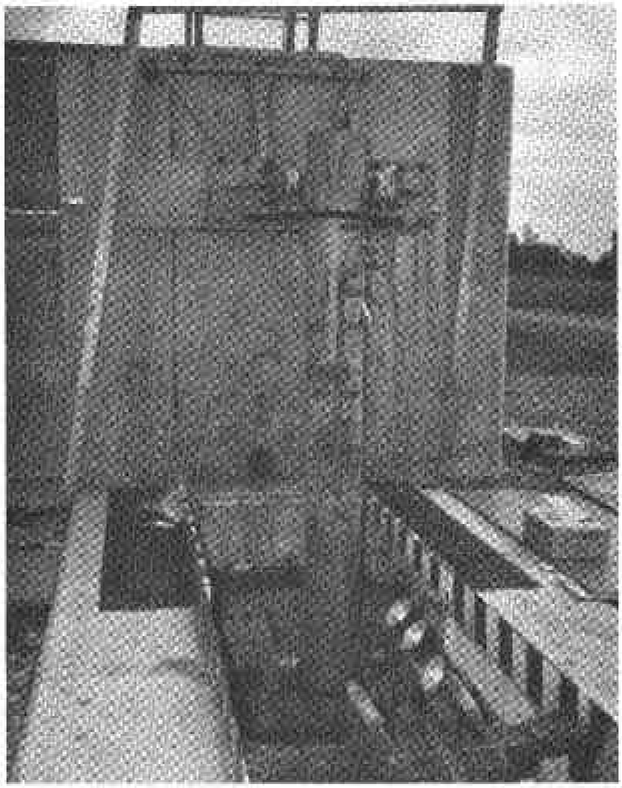
An S.A.E.-type flat faced concrete barrier, with dimensions of approximately 15 feet wide, 10.5 feet high and 6 feet thick, was used for this series of tests. The barrier is constructed at the end of a 792 foot long and 8 foot wide approach lane. Figure 2-2 shows a frontal and side view of the barrier along with the photographic pit immediately in front of it. Positive vehicle guidance is afforded by a single rail mounted along the center of the roadbed and a pair of guiding rollers mounted to the underside of the test vehicles. Mounted behind the barrier is a stationary winch-type towing system which is powered by a high performance automobile V-8 engine. At the opposite end of the track is an automatic vehicle abort system, composed of a large winch and braking system. A 1/2 inch steel cable links the abort drum to the test vehicle.

Also shown in Figure 2-2 is the rigid 12-3/4 inch diameter impact pole, mounted in front of the flat barrier. The removable pole is supported by three load cells at its upper end and three cells at its lower end beneath the level of the road surface. The load cells are used to measure forces produced by an impacting vehicle.

Single vehicle low speed collisions were performed with the vehicles pulled into the barrier by a forward tow cable. Vehicle velocity is controlled by a servo control system operating on the tow engine. A small drag force is maintained on the test vehicle through the abort brake cable, attached to the rear of the vehicle. This small retarding force aids in stabilizing the control system. The test vehicle is disengaged from the tow cable immediately before impact.

2.2 Instrumentation

Vehicle instrumentation consisted of triaxial accelerometers mounted on small reinforcing plates at different locations on the compartment floor. Figure 2-3 shows three typical placements of the accelerometers in the modified vehicles. Generally, the compartment tunnel accelerometer data were used to describe the deceleration response of the compartment.



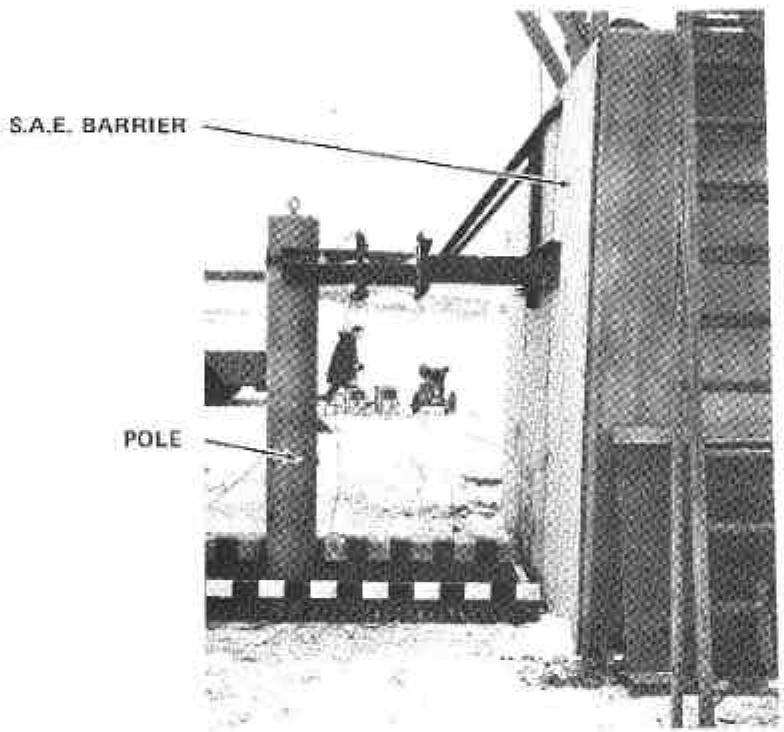


Figure 2-2 IMPACT OBSTACLES

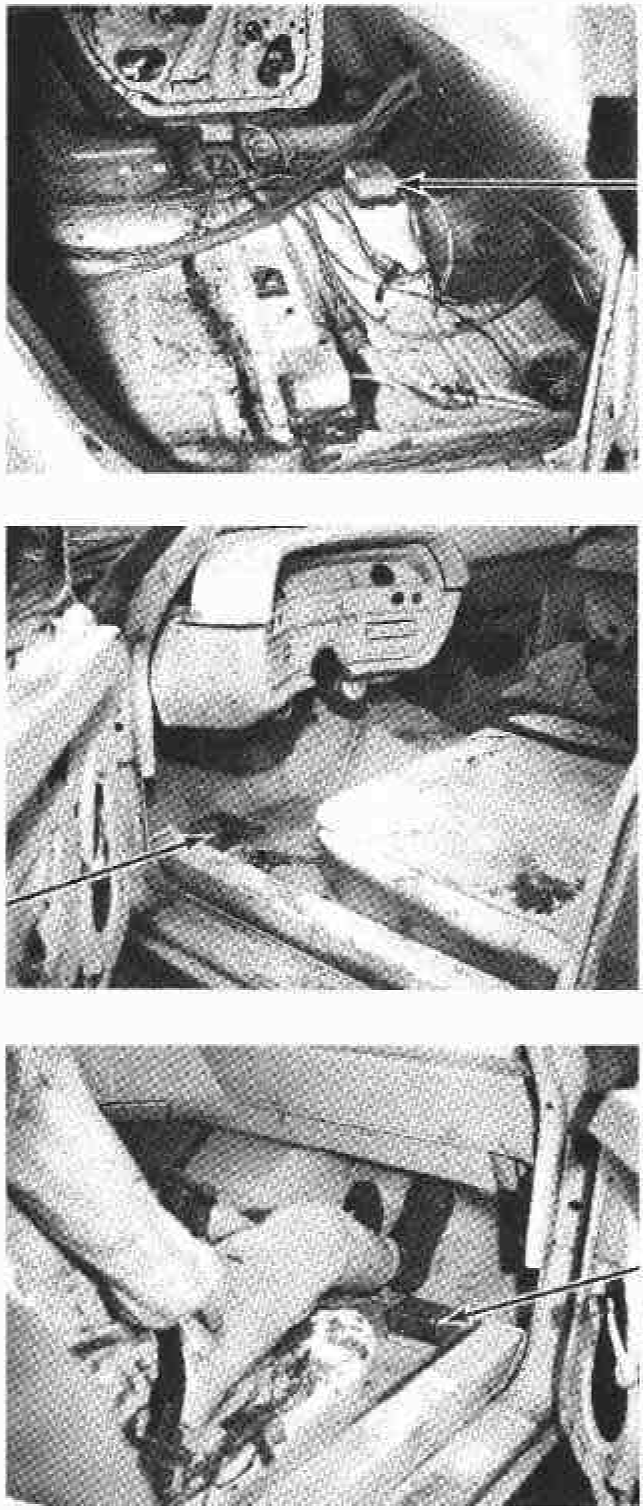


Figure 2-3 ACCELEROMETER TYPICAL MOUNTING POSITIONS IN MODIFIED VEHICLES

In the tests where these data are not available, the front floor accelerometer data were used. It should be noted, however, that in these low speed tests, the accelerations measured at the tunnel and the front floor locations were generally similar because permanent floor pan deformation did not occur.

Dummy instrumentation consisted of three orthogonally positioned accelerometers in the A-P (fore-aft), lateral (side) and S-I (vertical) directions. Each package of three transducers were mounted in the head, chest, and pelvic areas of the dummies. The same type of accelerometer was used in the vehicle and dummies. Response characteristics for these transducers are presented in Table 2-2.

Signals from the on-board vehicle transducers were amplified and transmitted through an umbilical cable to the remote station, where they were recorded on 14 Channel Sangamo FM tape recorders.

Vehicle impact speed was determined by a special trap device consisting of two vertical carbon rods held rigidly in a frame 40 inches apart. When the two rods were sequencially broken by the passage of the test vehicle, an electrical signal was recorded at each interruption and hence, the time to traverse the gap was determined.

Time of vehicle-barrier impact was determined by pressure switches attached to the front of the test vehicles and on the face of the barrier. These switches, at the time of contact, fired a small strobe light for data correlation in the photographic films and also for a "zero" time indicator on the data records.

Details of the data recording system, equipment, and the technique used to reduce the recorded data are presented in Reference 2.

Table 2-2

ACCELEROMETER CHARACTERISTICS

TRANSDUCER	MANUFACTURER	TYPE	AMPLITUDE RANGE ~ g's	FLAT FREQ. RESPONSE ~ Hz
PASSENGER COMPT ACCELEROMETERS	CONSOLIDATED ELECTRO-DYNAMICS CORPORATION	STRAIN GAGE BIDIRECTIONAL	$\pm$250	0-1000

2.3 Photographic Coverage

Two to six high speed movie cameras, using 16 mm color film and operating at frame speeds of approximately 1000 frames per second, were used to obtain a visual record of the details of the vehicle and the dummy kinematics. Generally, two or three cameras were mounted at the roadside. For additional coverage during several tests, one camera was mounted on top of the barrier and one camera was mounted in the pit underneath the vehicle. A real-time panning camera (24 frames per second) was used to obtain documentary coverage. All high speed cameras were equipped with neon lamps that were triggered by a Red Lake Laboratory timing light generator for recording timing pulses on the films at .010 second intervals. Information on the general layout of the photographic equipment is furnished in Appendix A.

The test vehicles were prepared with high-visibility paint over which strips of photographic tape and targets were applied.

2.4 Data Processing

Vehicle compartment accelerometer data are designated as "Corner (1)" for the left front floor and "Corner (2)" for the right front floor positions. The triaxial accelerometer directions are defined as positive for the forward or longitudinal (x) axis direction, for the right lateral (y) axis direction, and down for the vertical (Z) axis direction. The same positive directions are used for reduction of the dummy data in the A-P, lateral, and S-I directions.

The filter characteristics, which were applied to all vehicle and dummy data presented in this report, are in accordance with S.A.E. Recommended Practice No. J211 (Reference 3). The specific values of the digital filters that were used are listed as follows:

Data Type	SAE J211 Channel Class	Filter Cut-off Frequency ~ Hz
Vehicle Acceleration	60	50
Dummy Head Acceleration	1000	1650
Dummy Chest Acceleration	180	300
Dummy Pelvis Acceleration*	180	300
Dummy Femur Loads	600	1000

*Not specified in SAE J211.

More detailed information on the data reduction technique are presented in reference 2.

3. MODIFIED VEHICLE DESCRIPTIONS

The ten modified vehicles considered in this report had significant changes to their forward structural components. Furthermore, generally different designs were developed for each respective vehicle size. Detailed information on the design for each vehicle class (e.g., subcompact, compact, etc.) are contained in References 4 through 7. In the following, only a very limited description of each vehicle modification is presented.

Subcompacts

The subcompact vehicles were modified 1971 Chevrolet Vega Sedans. The three modified cars, Mod. 6, Mod. 8, and Mod. 9, are shown before impact in Figure 3-1. The Mod. 6 design consisted of a built-up front bumper section of high strength steel and aluminum honeycomb, a truss type energy absorbing bumper support section, and tubular sections in each fender for additional energy absorption. A number of small urethane pads were situated between the front bumper and its supporting structure to provide some cushioning during low speed impacts. The Mod. 8 design contained basically the same bumper as the Mod. 6, plus a redesigned energy absorbing bumper support system, and an engine receiving box structure aft of the firewall. The drive shaft tunnel area was reinforced along with certain other critical reinforcement areas. The design of the Mod. 9 vehicle was very similar to the Mod. 8 except for small changes in reinforcing plates at the bumper connection points and thicker walled energy absorbing struts. A slight weight reduction was also achieved with the Mod. 9 design, which showed a test weight of 2380 lbs. compared to 2580 lbs. for the Mod. 8. The specific design details of these subcompact vehicles are presented in Reference 4.

Compacts

Modifications for compacts were applied to conventional Chevrolet II Novas. The two vehicles tested (Mod. 2G and Mod. 2H1) in this weight class, are shown in Figure 3-2. The Mod. 2G vehicle had a rigid box-type front bumper supported by steel tubular knee members. The A and B-

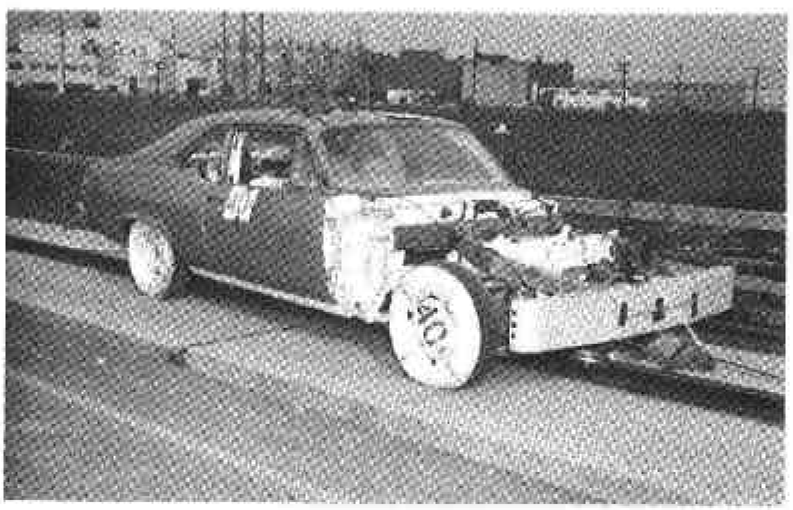
MOD. 6 VEGA

MOD. 8 VEGA

MOD. 9 VEGA

Figure 3-1 SUBCOMPACT MODIFIED VEHICLES,

MOD. 2G NOVA



MOD. 2H1 NOVA

Figure 3-2 COMPACT MODIFIED VEHICLES

pillars, as well as part of the roof, were strengthened. In addition, the main stub frame under the compartment was strengthened and extended to a point just aft of the B-pillar. The Mod. 2H1 vehicle was a refinement of this design. The front bumper, however, was redesigned to improve the low speed impact characteristics. Along with the front bumper change, the compartment tunnel area was reinforced with high strength steel sheet in a further attempt to limit engine intrusion. Details of these two vehicle designs are presented in Reference 5.

Standard Size Vehicles

The Mod. 1D series of standard size vehicles were modifications to 1969 Ford 4-door sedans. Figure 3-3 presents photographs of the four vehicles. The design of the Mod. 1D1 car was somewhat similar to that of the smaller weight vehicles in that it has a reinforced front bumper constructed of high strength steel, several solid urethane pads between the bumper and connecting struts, four energy absorbing steel tubular struts connecting the bumper to the frame, and frame modifications under the passenger compartment. Included in this design was an engine-compartment separating mechanism (deflection plate) at the firewall. The Mod. 1D2 vehicle was similar with the addition of a number of refinements in certain areas. The differences were in its polyurethane foam bumper system, the load distributing grille, a sandwich plate firewall construction and a high strength steel engine separating ramp mechanism. The following design, Mod. 1D3, contained certain changes and strengthening in areas such as, the tunnel/ firewall region, the forward frame, the passenger compartment lower sills, and the body/frame mount at the C-pillar. The Mod. 1D5A vehicle was similar to the Mod. 1D3 car except that it contained two energy absorbing cylinders mounted on the outside of the forward frame side rails for low speed impact energy management. The specific details on this vehicle are reported in Reference 6.

MOD. 1D1 FORD

MOD. 1D2 FORD

MOD. 1D3 FORD

MOD. 1D5A FORD

Figure 3-3 STANDARD SIZE MODIFIED VEHICLES

Large Size Vehicles

The Mod. 1F design, shown in Figure 3-4, contained the same basic structural elements as used on the standard size Mod. 1D1 vehicle. These consisted of a rigid front bumper bar connected through small cushioning pads to four separate energy absorbing steel tubes and an engine-compartment separating mechanism mounted at the firewall. One major change from previous vehicle designs was in the use of aluminum in the firewall reinforcing beam and in the engine deflection ramp. The specific design details of the Mod. 1F car can be found in Reference 7.

MOD. 1F BUICK

Figure 3-4 LARGE SIZE MODIFIED VEHICLE

4. TEST RESULTS

The results of modified vehicle impact tests are presented in this section. Those tests which are directly comparable to conventional vehicle tests are presented with corresponding data for the conventional vehicles. In this manner, not only the magnitudes of acceleration but also the timing of the various pulses can be compared. The conventional vehicle test data for the subcompact and standard size cars have been previously published in Reference 1 and are used here for comparison purposes.

Because the forward passenger compartment areas of most conventional automobiles are similar in geometric shape, including the seats and floor structure, the passenger motions relative to the vehicle interiors in all of the low speed impacts were very similar. The interior compartment surfaces, which were struck by the head, chest, and knees, were essentially the same for every modified vehicle test. Figure 4-1 shows a typical front compartment area and the various surfaces which were most often contacted by the unrestrained anthropometric dummies. The upper photograph shows the typical results of head contact against the windshield with the accompanying local spiral type cracks around the point of impact.

A summary of the test conditions, vehicle responses and dummy responses is presented in Table 4-1. In the listing, principal objects struck by various dummy components are also stated for the instances where this could be observed from the high speed movie films or as a result of the colored chalk applied to dummy surfaces. In all instances, data from the right front seat dummy are presented. In two tests, Mod. 6 and Mod. 9, the driver dummy data are also presented.

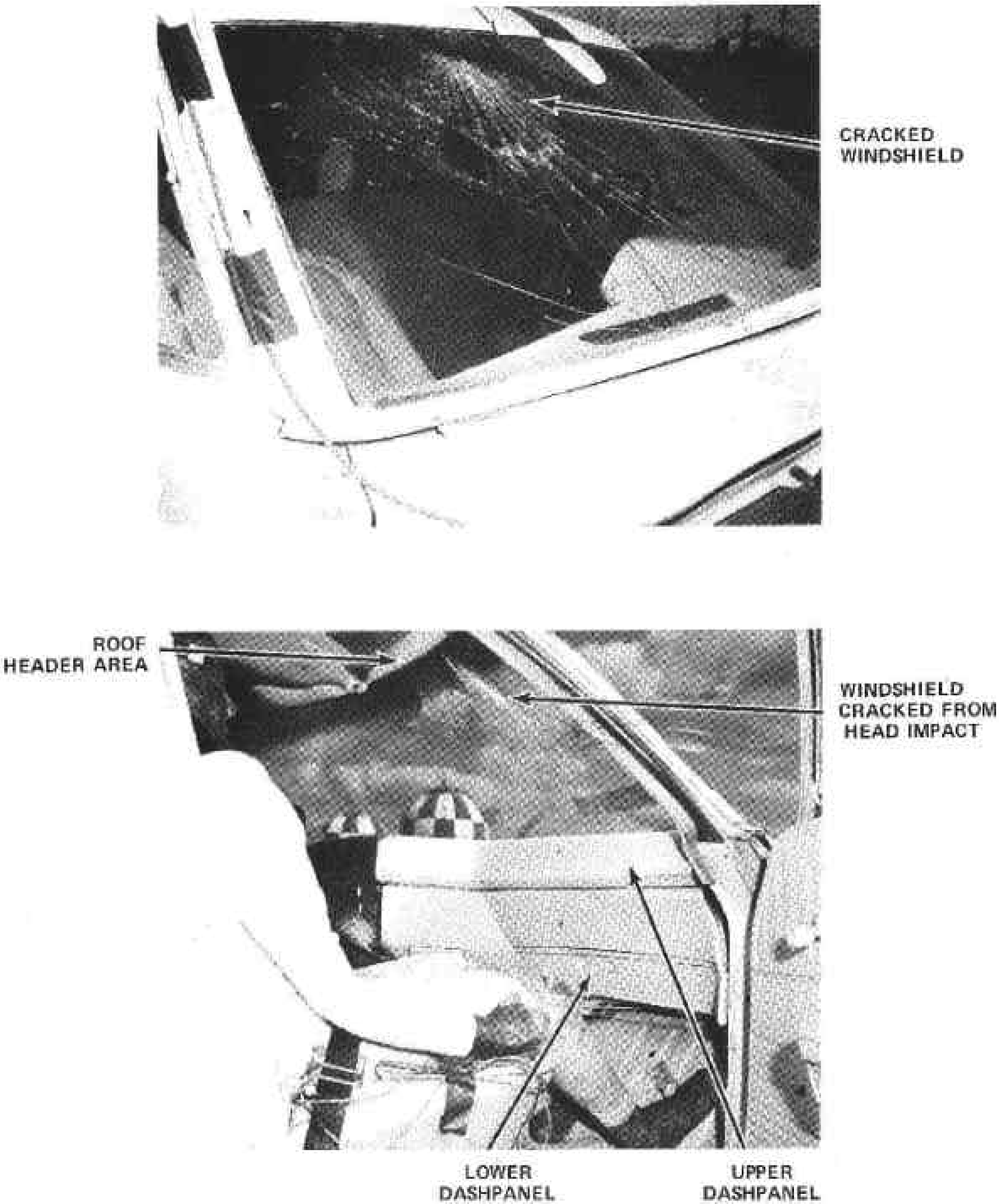


Figure 4-1 TYPICAL COMPARTMENT AREAS CONTACTED BY PASSENGER DUMMIES

Table 4-1
SUMMARY OF MODIFIED VEHICLE TEST RESULTS

VEHICLE TEST	TYPE OF TEST	PRGM TEST NO	VEHICLE DATA		DUMMY DATA (2)						
					HEAD			CHEST		PELVIS	
			IMPACT VELOCITY ~ MPH	MAX. (1) COMPT. DECEL. ~ g	MAX. (3) DECEL. ~ g	S.I.	OBJECT CONTACTED	MAX. (3) DECEL. ~ g	OBJECT CONTACTED	MAX. (3) DECEL. ~ g	OBJECT CONTACTED
MOD. 6 ('71 VEGA)	FRONTAL POLE, (RT.FRT.PASS.)	50	5.1	20.	24.	41.	FRONT-TOP OF HEAD HIT WINDSHILED	6.	NO CONTACT	8.	KNEES INTO LOWER DASH PANEL
MOD. 6 ('71 VEGA)	FRONTAL POLE (DRIVER)	50	5.1	20.	19.	15.	FOREHEAD HIT WINDSHIELD, NOSE THEN HIT STRG. WHEEL	5.	CONTACT WITH STRG.WHEEL RIM	16.	KNEES INTO PADDED KNEE-BAR
MOD. 8 ('71 VEGA)	FRONTAL, BARRIER	78A	8.0	58. (4)	28.	135.	FOREHEAD HIT WINDSHIELD	11.	NO CONTACT	14.	KNEES INTO LOWER PADDED DASH PANEL
MOD. 9 ('71 VEGA)	FRONTAL, BARRIER, (DRIVER)	80A	8.3	58. (5)	39.	112.	CONTACT WITH HEADER AND WINDSHIELD	13.	CONTACT WITH STRG. WHEEL RIM	12.	LOWER DASH PANEL BRACKETS
MOD. 2G ('58 NOVA)	FRONTAL, POLE	22A	6.7	31.	50.	365.	HEAD HIT ROOF HEADER	12.	NO CONTACT	—	-----
MOD. 2H1 ('68 NOVA)	FRONTAL, BARRIER	40B	10.8	48.	36.	100.	FOREHEAD AND THEN NOSE HIT WINDSHIELD	13.	NO CONTACT	22.	KNEES HIT LOWER DASH-PANEL
MOD. 2H1 ('68 NOVA)	FRONTAL, POLE	40C	6.8	24.	6.	13.	TOP OF HEAD HIT WINDSHIELD	7.	NO CONTACT	12.	KNEES HIT LOWER DASH-PANEL
MOD. 1D1 ('69 FORD)	FRONTAL, BARRIER	33A	5.5	12.	21.	17.	HEAD HIT ROOF HEADER	12.	NO CONTACT	8.	KNEES HIT LOWER DASH-PANEL
MOD. 1D2 ('69 FORD)	FRONTAL, BARRIER	53C	8.1	28.	40.	80.	FOREHEAD HIT WINDSHIELD	19.	NO CONTACT	—	KNEES HIT LOWER PADDED DASH-PANEL
MOD. 1D3 ('69 FORD)	FRONTAL, BARRIER	64B	8.2	22.	31.	78.	FOREHEAD AND THEN NOSE HIT WINDSHIELD	10.	NO CONTACT	12.	KNEES HIT LOWER PADDED STRUCTURE
MOD. 1D5A ('69 FORD)	FRONTAL, BARRIER	75A	9.0	27.	32.	160.	FOREHEAD HIT WINDSHIELD	10.	NO CONTACT	10.	KNEES HIT LOWER DASH PANEL
MOD. 1D5A ('69 FORD)	FRONTAL, POLE	75D	7.9	14.	14.	17.	FOREHEAD HIT WINDSHIELD	6.	NO CONTACT	11.	KNEES HIT LOWER DASH-PANEL
MOD. 1F ('68 BUICK)	FRONTAL, POLE	38	7.3	12.	18.	19.	FOREHEAD HIT ROOF HEADER	4.	NO CONTACT	10.	KNEES HIT LOWER DASH-PANEL

1. COMPONENT "X" OF COMPARTMENT TUNNEL ACCELERATION
2. 50TH PERCENTILE MALE DUMMY WAS IN THE RIGHT FRONT SEAT; MOD. 6 AND MOD. 9 ALSO CONTAINED DRIVER DUMMY
3. PEAK RESULTANT DECELERATION AT TIME INCREMENT OF .003 SEC.
4. COMPONENT "X" OF COMPARTMENT RIGHT FRONT FLOOR ACCELERATION
5. COMPONENT "X" COMPARTMENT LEFT FRONT FLOOR ACCELERATION

4.1 Subcompact Vehicles

The subcompact Mod. 6 Vega data were not directly comparable with baseline tests so they will not be discussed in this section. Time histories of the Mod. 8 vehicle decelerations, during its barrier impact at 8 MPH, and the baseline Vega test at 8.4 MPH are shown in Figure 4-2. It is obvious from the vehicle accelerations (upper plot) that the Mod. 8 vehicle possessed a much stiffer front section than the conventional vehicle. The Mod. 8 trace rises rapidly to a peak of about 58 g's compared to the more gradual increase of the standard vehicle to a maximum of about 12 g's. The remaining graphs in this figure show the right front dummy responses to the vehicle impacts. The maximum head acceleration of the Mod. 8 dummy was approximately 28 g's compared with the 38 g's of the conventional vehicle dummy. In both cases, the vehicles were totally stopped before the dummy heads contacted the windshields.

The chest peak accelerations of the dummies in both vehicles were very similar (about 11 g's), but the modified vehicles occupant showed higher pelvic accelerations, about 14 g's, compared to 7 g's for the standard vehicle occupant. Note that the acceleration pulses of all the dummy components in the modified vehicle occurred much sooner than in the conventional car. Additional dummy component data are presented in the Appendix for the Mod. 8 vehicle test.

The Mod. 9 Vega test data are shown in Figure 4-3 along with the baseline Vega data. The impact velocities for these two tests are nearly identical (8.3 MPH and 8.4 MPH). The upper graph shows the typical rapid rise of the modified vehicle deceleration curve and the low level values of the standard car. The maximum head resultant decelerations of the driver dummies were very similar in each test, showing about 39 g's (Severity Index = 112) for the modified vehicle and 42 g's (Severity Index = 130) in the conventional car. In this case, with the presence of a steering wheel in front of each dummy, both head contacts occurred at the roof header and windshield area, resulting in cracked windshields in both instances. Dummy

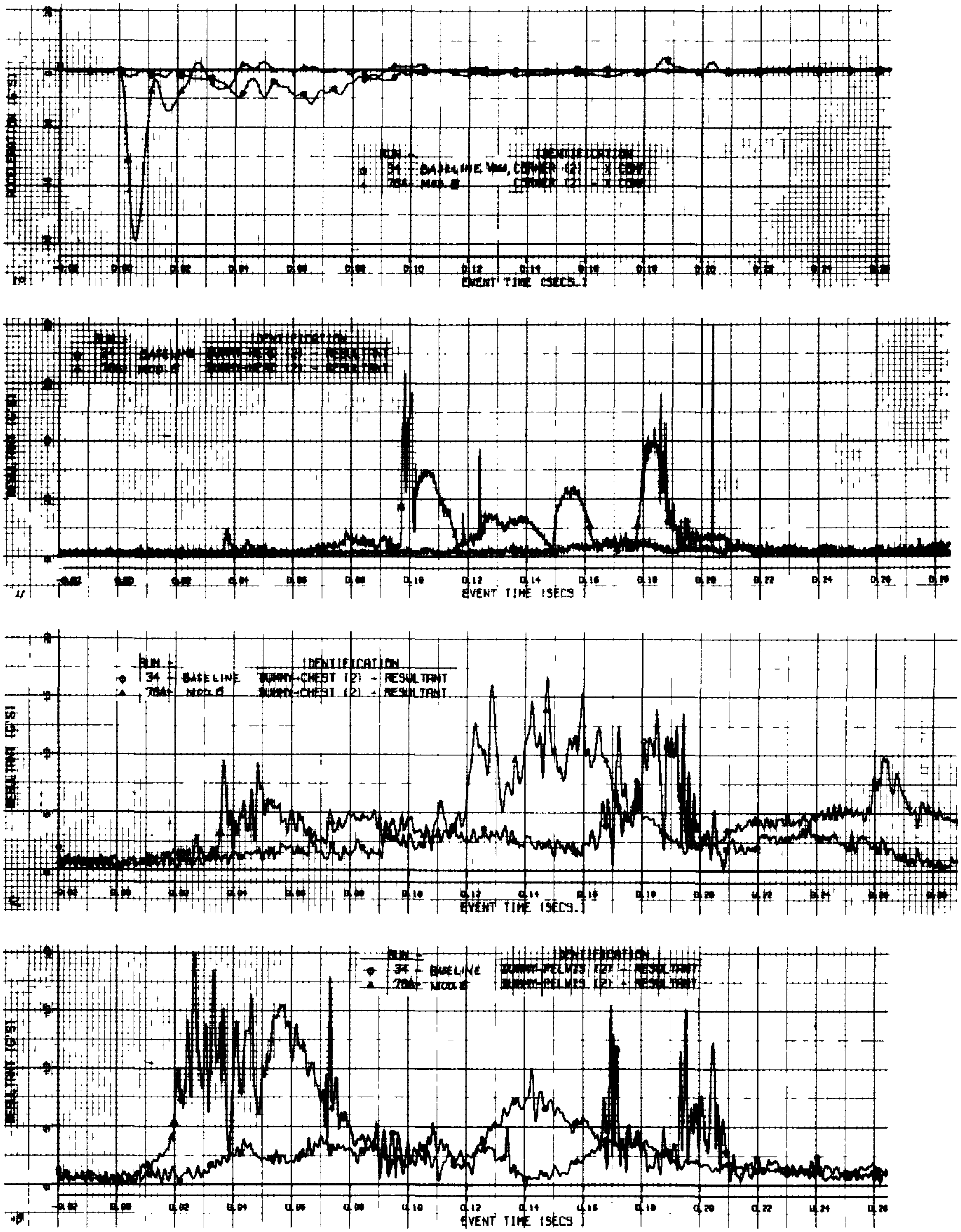


Figure 4-2 COMPARISON OF MOD. 8 AND BASELINE VEGA TEST DATA

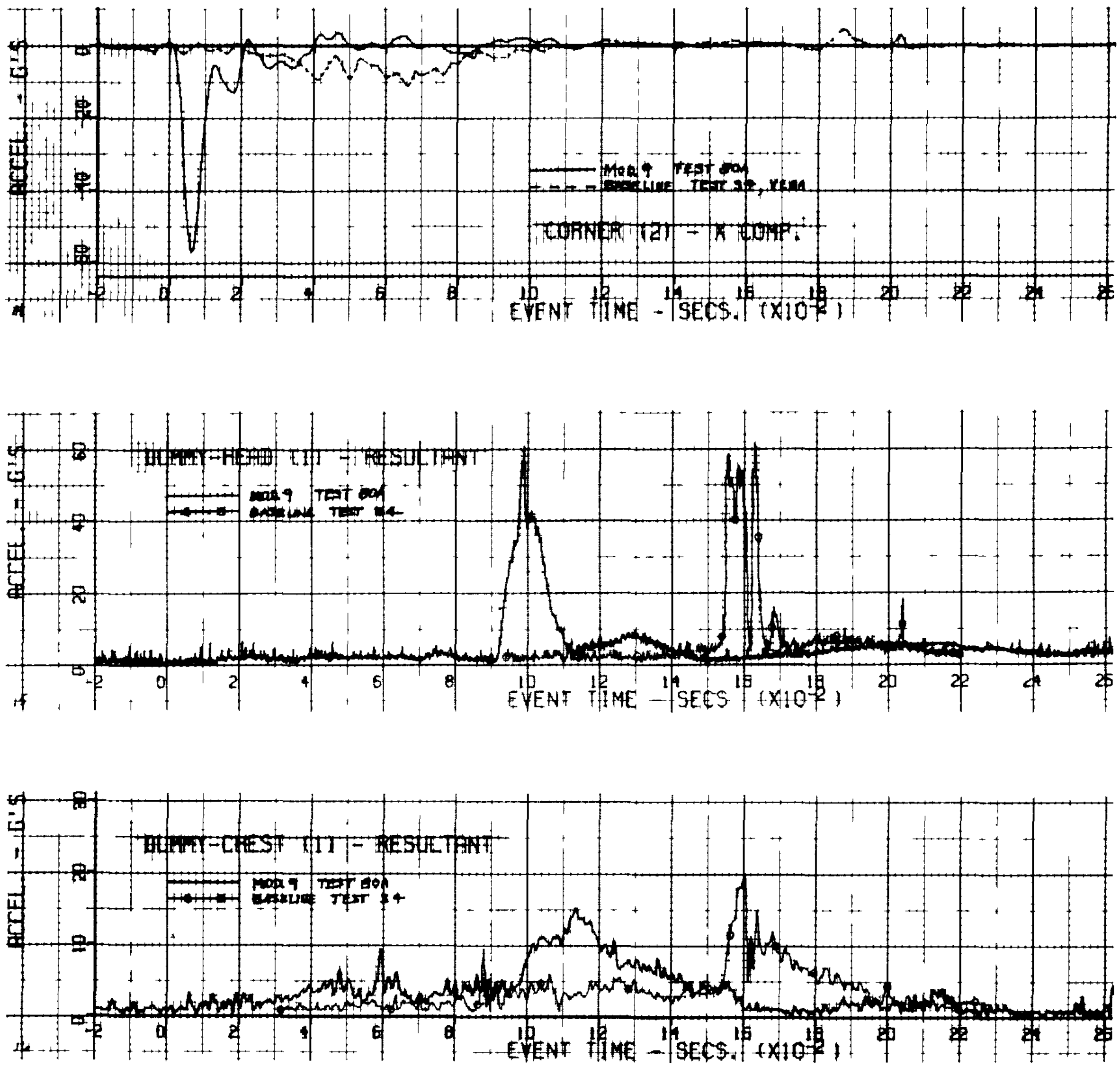


Figure 4-3 COMPARISON OF MOD. 9 AND BASELINE VEGA TEST DATA

chest peak accelerations were also of the same levels in both tests - about 13 g's. Acceleration component data for the driver dummy of the Mod. 9 test are presented in the Appendix B.

4.2 Compact Vehicles

The test of the Mod. 2G Nova is not directly comparable to standard vehicle data because of its intermediate impact velocity of 6.7 MPH. The Mod. 2H1 vehicle, however, (10.8 MPH barrier impact - test weight = 3400 lbs.) is comparable to the conventional Nova test (10.6 MPH - test weight = 3210 lbs.). These data are presented in Figure 4-4, which show the vehicle tunnel accelerations and the head and chest pulses of the right front dummies. In the upper graph of compartment tunnel acceleration, it is noted that the modified vehicle produced a much higher deceleration peak than the conventional car, about 48 g's compared to approximately 13 g's. The dummy trace comparisons show that the heads received peak values of 36 g's and 38 g's for the modified and the standard vehicle tests, respectively. Head contact point in the modified car was on the upper windshield surface, which cracked the glass. In the conventional vehicle, the head initial impact was on the roof header followed by a downward sliding motion onto the windshield glass. The glass was not broken in this particular test. It is interesting to note the difference in the shapes of these head pulses; the glass impact produced a much lower onset rate of about 2400 g/sec., compared to the more rigid roof header pulse of about 16,000 g/sec. The chest acceleration curves indicate that the modified vehicle dummy received an impulse much earlier at a slightly higher level than did the conventional vehicle occupant. From the high speed movie films, the indications were that neither chest contacted the instrument panel.

4.3 Standard Size Vehicles

For comparison of the modified vehicles with the conventional cars, the Mod. 1D2 and Mod. 1D3 vehicle data, for barrier impacts at 8 MPH, were overlayed with the baseline data as presented in Figure 4-5. In the upper plot of compartment acceleration, the modified cars show peaks

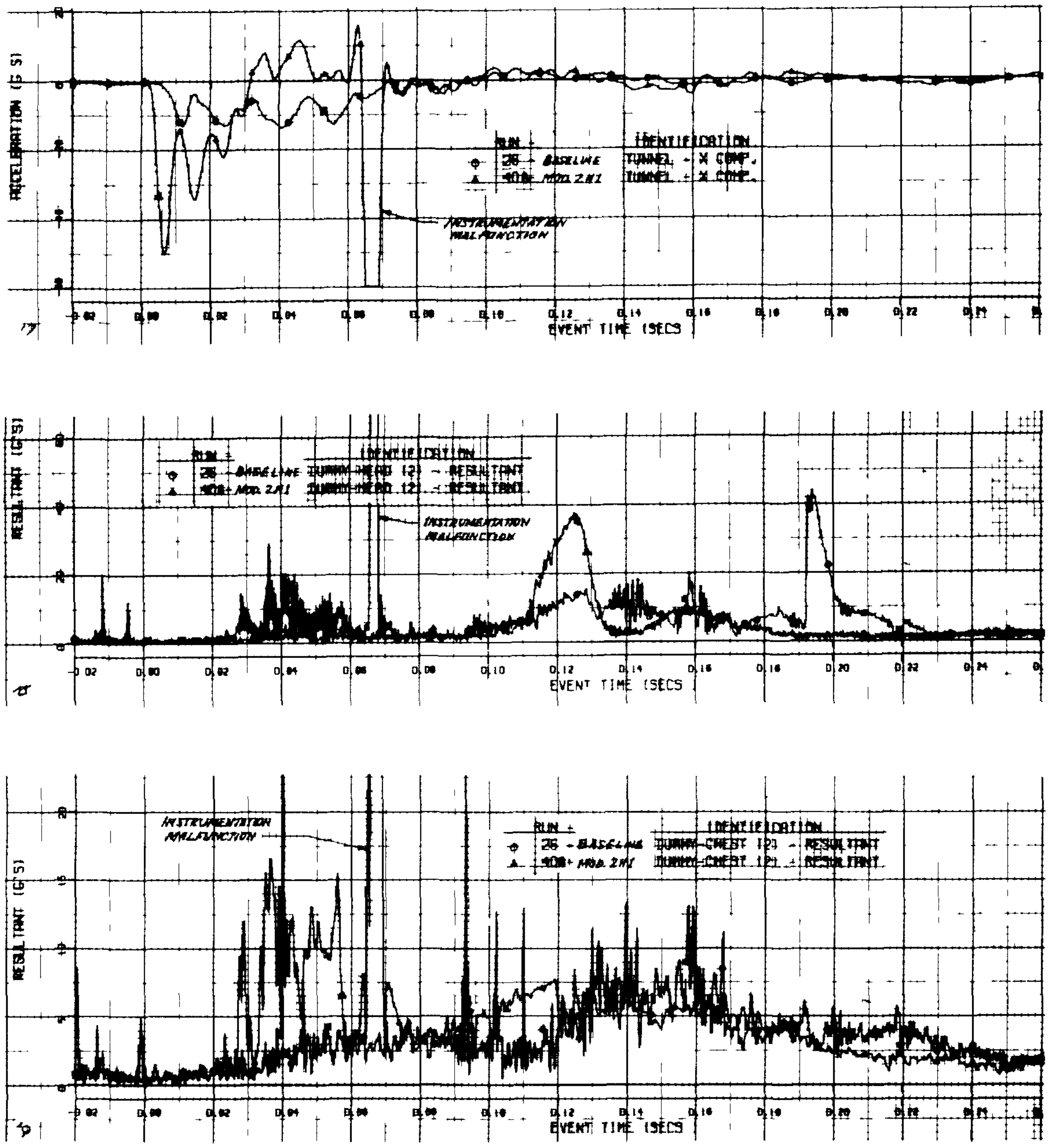


Figure 4-4 COMPARISON OF MOD. 2H1 AND BASELINE NOVA TEST DATA

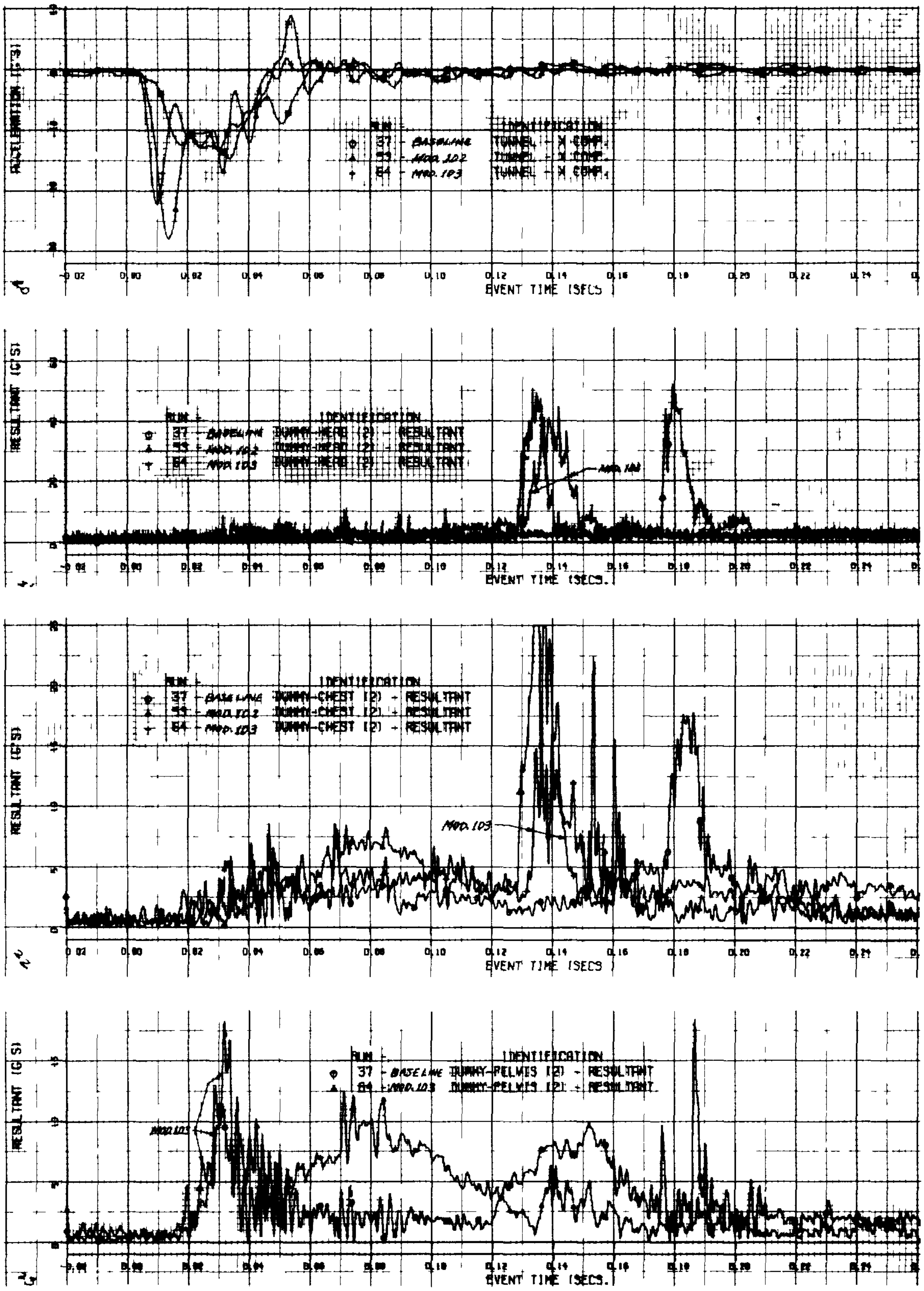


Figure 4-5 COMPARISON OF MOD. 1D2, MOD. 1D3 AND BASELINE FORD TEST DATA

of 28 g's and 22 g's for the Mod. 1D2 and Mod. 1D3, respectively. These accelerations are compared with the 14 g's peak of the conventional vehicle. Again, as in the compact car tests, the stiffer vehicle front structures produced somewhat higher deceleration levels than the standard vehicles.

The right front dummy head data, presented in Figure 4-5, show two pulses of similar shape and timing for the modified cars with the Mod. 1D2 dummy recording a maximum of 40 g's (Severity Index = 80). In the conventional car, the head recorded a peak of 41 g's, which is very much like that for the modified car occupant, but these pulses were delayed about .046 seconds. All head impacts were to the upper windshield area, producing cracks in the glass in each test. Head contact in the conventional car appeared to be on both the roof header and the windshield glass at the same instant, which also resulted in a cracked windshield. The dummy chest impact data indicate the same trends as the head data; that is, both pulses for the modified cars began at the same time, about .130 seconds from impact, with a delay for the conventional car pulse of approximately .046 seconds. Of the three tests, the Mod. 1D2 dummy chest recorded the highest peak acceleration - about 19 g's. The dummy pelvis data are shown at the bottom of the figure with only two tests compared, the Mod. 1D3 and the conventional car. Both pulses for the pelvic areas of the two dummies started at about .020 seconds after vehicle impact and continued for approximately .160 seconds. The maximum acceleration levels were comparable, with an average of about 11 g's. The similarity of these two pelvic pulses was probably due to the initial position of the knees relative to the lower dash panel and structure, about two inches separation distance in both vehicles.

The Mod. 1D5A modified vehicle data are compared with conventional car data in Figure 4-6 for a barrier collision of 8 MPH. The upper graph in Figure 4-6 presents the compartment deceleration pulses for this vehicle and the standard car. The curve shows that the performance of this bumper system is not vastly different from that of the other Mod. 1D series vehicles, which utilized a polyurethane energy absorbing system.

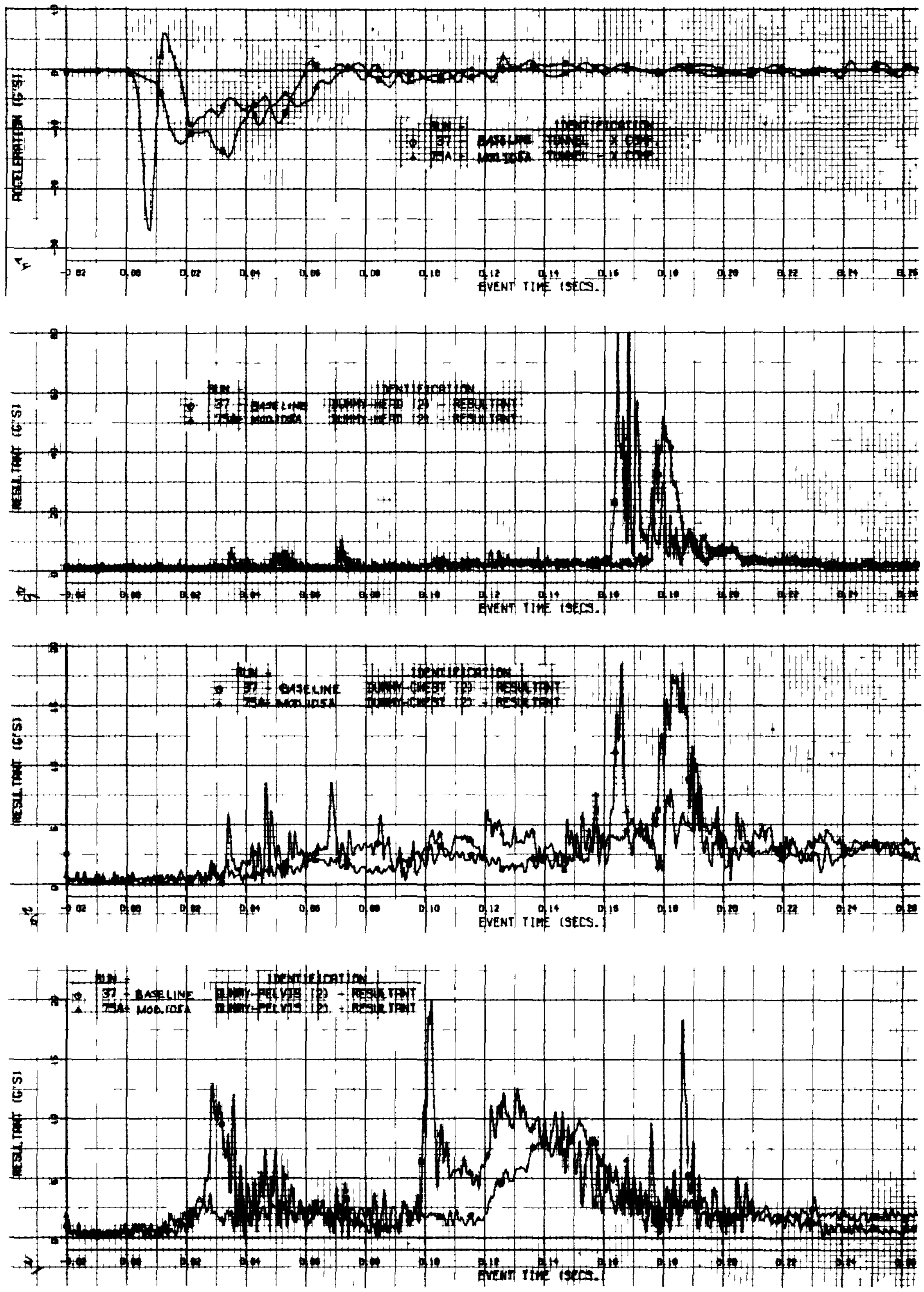


Figure 4-6 COMPARISON OF MOD. 1D5A AND BASELINE FORD TEST DATA, BARRIER IMPACT

A peak compartment deceleration of 27 g's was recorded during this test. The dummy head maximum acceleration was about 32 g's (Severity Index = 160) and the chest and pelvic levels were both about 10 g's. These accelerations were similar to those recorded for the Mod. 1D3 vehicle discussed previously. The only apparent difference between the Mod. 1D5A and Mod. 1D3 data is that the dummy component pulses were all delayed somewhat in the Mod. 1D5A test; that is, the Mod. 1D5A dummy maximum head and chest pulses occurred at about .162 seconds, whereas in the Mod. 1D3, pulses started at about .128 seconds. The standard vehicle dummy head and chest impacts both occurred at about .176 seconds.

A comparison of pole barrier impact data at 8 MPH of the Mod. 1D5A with a conventional car is presented in Figure 4-7. The compartment accelerations of the two vehicles differ considerably with the modified vehicle showing a maximum of about 14 g's and the standard car approximately 5 g's. The dummy head impact pulses were also dissimilar because of the different objects struck within the compartment. In this case the head of the modified vehicle occupant contacted the upper windshield area resulting in cracked glass and a maximum acceleration of about 14 g's. The standard car dummy, on the other hand, hit its head lightly on the corner of the rear view mirror and then slid down toward the dash panel. The head deceleration peak was only about 5 g's in this case. The maximum acceleration for the chest and pelvic areas of the modified car dummy were somewhat higher than the conventional vehicle dummy, however their absolute levels were quite low at about 6 g's for the chest and 11 g's for the pelvis area. Additional dummy component data for the two Mod. 1D5A impact tests are presented in the Appendix B.

4.4 Large Size Vehicles

The large size vehicle, Mod. 1F (modified Buick Electra 225), was impacted into a pole at a velocity of 7.3 MPH. For comparison, there were no data available of a conventional car tested at the same speed, but one of the conventional Buicks was impacted into the pole barrier at 4.6 MPH.

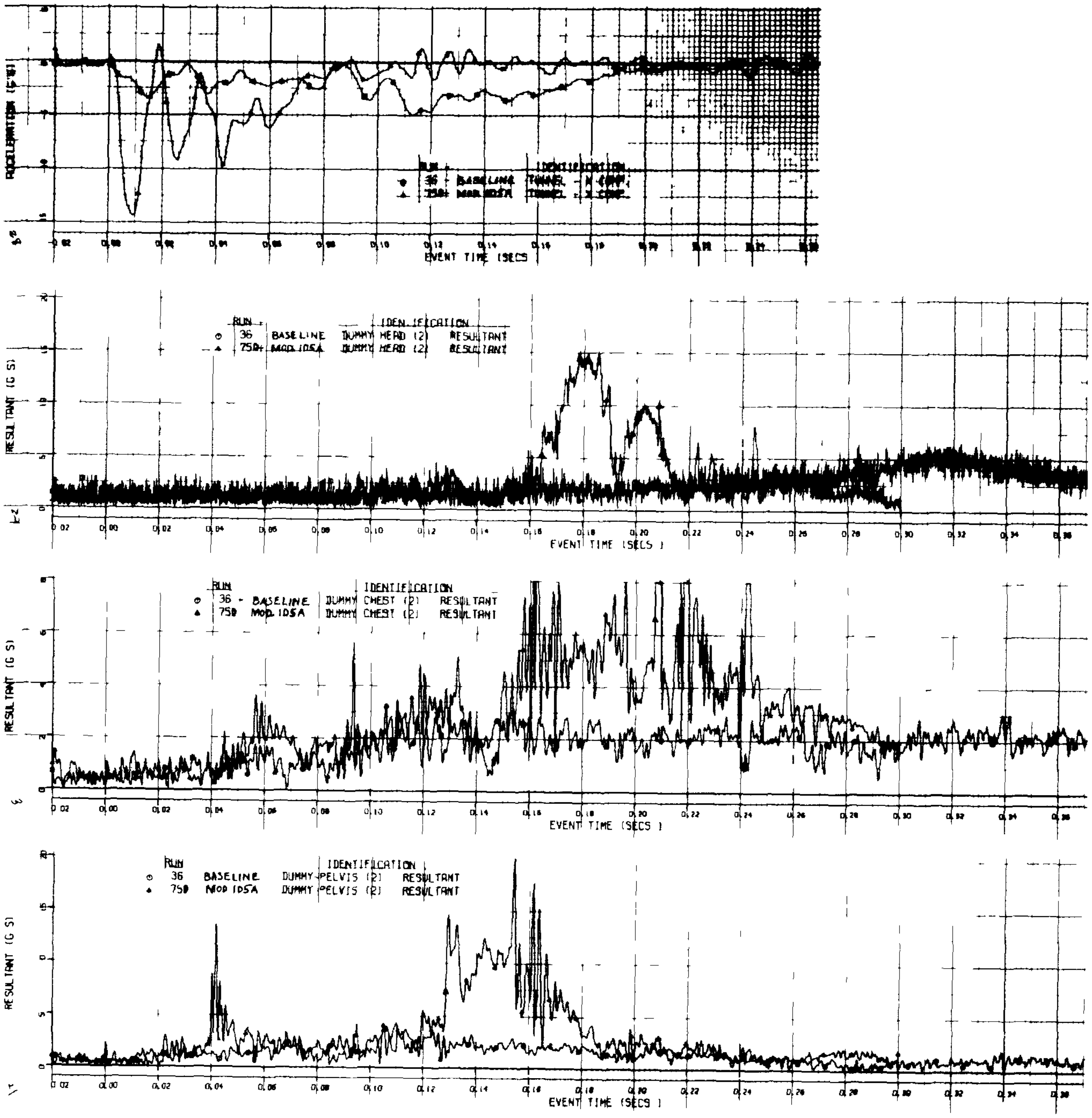


Figure 4-7 COMPARISON OF MOD. 1D5A AND BASELINE FORD TEST DATA, POLE IMPACT

It must be kept in mind, however, that the impact energy level between these two tests was quite different. The Mod. 1F test data are presented in Figure 4-8. As seen in the upper graph, the passenger compartment peak deceleration was about 12 g's. The conventional Buick (impacted at only 4.6 MPH), showed a very low level of compartment deceleration of approximately 2.5 g's. The dummy in the modified vehicle recorded a peak head acceleration of about 18 g's as a result of an impact to the roof header. No cracks could be detected in the windshield glass after the test. The conventional car dummy experienced such a mild head deceleration that the recorded traces indicated only a slight change from the zero position - on the order of 2.4 g's. Furthermore, the dummy torso and head did not contact the compartment interior. In the case of the Mod. 1F vehicle, the chest and pelvis of the dummy experienced peak decelerations of about 4 g's and 10 g's, respectively. The chest pulse of the conventional car dummy showed a very mild deceleration of about 1.7 g's. Additional vehicle and dummy component data for the Mod. 1F impact test are presented in the Appendix B.

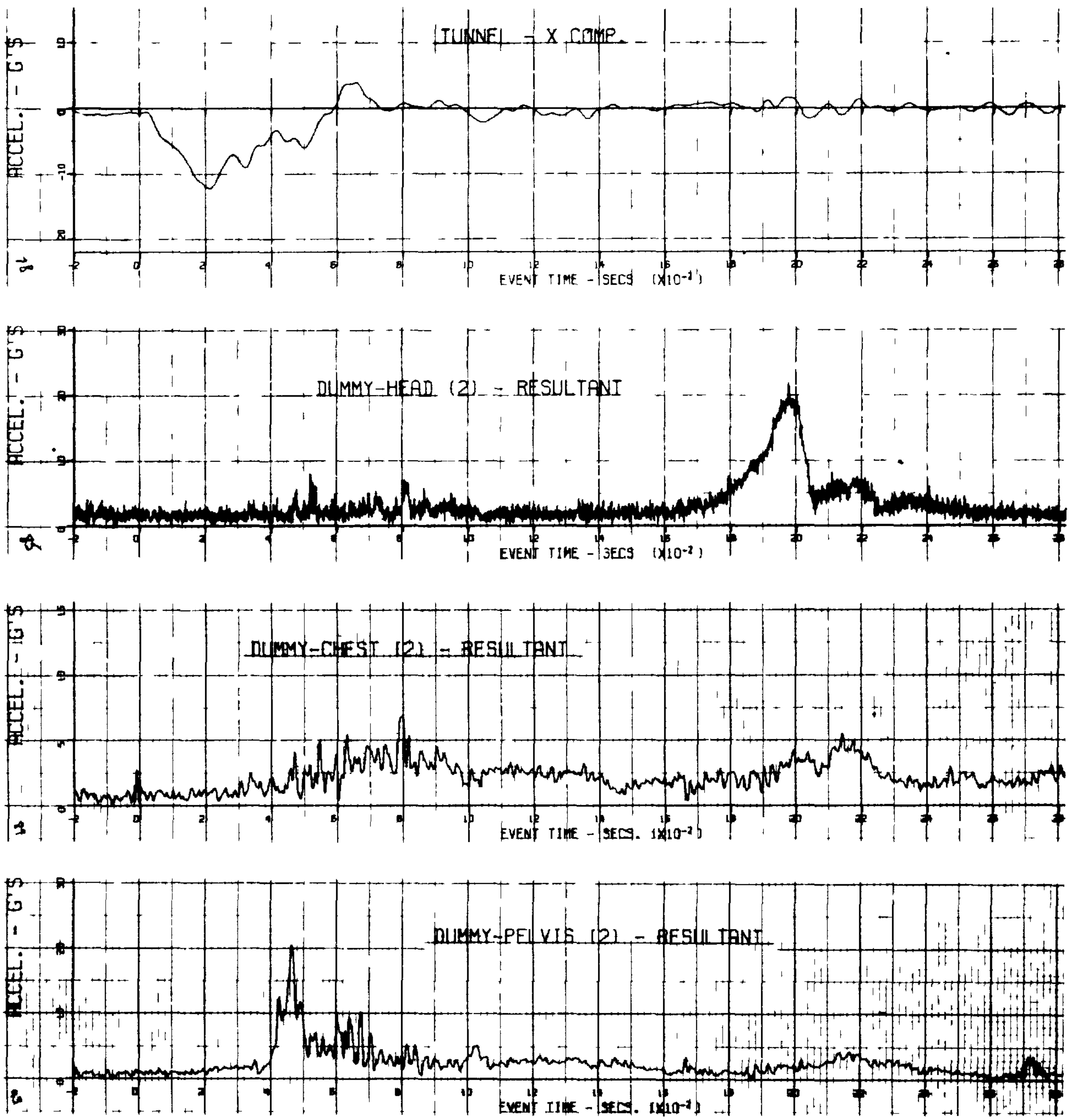


Figure 4-8 VEHICLE AND DUMMY DATA FOR MOD. 1F POLE IMPACT TEST

5. DISCUSSION OF RESULTS AND CONCLUSIONS

The passenger compartment acceleration data are plotted versus vehicle impact velocity in Figure 5-1. The two highest accelerations, at levels of about 58 g's, were recorded in the two subcompact vehicles, Mod. 8 and Mod. 9. Both of these cars were designed with no low speed shock attenuating devices, such as the polyurethane bumper system of the standard size vehicles. The absence of the energy absorbers probably contributed to the relatively high vehicle accelerations.

These particular vehicles do not appear to demonstrate increasing compartment decelerations (peaks) with increasing vehicle impact speed. The reason for the somewhat random pattern of the upper graph of Figure 5-1 may be the lack of a sufficient number of tests and also in the design differences of the front bumper systems of the various vehicles. Comparable results were expected for both pole and flat barrier tests, however, because of the rigid front bumper systems of the modified cars.

The lower graph in Figure 5-1 presents the head impact data of the right front passenger dummies as well as the two data points for driver dummies. Aside from the one data point of the Mod. 2G at 80 g's, all other data show maximum deceleration levels of 40 g's and below. These data are, therefore, well below the head fatal injury limit of 80 g's suggested in SAE J885a (Reference 8).

A further inspection of the head data shows a general increase of head acceleration levels with impact speed of the vehicles, however, the correlation is not very high due to the fact that the head data are functions of a number of additional variables, such as, the "softness" of the contact material, knee impact conditions, and dummy initial positions. Rigid control over such variables during the tests was not attempted. The dummies were placed in the compartments in "standard" seated positions with their seats about mid-way in the fore-aft range.

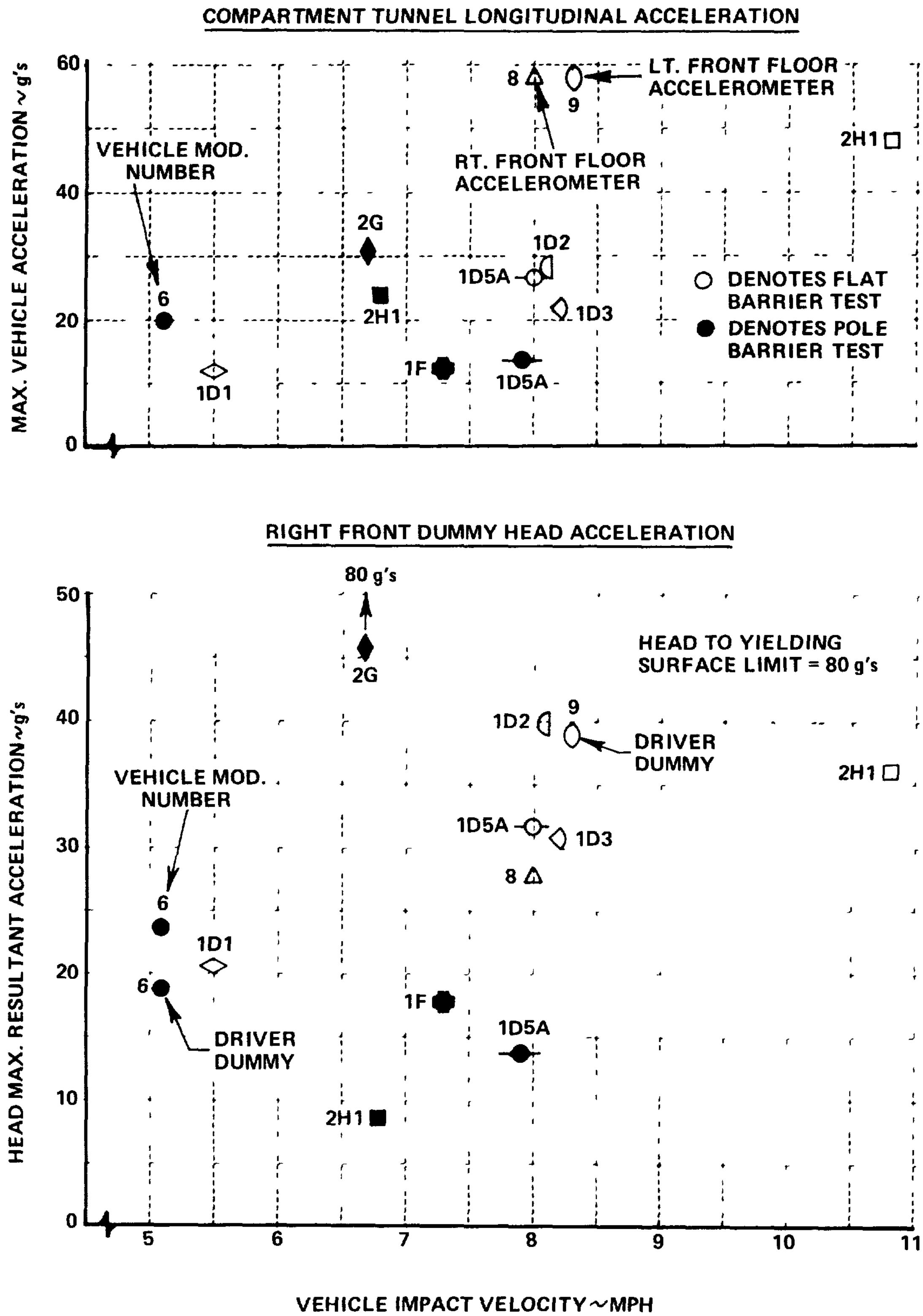


Figure 5-1 VEHICLE AND DUMMY HEAD ACCELERATION DATA

The two test points for driver dummies shown in the graph may be compared with the passenger data. In the Mod. 6 test, both head impacts of the driver and passenger were of similar magnitude, about 24 g's for the passenger and 19 g's for the driver. Both dummy heads contacted the upper windshield area. Because these two dummies were in the same test vehicle, they experienced the same impact environment. Consequently, these data indicate virtually no difference between the two seated positions.

Because of the scarcity of data for all vehicle types, it is not possible to determine the effect of vehicle size on head accelerations. However, from the evidence available, it appears that there is little correlation between head accelerations and size of the modified vehicles (or compartment size). For example, in the series of pole barrier tests, the Mod. 1F Buick dummy received 18 g's head deceleration at 7.3 mph, the Mod. 1D5A Ford dummy showed 14 g's at 7.9 mph, and the Mod. 6 Vega dummy recorded 24 g's at 5.1 mph impact velocity. This is not the same trend that was observed in the conventional vehicle tests of Reference 1 where the head accelerations of the smaller car dummies were definitely higher than the larger vehicle occupants. The reason for the scattering of the modified vehicle data may be in the fact that all the vehicles (large or small) are decelerated rather quickly, allowing the dummies to contact compartment obstacles at approximately their initial velocities. Thus, the deceleration levels of the heads are much more dependent on what they contact than on the internal size of the compartment.

The interior compartment geometries of the modified vehicles were generally conventional, especially in the upper dash areas, the windshields and the roof headers. The effect of head contact with several of these areas on head deceleration levels is not clear due to the limited number of test points. Head contacts directly on the rigid roof headers were determined by analysis of high-speed movie films in three tests, Mod. 9, Mod. 2G, and Mod. 1D1. In the Mod. 1D1 test, the dummy head sustained a maximum deceleration of about 21 g's without windshield glass breakage. At a vehicle speed comparable to this test, the Mod. 6 dummy recorded a maximum head deceleration of 24 g's during a hit to the windshield area, which also produced no fracture of the glass. Note that the results of these two tests were very similar, but the head impacts occurred to two different areas. It appears that, even in the cases of windshield glass breakage, the range of head deceleration levels was considerable, from about 15 g's to 40 g's. It must be concluded that the differences between head impacts on the windshield and those on the roof header are small under the conditions of these low speed tests and that those differences that do appear are attributable to other variables, such as dummy initial positioning and knee contact conditions.

Head severity indices (S.I.) for the data in Figure 5-1 are presented in Table 4-1. When these indices are compared to "a danger to life" limit value of 1000, the data fall well below the criterion. The maximum S.I. observed was 365, which occurred during the Mod. 2G test. For several of the high S.I. values, a Head Injury Criteria (HIC) value was calculated as suggested in the amendment to FMVSS 208 (Reference 9). The HIC number for the Mod. 2G head impulse was 322 compared to the S.I. value of 365. Similarly, HIC numbers of 93 and 90 were calculated for tests Mod. 9 and Mod. 1D5A (barrier), respectively.

The results of dummy chest accelerations are plotted in Figure 5-2 for various vehicle impact velocities. The data appear to be clustered around the 10 g's level for most of the tests, somewhat independent of impact velocity. A maximum chest deceleration of 19 g's was recorded for the Mod. 1D2 passenger, which was well below the limit of 60 g's suggested in Reference 9. From the high-speed movie films of the dummies, actual chest contacts were not observed, except for the case of the driver dummies. In the two tests of driver dummies, the chests contacted the steering wheel rims at approximately the same time the heads contacted the upper windshield areas. The driver of the Mod. 9 vehicle sustained a maximum chest deceleration of 13 g's. Note that these values are at about the same level of those data recorded in the conventional vehicle tests presented in Reference 1, which were about 14 g's.

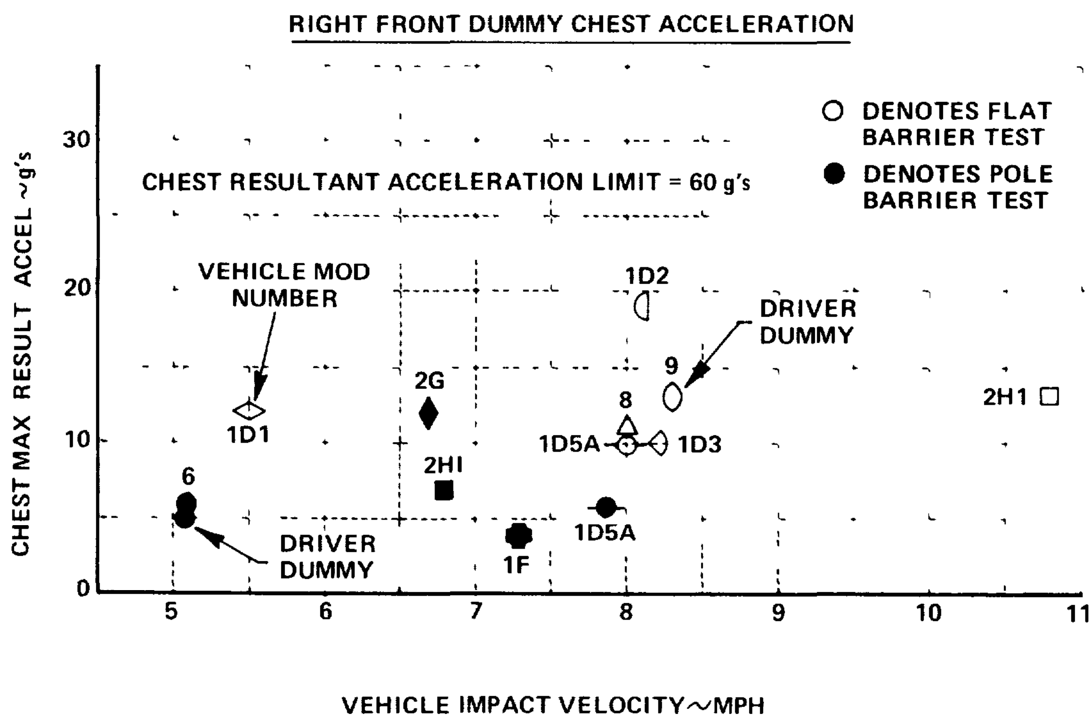


Figure 5-2 DUMMY CHEST ACCELERATION DATA

A comparison of the driver data and the passenger data in the modified vehicles shows little difference. The small deviations of the passenger chest accelerations in Figure 5-2 probably stem from the fact that there are actually no rigid protruding surfaces in front of the passengers that could have been struck under the test conditions. During the impact sequence, the knees contact the lower dash panel, generally first, and then the head impacts the upper windshield area, with the chest barely touching the upper dash panel. Vehicle impact velocities would have to be substantially increased or the shape of the dash panel changed to produce actual contact between the chest and the upper panel.

Dummy pelvic acceleration data are presented in Table 4-1. In addition, time histories of femur loads for the dummies in the Mod. 8 and Mod. IF tests are shown in Appendix B. The maximum pelvic acceleration obtained in this series of tests was 22 g's during the Mod. 2H1 barrier impact at 10.8 mph. If this value is converted to a single femur load, by use of the graph presented in Reference 10 of pelvic acceleration versus femur force for various dummy tests, a femur force of about 570 lbs. is obtained (using the linear relationship). This load level is well below the criterion of 1700 lbs. (FMVSS 208, Reference 9) for a single femur load.

A comparison of head impact accelerations for all the low speed tests of both modified and conventional vehicles is presented in Figure 5-3. On the left side of the bar graph are the conventional car data that were previously published in Reference 1, plus a standard Chevrolet Nova test. On the opposite side of the graph are plotted the modified vehicle data. With the exception of the Mod. 2G test, it is clear that all of the head accelerations were about 40 g's and below for both driver and passenger positions. In addition, these data show that the modified vehicles do not differ appreciably from the conventional cars and it may be concluded that both sets of vehicles yielded about the same occupant head acceleration levels. The Mod. 2G test produced a rather sharp, pointed-type head acceleration pulse with a very high onset rate and short duration of about .009 seconds. In two other comparable tests, at slightly higher vehicle impact speeds (baseline test No. 26

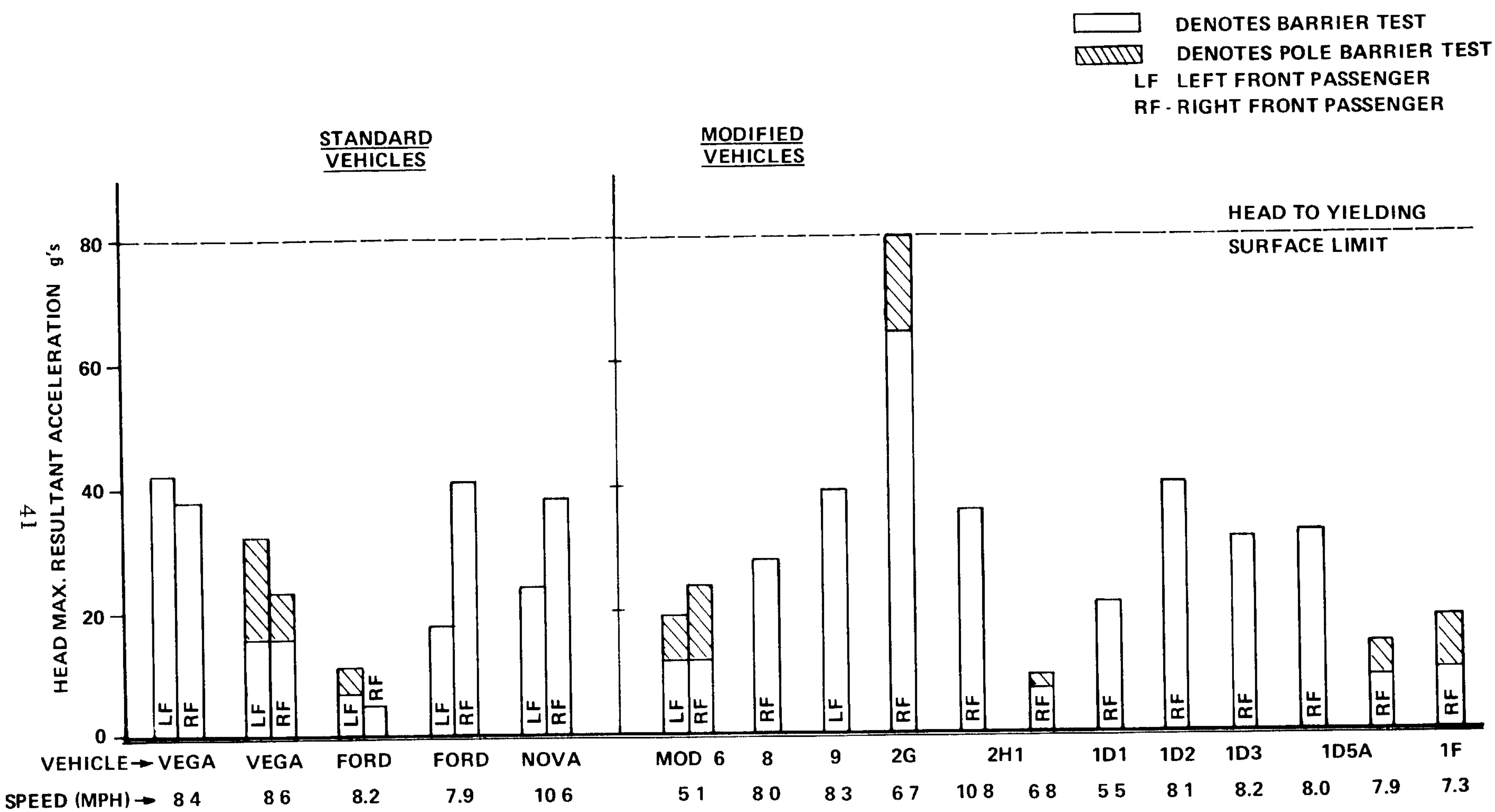


Figure 5-3 COMPARISON OF DUMMY HEAD ACCELERATIONS FOR STANDARD AND MODIFIED VEHICLES

YB-2987-V-17

and No. 34) and with head contacts in the same area, the pulse peaks were much less, at about the 40 g level.

In the above discussion a number of general statements were made pertaining to the results of this series of vehicle tests. It is realized that there were a limited number of these tests resulting in a rather small amount of data so that the trends and conclusions that are discussed here may not be the general rules for all low speed tests of structurally modified vehicles. With this in mind, several conclusions obtained from these tests are listed below.

1. Passenger and driver dummies in the modified vehicles experienced approximately the same maximum decelerations as those in similar tests of conventional vehicles.

2. Occupant deceleration differences could not be discerned between the small modified cars and the large modified vehicles. That is, occupants of subcompact vehicles appeared to experience the same magnitudes of maximum deceleration as occupants of standard and large size cars.

3. In the low speed range, up to approximately 8 mph, pole impacts had approximately the same effect on dummy response as the barrier collisions.

4. Dummy head deceleration levels in the modified vehicles were well below the injury criteria of 80 g's maximum acceleration and Severity Index (or Head Injury Criteria) value of 1000. Generally, the head accelerations were about 40 g's and below with a maximum S.I. value of approximately 160 or 90 for the HIC value. In addition, it was observed that head contacts to the upper windshield area were not significantly different from those to the metal roof header as far as maximum decelerations were concerned.

5. Dummy chest impacts showed peak accelerations on the order of 10 g's (average) with a maximum recorded value of 19 g's. When compared to the human tolerance limit of 60 g's, these values would indicate little injury potential. The two tests involving driver dummies recorded maximum chest values of only 13 g's and 5 g's for contacts against the steering assembly.

6. Dummy pelvic acceleration data were of sufficiently low magnitude as to indicate little probability of injury, even in the tests which contained the somewhat modified and more rigid lower dash panels. The average level of pelvic acceleration was about 12 g's with a maximum value of 22 g's. Interpreting this maximum acceleration value in terms of femur loads, a force of about 750 lbs. was obtained for a single upper leg, which is much lower than the established severe injury criterion of 1700 lbs.

6. REFERENCES

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3. S.A.E. Recommended Practice, S.A.E. J211, "Instrumentation for Barrier Collision Tests", October 1970.

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8. S.A.E. Recommended Practice, S.A.E. J885a, "Human Tolerance to Impact Conditions as Related to Motor Vehicle Design", October 1966.

9. Federal Motor Vehicle Safety Standard No. 208, Occupant Crash Protection, January 1, 1972.

10. Carter, R. L., "Passive Protection at 50 Miles Per Hour", S.A.E. Report No. 720445, Second International Conference on Passive Restraints, May 22-25, 1972.

APPENDIX A

CRASH TEST DATA FORMS

INSTRUMENTATION REQUIREMENTS

FACILITY TEST NO. 142 PROGRAM TEST NO. 78A

PROGRAM: Crashworthiness II

TEST DESCRIPTION: Low Speed Barrier Test, Frontal 90°

VEHICLE TYPE. Mod. 8 Vega

VEHICLE DESIGNATION	COM-PONENT	COMPARTMENT				ENGINE	DUMMIES (*)			RESTRAINT			RECORDER	OTHER
		TUNNEL	(1) (2) CORNERS ( ) (3)	REAR DECK	OTHER		HEAD	CHEST	PELVIS	LAP	SHOULDER	OTHER		Femur
Mod. 8 Vega	X		A	A		A	A	A	A					Left L
	Y		A	A		A	A	A	A					Right L
	Z		A	A		A	A	A	A					
	X													
	Y													
	Z													

MISCELLANEOUS
1) CONTACT SWITCH/BAR:
2) AIR BAG SENSORS:
3) POSITION OF CARS:
4) SPEED WINDOW:

*Right Front Dummy, 50th Percentile Sierra, Unrestrained.

LEGEND:

A - ACCELEROMETER
V - VELOCITY METER
D - DISPLACEMENT METER
L LOAD CELL

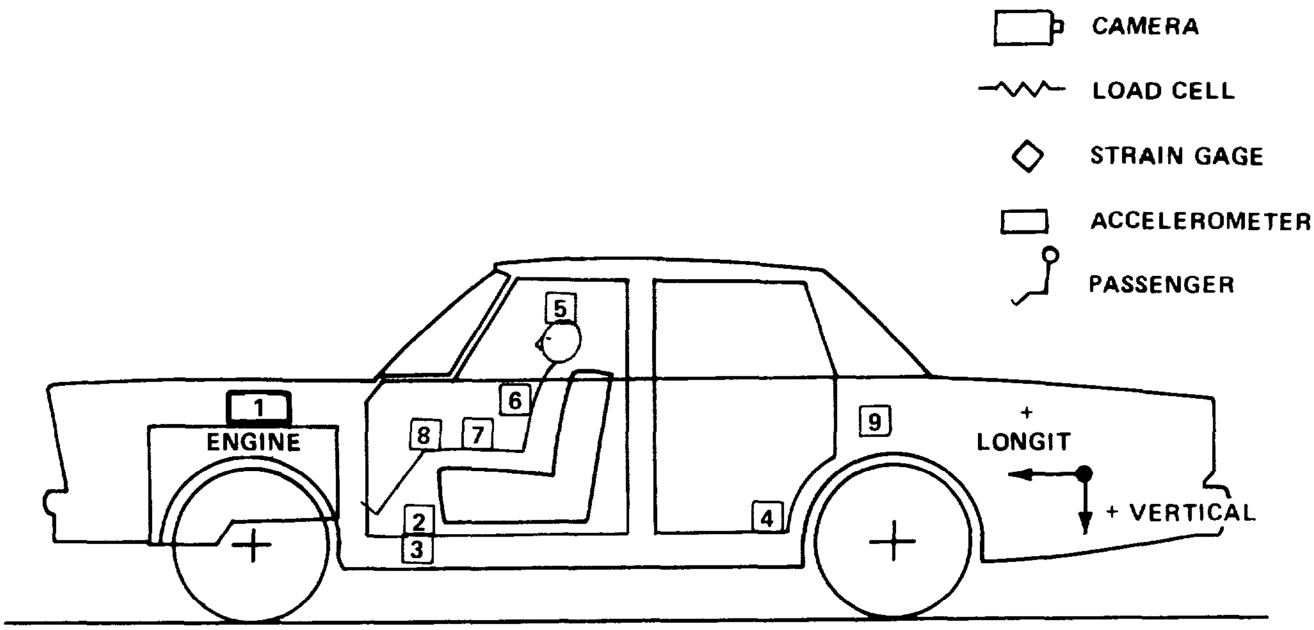
**DESCRIBE "OTHER"
**IF MORE THAN 1 DUMMY, NUMBER SEQUENTIALLY IN CLOCKWISE (FROM TOP VIEW) DIRECTION (i e DRIVER 1, PASS FRONT 2, etc)

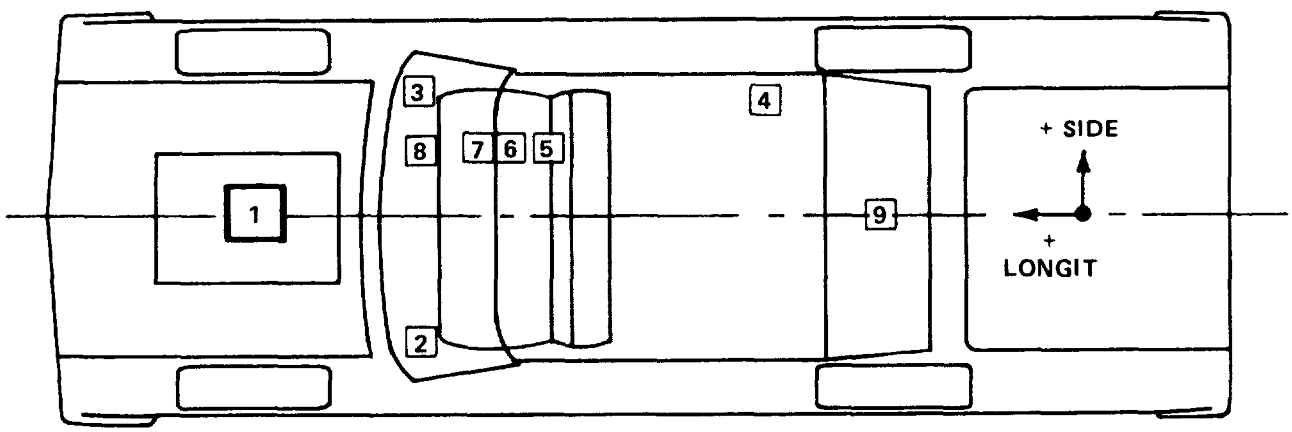
VEHICLE MOUNTED SENSORS

PROJECT Crashworthiness II

TEST NO 78A

DATE 10-19-72





REMARKS

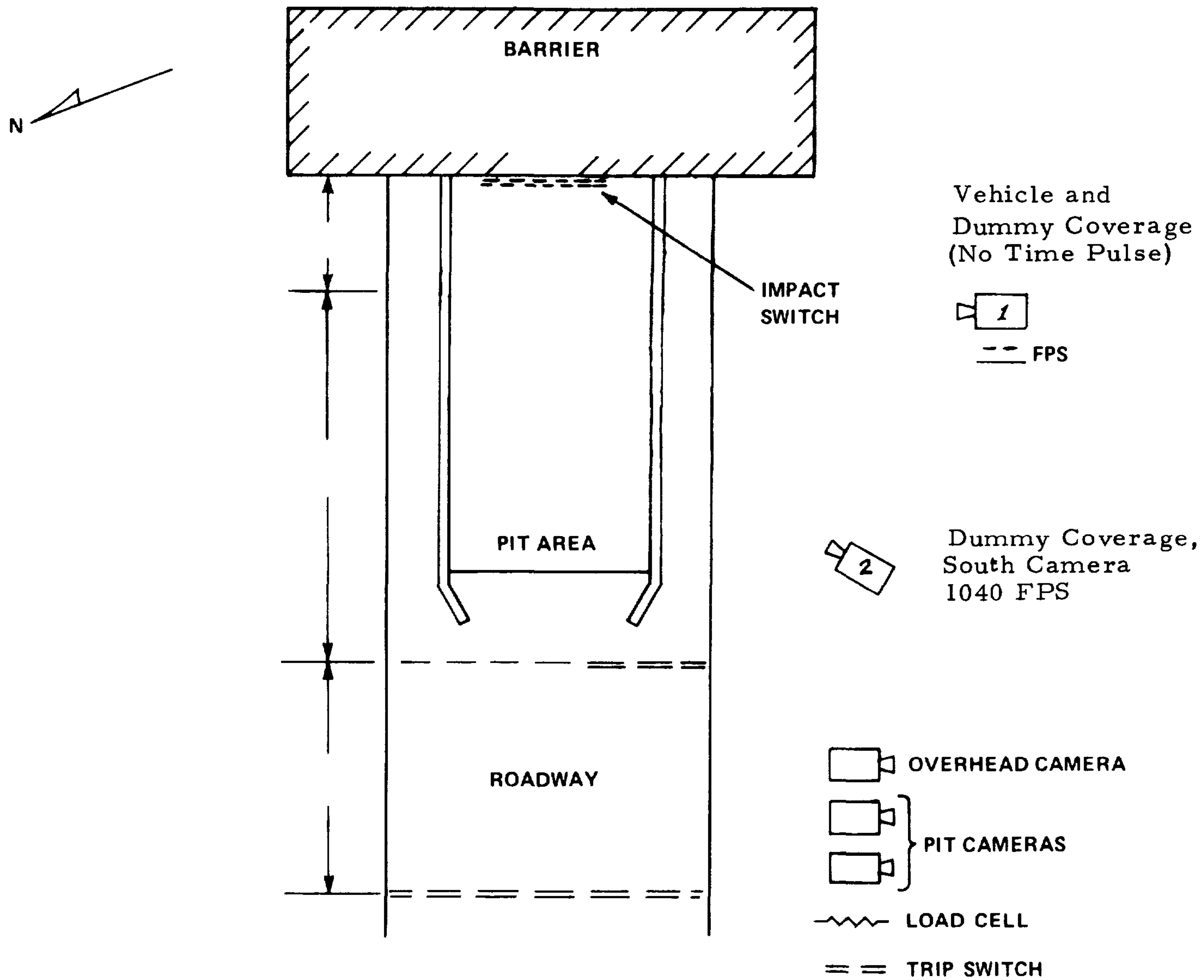
1. Triaxial accelerometer was mounted on engine at station 1.
2. Triaxial accelerometers were mounted at vehicle stations 2, 3, and 4.
3. Triaxial accelerometers were mounted in the dummies head, chest, and pelvis at stations 5, 6, and 7, respectively.
4. Strain gages were mounted on the dummies femurs (left and right) at station 8.
5. Triaxial accelerometer was mounted at vehicle station 9 on rear deck.

PROJECT: Crashworthiness II **TEST NO:** 78A

FACILITY TEST NO: 142 **DATE:** 10-18-72

TEST SITE LOCATION OF SENSORS AND CAMERAS

TEST VEHICLE Mod. 8 Vega - Low Speed



REMARKS

INSTRUMENTATION REQUIREMENTS

FACILITY TEST NO 144 PROGRAM TEST NO. 80 A

PROGRAM Crashworthiness II

TEST DESCRIPTION. Low speed: Vega into Flat barrier at 8 MPH

VEHICLE TYPE Mod. 9 Vega

VEHICLE DESIGNATION	COM-PONENT	COMPARTMENT				ENGINE	DUMMIES (5)			RESTRAINT			RECORDER	OTHER
		TUNNEL	(1) (2) CORNERS ( ) ( )	REAR DECK	OTHER		HEAD	CHEST	PELVIS	LAP	SHOULDER	OTHER		
Mod. 9 Vega	X		A	A		A	A	A	A					
	Y		A	A			A	A	A					
	Z		A	A			A	A	A					
	X													
	Y													
	Z													

MISCELLANEOUS

1) CONTACT SWITCH/BAR:
2) AIR BAG SENSORS:
3) POSITION OF CARS:
4) SPEED WINDOW 8.0 MPH
5) Dummy #1, 50% male in Vega (Driver Position)

LEGEND.

A - ACCELEROMETER
V - VELOCITY METER
D - DISPLACEMENT METER
L LOAD CELL

**DESCRIBE "OTHER"

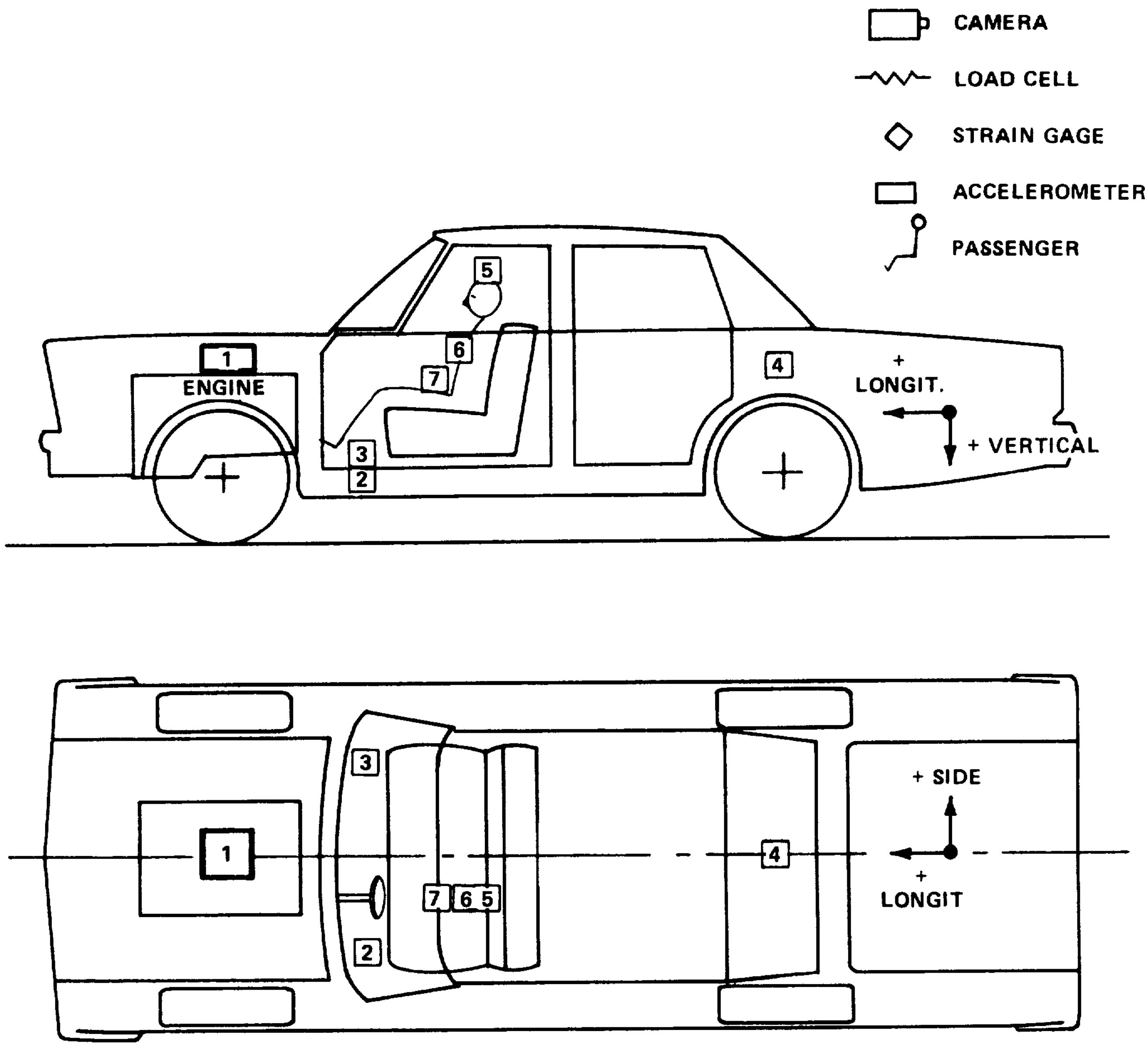
**IF MORE THAN 1 DUMMY, NUMBER SEQUENTIALLY IN CLOCKWISE (FROM TOP VIEW) DIRECTION (i.e. DRIVER 1, PASS FRONT 2, etc)

VEHICLE MOUNTED SENSORS

PROJECT Crashworthiness II

TEST NO. 80 A

DATE 11-20-72



REMARKS.

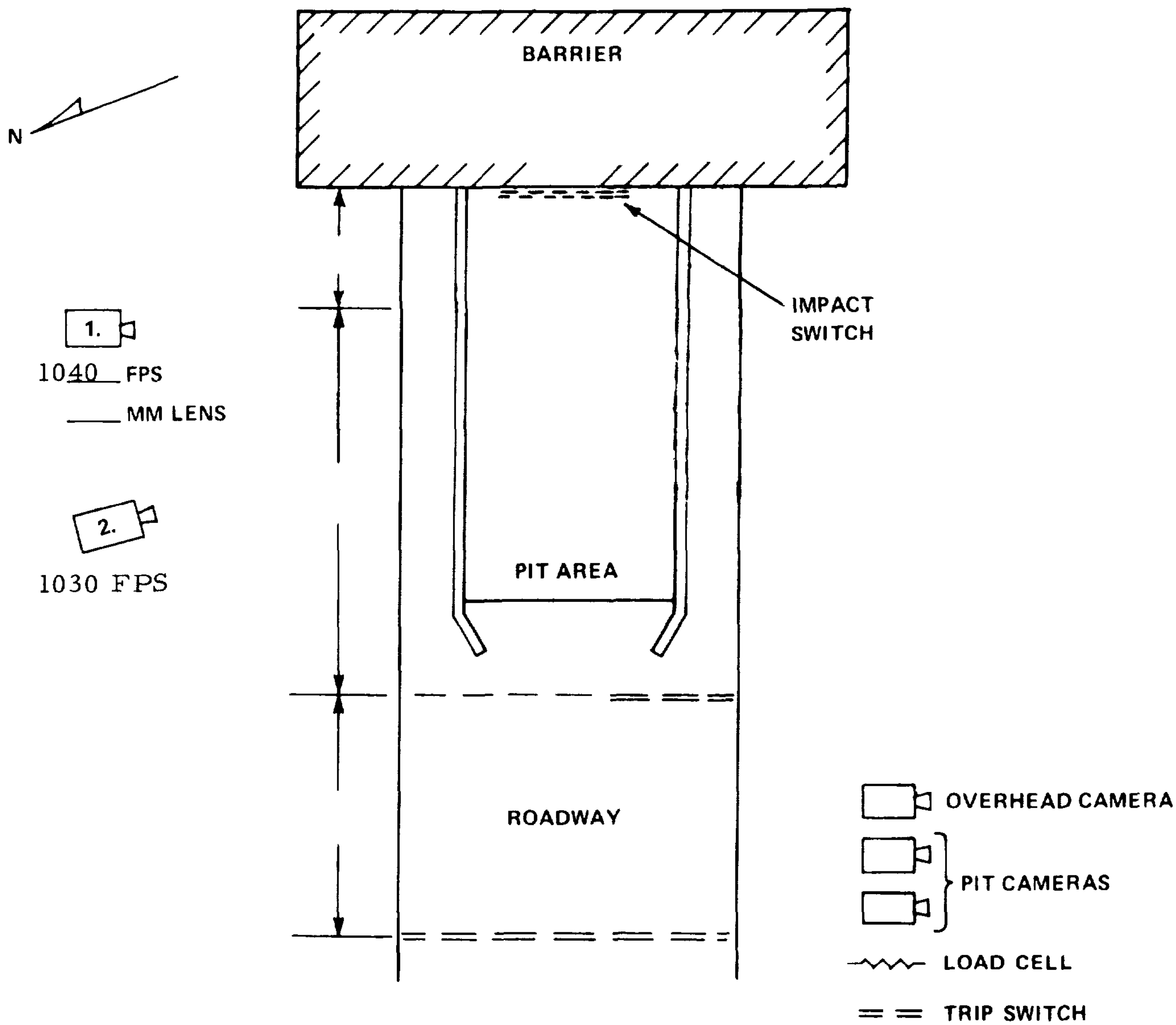
1. A single axis accelerometer was mounted on the engine in the longitudinal direction at station 1.
2. Triaxial accelerometers were mounted at vehicle stations 2 and 3.
3. Triaxial accelerometer was mounted at vehicle station 4 on the rear deck.
4. Triaxial accelerometers were mounted in the dummies head, chest, and pelvis at stations 5, 6, and 7, respectively.

PROJECT: Crashworthiness II **TEST NO.** 80 A

FACILITY TEST NO: 144 **DATE** 11-20-72

TEST SITE LOCATION OF SENSORS AND CAMERAS

TEST VEHICLE Mod. 9 Vega - Low Speed



REMARKS

#1 Camera - covers front 2/3's of vehicle plus barrier.

#2 Camera - tight in on dummy to cover its forward movement. (Dummy will be unrestrained.)

Note: Require compartment inside lights and zero-time light on barrier.

INSTRUMENTATION REQUIREMENTS

FACILITY TEST NO. 139 PROGRAM TEST NO 75A and 75D

PROGRAM: Crashworthiness II

TEST DESCRIPTION: Low Speed Barrier (Flat/Pole) Test

VEHICLE TYPE: Mod. 1D5A

VEHICLE DESIGNATION	COM-PONENT	COMPARTMENT				ENGINE	DUMMIES (*)			RESTRAINT			RECORDER	OTHER
		TUNNEL	(1) (2) CORNERS (4) (3)	REAR DECK	OTHER		HEAD	CHEST	PELVIS	LAP	SHOULDER	OTHER		
Mod. 1D5A	X	A	1A, 2A, 3A, 4A				A	A	A					1) Displacement Pots. on front bumper @ shock location. 2) 3 Load Cells on Pole & Flat Barrier
	Y	A	1A, 2A, 3A, 4A				A	A	A					
	Z	A	1A, 2A, 3A, 4A				A	A	A					
	X													
	Y													
	Z													

MISCELLANEOUS

1) CONTACT SWITCH/BAR: ON BARRIER
2) AIR BAG SENSORS: NONE
3) POSITION OF CARS:
4) SPEED WINDOW: 8 ±0.5; for both pole & flat barrier.

*Dummy Right Front Seat (50%)

LEGEND:

A - ACCELEROMETER
V - VELOCITY METER
D - DISPLACEMENT METER
L - LOAD CELL

**DESCRIBE "OTHER"

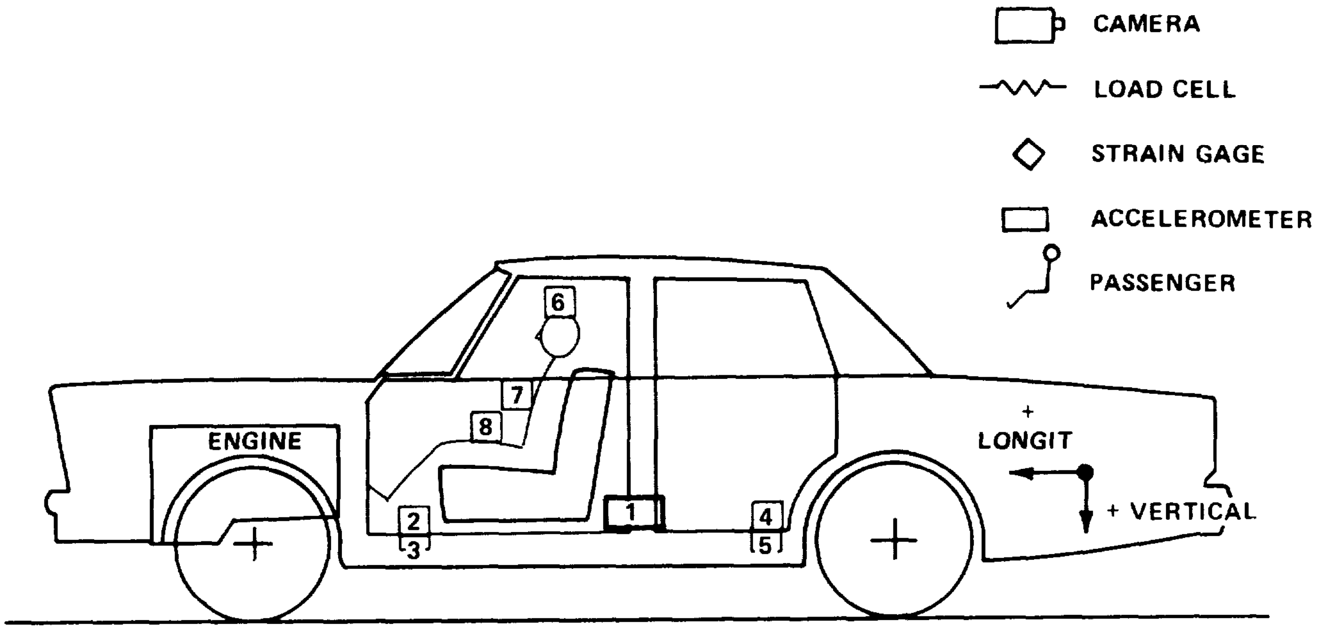
**IF MORE THAN 1 DUMMY, NUMBER SEQUENTIALLY IN CLOCKWISE (FROM TOP VIEW) DIRECTION (i.e DRIVER 1, PASS FRONT 2, etc)

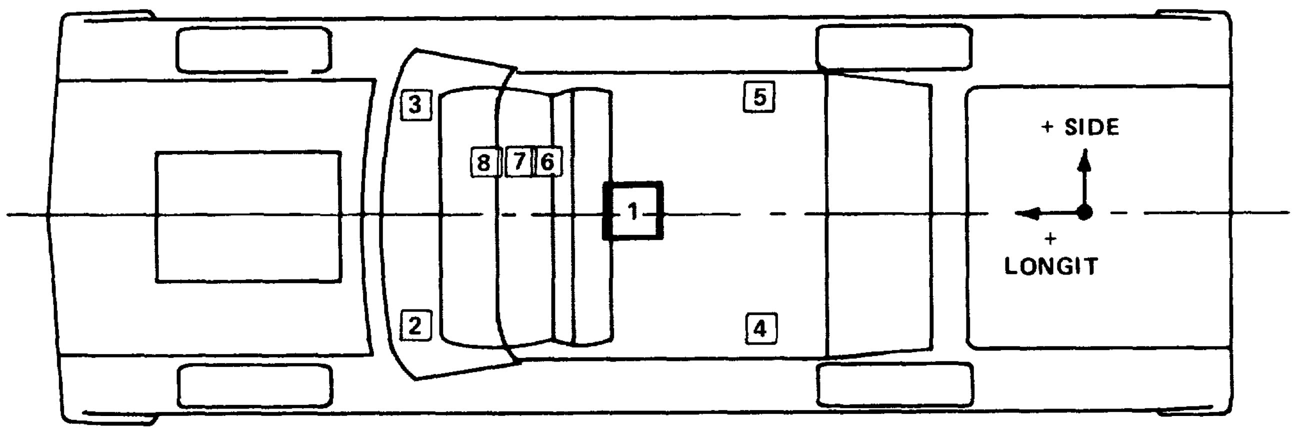
VEHICLE MOUNTED SENSORS

PROJECT Crashworthiness II

TEST NO 75A and 75D (Flat Barrier and Pole)

DATE 9-18-72, 9-22-72





REMARKS

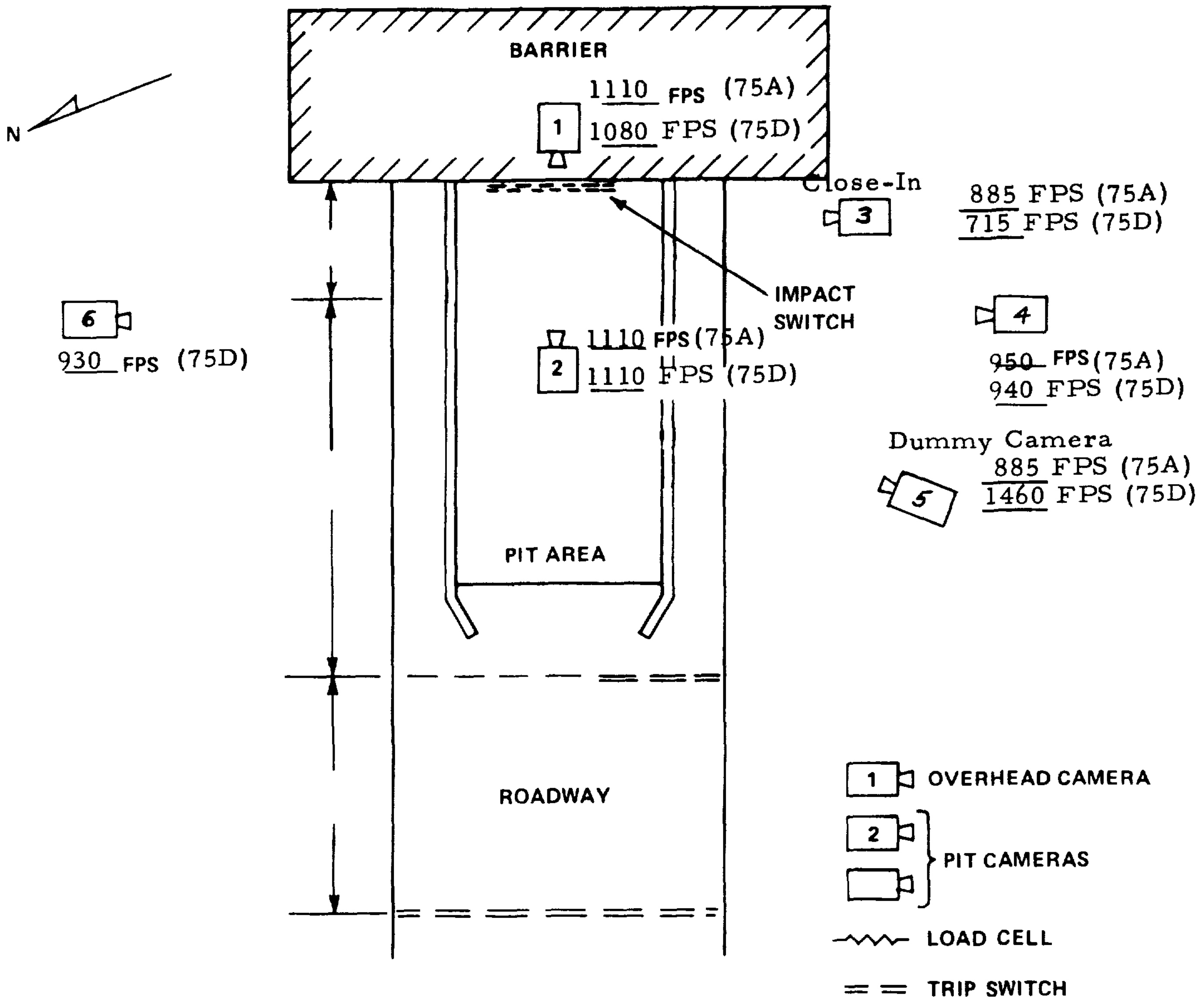
1. Triaxial accelerometer was mounted on the tunnel at station 1.
2. Triaxial accelerometers were mounted at the compartment corners, Stations 2, 3, 4 and 5.
3. Triaxial accelerometers were mounted in the dummies head, chest, and pelvis at stations 6, 7, and 8, respectively.

PROJECT: Crashworthiness II **TEST NO:** 75A and 75D

FACILITY TEST NO: 139 **DATE:** 9-18, 9-22-72

TEST SITE LOCATION OF SENSORS AND CAMERAS

TEST VEHICLE Mod. 1D5A Ford



REMARKS

1. Number in parentheses following camera speeds indicate test numbers:
   Test No. 75A - was Flat Barrier Impact.
   Test No. 75D - was Pole Impact.

INSTRUMENTATION REQUIREMENTS

FACILITY TEST NO 92 PROGRAM TEST NO 38

PROGRAM Crashworthiness II

TEST DESCRIPTION 5 MPH (low speed) into Pole

VEHICLE TYPE Mod. 1F Buick

VEHICLE DESIGNATION	COM PONENT	COMPARTMENT				ENGINE	DUMMIES (5)			RESTRAINT			RECORDER	OTHER
		TUNNEL	(1) (2) CORNERS (4) (3)	REAR DECK	OTHER		HEAD	CHEST	PELVIS	LAP	SHOULDER	OTHER		
Mod. 1F	X	A	1 - 3A	A		A	A	A	A					(6) Displacement and femur loads.
	Y	A	1 - 3A	A			A	A	A					
	Z	A	1 - 3A	A		A	A	A	A					
	X													
	Y													
	Z													

MISCELLANEOUS

1) CONTACT SWITCH/BAR
2) AIR BAG SENSORS:
3) POSITION OF CARS
4) SPEED WINDOW 7.0 MPH
5) Dummies 2 & 3 for low speed test, 50th Male in Ft. Rt. Seat and 5th Female in Rear Rt. Seat.
6) Three displacement measurements will be made on front bumper during low speed test and also dummy femur loads.

LEGEND:

A - ACCELEROMETER
V - VELOCITY METER
D - DISPLACEMENT METER
L LOAD CELL

**DESCRIBE "OTHER"

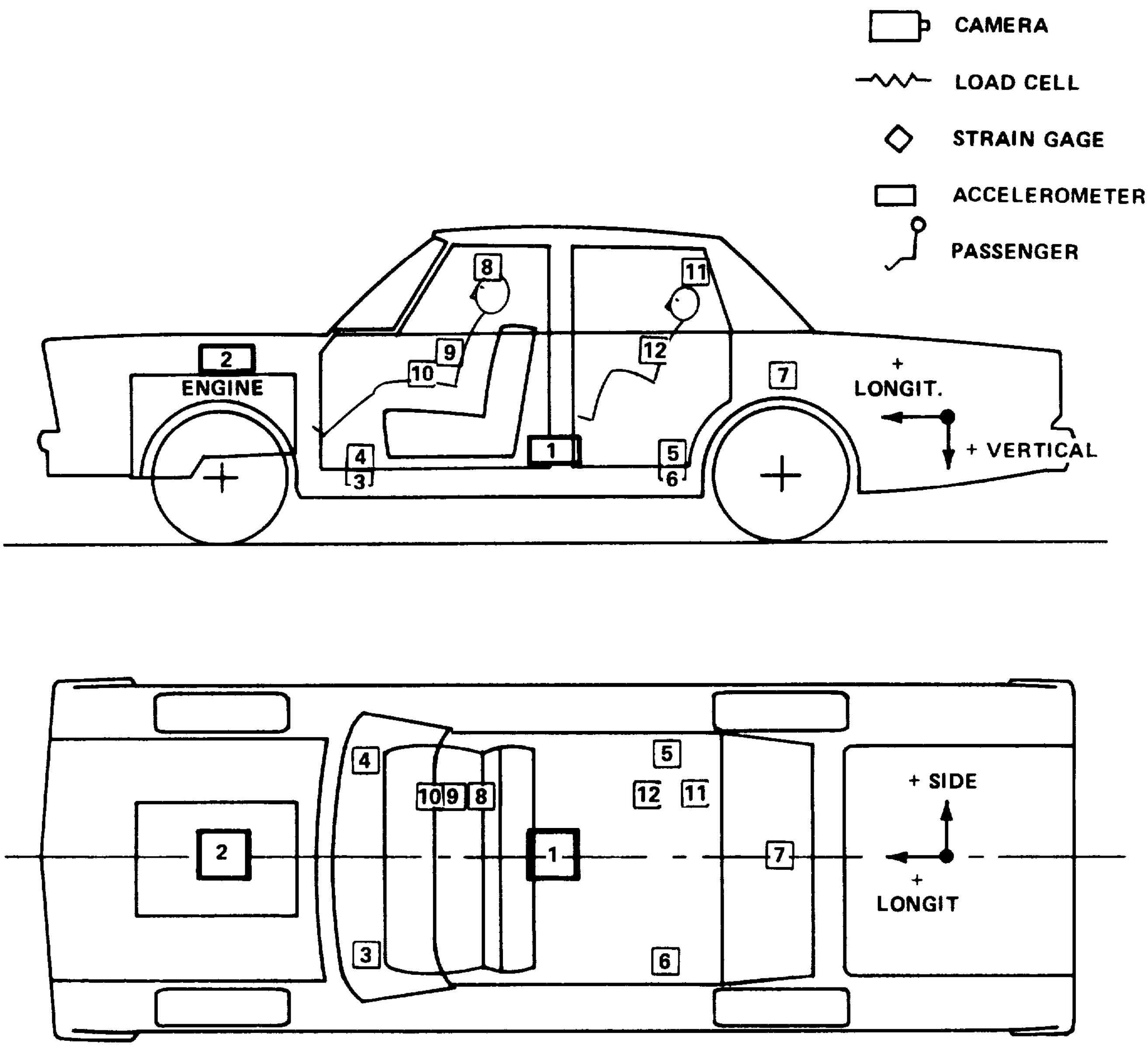
**IF MORE THAN 1 DUMMY, NUMBER SEQUENTIALLY IN CLOCKWISE (FROM TOP VIEW) DIRECTION (i e DRIVER 1, PASS FRONT 2, etc)

VEHICLE MOUNTED SENSORS

PROJECT Crashworthiness II

TEST NO. 38

DATE 10-14-71



REMARKS

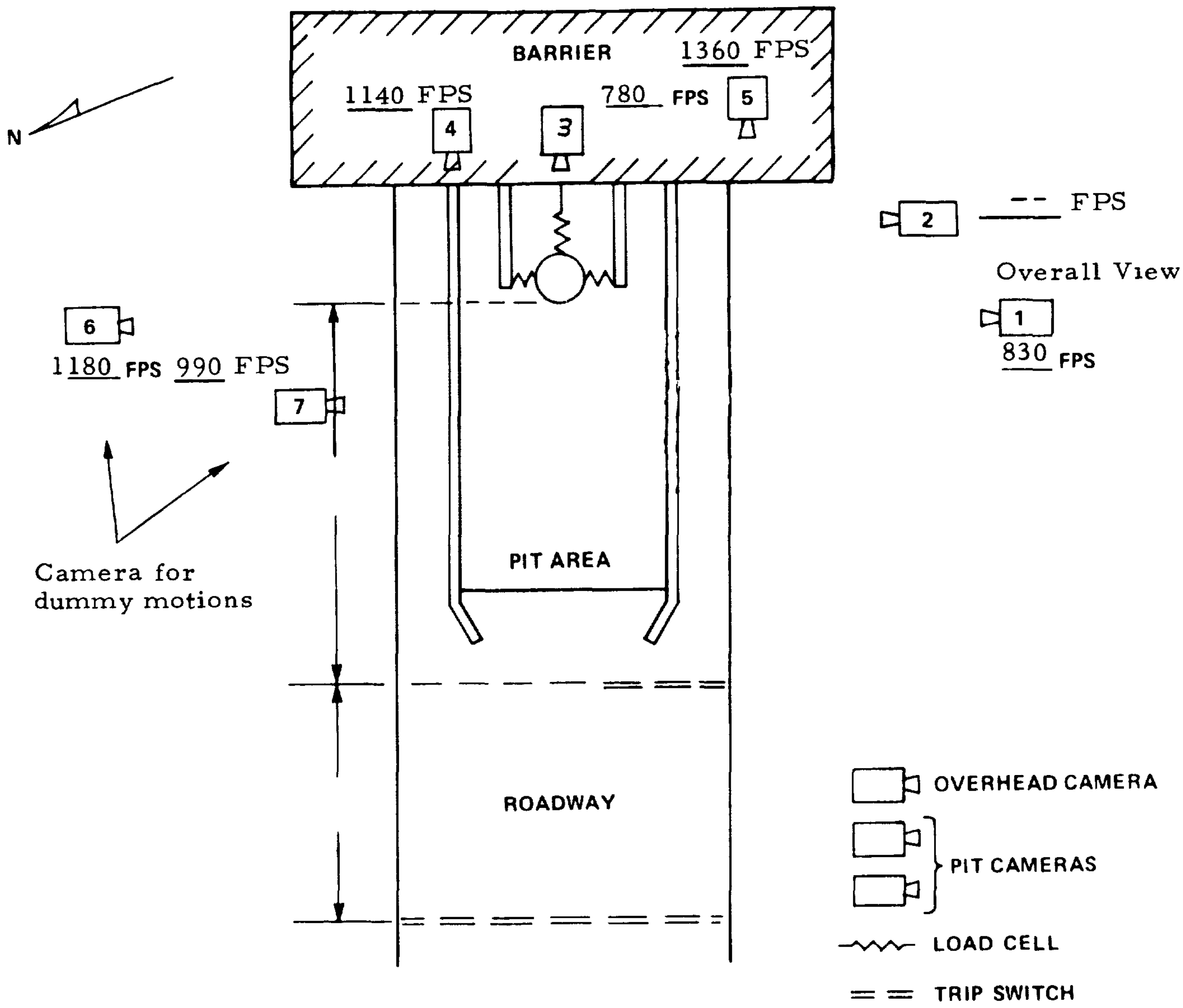
1. Triaxial accelerometer was mounted on the tunnel at station 1.
2. The accelerometer package on the engine, station 2, contained a longitudinal and vertical sensor.
3. Triaxial accelerometers were mounted at the compartment corners, stations 3, 4, 5, and 6.
4. Triaxial accelerometer was mounted on the rear deck at station 7.
5. Triaxial accelerometers were mounted in the front dummies head, chest, and pelvis at stations 8, 9, and 10, respectively.
6. Triaxial accelerometers were mounted in the rear dummies head and chest at stations 11 and 12, respectively.

PROJECT Crashworthiness II TEST NO 38

FACILITY TEST NO 92 DATE 10-14-71

TEST SITE LOCATION OF SENSORS AND CAMERAS

TEST VEHICLE Low Speed Mod. 1F Tests



REMARKS

There were no timing pulse marks on film of Camera No. 2.

APPENDIX B

ADDITIONAL TEST DATA

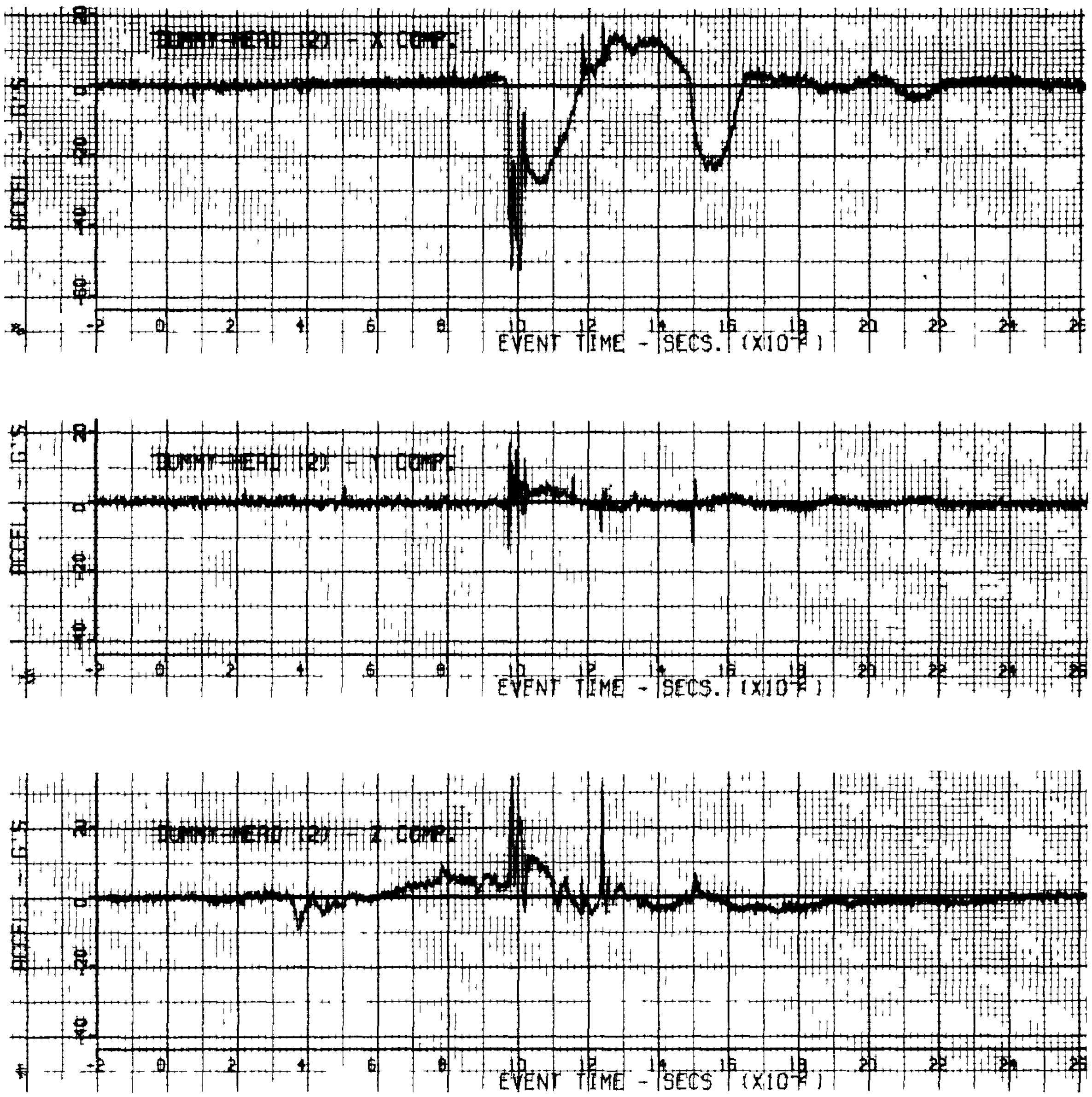


Figure B-1 RIGHT FRONT DUMMY HEAD COMPONENT ACCELERATIONS, MOD. 8 TEST

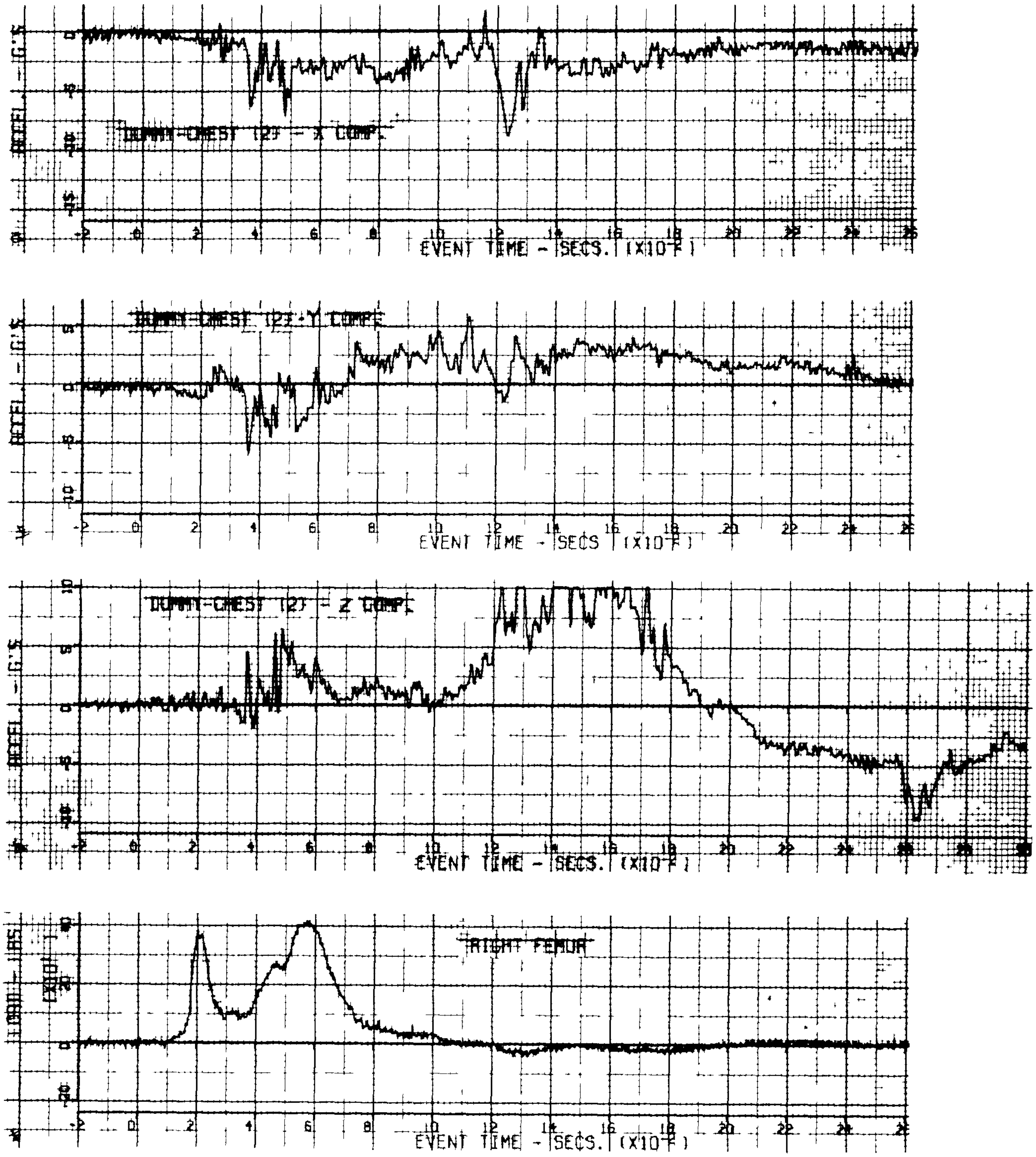


Figure B-2 RIGHT FRONT DUMMY CHEST AND FEMUR COMPONENT DATA, MOD. 8 TEST

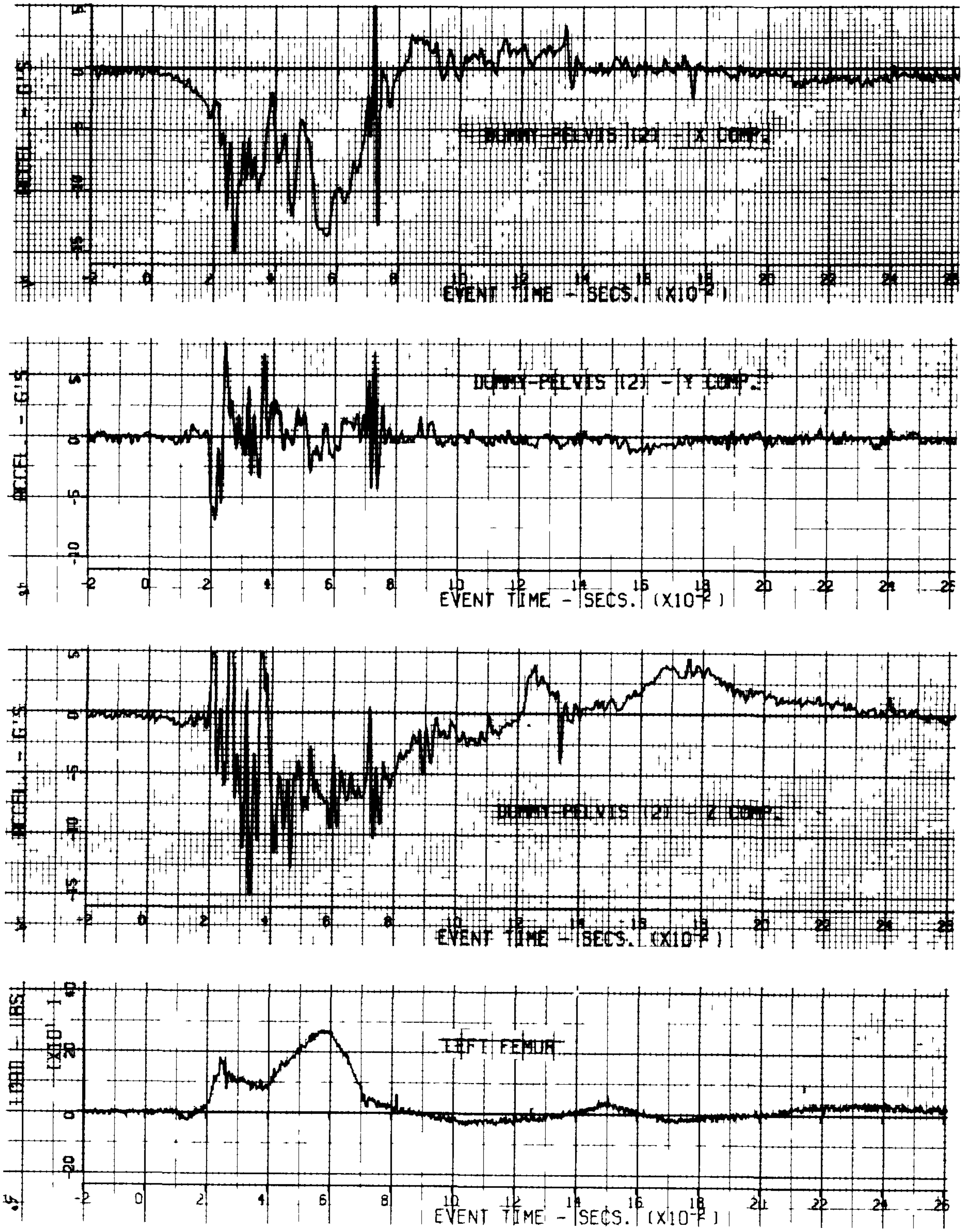


Figure B-3 RIGHT FRONT DUMMY PELVIS AND FEMUR COMPONENT DATA, MOD. 8 TEST

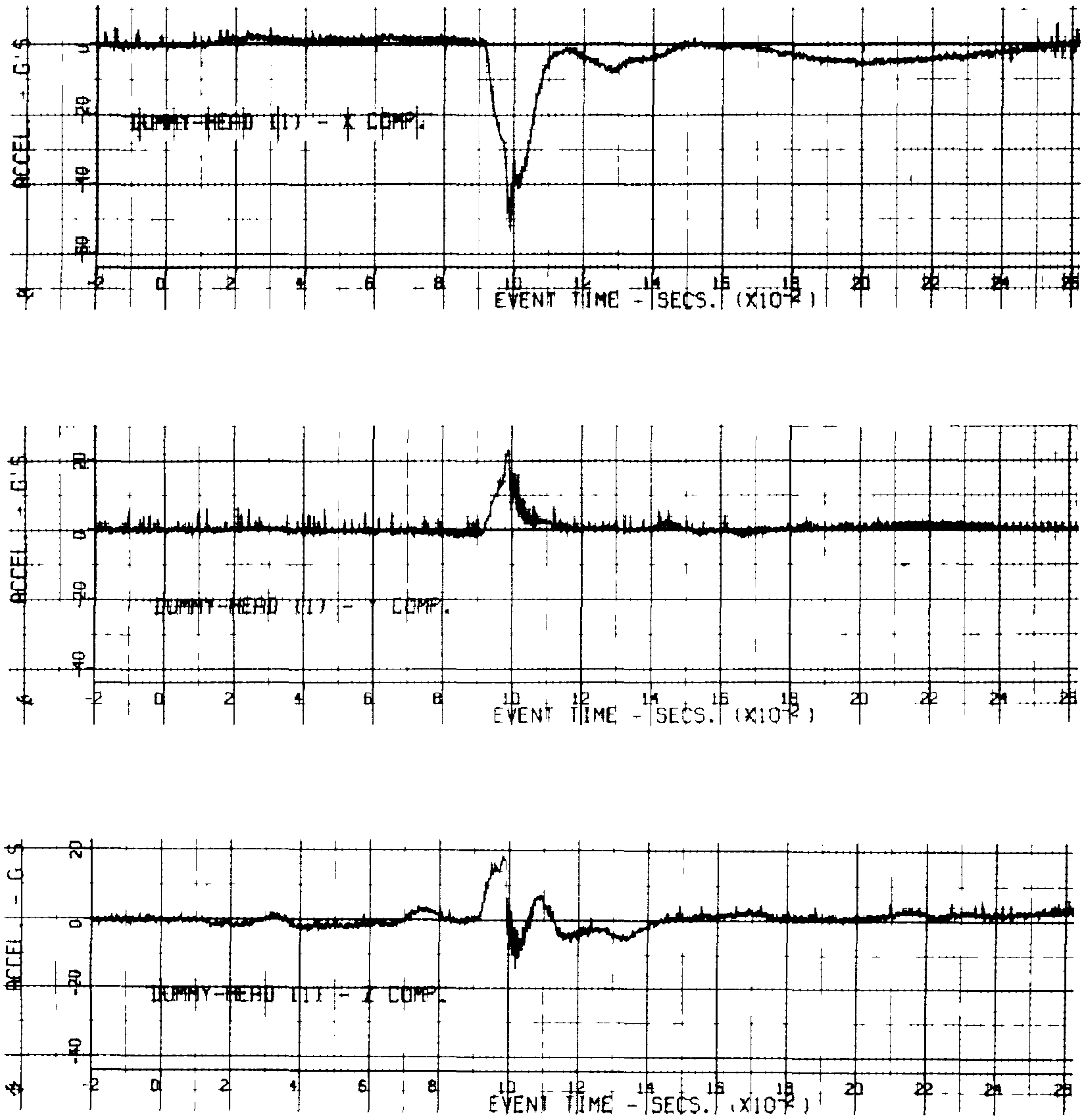


Figure B-4 LEFT FRONT DUMMY HEAD COMPONENT ACCELERATIONS, MOD. 9 TEST

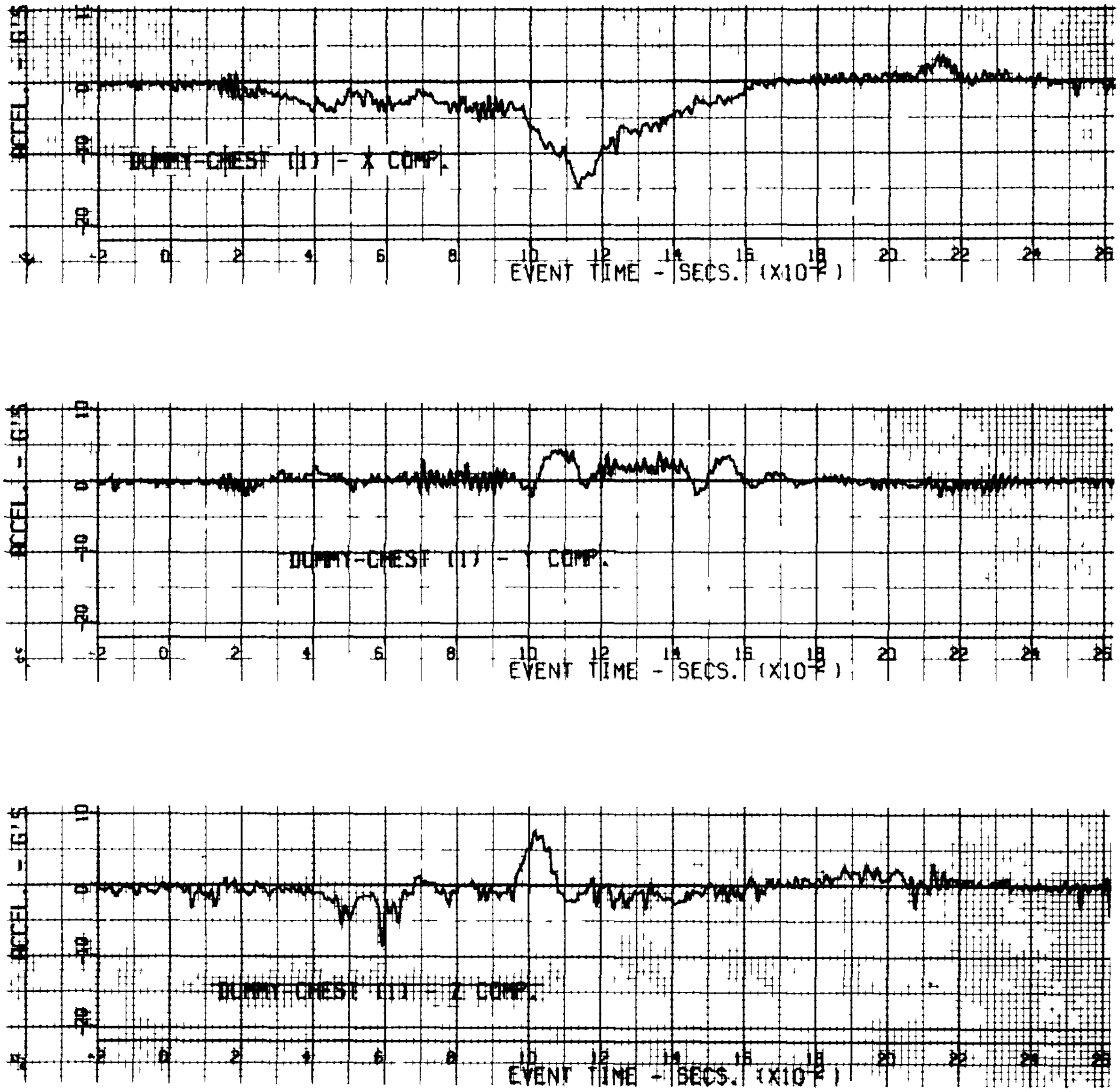


Figure B-5 LEFT FRONT DUMMY CHEST COMPONENT ACCELERATIONS, MOD. 9 TEST

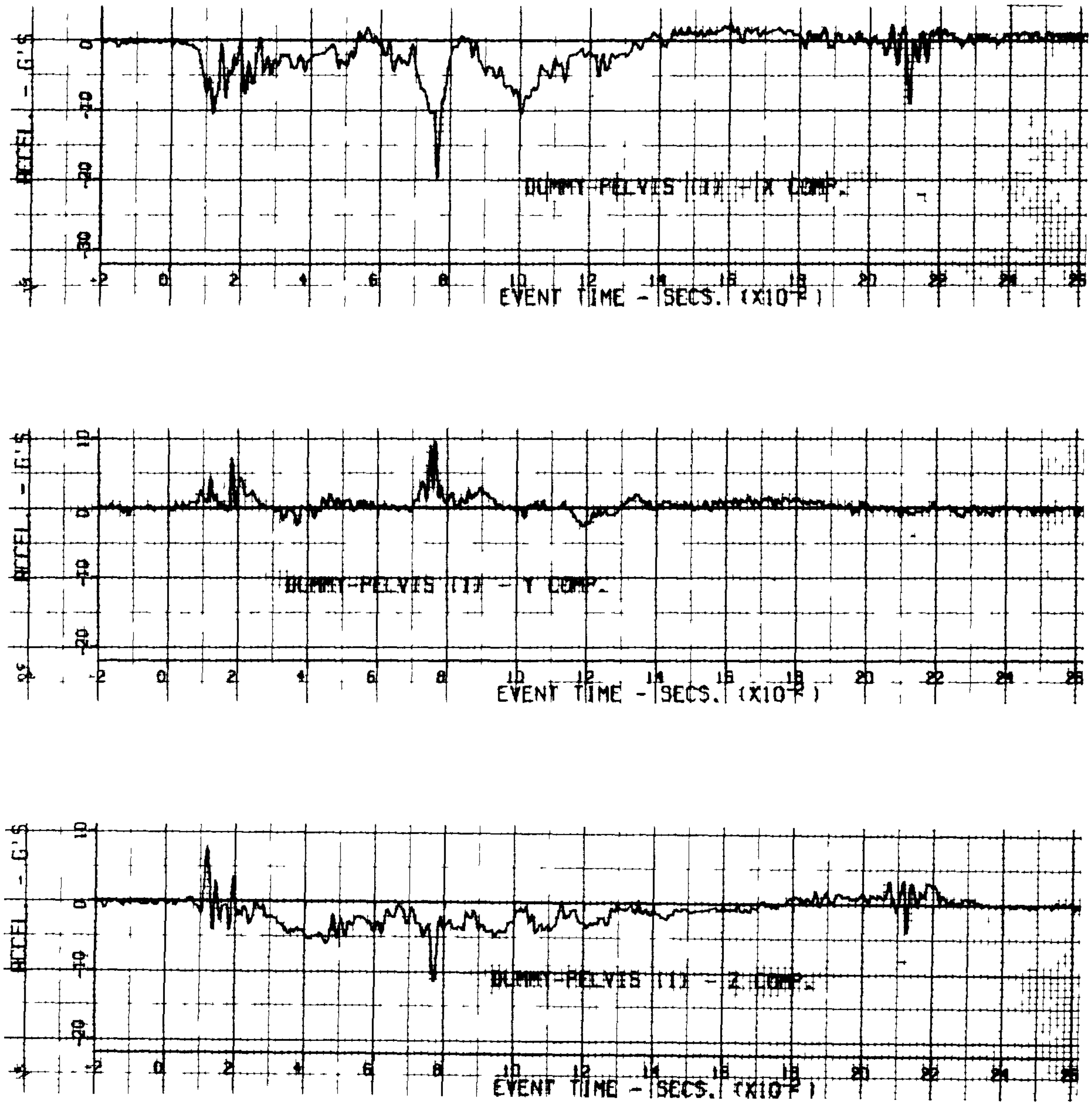


Figure B-6 LEFT FRONT DUMMY PELVIC COMPONENT ACCELERATIONS, MOD. 9 TEST

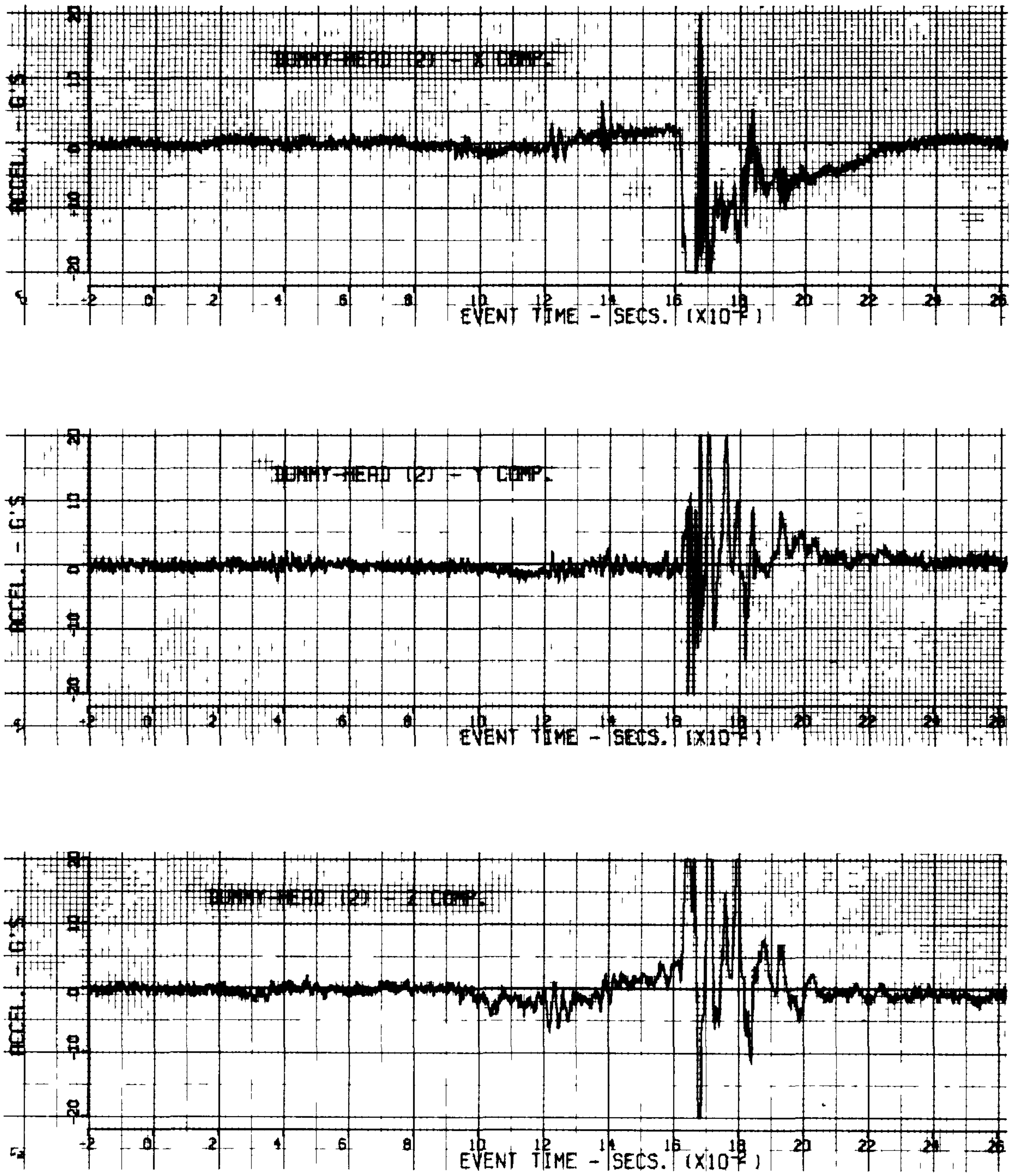


Figure B-7 RIGHT FRONT DUMMY HEAD COMPONENT ACCELERATIONS, MOD. 1D5A BARRIER TEST

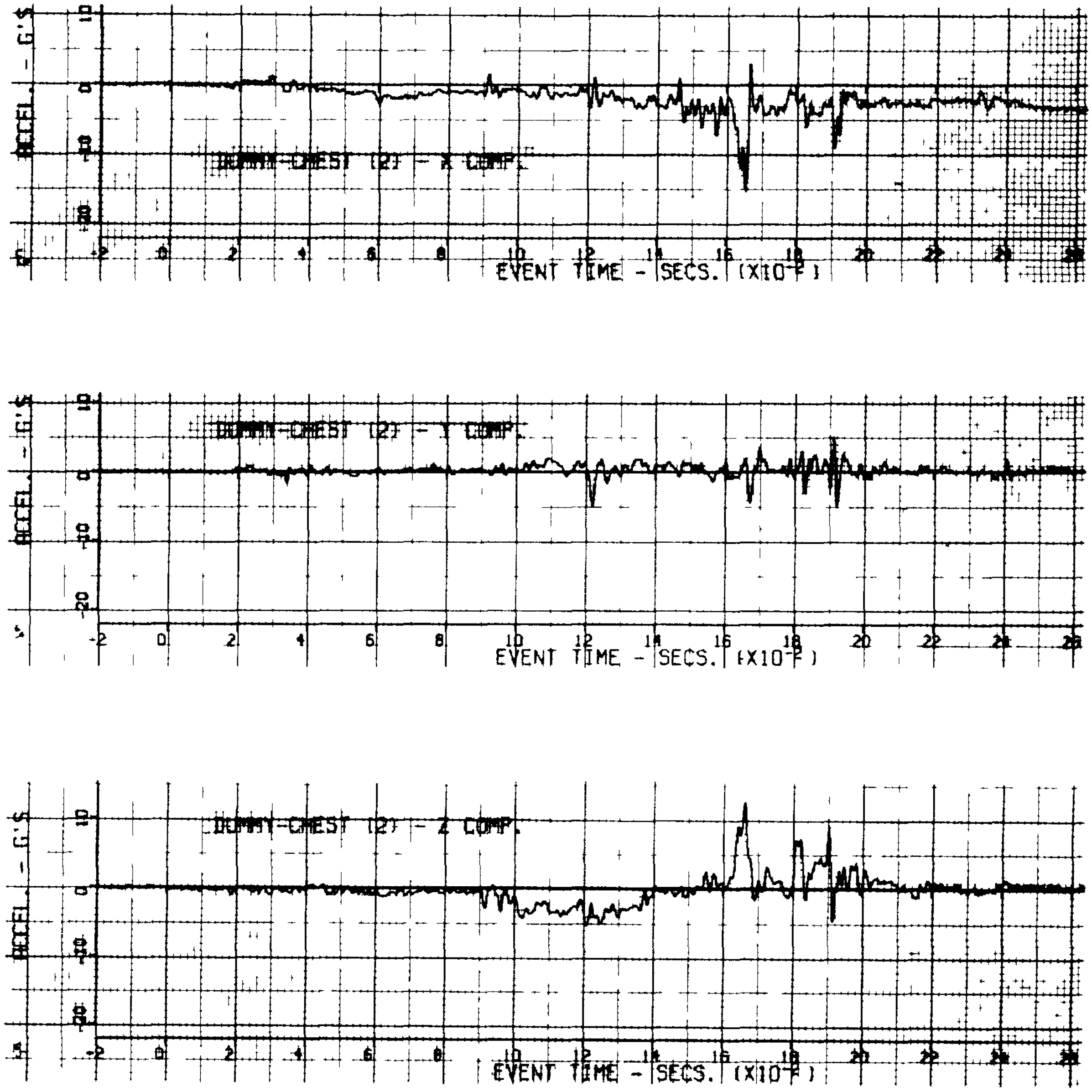


Figure B-8 RIGHT FRONT DUMMY CHEST COMPONENT ACCELERATIONS, MOD. 1D5A BARRIER TEST

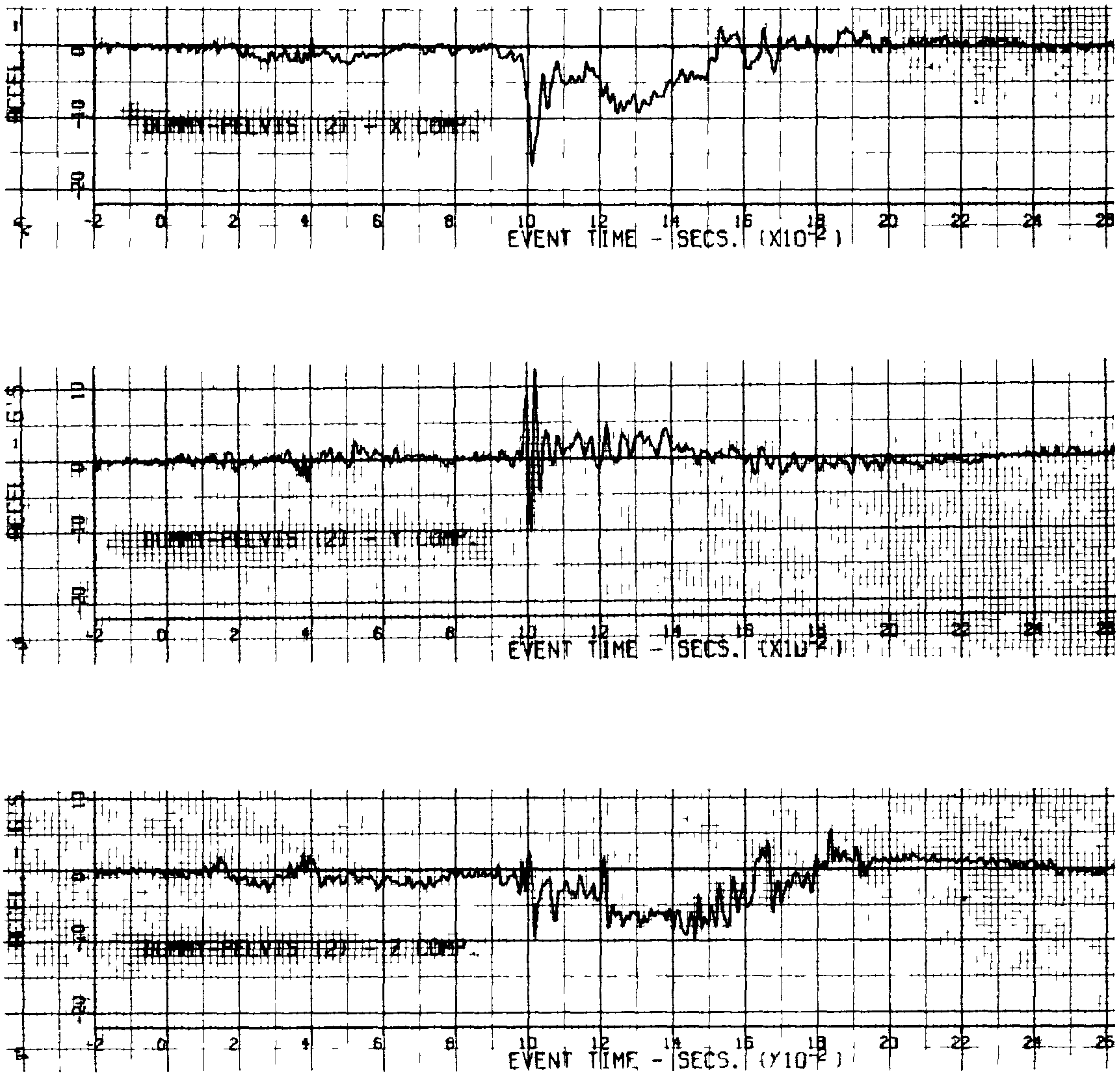


Figure B-9 RIGHT FRONT DUMMY PELVIC COMPONENT ACCELERATIONS, MOD. 1D5A BARRIER TEST

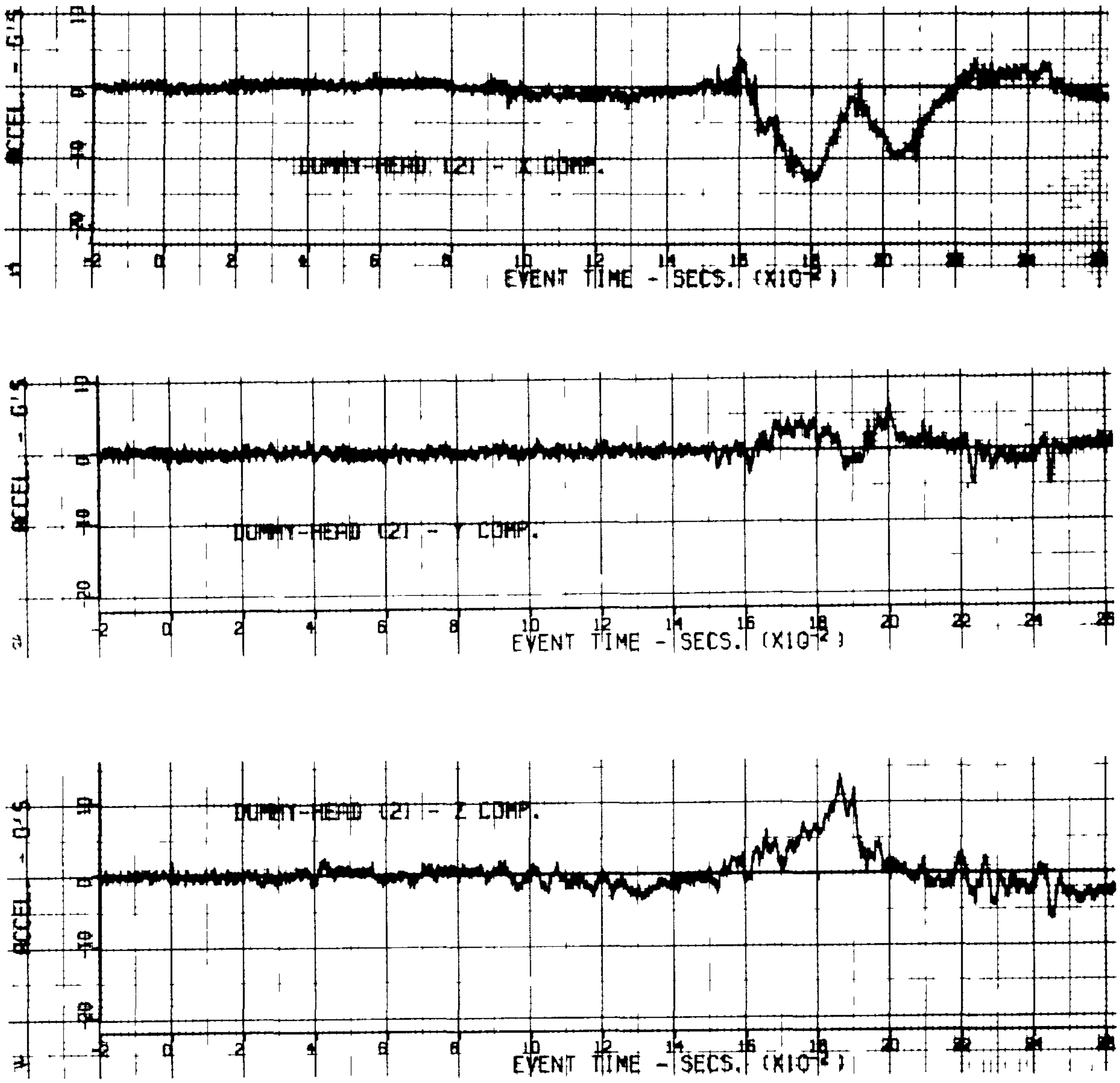


Figure B-10 RIGHT FRONT DUMMY HEAD COMPONENT ACCELERATIONS, MOD. 1D5A POLE TEST

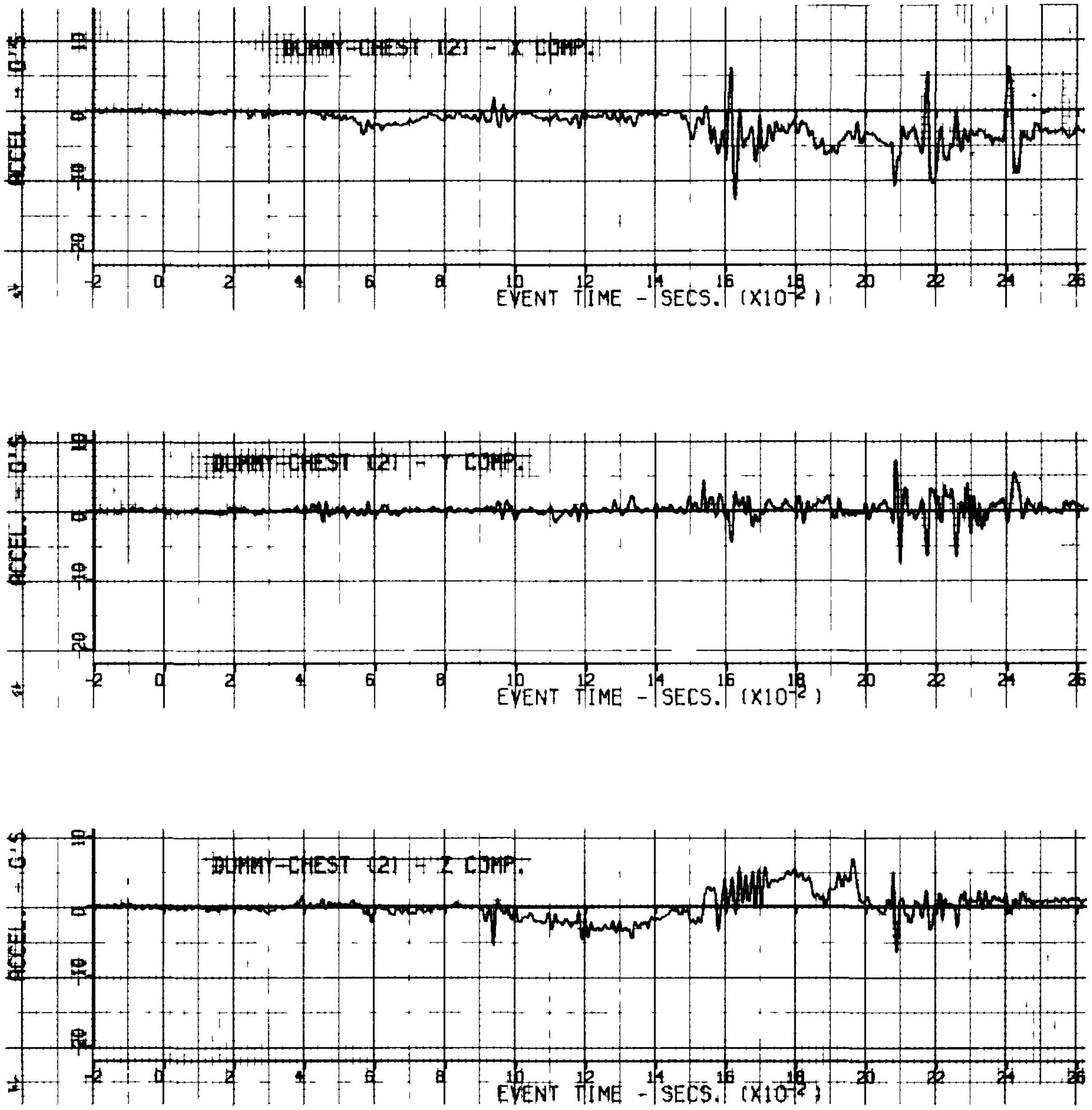


Figure B-11 **RIGHT FRONT DUMMY CHEST COMPONENT ACCELERATIONS, MOD. 1D5A POLE TEST**

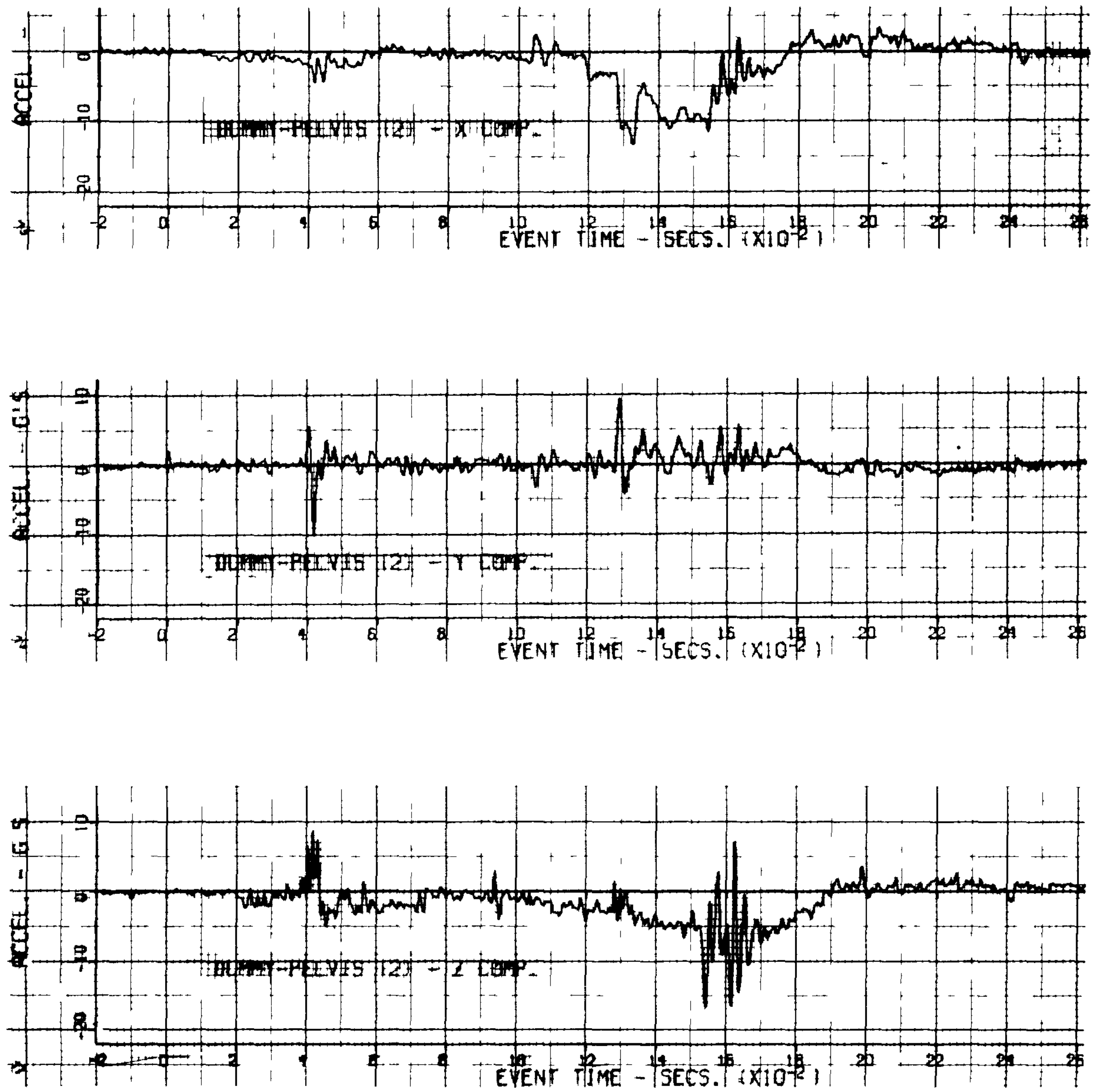


Figure B-12 RIGHT FRONT DUMMY PELVIC COMPONENT ACCELERATIONS, MOD. 1D5A POLE TEST

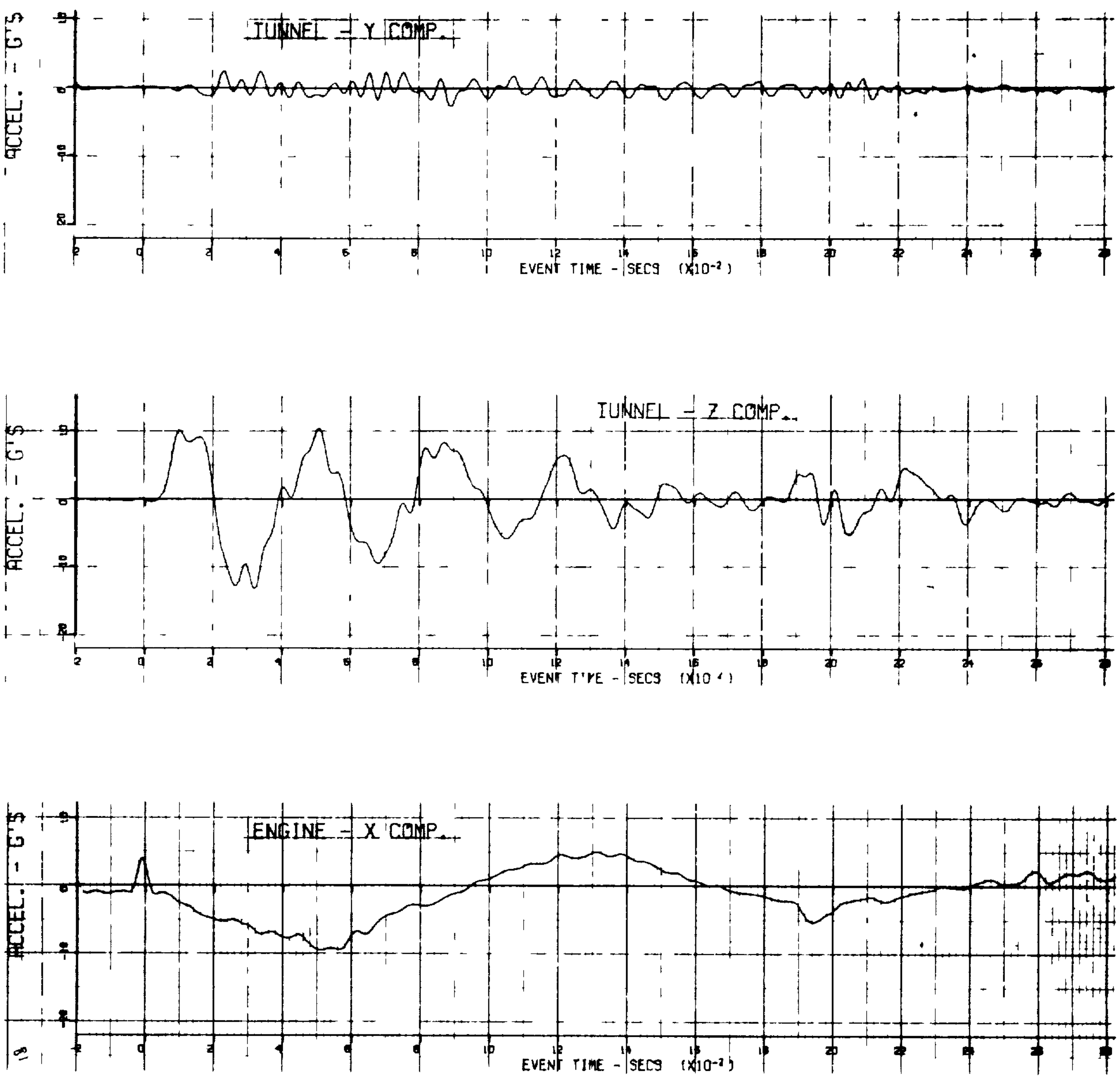


Figure B-13 MOD. 1F VEHICLE COMPONENT ACCELERATIONS, TEST NO. 38

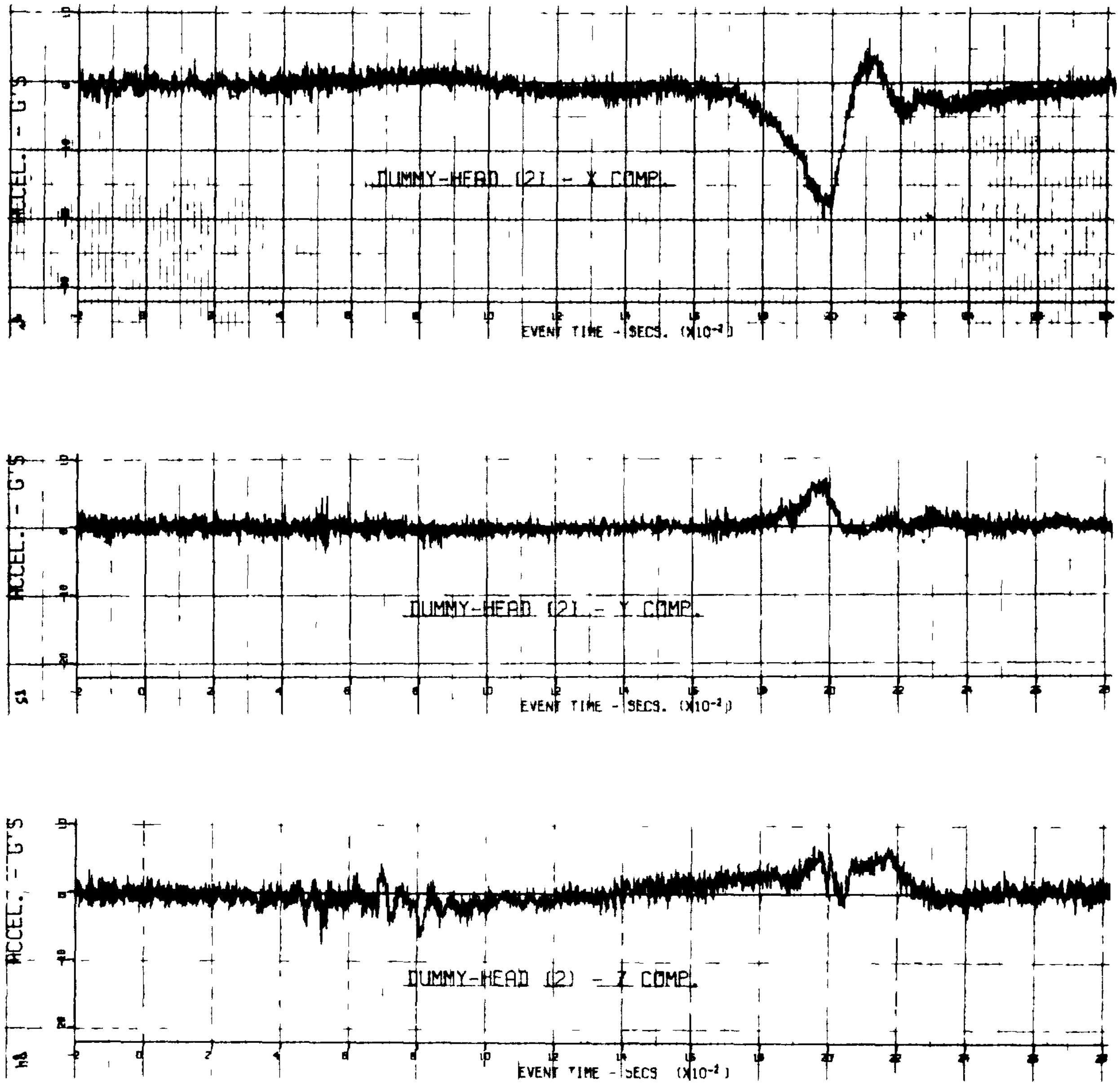


Figure B-14 RIGHT FRONT DUMMY HEAD COMPONENT ACCELERATIONS, MOD. 1F TEST NO. 38

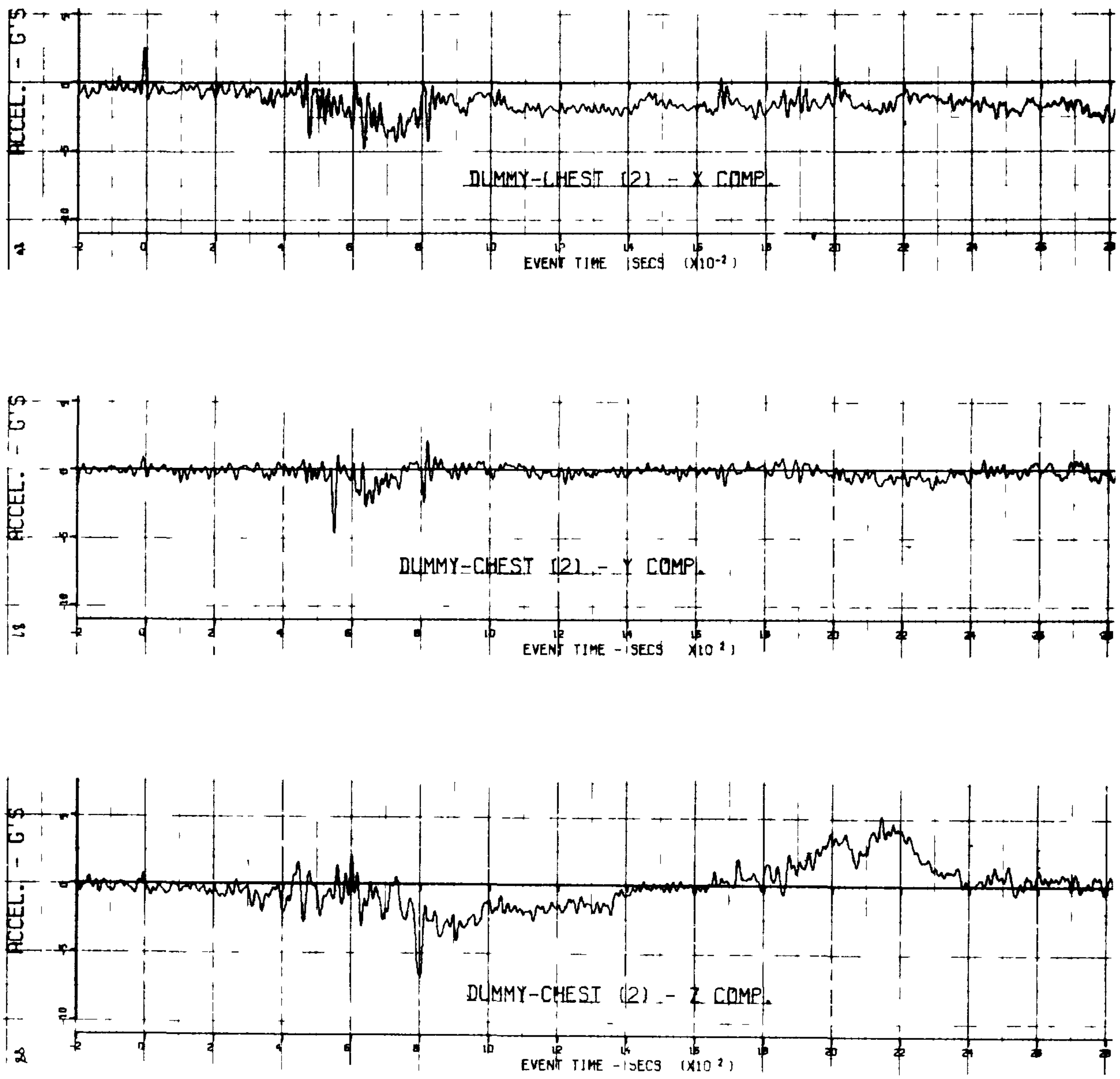


Figure B-15 RIGHT FRONT DUMMY CHEST COMPONENT ACCELERATIONS, MOD. 1F TEST NO. 38

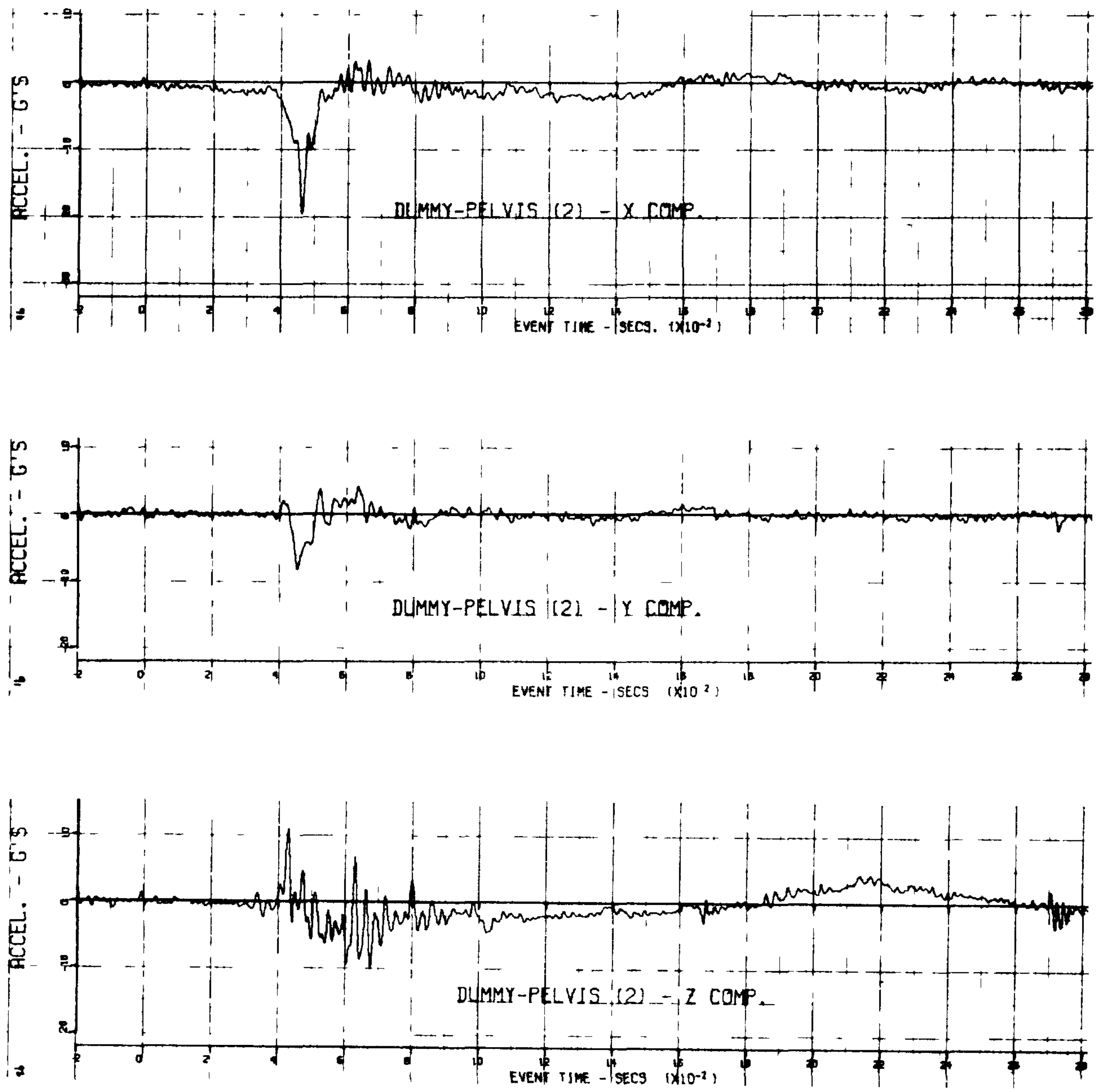
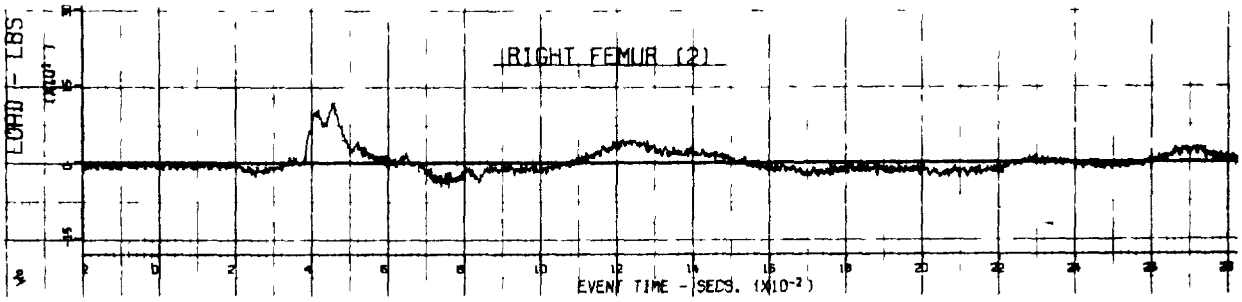


Figure B-16 RIGHT FRONT DUMMY PELVIC COMPONENT ACCELERATIONS, MOD. 1F TEST NO. 38



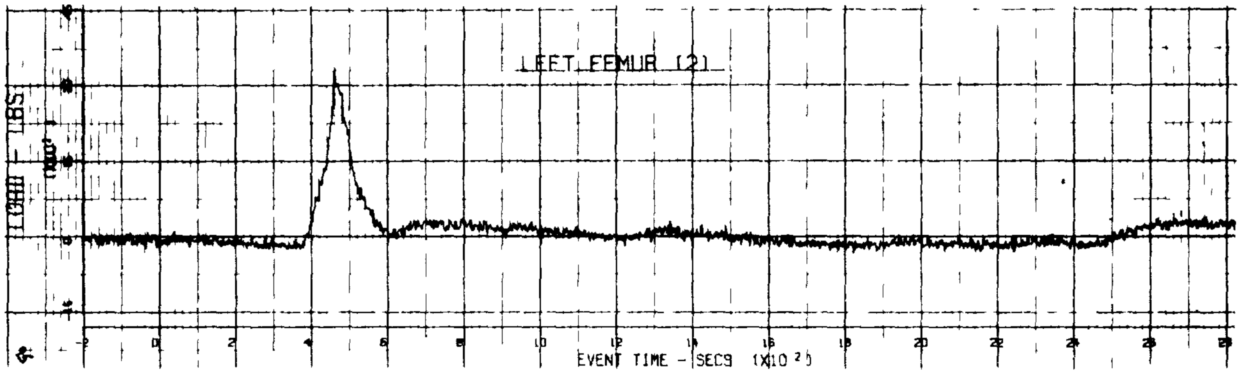


Figure B-17 RIGHT FRONT DUMMY FEMUR LOADS, MOD. 1F TEST NO. 38