Final Report
UM-HSRI-81-29

Project No. 1151

BASELINE DATA FOR DESCRIBING OCCUPANT SIDE IMPACTS AND PEDESTRIAN FRONT IMPACTS IN TWO DIMENSIONS

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EXECUTIVE SUMMARY

Two areas of current interest and activity in automotive safety are the protection of occupants in side impacts and the protection of pedestrians. During the past ten years a variety of projects have been conducted to study the interaction of pedestrians with motor vehicles. Somewhat more recently the emphasis has been on studying the interaction of a vehicle occupant with side door structures. Experimental studies have utilized both dummy and cadaver test subjects and a variety of vehicle types, both experimental and production. Analytical studies have been conducted using both two- and three-dimensional crash simulation models.

An FY 80 project at HSRI supported by MVMA had the objective of reviewing past simulation efforts on these two topics and developing practical baseline data sets for use with three-dimensional crash simulation software. This report details the extension of these three-dimensional data sets to two dimensions. The resulting baseline two-dimensional data sets have been developed for use with the existing Version 4 of the MVMA two-dimensional dynamic occupant/pedestrian simulation (DOPS).

The data sets have been described in the language of anticipated automotive users. The procedures and assumptions used in developing the data have also been explained. Sample outputs and graphical results from computer exercises using the data sets are included. It was found that the two-dimensional approach yields kinematic results which are quite similar to those obtained using a three-dimensional simulation. In order to make the predictions more realistic than those obtained during the three-dimensional modeling project, friction between the pedestrian and the vehicle as well as energy absorption by the various contact panels were added. The improvements were dramatic.

There are two versions of the MVMA two-dimensional dynamic occupant/pedestrian simulation (DOPS) which are in use at present - Version 3 and Version 4. Version 3 is most commonly used in the automobile industry while Version 4 is most common outside. The data sets used in this project should be applicable to both versions although it is anticipated that some storage problems could arise in the pedestrian simulation using Version 3 due to the large number of potential contacts.

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16. Abstract

The objective of this project has been to modify baseline data sets developed for use with the Calspan three-dimensional crash victim simulation (HSRI Version, 1981) to a form compatible with Version 4 of the MVMA two-dimensional dynamic occupant/pedestrian simulation. The report describes the baseline vehicle geometry in Part 2. The occupant and pedestrian along with their contact interactions with the vehicle are described in Parts 3 and 4. The baseline input data sets and a sampling of the resulting computer program output are given in Part 5.

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1.0 INTRODUCTION

The objective of this project has been to modify baseline data sets developed for use with the Calspan three-dimensional crash victim simulation (HSRI Version, 1981) to a form compatible with Version 4 of the MVMA two-dimensional dynamic occupant/pedestrian simulation (1). This project is a continuation of Project 1150 from Fiscal Year 1980 (2).

This report describes the baseline vehicle geometry in Part 2. The occupant and pedestrian along with their contact interactions with the vehicle are described in Parts 3 and 4. The baseline data sets and a sampling of the resulting computer program output are given in Part 5.

2.0 THE VEHICLES

In order to define the geometry of vehicle components with which an occupant might possibly interact during a side impact event or the front exterior components of a vehicle in the case of a pedestrian, it was necessary to obtain measurements from existing vehicles. Three vehicles were selected which are representative of the most modern domestic small car production.

For the front exterior of each vehicle, at least three points were measured with respect to a common inertial coordinate system to define the following surfaces approximately as planes:

- bumper
- grille
- hood
- windshield
- roof

For the vehicle interior the following surfaces were anticipated to be involved during lateral or 300° oblique impact:

- seat cushion
- seat back
- front door sill region (foot/lower leg contact)
- door panel lower region (hip and upper leg contact)
- door panel upper region (head contact)
- window panel (head contact)
- door header (head contact)
- floor (foot contact)
- B-pillar (head contact)

Other data were obtained which would make it possible to expand the simulation to cases of frontal impact.

2.1. BASELINE INTERIOR FOR SIDE IMPACT

Figure 1 illustrates the individual and average baseline panel locations which form the basis for construction of a side impact data set. These data are used in constructing the actual data sets described in Part 5 of this report.

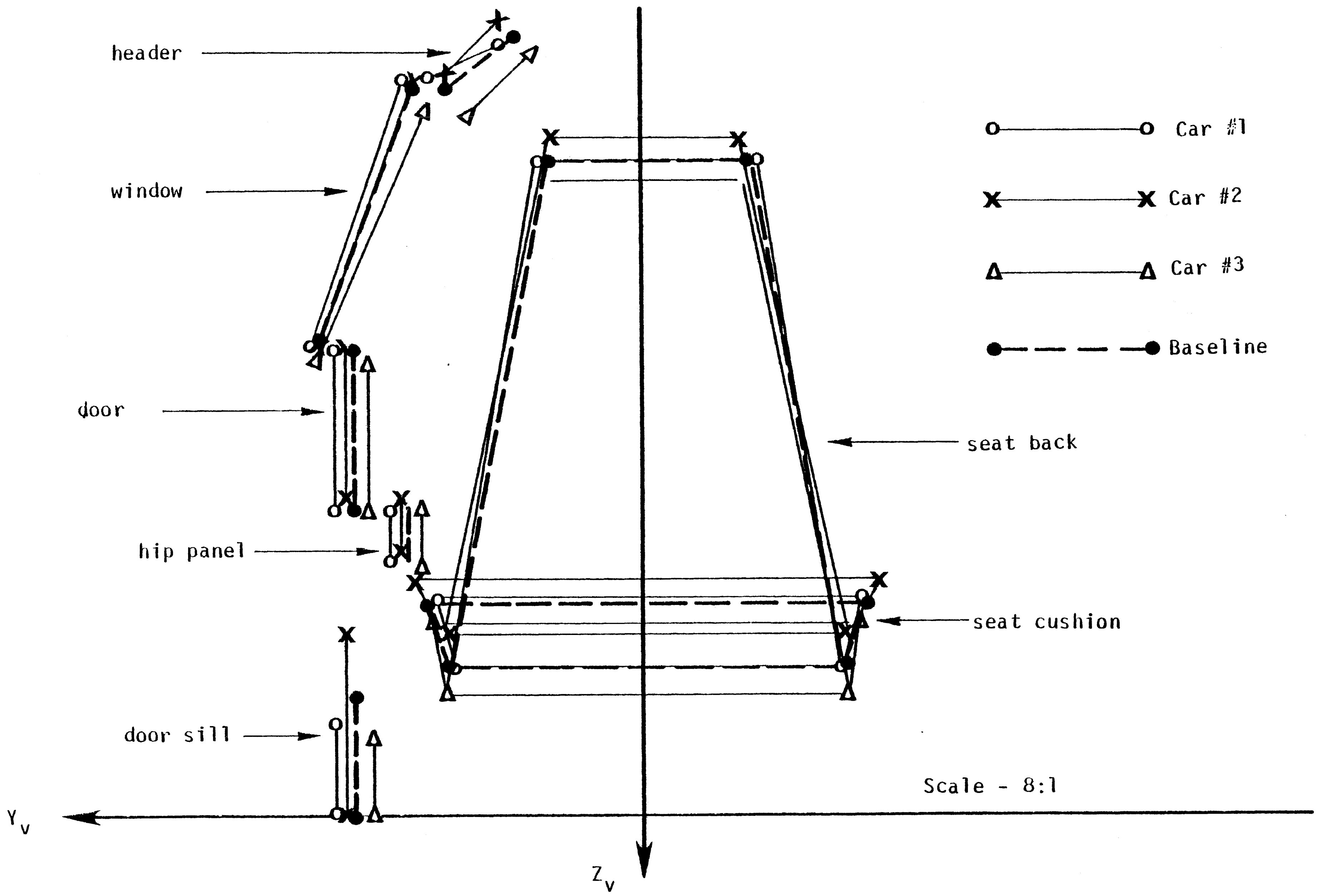

Figure 1. Vehicle interior for side impact (Front view)

2.2. BASELINE EXTERIOR FOR PEDESTRIAN IMPACT

Figure 2 illustrates the individual and average baseline panel locations which form the basis for a vehicle exterior intended for use in simulation of a pedestrian accident event. The baseline location has been used in constructing the actual data set described in Part 5 of this report. One surface which is not shown is the interface between the grille and hood. There was no clear definition for such a surface based on simple vehicle exterior measurements. Selection of a surface to represent this region was made to describe the intersection between the grille and the hood - a region which is estimated to have force-deformation properties different from those used to model the hood or grille regions.

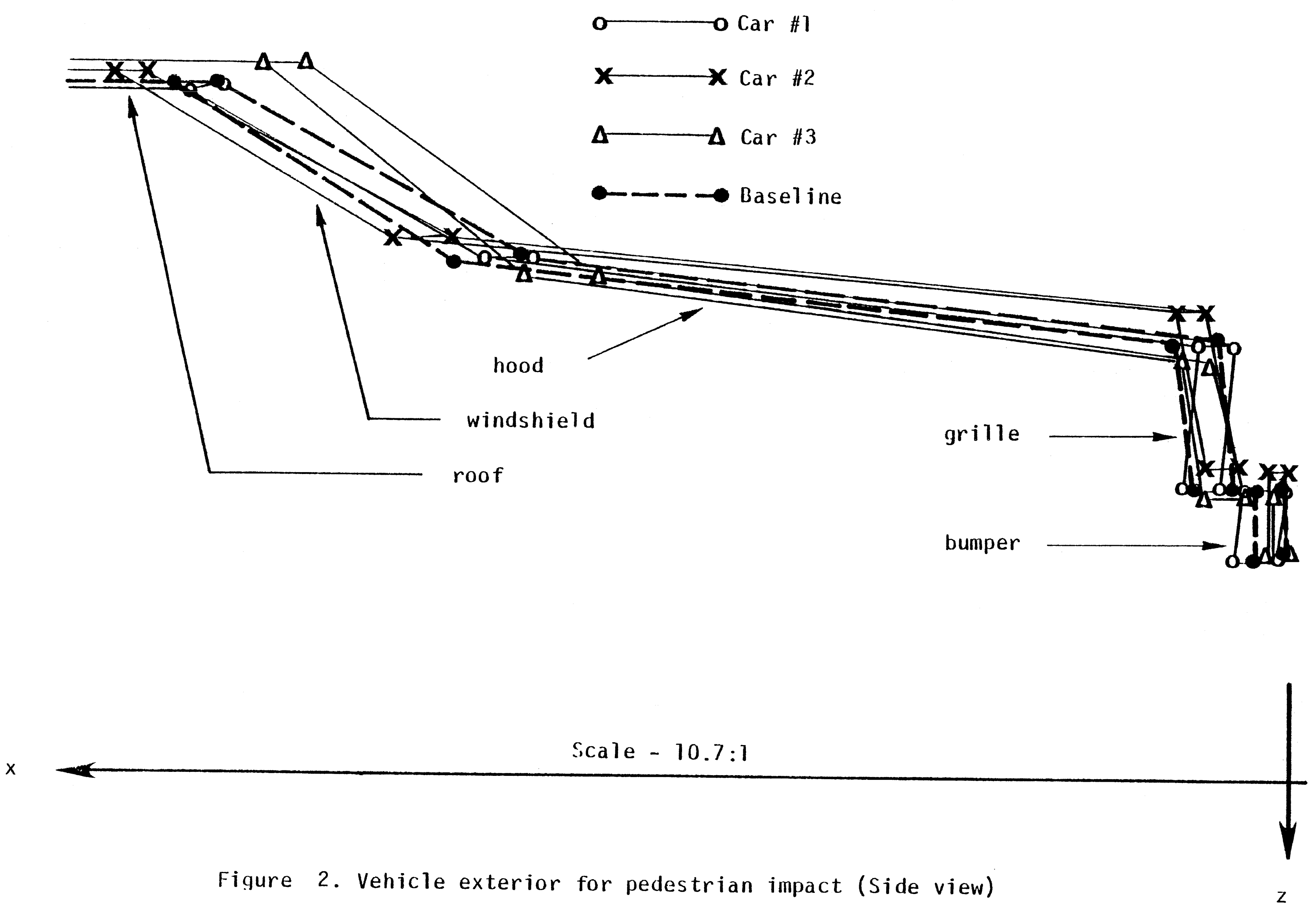

Figure 2. Vehicle exterior for pedestrian impact (Side view)

3.0 THE OCCUPANT AND PEDESTRIAN MODELS

During the previous project a survey was conducted to identify sources for the most complete and recent data sets describing, in three dimensions, an occupant in a side impact simulation and a pedestrian. Surprisingly little information was publicly available at the time. More recently, the Version 20 release tape containing the Calspan CVS included the most recent Part 572 experimental data. Although the data are not yet documented in a written report, they are so much more complete than any available up to this time that they were selected for use in constructing the baseline data sets for the current project.

3.1 OCCUPANT FOR SIDE IMPACT SIMULATION

There were two steps in selecting the occupant. The first step was to project the original three-dimensional geometry to two dimensions. The second was to adjust the data to reflect the new Part 572 parameters. Figures 3 and 4 show side and rear views of the occupant model as they were modeled in three dimensions. Figure 5 illustrates the two-dimensional projection as it was used for the MVMA 2-D simulations. It should be noted that occupant outlines, as defined by contact ellipses, are very similar in Figures 4 and 5. The primary differences are the lack of a right arm and the lumping together of the left and right leg masses.

The numerical values for quantities such as segment mass, moment of inertia, position in space, ellipse axes, link angles, and joint properties are included in Part 5 which contains the complete listing of the output of the input data set. The mass of the upper arm was added to the torso while the mass and inertial properties of the upper and lower legs were combined. The new Part 572 data supplied with Calspan CVS Version 20 were used as a basis.

3.2 PEDESTRIAN FOR IMPACT SIMULATION

The original three-dimensional pedestrian data set represented a person walking perpendicular to the path of the vehicle. Figure 6 shows the left side of the pedestrian with the left front of the vehicle behind him. In Figure 7 the view is that of the back of the pedestrian with a front-to-rear section of the vehicle projected through the ycoordinate of the lower torso center of gravity. This section is on the left, or driver's side of the vehicle. This view was used as the basis for projecting the three-dimensional geometry to two dimensions as is shown in Figure 8. The outlines of the pedestrian, as defined by the contact ellipses, are similar in Figures 7 and 8. The differences are on the left side of the body in the arm and leg. The left arm is deleted and the mass lumped with the torso.

It was necessary to simplify the linkage for the two-dimensional case. To simulate the presence of two legs, a feature believed to be important because of the large mass and inertial properties of these segments as well as the fact that the initial energy transfer to the linkage is through the legs, two joints (4 and 5 as shown in Figure 8) were superimposed at the hip pivot point. This mechanism allowed the mass of the left leg to be represented by M4 while the right upper leg is represented by M5 and the right lower leg by M6. Contact between the left and right legs or between any of these segments and the vehicle is through the contact surfaces which are not affected (in inertial space) by this rearrangement of the linkage. The left and right legs pivot independently at the "hip."

The numerical values for quantities such as segment mass, moment of inertia, position in space, ellipse axes, link angles, and joint properties are included in Part 5 which contains the complete listing of the output of the input data set. The pelvic mass is ordinarily associated with the link between joints 4 and 5. As this link is now being used to simulate the leg leg (M4), the pelvic mass is moved to the link between joints 3 and 4 and lumped with the abdominal mass. The locations for centers of gravity, the mass values, and the moments of inertia are all derived from the new Part 572 data.

In the original three-dimensional simulation, all joints were free of constraints. It is believed that this is due to the fact that a purpose of simulation was to model the kinematics of a cadaver with no muscle tension to keep the body erect. The correct values for joint flexual properties were included to simulate Part 572.

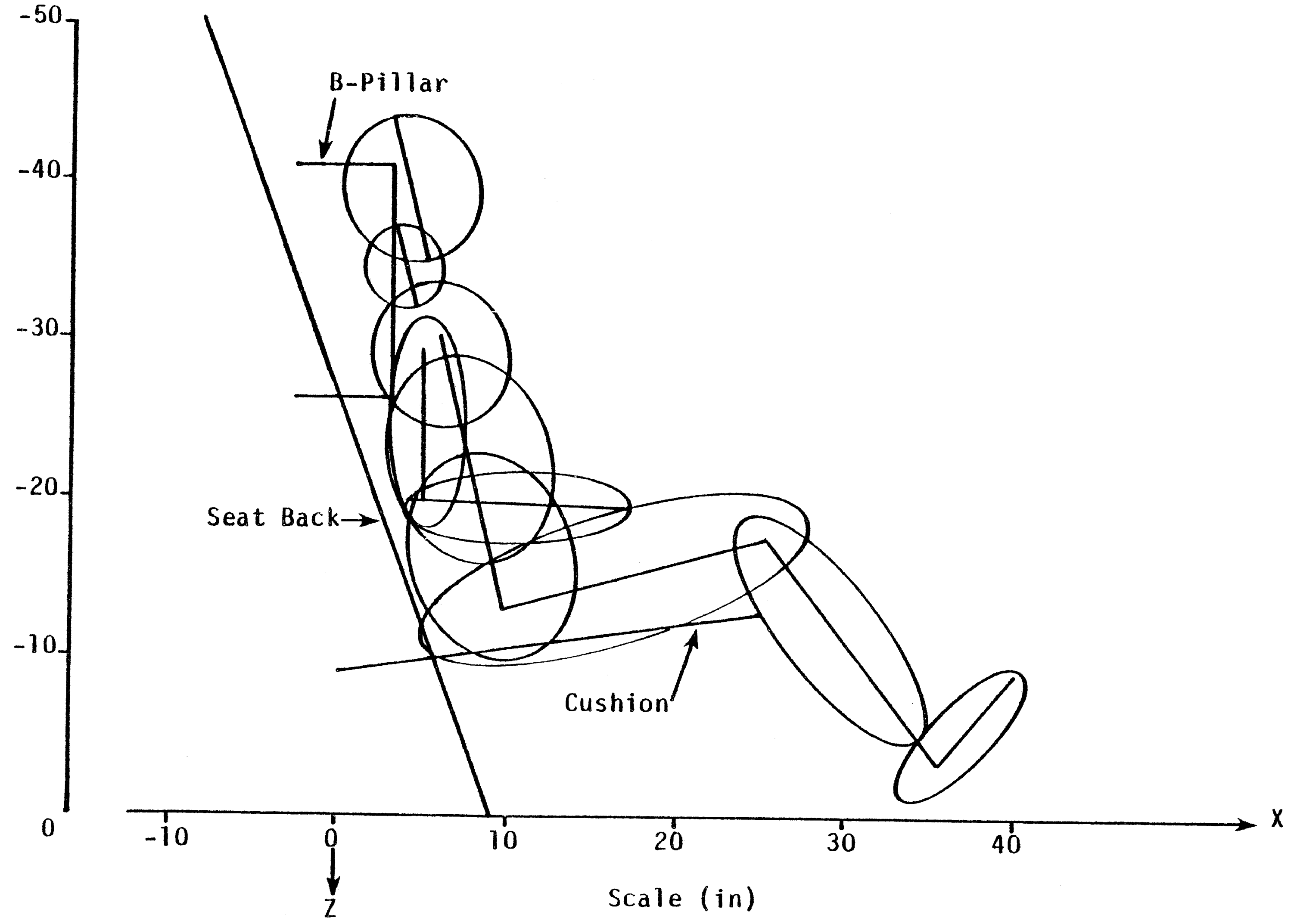

Fig. 3. Occupant for Side Impact Simulation (Side View)

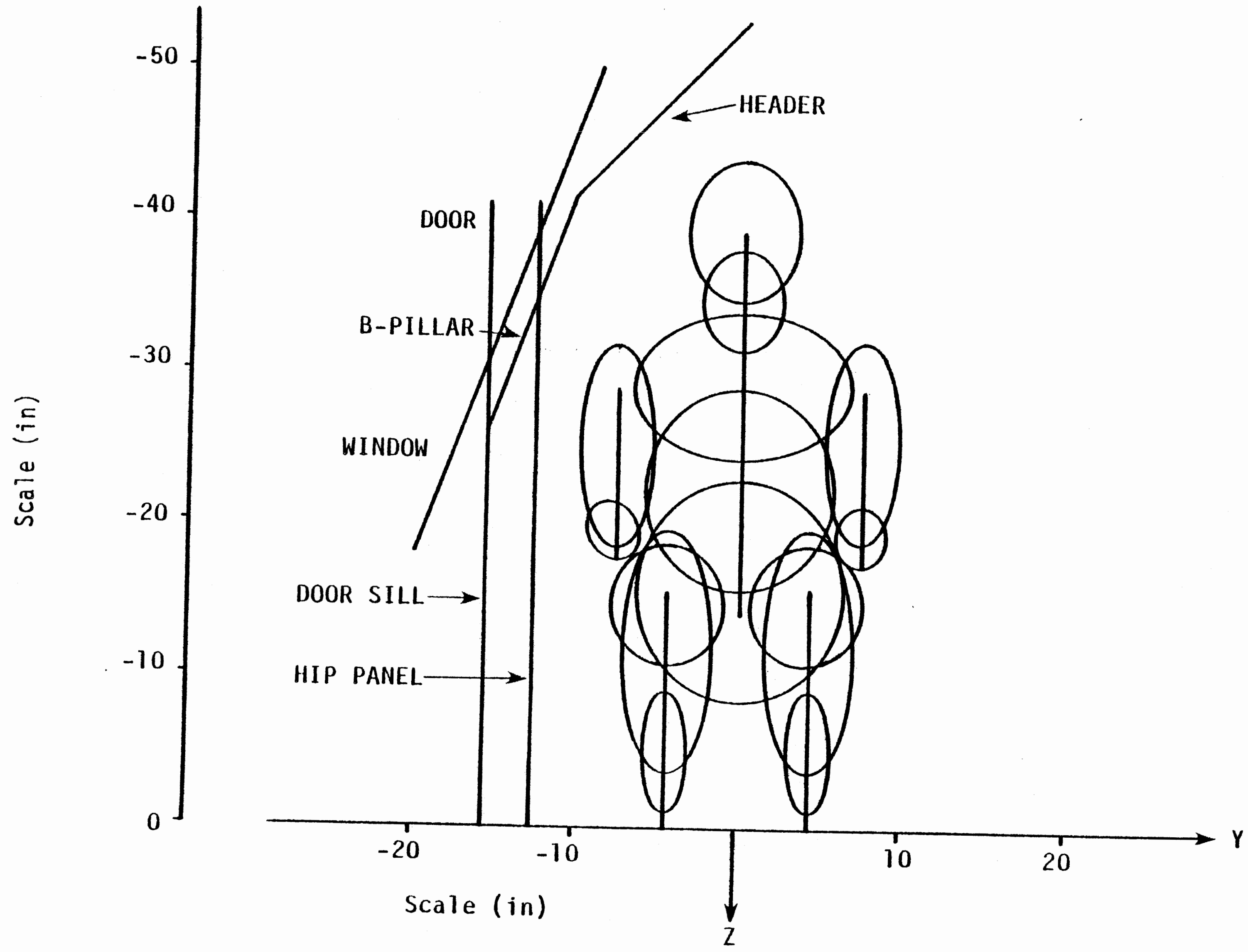

Fig. 4. Occupant for Side Impact Simulation (Rear View)

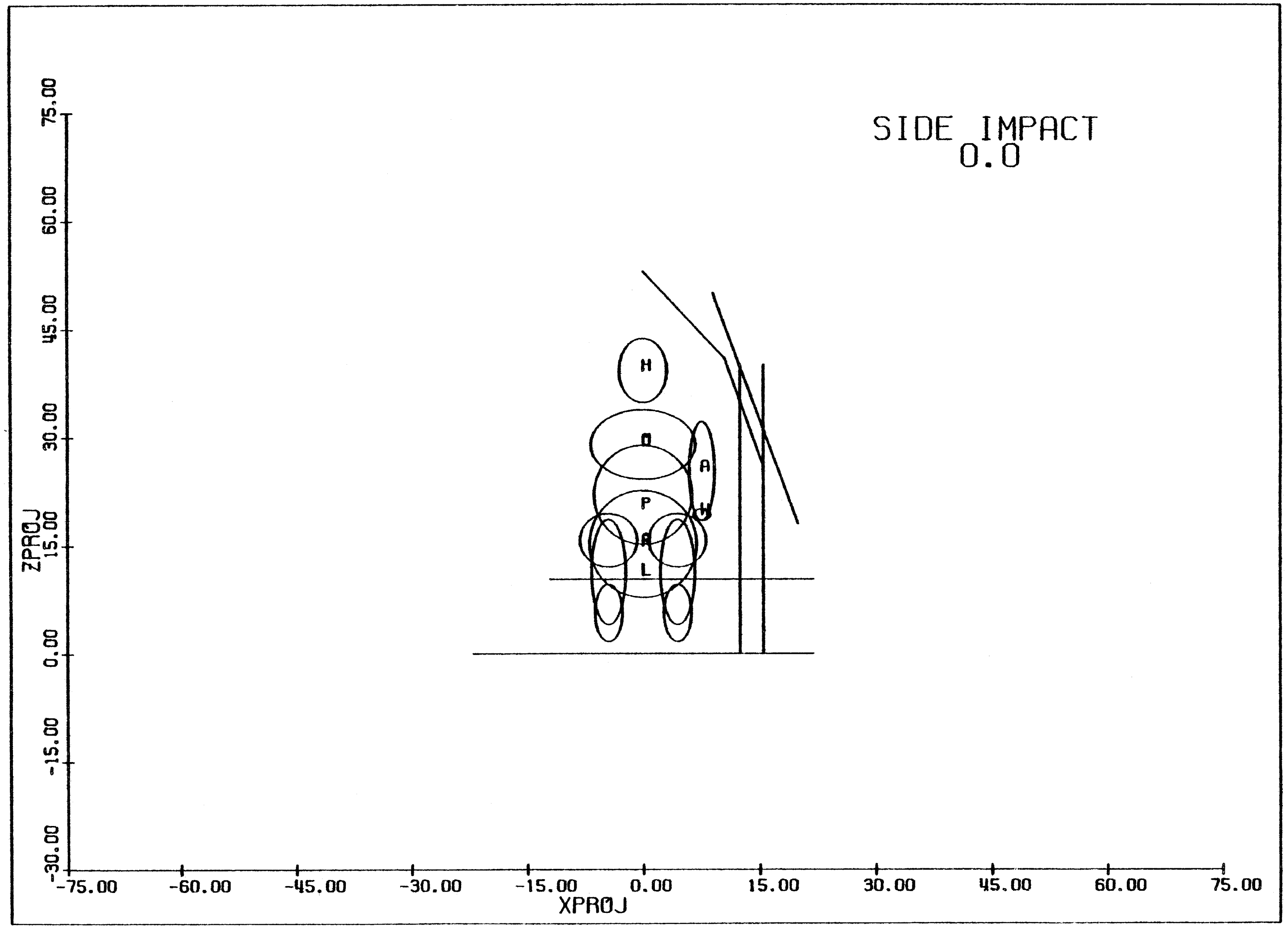

Fig. 5. Two-Dimensional Projection for Side Impact Simulation

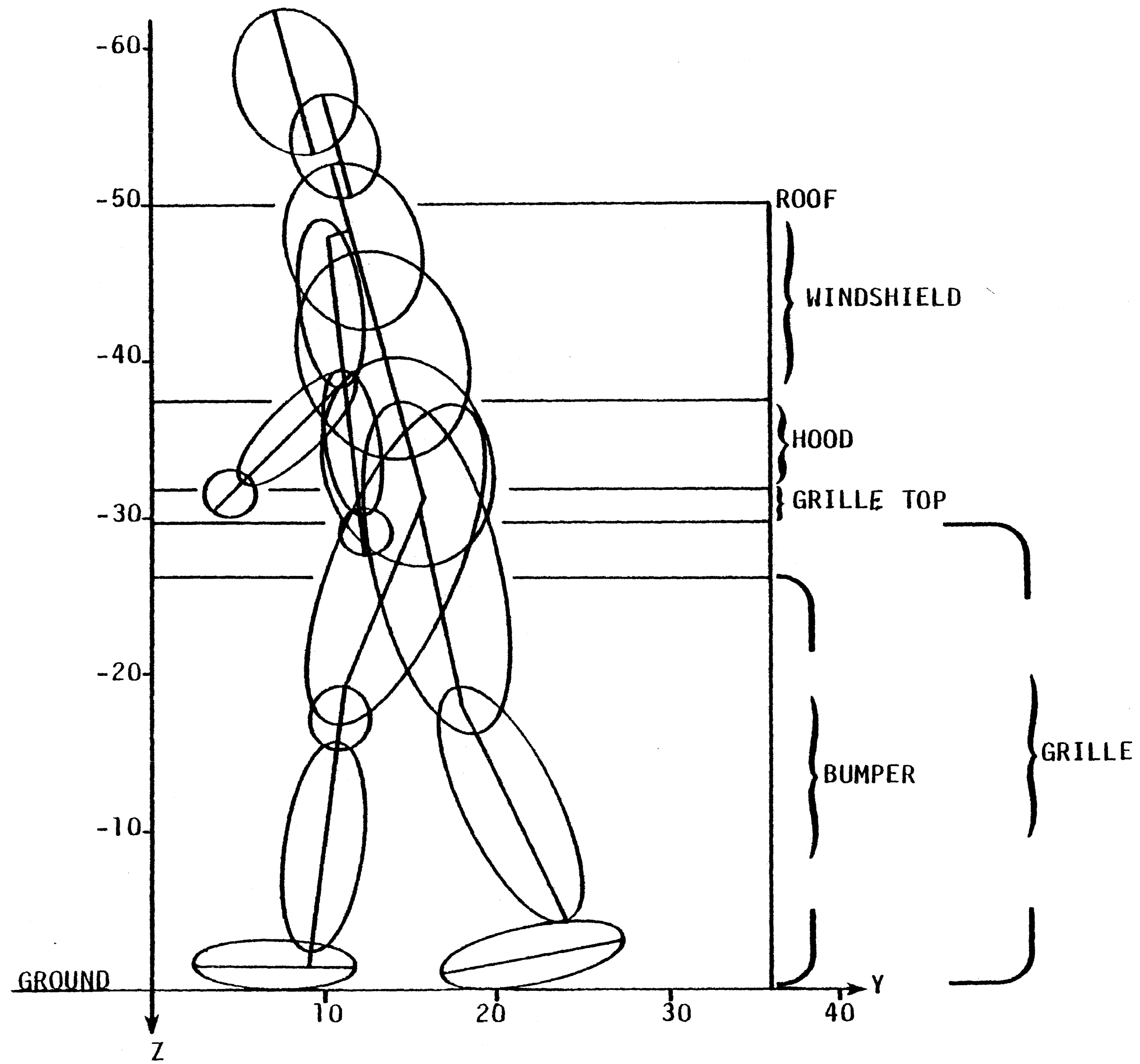

Fig. 6. Side View of Pedestrian (Initial Position).

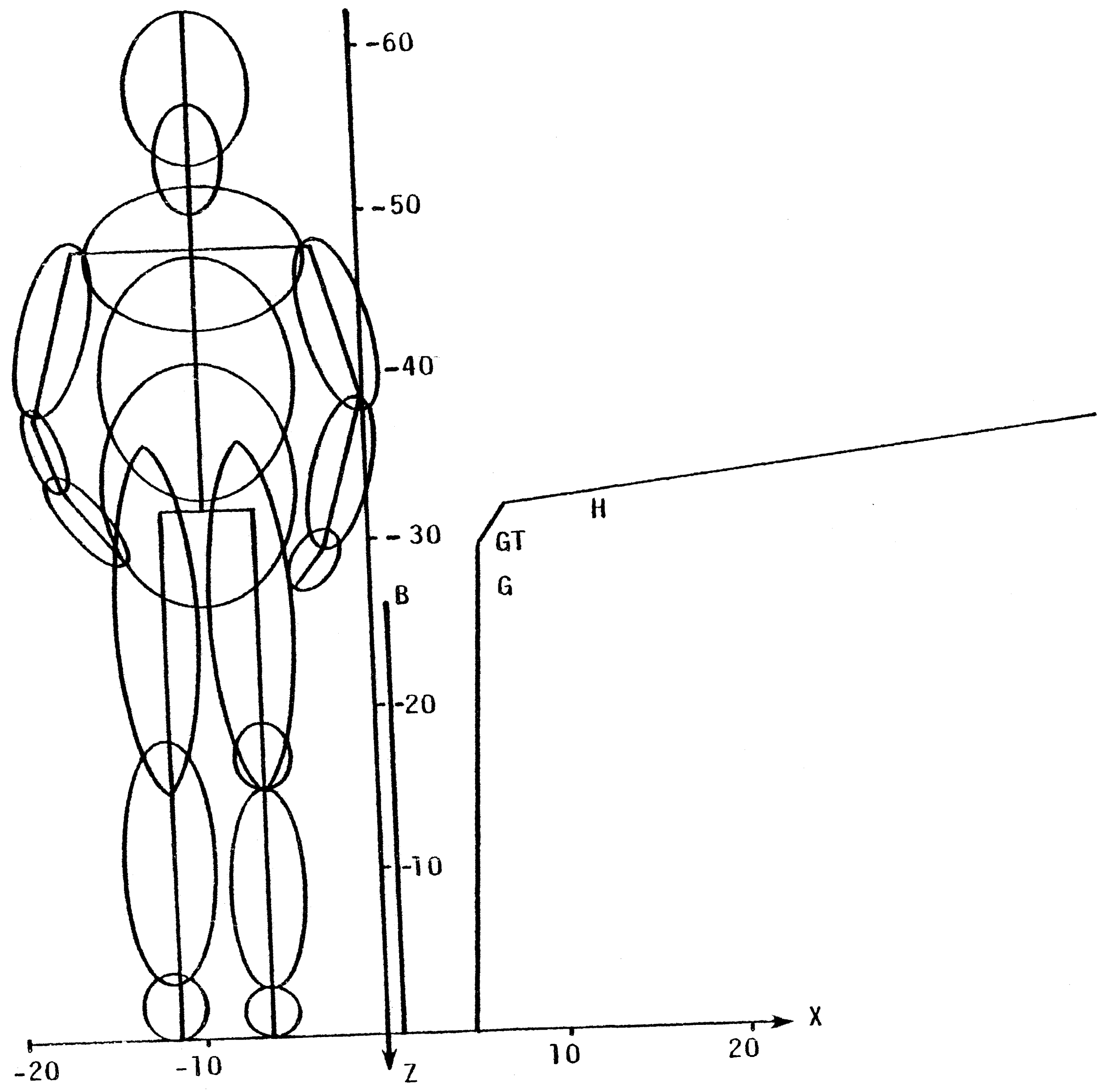

Fig. 7. Back View of Pedestrian (Initial Position)

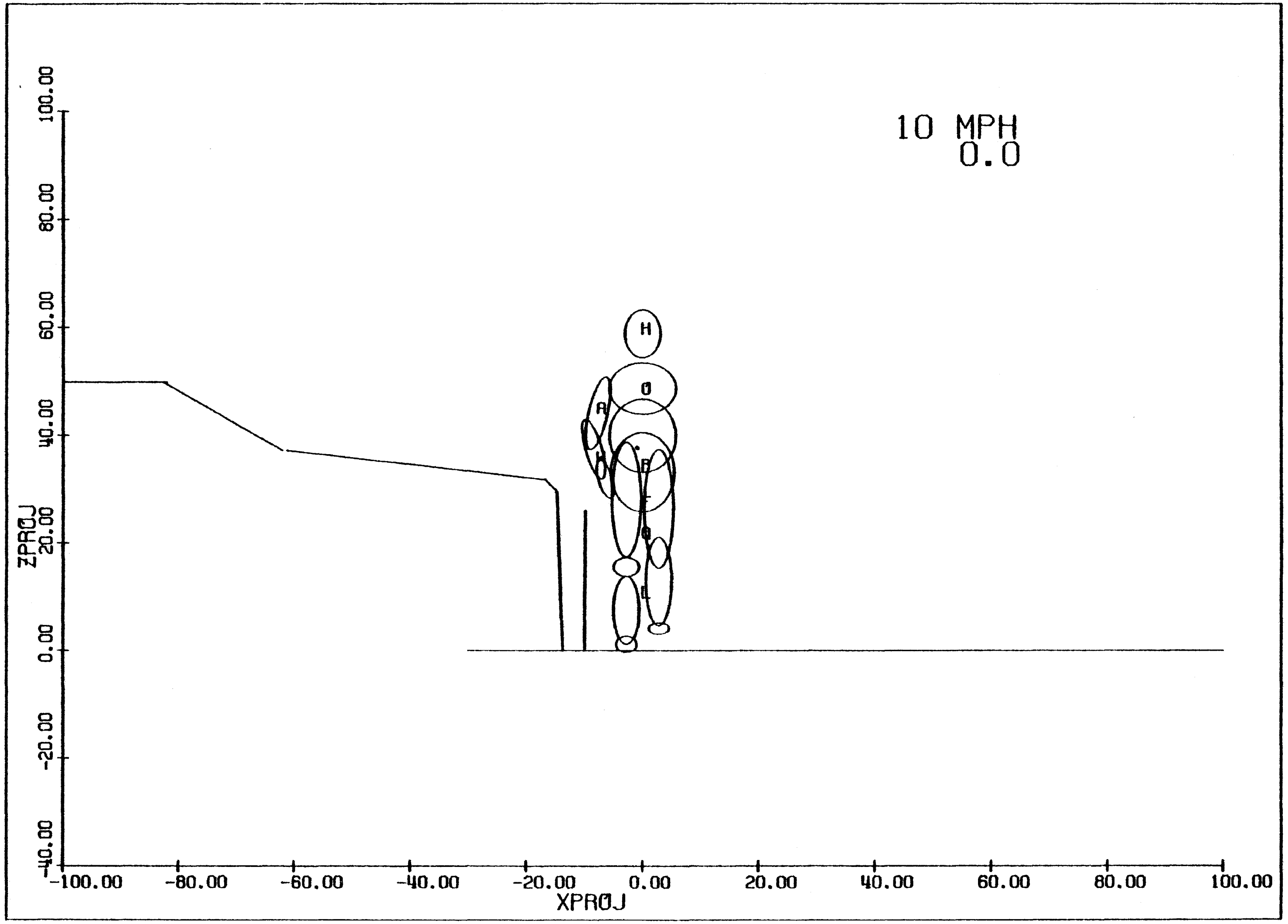

Fig. 8. Two-Dimensional Projection for Pedestrian Simulation.

A feature of the three-dimensional simulation was a special joint to model breaking of the lower leg. Because of limitations in the number of available masses for the MVMA 2-D model, breaking of the knee was substituted. This was handled by locking the joint using the Conlomb friction joint resistance option. The friction value was set at an estimated lateral knee joint fracture level.

4.0 CONTACT INTERACTIONS WITH THE VEHICLE

A variety of contacts are allowed for both the occupant with the vehicle interior and the pedestrian with the vehicle exterior. Occupant or pedestrian ellipses may contact either flat panels attached to the vehicle or other of the ellipses on the subject. Table 1 shows the potential contacts which are allowed for the side impact occupant while Table 2 refers to the pedestrian.

The force-deflection characteristic curves governing interactions between the occupant or pedestrian and the vehicle have been derived from a variety of sources. Some are based on idealized vehicle component tests. Others are hypothetical estimates chosen to fill voids in our compilation of published, realistic vehicle descriptive data. All are intended to be treated as baseline data which should be replaced when measured data are available for use in actual engineering studies.

4.1 VEHICLE INTERIOR FORCE - DEFORMATION CHARACTERISTICS

Five different force-deflection characteristic curves are used to define the properties of the contact surfaces used to define the vehicle interior for side impact. Figure 9 illustrates the curve for a structure entitled, "panel." Tabular implementation of these data define the deformation of the header, front door sill, and hip panel region. The door panel shoulder region contact surface is modeled as a fifth order polynomial fit to the table. The symbol "x" on Figure 9 shows the closeness of fit of this polynomial. The polynomial form is used for this contact surface to allow mutual deformation of the vehicle and occupant thorax. These data are derived from dynamic deformation tests of door interiors and represent a somewhat stiffer structure than that used in recent side impact simulations by Padgaonkar and Prasad (3). Because of a lack of experimental information on the header and front door sill, the data shown in Figure 9 have also been selected as hypothetical estimates for these surfaces.

Figure 10 shows the representative force-deflection curve for side window tempered glass which has been selected for inclusion in the data.

TABLE 1. OCCUPANT/VEHICLE INTERIOR CONTACTS

Ellipse Name	Contact Panel or Ellipse Name
Head	Window
Head	Header
Head	B-Pillar
Upper Torso	Door
Lower Torso	Seat Cushion
Lower Torso	Hip Panel
Right Upper Leg	Seat Cushion
Right Foot	Floor
Left Upper Leg	Seat Cushion
Left Upper Leg	Hip Panel
Left Lower Leg	Door Sill
Left Foot	Floor
Left Foot	Door Sill
Left Upper Arm	B-Pillar
Left Upper Arm	Door
Left Lower Arm	Door

TABLE 2. PEDESTRIAN/VEHICLE EXTERIOR CONTACT

Ellipse Name	Contact Panel or Ellipse Name
Head	Windshield
Head	Hood
Head	Car Front (Grille Top)
Head	Roof
Upper Torso	Roof
Upper Torso	Windshield
Upper Torso	Hood
Upper Torso	Car Front (Grille Top)
Lower Torso	Windshield
Lower Torso	Hood
Lower Torso	Car Front (Grille Top)
Lower Torso	Grll* (Grille)
Right Upper Leg	Hood
Right Upper Leg	Grll* (Grille)
Right Upper Leg	Car Front (Grille Top)
Right Upper Leg	Left Upper Leg
Right Knee	Bumper
Right Shin	Bumper
Right Foot	Ground
Right Foot	Grll* (Grille)
Left Upper Leg	Hood
Left Upper Leg	Grll* (Grille)
Left Upper Leg	Car Front (Grille Top)
Left Lower Leg	Bumper
Left Foot	Ground
Left Foot	Bumper
Left Foot	Grll* (Grille)
Right Upper Arm	Hood
Right Upper Arm	Windshield
Right Lower Arm	Hood
Right Lower Arm	Grll* (Grille)
Right Lower Arm	Car Front (Grille Top)

*Note: The term "Grll" is the name used in the data set for the word "Grille".

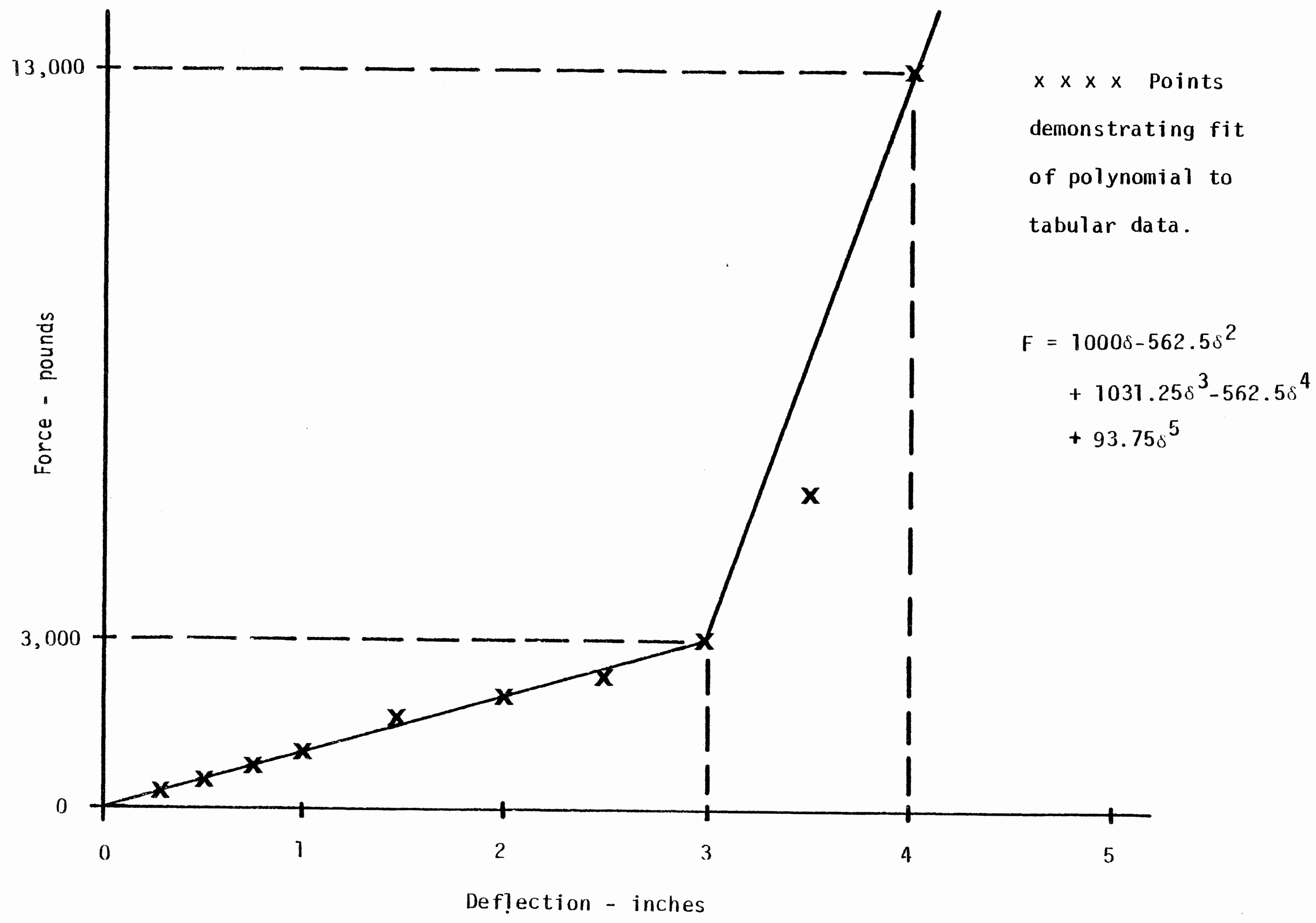

Figure 9. Panel force-deflection curve.

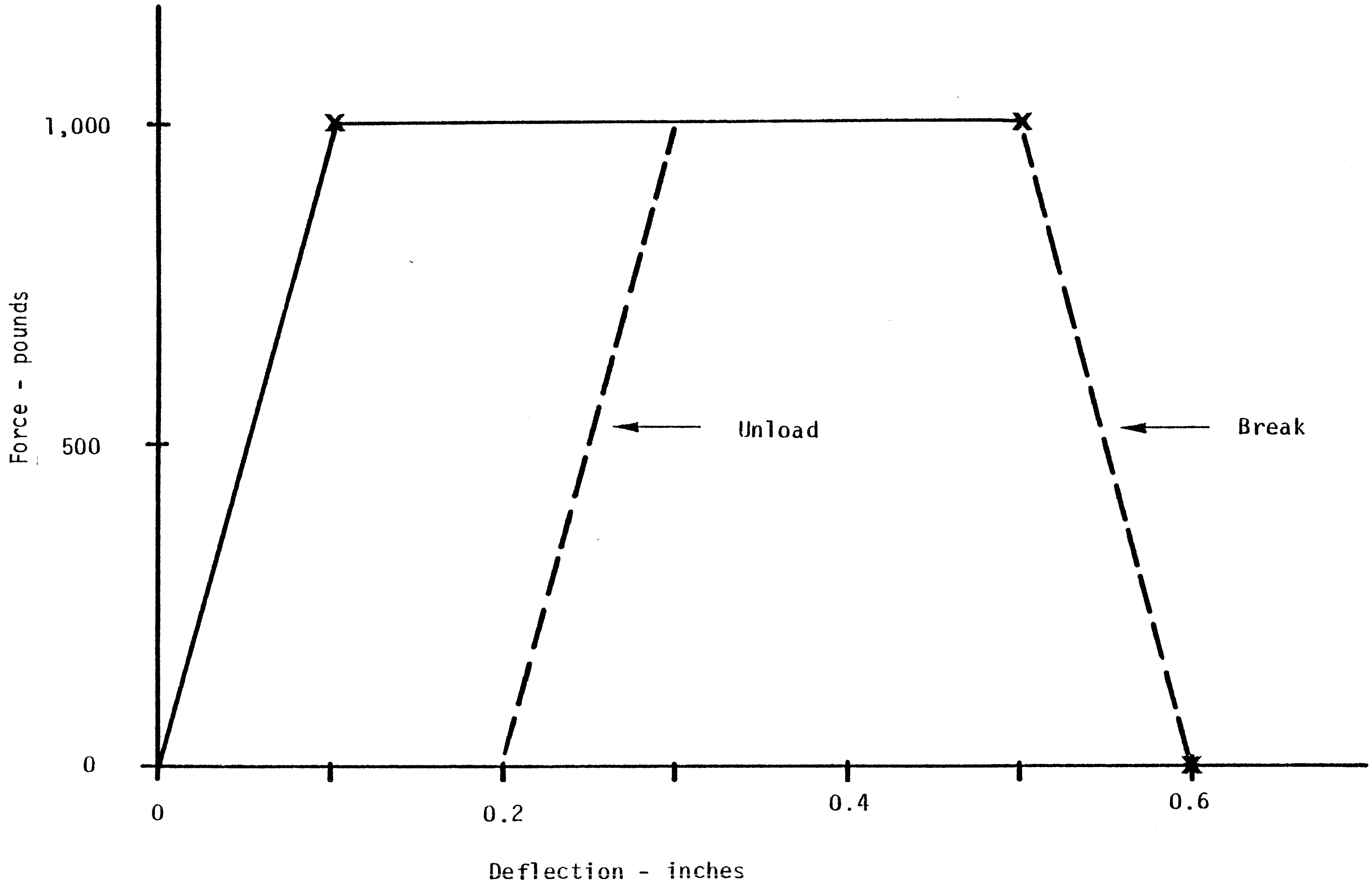

Figure 10. Side window force-deflection curve

This is an idealization of data presented at the 11th Stapp Car Crash Conference by Siemonsen and Bruckner (4). It should be noted that tempered glass holds substantial force for a larger deformation than annealed or laminated glass due to its larger bending stiffness. It is presumed that the glass panel breaks upon reaching a deflection of 0.5 inch and behaves elastically until that deformation is reached.

The floor, seat back, seat cushion, and B-pillar are modeled as linear polynomials in force and deformation. The following coefficients were supplied with the original frontal impact data set by Calspan Corporation while the B-pillar coefficient is a hypothetical estimate:

1. Seat back and seat cushion - 40 lb/in.
2. Floor - 860 lb/in.
3. B-pillar - 4000 lb/in.

4.1.1 INTRUSION OF VEHICLE COMPONENTS DURING SIDE IMPACT

Figure 11 shows the intrusion of the hip and door contact surfaces during the baseline side impact accident event. The overall motions of the vehicle take place in the coordinate system indicated in the figure. However, in the case of intrusion, the various components of the vehicle move and deform with respect to the vehicle. To represent this physically observed phenomena and to provide a realistic, but hypothetical, example for the baseline exercise, the hip panel and door are seen to begin intrusion at 5 ms and continue moving inward until 30 ms when they stop with respect to the remainder of the vehicle. Total intrusion is 5 inches. The software is capable of linear motion, as is the case used in this example, and also of panel rotation.

4.2 VEHICLE EXTERIOR FORCE-DEFORMATION CHARACTERISTICS

Three different force-deflection loading characteristic curves are used to define the properties of the seven contact surfaces which define the vehicle exterior and ground for pedestrian impact. All these curves are linear polynomials in deformation. The roof, windshield, hood, grille (GRLL), and bumper have a coefficient of 1000 lb/in. The ground coefficient is 470 lb/in. The grille top (car front) surface was to be twice the average of the hood and grille, which is 2000 lb/in. The body ellipses are all assumed to be rigid.

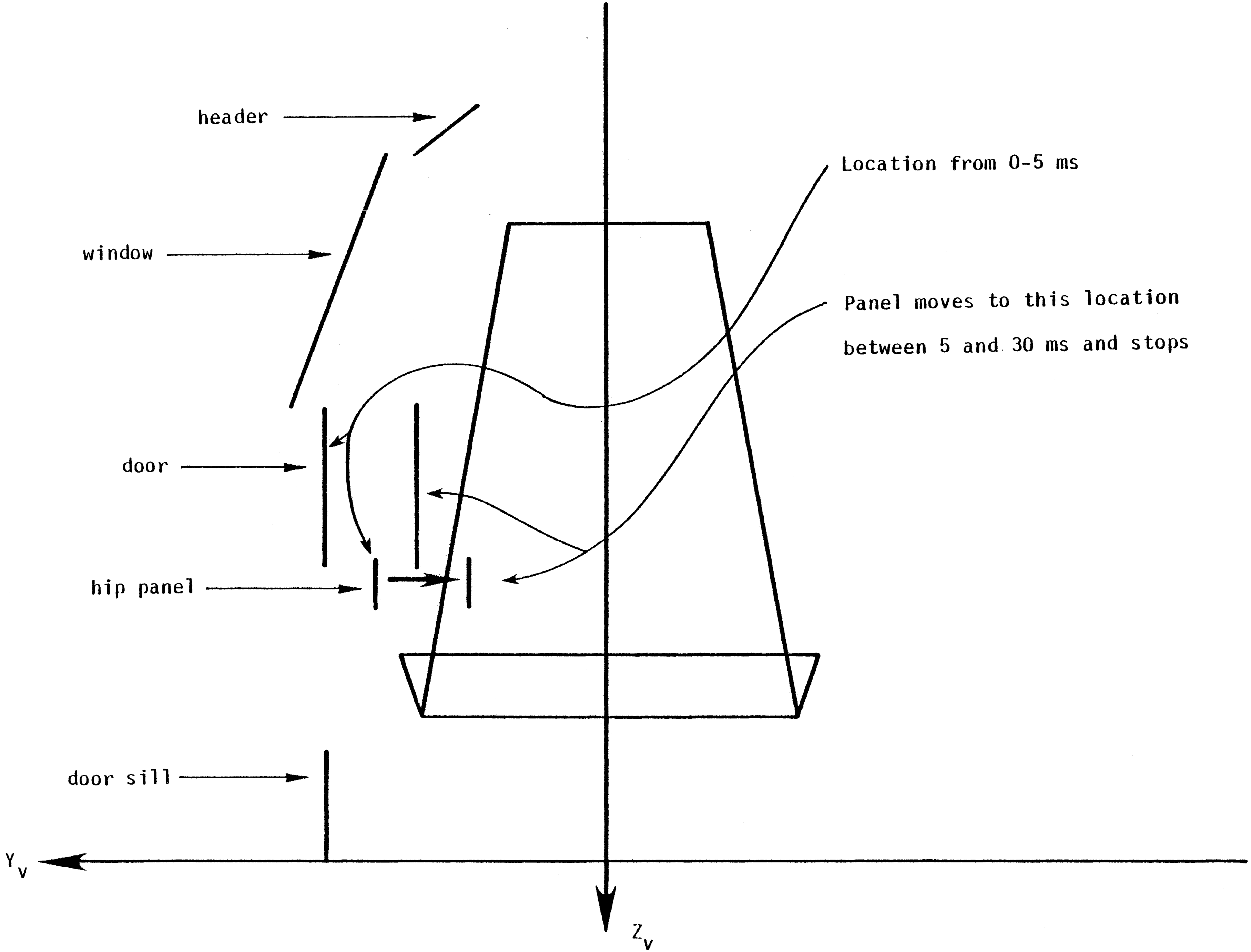

Figure 11. Intrusion of baseline hip panel and door contact surfaces during simulation.

Although the force-deflection loading curves used with the MVMA 2-D model are the same ones used in the three-dimensional simulations, the unloading curves are not. Pedestrian kinematics observed in the three-dimensional simulations and in the initial two-dimensional simulations resembled those of a rubber ball bouncing off the hood of the vehicle. These unloading curves demonstrated pure elastic behavior. To compensate for this problem the input data for unloading define an energy absorption of 99%. This had a marked effect on eliminating the marked vertical motion of the pedestrian.

Even with the changes just mentioned the results with the MVMA 2-D model still were not good. The pedestrian was not conforming to the vehicle, but rather, was sliding off. Contact friction was added for all interactions of the pedestrian with the vehicle. This change served to simulate the pedestrian in a manner similar to that observed in high speed movies of experimental impacts. It should be noted that contact with the ground was already modeled by a friction coefficient of 1.0 in both the MVMA 2-D and three dimensional simulations.

These data are incomplete and represent only hypothetical estimates for the properties of a vehicle exterior. It is recommended that the force-deformation and friction data contained in this baseline be regarded as preliminary and that further work should be done to improve their quality.

5.0 THE COMPUTER EXERCISES

The purpose of this part of the report is to present the numerical details of the two baseline data sets and give summary details of the resulting computer exercises. For a complete copy of the simulation output it is necessary to exercise the data set or obtain a copy of the tape containing the exercise from MVMA or HSRI.

5.1 VEHICLE DECELERATIONS AND MOTIONS

The dynamics of the side impact simulation are initiated by forcing an acceleration of the occupant compartment. This causes the vehicle (and its contact surfaces) to begin to move with respect to inertial coordinates. Superimposed upon this movement is the prescribed intrusion of the side door hip contact panel with respect to the vehicle coordinate system. The occupant, initially at rest with respect to both inertial and vehicle coordinate systems, is carried along by the vehicle motions through impacts with the vehicle interior contact surfaces. The lateral acceleration profile applied to the vehicle is shown graphically in Figure 12.

The pedestrian impact is initiated by prescribing motions for the vehicle which is given an initial velocity of 10 mph and maintains this non-stop velocity throughout the simulation. The contact surfaces of the vehicle are rigidly attached to the moving vehicle coordinate system. The occupant is motionless in inertial space at the beginning of the simulation and begins dynamic excursions when impacted by the bumper. The contact surface representing the ground does not move.

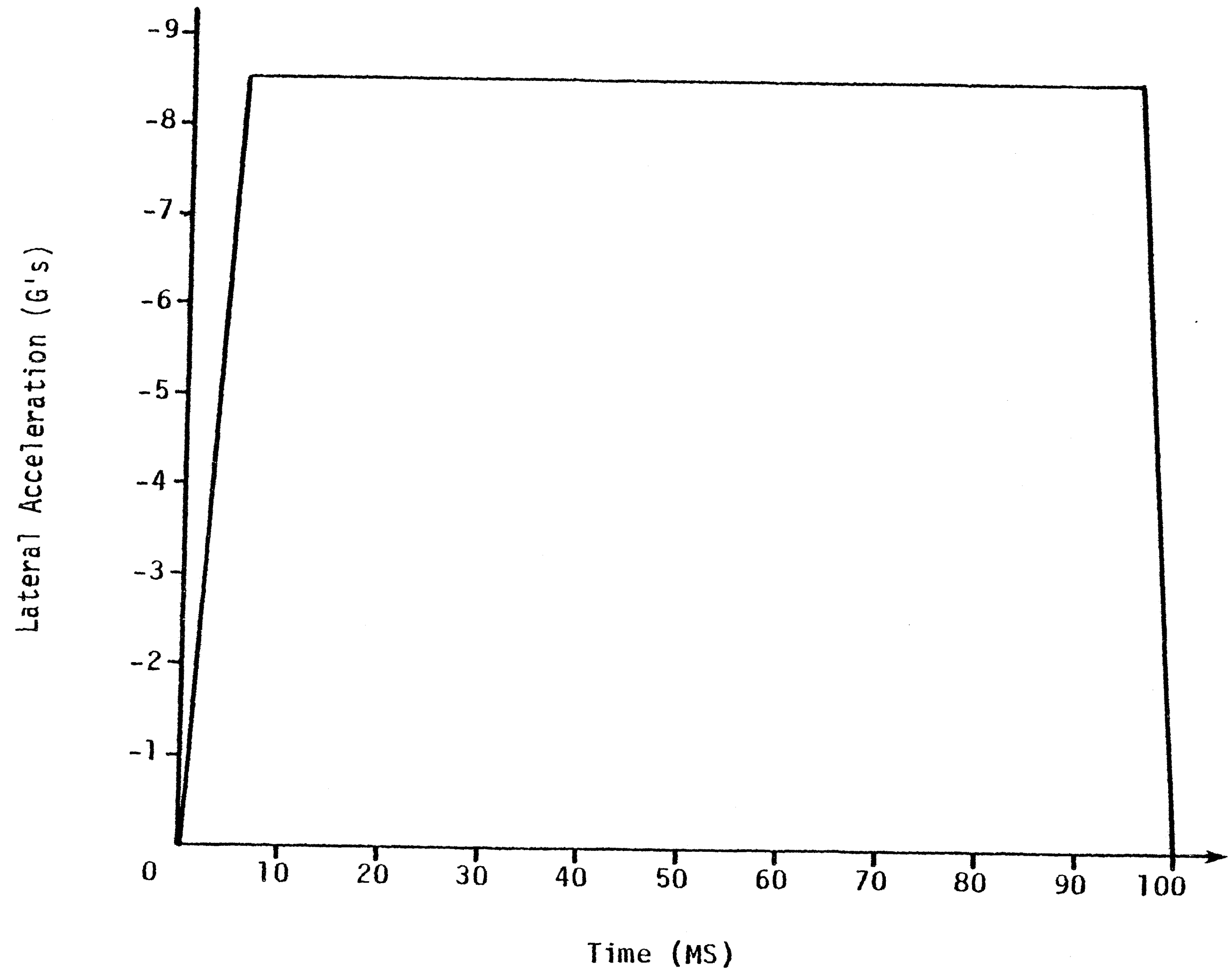

Fig. 12. Side Impact Vehicle Acceleration Curve.

5.2 SIDE IMPACT INPUT DATA

This part of the report contains the numerical details of the baseline MVMA 2-D side impact data set. Table 3 contains the output of the input data set after the input file has been processed by the IN section of the program. Not all pages are included. Those which are contain details of the linkage, joints, masses, inertial properties, contact ellipses, and program controls. Table 4 is a copy of the baseline data file which was constructed for the exercise.

```
 JUN 16, 1981  10:22:09              SIDE IMPACT #1 -- 12 DEGREES                            VER. 4      PAGE   1-00
3D-2D:  LEFT ARM-ARM LINKS/RIGHT ARM-LUMPED WITH TORSO/RIGHT AND LEFT LEGS-LUMPED TOGETHER    OCCUPANT IS STRUCK FROM LEFT SIDE


                                    SIMULATION CONTROL DATA

NO RESTRAINT BELTS PRESENT

FIXED RUNGE-KUTTA INTEGRATION METHOD IS USED

ACCELERATION DUE TO GRAVITY            32.1740(FT/SEC**2)

MINIMUM ACCELERATION MAGNITUDE           0.0          (IN/SEC**2)  OR (RAD/SEC**2)

BEGINNING TIME               0.0     (MSEC)

FINAL TIME           100.00000(MSEC)

NUMERICAL INTEGRATION STEP SIZE                1.00000(MSEC)

OUTPUT PRINT INCREMENT               1.00000(MSEC)

OUTPUT PLOT INCREMENT            205.00000(MSEC) IF ZERO, NO PLOT RECORDING

ENGLISH UNITS ARE USED

STEERING COLUMN INTERACTION IS NOT DESIRED

AIRBAG INTERACTION IS NOT DESIRED

ELLIPSE-ELLIPSE CONTACTS SPECIFIED ON 106 CARDS ARE ALLOWED

ELLIPSE-REGION CONTACTS SPECIFIED ON 106 CARDS ARE ALLOWED

ELLIPSE-ELLIPSE CONTACTS CAN OCCUR

LENGTH OF SCALING RAMP TO INSURE CONTINUITY IN CONTACT FRICTION          10.000(IN/SEC)

RELATIVE ERROR TOLERANCE FOR SINGULARITY IN MATRIX INVERSION STEP          0.000001

CPU TIME LIMIT FOR EXECUTION                    2(MIN)
```

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 1 of 8).

INTEGRATION CONTROLS

MAXIMUM STEP TO SEARCH FOR BALANCE IN SHARED DEFLECTION	0.200(IN)
MINIMUM STEP TO SEARCH FOR BALANCE IN SHARED DEFLECTION	0.020000(IN)
MAXIMUM FORCE FOR RIGID-RIGID CONTACT	600.00(LB)
LINEAR ELASTIC COEFFICIENT FOR RIGID-RIGID CONTACT	500.00(LB/IN)
MAXIMUM NUMBER OF ITERATIONS TO FIND FORCE BALANCE	30
FRACTION OF CURRENT RAMP LENGTH FOR VELOCITY CHANGE IN MOVING CONTACT LINES	0.050
NUMBER OF INTEGRATION STEPS FOR MAXIMUM RAMP LENGTH FOR VELOCITY CHANGE IN MOVING CONTACT LINES	10.
MINIMUM RATIO OF SHORTER TO LONGER SEMI-MAJOR AXIS FOR ELLIPSE TO BE TREATED AS CIRCLE	1.000
FRACTIONAL POSITION OF CIRCLE CENTER ALONG SEMI-MAJOR AXIS RELATIVE TO POSITION FOR CIRCLE-ELLIPSE TANGENCY AT END OF AXIS	1.000

DEBUGGING CONTROLS

TIME TO SET DEBUG SWITCHES (MSEC)	0.0	2000.0000	0.0	0.0
DEBUG SWITCH SETTING IN HEXADECIMAL FORMAT	00000000	00000000	00000000	00000000
TIME TO SET DEBUG SWITCHES (MSEC)	0.0	0.0	0.0	0.0
DEBUG SWITCH SETTING IN HEXADECIMAL FORMAT	00000000	00000000	00000000	00000000

DEBUG CONTROLS ARE TO OPERATE FOR ALL INTEGRATION EVALUATIONS AT EACH TIME

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 2 of 8).

JUN 16, 1981 10:22:09 SIDE IMPACT #1 -- 12 DEGREES VER. 4 PAGE 3-00
3D-2D: LEFT ARM-ARM LINKS/RIGHT ARM-LUMPED WITH TORSO/RIGHT AND LEFT LEGS-LUMPED TOGETHER OCCUPANT IS STRUCK FROM LEFT SIDE

BODY PARAMETERS

BODY SEGMENT LENGTHS (IN)	
HEAD LENGTH=	0.0
UPPER TORSO LENGTH=	8.80
MIDDLE TORSO LENGTH=	4.70
LOWER TORSO LENGTH=	4.89
HIP-KNEE LENGTH=	4.24
UPPER TORSO-SHOULDER=	0.0
SHOULDER-ELBOW LENGTH=	10.70
X REST POINT OF SHOULDER=	1.57
Z REST POINT OF SHOULDER=	-7.60

END OF LINK TO CENTER-OF-MASS LENGTHS (IN)	
HEAD/NECK JOINT-HEAD CM LENGTH=	3.23
NECK-CHEST CM LENGTHS=	2.15
UPPER TORSO JOINT-MIDDLE TORSO CM LENGTH=	2.25
LOWER TORSO JOINT LOWER TORSO CM LENGTH=	2.45
HIP-UPPER LEG CM LENGTH=	2.20
KNEE-LOWER LEG CM LENGTH=	6.05
SHOULDER-UPPER ARM CM LENGTH=	5.25
ELBOW-LOWER ARM CM LENGTH=	0.57

MASS OF BODY SEGMENTS (LBS SEC**2 IN)	
HEAD MASS=	0.0250
CHEST MASS=	0.0950
MIDDLE TORSO MASS=	0.0310
LOWER TORSO MASS=	0.0980
UPPER LEG (BOTH LEGS)=	0.0900
LOWER LEG (BOTH LEGS)=	0.0500
UPPER ARM (BOTH ARMS)=	0.0120
LOWER ARM (BOTH ARMS)=	0.0120
HEAD-NECK MASS=	0.0036
UPPER TORSO-NECK MASS=	0.0011

	MOMENTS OF INERTIA (ABOUT CM) (LBS SEC**2 IN)	"NATURAL" LINK ANGLES (FOR ZERO TORQUE) (DEG)	INITIAL BODY LINK ANGLES (RELATIVE TO VEHICLE) (DEG)	INITIAL ANGULAR VELOCITIES (RELATIVE TO VEHICLE) (DEG/SEC)
HEAD	0.2970	0.0	90.00	0.0
UPPER TORSO	2.1700	0.0	90.00	0.0
MIDDLE TORSO	0.3100	0.0	90.00	0.0
LOWER TORSO	1.7800	0.0	90.00	0.0
UPPER LEG	0.7700	-180.00	90.00	0.0
LOWER LEG	1.0000	180.00	-90.00	0.0
UPPER ARM	0.1370	0.0	-90.00	0.0
LOWER ARM	0.2700	0.0	-90.00	0.0
NECK	0.0		90.00	0.0

OCCUPANT JOINT PARAMETERS

	LINEAR ANGULAR DEFLECTION COEF. (IN-LBS/DEG)	QUADRATIC ANGULAR DEFLECTION COEF. (IN-LBS/DEG**2)	CUBIC ANGULAR DEFLECTION COEF. (IN-LBS/DEG**3)	CONSERVED-ABSORBED ENERGY RATIO
HEAD-NECK FORWARD	31.20000	0.0	0.0	1.00
NECK-UPPER TORSO FORWARD	31.20000	0.0	0.0	1.00
UPPER SPINE	50.00000	0.0	0.0	1.00
LOWER SPINE	50.00000	0.0	0.0	1.00
HIP	16.00000	0.0	0.0	1.00
KNEE	0.0	0.0	0.0	1.00
UPPER ARM-UPPER TORSO	0.0	0.0	0.0	0.0
ELBOW	0.0	0.0	0.0	0.0
HEAD-NECK REAR	31.20000	0.0	0.0	1.00
NECK-UPPER TORSO REAR	31.20000	0.0	0.0	1.00
NECK (EXTENSIBLE) **	751.00000	0.0	757.00000	NA
SHOULDER (EXTENSIBLE) **	1000.00000	0.0	800.00000	1.00
NECK (COMPRESSIBLE) **	751.00000	0.0	757.00000	NA

** UNITS FOR THE NECK (EXTENSIBLE),(COMPRESSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB/IN) (LB/IN**2) (LB/IN**3)

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 3 of 8).

	VISCOUS FRICTION	CONSTANT FRICTION COEFFICIENT	VELOCITY THRESHOLD FOR CONST. FRICTION	POS.JOINT STOP	NEG.JOINT STOP
	(IN LBS SEC/DEG)	(IN-LBS)	(DEG/SEC)	(DEG)	(DEG)
HEAD-NECK FORWARD	0.0	0.0	0.0	0.0	0.0
NECK-UPPER TORSO FORWARD	0.0	0.0	0.0	0.0	0.0
UPPER SPINE	0.0	0.0	0.0	0.0	0.0
LOWER SPINE	0.0	0.0	0.0	0.0	0.0
HIP	0.0	0.0	0.0	0.0	0.0
KNEE	0.0	0.0	0.0	0.0	0.0
UPPER ARM-UPPER TORSO	0.0	0.0	0.0	0.0	0.0
ELBOW	0.0	0.0	0.0	0.0	0.0
HEAD-NECK REAR	0.0	0.0	0.0	0.0	0.0
NECK-UPPER TORSO REAR	0.0	0.0	0.0	0.0	0.0
NECK (EXTENSIBLE) **	1.9800	NA	NA	NA	NA
SHOULDER (EXTENSIBLE)**	2.5000	NA	NA	0.0	NA
NECK (COMPRESSIBLE) **	1.9800	NA	NA	NA	NA

**UNITS FOR THE NECK (EXTENSIBLE),(COMPRESSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB SEC/IN) (IN)

MUSCLE TENSION COEFFICIENTS

	STIFFNESS COEF. A1 (K=A1+A2|M1|) (IN-LBS/DEG)	STIFFNESS COEF. A2 (K=A1+A2|M1|) (1/DEG)	DAMPING COEF. A3 (C=A3[M]) (SEC/DEG)	INIT. MUSCLE FORCE OR MOMENT RESULTANT (IN-LBS)	NAME ASSIGNED TO MUSCLE TENSION TABLE (M) VS TIME
HEAD-NECK	0.0	0.0	0.0	0.0	
NECK-UPPER TORSO	0.0	0.0	0.0	0.0	
UPPER SPINE	0.0	0.0	0.0	0.0	
LOWER SPINE	0.0	0.0	0.0	0.0	
HIP	0.0	0.0	0.0	0.0	
KNEE	0.0	0.0	0.0	0.0	
UPPER ARM-UPPER TORSO	0.0	0.0	0.0	0.0	
ELBOW	0.0	0.0	0.0	0.0	
SHOULDER-UPPER TORSO	0.0	0.0	0.0	0.0	
NECK (EXTENSIBLE) **	0.0	0.0	0.0	0.0	
SHOULDER (EXTENSIBLE)**	0.0	0.0	0.0	0.0	

**UNITS FOR NECK (EXTENSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB/IN) (1/IN) (SEC/IN) (LB)

TABLE 3. Output of Baseline Input Data Set. Side Impact. (Page 4 of 8).

INITIAL CONDITIONS FOR UPPER TORSO AND NECK

INITIAL (X,Z) COORDINATE OF CENTERLINE POINT NUM.1 RELATIVE TO VEHICLE ORIGIN IN (IN) (0.0 , -29.00)

INITIAL (X,Z) VELOCITY OF CENTERLINE POINT NUM. 1 RELATIVE TO VEHICLE ORIGIN IN (FT/SEC) (0.0 , 0.0)

INITIAL NECK LENGTH 4.89(IN)

INITIAL RATE OF EXTENSION OF NECK 0.0 (IN/SEC)

INITIAL SHOULDER LOCATION AND VELOCITY RELATIVE TO UPPER TORSO ATTACHMENT

INITIAL (X,Z) COORDINATES OF SHOULDER JOINT RELATIVE TO UPPER TORSO ATTACHMENT POINT IN (IN)(0.0 , 0.0)

INITIAL (X,Z) VELOCITY IN UPPER TORSO SYSTEM IN (IN/SEC) (0.0 , 0.0)

OCCUPANT ACCELEROMETER AND BELT ATTACHMENT PARAMETERS

DISTANCE ALONG HEAD-NECK CENTERLINE TO HEAD ACCELEROMETER 3.19(IN)

DISTANCE ALONG UPPER TORSO CENTERLINE TO CHEST ACCELEROMETER 2.13(IN)

VEHICLE INITIAL CONDITIONS AND ACCELEROMETER LOCATION

(X,Z) COORDINATES OF VEHICLE ORIGIN IN (IN) (0.0 , 0.0)

INITIAL (X,Z) VEHICLE VELOCITY IN (FT/SEC) (0.0 , 0.0)

INITIAL VEHICLE PITCH ANGLE 0.0 (DEG)

INITIAL VEHICLE PITCH ANGULAR VELOCITY 0.0 (DEG/SEC)

(X,Z) COORDINATES OF VEHICLE ACCELEROMETER IN (IN) (0.0 , 0.0)

MASS OF VEHICLE 0.0 (LBS SEC**2/IN)

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 5 of 8).

```
                              ELLIPSES ATTACHED TO THE HEAD

NAME OF ELLIPSE IS HEAD                      ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG X-COORDINATE=  4.490(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG Z-COORDINATE=  3.100(IN)

                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE HEAD

          WINDOW

          HEADER

          B-PILLAR

                              ELLIPSES ATTACHED TO THE UPPER TORSO

NAME OF ELLIPSE IS UPPER TORSO            ELLIPSE MATERIAL IS THORAX MATERIAL        FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG X-COORDINATE=  4.832(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG Z-COORDINATE=  6.780(IN)

                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE UPPER TORSO

          DOOR

                              ELLIPSES ATTACHED TO THE MIDDLE TORSO

NAME OF ELLIPSE IS CENTER TORSO              ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -1.956(IN)       SEMI-AXIS LENGTH ALONG X-COORDINATE=  6.876(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG Z-COORDINATE=  6.350(IN)

                              ELLIPSES ATTACHED TO THE LOWER TORSO

NAME OF ELLIPSE IS LOWER TORSO               ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG X-COORDINATE=  7.434(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)      SEMI-AXIS LENGTH ALONG Z-COORDINATE=  6.940(IN)

                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LOWER TORSO

          SEAT CUSHION

          HIP PANEL
```

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 6 of 8).

ELLIPSES ATTACHED TO THE UPPER LEG

NAME OF ELLIPSE IS LEFT UPPER LEG ELLIPSE IS ASSUMED RIGID FRICTION CLASS IS 1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 0.782(IN) SEMI-AXIS LENGTH ALONG X-COORDINATE= 3.729(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -4.450(IN) SEMI-AXIS LENGTH ALONG Z-COORDINATE= 3.740(IN)

REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT UPPER LEG

SEAT CUSHION

HIP PANEL

NAME OF ELLIPSE IS RIGHT UPPER LEG ELLIPSE IS ASSUMED RIGID FRICTION CLASS IS 1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 0.782(IN) SEMI-AXIS LENGTH ALONG X-COORDINATE= 3.729(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 4.450(IN) SEMI-AXIS LENGTH ALONG Z-COORDINATE= 3.740(IN)

REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT UPPER LEG

SEAT CUSHION

ELLIPSES ATTACHED TO THE LOWER LEG

NAME OF ELLIPSE IS LEFT LOWER LEG ELLIPSE IS ASSUMED RIGID FRICTION CLASS IS 1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -0.364(IN) SEMI-AXIS LENGTH ALONG X-COORDINATE= 7.338(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 4.450(IN) SEMI-AXIS LENGTH ALONG Z-COORDINATE= 2.230(IN)

REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT LOWER LEG

DOOR SILL

NAME OF ELLIPSE IS LEFT FOOT ELLIPSE IS ASSUMED RIGID FRICTION CLASS IS 1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 5.322(IN) SEMI-AXIS LENGTH ALONG X-COORDINATE= 3.999(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 4.450(IN) SEMI-AXIS LENGTH ALONG Z-COORDINATE= 1.800(IN)

REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT FOOT

FLOOR

DOOR SILL

NAME OF ELLIPSE IS RIGHT FOOT ELLIPSE IS ASSUMED RIGID FRICTION CLASS IS 1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 5.322(IN) SEMI-AXIS LENGTH ALONG X-COORDINATE= 3.999(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -4.450(IN) SEMI-AXIS LENGTH ALONG Z-COORDINATE= 1.800(IN)

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 7 of 8).

```
                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT FOOT

          FLOOR

NAME OF ELLIPSE IS RIGHT LOWER LEG                  ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -0.364(IN)        SEMI-AXIS LENGTH ALONG X-COORDINATE=  7.338(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -4.450(IN)        SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.230(IN)

                              ELLIPSES ATTACHED TO THE UPPER ARM

NAME OF ELLIPSE IS LEFT UPPER ARM                   ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG X-COORDINATE=  6.880(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.640(IN)

                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT UPPER ARM

          B-PILLAR

          DOOR

                              ELLIPSES ATTACHED TO THE LOWER ARM

NAME OF ELLIPSE IS LEFT LOWER ARM                   ELLIPSE IS ASSUMED RIGID                FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG X-COORDINATE=  0.818(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.110(IN)

                    REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT LOWER ARM

          DOOR
```

TABLE 3. Output of Baseline Input Data Set. Side Impact (Page 8 of 8).

```
1                               SIDE IMPACT #1 -- 12 DEGREES                                100
2     3D-2D:  LEFT ARM-AR                                                                   200
3     M LINKS/RIGHT ARM-L                                                                   300
4     UMPED WITH TORSO/RI                                                                   400
5     GHT AND LEFT LEGS-L                                                                   500
6     UMPED TOGETHER                                                                        600
7     OCCUPANT IS STRUCK                                                                    700
8     FROM LEFT SIDE                                                                        800
9     1.       1.       32.174  0.       0.       100.     1.       1.       205.           101
10    0.       0.       0.      0.       0.       0.       10.      .000001  2.             102
11    .2       .02      600.    500.     30.      .05      10.      1.       1.             103
12    HEAD              WINDOW                                                              106
13    HEAD              HEADER                                                              106
14    HEAD              B-PILLAR                                                            106
15    UPPER TORSO       DOOR                                                                106
16    LOWER TORSO       SEAT CUSHION                                                        106
17    LOWER TORSO       HIP PANEL                                                           106
19    RIGHT UPPER LEG   SEAT CUSHION                                                        106
20    RIGHT FOOT        FLOOR                                                               106
21    LEFT UPPER LEG    SEAT CUSHION                                                        106
22    LEFT UPPER LEG    HIP PANEL                                                           106
23    LEFT LOWER LEG    DOOR STILL                                                          106
24    LEFT FOOT         FLOOR                                                               106
25    LEFT FOOT         DOOR STILL                                                          106
26    LEFT UPPER ARM    B-PILLAR                                                            106
26.1  LEFT UPPER ARM    DOOR                                                                106
26.2  LEFT LOWER ARM    DOOR                                                                106
27    0.       0.       0.      0.       0.       0.       1.       0.       1.             107
28    0.       0.       0.      0.       0.       0.       1.       0.       1.             108
29    1.       1.       0.      0.       0.       0.       0.       0.       1.             109
30    1.       1.       0.      0.       0.       1.       1.       1.       1.             110
31    0.       0.       1.      0.       0.       0.       0.       0.       0.             111
32    HEAD                               1.       1.                                        219
33    HEAD              0.      0.       4.4897   3.1                                       220
34    UPPER TORSO       THORAX MATERIAL  2.       1.                                        219
35    UPPER TORSO       0.      0.       4.83205  6.78                                      220
36    CENTER TORSO                       3.       1.                                        219
37    CENTER TORSO      -1.9563 0.       6.87638  6.35                                      220
38    LOWER TORSO                        4.       1.                                        219
39    LOWER TORSO       0.      0.       7.4339   6.94                                      220
40    LEFT UPPER LEG                     5.       1.                                        219
41    LEFT UPPER LEG    .781836 -4.45    3.72875  3.74                                      220
42    LEFT LOWER LEG                     6.       1.                                        219
43    LEFT LOWER LEG    -.36406 4.45     7.33778  2.23                                      220
44    LEFT FOOT                          6.       1.                                        219
45    LEFT FOOT         5.32208 4.45     3.99875  1.8                                       220
46    RIGHT UPPER LEG                    5.       1.                                        219
47    RIGHT UPPER LEG   .781836  4.45    3.72875  3.74                                      220
48    RIGHT FOOT                         6.       1.                                        219
49    RIGHT FOOT        5.32208 -4.45    3.99875  1.8                                       220
50    LEFT UPPER ARM                     7.       1.                                        219
51    LEFT UPPER ARM    0.      0.       6.88     1.64                                      220
52    LEFT LOWER ARM                     8.       1.                                        219
53    LEFT LOWER ARM    0.      0.       .817523  1.11                                      220
54    RIGHT LOWER LEG                    6.       1.                                        219
55    RIGHT LOWER LEG   -.36406 -4.45    7.33778  2.23                                      220
56    0.       8.80333  4.69511 4.89074  4.24              10.7     1.56504  -7.6           201
57    3.22789  2.15193  2.24974 2.44537  2.1982   6.05145  5.25     .573486  .76            202
58    .025     .095     .031    .098     .090     .050     .012     .012     .0047          203
59    .297     2.17     .31     1.78     .77      1.0      .137     .27                     204
```

TABLE 4. Listing of Baseline Side Impact Input Data File. (Page 1 of 3).

```
31.2      0.        0.        0.        0.        0.        0.        0.        1.                  205
31.2      0.        0.        0.        0.        0.        0.        0.        1.                  206
50.       0.        0.        0.        0.        0.        0.        0.        1.                  207
50.       0.        0.        0.        0.        0.        0.        0.        1.                  208
16.       0.        0.        0.        0.        0.        0.        0.        1.                  209
0.        0.        0.        0.        0.        0.        0.        0.        1.                  210
                                                                                                  211
                                                                                                  212
751.      0.        757.      1.98                                                                213
1000.     0.        800.      2.5                           0.                  1.                  214
31.2      0.        0.        0.        0.        0.        0.        0.        1.                  215
31.2      0.        0.        0.        0.        0.        0.        0.        1.                  216
751.      0.        757.      1.98                                                                242
0.        0.        0.        0.        -180.     180.      0.        0.                            217
3.188     2.125     0.                                                                            218
THORAX MATERIAL     0.        0.        50.       100.      101.      0.        0.                  221
THORAX MATERIAL     1.                                      THORAX    ZERO      GRRATIO             222
THORAX    -1.       4080.                                                                         225
90.       90.       90.       90.       90.       -90.      -90.      -90.      90.                 301
0.        0.        -29.      0.        4.89074   0.                                                303
HEADER              PANEL MATERIAL      0.        1.        1.        1.                            401
DOOR SILL           PANEL MATERIAL      0.        1.        1.        1.                            401
B-PILLAR            PILLAR MATERIAL     0.        1.        1.        1.                            401
HIP PANEL           PANEL MATERIAL      0.        1.        1.        1.                            401
WINDOW              GLASS MATERIAL      0.        1.        1.        1.                            401
DOOR                DOOR MATERIAL       0.        1.        1.        1.                            401
FLOOR               FLOOR MATERIAL      0.        1.        1.        1.                            401
SEAT CUSHION        SEAT MATERIAL       0.        1.        1.        1.                            401
HEADER              1.        1.        1.        0.        1.                                      402
DOOR SILL           1.        1.        1.        0.        1.                                      402
B-PILLAR            1.        1.        1.        0.        1.                                      402
HIP PANEL           1.        1.        1.        0.        1.                                      402
WINDOW              1.        1.        1.        0.        1.                                      402
DOOR                1.        1.        1.        0.        1.                                      402
FLOOR               1.        1.        1.        0.        1.                                      402
SEAT CUSHION        1.        1.        1.        0.        1.                                      402
PANEL MATERIAL      0.        0.        50.       100.      101.      0.        0.                  403
PILLAR MATERIAL     0.        0.        50.       100.      101.      0.        0.                  403
DOOR MATERIAL       0.        0.        50.       100.      101.      0.        0.                  403
FLOOR MATERIAL      0.        0.        50.       100.      101.      0.        0.                  403
SEAT MATERIAL       0.        0.        50.       100.      101.      0.        0.                  403
GLASS MATERIAL      0.        0.        .001      .5        .6        0.        0.                  403
PANEL MATERIAL      1.                                      PANEL     ZERO      GRRATIO             404
PILLAR MATERIAL     1.                                      PILLAR    ZERO      GRRATIO             404
DOOR MATERIAL       1.                                      DOOR      ZERO      GRRATIO             404
FLOOR MATERIAL      1.                                      FLOOR     ZERO      GRRATIO             404
SEAT MATERIAL       1.                                      SEAT      ZERO      GRRATIO             404
GLASS MATERIAL      1.                                      GLASS     ZERO      GRRATIO             404
GRRATIO   -1.       0.                                                                            405
GRRATIO   -1.       1.                                                                            406
PANEL     0.        0.                                                                            407
PANEL     3.        3000.                                                                         407
PANEL     4.        13000.                                                                        407
PILLAR    -1.       4000.                                                                         407
DOOR      -1.       1000.     -562.5    1031.25   -562.5    93.75                                 407
FLOOR     -1.       860.                                                                          407
SEAT      -1.       40.                                                                           407
GLASS     -1.       10000.                                                                        407
ZERO      -1.       0.                                                                            408
HEADERLINE          HEADER              4.5       .281      1.        1.                          409
```

TABLE 4. Listing of Baseline Side Impact Input Data File. (Page 2 of 3).

120	DOOR SILL LINE		DOOR SILL		7.	0.	1.	1.		409
121	B-PILLAR LINE		B-PILLAR		7.	.284	1.	1.		409
122	HIP PANEL LINE		HIP PANEL		7.5	0.	1.	1.		409
123	WINDOW LINE		WINDOW		4.5	0.	1.	1.		409
124	DOORLINE		DOOR		6.8	0.	1.	1.		409
125	FLOORLINE		FLOOR		4.	0.	1.	1.		409
126	SEAT CUSHION LN.		SEAT CUSHION		7.5	0.	-1.	1.		409
127	HEADERLINE		1.							410
128	DOOR SILL LINE		1.							410
129	B-PILLAP LINE		1.							410
130	HIP PANEL LINE		4.							410
131	WINDOW LINE		1.							410
132	DOORLINE		4.							410
133	FLOORLINE		1.							410
134	SEAT CUSHION LN.		1.							410
135	HEADERLINE		-1.	-10.5	-41.	0.	-53.			411
136	DOOR SILL LINE		-1.	-15.5	0.	-15.5	-26.			411
137	B-PILLAR LINE		-1.	-15.5	-26.	-10.5	-41.			411
138	HIP PANEL LINE		0.	-12.5	0.	-12.5	-40.			411
139	HIP PANEL LINE		5.	-12.5	0.	-12.5	-40.			411
140	HIP PANEL LINE		30.	-7.5	0.	-7.5	-40.			411
141	HIP PANEL LINE		100.	-7.5	0.	-7.5	-40.			411
142	WINDOW LINE		-1.	-20.	-18.	-9.	-50.			411
143	DOORLINE		0.	-15.5	0.	-15.5	-40.			411
144	DOORLINE		5.	-15.5	0.	-15.5	-40.			411
145	DOORLINE		30.	-10.5	0.	-10.5	-40.			411
146	DOORLINE		100.	-10.5	0.	-10.5	-40.			411
147	FLOORLINE		-1.	-22.	.00001	22.	.00001			411
148	SEAT CUSHION LN.		-1.	-22.	-10.35	12.	-10.35			411
149	1.	1.	0.							412
150	0.	0.	0.	0.	0.	0.	0.	0.	0.	601
151	4.	1.	1.							602
152	0.	0.	5.	8.5	95.	8.5	100.	0.		
153	2.	0.	1.							603
154	0.	0.	200.	0.						
155	2.	0.								604
156	0.	0.	200.	0.						
1000										1000
1001	-1									1001
1002	1.	0.	-40.	40.	3.	-55.	5.	1.		1500
1003	21.	0.	0.	1.	1.	0.	1.	0.	0.	1501
1004										1600

END OF FILE

TABLE 4. Listing of Baseline Side Impact Input Data File. (Page 3 of 3).

5.3 PEDESTRIAN IMPACT INPUT DATA

This part of the report contains the numerical details of the baseline MVMA 2-D pedestrian impact data set. Table 5 contains the output of the input data set after the input file has been processed by the IN section of the program. Not all pages are included. Those which are contain details of the linkage, joints, masses, inertial properties, contact ellipses, and program controls. Table 6 is a copy of the baseline data file which was constructed for the exercise.

SIMULATION CONTROL DATA

NO RESTRAINT BELTS PRESENT

FIXED RUNGE-KUTTA INTEGRATION METHOD IS USED

ACCELERATION DUE TO GRAVITY 32.1740(FT/SEC**2)

MINIMUM ACCELERATION MAGNITUDE 0.0 (IN/SEC**2) OR (RAD/SEC**2)

BEGINNING TIME 0.0 (MSEC)

FINAL TIME 1000.00000(MSEC)

NUMERICAL INTEGRATION STEP SIZE 5.00000(MSEC)

OUTPUT PRINT INCREMENT 5.00000(MSEC)

OUTPUT PLOT INCREMENT 540.00000(MSEC) IF ZERO, NO PLOT RECORDING

ENGLISH UNITS ARE USED

STEERING COLUMN INTERACTION IS NOT DESIRED

AIRBAG INTERACTION IS NOT DESIRED

ELLIPSE-ELLIPSE CONTACTS SPECIFIED ON 106 CARDS ARE ALLOWED

ELLIPSE-REGION CONTACTS SPECIFIED ON 106 CARDS ARE ALLOWED

ELLIPSE-ELLIPSE CONTACTS CAN OCCUR

LENGTH OF SCALING RAMP TO INSURE CONTINUITY IN CONTACT FRICTION 10.000(IN/SEC)

RELATIVE ERROR TOLERANCE FOR SINGULARITY IN MATRIX INVERSION STEP 0.000001

CPU TIME LIMIT FOR EXECUTION 2(MIN)

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 1 of 9).

JUN 16, 1981 10:24:11 PEDESTRIAN #1 -- 15 DEGREES VER. 4 PAGE 2-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS IMPACT FROM RT

INTEGRATION CONTROLS

MAXIMUM STEP TO SEARCH FOR BALANCE IN SHARED DEFLECTION	0.200(IN)
MINIMUM STEP TO SEARCH FOR BALANCE IN SHARED DEFLECTION	0.020000(IN)
MAXIMUM FORCE FOR RIGID-RIGID CONTACT	600.00(LB)
LINEAR ELASTIC COEFFICIENT FOR RIGID-RIGID CONTACT	500.00(LB/IN)
MAXIMUM NUMBER OF ITERATIONS TO FIND FORCE BALANCE	30
FRACTION OF CURRENT RAMP LENGTH FOR VELOCITY CHANGE IN MOVING CONTACT LINES	0.050
NUMBER OF INTEGRATION STEPS FOR MAXIMUM RAMP LENGTH FOR VELOCITY CHANGE IN MOVING CONTACT LINES	10.
MINIMUM RATIO OF SHORTER TO LONGER SEMI-MAJOR AXIS FOR ELLIPSE TO BE TREATED AS CIRCLE	1.000
FRACTIONAL POSITION OF CIRCLE CENTER ALONG SEMI-MAJOR AXIS RELATIVE TO POSITION FOR CIRCLE-ELLIPSE TANGENCY AT END OF AXIS	1.000

DEBUGGING CONTROLS

TIME TO SET DEBUG SWITCHES (MSEC)	0.0	2000.0000	0.0	0.0
DEBUG SWITCH SETTING IN HEXADECIMAL FORMAT	00000000	00000000	00000000	00000000
TIME TO SET DEBUG SWITCHES (MSEC)	0.0	0.0	0.0	0.0
DEBUG SWITCH SETTING IN HEXADECIMAL FORMAT	00000000	00000000	00000000	00000000

DEBUG CONTROLS ARE TO OPERATE FOR ALL INTEGRATION EVALUATIONS AT EACH TIME

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 2 of 9).

BODY PARAMETERS

BODY SEGMENT LENGTHS (IN)		END OF LINK TO CENTER-OF-MASS LENGTHS (IN)		MASS OF BODY SEGMENTS (LBS SEC**2 IN)	
HEAD LENGTH=	0.0	HEAD/NECK JOINT-HEAD CM LENGTH=	3.19	HEAD MASS=	0.0250
UPPER TORSO LENGTH=	8.69	NECK-CHEST CM LENGTHS=	3.11	CHEST MASS=	0.1260
MIDDLE TORSO LENGTH=	8.49	UPPER TORSO JOINT-MIDDLE TORSO CM LENGTH=	8.49	MIDDLE TORSO MASS=	0.0790
LOWER TORSO LENGTH=	0.0	LOWER TORSO JOINT LOWER TORSO CM LENGTH=	12.66	LOWER TORSO MASS=	0.0800
HIP-KNEE LENGTH=	13.41	HIP-UPPER LEG CM LENGTH=	6.95	UPPER LEG (BOTH LEGS)=	0.0540
UPPER TORSO-SHOULDER=	0.0	KNEE-LOWER LEG CM LENGTH=	10.32	LOWER LEG (BOTH LEGS)=	0.0250
SHOULDER-ELBOW LENGTH=	10.64	SHOULDER-UPPER ARM CM LENGTH=	5.22	UPPER ARM (BOTH ARMS)=	0.0120
X REST POINT OF SHOULDER=	1.55	ELBOW-LOWER ARM CM LENGTH=	3.98	LOWER ARM (BOTH ARMS)=	0.0120
Z REST POINT OF SHOULDER=	6.60			HEAD-NECK MASS=	0.0036
				UPPER TORSO-NECK MASS=	0.0011

	MOMENTS OF INERTIA (ABOUT CM) (LBS SEC**2 IN)	"NATURAL" LINK ANGLES (FOR ZERO TORQUE) (DEG)	INITIAL BODY LINK ANGLES (RELATIVE TO VEHICLE) (DEG)	INITIAL ANGULAR VELOCITIES (RELATIVE TO VEHICLE) (DEG/SEC)
HEAD	0.2970	0.0	90.00	0.0
UPPER TORSO	2.8800	0.0	90.00	0.0
MIDDLE TORSO	2.1900	0.0	90.00	0.0
LOWER TORSO	1.0000	0.0	90.00	0.0
UPPER LEG	0.7700	0.0	-90.00	0.0
LOWER LEG	1.0000	0.0	-90.00	0.0
UPPER ARM	0.1370	-12.00	-78.00	0.0
LOWER ARM	0.2700	27.00	-105.00	0.0
NECK	0.0		90.00	0.0

OCCUPANT JOINT PARAMETERS

	LINEAR ANGULAR DEFLECTION COEF. (IN-LBS/DEG)	QUADRATIC ANGULAR DEFLECTION COEF. (IN-LBS/DEG**2)	CUBIC ANGULAR DEFLECTION COEF. (IN-LBS/DEG**3)	CONSERVED-ABSORBED ENERGY RATIO
HEAD-NECK FORWARD	31.20000	0.0	0.0	1.00
NECK-UPPER TORSO FORWARD	31.20000	0.0	0.0	1.00
UPPER SPINE	50.00000	0.0	0.0	1.00
LOWER SPINE	16.00000	0.0	0.0	1.00
HIP	16.00000	0.0	0.0	1.00
KNEE	0.0	0.0	0.0	0.0
UPPER ARM-UPPER TORSO	-10.00000	10.00000	0.0	0.25
ELBOW	-10.00000	10.00000	0.0	0.25
HEAD-NECK REAR	31.20000	0.0	0.0	1.00
NECK-UPPER TORSO REAR	31.20000	0.0	0.0	1.00
NECK (EXTENSIBLE) **	751.00000	0.0	757.00000	NA
SHOULDER (EXTENSIBLE)**	10.00000	0.0	100.00000	0.50
NECK (COMPRESSIBLE) **	751.00000	0.0	757.00000	NA

** UNITS FOR THE NECK (EXTENSIBLE),(COMPRESSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB/IN) (LB/IN**2) (LB/IN**3)

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 3 of 9).

JUN 16, 1981 10:24:11 PEDESTRIAN #1 -- 15 DEGREES VER. 4 PAGE 4-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS IMPACT FROM RT

	VISCOUS FRICTION (IN LBS SEC/DEG)	CONSTANT FRICTION COEFFICIENT (IN-LBS)	VELOCITY THRESHOLD FOR CONST. FRICTION (DEG/SEC)	POS.JOINT STOP (DEG)	NEG.JOINT STOP (DEG)
HEAD-NECK FORWARD	0.0	0.0	0.0	0.0	0.0
NECK-UPPER TORSO FORWARD	0.0	0.0	0.0	0.0	0.0
UPPER SPINE	0.0	0.0	0.0	0.0	0.0
LOWER SPINE	0.0	0.0	0.0	0.0	0.0
HIP	0.0	0.0	0.0	0.0	0.0
KNEE	0.0	505.50	1.00	0.0	0.0
UPPER ARM-UPPER TORSO	0.0	0.0	0.0	18.00	-42.00
ELBOW	0.0	0.0	0.0	57.00	-3.00
HEAD-NECK REAR	0.0	0.0	0.0	0.0	0.0
NECK-UPPER TORSO REAR	0.0	0.0	0.0	0.0	0.0
NECK (EXTENSIBLE) **	1.9800	NA	NA	NA	NA
SHOULDER (EXTENSIBLE)**	0.0	NA	NA	3.00	NA
NECK (COMPRESSIBLE) **	1.9800	NA	NA	NA	NA

**UNITS FOR THE NECK (EXTENSIBLE),(COMPRESSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB SEC/IN) (IN)

MUSCLE TENSION COEFFICIENTS

	STIFFNESS COEF. A1 (K=A1+A2|M1|) (IN-LBS/DEG)	STIFFNESS COEF. A2 (K=A1+A2|M1|) (1/DEG)	DAMPING COEF. A3 (C=A3[M]) (SEC/DEG)	INIT. MUSCLE FORCE OR MOMENT RESULTANT (IN-LBS)	NAME ASSIGNED TO MUSCLE TENSION TABLE (M) VS TIME
HEAD-NECK	0.0	0.0	0.0	0.0	
NECK-UPPER TORSO	0.0	0.0	0.0	0.0	
UPPER SPINE	0.0	0.0	0.0	0.0	
LOWER SPINE	0.0	0.0	0.0	0.0	
HIP	0.0	0.0	0.0	0.0	
KNEE	0.0	0.0	0.0	0.0	
UPPER ARM-UPPER TORSO	0.0	0.0	0.0	0.0	
ELBOW	0.0	0.0	0.0	0.0	
SHOULDER-UPPER TORSO	0.0	0.0	0.0	0.0	
NECK (EXTENSIBLE) **	0.0	0.0	0.0	0.0	
SHOULDER (EXTENSIBLE)**	0.0	0.0	0.0	0.0	

**UNITS FOR NECK (EXTENSIBLE) AND SHOULDER (EXTENSIBLE) PARAMETERS ARE GIVEN IN THE ROW BELOW
(LB/IN) (1/IN) (SEC/IN) (LB)

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 4 of 9).

INITIAL CONDITIONS FOR UPPER TORSO AND NECK

INITIAL (X,Z) COORDINATE OF CENTERLINE POINT NUM.1 RELATIVE TO VEHICLE ORIGIN IN (IN) (0.0 , -47.63)

INITIAL (X,Z) VELOCITY OF CENTERLINE POINT NUM. 1 RELATIVE TO VEHICLE ORIGIN IN (FT/SEC) (14.6667, 0.0)

INITIAL NECK LENGTH 4.83(IN)

INITIAL RATE OF EXTENSION OF NECK 0.0 (IN/SEC)

INITIAL SHOULDER LOCATION AND VELOCITY RELATIVE TO UPPER TORSO ATTACHMENT

INITIAL (X,Z) COORDINATES OF SHOULDER JOINT RELATIVE TO UPPER TORSO ATTACHMENT POINT IN (IN) (0.0 , 0.0)

INITIAL (X,Z) VELOCITY IN UPPER TORSO SYSTEM IN (IN/SEC) (0.0 , 0.0)

OCCUPANT ACCELEROMETER AND BELT ATTACHMENT PARAMETERS

DISTANCE ALONG HEAD-NECK CENTERLINE TO HEAD ACCELEROMETER 3.19(IN)

DISTANCE ALONG UPPER TORSO CENTERLINE TO CHEST ACCELEROMETER 2.13(IN)

VEHICLE INITIAL CONDITIONS AND ACCELEROMETER LOCATION

(X,Z) COORDINATES OF VEHICLE ORIGIN IN (IN) (0.0 , 0.0)

INITIAL (X,Z) VEHICLE VELOCITY IN (FT/SEC) (-14.67, 0.0)

INITIAL VEHICLE PITCH ANGLE 0.0 (DEG)

INITIAL VEHICLE PITCH ANGULAR VELOCITY 0.0 (DEG/SEC)

(X,Z) COORDINATES OF VEHICLE ACCELEROMETER IN (IN) (0.0 , 0.0)

MASS OF VEHICLE 0.0 (LBS SEC**2/IN)

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 5 of 9).

```
JUN 16, 1981   10:24:11                        PEDESTRIAN #1 -- 15 DEGREES                              VER. 4      PAGE   9-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS     IMPACT FROM RT

                                          ELLIPSES ATTACHED TO THE HEAD

 NAME OF ELLIPSE IS HEAD                             ELLIPSE IS ASSUMED RIGID                          FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)            SEMI-AXIS LENGTH ALONG X-COORDINATE=  4.434(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)            SEMI-AXIS LENGTH ALONG Z-COORDINATE=  3.100(IN)

                               REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE HEAD

                    WINDSHIELD

                    HOOD

                    CAR FRONT

                    ROOF

                                          ELLIPSES ATTACHED TO THE UPPER TORSO

 NAME OF ELLIPSE IS UPPER TORSO                      ELLIPSE IS ASSUMED RIGID                          FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -0.983(IN)             SEMI-AXIS LENGTH ALONG X-COORDINATE=  4.772(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)            SEMI-AXIS LENGTH ALONG Z-COORDINATE=  5.800(IN)

                               REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE UPPER TORSO

                    ROOF

                    WINDSHIELD

                    HOOD

                    CAR FRONT

 NAME OF ELLIPSE IS CENTER TORSO                     ELLIPSE IS ASSUMED RIGID                          FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  7.759(IN)             SEMI-AXIS LENGTH ALONG X-COORDINATE=  6.790(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)            SEMI-AXIS LENGTH ALONG Z-COORDINATE=  5.750(IN)

                                          ELLIPSES ATTACHED TO THE MIDDLE TORSO

 NAME OF ELLIPSE IS LOWER TORSO                      ELLIPSE IS ASSUMED RIGID                          FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.426(IN)             SEMI-AXIS LENGTH ALONG X-COORDINATE=  7.341(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)            SEMI-AXIS LENGTH ALONG Z-COORDINATE=  5.500(IN)

                               REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LOWER TORSO

                    WINDSHIELD
```

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 6 of 9).

```
JUN 16, 1981  10:24:11                        PEDESTRIAN #1 -- 15 DEGREES                                    VER. 4      PAGE  10-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS   IMPACT FROM RT

                      REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LOWER TORSO

              HOOD

              CAR FRONT

              GRLL


                                  ELLIPSES ATTACHED TO THE LOWER TORSO

 NAME OF ELLIPSE IS LEFT UPPER LEG                          ELLIPSE IS ASSUMED RIGID                        FRICTION CLASS IS    1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -5.460(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE= 11.030(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.500(IN)

                      REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT UPPER LEG

              HOOD

              GRLL

              CAR FRONT

                      ELLIPSES WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT UPPER LEG

              RIGHT UPPER LEG

 NAME OF ELLIPSE IS LEFT LOWER LEG                          ELLIPSE IS ASSUMED RIGID                        FRICTION CLASS IS    1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  8.005(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE=  8.220(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.230(IN)

                      REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT LOWER LEG

              BUMPER

 NAME OF ELLIPSE IS LEFT FOOT                               ELLIPSE IS ASSUMED RIGID                        FRICTION CLASS IS    2

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= 16.752(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE=  1.085(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.800(IN)

                      REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE LEFT FOOT

              GROUND

              BUMPER

              GRLL
```

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 7 of 9).

```
JUN 16, 1981   10:24:11                               PEDESTRIAN #1 -- 15 DEGREES                             VER. 4      PAGE  11-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS      IMPACT FROM RT

                                          ELLIPSES ATTACHED TO THE UPPER LEG

 NAME OF ELLIPSE IS RIGHT UPPER LEG                     ELLIPSE IS ASSUMED RIGID                      FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -1.427(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE= 10.652(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.500(IN)

                            REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT UPPER LEG

                 HOOD

                 GRLL

                 CAR FRONT

                            ELLIPSES WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT UPPER LEG

                 LEFT UPPER LEG

                                          ELLIPSES ATTACHED TO THE LOWER LEG

 NAME OF ELLIPSE IS RIGHT KNEE                          ELLIPSE IS ASSUMED RIGID                      FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -5.699(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE=  1.740(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.230(IN)

                            REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT KNEE

                 BUMPER

 NAME OF ELLIPSE IS RIGHT SHIN                          ELLIPSE IS ASSUMED RIGID                      FRICTION CLASS IS      1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  2.342(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE=  6.305(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  2.230(IN)

                            REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT SHIN

                 BUMPER

 NAME OF ELLIPSE IS RIGHT FOOT                          ELLIPSE IS ASSUMED RIGID                      FRICTION CLASS IS      2

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  8.642(IN)          SEMI-AXIS LENGTH ALONG X-COORDINATE=  1.520(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -2.800(IN)          SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.800(IN)

                            REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT FOOT

                 GROUND

                 GRLL
```

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 8 of 9).

```
JUN 16, 1981  10:24:11                    PEDESTRIAN #1 -- 15 DEGREES                                   VER. 4     PAGE  12-00
3D-2D:RT ARM-ARM LINKS/LT ARM-LUMPED W.TORSO/RT LEG-LEG LINKS/LT LEG-LOWER TORSO LINK/TORSO-UP AND MID TORSO LINKS   IMPACT FROM RT

                                          ELLIPSES ATTACHED TO THE UPPER ARM

 NAME OF ELLIPSE IS RIGHT UPPER ARM                   ELLIPSE IS ASSUMED RIGID                       FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG X-COORDINATE=  6.842(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.640(IN)

                              REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT UPPER ARM

                  HOOD

                  WINDSHIELD

                                          ELLIPSES ATTACHED TO THE LOWER ARM

 NAME OF ELLIPSE IS RIGHT LOWER ARM                   ELLIPSE IS ASSUMED RIGID                       FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES= -2.566(IN)         SEMI-AXIS LENGTH ALONG X-COORDINATE=  5.718(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.0   (IN)        SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.400(IN)

                              REGIONS WHICH ARE ALLOWED TO CONTACT THE ELLIPSE RIGHT LOWER ARM

                  HOOD

                  GRILL

                  CAR FRONT

 NAME OF ELLIPSE IS RIGHT HAND                        ELLIPSE IS ASSUMED RIGID                       FRICTION CLASS IS     1

X-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  3.333(IN)         SEMI-AXIS LENGTH ALONG X-COORDINATE=  3.680(IN)
Z-COORDINATE OF ELLIPSE CENTER IN BODY SEGMENT COORDINATES=  0.515(IN)         SEMI-AXIS LENGTH ALONG Z-COORDINATE=  1.200(IN)
```

TABLE 5. Output of Baseline Input Data Set. Pedestrian Impact (Page 9 of 9).

```
$SIG SNZQ T=1M P=500 C=0 PRIO=D 'J.M.BECKER'
BATCH,DEFERRED,UNIV
**LAST SIGNON WAS: 10:27:49    WED MAY 20/81
 USER "SNZQ" SIGNED ON AT  00:26:34 ON THU MAY 21/81
INCOMING MESSAGES: 1 (1 NOT ACCESSED)


$GET 15WALK1A
READY.
   $.01,     $.04T
$SOURCE RUNM2D10
   $.00,     $.04T
$EMPTY P10C1 OK
DONE.
   $.00,     $.04T
$EMPTY CF8 OK
DONE.
   $.00,     $.04T
$EMPTY CF7 OK
DONE.
   $.00,     $.04T
$EMPTY CF9 OK
DONE.
   $.00,     $.04T
$EMPTY CF10 OK
DONE.
   $.00,     $.05T
$EMPTY TSRCA OK
DONE.
   $.00,     $.05T
$EMPTY TSRCB OK
DONE.
   $.00,     $.05T
$EMPTY TOBJA OK
DONE.
   $.00,     $.05T
$LIST *AFD*
                              PEDESTRIAN #1 -- 15 DEGREES                                        100
       3D-2D:RT ARM-ARM LI                                                                       200
       NKS/LT ARM-LUMPED W                                                                       300
       .TORSO/RT LEG-LEG L                                                                       400
       INKS/LT LEG-LOWER T                                                                       500
       ORSO LINK/TORSO-UP                                                                        600
       AND MID TORSO LINKS                                                                       700
          IMPACT FROM RT                                                                         800
       1.        1.        32.174  0.        0.        1000.   5.        5.       540.           101
       0.        0.        0.      0.        0.        0.      10.       .000001  2.             102
       .2        .02       600.    500.      30.       .05     10.       1.       1.             103
       HEAD                WINDSHIELD                                                            106
       HEAD                HOOD                                                                  106
       HEAD                CAR FRONT                                                             106
       HEAD                ROOF                                                                  106
       UPPER TORSO         ROOF                                                                  106
       UPPER TORSO         WINDSHIELD                                                            106
       UPPER TORSO         HOOD                                                                  106
       UPPER TORSO         CAR FRONT                                                             106
       LOWER TORSO         WINDSHIELD                                                            106
       LOWER TORSO         HOOD                                                                  106
       LOWER TORSO         CAR FRONT                                                             106
```

TABLE 6. Listing of Baseline Pedestrian Impact Input Data File. (Page 1 of 4).

```
LOWER TORSO       GRLL                                                                        106
RIGHT UPPER LEG HOOD                                                                          106
RIGHT UPPER LEG GRLL                                                                          106
RIGHT UPPER LEG CAR FRONT                                                                     106
RIGHT UPPER LEG LEFT UPPER LEG                                                                106
RIGHT KNEE        BUMPER                                                                      106
RIGHT SHIN        BUMPER                                                                      106
RIGHT FOOT        GROUND                                                                      106
RIGHT FOOT        GRLL                                                                        106
LEFT UPPER LEG    HOOD                                                                        106
LEFT UPPER LEG    GRLL                                                                        106
LEFT UPPER LEG    CAR FRONT                                                                   106
LEFT LOWER LEG    BUMPER                                                                      106
LEFT FOOT         GROUND                                                                      106
LEFT FOOT         BUMPER                                                                      106
LEFT FOOT         GRLL                                                                        106
RIGHT UPPER ARM HOOD                                                                          106
RIGHT UPPER ARM WINDSHIELD                                                                    106
RIGHT LOWER ARM HOOD                                                                          106
RIGHT LOWER ARM GRLL                                                                          106
RIGHT LOWER ARM CAR FRONT                                                                     106
0.        0.        0.        0.        0.        0.        1.        0.        1.            107
0.        0.        0.        0.        0.        0.        1.        0.        1.            108
1.        1.        0.        0.        0.        0.        0.        0.        1.            109
1.        1.        0.        0.        0.        1.        1.        1.        1.            110
0.        0.        1.        0.        0.        0.        0.        0.        0.            111
HEAD                                    1.        1.                                          219
HEAD                0.        0.        4.4336    3.1                                         220
UPPER TORSO                             2.        1.                                          219
UPPER TORSO         -.983     0.        4.77167 5.8                                           220
CENTER TORSO                            2.        1.                                          219
CENTER TORSO        7.7592    0.        6.79046 5.75                                          220
LOWER TORSO                             3.        1.                                          219
LOWER TORSO         .42616    0.        7.34104 5.5                                           220
LEFT UPPER LEG                          4.        1.                                          219
LEFT UPPER LEG      -5.46     2.8       11.029852.5                                           220
LEFT LOWER LEG                          4.        1.                                          219
LEFT LOWER LEG      8.005     2.8       8.22021 2.23                                          220
LEFT FOOT                               4.        2.                                          219
LEFT FOOT           16.752    2.8       1.0853    1.8                                         220
RIGHT UPPER LEG                         5.        1.                                          219
RIGHT UPPER LEG -1.4266 -2.8            10.6518 2.5                                           220
RIGHT KNEE                              6.        1.                                          219
RIGHT KNEE          -5.6986 -2.8        1.7404    2.23                                        220
RIGHT SHIN                              6.        1.                                          219
RIGHT SHIN          2.34211 -2.8        6.30527 2.23                                          220
RIGHT FOOT                              6.        2.                                          219
RIGHT FOOT          8.6424    -2.8      1.52      1.8                                         220
RIGHT UPPER ARM                         7.        1.                                          219
RIGHT UPPER ARM 0.        0.            6.84231 1.64                                          220
RIGHT LOWER ARM                         8.        1.                                          219
RIGHT LOWER ARM -2.5659 0.              5.7185    1.4                                         220
RIGHT HAND                              8.        1.                                          219
RIGHT HAND          3.3335    .5148     3.67973 1.2                                           220
0.        8.693     8.49      0.        13.410              10.641    1.545     6.6             201
3.188     3.108     8.49      12.660    6.952     10.317    5.221     3.978     .76             202
.025      .126      .079      .080      .054      .025      .012      .012      .0047           203
.297      2.88      2.19      1.0       .77       1.0       .137      .27                       204
31.2      0.        0.        0.        0.        0.        0.        0.        1.              205
31.2      0.        0.        0.        0.        0.        0.        0.        1.              206
```

TABLE 6. Listing of Baseline Pedestrian Impact Input Data File. (Page 2 of 4).

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 83   50.       0.        0.        0.        0.        0.        0.        0.        1.                 207
 84   16.       0.        0.        0.        0.        0.        0.        0.        1.                 208
 85   16.       0.        0.        0.        0.        0.        0.        0.        1.                 209
 86   0.        0.        0.        0.        595.5     1.        0.        0.        0.                 210
 87   -10.      10.       0.        0.        0.        0.        18.       -42.      .25                211
 88   -10.      10.       0.        0.        0.        0.        57.       -3.       .25                212
 89   751.      0.        757.      1.98                                                               213
 90   10.       0.        100.      0.                            3.                  .5                 214
 91   31.2      0.        0.        0.        0.        0.        0.        0.        1.                 215
 92   31.2      0.        0.        0.        0.        0.        0.        0.        1.                 216
 93   751.      0.        757.      1.98                                                               242
 94   0.        0.        0.        0.        0.        0.        -12.      27.                          217
 95   3.188     2.125     0.                                                                           218
 96   90.       90.       90.       90.       -90.      -90.      -78.      -105.     90.                301
 97   0.        14.6667 -47.625 0.          4.8296    0.                                               303
 98   BUMPER              PANEL MATERIAL      0.        1.        1.        1.                         401
 99   GRLL                PANEL MATERIAL      0.        1.        1.        1.                         401
100   CAR FRONT           GRILL TOP MATL.     0.        1.        1.        1.                         401
101   HOOD                PANEL MATERIAL      0.        1.        1.        1.                         401
102   WINDSHIELD          PANEL MATERIAL      0.        1.        1.        1.                         401
103   ROOF                PANEL MATERIAL      0.        1.        1.        1.                         401
104   GROUND              PAVEMENT            0.        1.        1.        1.                         401
105   BUMPER              1.        1.        1.        0.        1.                                   402
106   GRLL                1.        1.        1.        0.        1.                                   402
107   CAR FRONT           1.        1.        1.        0.        1.                                   402
108   HOOD                1.        1.        1.        0.        1.                                   402
109   WINDSHIELD          1.        1.        1.        0.        1.                                   402
110   ROOF                1.        1.        1.        0.        1.                                   402
111   GROUND              1.        2.        1.        1.        1.                                   402
112   PANEL MATERIAL      0.        0.        50.       100.      101.      0.        0.                 403
113   GRILL TOP MATL.     0.        0.        50.       100.      101.      0.        0.                 403
114   PAVEMENT            0.        0.        50.       100.      101.      0.        0.                 403
115   PANEL MATERIAL      1.                                      PANEL     ZERO      GRRATIO            404
116   GRILL TOP MATL.     1.                                      GRILL     ZERO      GRRATIO            404
117   PAVEMENT            1.                                      CONCRETEZERO        GRRATIO            404
118   GRRATIO -1.         .99                                                                          405
119   GRRATIO -1.         .01                                                                          406
120   PANEL    -1.        1000.                                                                        407
121   GRILL    -1.        2000.                                                                        407
122   CONCRETE-1.         470.                                                                         407
123   ZERO     -1.        0.                                                                           408
124   BUMPERLINE          BUMPER              8.25      0.        1.        1.                         409
125   GRILL               GRLL                11.       .36       1.        1.                         409
126   GRILL TOP           CAR FRONT           11.       .5        -1.       1.                         409
127   HOODLINE            HOOD                11.       .2378     -1.       1.                         409
128   WINDSHIELDLINE      WINDSHIELD          4.5       0.        1.        1.                         409
129   ROOFLINE            ROOF                4.5       0.        -1.       1.                         409
130   ROAD SURFACE        GROUND              30.       0.        1.        1.                         409
131   BUMPERLINE          1.                                                                           410
132   GRILL               1.                                                                           410
133   GRILL TOP           1.                                                                           410
134   HOODLINE            1.                                                                           410
135   WINDSHIELDLINE      1.                                                                           410
136   ROOFLINE            1.                                                                           410
137   ROAD SURFACE        1.                                                                           410
138   BUMPERLINE          -1.       9.98      0.        9.81      -26.                                 411
139   GRILL               -1.       13.74     0.        14.73     -29.5                                411
140   GRILL TOP           -1.       14.67     -29.5     16.73     -31.74                               411
141   HOODLINE            -1.       16.72     -31.74    61.184    -37.17                               411
142   WINDSHIELDLINE      -1.       62.034    -37.17    82.674    -49.83                               411
```

TABLE 6. Listing of Baseline Pedestrian Impact Input Data File. (Page 3 of 4).

```
  143     ROOFLINE          -1.       82.016    -49.83    110.346 -49.83                                    411
  144     ROAD SURFACE      -1.       -120.     .000001 30.       .000001                                   411
  145     1.        1.      1.                                                                              412
  146     1.        2.      1.                                                                              412
  147     2.        1.      1.                                                                              412
  148     2.        2.      1.                                                                              412
  149     0.        -14.667 0.        0.        0.        0.        0.        0.        0.                  601
  150     2.        0.      1.                                                                              602
  151     0.        0.      2000.     0.
  152     2.        0.      1.                                                                              603
  153     0.        0.      2000.     0.
  154     2.        0.                                                                                      604
  155     0.        0.      2000.     0.
  156                                                                                                      1000
 1001     -1                                                                                               1001
 1002     1.        0.      -4.       86.       3.        -65.      5.        1.                             1500
 1003     26.       0.      0.        1.        1.        0.        1.        0.        0.                   1501
 1004                                                                                                      1600
END OF FILE
   $.06,     $.12T

$RUN SPLN:INP.O 1=TSRCA 5=*AFD* 8=CF8  2=TSRCB T=1M
EXECUTION BEGINS    00:26:43
```

TABLE 6. Listing of Baseline Pedestrian Impact Input Data File. (Page 4 of 4).

5.4 REPRESENTATIVE SIDE IMPACT OUTPUT

Figures 13 through 15 are a graphical presentation of some of the important kinematic and dynamic variables produced by the computer exercise using the baseline side impact data. Figure 13 shows a sequence of three contacts as the occupant interacts with the side structures. It should be noted that significant forces are built up in the lower torso (hip) region by 30 ms. This point would have occurred much later without the intrusion of the door and hip panels. The upper torso forces reach their maximum at about 60 ms which reflects the fact that the door panel is outboard in the vehicle from the hip panel. The left arm (simulating Part 572 rather than dummies with collapsible shoulder structures) contacts the door at a much earlier period in time. The head rotates toward the window and hits side structures very hard by 75 ms after which rebound begins.

Figure 14 shows a trace of the motions of several body segments during the simulation. Lower torso linear motion to the side is relatively small due to the early interaction of the hip with the intruding hip panel. However, this does not prevent rotation of the lower legs toward the forward portion of the door structures which are not programmed for intrusion. The head pitches to the side but interacts only with the side header and B-pillar. In cases where B-pillar interaction is not expected, this contact should be suppressed for MVMA 2-D simulations as the B-pillar line will always be inboard from the window line thus preventing initial window contact. Also, the fact that lower torso side motion is limited due to the intrusion prohibits the head from moving too far to the side. Figure 15 is an assembly of Calcomp plots produced by the movie generation post-processor routines graphically documenting the kinematics just discussed.

Table 7 is a summary of all occupant/vehicle contact interactions. The time, deflection, and force are given for initiation of contact, peak force, and the final time of a contact event. In one case it is seen that the peak force occurs at the end of the simulation. For a further study of the output, including any cases of multiple peaks, it is necessary to review the complete simulation output.

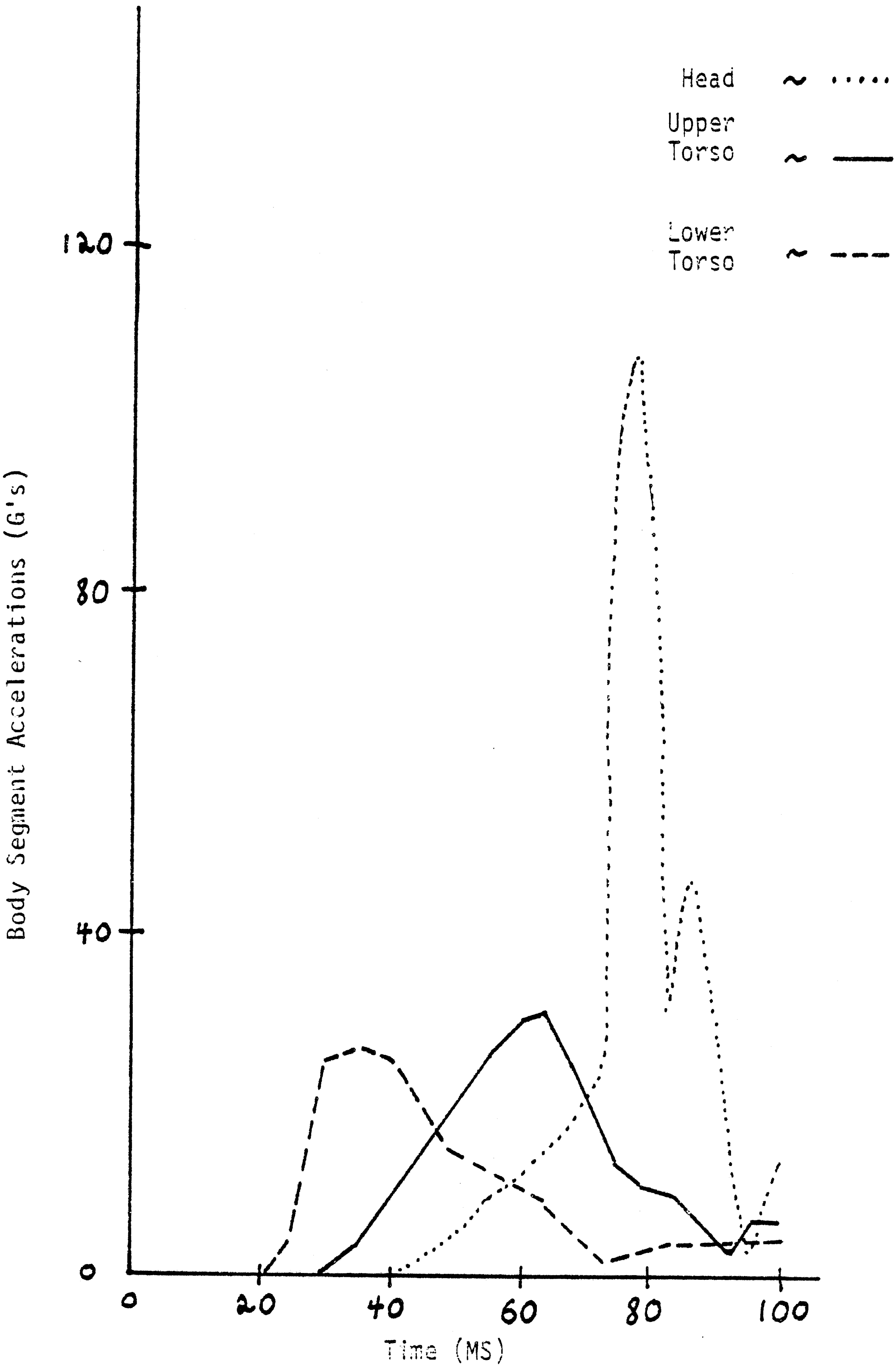

Fig. 13. Body Segment Accelerations. Side Impact.

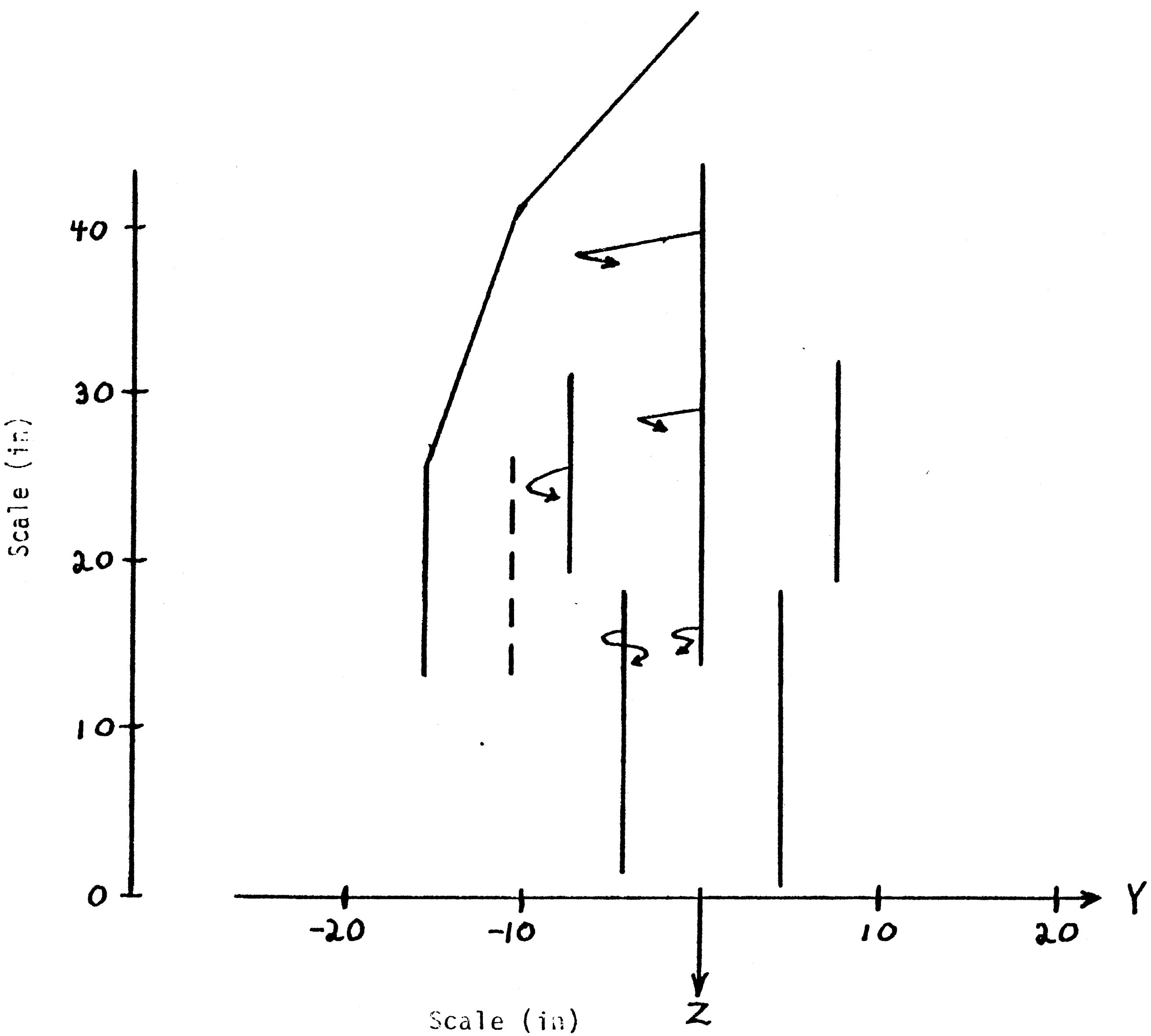

Fig. 14. Occupant Segment Motions in Side Impact Simulation.

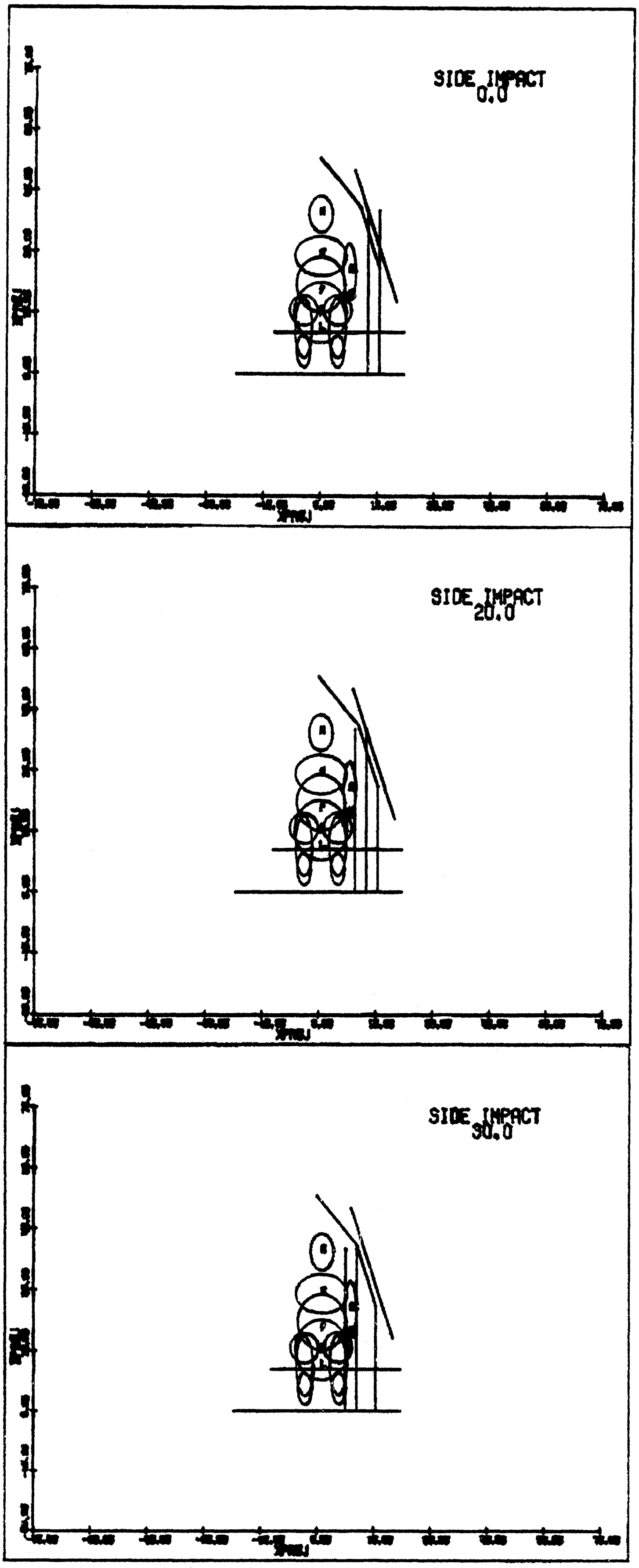

Fig. 15. Side Impact Occupant Kinematics. (1 of 2; 0, 20, 30 ms)

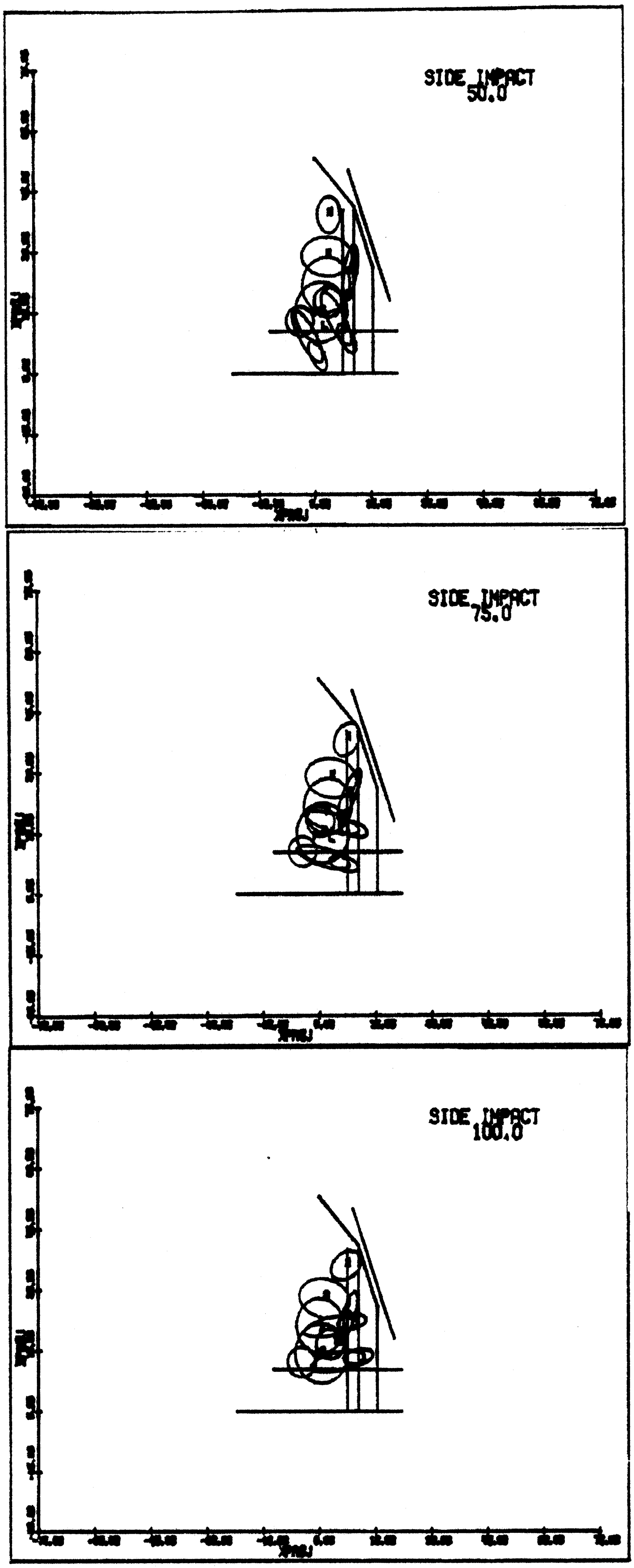

Fig. 15. Side Impact Occupant Kinematics. (2 of 2; 50, 75, 100 ms)

TABLE 7. SIDE IMPACT OCCUPANT/VEHICLE CONTACT HISTORY

Ellipse Name	Contact Name	Initial Contact Time (ms)	Initial Contact Deflection (in)	Initial Contact Force (lb)	Peak Contact Time (ms)	Peak Contact Deflection (in)	Peak Contact Force (lb)	Final Contact Time (ms)	Final Contact Deflection (in)	Final Contact Force (lb)
Lower Torso	Seat Cushion	0	2.6	103	100	3.5	141	100	3.5	141
	Hip Panel	28	0.1	94	43	1.1	1092	95	0.0	16
Upper Torso	Door	60	0.0	1	62	0.0	13	63	0.0	9
Head	Header	73	0.0	3	76	0.2	98	79	0.1	38
	B-Pillar	74	0.0	22	79	0.4	978	83	0.1	155
Right Upper Leg	Seat Cushion	44	0.1	3	77	3.6	145	100	2.0	78
Left Upper Leg	Hip Panel	24	0.3	250	33	1.9	1880	48	0.1	110
Left Upper Arm	Door	31	0.1	77	62	1.2	1198	92	0.0	4
Left Lower Arm	Door	37	0.1	46	40	0.1	129	43	0.0	23

5.5 REPRESENTATIVE PEDESTRIAN IMPACT OUTPUT

Figure 16 includes a series of frames showing pedestrian kinematics at various time points during the exercise. The initial bumper contact with the right knee segment starts at 35 ms, peaks at 45 ms, and is over by 100 ms. The grille, grille top, and hood also contact the pedestrian lower torso and right lower arm early in the simulation. The right upper leg also is observed to contact the left lower leg.

The next sequence of major contacts is observed to take place as the upper torso rotates over onto the hood. Both segments of the right arm, the upper torso, and the head are active in this stage of the impact. Following this the pedestrian is pitched upward and in front of the moving vehicle.

By 815 ms the final stage of the impact event is begun as the feet hit the ground and the body begins to collapse. Contacts with the moving vehicle are again sensed near the end of the simulation. A three dimensional simulation would be required to sense whether the pedestrian rolled off to the side of the vehicle or ends up in a position where the vehicle can pass over him.

Table 8 is a summary of all pedestrian/vehicle exterior contacts. As in Table 7, the time, deflection, and force are given for initiation of contact, peak force and the final time of each contact event.

Figures 17 through 19 give the resultant accelerations predicted in the upper torso, head, and hip segment while Figures 20 through 23 report the time history of four important contact interactions. The hip acceleration and resulting contact force between the lower torso and the grille appear to provide the major initial force in controlling overall body kinematics. The upper torso and head accelerations peak at a later time. The leading force transmitter in this second interaction is the right upper arm which interacted with the hood.

It was necessary to "soften" the flexible shoulder element in order to obtain a successful exercise. A total of 5 inches of shoulder joint motion in the inferior direction was predicted as the subject rotated onto the hood (See Figure 16 at 160 ms.)

It should be noted that the force-deflection curves used to govern the interactions between the vehicle and pedestrian are hypothetical. In order to improve the qualitative agreement between the simulation and observed movies of experimental pedestrian impacts, both energy absorption and friction were included with dramatic effect. Before inclusion of these factors, the results very nearly matched the predictions obtained in the earlier project using the HSRI version of the CAL3D model.

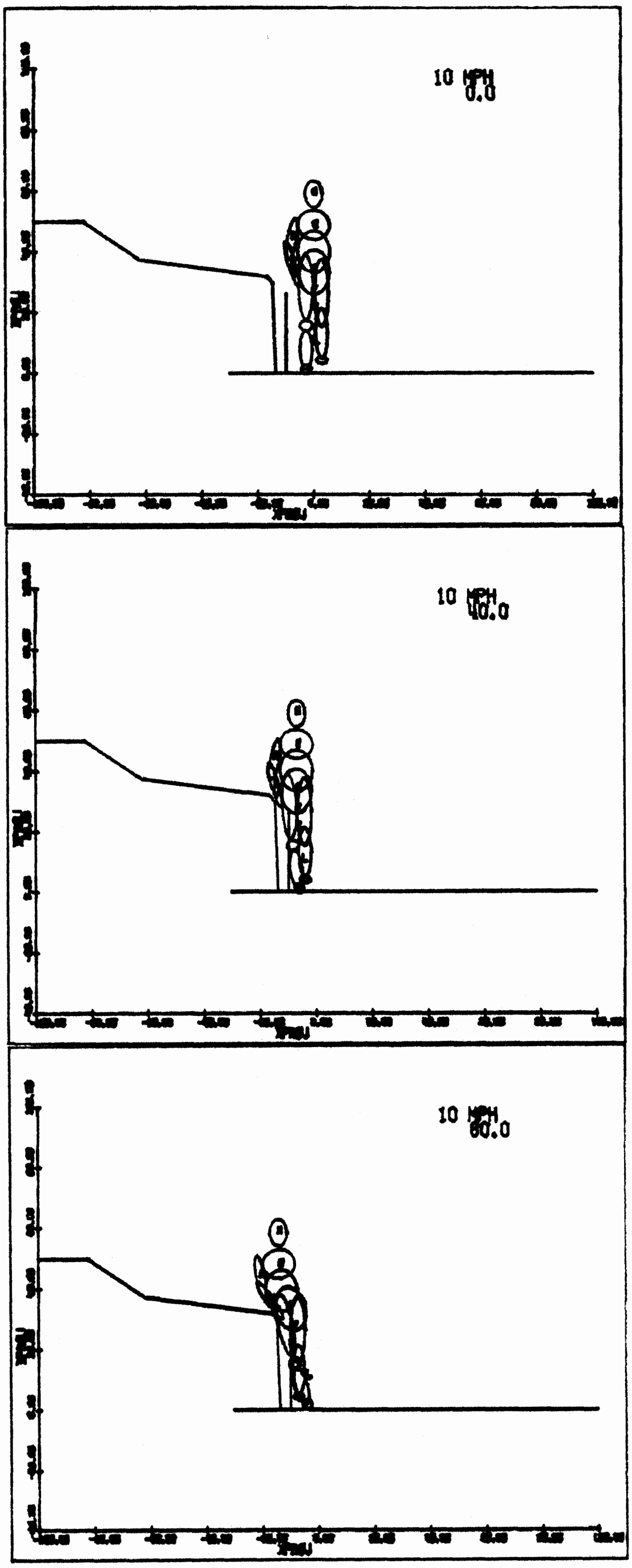

Fig. 16. Pedestrian Kinematics. (1 of 3; 0, 40, 80 ms)

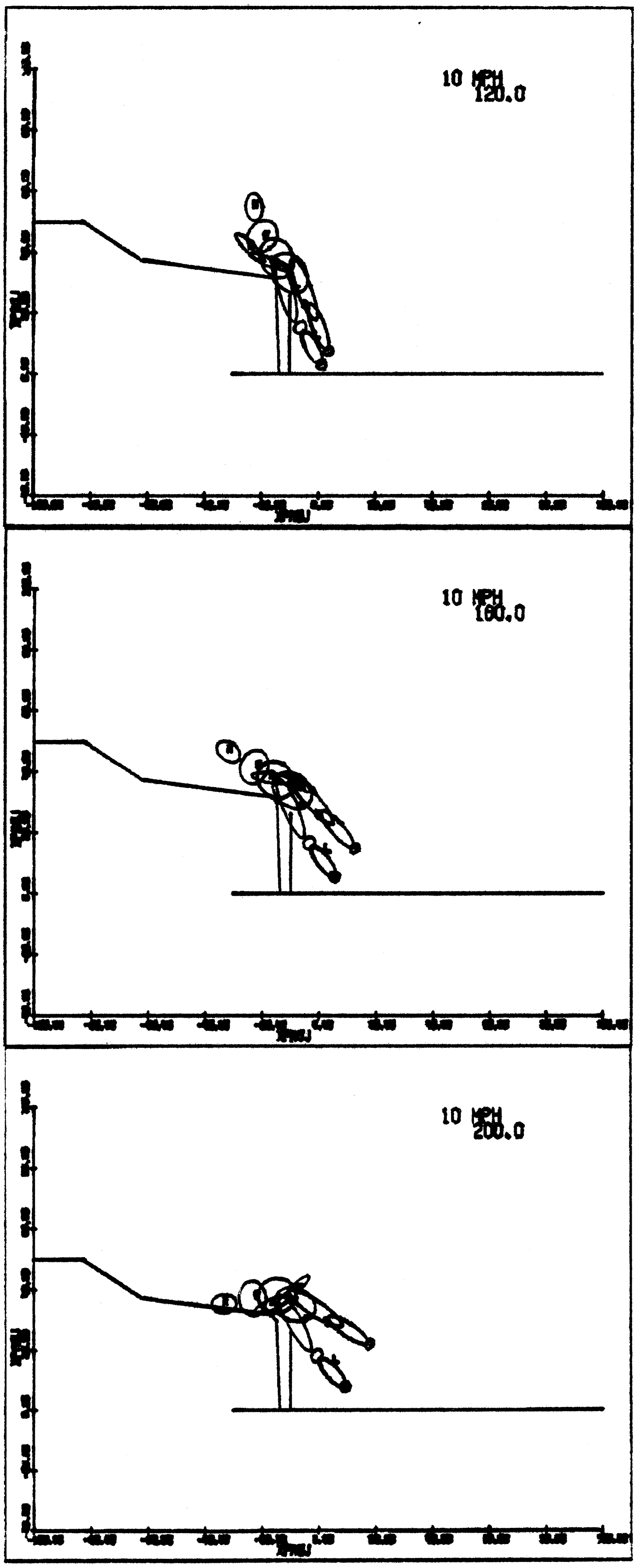

Fig. 16. Pedestrian Kinematics. (2 of 3; 120, 160, 200 ms)

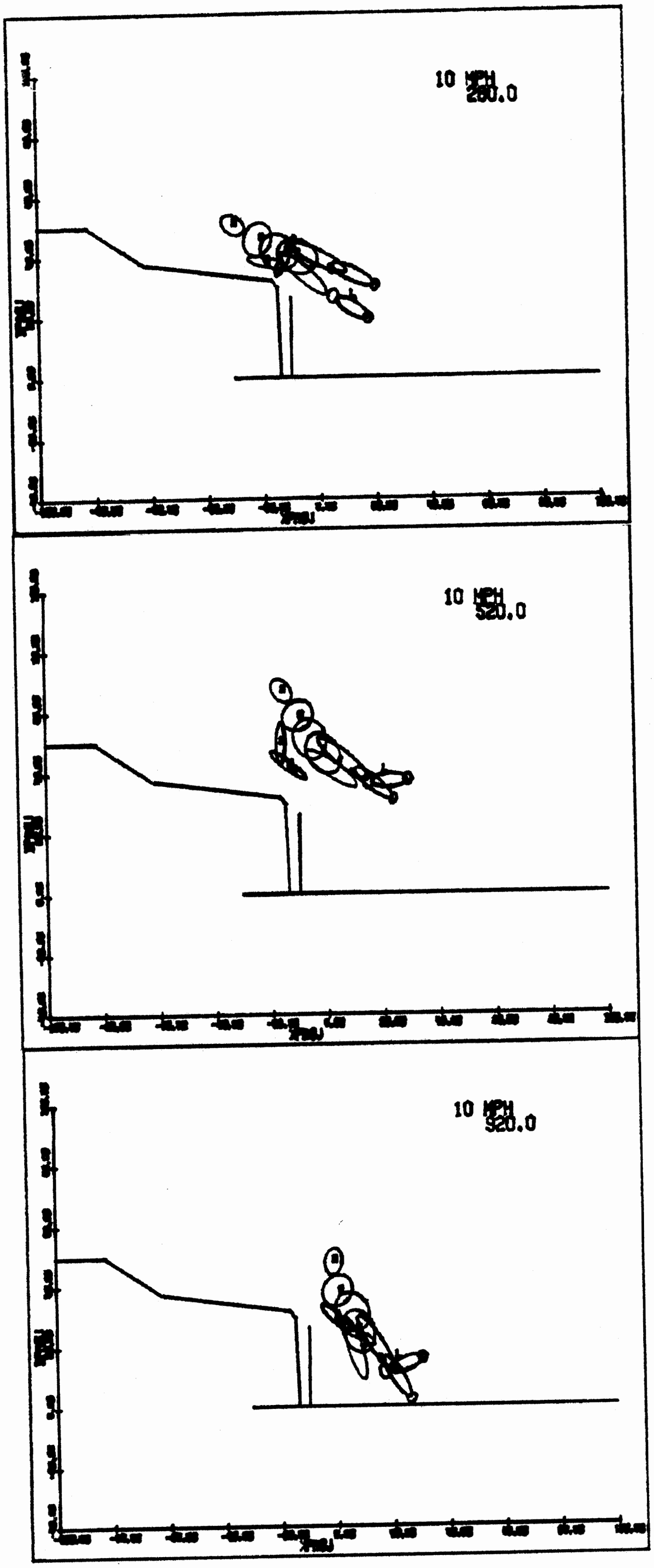

Fig. 16. Pedestrian Kinematics. (3 of 3; 280, 520, 920 ms)

TABLE 8. PEDESTRIAN/VEHICLE CONTACT HISTORY (PAGE 1 of 2)

Ellipse Name	Contact Name	Initial Contact Time (ms)	Initial Contact Deflection (in)	Initial Contact Force (lb)	Peak Contact Time (ms)	Peak Contact Deflection (in)	Peak Contact Force (lb)	Final Contact Time (ms)	Final Contact Deflection (in)	Final Contact Force (lb)
Right Foot	Road Surface	0	0.34	160	25	0.52	243	70	0.03	16
		815	0.28	131	830	1.46	686	835	0.95	446
Right Knee	Bumperline	35	0.36	360	45	0.86	860	100	0.07	69
Lower Torso	Hoodline	35	4.63	17	60	5.02	736	220	0.12	11
Lower Torso	Grille	55	0.02	8	130	1.47	359	230	0.00	1
Right Lower Arm	Hoodline	45	0.03	13	55	0.24	115	60	0.10	51
		180	1.11	397	185	1.46	513	190	0.51	181
	Grille Top	55	0.18	138	55	0.18	138	60	0.18	104
	Grille	115	9.27	117	145	5.49	220	170	0.32	77
		200	0.03	7	215	0.92	118	220	0.59	86
		265	0.21	59	275	1.35	399	280	0.68	205
		315	0.27	22	315	0.27	22	320	0.41	9
		560	0.64	6	560	0.64	6	565	0.84	0
Right Upper Arm	Hoodline	175	0.16	106	180	0.61	392	185	0.13	76
		200	0.37	276	200	0.37	276	205	0.04	28
		215	0.09	67	215	0.09	67	220	0.02	13
		980	6.20	18	990	5.76	356	1000	4.12	294
Head	Hoodline	190	0.66	662	195	1.80	1801	205	0.55	548

TABLE 8. PEDESTRIAN/VEHICLE CONTACT HISTORY (PAGE 2 of 2)

Ellipse Name	Contact Name	Initial Contact Time (ms)	Initial Contact Deflection (in)	Initial Contact Force (lb)	Peak Contact Time (ms)	Peak Contact Deflection (in)	Peak Contact Force (lb)	Final Contact Time (ms)	Final Contact Deflection (in)	Final Contact Force (lb)
Upper Torso	Hoodline	190	0.22	184	210	1.62	1295	225	0.59	477
Left Foot	Road Surface	825	0.42	199	865	3.09	1451	905	0.08	36
Left Upper Leg	Right Upper Leg	45	0.47	233	65	2.35	600	90	0.66	328
		165	0.03	15	210	0.35	175	260	0.01	3
		345	0.16	82	355	0.62	310	365	0.03	14
		495	0.08	39	505	0.15	73	515	0.07	34
		605	0.02	8	615	0.08	41	625	0.03	16
		845	0.07	35	875	0.45	226	910	0.03	13
		970	0.11	57	980	0.80	401	990	0.37	185

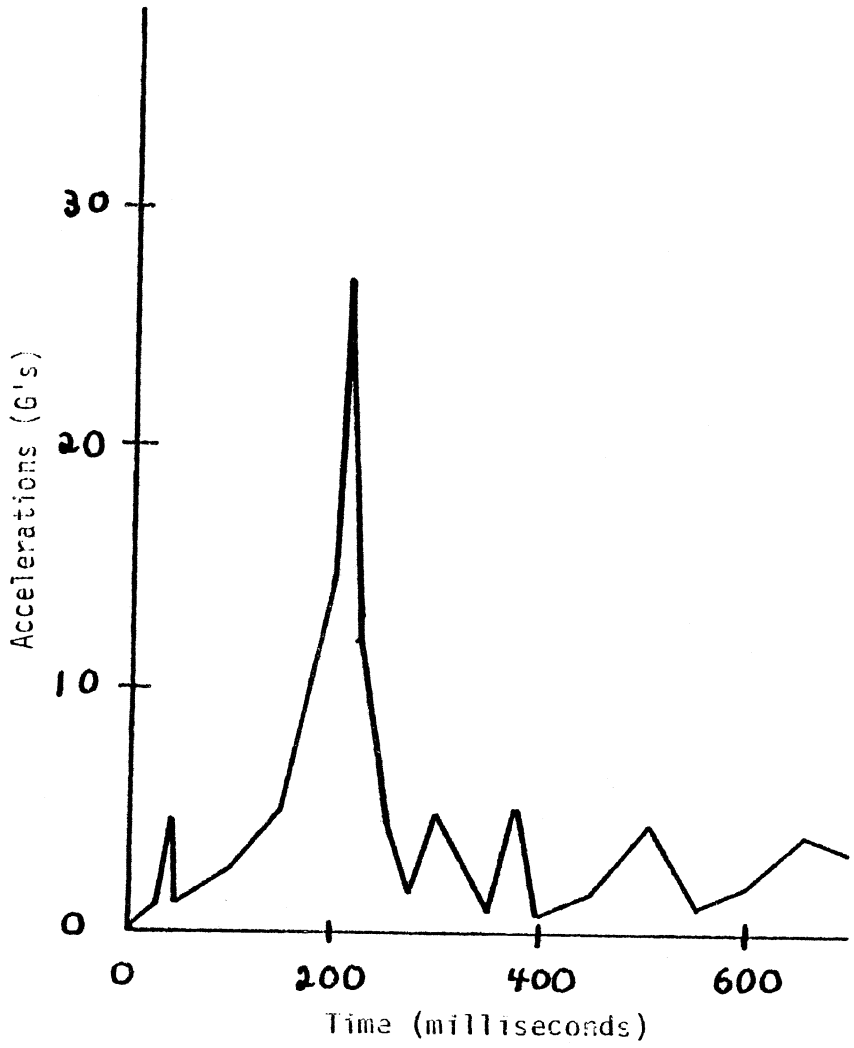

Fig. 17. Upper Torso Accelerations

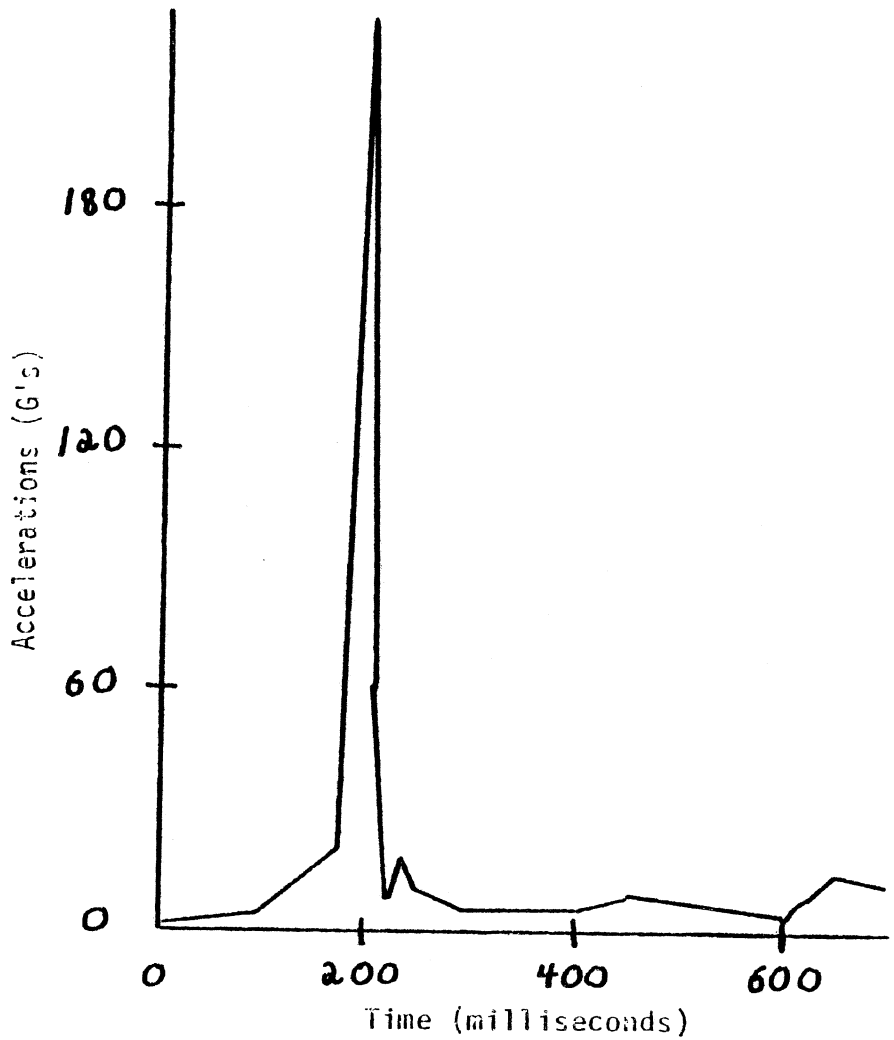

Fig. 18. Head Acceleration

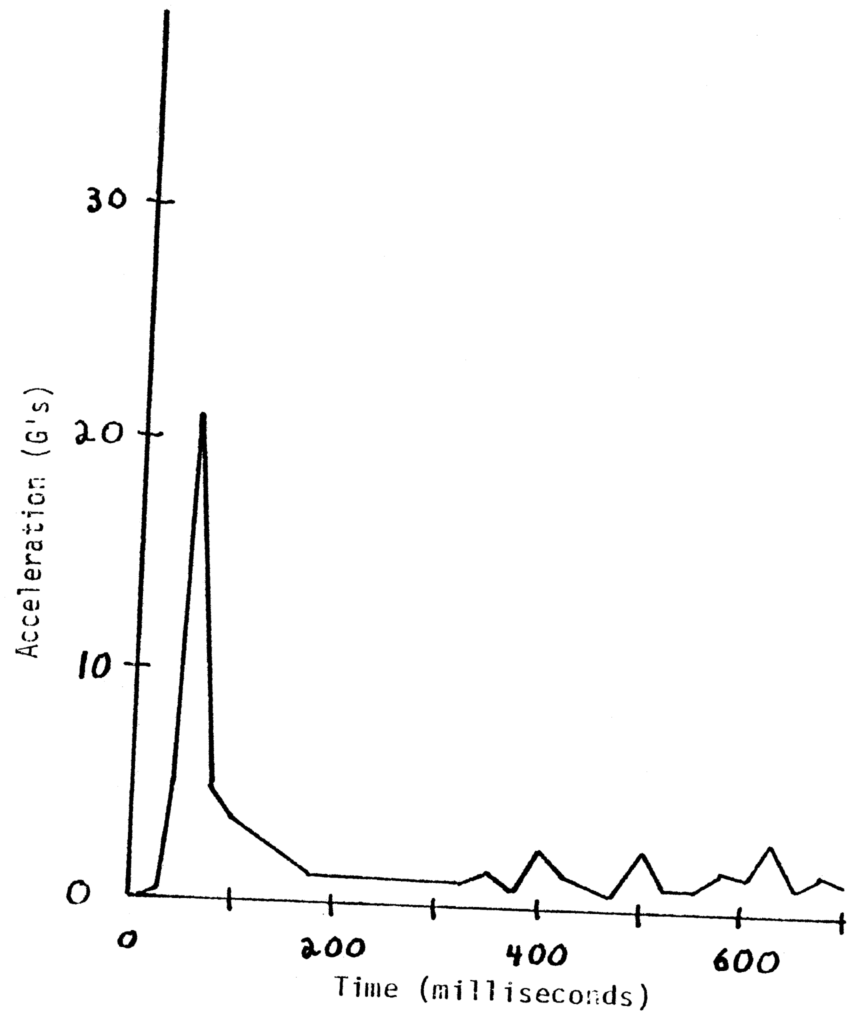

Fig. 19. Hip Accelerations

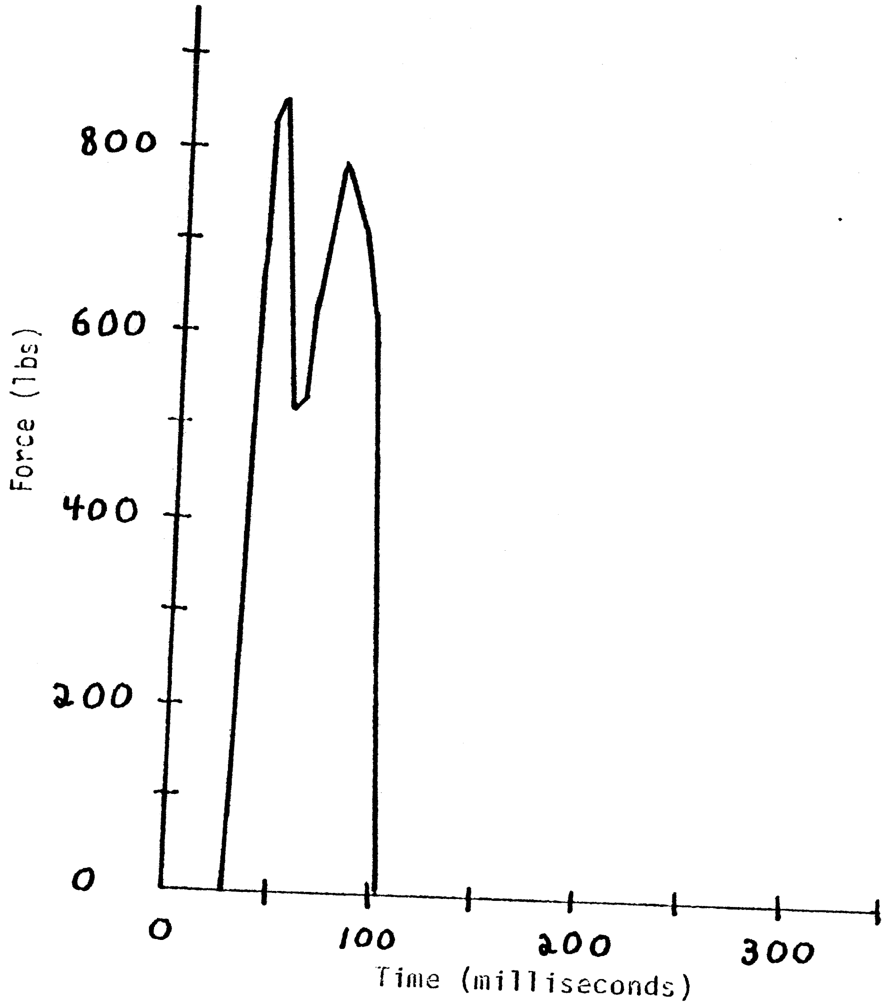

Fig. 20. Contact Force. Knee-bumper.

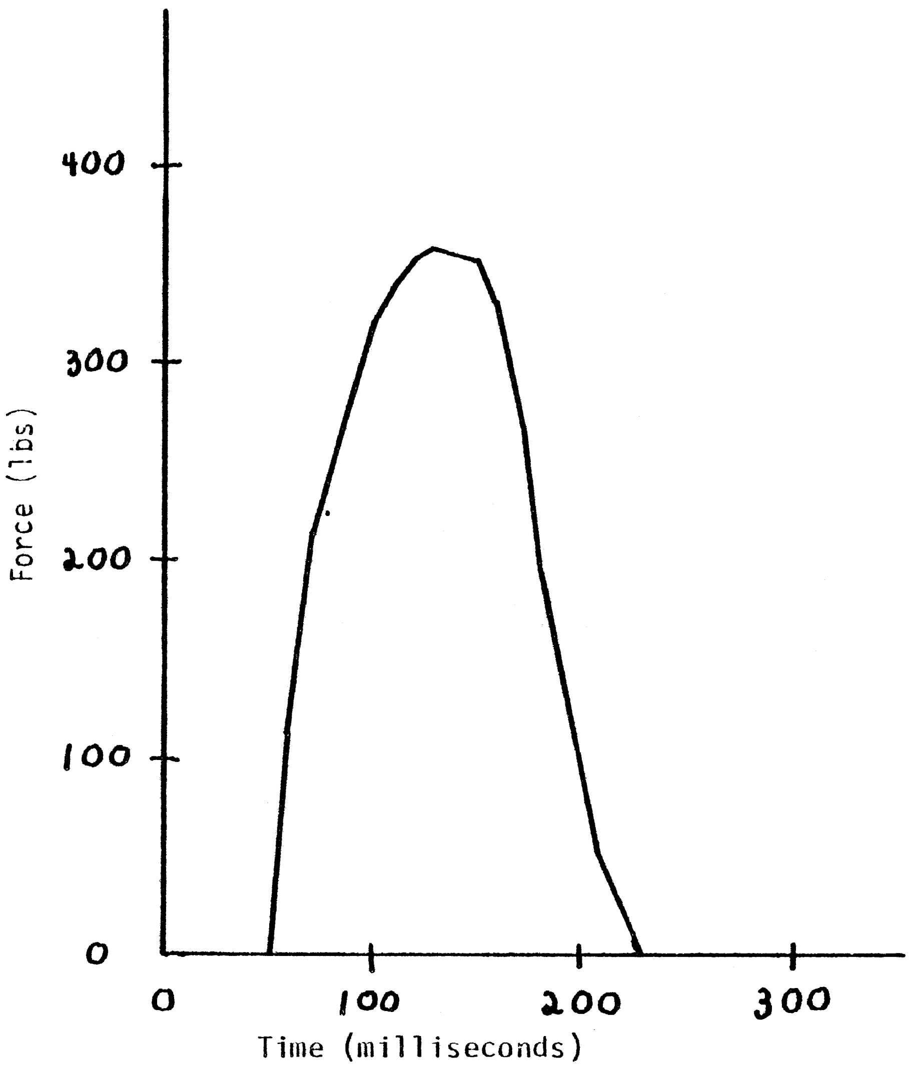

Fig. 21. Contact Force. Lower Torso/Grille.

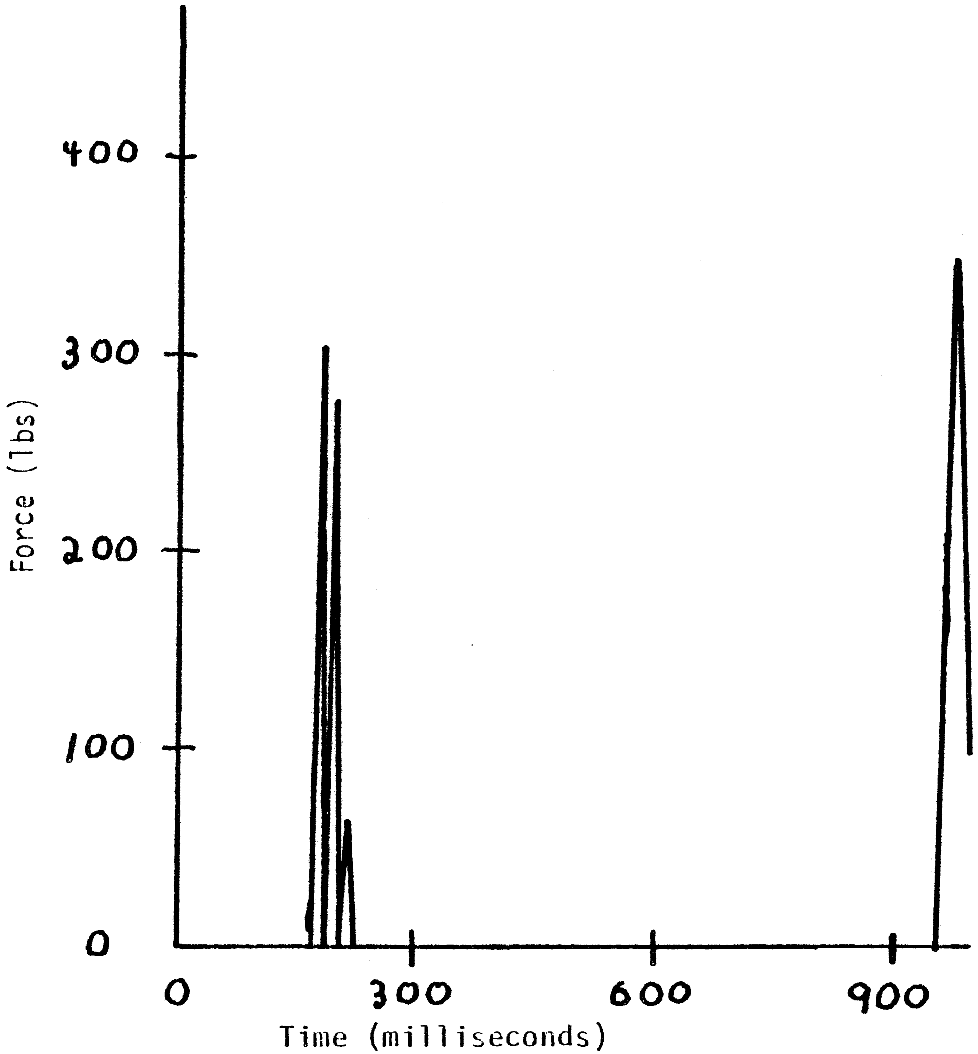

Fig. 22. Contact Force. Right Upper Arm/Hood.

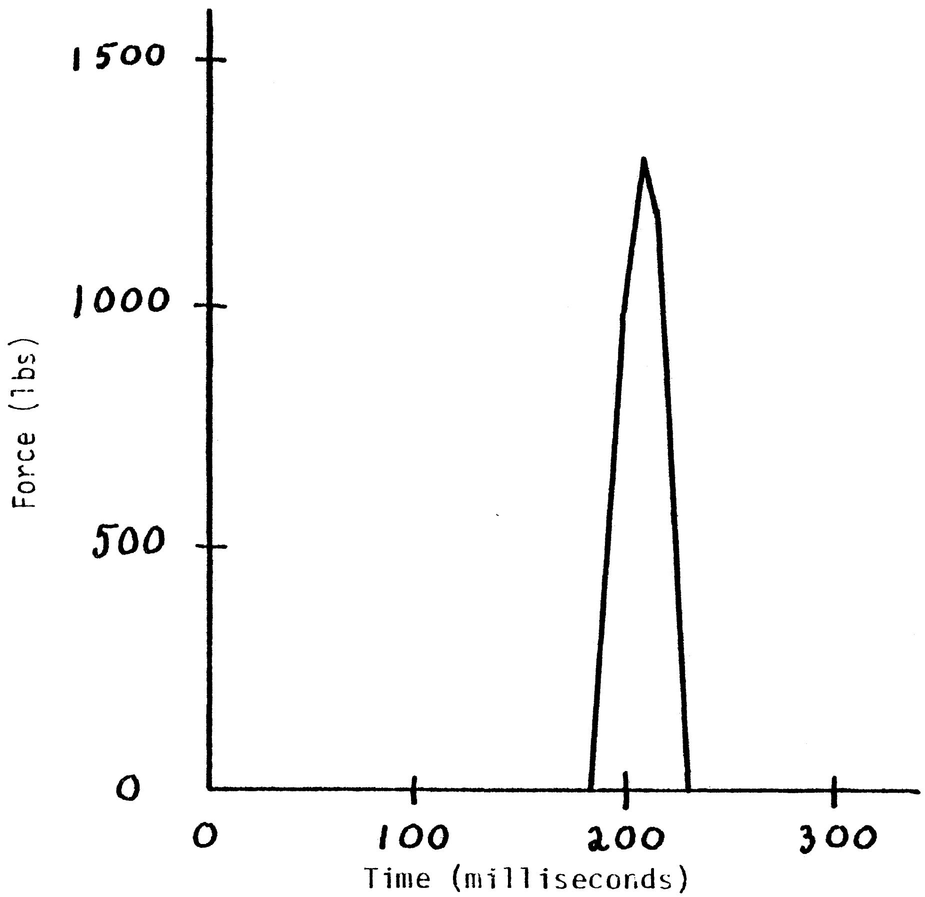

Fig. 23. Contact Force. Upper Torso/Hood.

6.0 REFERENCES

1. Bowman, B.M., Bennett, R.O., and Robbins, D.H., "MVMA Two-Dimensional Crash Victim Simulation, Version 4," 3 Vols., Report Nos. UM-HSRI-79-5-1, 2, 3, University of Michigan, Highway Safety Research Institute, Ann Arbor, June 1979.

2. Robbins, D.H., Becker, J.M., Bennett, R.O., and Bowman, B.M., "Accident Data Simulation. Pedestrian and Side Impact-3D," Report No. UM-HSRI-80-75, University of Michigan, Highway Safety Research Institute, Ann Arbor, Dec. 1980.

3. Padgaonkar, A.J. and Prasad, P., "Simulation of Side Impact Using the CAL3D Occupant Simulation Model," SAE Paper No. 791007, Proc. 23rd Stapp Car Crash Conf., pp. 133-158, Nov. 1979.

4. Siemonsen, H.D. and Bruckner, F., "Impacts on Plates, Particularly Glass Plates," SAE Paper No. 670924, Proc. 11th Stapp Car Crash Conf., pp. 293-298, Nov. 1967.