DYNAMIC IMPACT TEST OF A SCHOOL BUS WITH A 10,000 POUND MOVING BARRIER WITH CONTOURED FRONT END

1987 CARPENTER CONVENTIONAL SCHOOL BUS
65 PASSENGER

NHTSA NO. CH0902

MOBILITY SYSTEMS AND EQUIPMENT COMPANY
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MARCH 1989

FINAL REPORT

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For

U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Office of Crashworthiness Research
400 Seventh Street, S.W.
Washington, DC 20590

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Date

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16. Abstract

Tests were conducted on the subject 1985 Carpenter Conventional School Bus 65 Pass. vehicle in accordance with the specifications of the Office of Vehicle Safety Compliance Test Procedure TP-219-03 as modified for this project for determination of school bus floor joint strength. The results are presented in this report.

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SECTION 1

INTRODUCTION

A series of dynamic impact tests were conducted on selected school buses to evaluate the structural performance of school bus floor joints and overall bus structure. The impacting vehicle was a 10,000 pound moving barrier with a rigid/contoured front end.

This report describes the ninth of the series of ten tests. The test vehicle was a 1987 Carpenter Conventional School Bus with a 65 passenger capacity. The test was conducted with 7 channels of acceleration data, 5 high-speed cameras, and one real-time camera.

Section 2 of the report describes the test procedure and presents the summary data. Section 3 of the report shows all the test results.

SECTION 2

TEST PROCEDURE AND SUMMARY DATA

The 1987 Carpenter Conventional School Bus, NHTSA No. CH0902 was tested on 07 February 1989. The bus was positioned to be impacted at a 30° angle relative to the incoming 10,000 lb contoured moving barrier. The target impact location was on the left side just aft of the "A" pillar. Pretest photographs of the barrier positioned against the bus are shown in Figures 2-1 to 2-4. Pretest closeup views of the impact area are shown in Figures 2-5 to 2-8. The certification and manufacturer's label are shown in Figure 2-9.

Five high-speed movie cameras were used to document this test. Their relative positions and placement are given in Figure 2-10.

A triaxial accelerometer was placed at the bus longitudinal c.g. One biaxial accelerometer was placed at the front axle and one at the rear axle of the moving barrier.

The gas tank and protective cage are located on the impacted side of the bus. They were removed before the impacted test.

A test summary is given in Table 2-1 and a sketch of crush and joint separation profiles is given in Figure 2-11.

FIGURE 2-1 LEFT SIDE OVERALL VIEW – PRETEST

FIGURE 2-2 FRONT VIEW - PRETEST

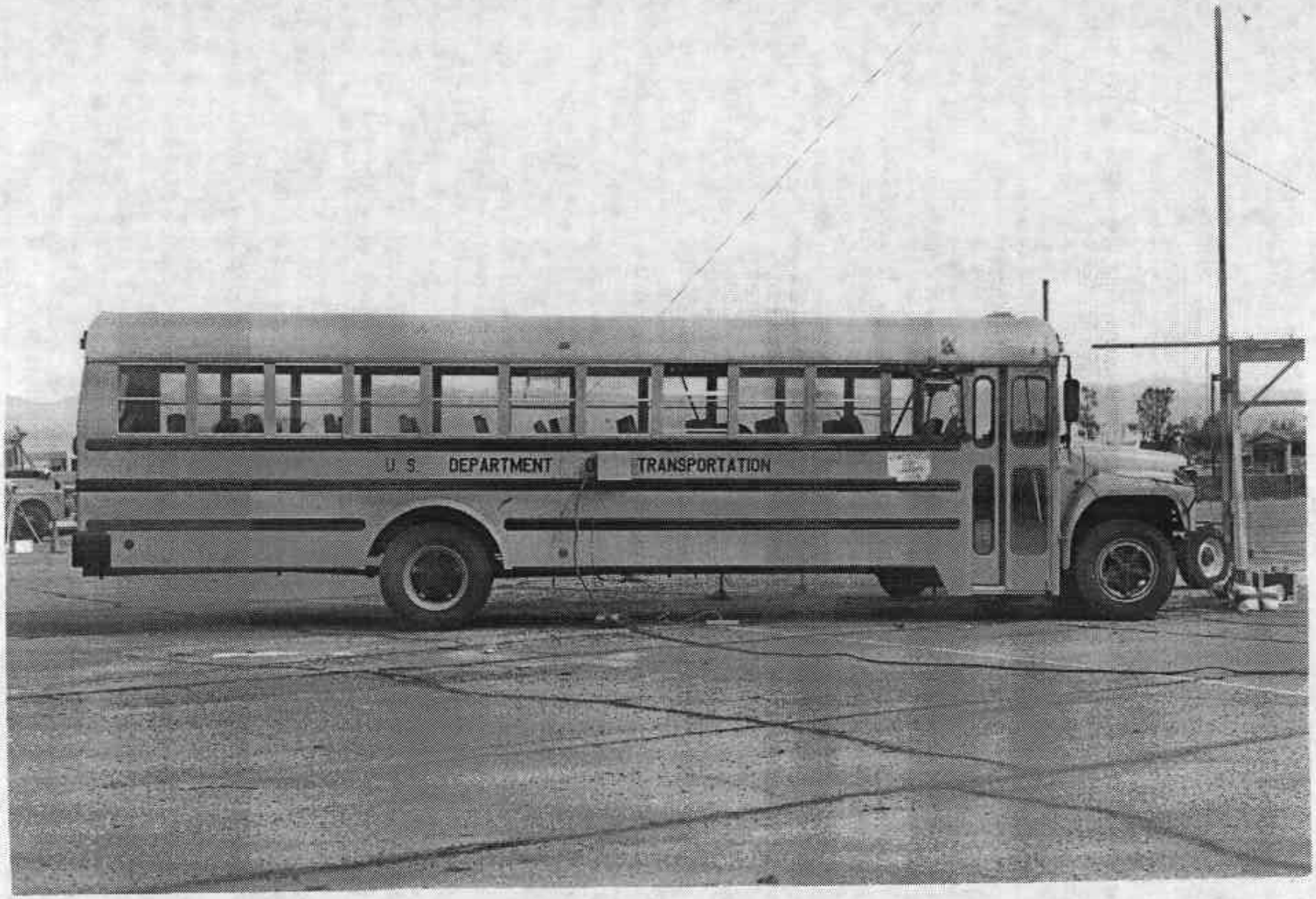


FIGURE 2-3 RIGHT SIDE OVERALL VIEW - PRETEST

FIGURE 2-4 REAR VIEW - PRETEST

FIGURE 2-5 CLOSEUP VIEW OF IMPACT AREA - PRETEST

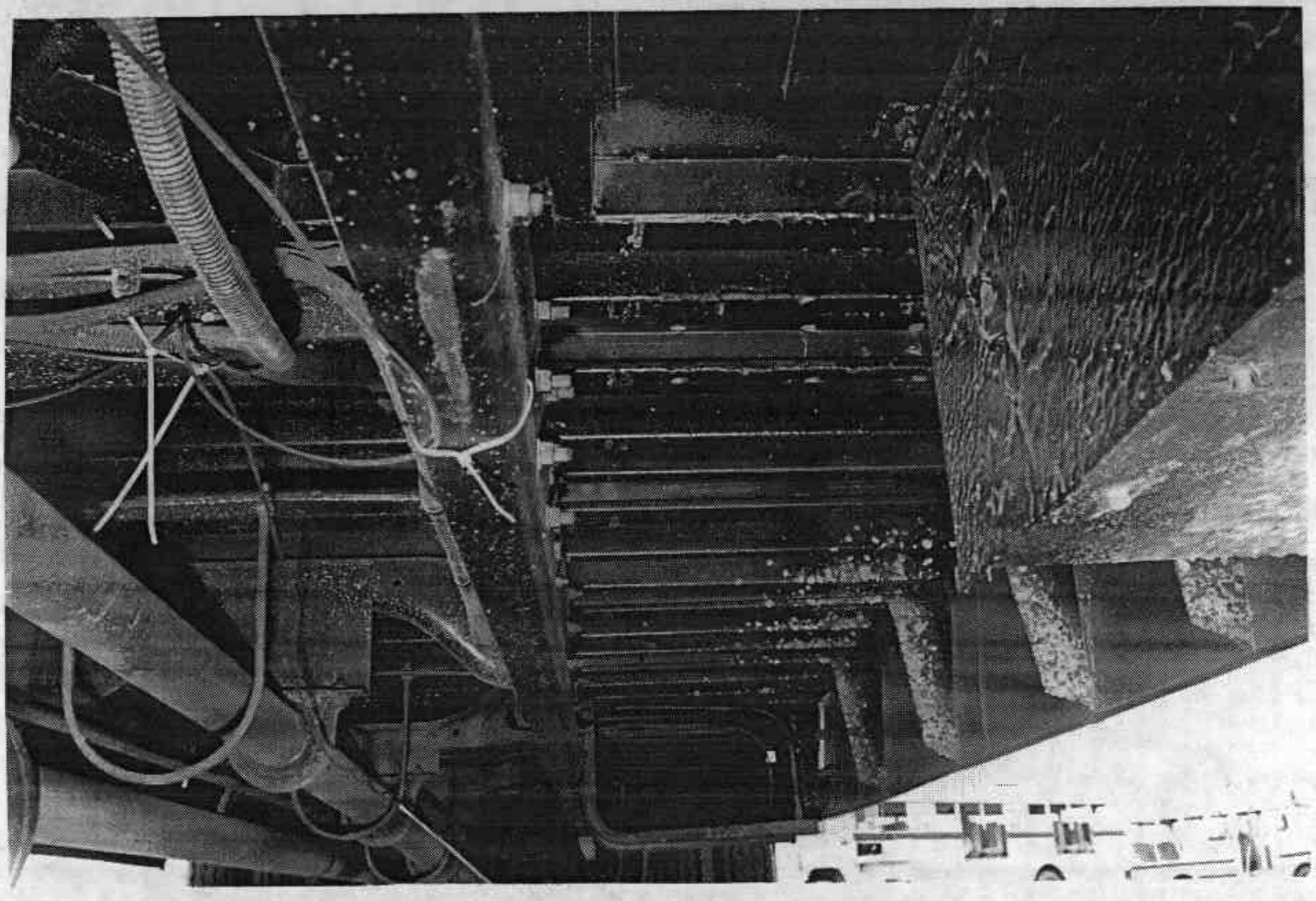


FIGURE 2-6 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING FRONT TO REAR - PRETEST

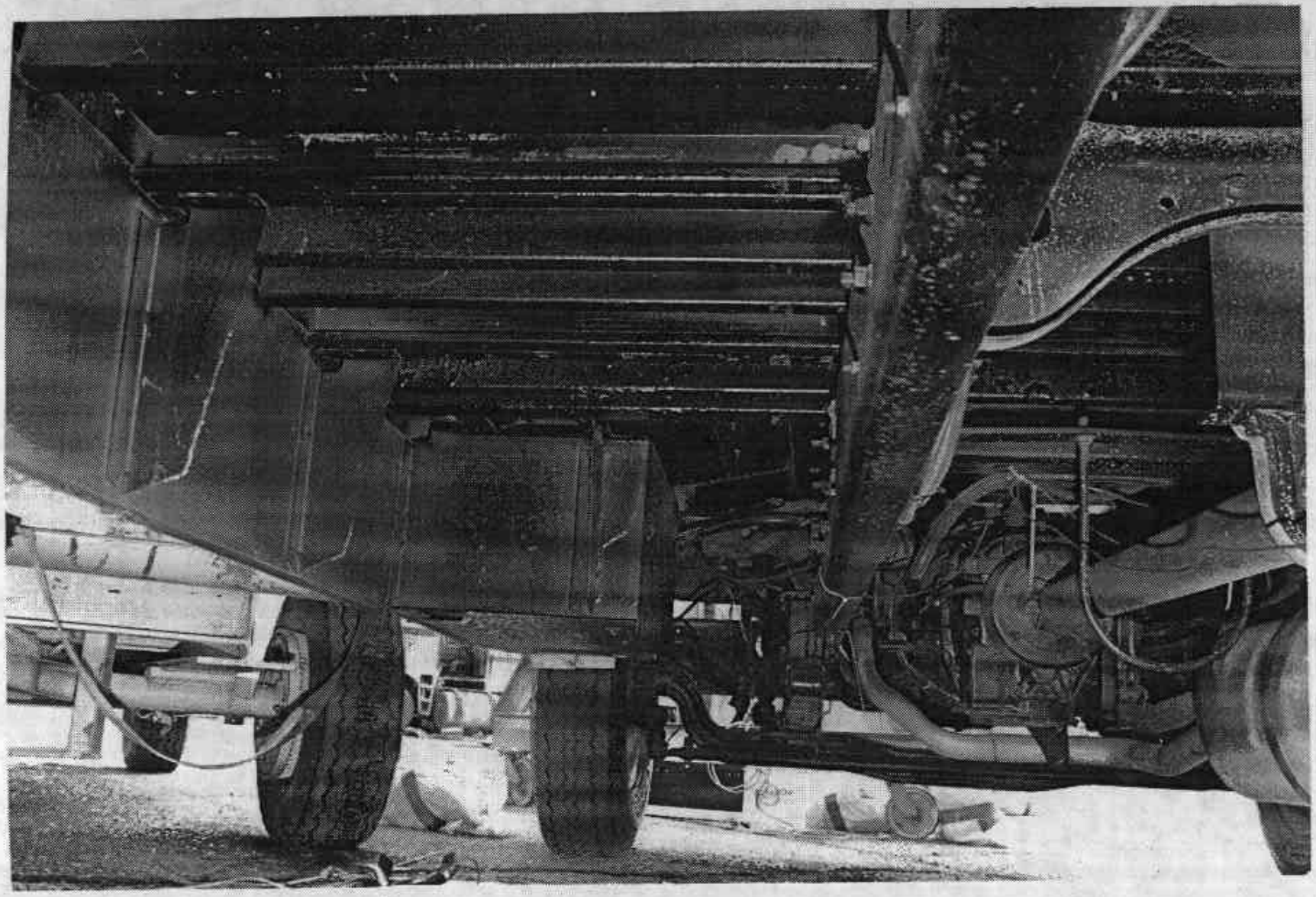


FIGURE 2-7 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING REAR TO FRONT - PRETEST

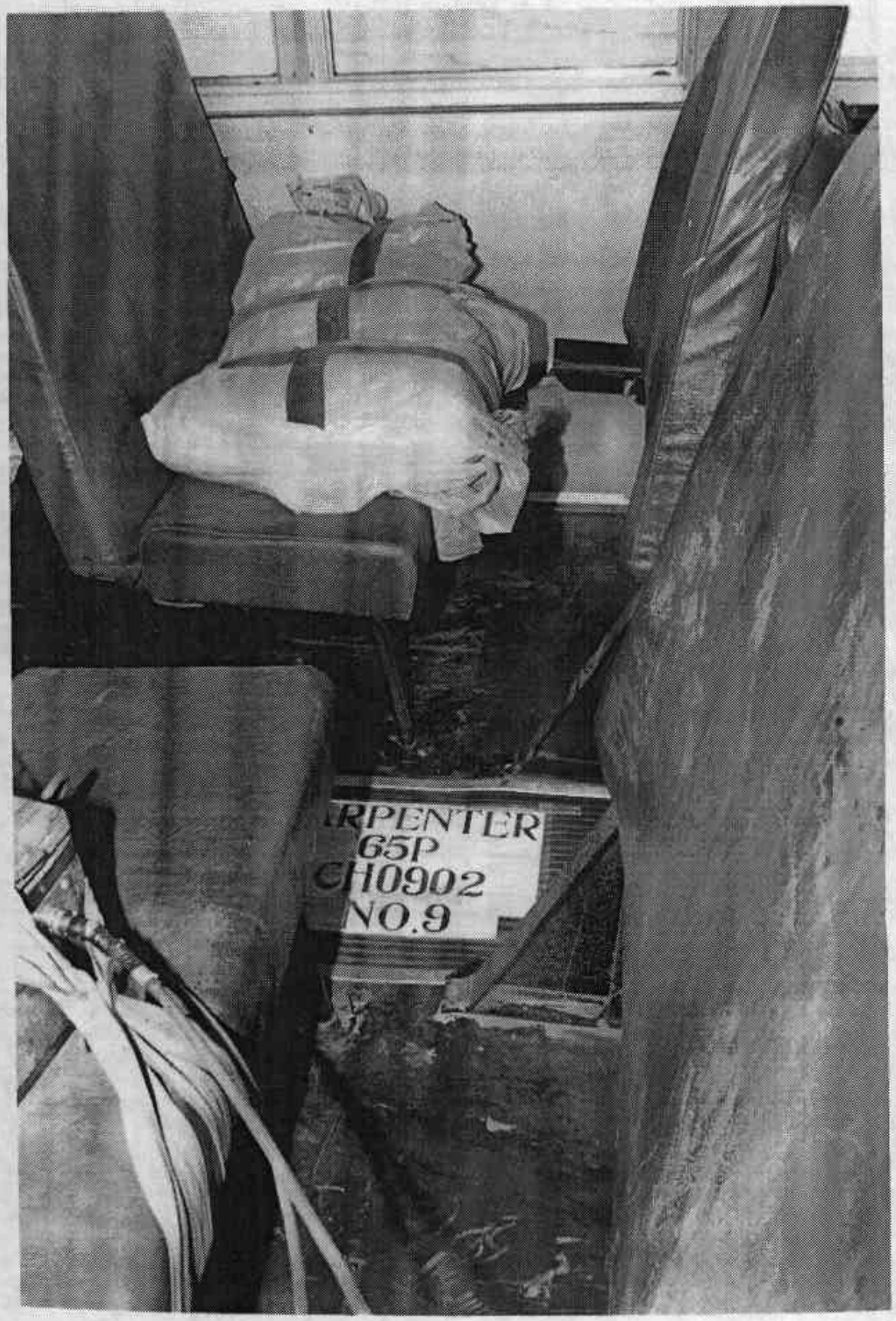


FIGURE 2-8 INTERIOR VIEW OF FLOOR - PRETEST

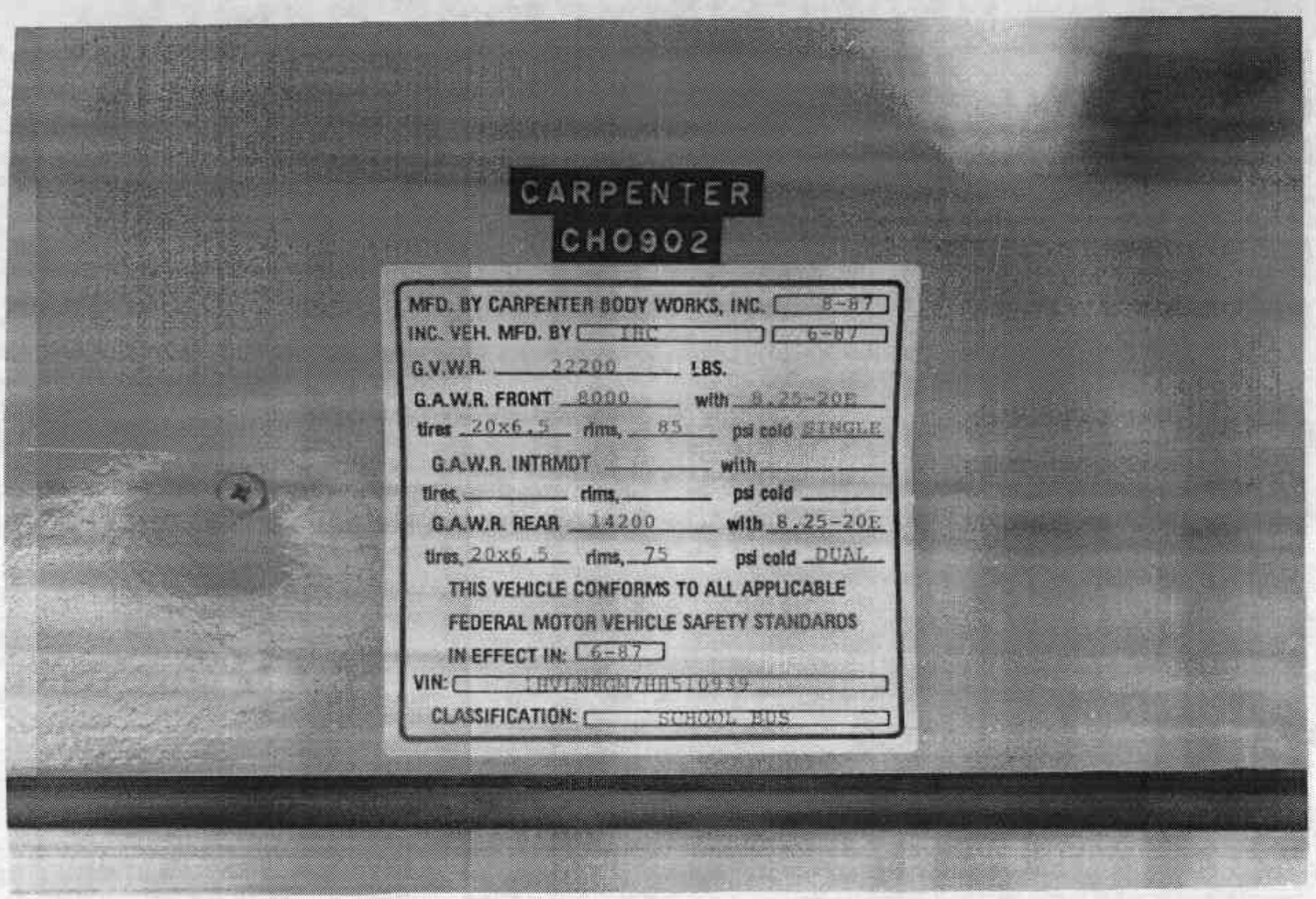
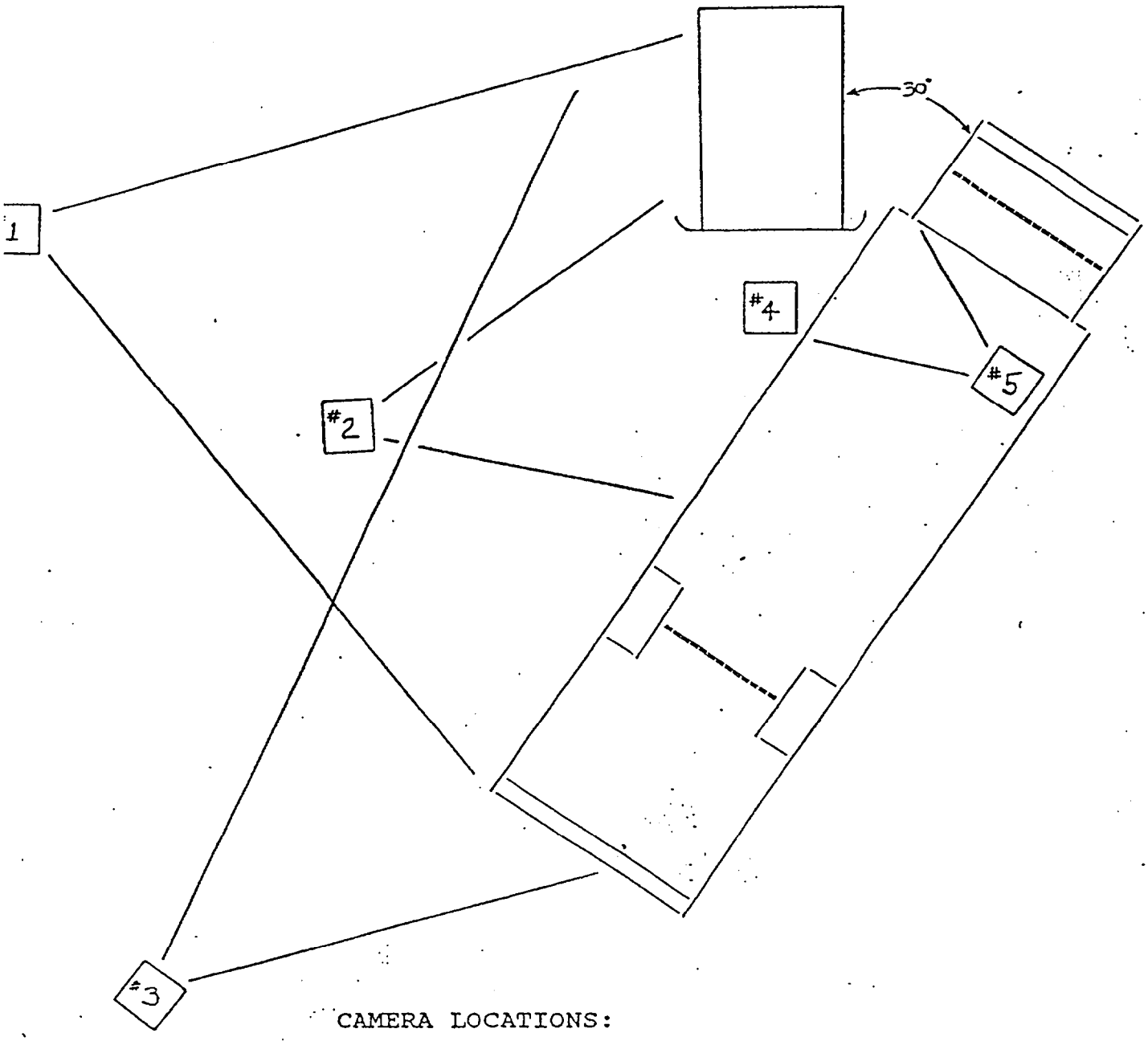


FIGURE 2-9 MANUFACTURER'S CERTIFICATION LABEL



CAMERA LOCATIONS:

NO. 1 - Overall left side view.
NO. 2 - Closeup view of impact area.
NO. 3 - Overall view from behind impact area.
NO. 4 - Overhead of impact area.
NO. 5 - Onboard looking directly at floor.

FIGURE 2-10 HIGH SPEED CAMERA POSITIONS

TABLE 2-1 SCHOOL BUS DYNAMIC IMPACT TEST, SUMMARY

YEAR/MAKE/MODEL: 1987/CARPENTER/CONVENTIONAL

BODY STYLE: 65 PASSENGER SCHOOL BUS TEST NO: 9

NHTSA NO: CH0902 TEST DATE: 02/07/89

ADDED BALLAST WEIGHT: 3,900 lbs

TOTAL TEST VEHICLE WEIGHT: 17,450 lb

BUS IMPACTED ON X LEFT SIDE ____ RIGHT SIDE.

BUS POSITIONED AT A 30° ANGLE RELATIVE TO ONCOMING SLED.

C.G. LOCATED 163.1 INCHES REAR OF FRONT AXLE.

ACTUAL IMPACT SPEED: 30.22 mph

MAXIMUM CRUSH DISTANCE: 8.2 in

RESULTANT ACCELERATION OF BUS C.G. 20.5 g

JOINT SEPARATION SUMMARY: One floor joint separated during the impact. The separated joint was located 79 inches rearward of the font axle, behind the driver's seat. The joint separated 36.5 inches laterally across the bus.

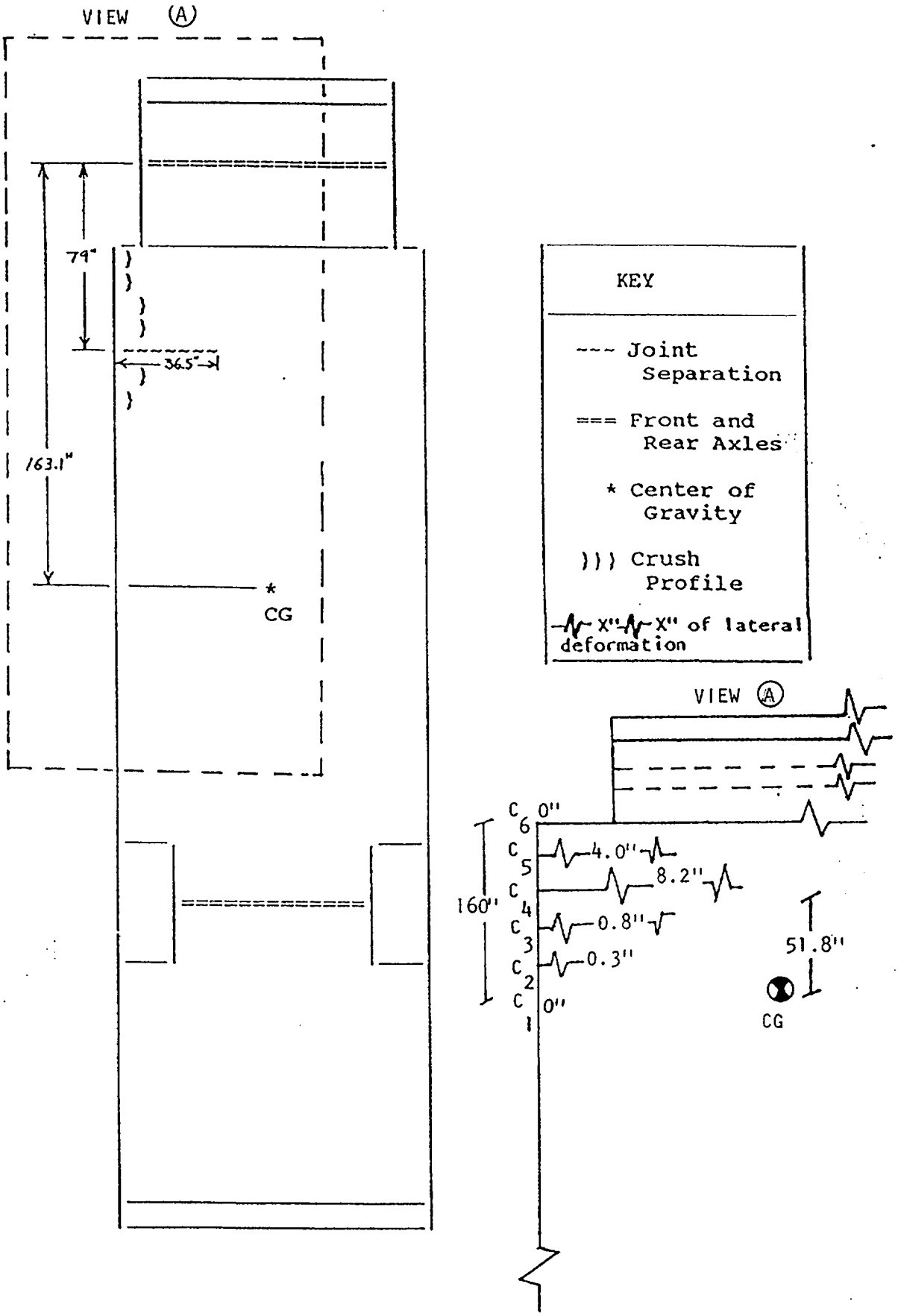


FIGURE 2-11 APPROXIMATE CRUSH AND JOINT SEPARATION PROFILES

SECTION 3

TEST RESULTS

The 1987 Carpenter Conventional School Bus, NHTSA No. CH0902 was impacted by a 10,000 pound contoured moving barrier on 07 February 1989 at an actual impact speed of 30.22 mph. The impact was on the left side of the bus just aft of the "A" pillar. The bus was positioned at a 30° angle relative to the oncoming barrier. Test vehicle information is given in Table 3-1.

The bus was impacted 31.3 inches rearward of the front axle and was crushed inwards a maximum of 8.2 inches. There was floor joint separation at one location in the bus. Test result details are given in Table 3-2. Posttest views of the outer, underneath and inner structure of the bus are shown in Figures 3-1 to 3-8.

Seven accelerometer channels were recorded and analyzed. Accelerometer locations are given in Table 3-3. A summary of peak accelerometer values is given in Table 3-4. Data plots of acceleration versus time for all channels are shown in Figures 3-9 to 3-16.

TABLE 3-1 TEST VEHICLE INFORMATION

VEHICLE MANUFACTURER: CARPENTER BODY WORKS, INC.

MAKE/MODEL: CARPENTER CONVENTIONAL

BODY STYLE: 65 PASSENGER SCHOOL BUS MODEL YEAR: 1987

VIN: 1HVLNHGM7HH510939 BUILD DATE: 08/87

NHTSA NO: CH0902

GVWR: 22,200 lb

GAWR FRONT: 8,000 lb GAWR REAR: 14,200 lb

WHEELBASE: 254.0 in TOTAL LENGTH: 386.0 in

BUS FLOOR IS 40.0 INCHES ABOVE GROUND LEVEL

TEST VEHICLE WEIGHT (READY FOR TEST):

TOTAL FRONT WEIGHT: 6,190 lb (35.5 % OF TOTAL WT.)

TOTAL REAR WEIGHT: 11,260 lb (64.5 % OF TOTAL WT.)

TOTAL TEST WEIGHT: 17,450 lb

Which includes 3,900 lb (65 x 60 lb) of added ballast weight.

CENTER OF GRAVITY LOCATED 163.1 INCHES REAR OF FRONT AXLE.

TABLE 3-2 TEST RESULTS

TEST VEHICLE: 1987 CARPENTER CONVENTIONAL SCHOOL BUS

TEST NO. 9 TEST DATE: 02/07/89

ACTUAL IMPACT SPEED: 30.22 mph

IMPACT POINT IS 31.3 in REARWARD OF FRONT AXLE.

BUS IMPACTED ON left HAND SIDE.

BUS POSITIONED AT A 30° ANGLE RELATIVE TO MOVING BARRIER.

MOVING BARRIER WEIGHT: 10,000 lb

MAXIMUM CRUSH DISTANCE: 8.2 in

FLOOR CONSTRUCTION AT AREA OF IMPACT: The floor is constructed of 1/16 inch plate steel with vinyl covering. The first floor joint is located 79 inches rearward of the front axle, just behind the driver's seat. From this point on towards the rear of the bus the floor is composed of sections 28 inches wide by 91.5 inches long laid side by side. Two U shaped supports traverse the length of each section, welded in place 9 1/4 inches apart. Between floor sections are the floor joints which run the width of the bus. Therefore floor joints are spaced approximately 28 inches apart.

TABLE 3-2 TEST RESULTS (CONT.)

DAMAGE DETAILS: The 10,000 lb moving barrier contacted the bus just aft of the "A" pillar. Crush of the bus left side extended approximately 80 inches rearward of the impact point with a maximum lateral crush of 8.2 inches. The floor joint, located behind the driver's seat, 79 inches rearward of the front axle, separated 36.5 inches laterally across the bus. The floor immediately forward of this joint was badly buckled. No other joint separation was detected. The bus main body pulled away from the front engine compartment along the left side pulling 4 secured bolts out of the sheet metal. A second impact of the 10,000 lb sled occurred 160 inches rearward of the front axle. this caused minor side and floor damage, but no joint separation. Incidentally, the second impact occurred where the gas tank and the cage would have been, if they were not removed. There were no significant gaps created in the floor due to the joint separation. View (A) of Figure 2-11 shows the deformation at six different points along the 160" long crushed portion of the bus.

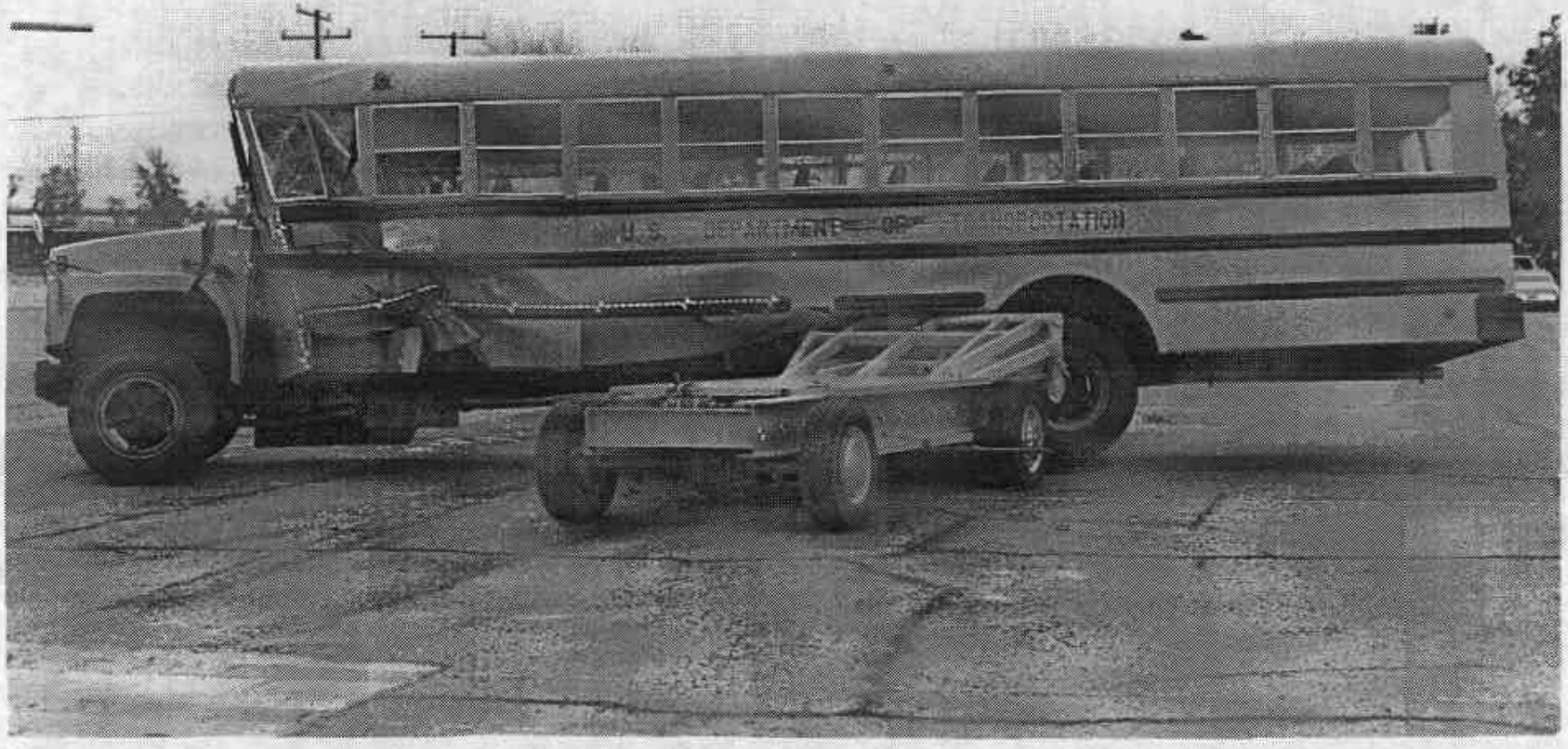


FIGURE 3-1 LEFT SIDE OVERALL VIEW - POSTTEST

FIGURE 3-2 FRONT VIEW – POSTTEST

FIGURE 3-3 RIGHT SIDE OVERALL VIEW - POSTTEST

FIGURE 3-4 REAR VIEW - POSTTEST

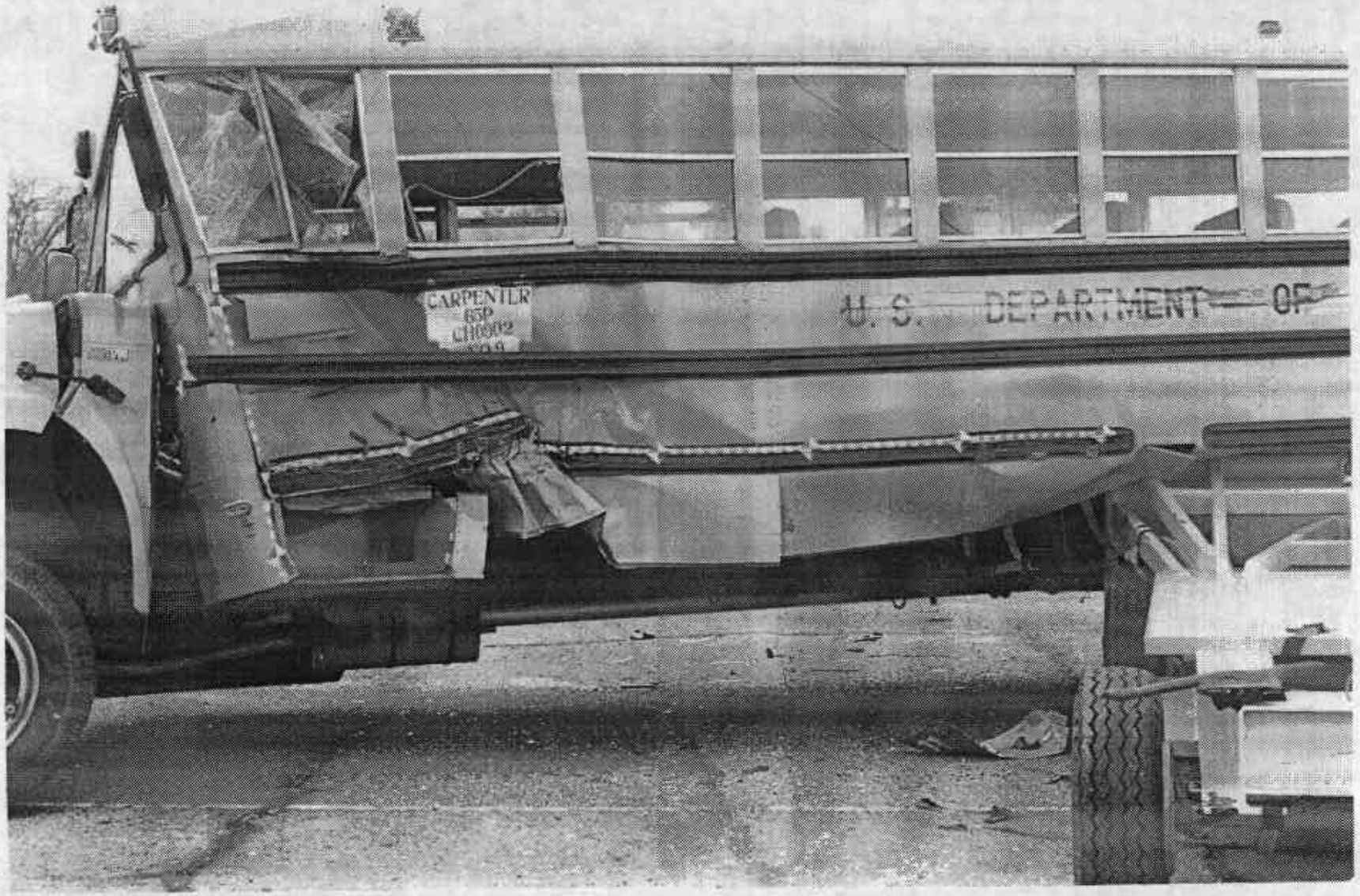


FIGURE 3-5 CLOSEUP VIEW OF IMPACT AREA – POSTTEST

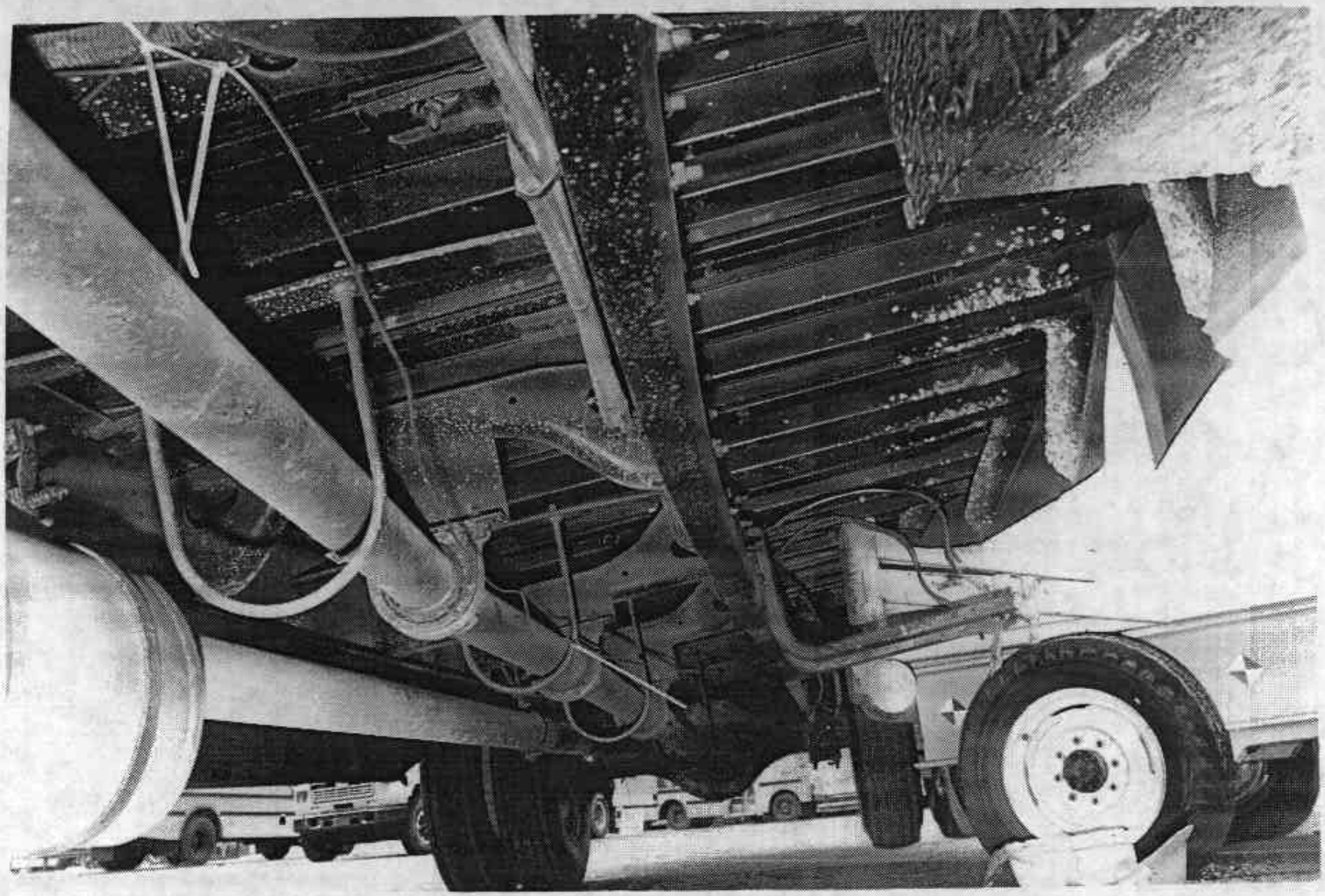


FIGURE 3-6 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING FRONT TO REAR - POSTTEST

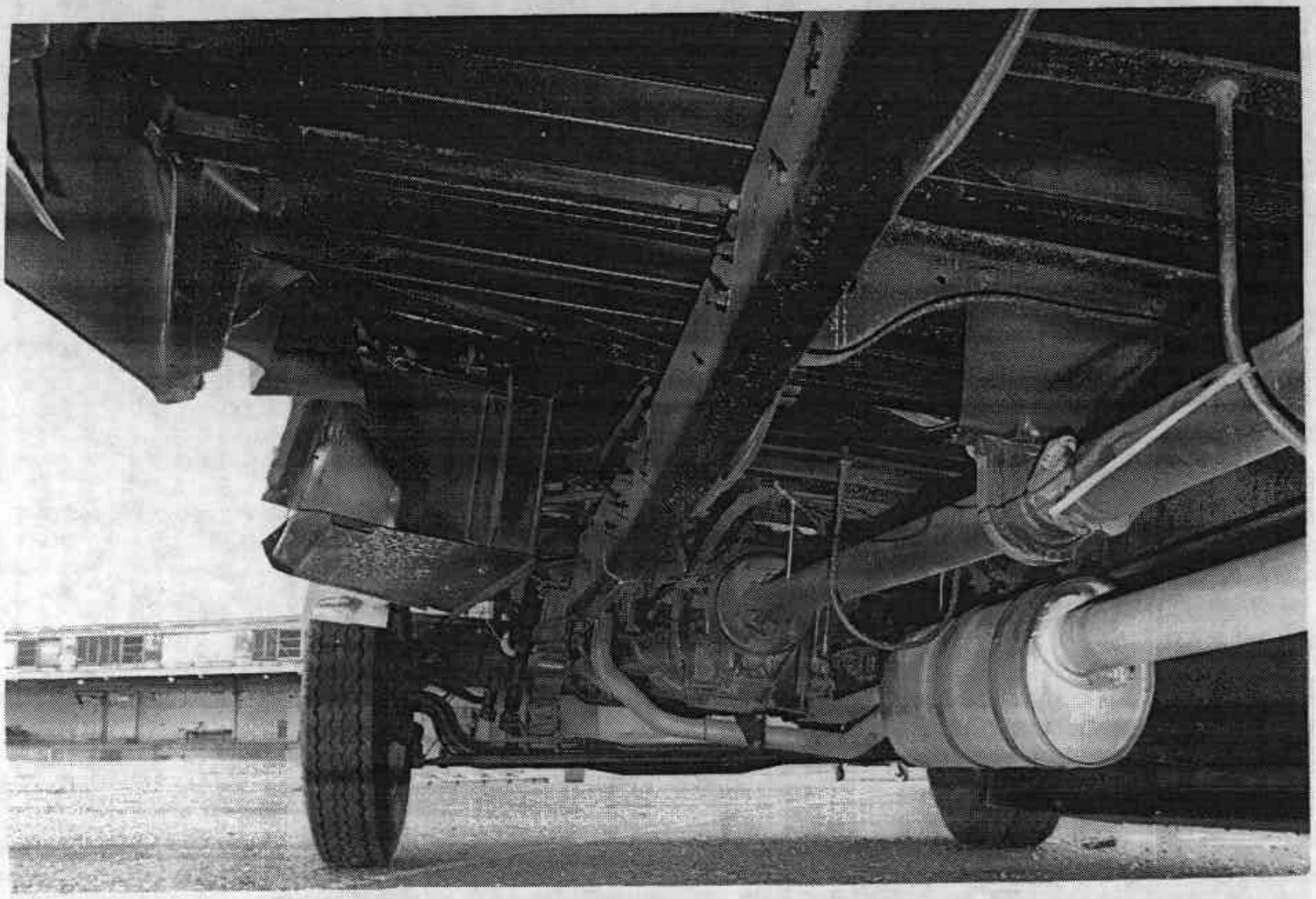


FIGURE 3-7 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING REAR TO FRONT - POSTTEST

FIGURE 3-8 INTERIOR VIEW OF JOINT SEPARATION - POSTTEST

TABLE 3-3 ACCELEROMETER LOCATIONS

TEST VEHICLE:

Triaxial accelerometer located at bus C.G.

X: 163.1 in rearward of front axle.

Y: Located on bus longitudinal centerline.

Z: 42.0 in above ground level.

MOVING BARRIER:

Biaxial accel. located on moving barrier front crossmember.

X: 1.5 in forward of front axle.

Y: Located on sled longitudinal centerline.

Z: 23.0 in above ground level.

Biaxial accel. located on moving barrier rear crossmember.

X: 1.0 in forward of rear axle.

Y: Located on sled longitudinal centerline.

Z: 25.5 in above ground level.

TABLE 3-4 ACCELEROMETER DATA SUMMARY

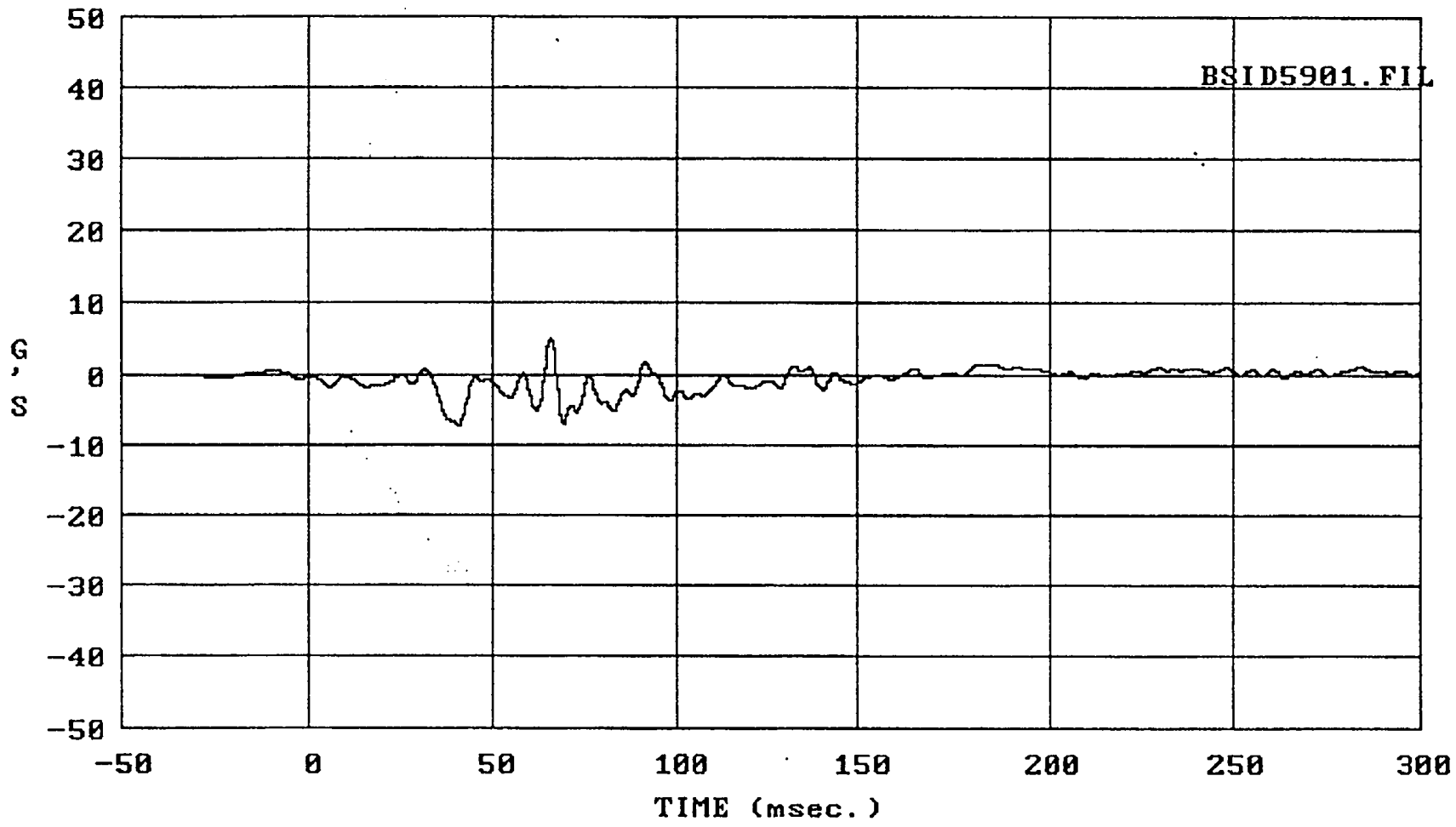
ACCEL. LOCATION	POS. DIRECT.		NEG. DIRECT.	
	Max (g)	Time (msec)	Max (g)	Time (msec)
Bus Center of Gravity				
Longitudinal X	5.2	65.4	-7.3	40.3
Lateral Y	19.4	44.9	-5.7	70.5
Vertical Z	5.8	92.1	-6.9	110.7
Resultant	20.5	40.0	0.0	0.0
Moving Barrier - Front Crossmember				
Longitudinal X	0.9	281.4	-8.3	44.5
Lateral Y	9.4	45.5	-3.5	41.5
Moving Barrier - Rear Crossmember				
Longitudinal X	0.9	283.9	-10.2	43.7
Lateral Y	6.1	42.3	-3.5	139.4

Accelerometer Orientation:

Longitudinal X - Positive Forward.

Lateral Y - Positive to the Right.

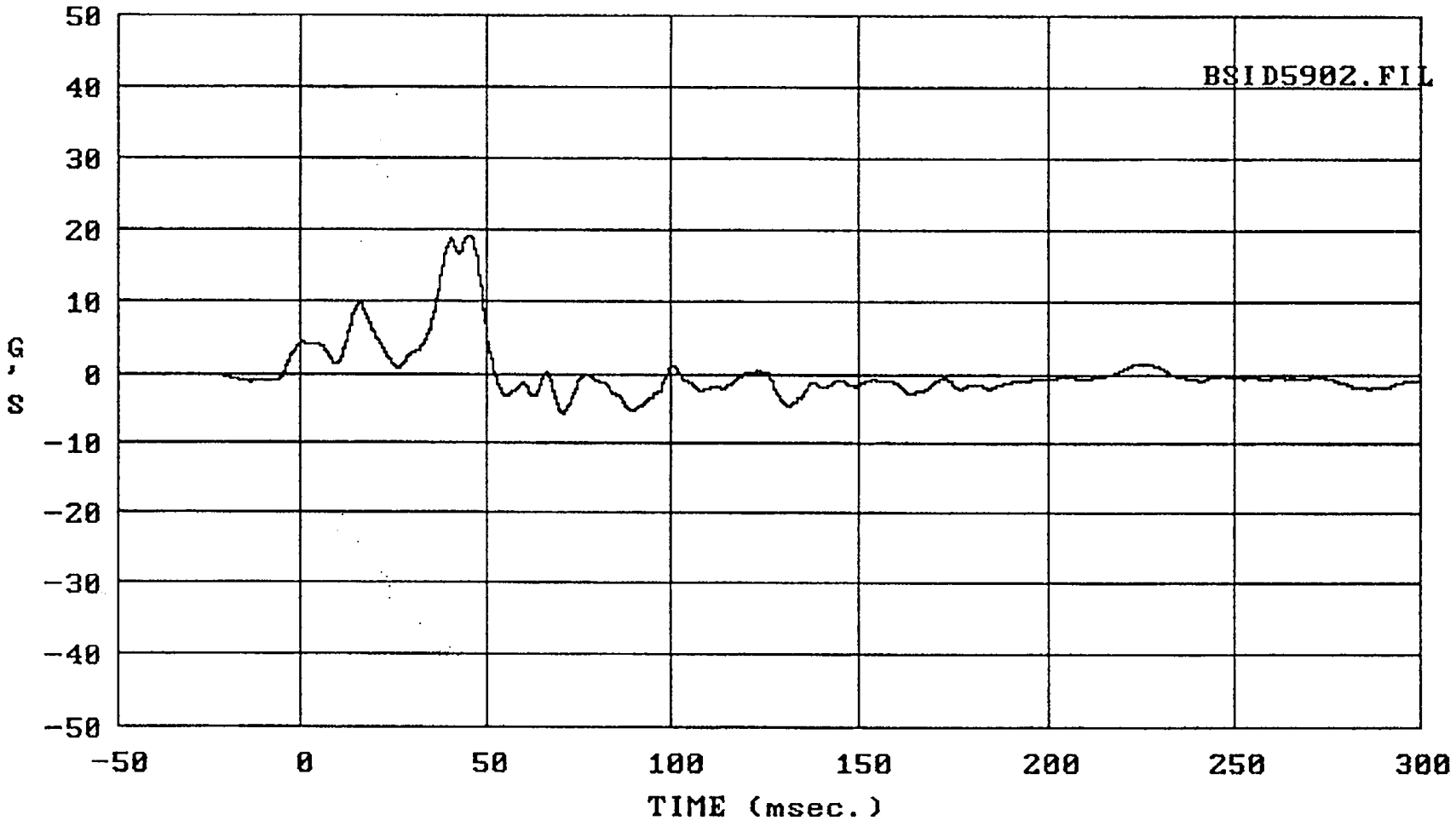
Vertical Z - Positive is Up.



Filter: SAE CLASS 60 Max = 5.2147 Min = -7.2983

MSE 02/07/89 -- Carpenter 65p Bus : Vehicle C/G, X-axis

FIGURE 3-9



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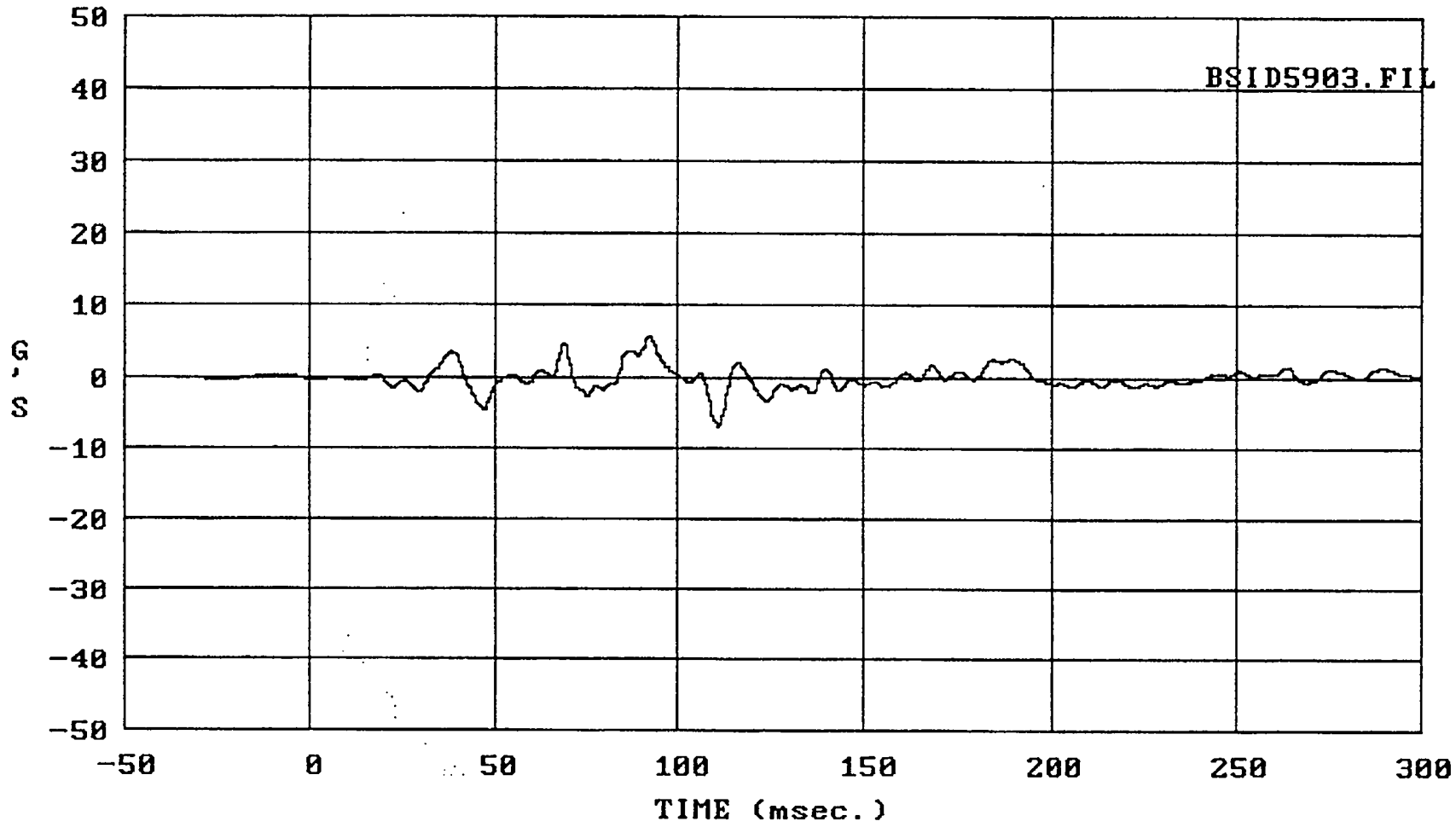
MSE 02/07/89 -- Carpenter 65p Bus : Vehicle C/G, Y-axis

FIGURE 3-10



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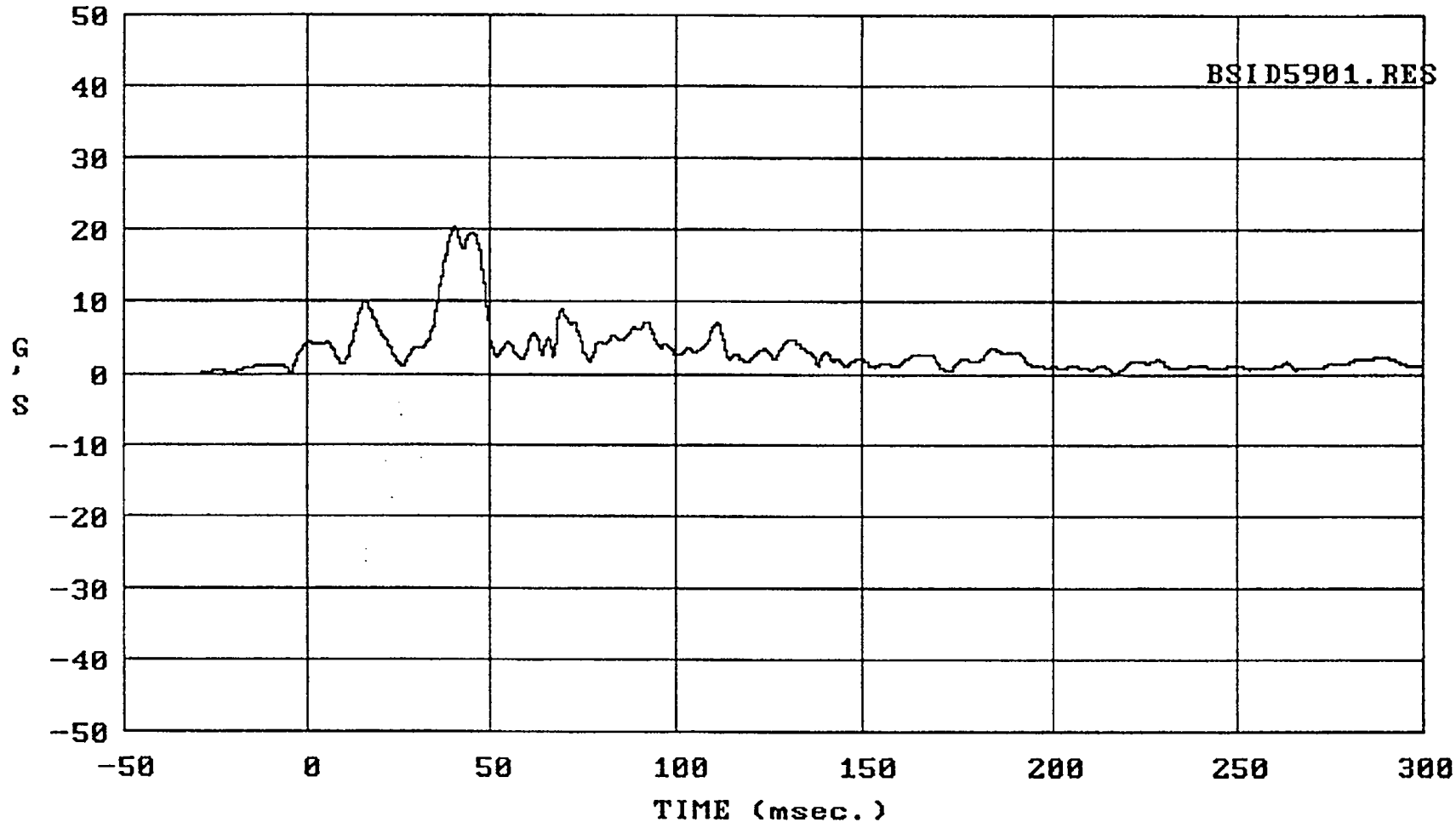
MSE 02/07/89 -- Carpenter 65p Bus : Vehicle C/G, Z-axis

FIGURE 3-11



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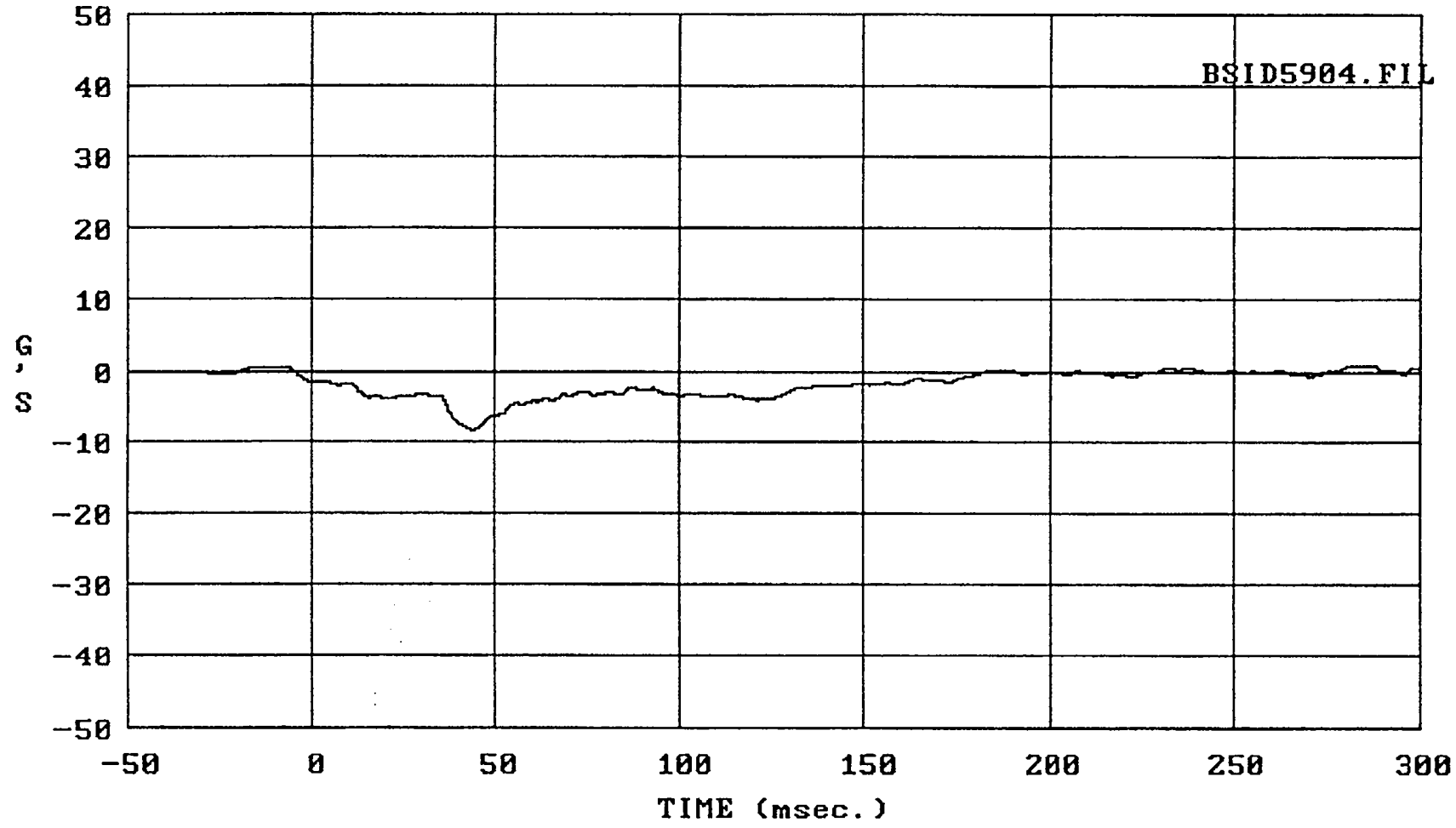
MSE 02/07/89 -- Carpenter 65p Bus : Vehicle C/G resultant accel.

FIGURE 3-12



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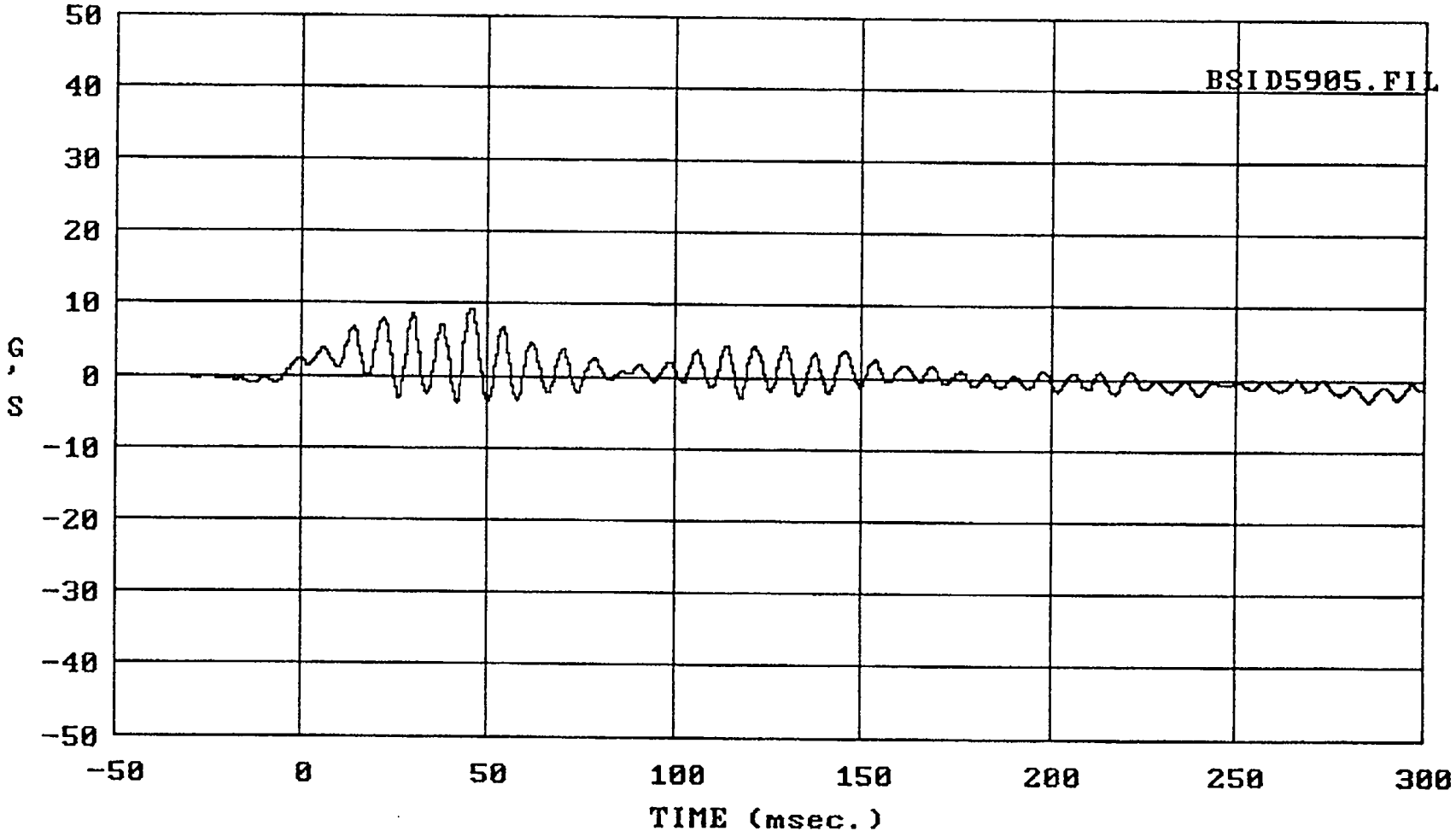
MSE 02/07/89 -- Carpenter 65p Bus : Impact Sled: Front Axle, X-axis

FIGURE 3-13



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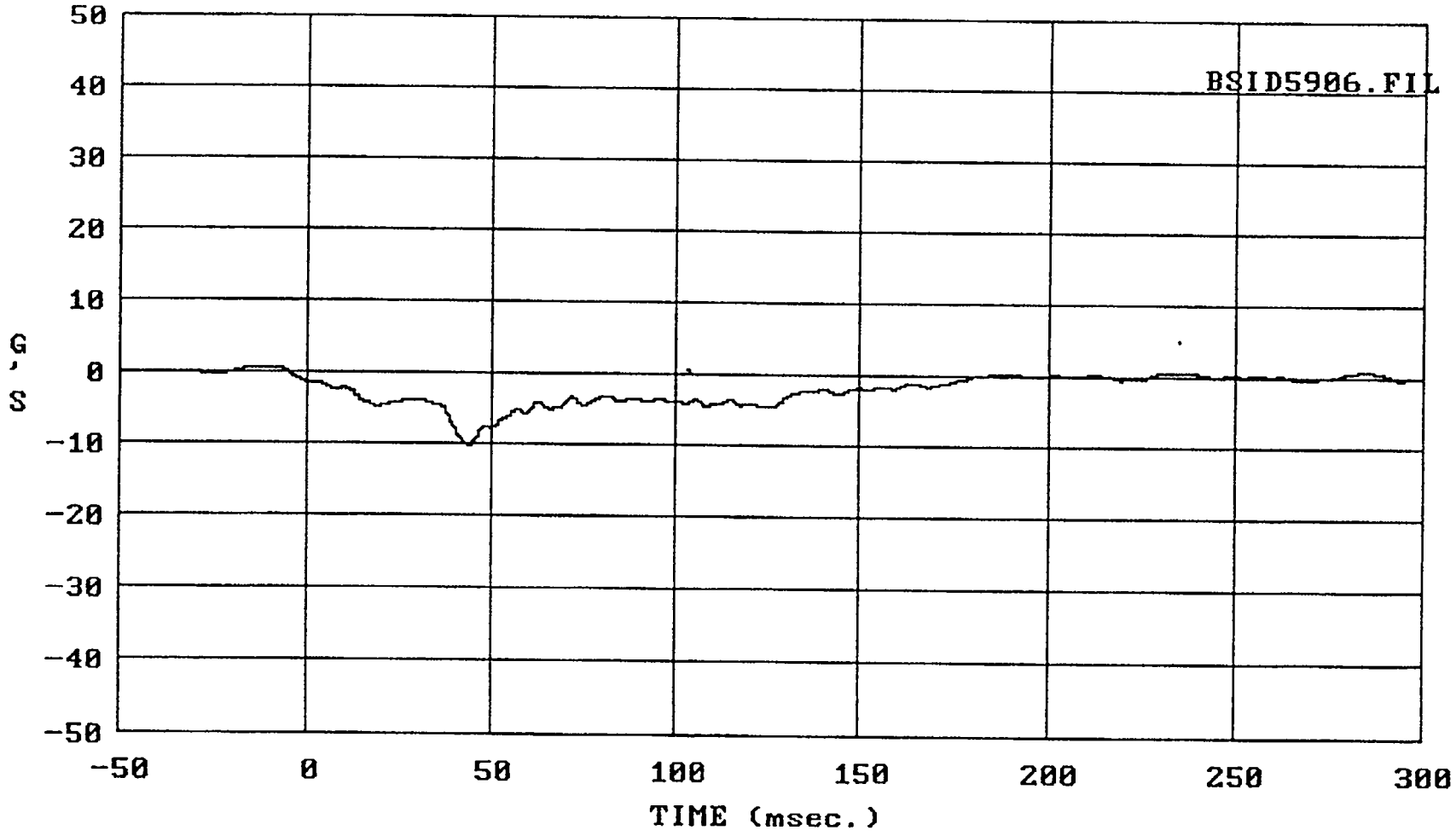
MSE 02/07/89 -- Carpenter 65p Bus : Impact Sled: Front Axle, Y-axis

FIGURE 3-14



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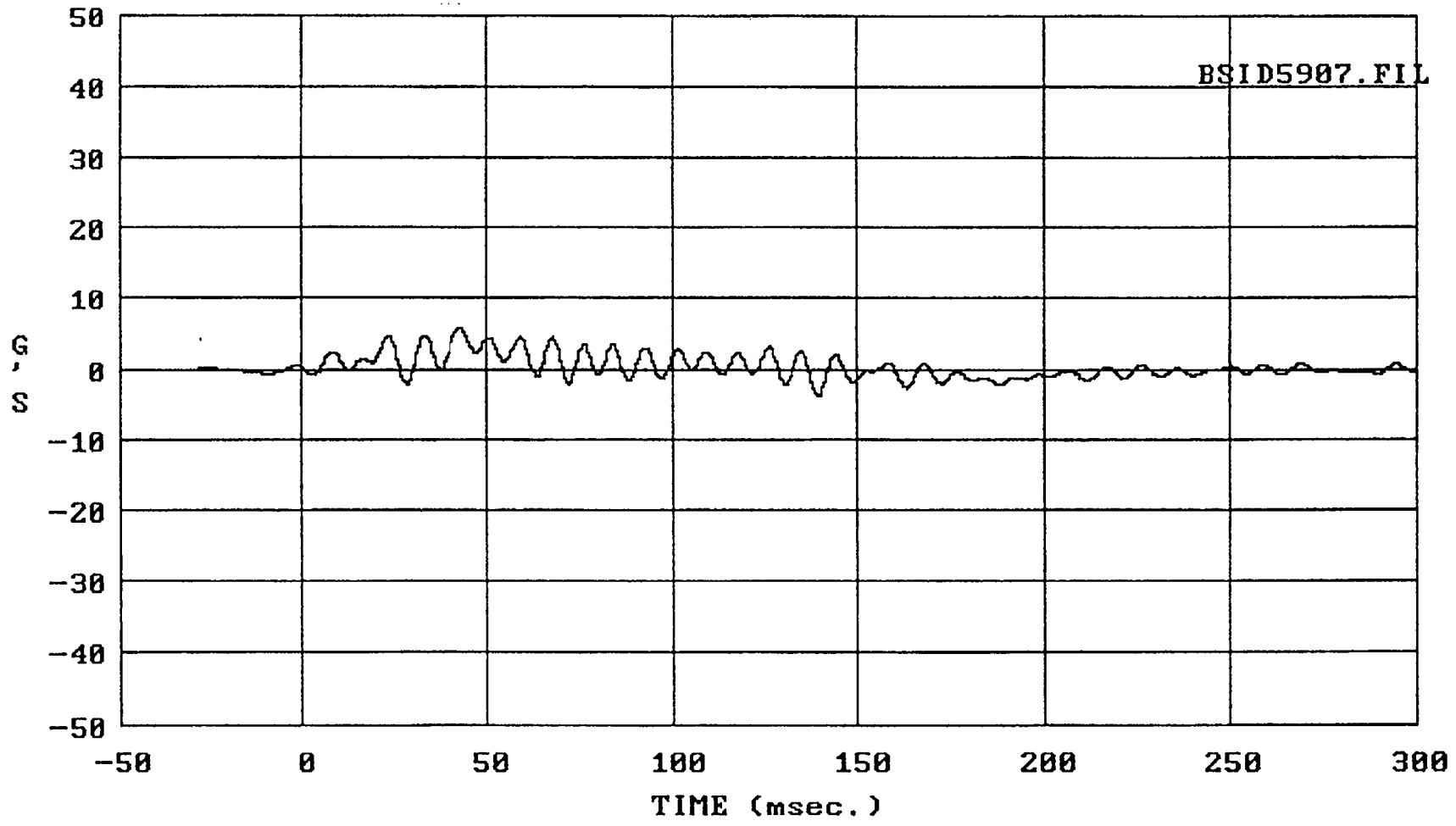
MSE 02/07/89 -- Carpenter 65p Bus : Impact Sled: Rear Axle, X-axis

FIGURE 3-15



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MSE 02/07/89 -- Carpenter 65p Bus : Impact Sled: Rear Axle, Y-axis

FIGURE 3-16