

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

1985 CARPENTER CADET SCHOOL BUS
24 PASSENGER

NHTSA NO. CF0902

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MARCH 1989

FINAL REPORT

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National Highway Traffic Safety Administration
Office of Crashworthiness Research
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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 seventh of the series of ten tests. The test vehicle was a 1985 Carpenter Cadet School Bus with a 24 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 1985 Carpenter Cadet School Bus, NHTSA No. CF0902 was tested on 19 January 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 "B" 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.

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

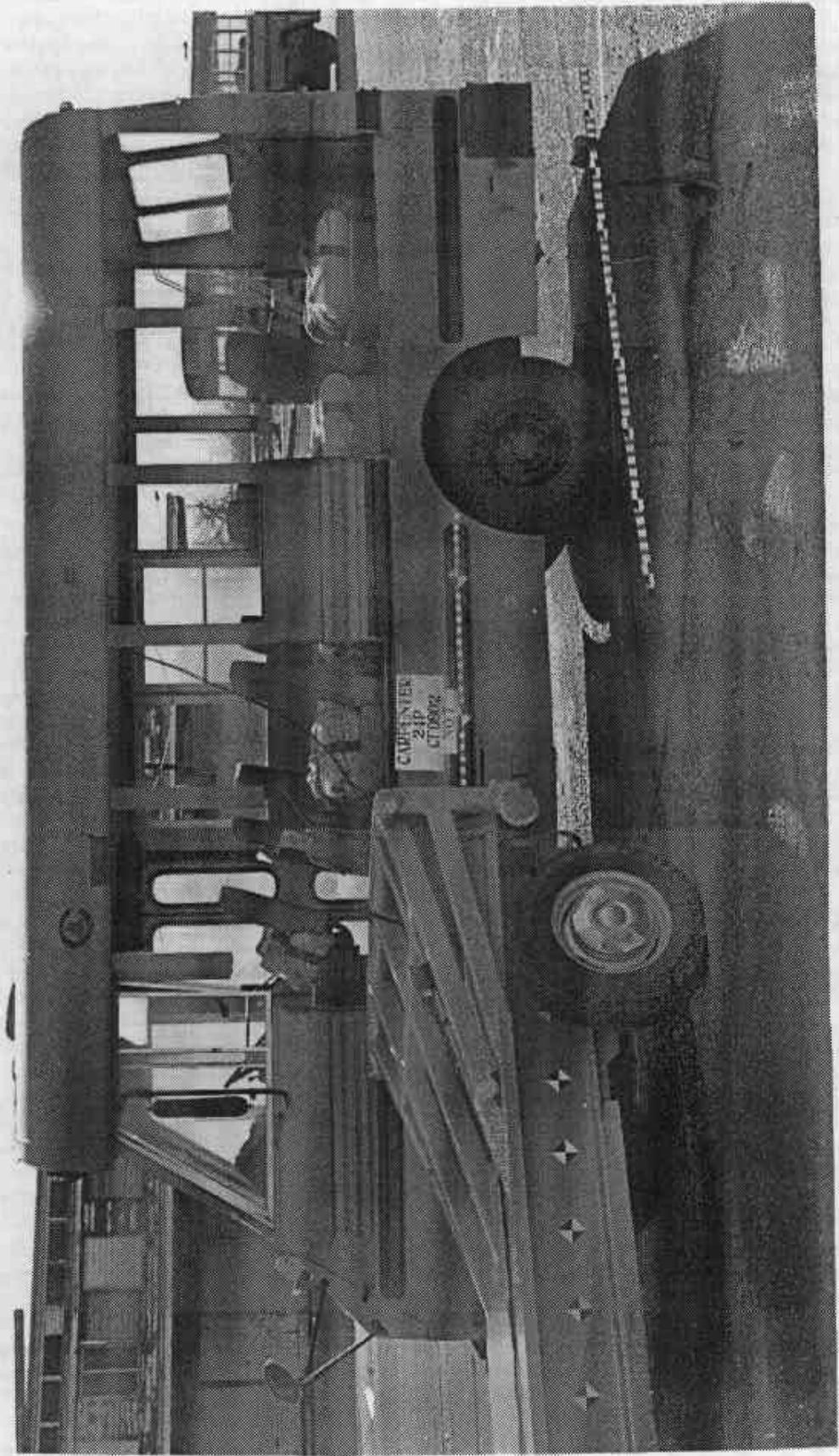


FIGURE 2-1 LEFT SIDE OVERALL VIEW - PRETEST

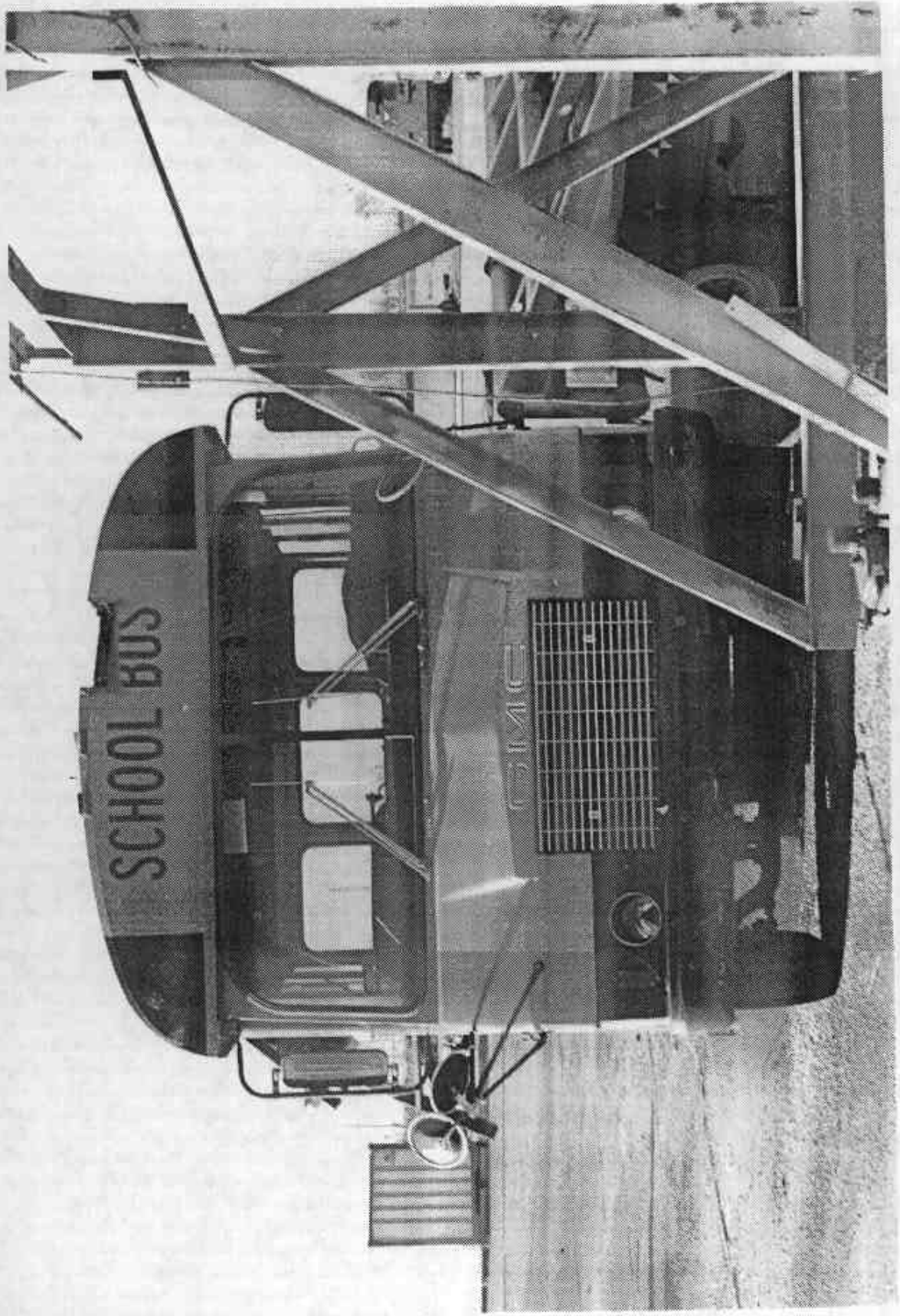


FIGURE 2-2 FRONT VIEW - PRETEST

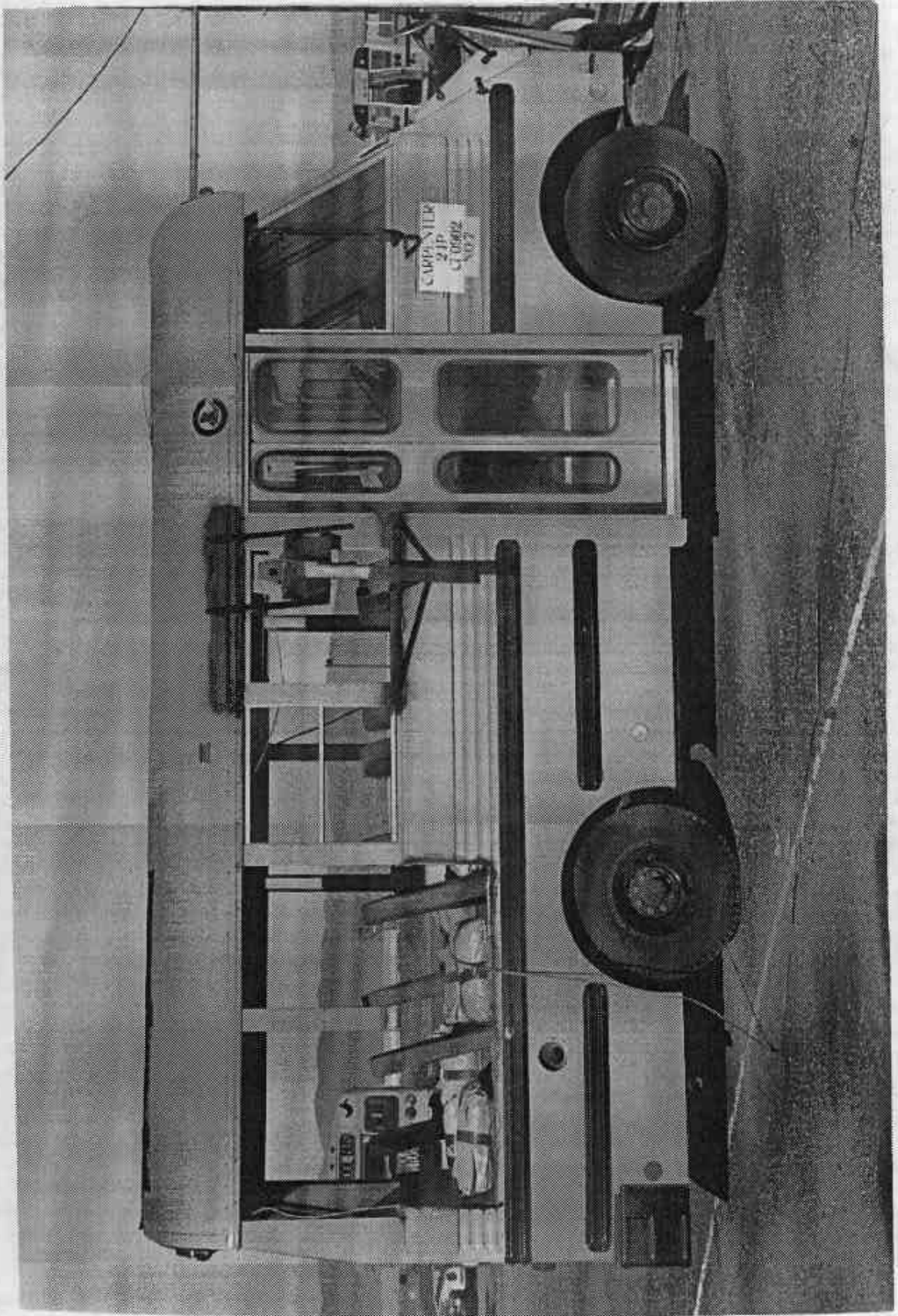


FIGURE 2-3 RIGHT SIDE OVERALL VIEW - PRETEST

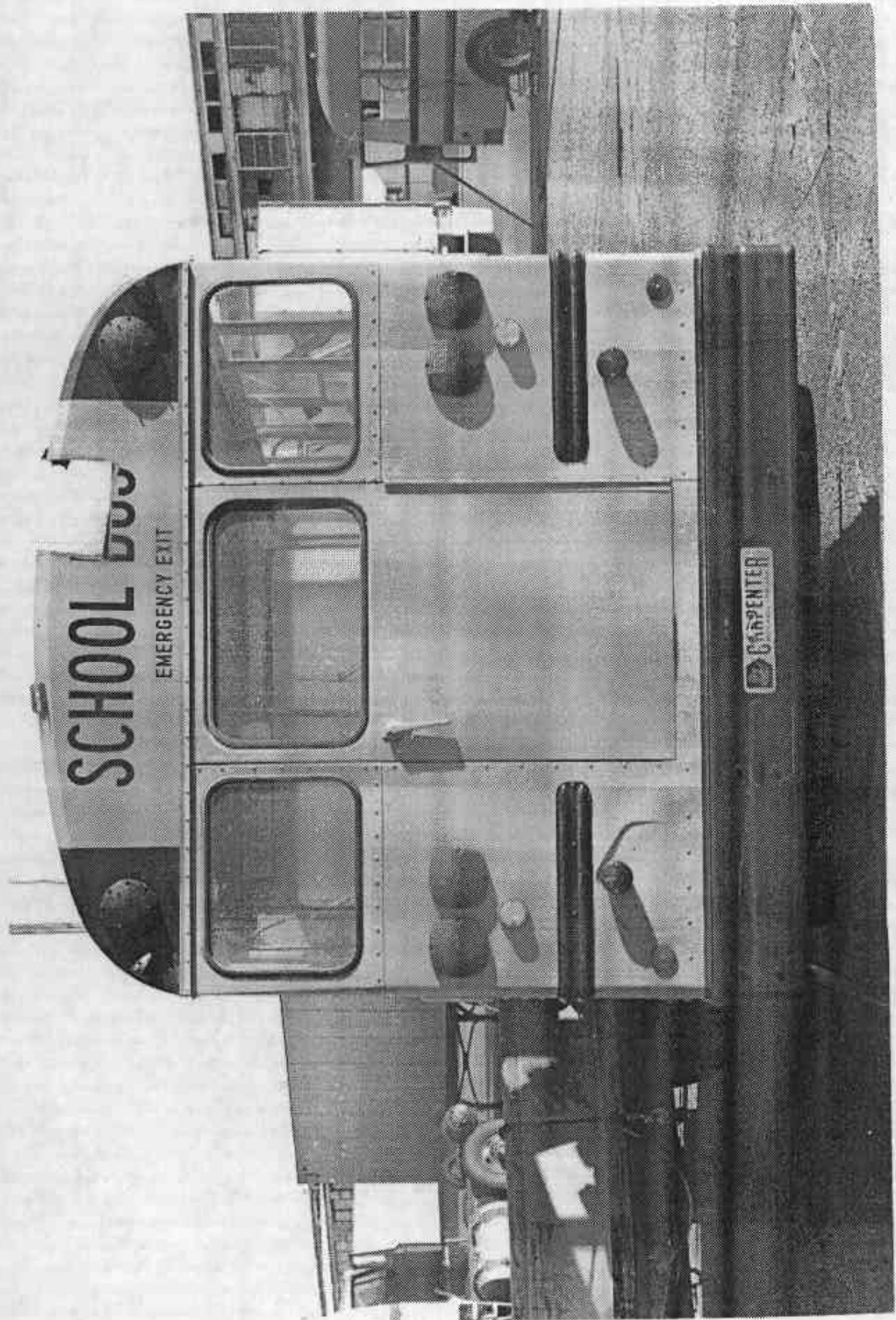


FIGURE 2-4 REAR VIEW - PRETEST



FIGURE 2-5 CLOSEUP VIEW OF IMPACT AREA - PRETEST

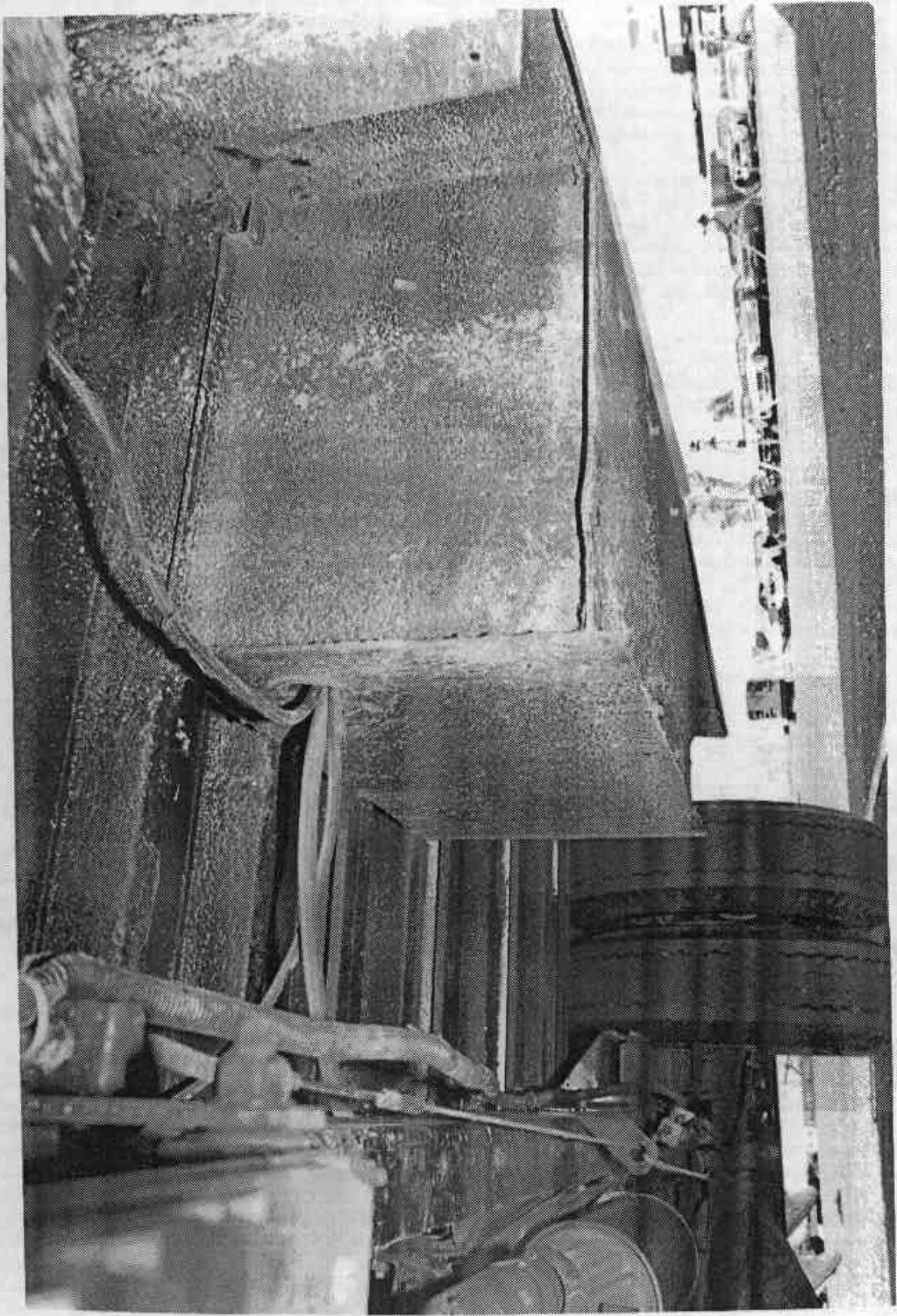


FIGURE 2-6 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING FRONT TO REAR - PRETEST

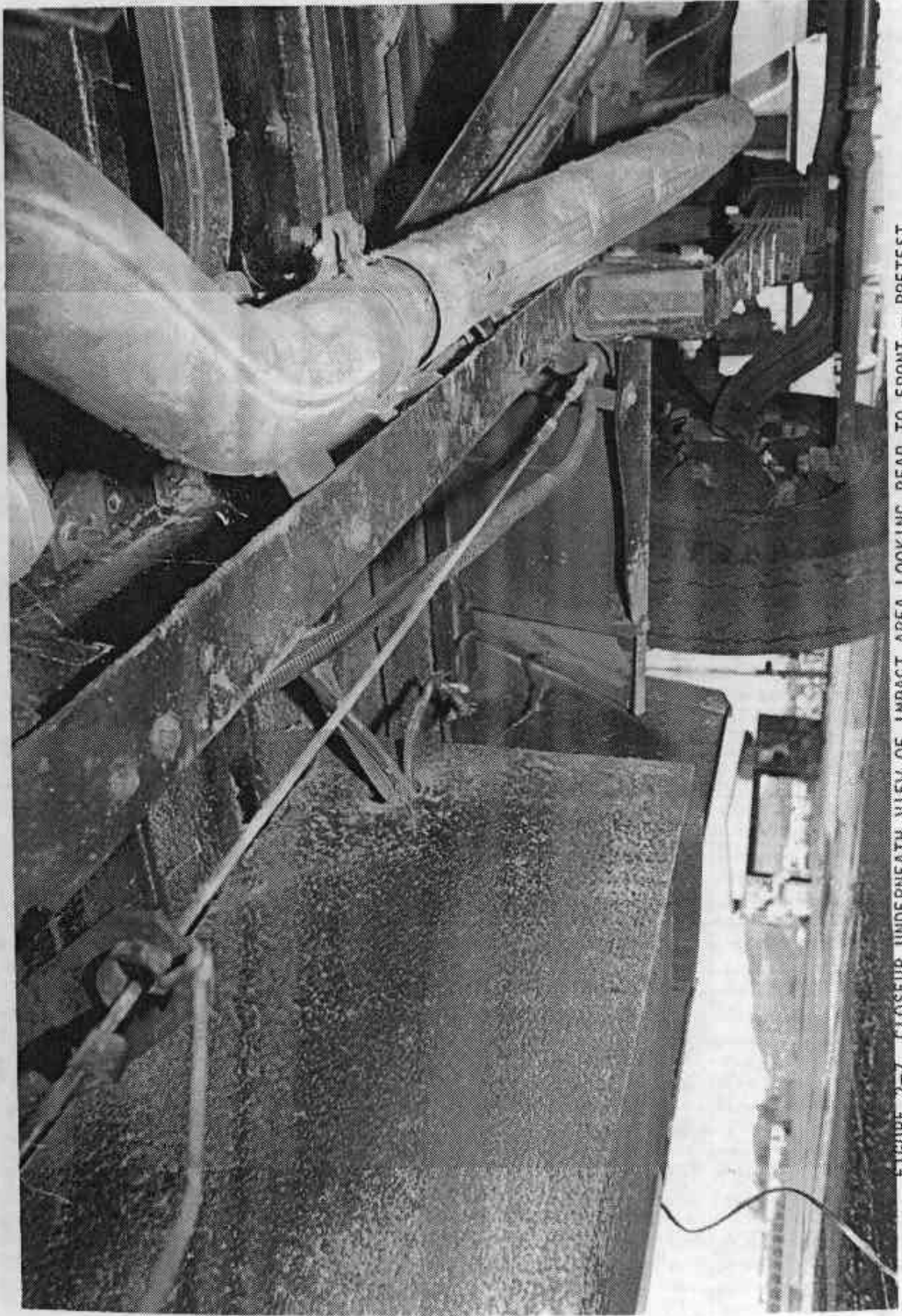


FIGURE 2-7 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING REAR TO FRONT - PRETEST

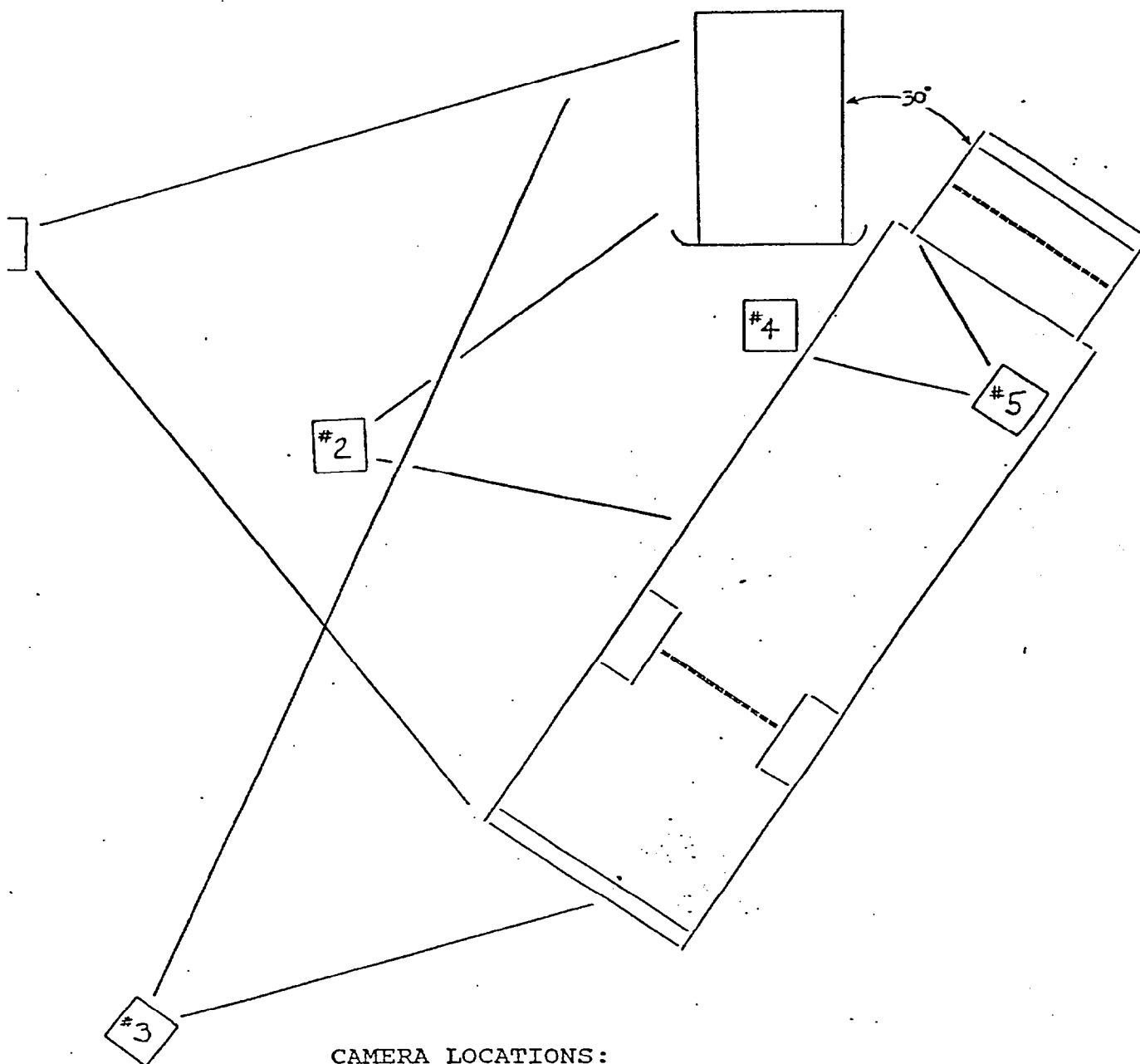


FIGURE 2-8 INTERIOR VIEW OF FLOOR - PRETEST

CARPENTER
CF0902

MFD. BY CARPENTER BODY WORKS, INC. 4-55
 INC. VEH. MFD. BY 1-55
 G.V.W.R. 11,500 LBS.
 G.A.W.R. FRONT 4,600 with 7.50x16D
 tires 16x0K rims, 5.5 per cold SINGLE
 G.A.W.R. INTRMDT _____ with _____
 tires _____ rims _____ per cold _____
 G.A.W.R. REAR 3,900 with 7.50x16D
 tires 16x0K rims, 5.5 per cold DUAL
 THIS VEHICLE CONFORMS TO ALL APPLICABLE
 FEDERAL MOTOR VEHICLE SAFETY STANDARDS
 IN EFFECT IN: 1-55
 VIN: 44-1338-1360-343
 CLASSIFICATION: 2100

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: 1985/CARPENTER/CADET

BODY STYLE: 24 PASSENGER SCHOOL BUS TEST NO: 7

NHTSA NO: CF0902 TEST DATE: 01/19/89

ADDED BALLAST WEIGHT: 1,440 lbs

TOTAL TEST VEHICLE WEIGHT: 9,260 lb

BUS IMPACTED ON X LEFT SIDE RIGHT SIDE.

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

C.G. LOCATED 176.2 INCHES REAR OF FRONT AXLE.

ACTUAL IMPACT SPEED: 30.38 mph

MAXIMUM CRUSH DISTANCE: 17.3 in

RESULTANT ACCELERATION OF BUS C.G. 29.7 g

JOINT SEPARATION SUMMARY: Two floor joints separated during the impact. The first joint was located 27 inches rearward of the front axle, just in front of the driver's seat. The joint separated laterally 32 inches inwards from the bus left side. The other separated joint was located 68.5 inches rearward of the front axle. It had a 12 inch length of separation located 53 inches from the bus left side, near the top of the stairway leading into the bus.

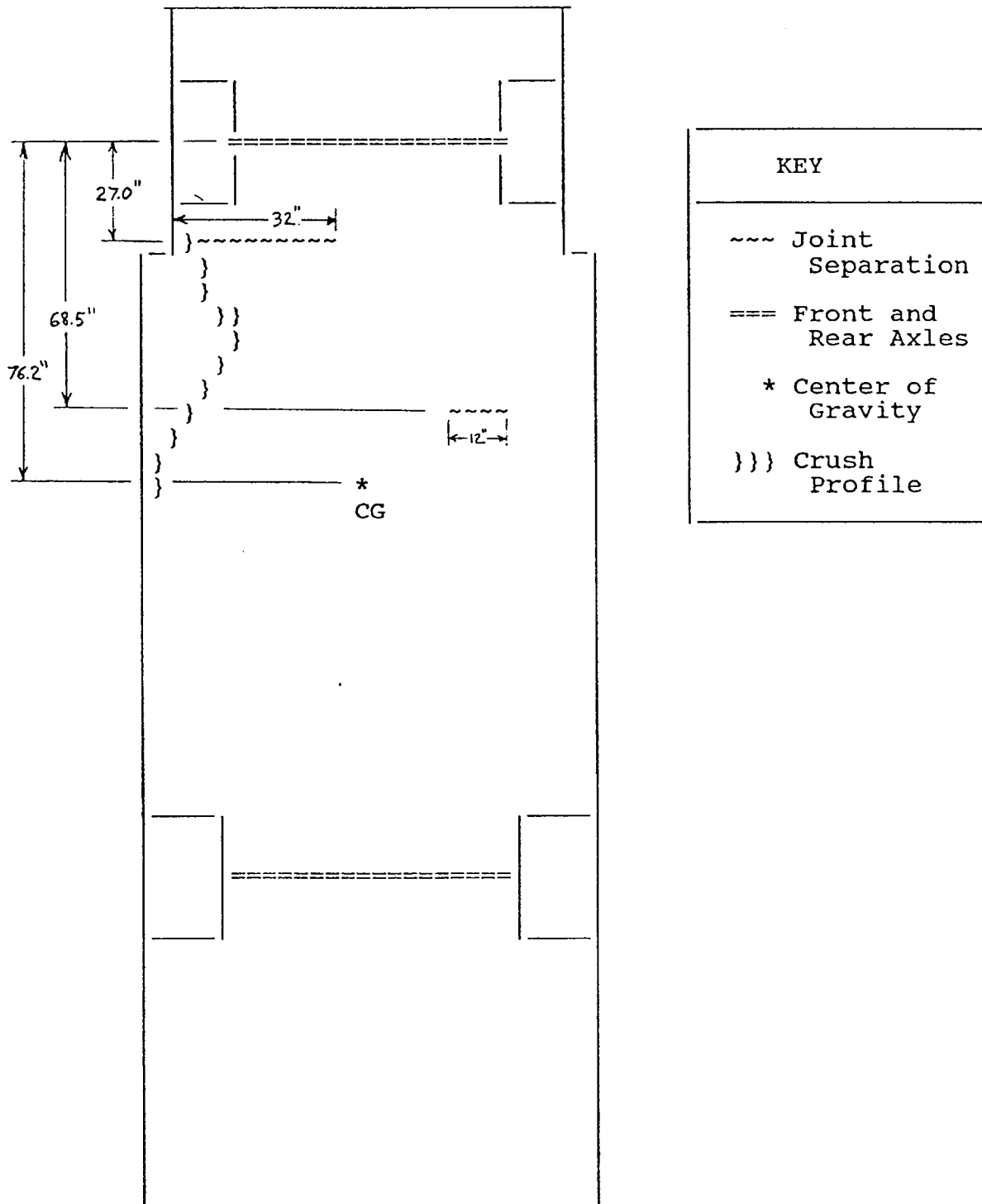


FIGURE 2-11 APPROXIMATE CRUSH AND JOINT SEPARATION PROFILES

SECTION 3

TEST RESULTS

The 1985 Carpenter Cadet School Bus, NHTSA No. CF0902 was impacted by a 10,000 pound contoured moving barrier on 19 January 1989 at an actual impact speed of 30.38 mph. The impact was on the left side of the bus just aft of the "B" 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 31.0 inches rearward of the front axle and was crushed inwards a maximum of 17.3 inches. There was floor joint separation at two locations 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 CADET

BODY STYLE: 24 PASSENGER SCHOOL BUS MODEL YEAR: 1985

VIN: 1GDJP32M9F3505345 BUILD DATE: 04/85

NHTSA NO: CF0902

GVWR: 11,500 lb

GAWR FRONT: 4,400 lb GAWR REAR: 7,900 lb

WHEELBASE: 125.5 in TOTAL LENGTH: 223.0 in

BUS FLOOR IS 29.0 INCHES ABOVE GROUND LEVEL

TEST VEHICLE WEIGHT (READY FOR TEST):

TOTAL FRONT WEIGHT: 3,640 lb (39.3 % OF TOTAL WT.)

TOTAL REAR WEIGHT: 5,620 lb (60.7 % OF TOTAL WT.)

TOTAL TEST WEIGHT: 9,260 lb

Which includes 1,440 lb (24 x 60 lb) of added ballast weight.

CENTER OF GRAVITY LOCATED 76.2 INCHES REAR OF FRONT AXLE.

TABLE 3-2 TEST RESULTS

TEST VEHICLE: 1985 CARPENTER CADET SCHOOL BUS

TEST NO. 7 TEST DATE: 01/19/89

ACTUAL IMPACT SPEED: 30.38 mph

IMPACT POINT IS 31.0 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: 17.3 in

FLOOR CONSTRUCTION AT AREA OF IMPACT: The floor is constructed of 1/16 inch plate steel with vinyl covering. The basic structure of the bus floor has separate sections jointed together at adjoining U shaped mating surfaces. Each section is supported by a U channel which is welded in the middle of the section. The first joint of this type is located 43.5 inches rear o the front axle and the second is 25 inches rear of the first. Sections are laid side by side to complete the bus floor.

TABLE 3-2 TEST RESULTS (CONT.)

DAMAGE DETAILS: The 10,000 lb moving barrier contacted the bus just aft of the "B" pillar. Crush of the bus extended approximately 65 inches rearward from the impact point with a maximum lateral crush of 17.3 inches. The floor separated at a point 27 inches rearward of the front axle, directly in front of the driver's seat. The length of the separation was 32 inches, starting from the bus left side. The floor at this point did not have a normal U shaped joint. The main floor of the bus was connected to the driver toeboard at this point by only an overlapping piece of sheet metal secured with 1/4 inch machine screws.

The only other separation occurred at a normal U shaped joint located 68.5 inches rearward of the front axle. The total length of the separation was 12 inches and occurred 53 inches from the bus left side, at the top, rear of the entrance stairway. It appears that one side of the joint was attached to the right frame rail at this point and was torn away from the other side of the joint due to the body distortion occurring during impact.

The bus floor was also buckled badly just aft of the driver's seat. This action caused no joint separation in that area.

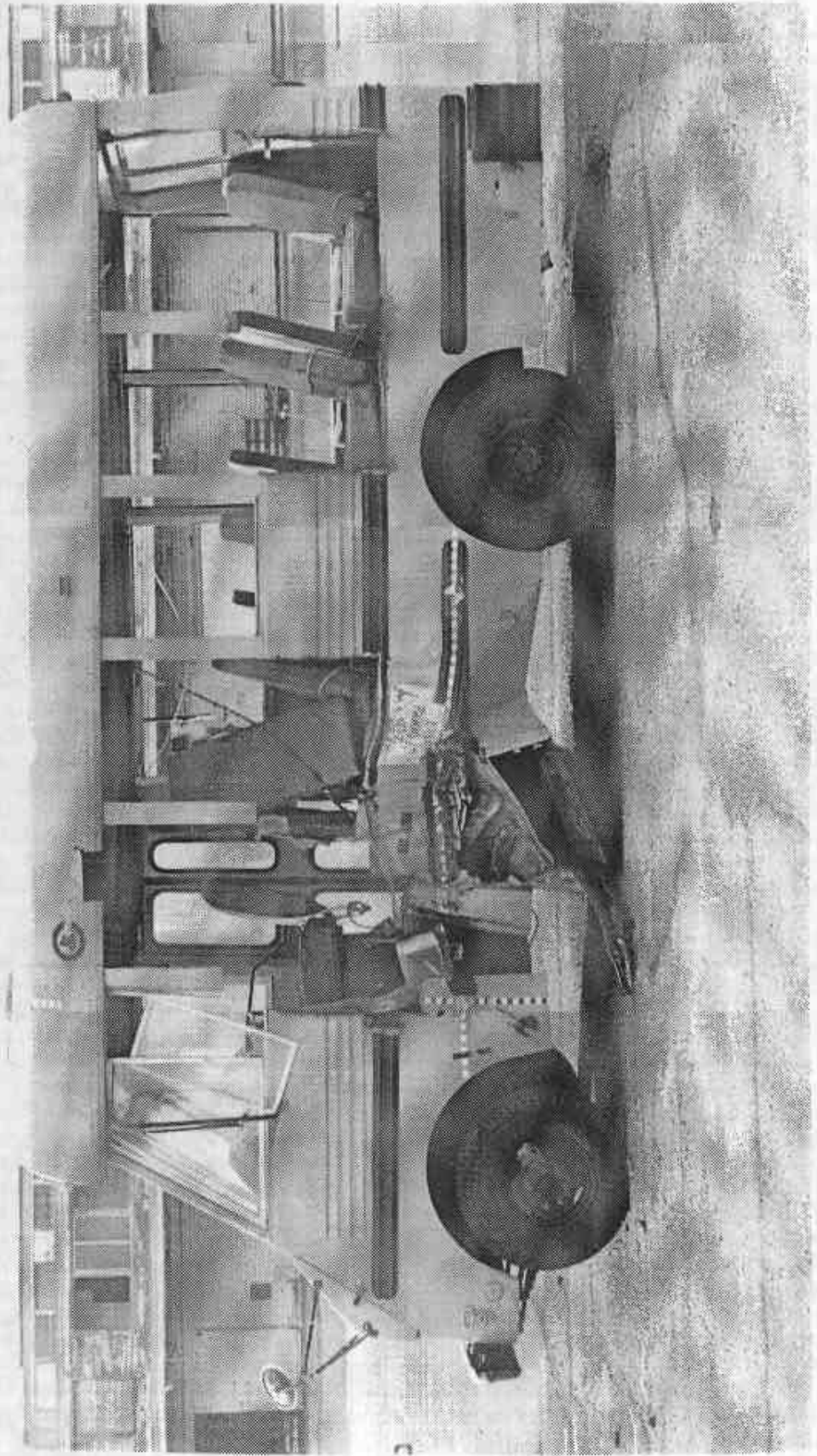


FIGURE 3-1 LEFT SIDE OVERALL VIEW - POSTTEST

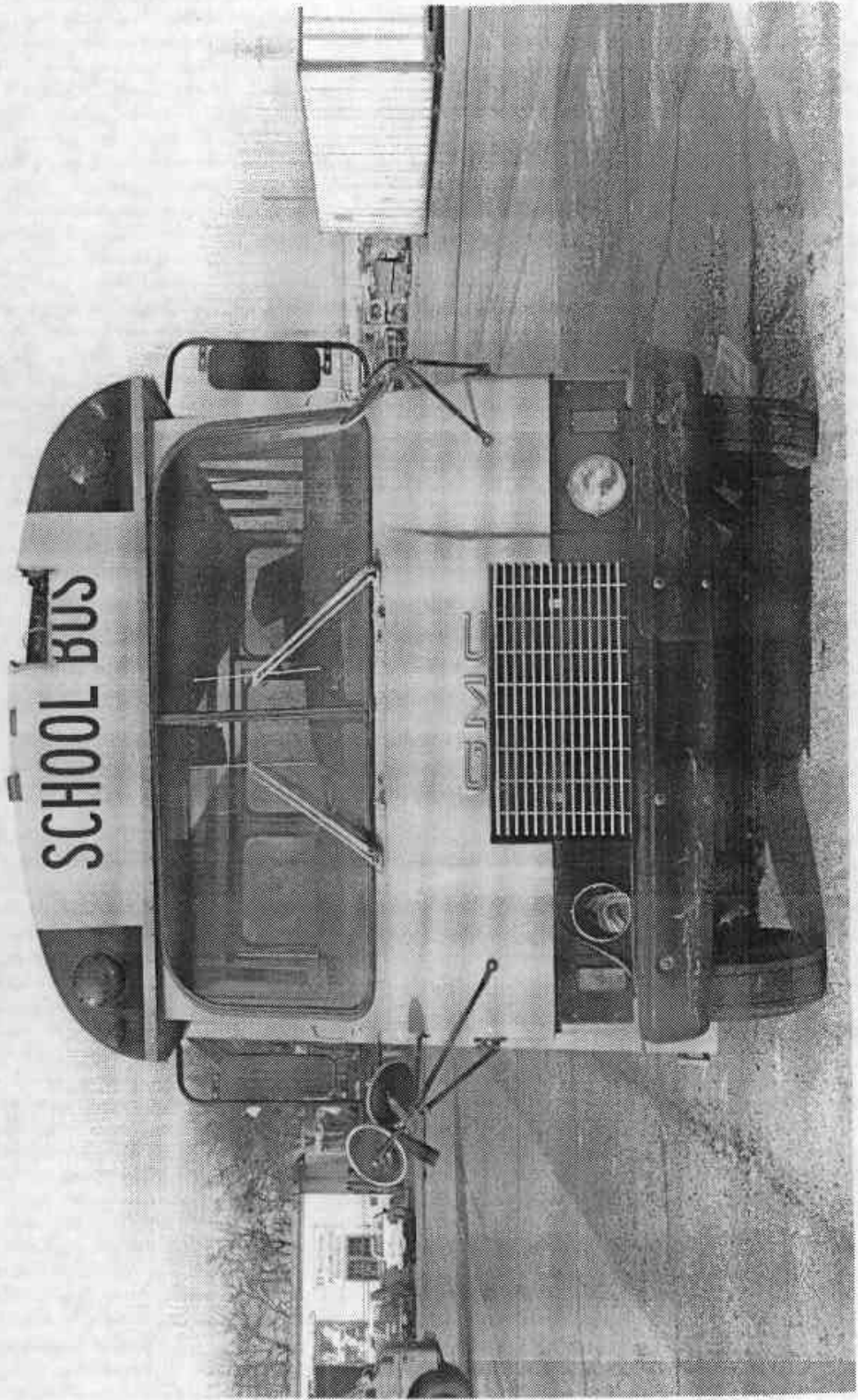


FIGURE 3-2 FRONT VIEW -- POSTTEST

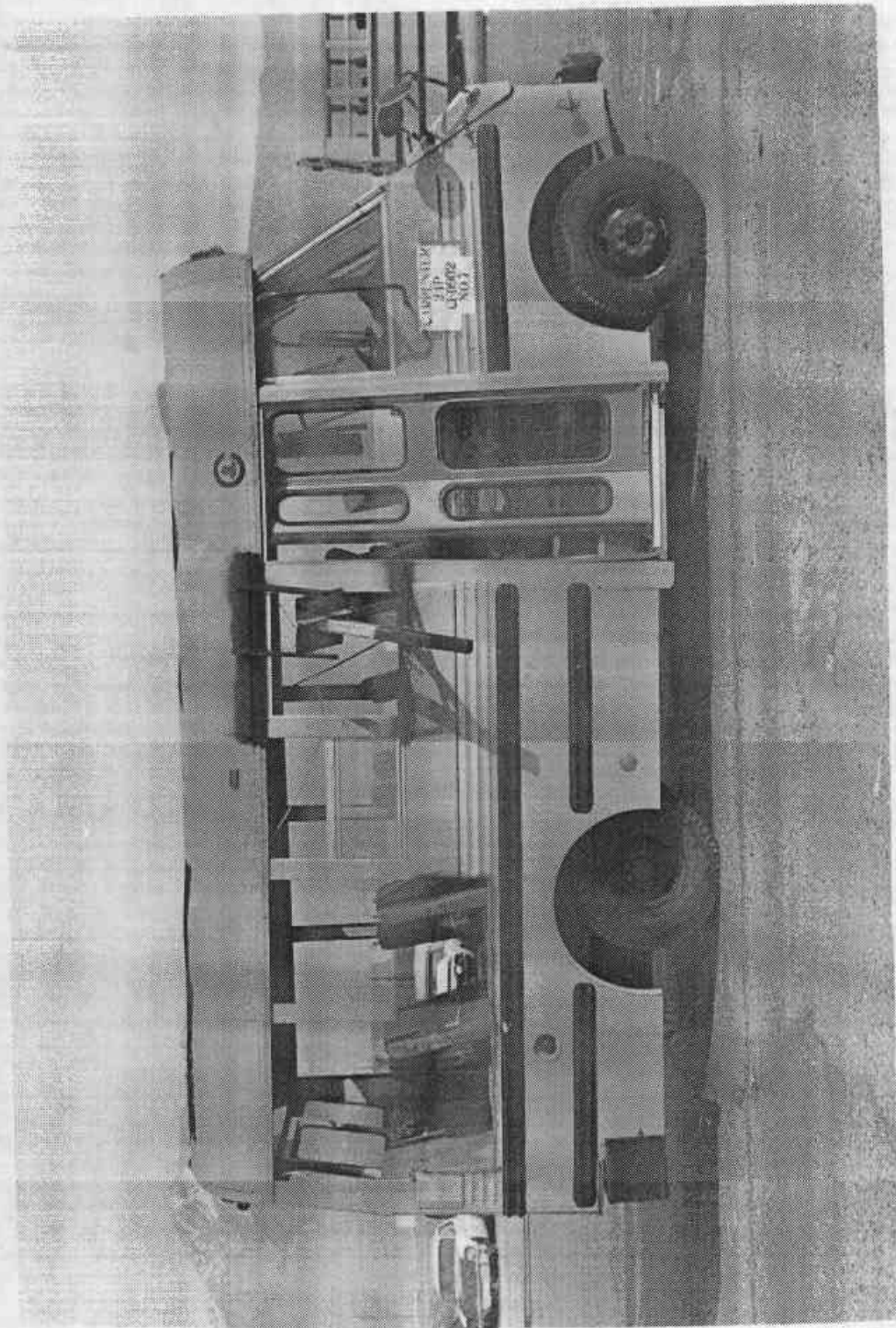


FIGURE 3-3 RIGHT SIDE OVERALL VIEW - POSTTEST

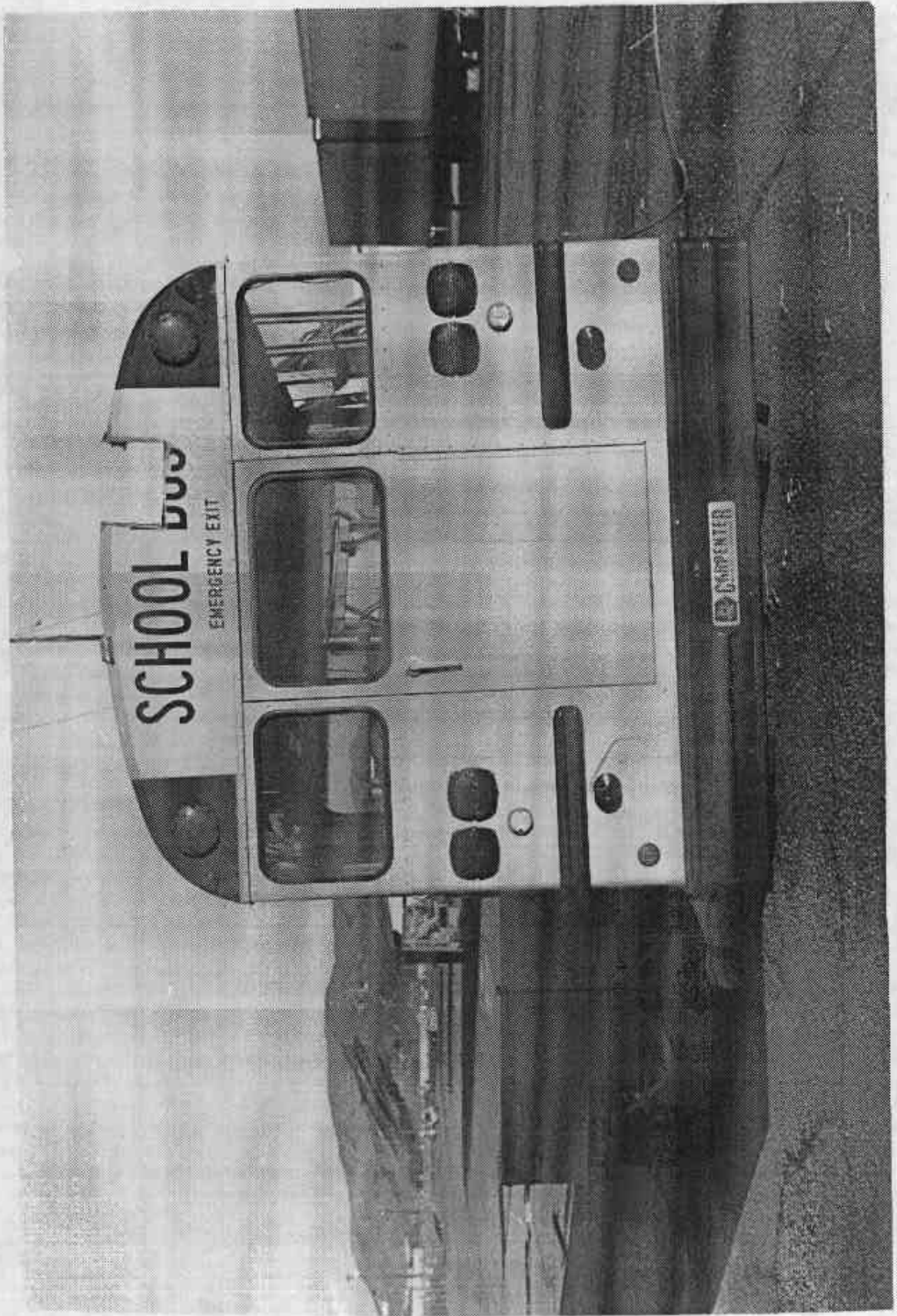


FIGURE 3-4 REAR VIEW - POSTTEST



FIGURE 3-5 CLOSEUP VIEW OF IMPACT AREA -- POSTTEST

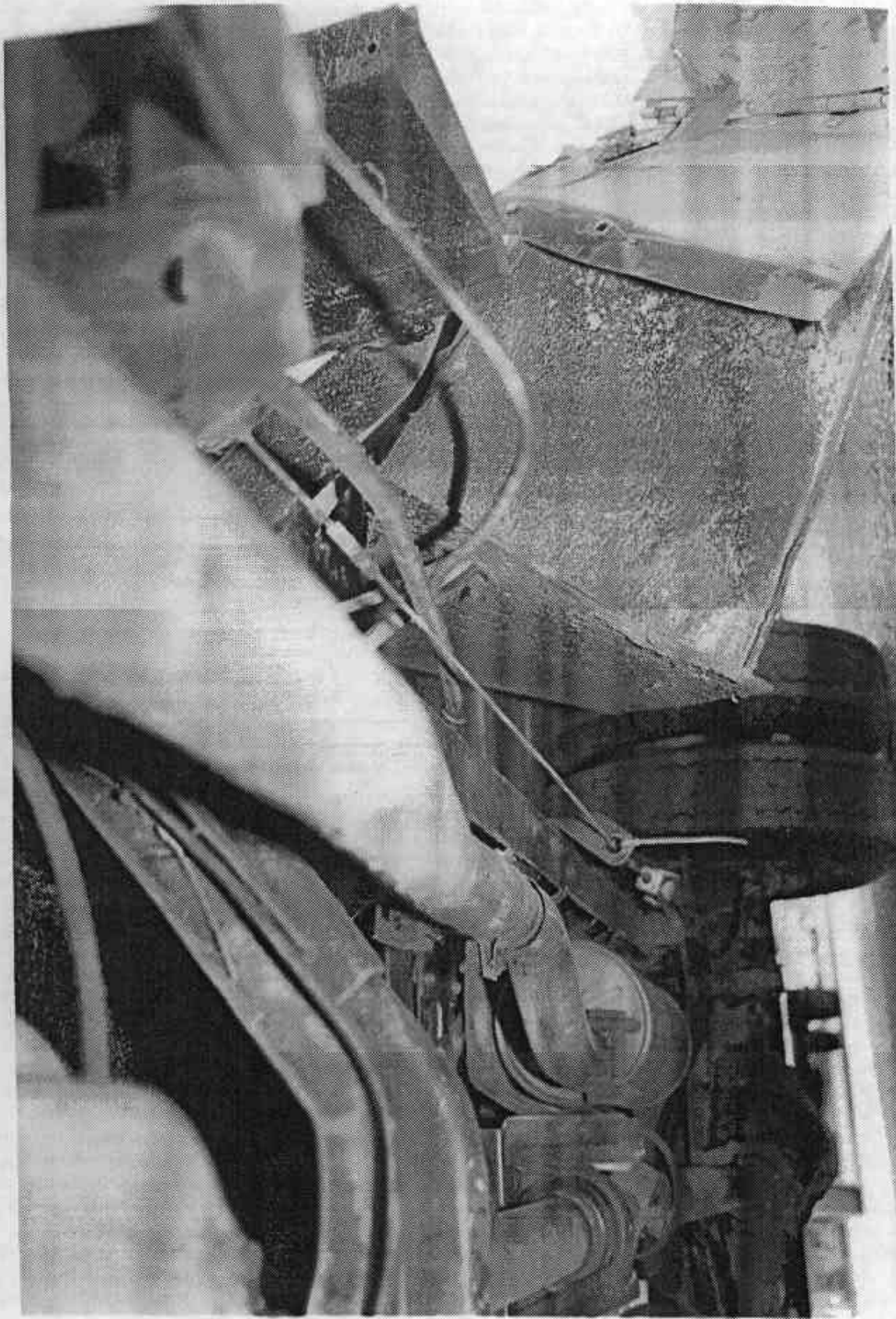


FIGURE 3-6 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING FRONT TO REAR -- POSTTEST

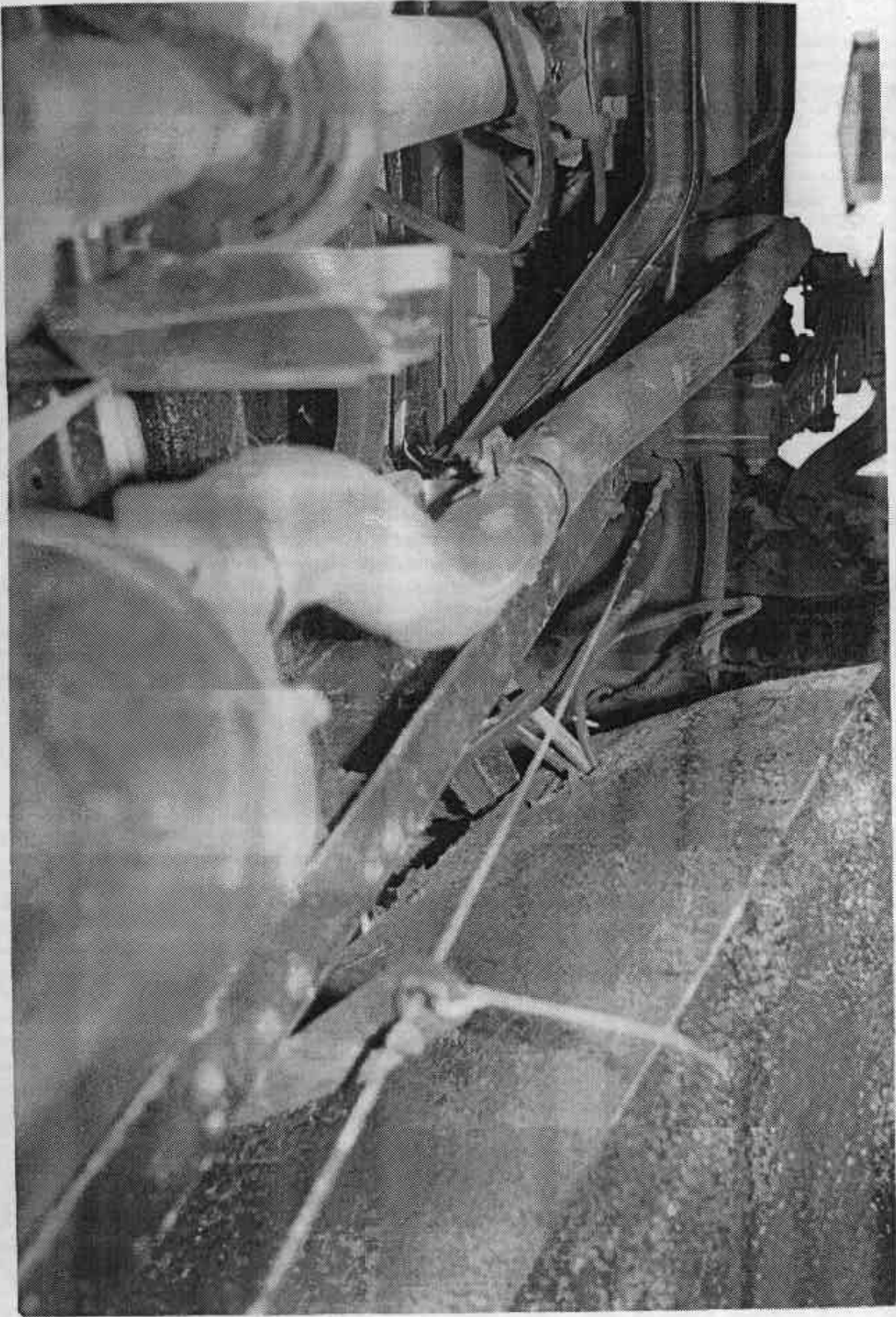


FIGURE 3-7 CLOSEUP UNDERNEATH VIEW OF IMPACT AREA LOOKING REAR TO FRONT - POSTTEST



FIGURE 3-8 INTERIOR VIEW OF JOINT SEPARATION - POSTTEST

TABLE 3-3 ACCELEROMETER LOCATIONS

TEST VEHICLE:

Triaxial accelerometer located at bus C.G.

X: 76.2 in rearward of front axle.

Y: Located on bus longitudinal centerline.

Z: 31.0 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

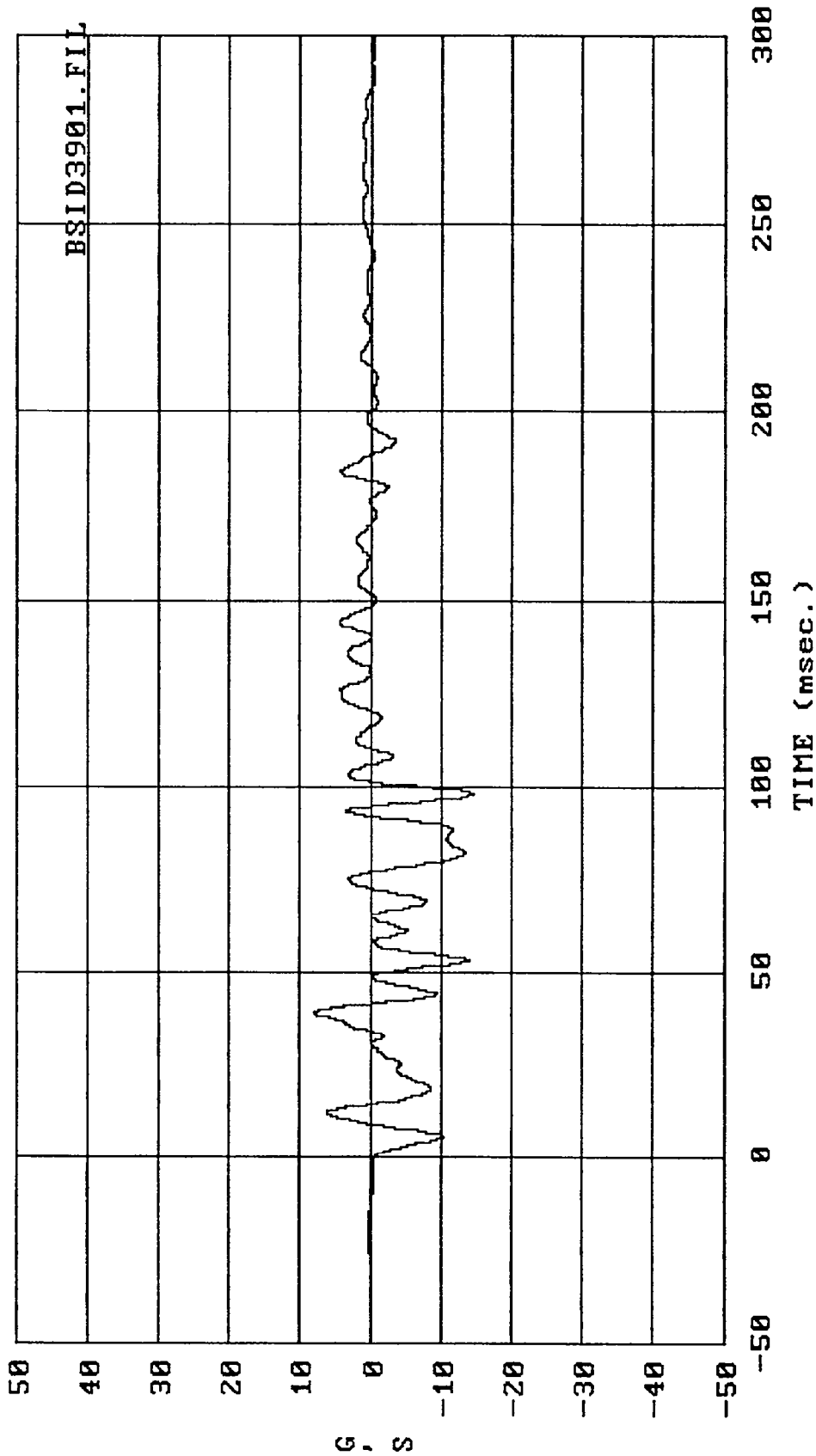
ACCEL. LOCATION	POS. DIRECT.		NEG. DIRECT.	
	Max (g)	Time (msec)	Max (g)	Time (msec)
Bus Center of Gravity				
Longitudinal X	8.1	39.0	-14.5	97.6
Lateral Y	28.4	6.5	-5.9	107.4
Vertical Z	24.1	95.5	-14.6	83.6
Resultant	29.7	6.4	0.0	0.0
Moving Barrier - Front Crossmember				
Longitudinal X	1.0	261.7	-5.3	90.4
Lateral Y	8.4	30.1	-6.6	26.3
Moving Barrier - Rear Crossmember				
Longitudinal X	0.7	213.6	-6.0	7.1
Lateral Y	7.4	18.1	-4.6	13.3

Accelerometer Orientation:

Longitudinal X - Positive Forward.

Lateral Y - Positive to the Right.

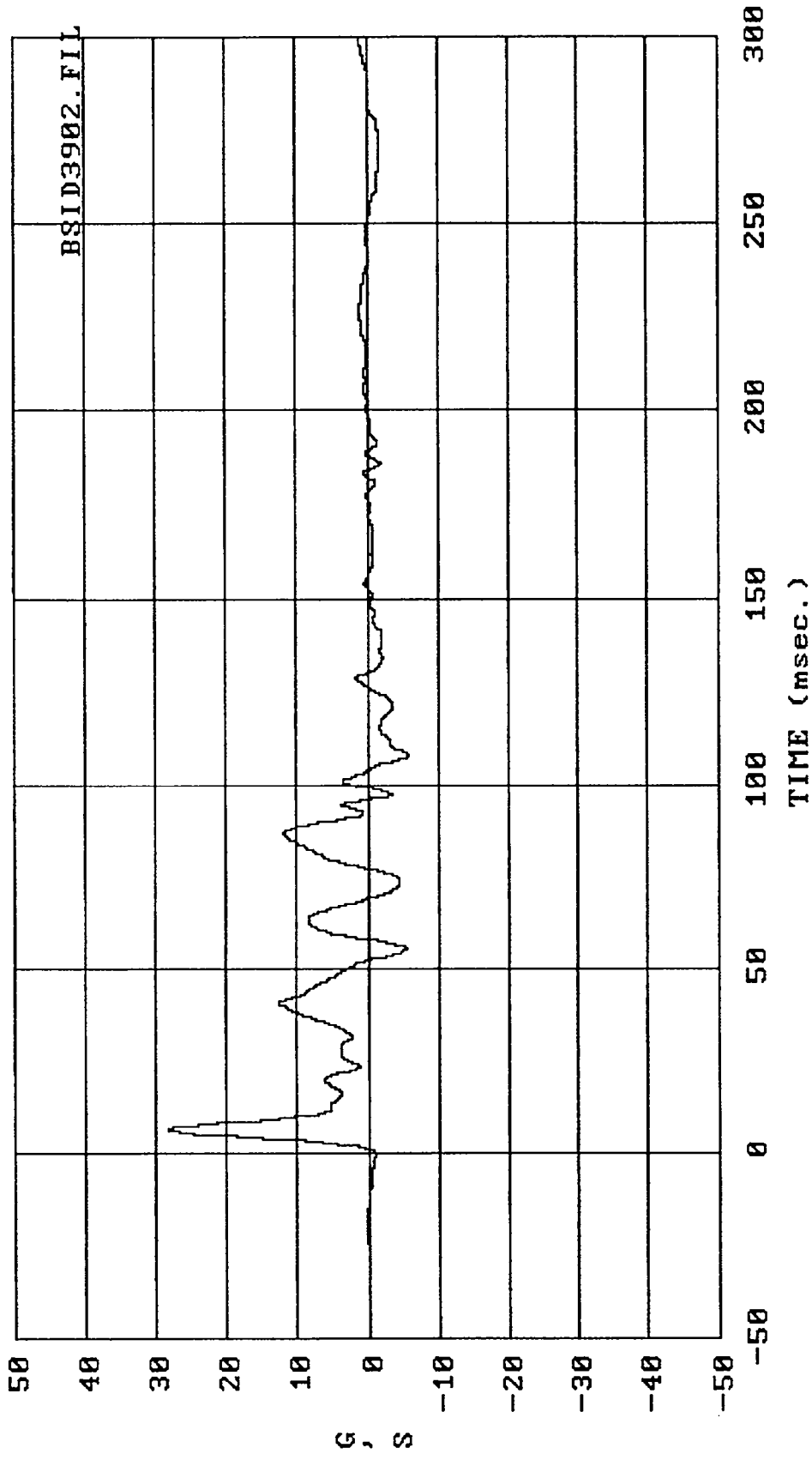
Vertical Z - Positive is Up.



Filter: SAE CLASS 60 Max = 8.0706 Min = -14.521

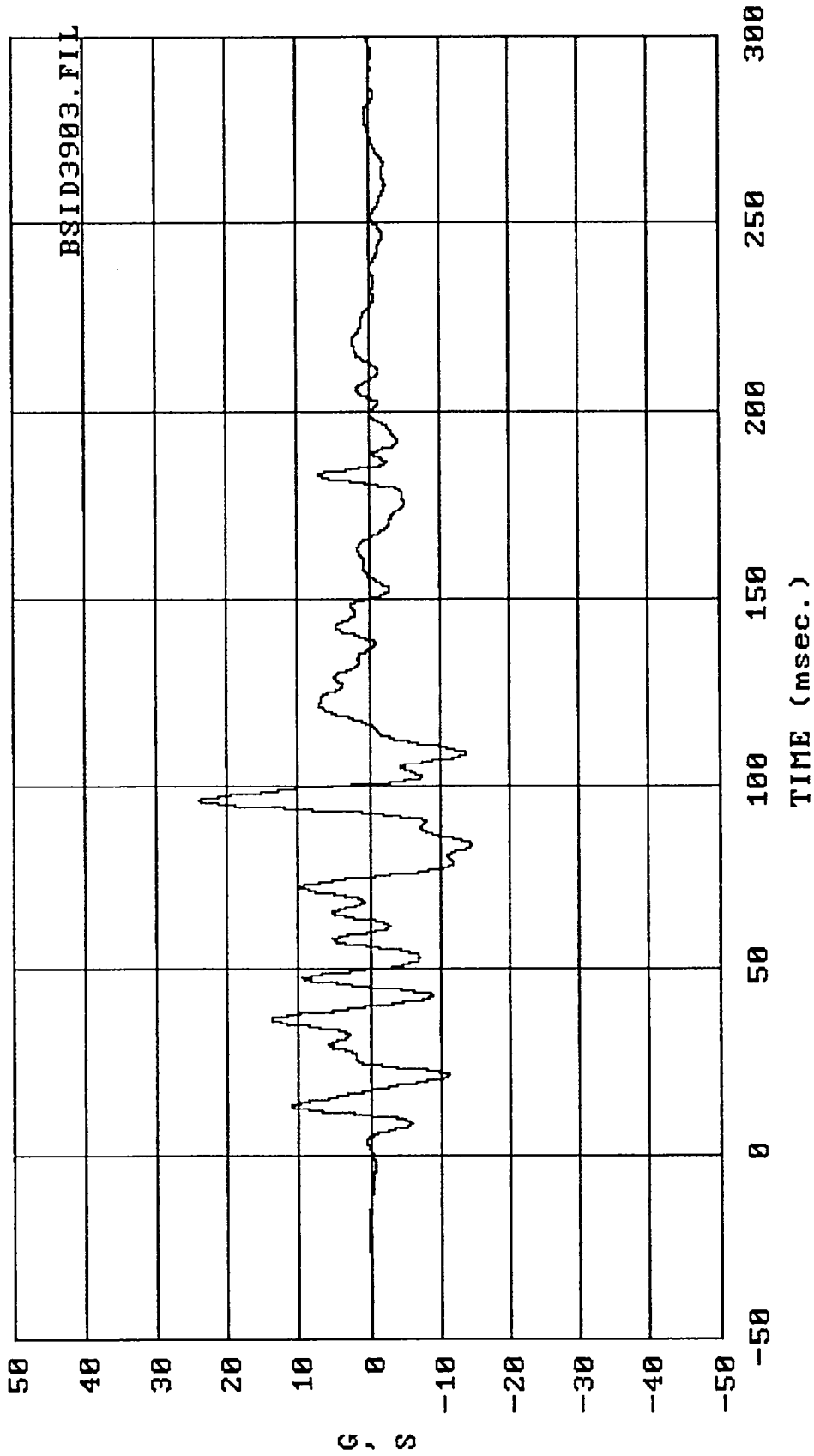
MSE 01/19/89 -- Carpenter 24p Bus : Vehicle C/G, X-axis

FIGURE 3-9



Filter: SAE CLASS 60 Max = 28.435 Min = -5.9110
 MSE 01/19/89 -- Carpenter 24p Bus : Vehicle C/G, Y-axis

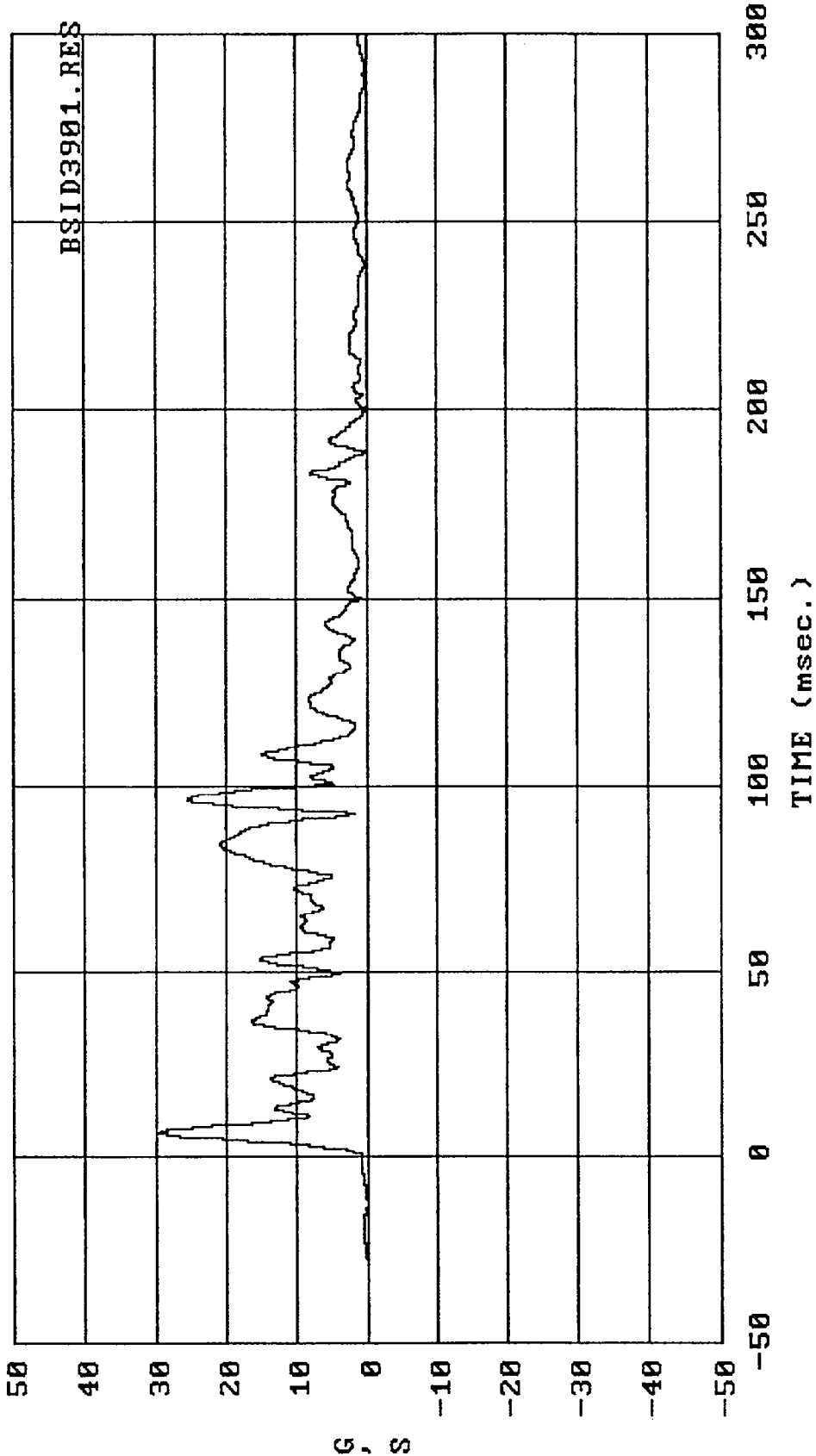
FIGURE 3-10



Filter: SAE CLASS 60 Max = 24.108 Min = -14.557

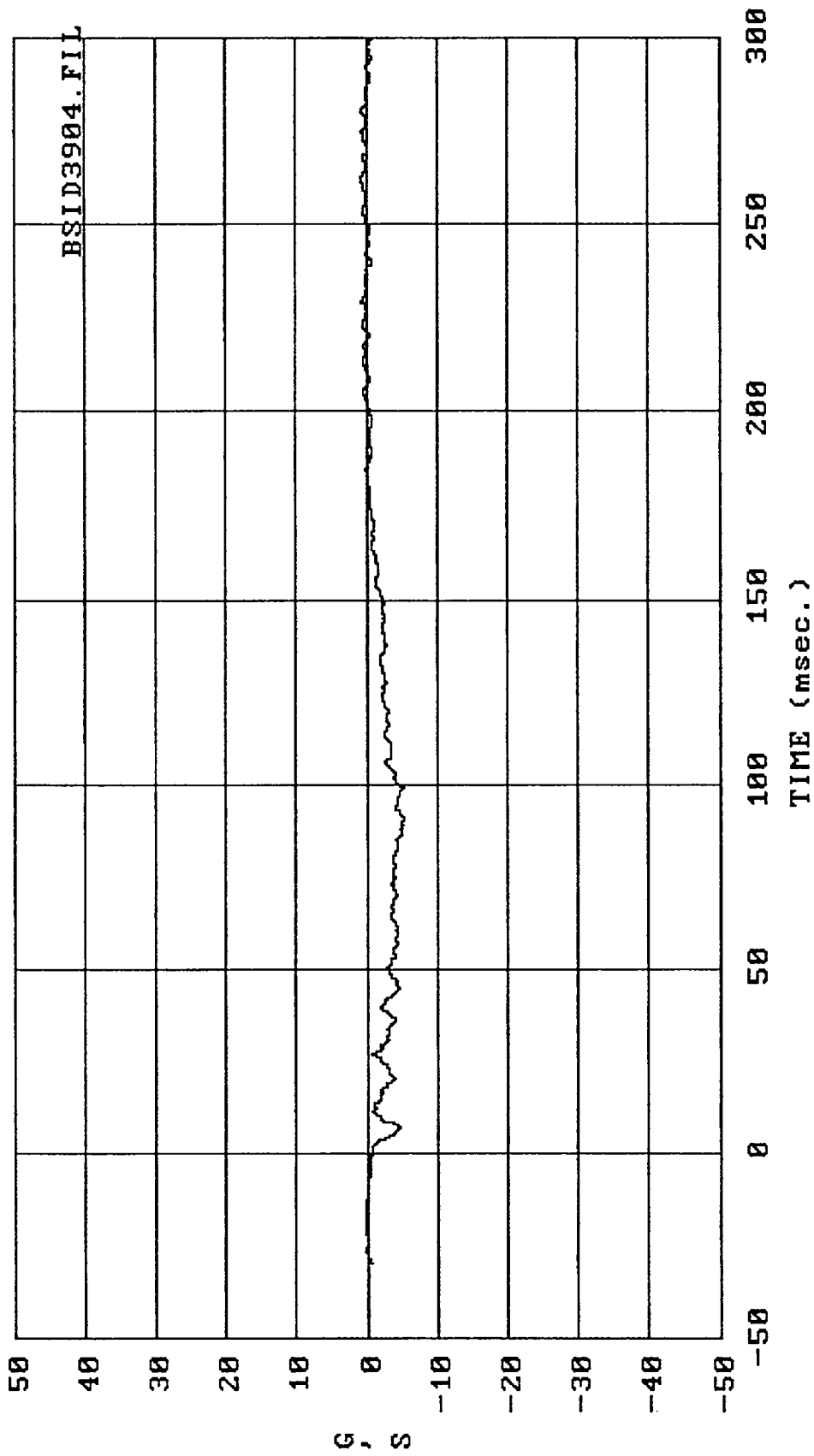
MSE 01/19/89 -- Carpenter 24p Bus : Vehicle C/G, Z-axis.

FIGURE 3-11



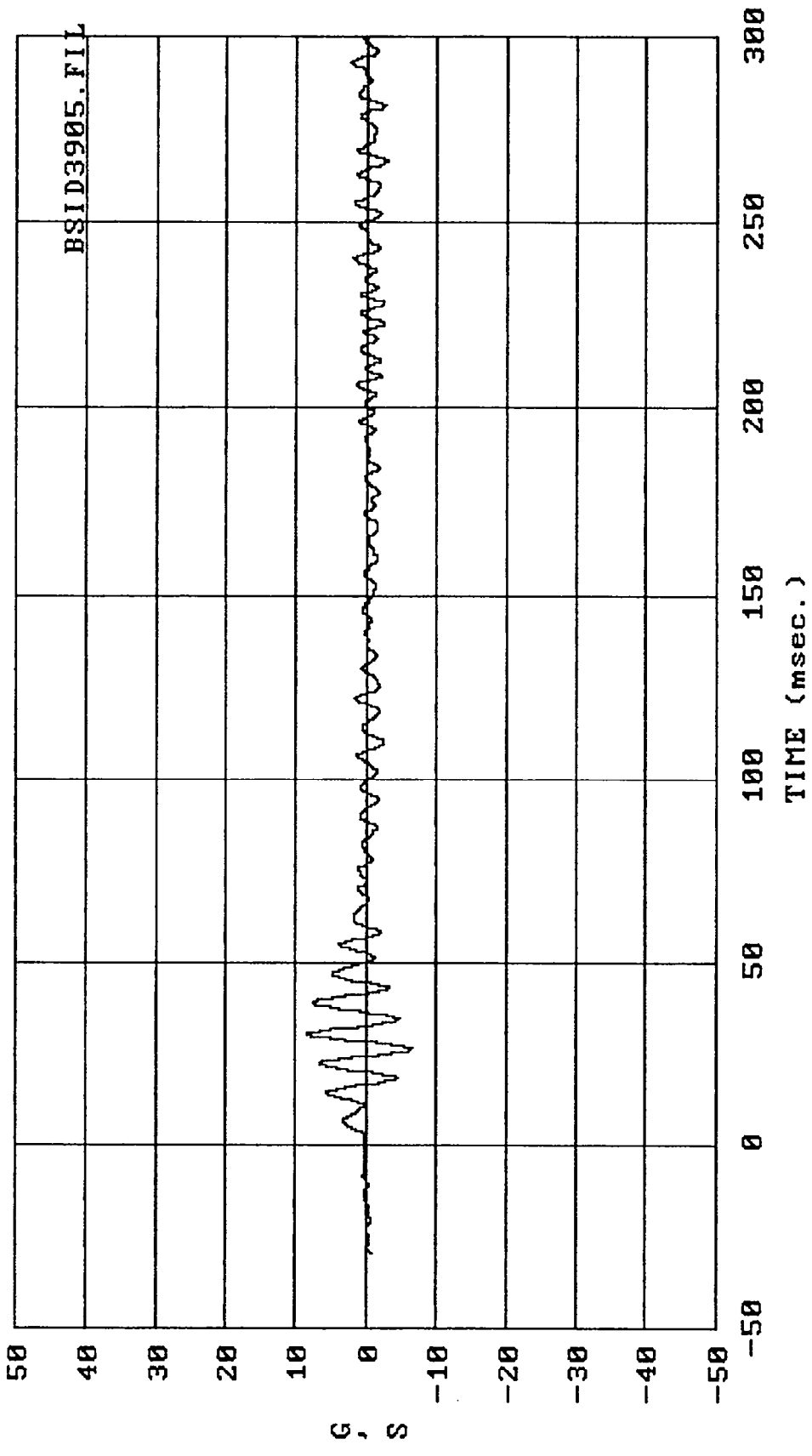
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 MSE 01/19/89 --- Carpenter 24p Bus : Vehicle C/G resultant accel.

FIGURE 3-12



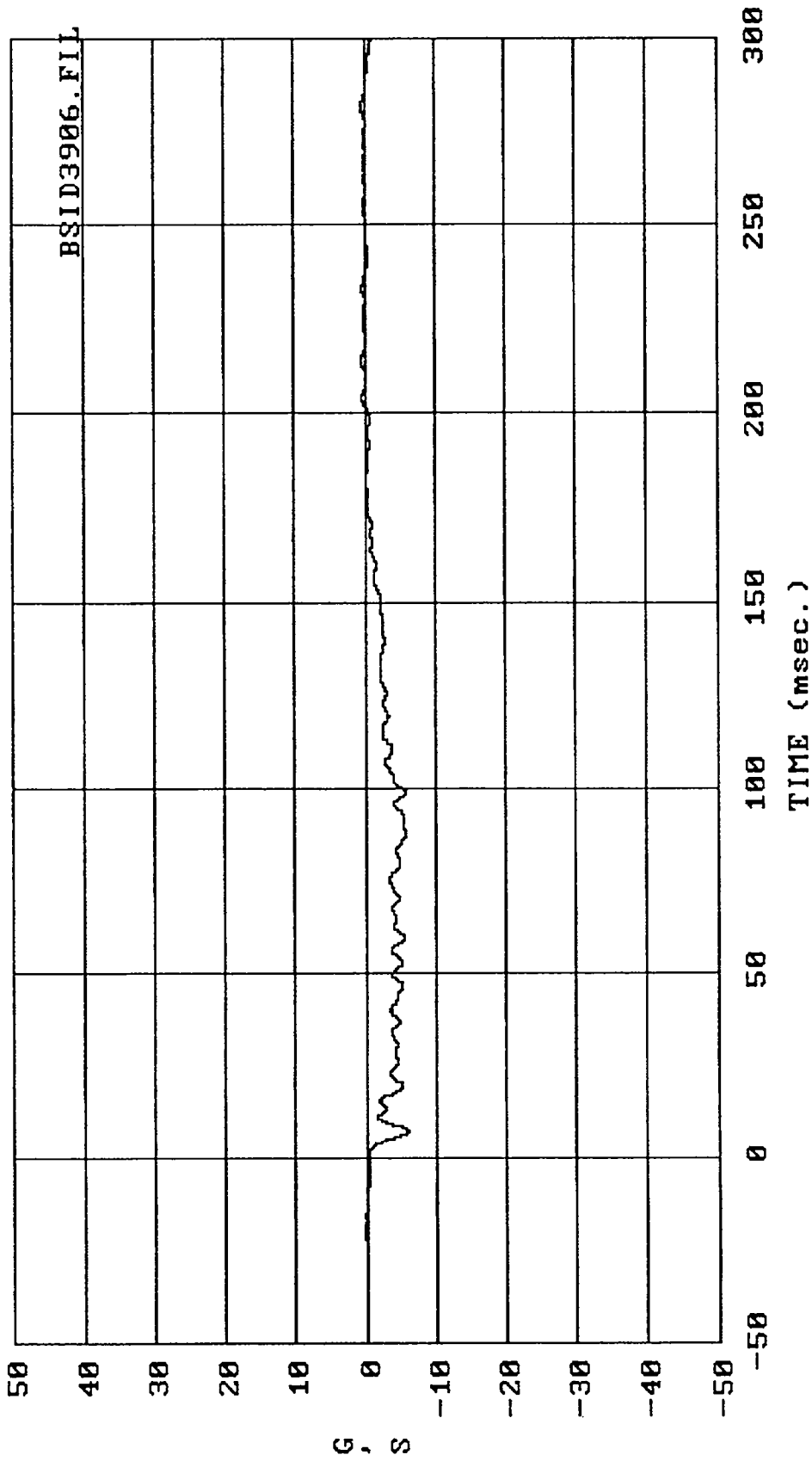
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MSE 01/19/89 -- Carpenter 24p Bus : Impact Sled: Front Axle, X-axis

FIGURE 3-13



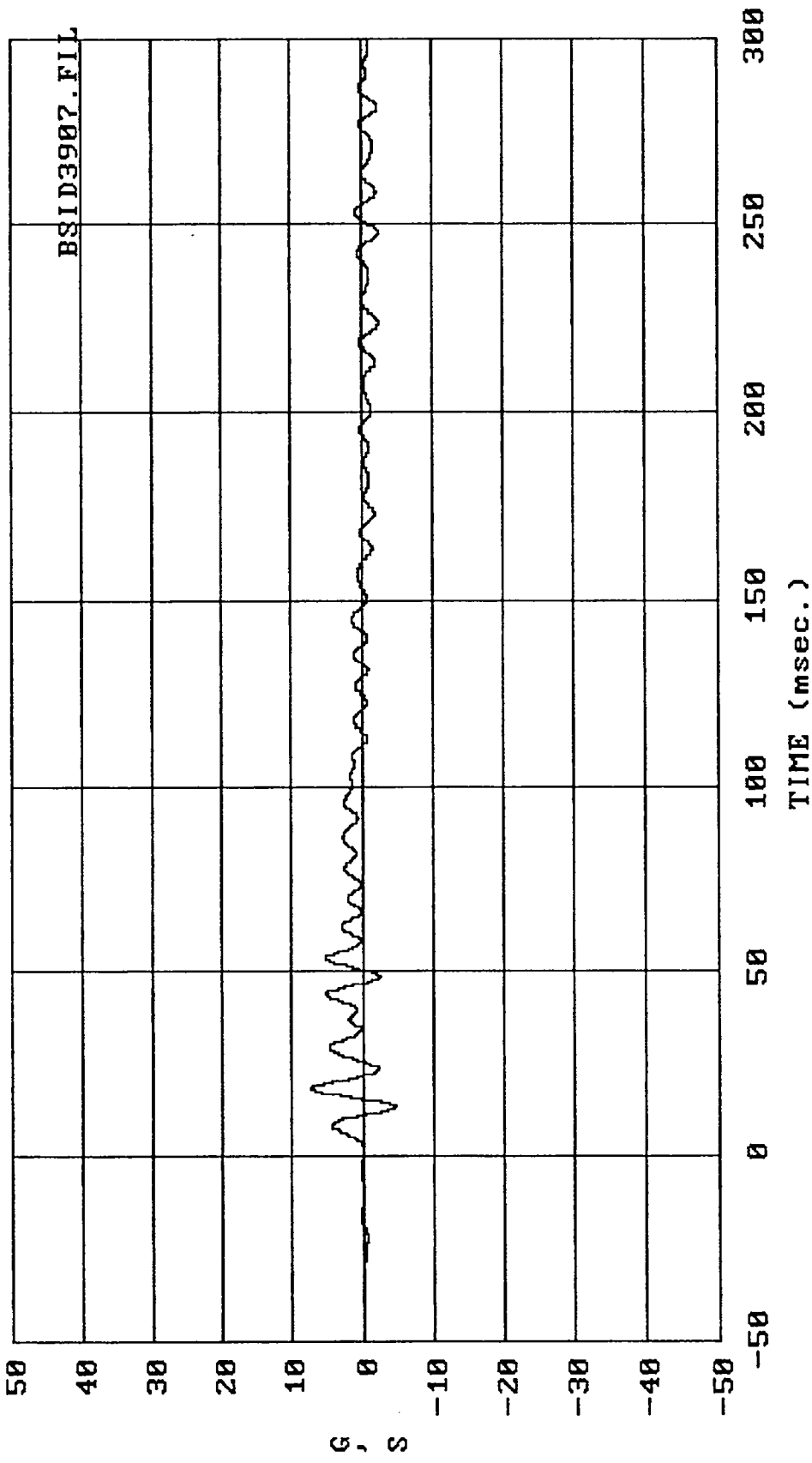
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 MSE 01/19/89 --- Carpenter 24p Bus : Impact Sled: Front Axle, Y-axis

FIGURE 3-14



Filter: SAE CLASS 60 Max = .66457 Min = -5.9859
 MSE 01/19/89 -- Carpenter 24p Bus : Impact Sled: Rear Axle, X-axis

FIGURE 3-15



Filter: SAE CLASS 60 Max = 7.4540 Min = -4.6189
 MSE 01/19/89 -- Carpenter 24p Bus : Impact Sled: Rear Axle, Y-axis

FIGURE 3-16