DOT HS-805 770

MAGEABILITY TESTS OF MINICARS RSV

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Contract No. DTNH22-80-C-07694
Contract Amt. $20,190

DECEMBER 1980
FINAL REPORT

Prepared For
U.S. DEPARTMENT OF TRANSPORTATION
National Highway Traffic Safety Administration
Washington, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No. DOT-HS-805-770	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle DAMAGEABILITY TESTS OF MINICARS RSV		5. Report Date December 1980 6. Performing Orgn Code
7. Author(s) R. Garn, S. Davis		8. Performing Orgn Rpt No. 8342-80-168A
9. Performing Organization Name and Address Dynamic Science, Inc. A Talley Industries Company 1850 West Pinnacle Peak Road Phoenix, Arizona 85027		10. Work Unit No. Research Operations 11. Contract or Grant No. DTNH22-80-C-07694
12. Sponsoring Agency Name and Address U.S. Department of Transportation National Highway Traffic Safety Administration 400 Seventh Street, S.W. Washington, D.C. 20590		13. Type of Report and Period Covered FINAL REPORT August - September 1980 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This document presents the results of a series of vehicle-to-vehicle and vehicle-to-fixed barrier low speed impact tests. These tests were conducted utilizing specially constructed Research Safety Vehicles (RSV) prepared by Minicars, Inc. of Goleta, California. The test program was structured to evaluate the damageability of the vehicle designs.

17. Key Words RSV, Head-On Barrier Impact, Side Impact, Front-to-Rear Impact	18. Distribution Statement This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. Pages 54	22. Price

Form DOT F 1700.7 (8-69)

METRIC CONVERSION FACTORS

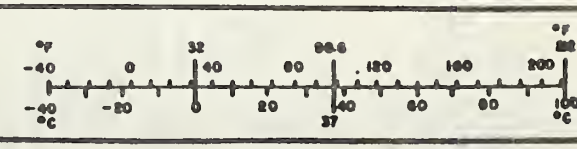
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1.0 INTRODUCTION

This report presents the results of a series of vehicle-to-vehicle and vehicle-to-fixed barrier low-speed impact tests. These tests were sponsored by the National Highway Traffic Safety Administration under Contract No. DTNH22-80-C-07694. A total of seven separate tests were conducted at various impact velocities as described later in this document.

The Contract Technical Manager was Mr. Charles Daye. The Contracting Officer was Ms. Linda Sink.

2.0 PURPOSE

The primary vehicles utilized in this test series were specially constructed Research Safety Vehicles (RSV) prepared by Minicars, Inc., of Goleta, California. The low speed impact tests were structured to evaluate the damageability of the vehicle design. One portion of the test series utilized a standard production vehicle (1980 Chevrolet Citation two-door) to obtain relative comparison data.

3.0 METHODOLOGY

A total of three vehicles were furnished by the government for this program:

Quantity	Make and Model	Designation
1	Minicars RSV	M5-10
1	Minicars RSV	M5-11
1	1980 Chevrolet Citation	2-Door

Each impact test was performed with one or two vehicles as defined in the test matrix, Table 3-1. The striking vehicle was designated as the bullet car, while the vehicle struck in the rear or side was designated as the target car. Impact speed in

TABLE 3-1. MINICARS RSV DAMAGEABILITY EVALUATION LOW SPEED IMPACTS 8342 TEST MATRIX

Test No.	Vehicles	Configuration	Impact Angle	Nominal Impact Speed	Actual Impact Speed
1	M5-10 into M5-11	Front-to-Rear	0°	12.5	12.9
2	M5-10 into M5-11	Front-to-Rear	0°	15	15.5
3	M5-10 into Citation	Front-to-Rear	0°	15	15.5
4	M5-10 into Citation	Front-to-Left Side	90°	5	5.2
5	M5-10 into M5-11	Front-to-Left Side	90°	5	5.1
6	M5-10 into Barrier	Head-On	0°	8	8.3
7	M5-10 into Barrier	Head-On	0°	17	17.5

Tests conducted August 27, 28, 29, 1980.

each case refers to the bullet car as the target car is stationary. All vehicles were re-used throughout the program with no repair or modification between subsequent tests.

The target car for front-to-rear impacts was centered longitudinally on the monorail track facing the barrier. For side impacts, the target car was placed perpendicular to the monorail track. In each case, the target car was stationary, with brakes released, and transmission in neutral.

The bullet car was towed to the specified test speed and released from the tow and guidance system immediately prior to impact with the target car. The service brakes of the bullet car were activated subsequent to impact with the target car. A delayed activation of the target car service brakes was effected at such time as the vehicle had rolled clear of the impact point.

All tests were conducted with both vehicle electrical systems disconnected. All windows were positioned closed and all movable body parts were closed and latched. Vehicles contained no instrumentation or surrogate occupants.

The front-to-rear impact point was defined as the point of coincidence of the longitudinal centerlines of the bullet and target cars. The front-to-side impact point was defined as the point of coincidence of the longitudinal centerline of the bullet car and the wheelbase centerline of the target car. Both vehicles were placed on the track such that the only contact during a test was with the other (impacting) vehicle.

Impact velocity was controlled within 0.5 mph of the nominal test speed. The bullet car was equipped with an on-board test abort system set to automatically activate if approach velocity exceeded the allowed margin in either direction.

4.0 DATA ACQUISITION

4.1 VEHICLE LOG

Documentation of vehicle pre-test preparation is contained in the Vehicle Preparation and Testing Log, included in this report as Appendix A. This log was maintained separately for each vehicle.

4.2 PHYSICAL MEASUREMENTS

Documentation of overall vehicle length, change in vehicle ride height, and maximum side impact deformation was accomplished through pre- and post-test measurements.

4.3 PHOTOGRAPHY REQUIREMENTS

The primary record of test performance and vehicle damage was provided by still and motion picture coverage. Up to six high-speed (400 frames-per-second), automatically activated cameras, along with two panning cameras (24 frames per second) were used to document each test.

Table 4-1 describes motion picture camera placement for the front-to-rear impacts. Table 4-2 describes camera placement for the front-to-side impacts, while Table 4-3 describes camera placement for the head-on barrier impacts.

An impact switch was attached to the forwardmost point on the bullet vehicle and connected to a strobe light, also attached to the bullet vehicle, to define the instant of impact for the benefit of all motion picture cameras.

Pre- and post-test still photographic coverage was provided for each test in accordance with the requirements detailed in Table 4-4.

TABLE 4-1. CAMERA LOCATIONS (FRONT-TO-REAR TESTS)

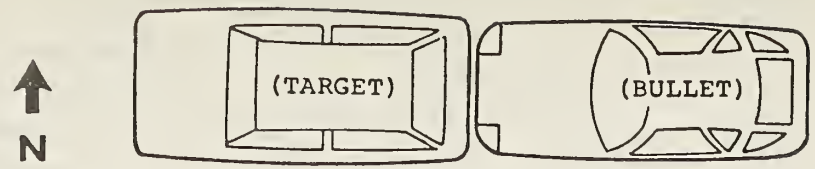
Test No: 1, 2, 3 Test Date: 8-27-80

Test Type: Front-to-Rear Tests

Vehicle A (bullet) RSV M5-10

Vehicle B (target) RSV M5-11, Chevrolet Citation

Comments: _____



CAMERA	YES
STILLS	X
SLIDES	X
MOVIE	X
POLAROID	
VIDEO	

CAMERA SYMBOLS

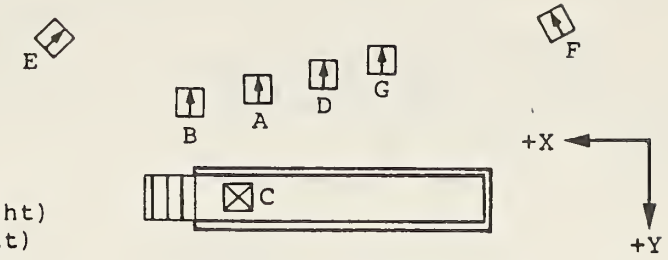
- PIT
- GROUND
- BARRIER
- OVERHEAD
- ON-BOARD

FRAME RATE

1. 1000 fr/sec
2. 200 fr/sec
3. Other 24 fr/sec
4. 400 fr/sec
5. 500 fr/sec
6. 128 fr/sec

TIMING LIGHT SPEED

1. 100 Hz (10 msec/light)
2. 200 Hz (5 msec/light)
3. Other _____



Loc. No.	Location	Field of View	Lens Size	Frm Rate	Tmng Spd	Ser No	Impact Dist-X	C.L. Dist-Y	CAM Hght-Z
A	South Side	Documentation (B staying on B)	12.5-75	3	n/a	30947	48"	54'	58"
B	South Side	Documentation (B going to T)	12.5-75	3	n/a	31488	106"	52'	62"
C	Catwalk	O/A elevated ⊥ view (both vehicles at impact)	12	6	n/a	900	105"	58'	19'8"
D	South Side	⊥ on bumper interaction	25	4	n/a	901	23"	54'	51"
E	South Side	Oblique uptrack - interaction to rest	16	4	n/a	6495	19'	45'	64"
F	South Side	Oblique downtrack - interaction to rest	25	4	n/a	902	-27'	59'	59"
G	South Side	⊥ panning close-up on bumper interaction	50	4	n/a	6548	6"	51'	36"
H	North Side	Opposite side ⊥ view - bumper interaction	25	4	n/a	6549	30"	-54'	61"

TABLE 4-2. CAMERA LOCATIONS (FRONT-TO-SIDE TESTS)

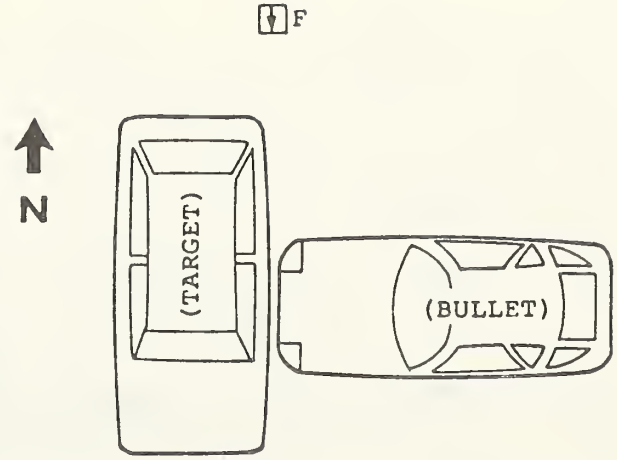
Test No: 4, 5 Test Date: 8-28-80

Test Type: Front-to-Side

Vehicle A (bullet) RSV M5-10

Vehicle B (target) RSV M5-11, Chevrolet Citation

Comments: _____



CAMERA	YES
STILLS	X
SLIDES	X
MOVIE	X
POLAROID	
VIDEO	

CAMERA SYMBOLS

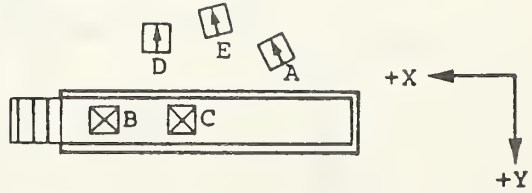
- PIT
- GROUND
- BARRIER
- OVERHEAD
- ON-BOARD

FRAME RATE

1. 1000 fr/sec
2. 200 fr/sec
3. Other 24 fr/sec
4. 400 fr/sec
5. 500 fr/sec
6. 128 fr/sec

TIMING LIGHT SPEED

1. 100 Hz (10 msec/light)
2. 200 Hz (5 msec/light)
3. Other _____



Loc. No.	Location	Field of View	Lens Size	Frm Rate	Tmng Spd	Ser No	Impact Dist-X	C.L. Dist-Y	CAM Hght-Z
A	South Side	Documentation (tracking)	12.5-75	3	n/a	31488	-76"	50'4"	60"
B	Catwalk	O/A elevated ⊥ view (both vehicles at impact)	18	6	n/a	900	0	57'	19'8"
C	Catwalk	Elevated ⊥ close-up, front end at impact	50	6	n/a	6548	-30"	57'4"	19'10"
D	South Side	⊥ view, front end at impact (medium shot)	25	6	n/a	901	-29"	51'	52"
E	South Side	⊥ view, front end at impact (extreme close-up)	50	2	n/a	902	-30"	49'3"	28"
F	North Side	Opposite side ⊥ view, front end at impact (med	25	6	n/a	6549	-19"	-30'	30"

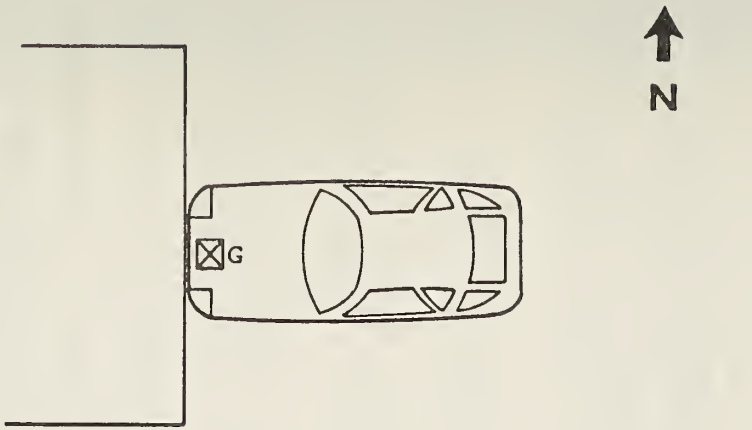
TABLE 4-3. CAMERA LOCATIONS (BARRIER TESTS)

Test No: 6, 7 Test Date: 8-29-80

Test Type: Head-On Barrier Impact

Vehicle A (bullet)	RSV M5-10	
Vehicle B (target)		

Comments: _____



CAMERA	YES
STILLS	X
SLIDES	X
MOVIE	X
POLAROID	
VIDEO	

CAMERA SYMBOLS

- PIT
- GROUND
- BARRIER
- OVERHEAD
- ON-BOARD

FRAME RATE

1. 1000 fr/sec
2. 200 fr/sec
3. Other 24 fr/sec
4. 400 fr/sec
5. 500 fr/sec
6. 128 fr/sec

TIMING LIGHT SPEED

1. 100 Hz (10 msec/light)
2. 200 Hz (5 msec/light)
3. Other _____

Loc. No.	Location	Field of View	Lens Size	Frm Rate	Tmng Spd	Ser No	Impact Dist-X	C.L. Dist-Y	CAM Hght-Z
A	South Side	Documentation (tracking)	12.5-75	3	n/a	31488	-48"	36'	62"
B	South Side	O/A ⊥ view, full vehicle at impact	16	6	n/a	6495	0	33'9"	58"
C	South Side	Medium ⊥ view, 2/3 vehicle at impact	25	4	n/a	6548	0	31'6"	43"
D	South Side	ECU ⊥ , bumper face at impact	50	4	n/a	902	-6"	30'9"	36"
E	Catwalk	CU ⊥ , elevated, bumper and nose at impact	50	4	n/a	900	-16"	43'9"	19"
F	North Side	Medium ⊥ view, 1/2 vehicle at impact, opp.side	25	4	n/a	6549	0	-24'	38"
G	Overhead	Front half of vehicle	16	4	n/a	901	-18"	0	23'

TABLE 4-4. STILL PHOTOGRAPHIC REQUIREMENTS

1. Left and right side view of each impacting vehicle.
2. Closeup views of bumper contact, left and right sides.
3. Front view of bullet vehicle.
   - Three-quarter left view.
   - Three-quarter right view.
4. Rear (or side) view of target vehicle.
   - Three-quarter left view.
   - Three-quarter right view.

Requirements pertain to color photos as well as 35 mm color slides.

Two release prints containing motion picture film coverage of each test, along with a complete set of color photos and 35 mm color slides from each test, have been forwarded to the sponsor in advance of this report.

4.4 VEHICLE DAMAGE APPRAISALS

Three independent damage appraisals were obtained for the Chevrolet Citation following tests no. 3 and 4. Each appraisal contains an analysis of the damage sustained and an estimate of parts and labor costs required to return the vehicle to original pre-test condition. A copy of each of these appraisals, along with a comprehensive summary sheet, is presented in Appendix B.

5.0 TEST RESULTS

A discussion of the configuration and test results from each of the seven impacts is included in this section of the report. Pre- and post-test photographs further describing each test are included in Appendix C.

5.1 TEST NO. 1: M5-10 FRONT-INTO-M5-11 REAR (12.5 MPH)

Figure C-1 presents an overall view of the test configuration while Figure C-2 presents a close-up view of the bumper match. Nominal impact speed was 12.5 mph, with actual test speed 12.9 mph.

5.1.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)
M5-11 Overall length = 177.5 inches (no change from pre-test)

Attitude:	M5-10	LF 30.8"	RF 30.3"	(no change from pre-test)
		LR 31.1"	RR 30.7"	
	M5-11	LF 30.5"	RF 30.7"	(no change from pre-test)
		LR 31.2"	RR 31.3"	

5.1.2 Post-test Observations

5.1.2.1 M5-10 Vehicle

The M5-10 bullet vehicle suffered no visible damage.

5.1.2.2 M5-11 Vehicle

Damage to the M5-11 target vehicle was minor and apparently cosmetic only. One small crack appeared at the lower left corner of the taillight panel, adjacent to the rear fender seam. During vehicle construction, this area was finished for painting by covering with a layer of body putty. The crack observed appeared to be in the body putty only (see Figure C-3).

A second small crack appeared in the seam where the lateral panel below the rear hatch window mates with the right rear fender panel. As with the previously noted crack, this appeared to extend into the body putty (seam filler) only (see Figure C-4).

A minor wrinkle appeared in the face of the rear bumper covering that was not significant enough to stand out in photographs.

Both the left and right hand passenger doors and the rear hatch door functioned normally post-test.

5.2 TEST NO. 2: M5-10 FRONT-INTO-M5-11 REAR (15.0 MPH)

The configuration for this test was similar to that for Test No. 1, shown in Figures C-1 and C-2. Nominal impact speed was 15.0 mph, with actual test speed 15.5 mph.

5.2.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)
M5-11 Overall length = 177.0 inches (shortened 0.5 inches)

Attitude:	M5-10	LF 30.8"	RF 30.3"	(no change from pre-test)
		LR 31.2"	RR 30.7"	
	M5-11	LF 30.6"	RF 30.7"	(no change from pre-test)
		LR 31.2"	RR 31.5"	

5.2.2 Post-test Observations

5.2.2.1 M5-10 Vehicle

The M5-10 bullet vehicle suffered no visible damage.

5.2.2.2 M5-11 Vehicle

The crack noted in the lower left corner of the M5-11 taillight panel, resulting from Test No. 1, propagated vertically an additional 1/2-3/4 inch, to a total of approximately 4.0 inches.

The bond line at the upper forward edge of the lateral panel below the rear hatch window failed, allowing the panel to translate upward approximately 1.5 inches (see Figure C-5). This action also caused a crack to appear in the fender seams adjoining this same panel, as shown in Figure C-6.

The rear bumper assumed a permanent bow as shown in Figure C-7. A slight bow was observed on the M5-11 vehicle upon delivery. This condition was exaggerated somewhat by testing.

The left rear inside fender panel-to-fender bond failed, allowing the panel to fall forward as shown in Figure C-8.

A wrinkle appeared in the horizontal upper surface of the rear bumper covering material, on both sides of the M5-11 vehicle, near the rear fender corners. This may be seen in the overall rear view of the vehicle presented in Figure C-9.

The above conditions appear to indicate that some level of permanent damage was sustained by the structure behind the soft bumper face material.

5.3 TEST NO. 3: M5-10 FRONT-INTO-CHEVROLET CITATION REAR (15.0 MPH)

Figure C-10 presents an overall view of the test configuration while Figure C-11 shows a close-up view of the bumper match. Nominal impact speed was 15.0 mph, with actual test speed 15.5 mph.

5.3.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)
Citation Overall length = 176.5 inches (shortened 1.5 inches)

Attitude: M5-10 LF 30.6" RF 30.3" (no change from pre-test)
LR 31.1" RR 30.6"

Citation LF 29.3" RF 29.3" (Rear end lowered
LR 28.0" RR 28.4" 1.0" from pre-test)

5.3.2 Post-test Observations

5.3.2.1 M5-10 Vehicle

The M5-10 bullet vehicle suffered no apparent damage.

5.3.2.2 Chevrolet Citation

Post-test examination of the Chevrolet Citation revealed significant pressure buckles forward of and above each rear wheel opening as shown in Figure C-12.

Both the left and right side taillight lenses cracked as shown in Figure C-13.

The bumper face bar showed no significant damage. The energy absorbers behind the bumper face bar stroked approximately 1.0 inch and returned to the pre-test condition.

A small pressure buckle occurred near the upper rear corner of the fuel fill door and at a corresponding point on the opposite side of the vehicle (see Figure C-14). This photograph also shows the general downward movement of the rear of the vehicle when compared to the pre-test condition.

Further examination of the Chevrolet Citation revealed definite damage to the rear body floor panel and unibody structure. Both the left and right side passenger doors and windows and the rear hatch door functioned normally post-test.

5.4 TEST NO. 4: M5-10 FRONT-INTO-CHEVROLET CITATION LEFT SIDE (5.0 MPH)

Figures C-15 and C-16 present the test configuration. Nominal impact speed was 5.0 mph, with actual test speed 5.2 mph.

5.4.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)

Citation Overall length = 176.5 inches (no change from pre-test)

Attitude: M5-10 LF 30.8" RF 30.4" (no change from pre-test)
LR 31.4" RR 30.4"

Citation LF 29.5" RF 29.3" (no change from pre-test)
LR 28.0" RR 28.5"

5.4.2 Post-test Observations

5.4.2.1 M5-10 Vehicle

The M5-10 bullet vehicle suffered no visible damage.

5.4.2.2 Chevrolet Citation

Obvious damage to the Chevrolet Citation was confined to the driver's door skin and lock pillar assembly. Maximum depression depth on the door skin was approximately 1.5 inches. The door opened and closed normally post-test, and the window remained intact and operational.

Probable damage occurred to the door frame and reinforcing beam behind the outer skin. Figures C-17 and C-18 present the post-test views of the vehicle.

5.5 TEST NO. 5: M5-10 FRONT-INTO-M5-11 LEFT SIDE (5.0 MPH)

The configuration for this test is presented in Figures C-19 and C-20. Nominal impact speed was 5.0 mph, with actual test speed 5.1 mph.

5.5.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)
M5-11 Overall length = 177.0 inches (no change from pre-test)

Attitude:	M5-10	LF 30.7"	RF 30.5"	(no change from pre-test)
		LR 31.1"	RR 30.2"	
	M5-11	LF 31.3"	RF 31.5"	(Front end raised 0.75
		LR 31.2"	RR 31.4"	inches from pre-test)

5.5.2 Post-test Observations

5.5.2.1 M5-10 Vehicle

The M5-10 bullet vehicle suffered no visible damage.

5.5.2.2 M5-11 Vehicle

Two small impressions were left on the outer skin of the M5-11 target vehicle door, corresponding to the hard spots on the front of the bullet vehicle (projections tangent to insides of head lights). Width of these impressions was approximately 6.0 inches in each case, with a 4.5-inch vertical line evident in the rear impression that was not evident in the front impression. Post-test operation of the gullwing door was normal, with no damage apparent to any of the window surfaces. It was not determined whether any damage occurred to the reinforcing member behind the outer door skin.

Post-test views of the vehicle, showing the damage noted on the previous page, are included as Figures C-21 and C-22.

5.6 TEST NO. 6: M5-10 FRONT-INTO-FIXED BARRIER (8.0 MPH)

The test configuration is shown in Figure C-23. Nominal impact speed was 8.0 mph, with actual test speed 8.3 mph.

5.6.1 Post-test Dimensional Measurements

M5-10 Overall length = 177.5 inches (no change from pre-test)

Attitude: M5-10 LF 30.7" RF 30.3" (no change from pre-test)
LR 31.0" RR 30.3"

5.6.2 Post-test Observations (M5-10 Vehicle)

The left and right side turn signal lamp frames were anchored to an aluminum base plate by four 1/4-inch bolts on each side. These bolts were threaded into nutsert fasteners installed in the base plate. During Test No. 6, the front pair of bolts on each lamp pulled the nutsert fasteners through the base plate material. Figure C-24 presents a post-test view of the right side lamp.

No other damage to the M5-10 vehicle was apparent as a result of this test.

5.7 TEST NO. 7: M5-10 FRONT-INTO-FIXED BARRIER (17.0 MPH)

The configuration for this test was similar to that for Test No. 6, shown in Figure C-23. Nominal impact speed was 17.0 mph, with actual test speed 17.5 mph.

5.7.1 Post-test Dimensional Measurements

M5-10 Overall length = 174.0 inches (shortened 3.5 inches from pre-test)

Attitude: M5-10 LF 30.5" RF 30.2" (no change from pre-test)
LR 31.0" RR 30.4"

5.7.2 Post-test Observations (M5-10 Vehicle)

Both headlight units broke loose from their lower retainers. The left and right side turn signal lamps, along with their base plate, were forced rearward, resulting in residual translation of approximately 6.0 inches. Noticeable permanent deformation occurred across the entire lateral bumper face with some structural damage occurring across the entire front surface behind the bumper face. The vehicle was observed leaking coolant fluid due to a broken feed line and/or torn radiator hose.

Post-test operation of both gullwing doors was normal. No cracks were observed in the windshield or in any of the other window surfaces. Post-test operation of the front luggage compartment lid and the rear hatch door were normal.

Figures C-25 through C-29 present various views of the post-test condition of the M5-10 vehicle.

APPENDIX A

VEHICLE PREPARATION AND TESTING LOG

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
N/A	Minicars RSV	M5-10

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
1	Inspect vehicle for defects such as loose structural or suspension components.	R.G.	8-27	Note nature of damage and corrective action in Vehicle Log. (Re-adjust left door)
2	Determine unloaded vehicle weight by wheel. Full liquid capacities, no cargo or occupants.	J.S. V.T.	8-27	LF 546 lb RF 588 lb LR 761 lb RR 707 lb 2602 lb
3	Wash vehicle if necessary.	J.S.	8-27	
4	Inflate tires to manufacturer's recommended pressure.	V.T.	8-27	Front 30 psi Rear 35 psi
5	Secure spare tire, jack, tools, etc., per manufacturer's specifications.	R.G.	8-27	
6	Scribe a level line on each side of the vehicle near each wheel. Record height at each position.	R.G.	8-27	LF 30.5" RF 30.5" LR 30.5" RR 30.5"
7	Determine overall length of vehicle.	R.G.	8-27	177.5"(at vehicle centerline)
8	Install tow and guide plates to forward understructure in approved manner.	V.T.	8-27	Bullet vehicle only. (M5-10)

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
N/A	Minicars RSV	M5-10

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
9	Verify fuel tank is filled and other liquids are at the proper levels.	V.T.	8-27	Gasoline drained and replaced with stoddard solvent.
10	Deliver vehicle to the Crash Test Facility			

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
N/A	Minicars RSV	M5-11

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
1	Inspect vehicle for defects such as loose structural or suspension components.	R.G.	8-27	Note nature of damage and corrective action in Vehicle Log. (none)
2	Determine unloaded vehicle weight by wheel. Full liquid capacities, no cargo or occupants.	J.S. V.T.	8-27	LF 540 lb RF 565 lb LR 729 lb RR 700 lb 2544 lb
3	Wash vehicle if necessary.	J.S.	8-27	
4	Inflate tires to manufacturer's recommended pressure.	V.T.	8-27	Front 30 psi Rear 35 psi
5	Secure spare tire, jack, tools, etc., per manufacturer's specifications.	R.G.	8-27	
6	Scribe a level line on each side of the vehicle near each wheel. Record height at each position.	R.G.	8-27	LF 30.5" RF 30.5" LR 30.5" RR 30.5"
7	Determine overall length of vehicle.	R.G.	8-27	177.5"(at vehicle centerline)
8	Install tow and guide plates to forward understructure in approved manner.	N/A		Bullet vehicle only. (M5-10)

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
N/A	Minicars RSV	M5-11

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
9	Verify fuel tank is filled and other liquids are at the proper levels.	V.T.	8-27	Gasoline drained and replaced with stoddard solvent.
10	Deliver vehicle to the Crash Test Facility			

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
1980	Chevrolet Citation	Two-Door

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
1	Inspect vehicle for defects such as loose structural or suspension components.	R.G.	8-28	Note nature of damage and corrective action in Vehicle Log. (none)
2	Determine unloaded vehicle weight by wheel. Full liquid capacities, no cargo or occupants.	J.S. V.T.	8-27	LF 896 lb RF 884 lb LR 484 lb RR 460 lb 2724 lb
3	Wash vehicle if necessary.	J.S.	8-28	
4	Inflate tires to manufacturer's recommended pressure.	V.T.	8-27	Front 26 psi Rear 26 psi
5	Secure spare tire, jack, tools, etc., per manufacturer's specifications.	R.G.	8-28	
6	Scribe a level line on each side of the vehicle near each wheel. Record height at each position.	R.G.	8-28	LF 29.3" RF 29.3" LR 28.8" RR 29.5"
7	Determine overall length of vehicle.	R.G.	8-28	178" (at vehicle centerline)
8	Install tow and guide plates to forward understructure in approved manner.	N/A		Bullet vehicle only. (M5-10)

APPENDIX A - VEHICLE PREPARATION AND TESTING LOG

PROJECT Damageability Tests of Minicars RSV

VEHICLE IDENTIFICATION:

Year	Make	Model
1980	Chevrolet Citation	Two-Door

TASK Low Speed Impacts

SUBTASK NUMBER	SUBTASK DESCRIPTION	DONE BY	DATE	SPECIAL INSTRUCTIONS/COMMENTS
9	Verify fuel tank is filled and other liquids are at the proper levels.	V.T.	8-27	
10	Deliver vehicle to the Crash Test Facility			

APPENDIX B

CHEVROLET CITATION DAMAGE APPRAISALS

TABLE B-1. APPRAISAL SUMMARY FOR REAR IMPACT AT 15.5 MPH

	Helpn-U Appraisals	Western Appraisers	Ed Johnson Auto Appraisers	Average
Labor	$436.50	$483.00	$325.50	$415.00
Parts	78.00	94.70	107.00	93.23
Sublet	47.80	166.00	33.00	82.27
Tax	6.29	13.04	7.00	8.78
Total	$568.59	$756.74	$472.50	$599.28

TABLE B-2. APPRAISAL SUMMARY FOR SIDE IMPACT AT 5.2 MPH

	Helpn-U Appraisals	Western Appraisers	Ed Johnson Auto Appraisers	Average
Labor	$223.50	$261.10	$310.50	$265.03
Parts	-	76.25	79.00	51.75
Sublet	24.50	34.30	33.00	30.60
Tax	1.23	5.53	5.60	4.12
Total	$249.23	$377.18	$428.10	$351.50

It should be noted that, on the original appraisal sheets, parts discounts from 0-15% were included. The figures shown above have been adjusted to 0% parts discount, in each case, to permit direct comparison.

RCA No [illegible]

CLIENT [illegible]

Page No 1 of 2

ATTN [illegible] Your No. P.O. #04948

INSURED

Name: [illegible] Service, Inc

Address: 13[illegible] Pinnacle Peak Rd.

Address (Cont.): Phoenix, Az 85027

Phone (Home & Business): 942-3300

CLAIMANT

Name:

Address: N/A

Address (Cont.):

Phone (Home & Business):

Vehicle Make, Year and Body Type	License No.	Serial/Identification No.	Mileage
480 Chev. Citation	NONE	1X1Z0B7A632639	00037

Tires	Exterior	Interior	Color	Approx. Retail:	Approx. Salvage:
NEW	NEW	NEW	RED	$ 6,500 00	$ N/A

Date of Loss	Assignment Received	Contacted Owner	Inspected Vehicle	Date of A/Price	Date Closed
N/A	9/9/0	9/9/0	9/11/0	9/12/0	9/16/0

The undersigned agrees to complete and guarantee the repairs listed on the attached sheet(s) at a total price of $ 556.31 including all towing and storage charges incidental thereto.

Repairer Courtesy Chevrolet

Address 1233 E Camelback Rd.

City/State Phoenix, 85014 Phone 279-3333

By: X [illegible]

Down Time (Approx.) N/A

OWNER MUST AUTHORIZE

Labor 29.1	Hours @ 15.00	$ 436.50
Labor —	Hours @ —	$ —
Parts 78.00	Less % 15%	$ 66.30
Parts	Less %	$ —
Sublet and Net Items		$ 47.80
Tax @ 5 % On $ 114.10		$ 5.71
Advance Charges		$ —
REPAIR TOTAL		$ 556.31 *
Deductible (—)		$ N/A
Betterment (—)		$ N/A
Appearance Allowance (+)		$ N/A
RECOMMENDATION		$ 556.31

COMMENTS

Exclude L/Door & L/Pillar Damage!

*Adjusted to $568.59 to delete parts discount.

Signature of Appraiser [illegible] No. 0055079 Kind of Loss Coll.

B-3

THIS IS NOT AN AUTHORIZATION TO MAKE REPAIRS

RCA 1/80

DAMAGE APPRAISAL SHEET

RCA No [illegible]

Owner [illegible]

Repair	Replace	DETAILS OF REPAIRS AND/OR REPLACEMENTS	Est. Labor	Flat Rate	Ref. Labor	Parts and Materials	Sublet and Net Items
X		Rear Bumper [illegible]		0.9	-	+	+
X		Straightening Time	1.5	-	-	+	+
	X	Rear Tail/Stop Lens - (Right) T-Type	-	0.4	-	39 00	+
	X	" " " (Left) "	-	0.4	-	39 00	+
X		Rear Body Panel Below Lift Gate	2.0	-	1.0	+	+
X		Rear Frame X-Member & Side Rails & Floor	8.0	-	1.0	+	+
X		R/Qt Panel Assy (Incl Reinforcement)	6.5	-	2.2	+	+
X		L/Qt " " (" " " " ") SEE NOTE:	4.0	-	1.8	+	+
		Paint Materials (5.4 Hrs @ 7.00 Hr)	-	-	-	+	47 80

NOTE: L/Qt Panel Metal finish & Paint Labor Time Excludes Damage at Left Lock Pillar!

AUTHORIZATION TO REPAIR MUST COME FROM OWNER

TOTALS 22.9 1.7 5.4 78 00 47 80

Page No 2 of 2 See Page No 1 for Recap and Shop Agreement

RCA 1 80

VEHICLE DAMAGE APPRAISAL SHEET

RCA No [illegible]

CLIENT [illegible]

Phone (602) 247-0903

Page No 1 of [illegible]

ATTN [illegible] Your No.: [illegible]

INSURED	CLAIMANT
Name: DYNAMIC SIGNAL INC.	Name:
Address: 1850 N. PINNACLE PEAK RD	Address: N/A
Address (Cont.): PHOENIX, AZ 85027	Address (Cont.):
Phone (Home & Business): 948-3300	Phone (Home & Business):

Vehicle Make, Year and Body Type	License No.	Serial/Identification No.	Mileage
198 Chev. Citation	NONE	1G1AT37A6S2639	000037.0

Tires	Exterior	Interior	Color	Approx. Retail:	Approx. Salvage:
NEW	NEW	NEW	RED	$6,500.00	$ N/A

Date of Loss	Assignment Received	Contacted Owner	Inspected Vehicle	Date of Appr.	Date Closed
N/A	9/9/0	9/9/0	9/11/0	9/15/0	9/15/0

The undersigned agrees to complete and guarantee the repairs listed on the attached sheet(s) at a total price of $ 249.23 including all towing and storage charges incidental thereto.

Repairer Ric's Body & Paint

Address 9245 N. Cave Creek Rd.

City/State Phoenix, Az. Phone 997-7506

By Ric

Down Time (Approx.) N/A

OWNER MUST AUTHORIZE

Labor	14.9 Hours @	15.00	$ 223.50
Labor	— Hours @	—	$ —
Parts	— Less %	—	$ —
Parts	— Less %	—	$ —
Sublet and Net Items			$ 24.50
Tax @	5 % On $	24.50	$ 1.23
Advance Charges			$ —
REPAIR TOTAL			$ 249.23
Deductible (—)			$ N/A
Betterment (—)			$ N/A
Appearance Allowance (+)			$ N/A
RECOMMENDATION			$ 249.23

COMMENTS

Side Impact Only: Exclude Impact Damage (Displaced Metal) Resulting From Rear Collision!

Signature of Appraiser [signature] No. 055079 Kind of Loss Coll.

THIS IS NOT AN AUTHORIZATION TO MAKE REPAIRS

RCA 1/80

VEHICLE DAMAGE APPRAISAL SHEET

RCA No [illegible]

Owner [illegible]

Repair	Replace	DETAILS OF REPAIRS AND/OR REPLACEMENTS	Est Labor	Flat Rate	Ref Labor	Parts and Materials	Sublet and Net Item
X		[illegible] Skin & [illegible]	1.0	4.4	3.5	-	-
X		H Qt & lock Filler [illegible]	3.0	-	1.0	-	-
		Paint Materials	-	-	-	-	54.5[illegible]
		TOTALS	7.0	4.4	3.5	-	54.5[illegible]

AUTHORIZATION TO REPAIR MUST COME FROM OWNER

Page No 2 of 2 See Page No. 1 for Recap and Shop Agreement

RCA 1 F

DAMAGE & EVALUATION APPRAISING OF AUTOMOBILES, TRUCKS, HEAVY EQUIPMENT, FARM MACHINERY & BOATS

Page I
Rear collision

WESTERN APPRAISERS
OF ARIZONA

TELEPHONE (602) 266-5626
P. O. BOX 7611
PHOENIX, ARIZONA 85011

Date Sept 3, 1980

Co. Claim No.

Final Billing c/o WESTERN APPRAISERS Office Phoenix Appraiser T. O'Donnell P-127-06 OUR FILE NUMBER

Assured Dynamic Services Claimant

MAKE	YEAR	MODEL	BODY STYLE	MOTOR NUMBER	LICENSE NO.	MILEAGE
Chevrolet	80	Citation	2DR.	1X08AG325634	None	37

REPAIR	REPLACE	DETAILS OF REPAIR AND REPLACEMENTS	FLAT RATE IN HOURS	ALLOWED LABOR IN HRS.	PARTS OR MATERIAL		SUBLET	
	X	Rear Bumper R/C		1.5			107	00
X		Energy absorbers R/S & P		0.5				
X		Rear Body Panel		1.5				
	X	R/C Tail Lamp		0.2	26	50		
	X	L/C Tail Lamp		0.2	26	50		
X		Deck Lid (HATCHBACK Assy)		0.4				
	X	R/C Bumper filler cap		0.2	20	95		
	X	L/C Bumper filler cap		0.2	20	95		
X		R/R 1/4 Panel		8.5				
X		L/R 1/4 Panel		3.5				
X		Unibody R&L Rail, weld both		8.5				
		Pin Stripe (Tape & P) Pnt		1.5			10	50
		Refinish		5.5			38	50
		Materials					10	00
		*Adjusted to $756.74 to delete parts						
		discount.						
		THIS IS NOT A REPAIR AUTHORIZATION Authorization must be obtained from owner of vehicle.		32.2	94	70	166	00

THIS DOES NOT VERIFY COVERAGE, NOR AN AGREEMENT TO PAY FOR REPAIR

For $ 746.27 less Ded. $ 0 the undersigned agrees to complete and guarantee all loss repairs to the above vehicle.

NO SUPPLEMENTS WITHOUT PRIOR APPROVAL

FIRM

ADDRESS

BY B-7

Form WA-101

Labor 32.2 @ 15.00	$ 483.00
Parts 4 10 90	
Net Parts	$ 85 23
Tax 251.23 x 5%	$ 12.56
Sublet	$ 166.00
Adv. Charges	$ 746.27
	$
GRAND TOTAL	$ 746.27*

DAMAGE & EVALUATION APPRAISING OF AUTOMOBILES TRUCKS HEAVY EQUIPMENT FARM MACHINERY & BOATS

WESTERN APPRAISERS
OF ARIZONA

TELEPHONE (602) 266-5626
P. O. BOX 7611
PHOENIX, ARIZONA 85011

Page II
4/5 Collision

Date Sept 3, 1980

Co. Claim No.

Final Billing c/o WESTERN APPRAISERS Office Phoenix Appraiser T O'Donnell P-127-06 OUR FILE NUMBER

Assured Dynamic Sciences Claimant

MAKE	YEAR	MODEL	BODY STYLE	MOTOR NUMBER	LICENSE NO.	MILEAGE
Chevrolet	80	Citation	2DR	1X08?A63.25639	None	37

REPAIR	REPLACE	DETAILS OF REPAIR AND REPLACEMENTS	FLAT RATE IN HOURS	ALLOWED LABOR IN HRS.	PARTS OR MATERIAL		SUBLET	
	X	4/5 Door outer Panel.		5.0	76	25		
X		Door Frame.		1.0				
X	X	4/R 1/4 Panel (LT Section)		5.0				
		Rock Pillar (Weld)		1.5				
		Refinish		4.4			34	30
		*Adjusted to $377.18 to delete parts discount.						
		THIS IS NOT A REPAIR AUTHORIZATION Authorization must be obtained from owner of vehicle.		17.4	76	25	34	30

THIS DOES NOT VERIFY COVERAGE, NOR AN AGREEMENT TO PAY FOR REPAIR

For $ 369.07 less Ded. $ -0- the undersigned agrees to complete and guarantee all loss repairs to the above vehicle.

NO SUPPLEMENTS WITHOUT PRIOR APPROVAL

FIRM

ADDRESS

BY

B-8

Form WA-101

Labor	17.4 @ 15.00	$ 261.10
Parts	4/10 %	
Net Parts		$ 68.62
Tax	102.92 % 5%	$ 5.15
Sublet		$ 34.30
Adv. Charges		$ 369.07
		$
GRAND TOTAL		$ 369.07*

Claim or Policy Number

ED JOHNSON AUTO APPRAISERS

Date

7214 NORTH 36th DRIVE • PHOENIX, ARIZONA 85021 • PHONE ~~939-8820~~ 841-7710 [illegible]

☐ Assured [illegible] ☐ Claimant

Place Inspected [illegible]

Remarks [illegible]

Appraiser [illegible]

CAR MAKE, YEAR AND BODY TYPE	MILEAGE	LICENSE NO.	MTR/SER. NO.
Chev. 80 Citation 2 Dr. Sed	00037	—	1X0S7AL325639

REPAIR	REPLACE	DETAILS OF REPAIRS AND/OR REPLACEMENTS	LABOR HOURS	PARTS AND MATERIAL (LIST PRICE)	SUBLET AND NET ITEMS
	✓	Bumper rear energy abs. L (R+L bumper)	0.9	33 15	
	✓	Tl lamp lens L	0.3	26 50	
	✓	" " " " R	0.3	26 50	
	✓	Bumper filler end R	0.2	20 85	
✓		Fend. & [illegible]	6.0	—	
✓		Qtr pnl L	7.0	—	
✓		" " "	2.0	—	
✓		Refinish	4.0	—	28 00
✓		RL - stripe (tape)	1.0	—	5 00

The undersigned agrees to complete and guarantee all repairs as listed for $ 472.50 including all towing & storage charges incidental thereto.

By ______ Repair

Insurance Co. ______

Betterment Charges	$ 0
Insurance Deductible	$ 0
To Be Deducted from Total	$ 0

Labor 21.7 Hrs. @ $15.00		$ 325.50
Parts Cost	$107.00	
Less Discount 0 %	$ 0	
Net Parts Cost		$ 107.00
Sublet		$ 33.00
Other Charges		$ —
Tax 5 % ( )		$ 7.00
Total		$ 472.50
Less Deduction		$ 0
GRAND TOTAL		$ 472.50

THIS IS NOT AN AUTHORIZATION TO REPAIR

INSURANCE COPY

Claim or Policy Number

ED JOHNSON AUTO APPRAISERS

7214 NORTH 36th DRIVE • PHOENIX, ARIZONA 85021 •

Date 8-11-7710

PHONE ~~939-8830~~

☒ Assured Dynamic Glass ☐ Claimant

Place Inspected 1952 W. Simpson

Remarks ~ Richard E. Kellum

Appraiser Ralph Bowman

CAR MAKE, YEAR AND BODY TYPE	MILEAGE	LICENSE NO.	VIN/SER. NO.
Chev-80, Estation 2 Dr Sed	60037	—	1X087A6325639

REPAIR	REPLACE	DETAILS OF REPAIRS AND/OR REPLACEMENTS	LABOR HOURS	PARTS AND MATERIAL (LIST PRICE)	SUBLET AND MET ITEMS
	✓	Door Skin	5.0	76 25	—
✓		" " Garnish	3.0	—	—
✓		" " Lock pillar	2.5	—	—
✓		Qtr Pnl Ft (Front of 1/2 pc)	5.0	—	—
	✓	Door Leading Mld	0.2	2 75	—
✓		Refinish (Qtr Pnl pro-rate 50%)	4.0	—	28 00
	✓	Restripe	1.0	—	5 00

The undersigned agrees to complete and guarantee all repairs as listed for $ 428.10 including all towing & storage charges incidental thereto.

By _____ Repair

Insurance Co. _____

Betterment Charges $ 0

Insurance Deductible $ 0

To Be Deducted from Total $ 0

Labor 20.7 Hrs. @ $ 15.00		$ 310.50
Parts Cost	$ 79.00	
Less Discount 0 %	$ 0	
Net Parts Cost		$ 79.00
Sublet		$ 33.00
Other Charges		$ —
Tax 5 % ( )		$ 5.60
Total		$ 428.10
Less Deduction		$ —
GRAND TOTAL		$ 428.10

THIS IS NOT AN AUTHORIZATION TO REPAIR

B-10

INSURANCE COPY

APPENDIX C

TEST SERIES PHOTOGRAPHS

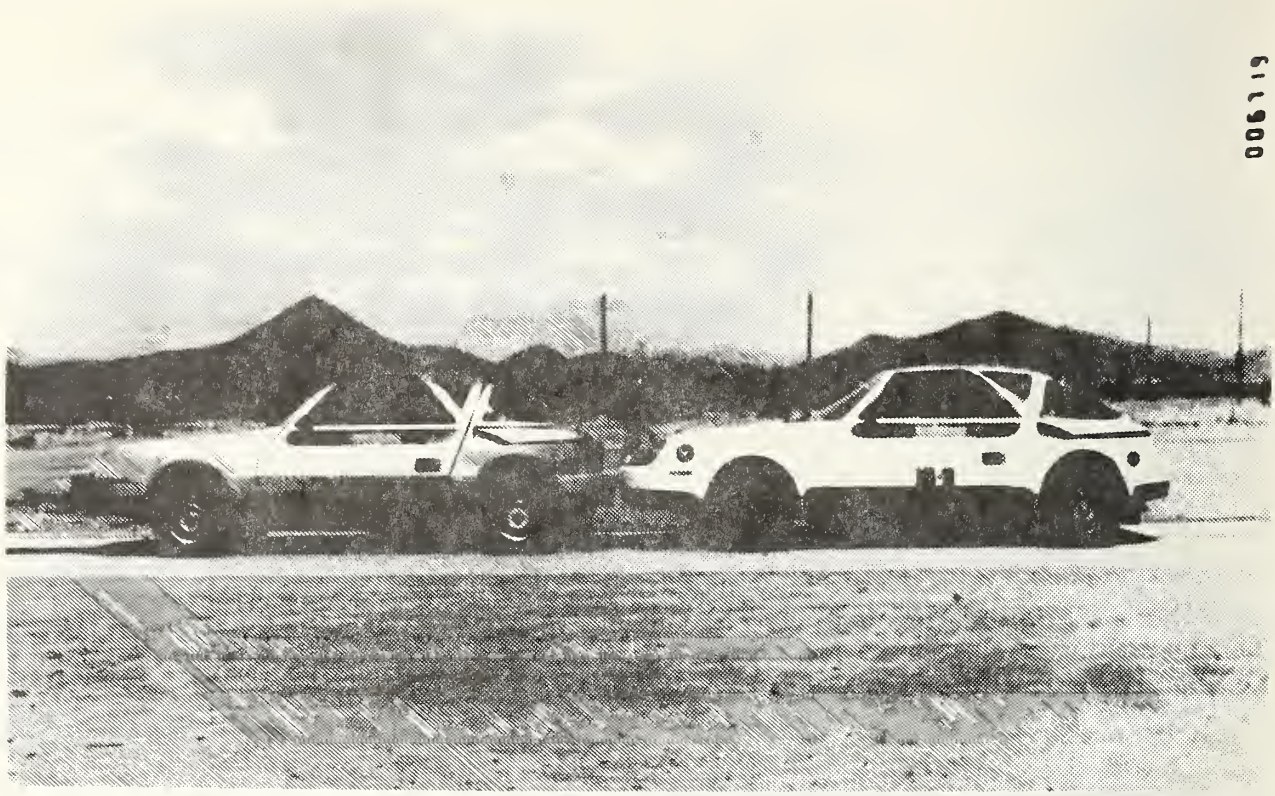


FIGURE C-1. PRE-TEST NO. 1, VEHICLE CONFIGURATION.

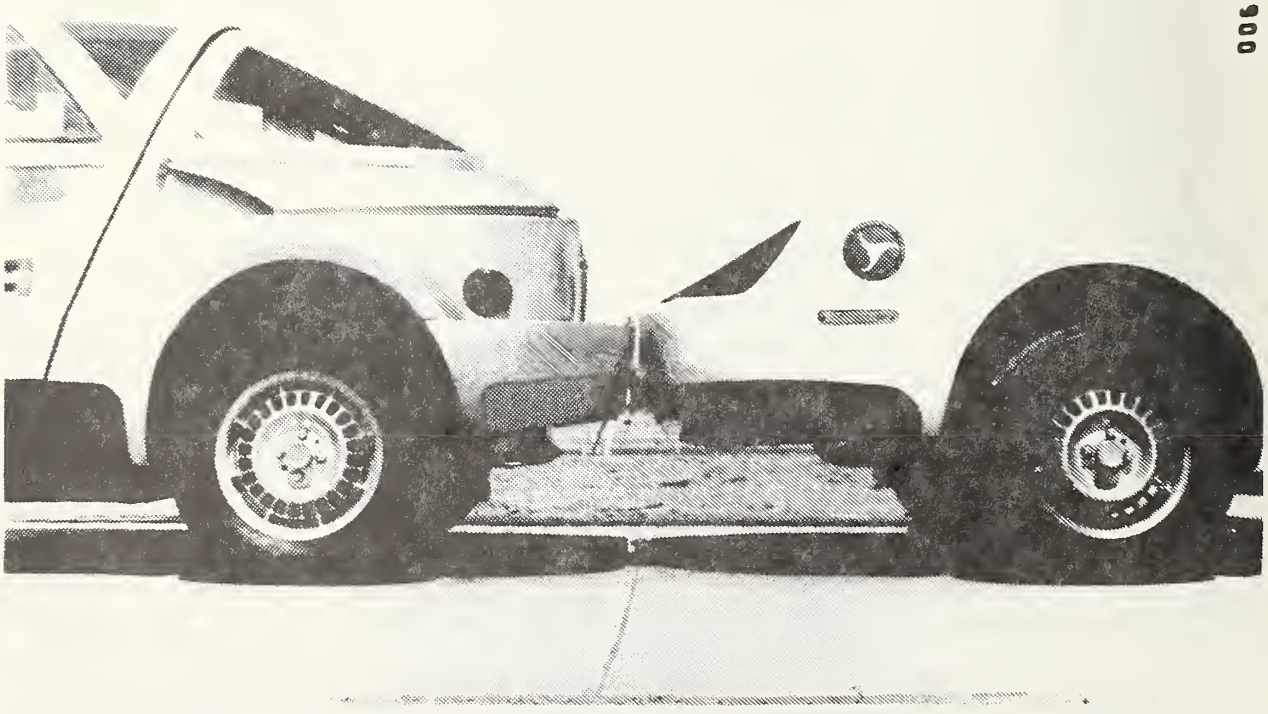


FIGURE C-2. PRE-TEST NO. 1, VEHICLE CONFIGURATION.

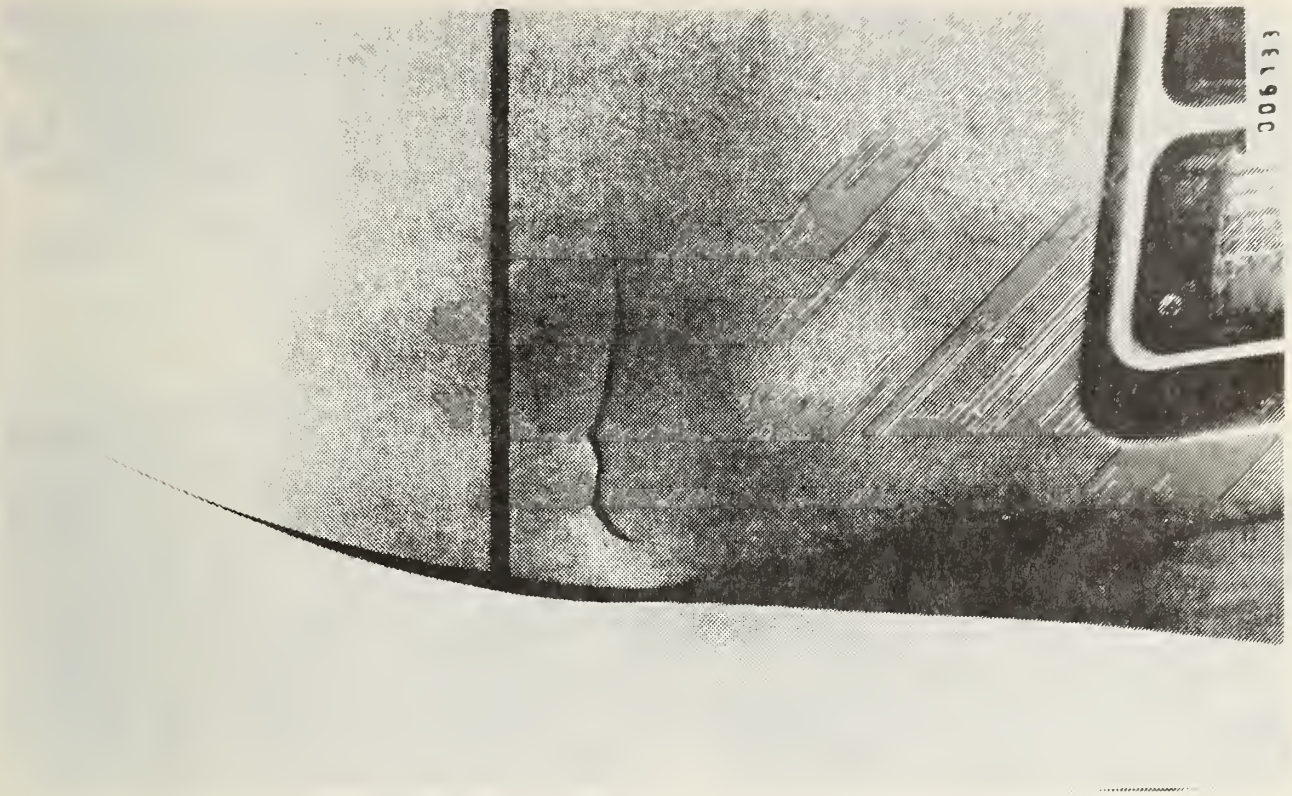


FIGURE C-3. POST-TEST NO. 1, CRACK IN TAILLIGHT PANEL OF M5-11 TARGET VEHICLE.

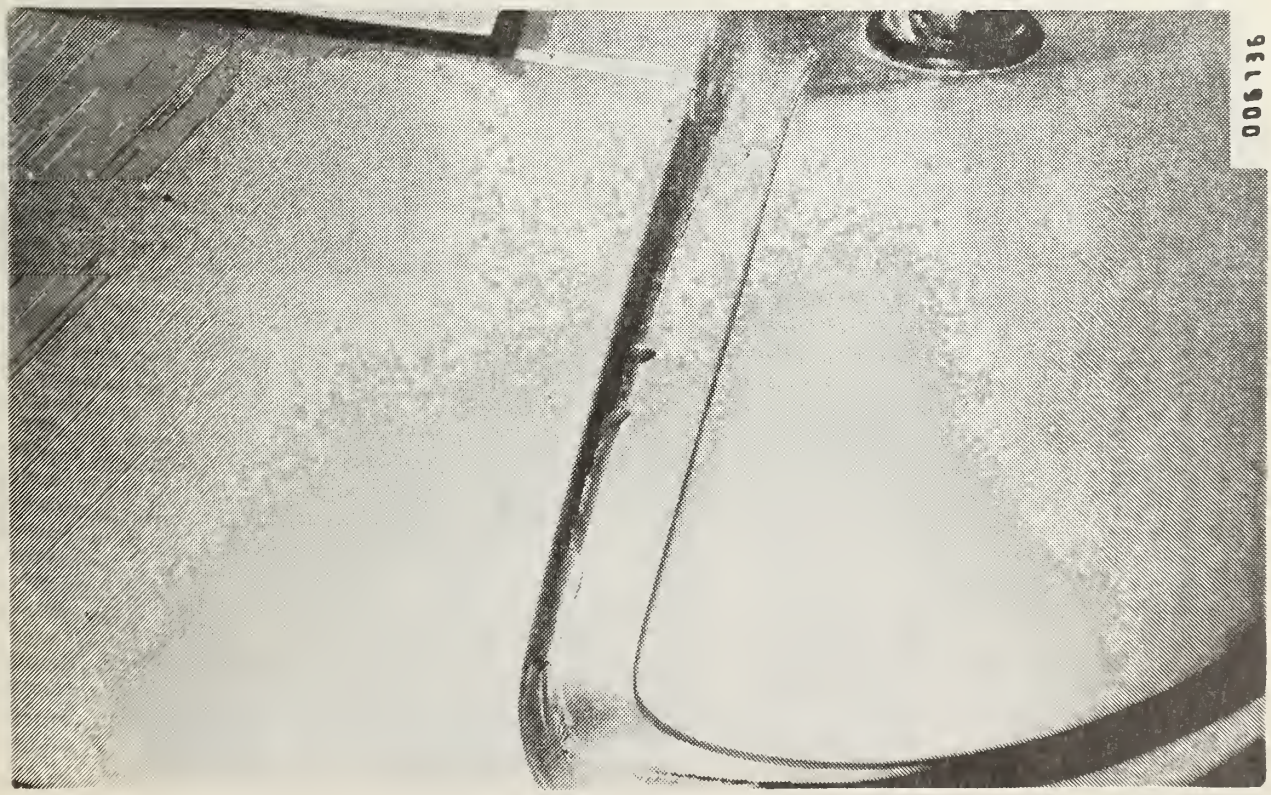


FIGURE C-4. POST-TEST NO. 1, CRACK IN REAR FENDER PANEL SEAM OF M5-11 TARGET VEHICLE.

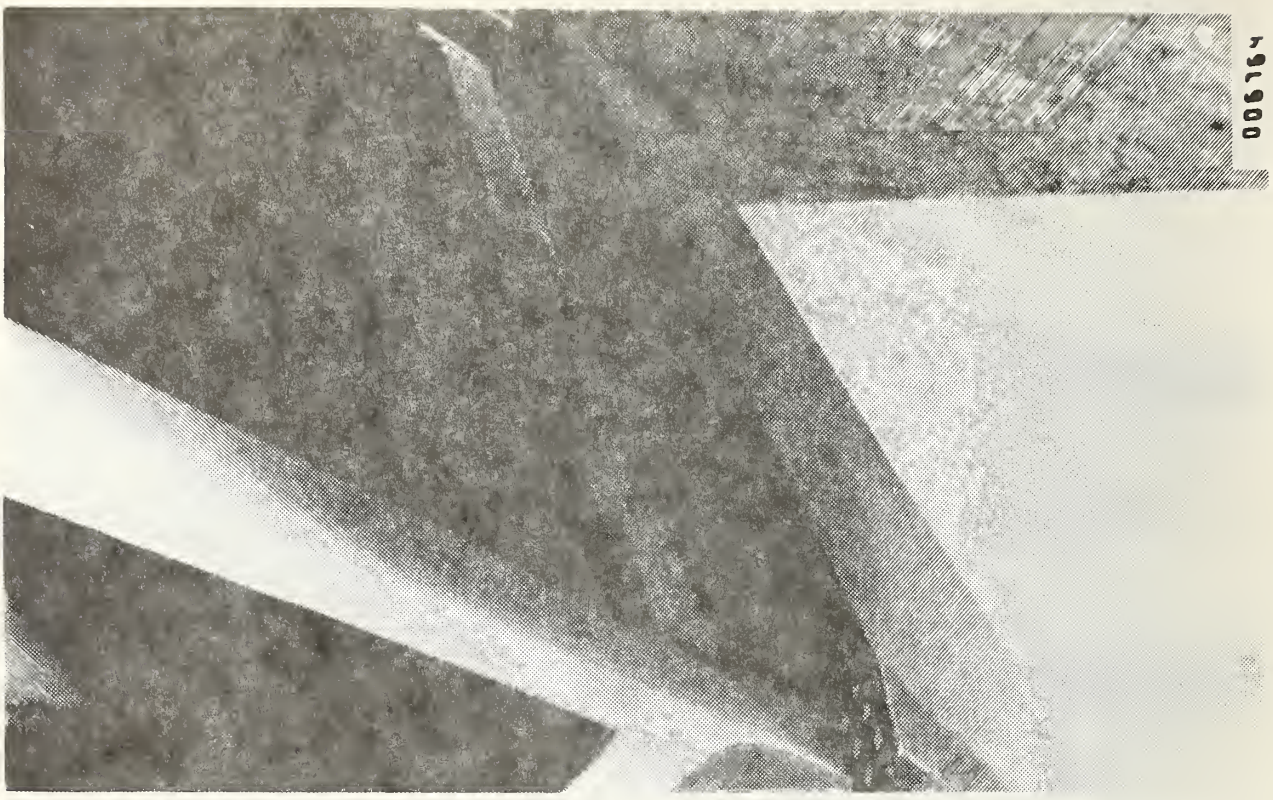


FIGURE C-5. POST-TEST NO. 2, BOND LINE FAILURE BELOW REAR HATCH DOOR OF M5-11 TARGET VEHICLE.

FIGURE C-6. POST-TEST NO. 2, CRACK IN REAR FENDER PANEL SEAM OF M5-11 TARGET VEHICLE.

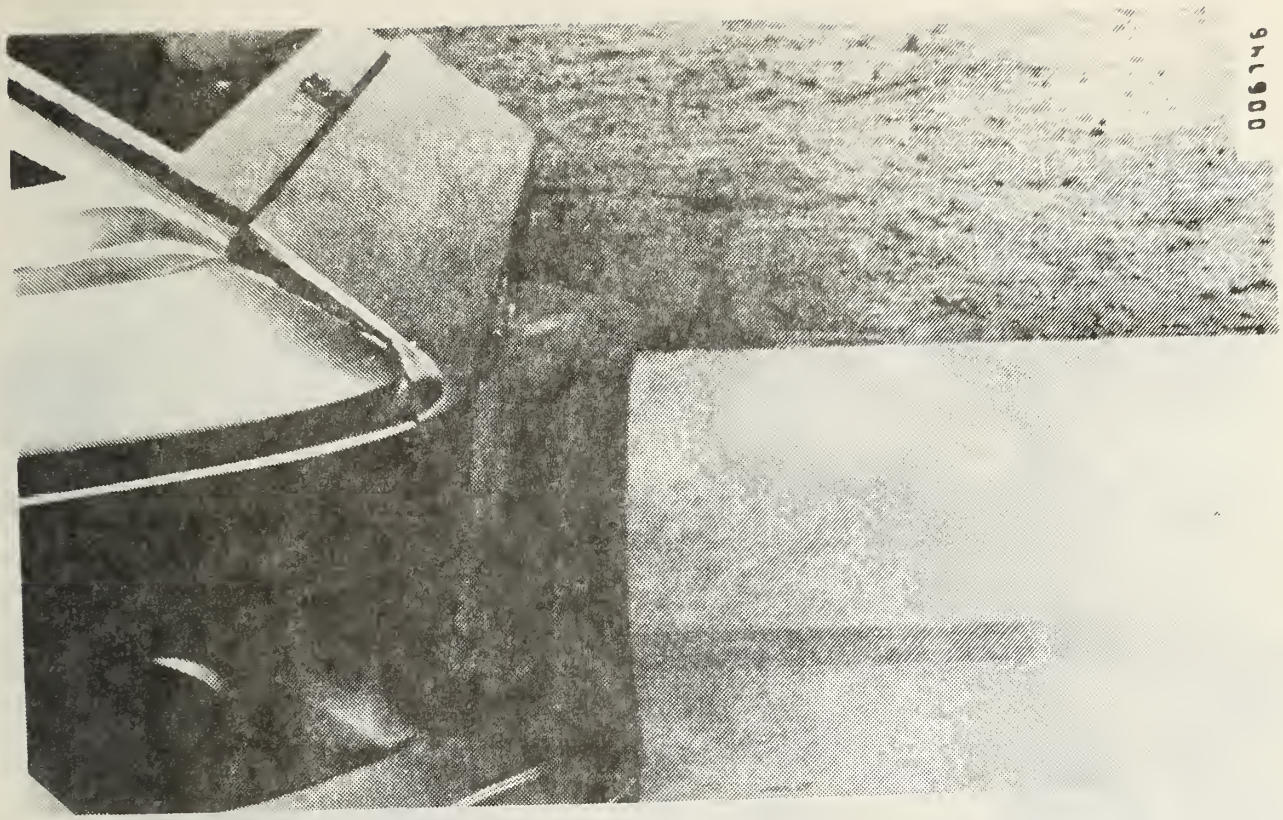


FIGURE C-7. POST-TEST NO. 2, REAR BUMPER OF M5-11 TARGET VEHICLE.

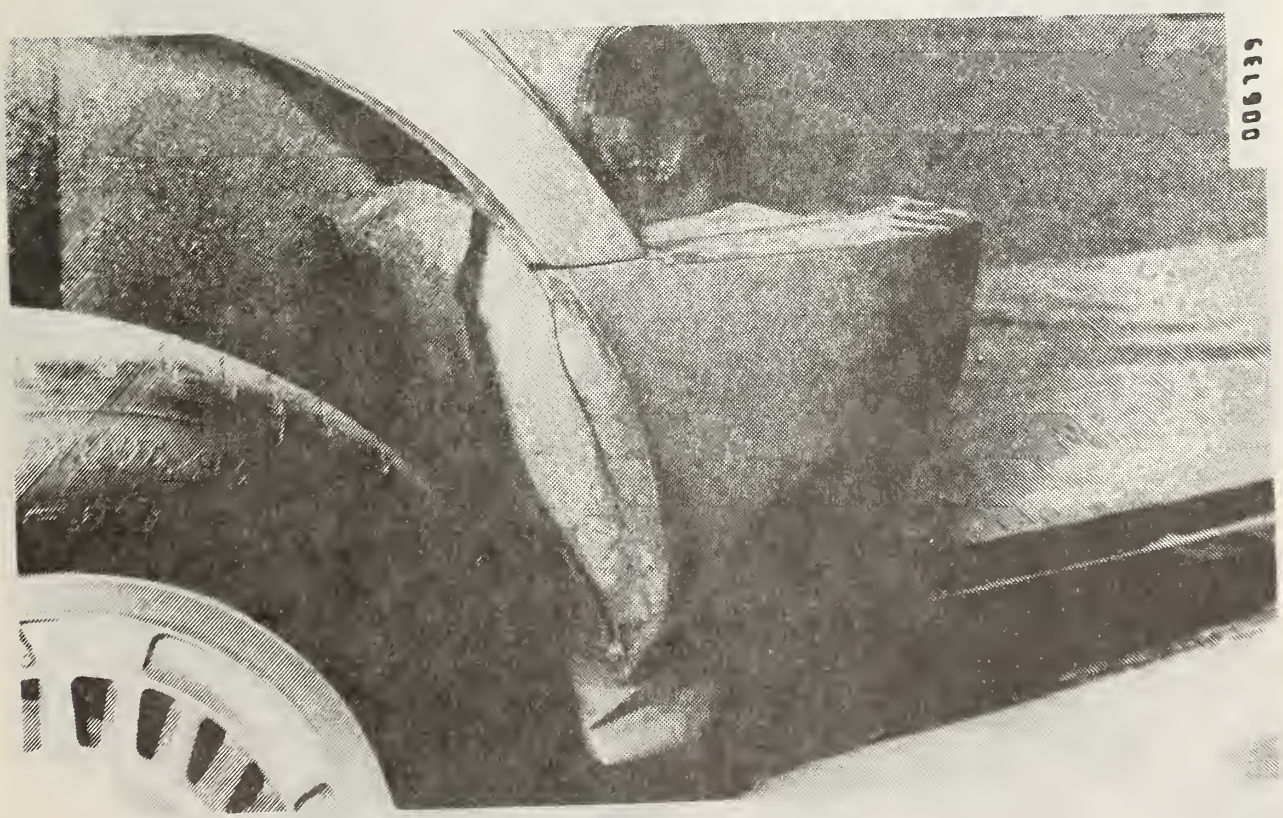


FIGURE C-8. POST-TEST NO. 2, INSIDE LEFT REAR FENDER PANEL OF M5-11 TARGET VEHICLE.

FIGURE C-9. POST-TEST NO. 2, OVERALL REAR VIEW OF M5-11 TARGET VEHICLE.

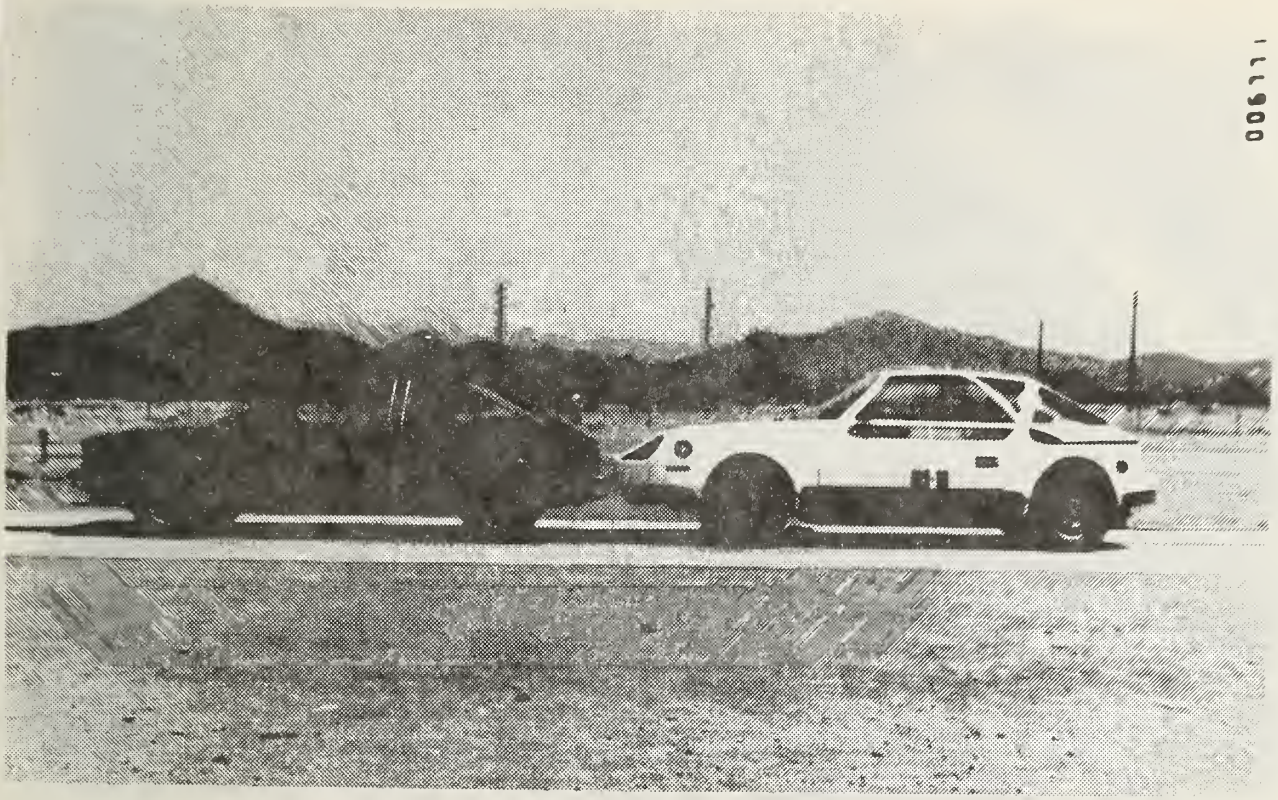


FIGURE C-10. PRE-TEST NO. 3, VEHICLE CONFIGURATION.

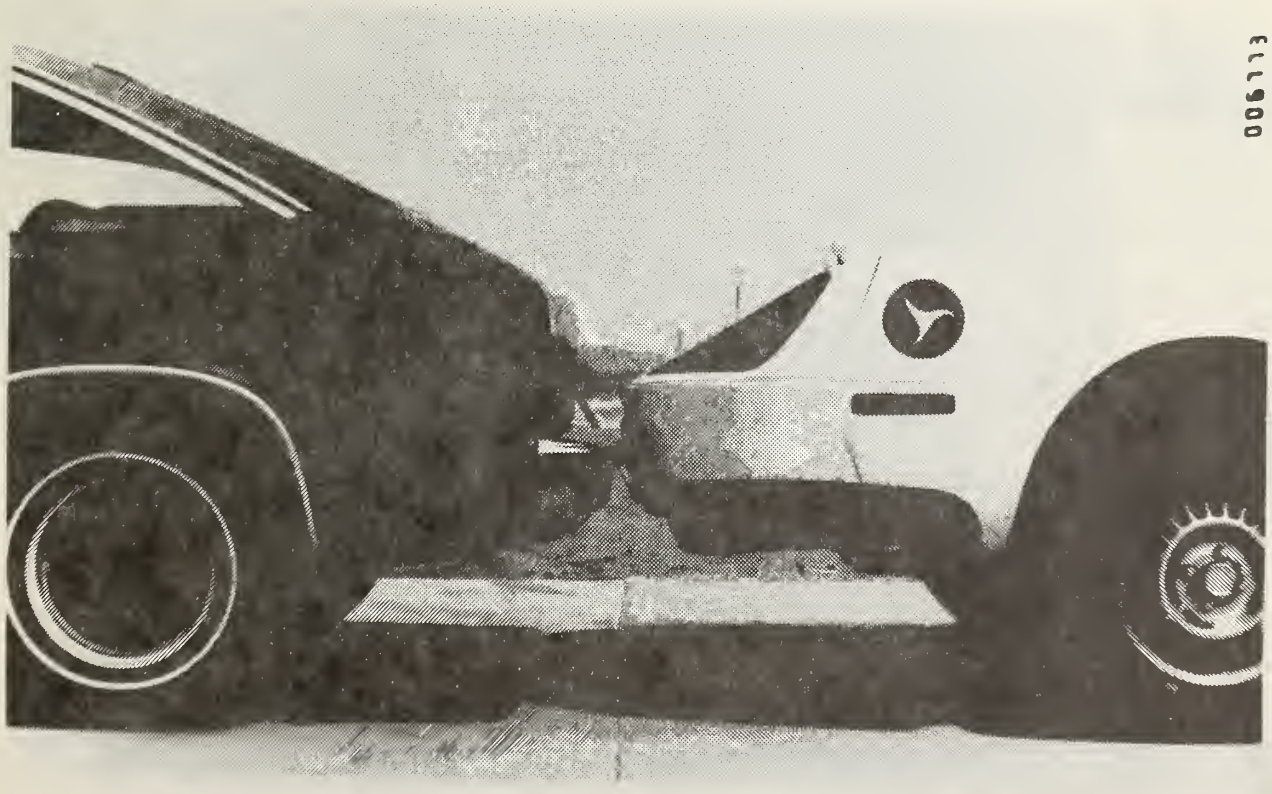


FIGURE C-11. PRE-TEST NO. 3, VEHICLE CONFIGURATION.

FIGURE C-12. POST-TEST NO. 3, REAR QUARTER PANEL OF CHEVROLET CITATION TARGET VEHICLE.

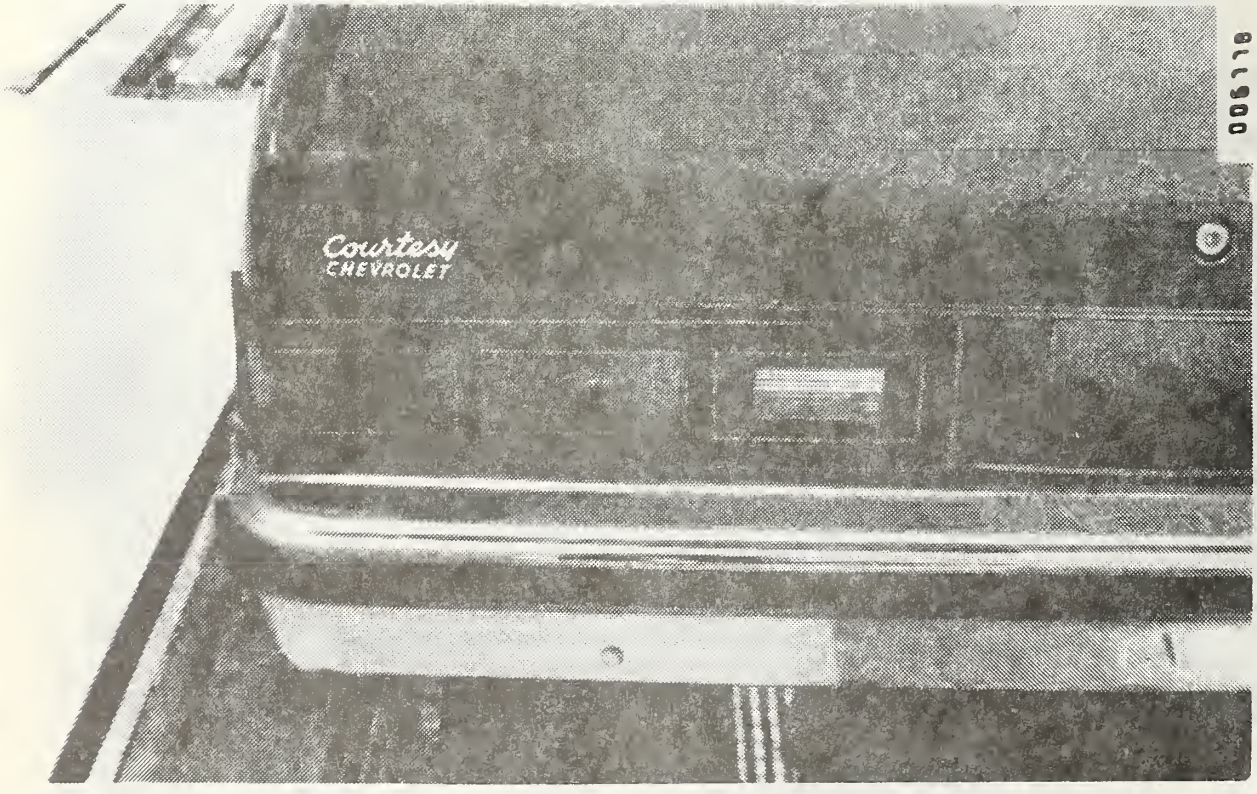


FIGURE C-13. POST-TEST NO. 3, REAR TAILLIGHT LENSE OF CHEVROLET CITATION TARGET VEHICLE.

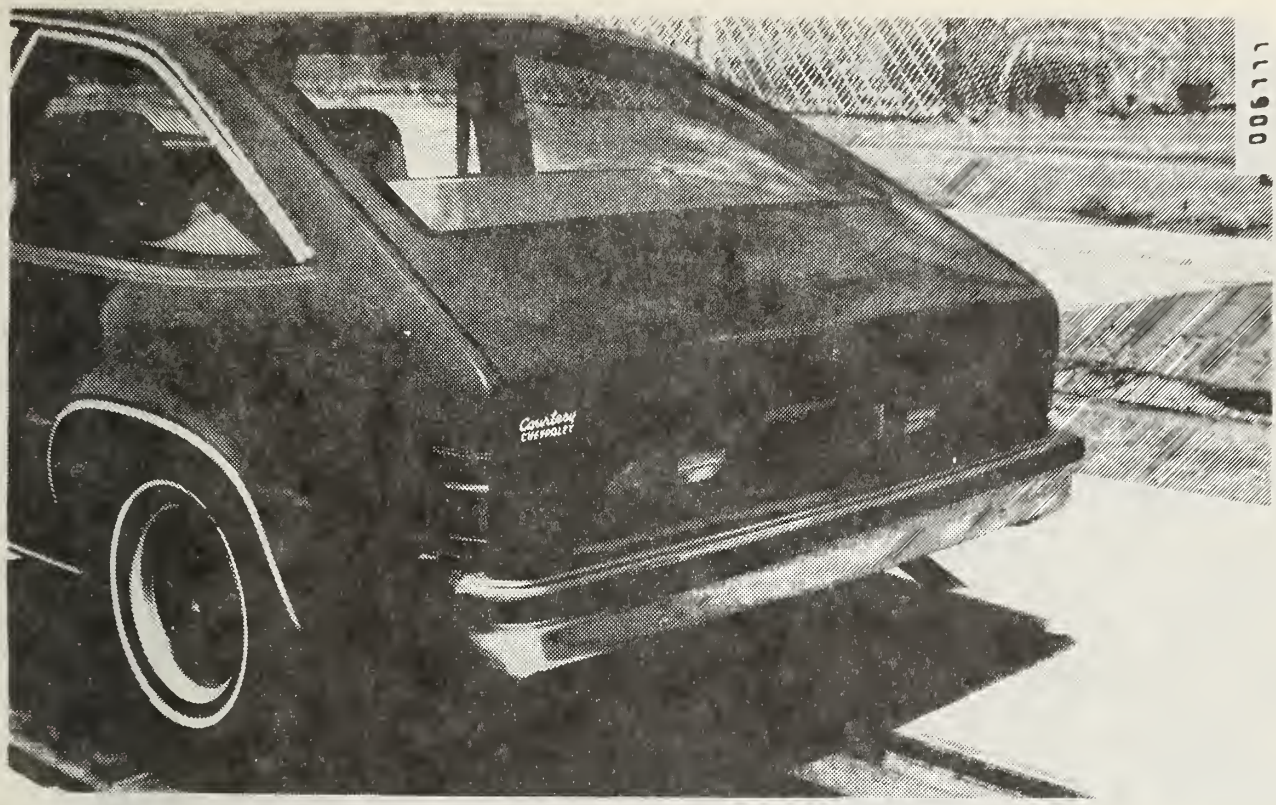


FIGURE C-14. POST-TEST NO. 3, REAR QUARTER PANEL OF CHEVROLET CITATION TARGET VEHICLE.

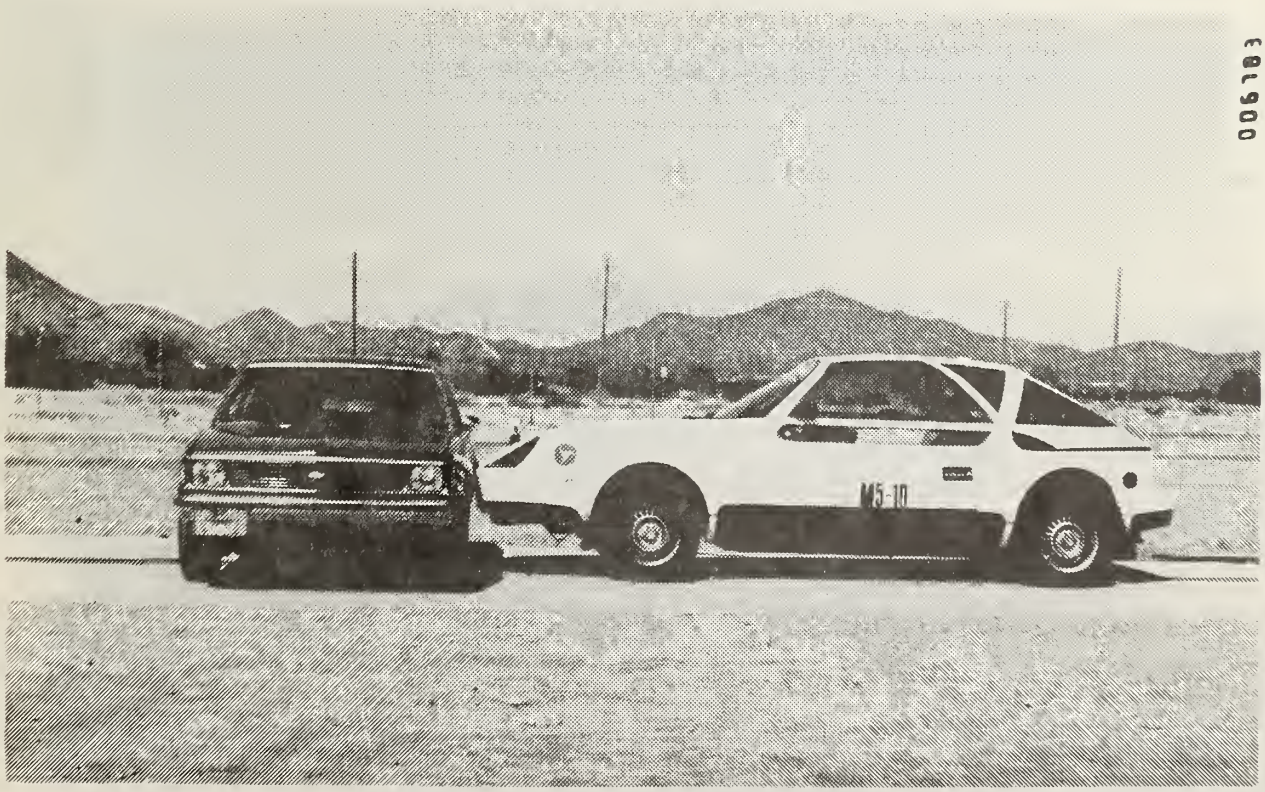


FIGURE C-15. PRE-TEST NO. 4, VEHICLE CONFIGURATION.

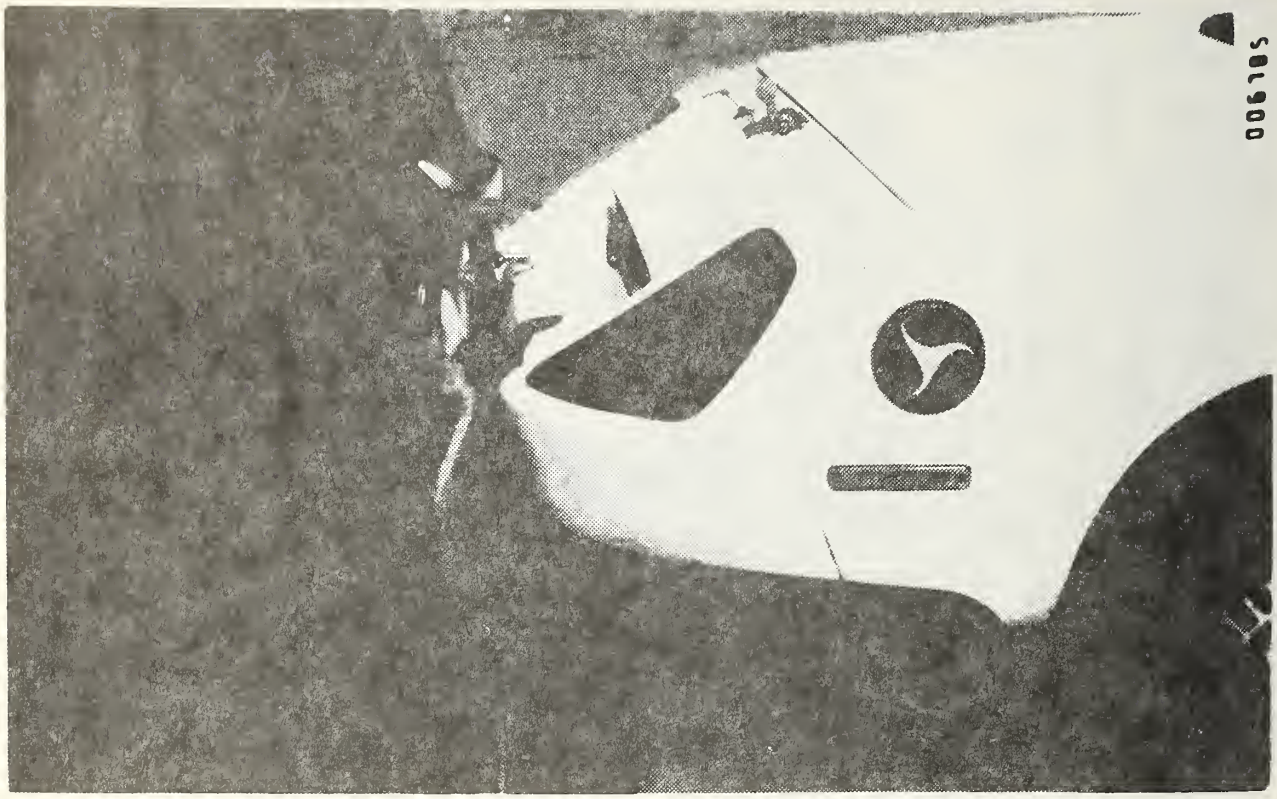


FIGURE C-16. PRE-TEST NO. 4, VEHICLE CONFIGURATION.

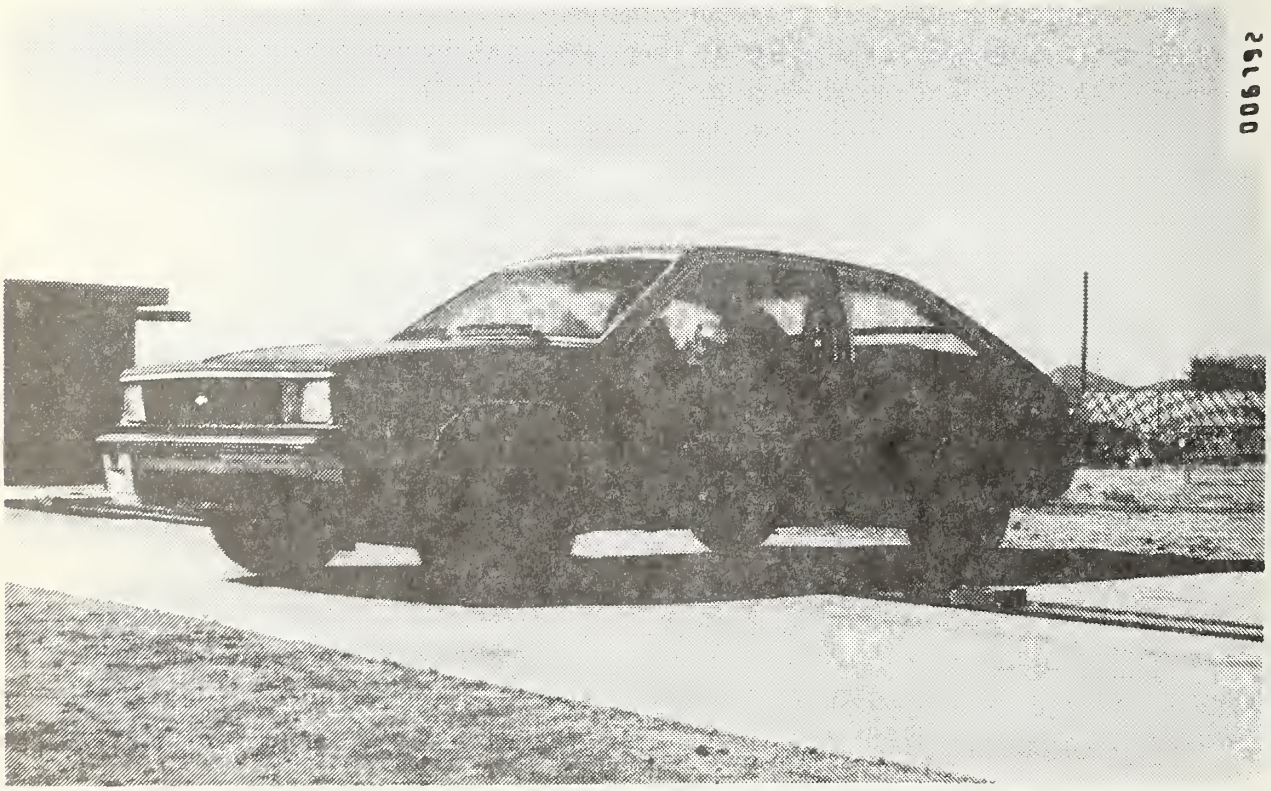


FIGURE C-17. POST-TEST NO. 4, OVERALL VIEW OF CHEVROLET CITATION TARGET VEHICLE.

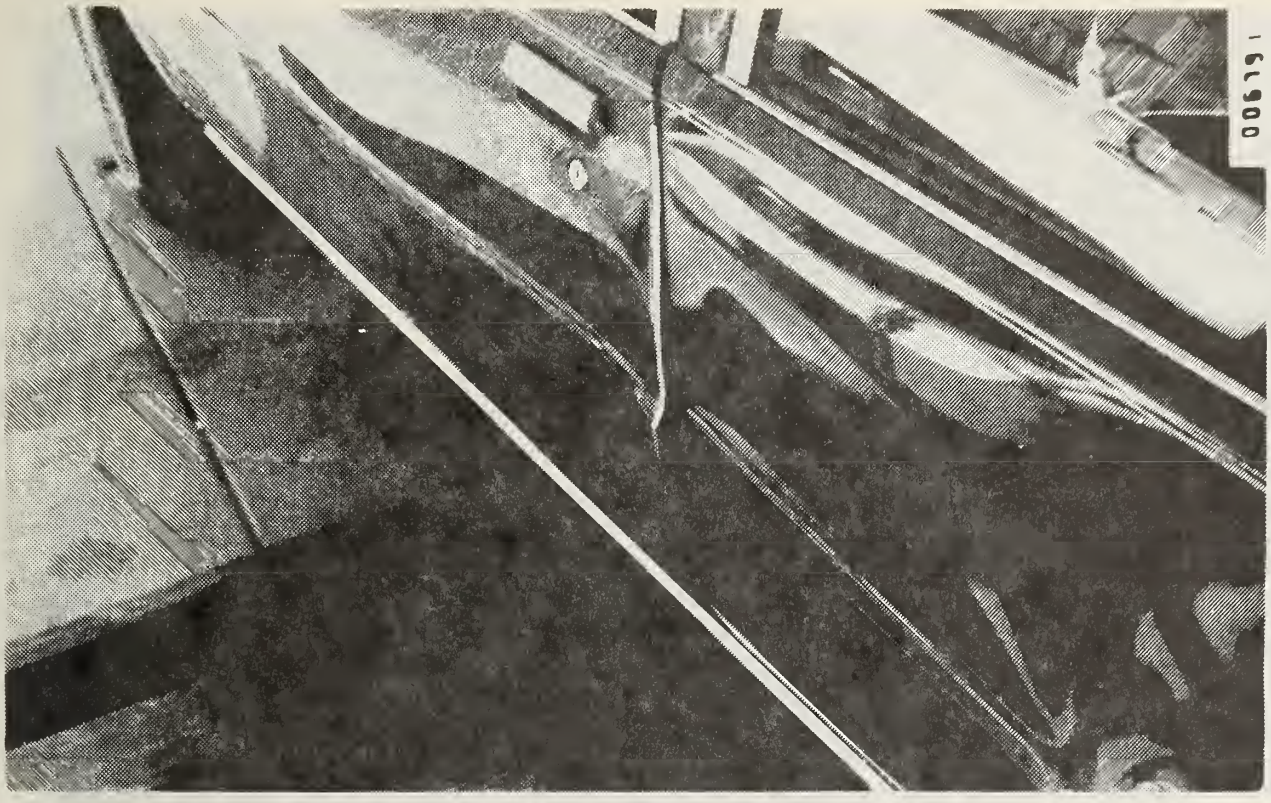


FIGURE C-18. POST-TEST NO. 4, LEFT SIDE DOOR OF CHEVROLET CITATION TARGET VEHICLE.

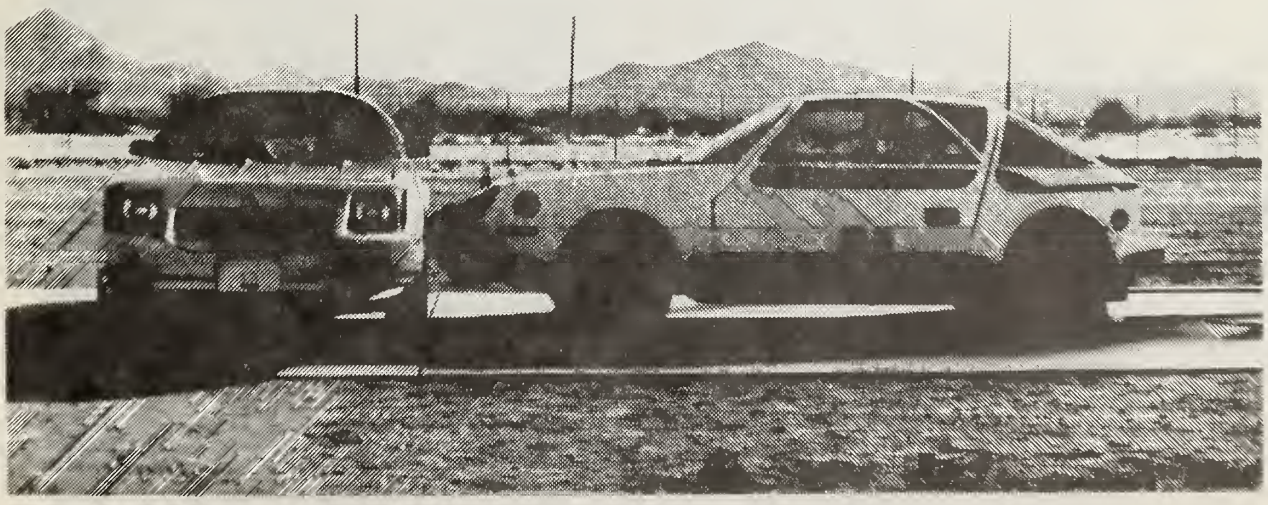


FIGURE C-19. PRE-TEST NO. 5, VEHICLE CONFIGURATION.

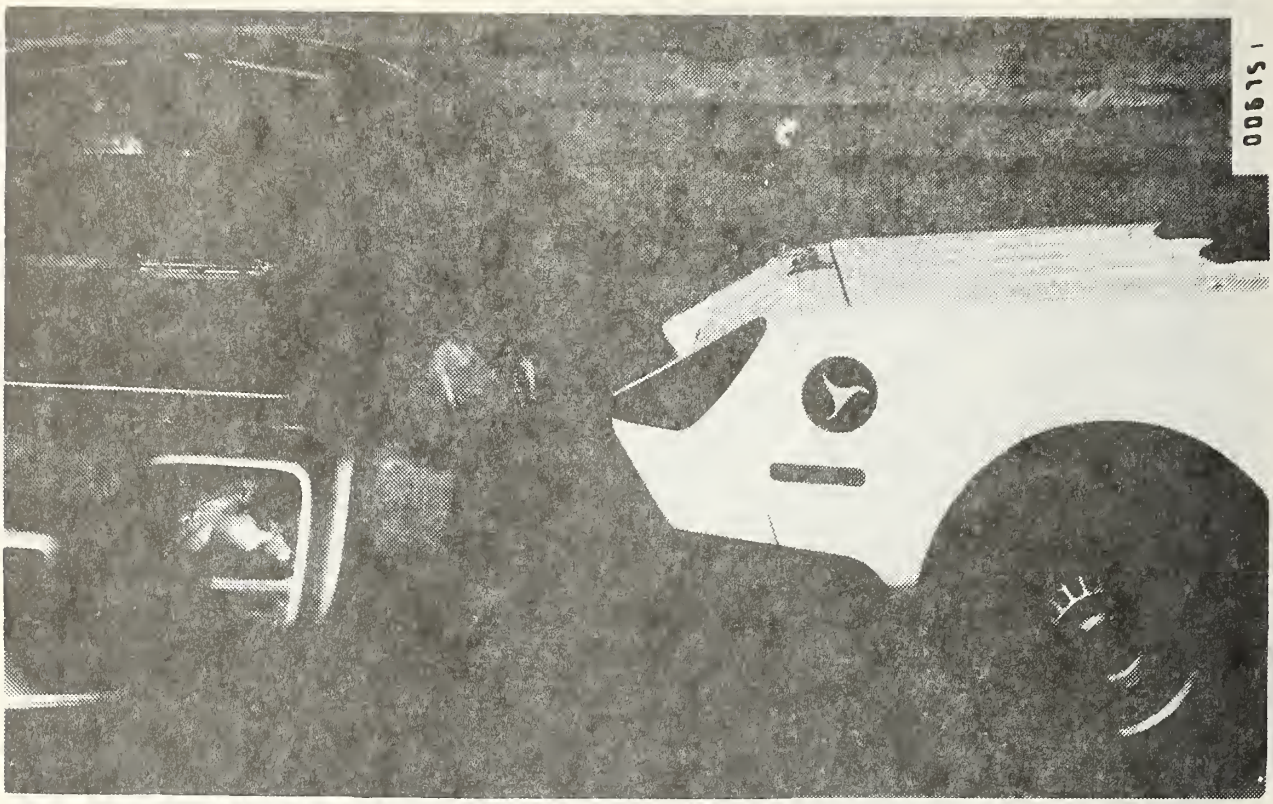


FIGURE C-20. PRE-TEST NO. 5, VEHICLE CONFIGURATION.

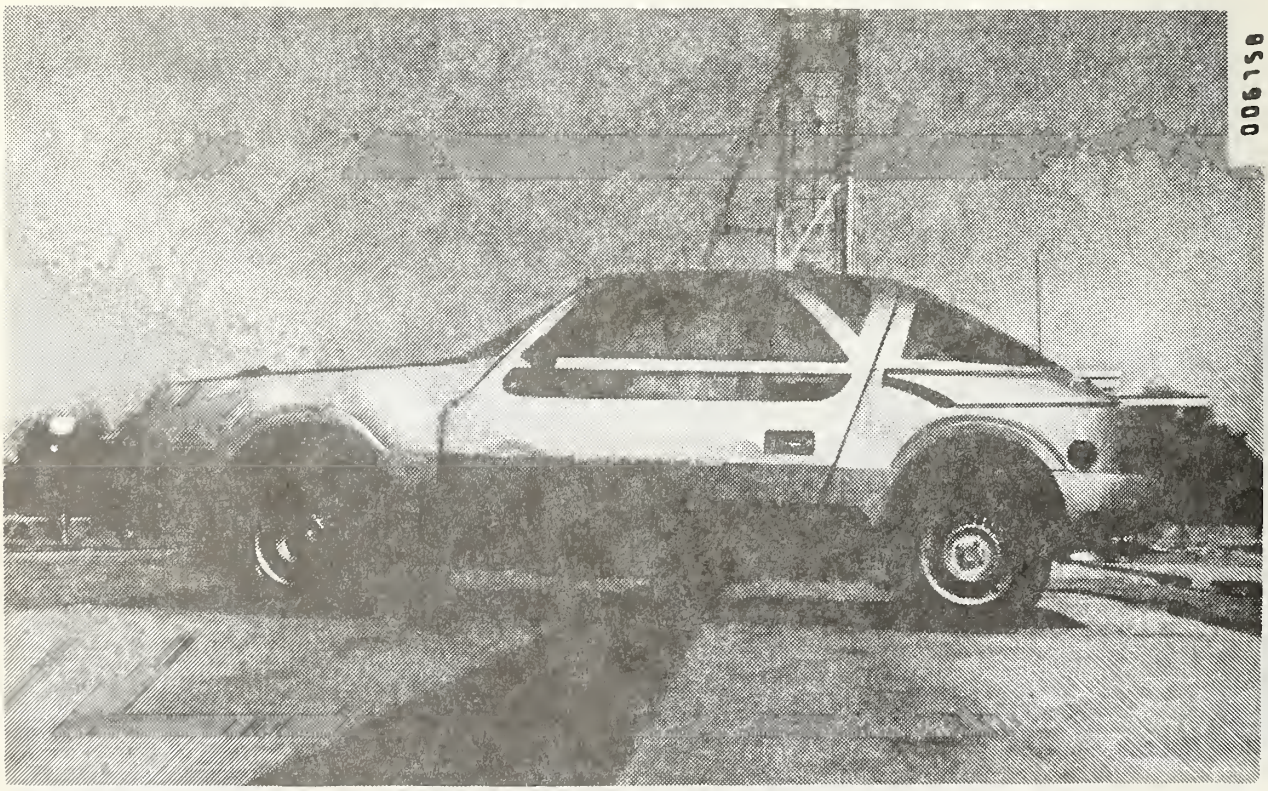


FIGURE C-21. POST-TEST NO. 5, OVERALL VIEW OF M5-11 TARGET VEHICLE.

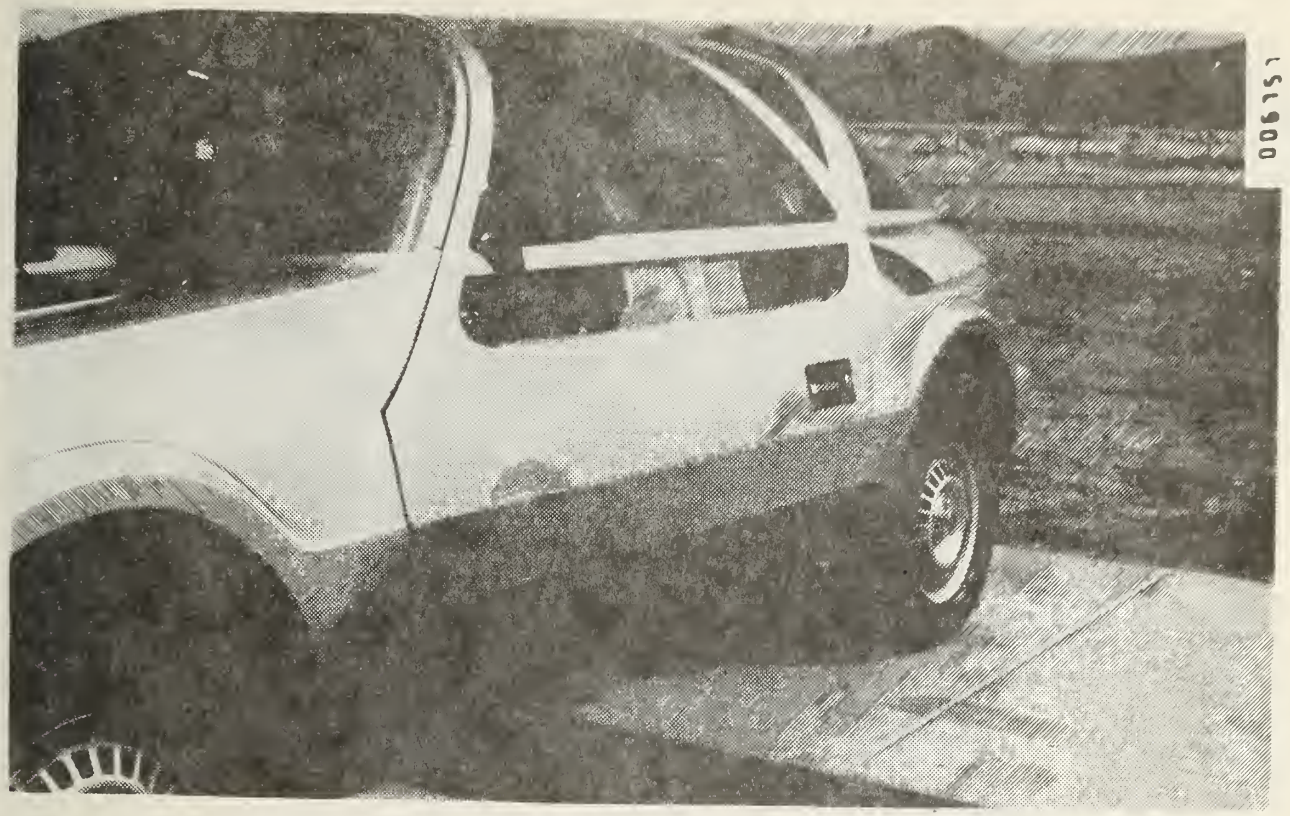


FIGURE C-22. POST-TEST NO. 5, LEFT SIDE DOOR OF M5-11 TARGET VEHICLE.

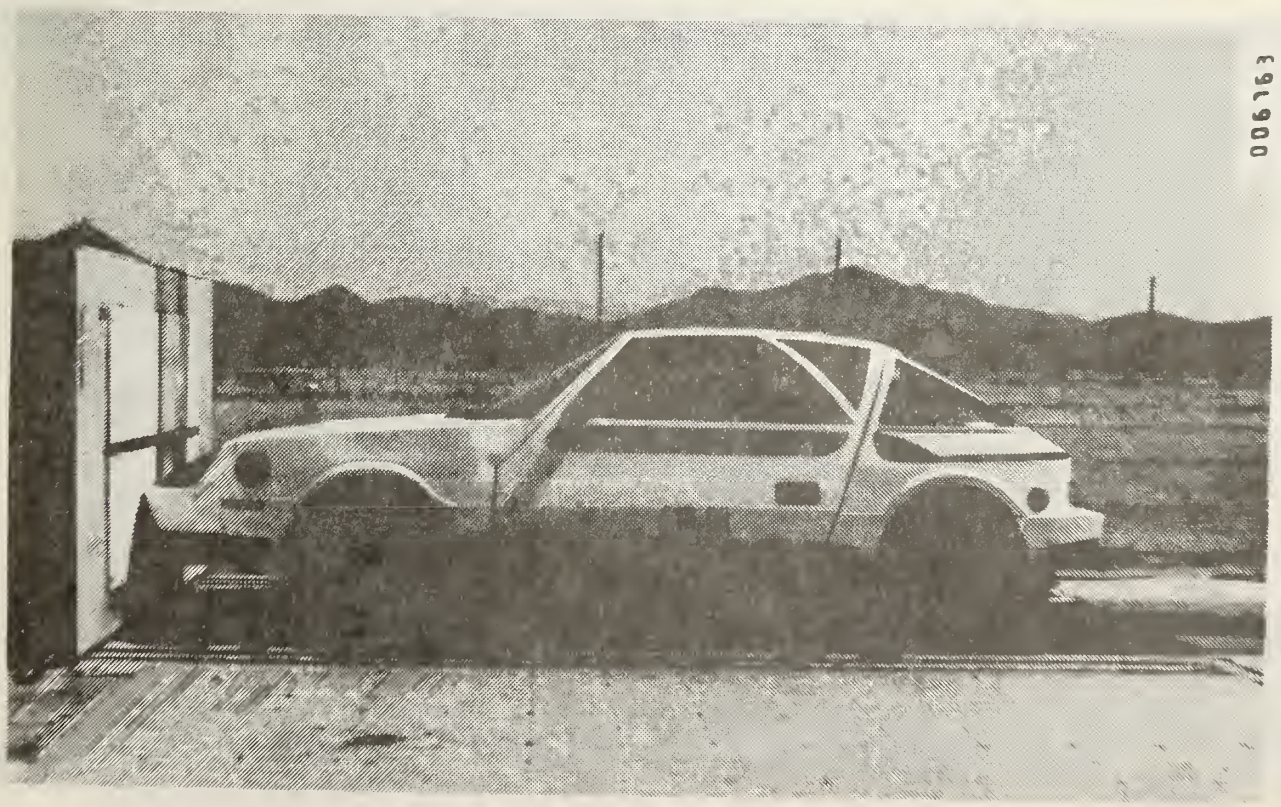


FIGURE C-23. PRE-TEST NO. 6, VEHICLE CONFIGURATION.

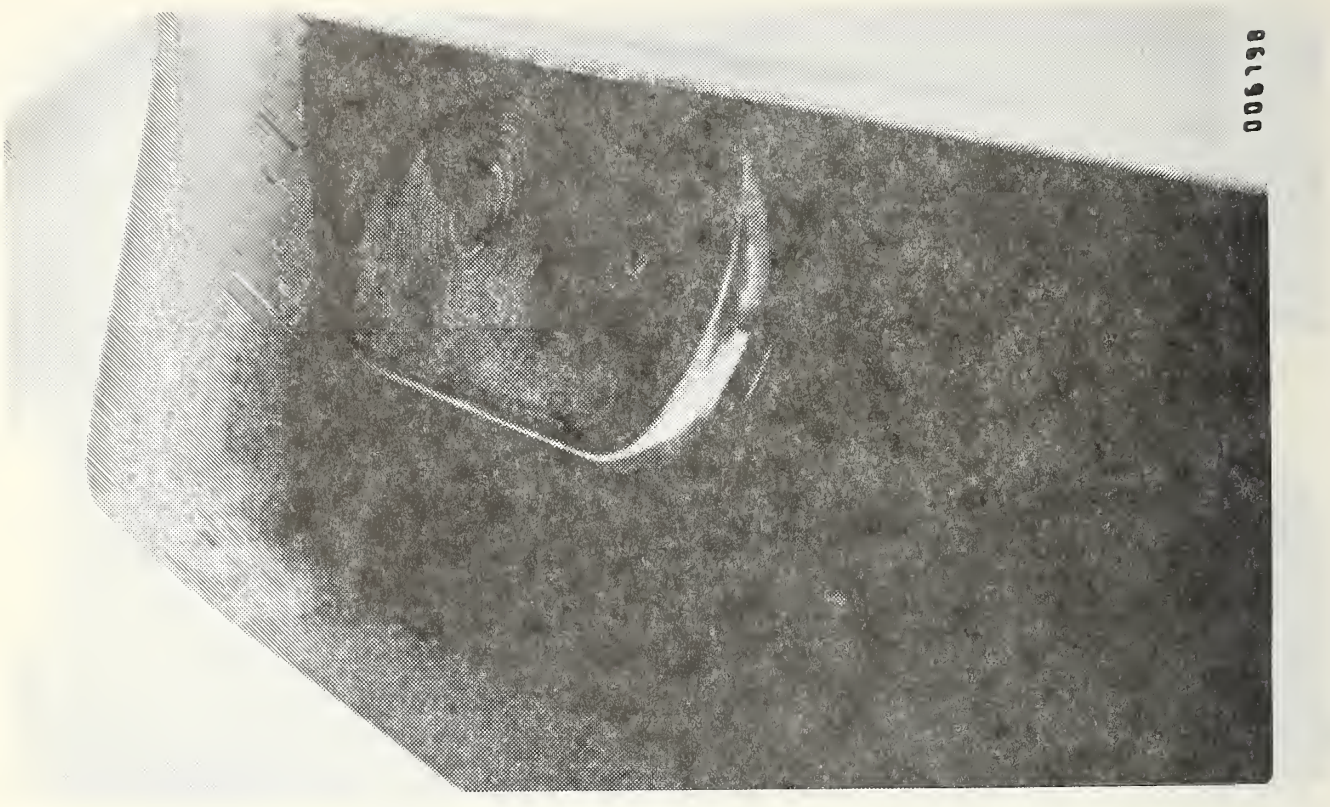


FIGURE C-24. POST-TEST NO. 6, RIGHT SIDE TURN SIGNAL LAMP AND FRAME OF M5-10 VEHICLE.

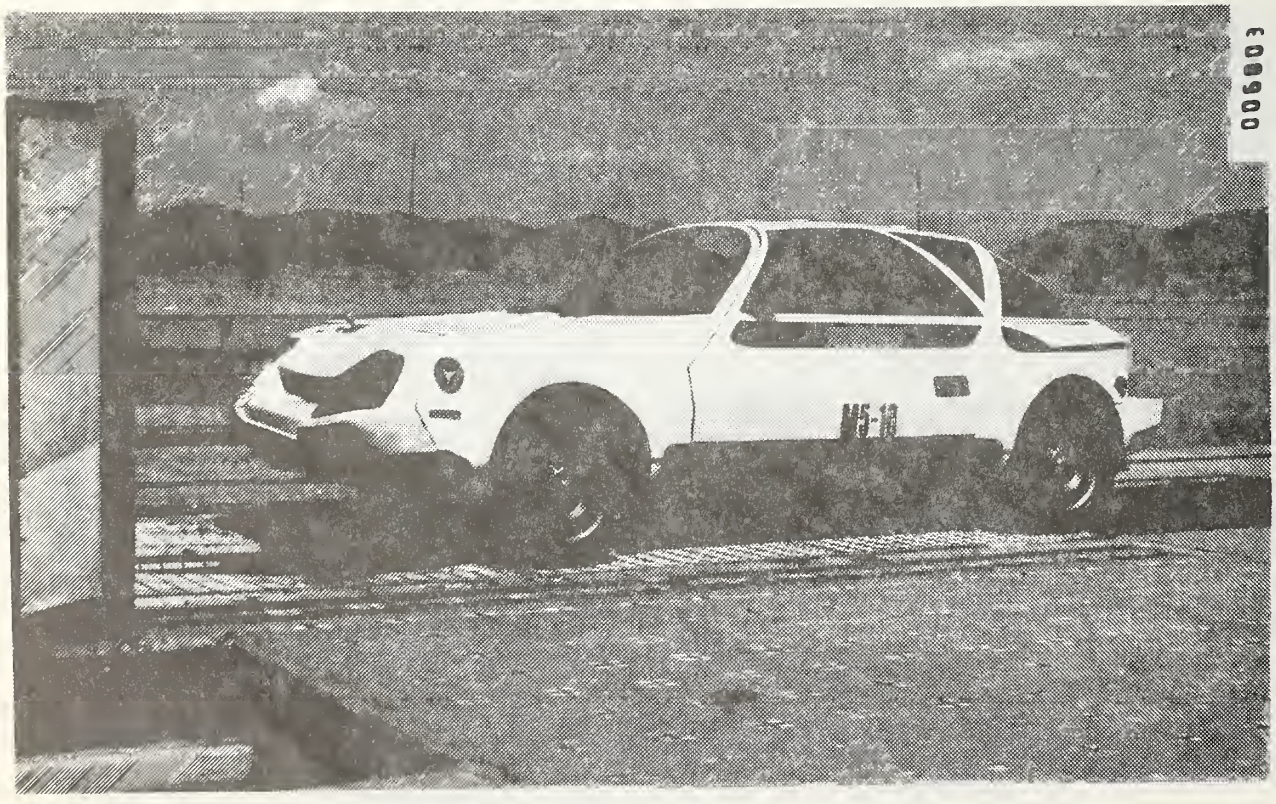


FIGURE C-25. POST-TEST NO. 7, OVERALL VIEW OF M5-10 VEHICLE.

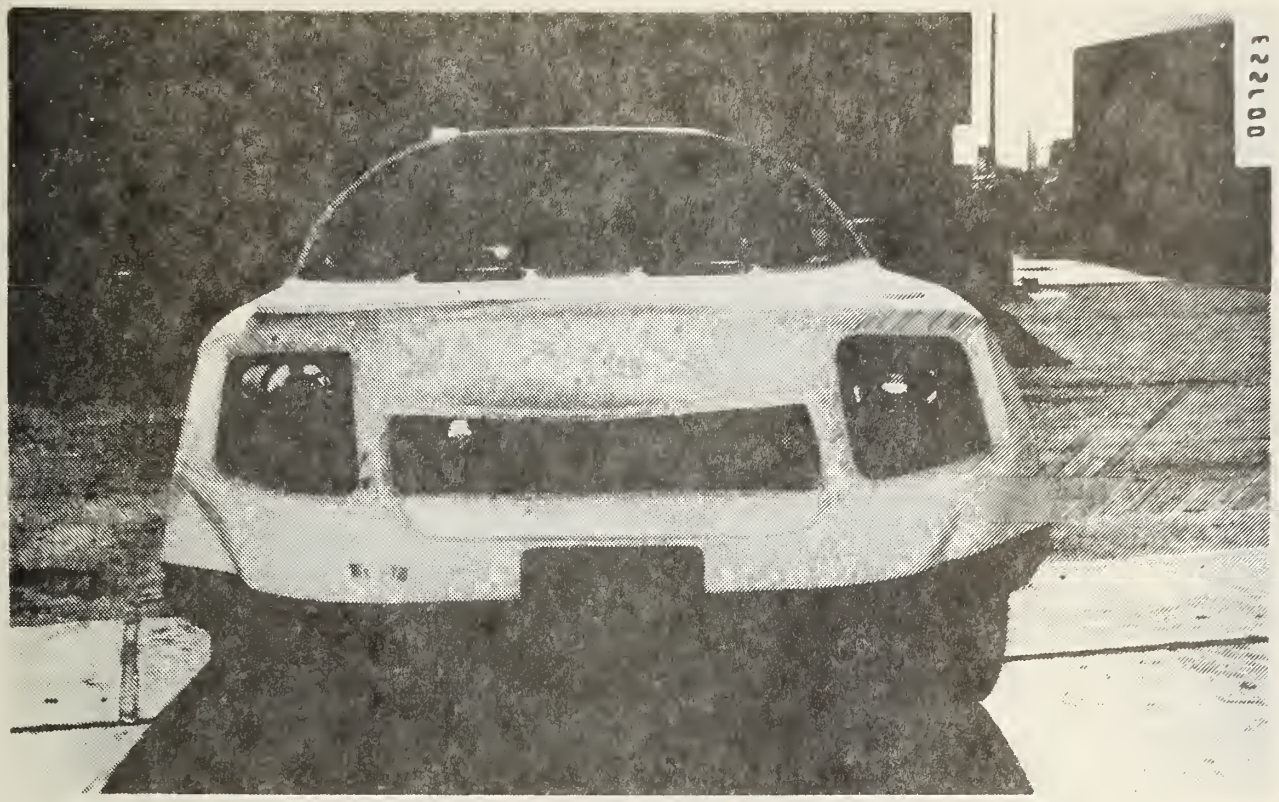


FIGURE C-26. POST-TEST NO. 7, FRONT VIEW OF M5-10 VEHICLE.

FIGURE C-27. POST-TEST NO. 7, LEFT SIDE HEADLIGHT - M5-10 VEHICLE.

FIGURE C-28. POST-TEST NO. 7, RIGHT SIDE HEADLIGHT - M5-10 VEHICLE.

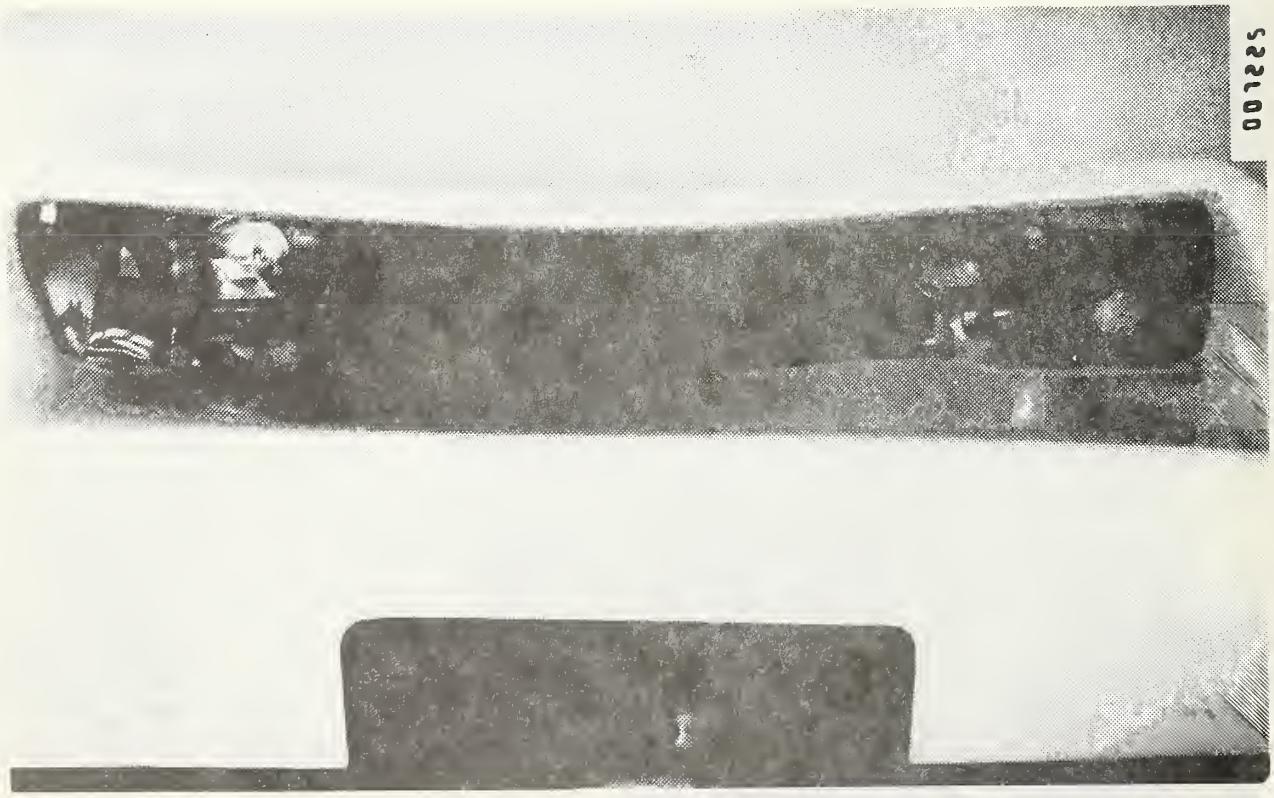


FIGURE C-29. POST-TEST NO. 7, TURN SIGNAL LAMPS AND MOUNTING FRAME - M5-10 VEHICLE.