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Eric F. Nordlin

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16. ABSTRACT

The results of a series of three full scale dynamic impact tests on wood post and timber pole sign supports are reported.

The first test (No. 151) of the series was performed on a 6" x 8" dimensioned wood post support using a 4540 lb. test vehicle at an impact speed of approximately 40 mph. The sign support for the second test (No. 152) was a Class 2 timber pole support with other test parameters similar to Test No. 151. In the final test (No. 153) a Class 2 pole support was modified by drilling three 4" diameter holes at 4u, 10" and 16" above the ground through the center of the pole parallel to the sign face. A 2000 lb. Volkswagen traveling at 40 mph was used as the test vehicle for this third test.

Test results indicate that wood posts and timber poles can be employed as accident safe supports for roadside signs provided their cross sectional areas near the ground line are within tolerable limits. Test results also indicate that a reduction in cross sectional area of a wood or timber sign support can be achieved with drilled holes parallel to the sign face as an effective method of reducing the impact resistance of the support without substantially altering its capacity to withstand the bending moments of design wind loadings.

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Testing, dynamic tests, sign structures, wood,
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# HIGHWAY RESEARCH REPORT

# DYNAMIC TESTS OF WOOD POST AND TIMBER POLE SIGN SUPPORTS SERIES XV

STATE OF CALIFORNIA

TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

NO. M & R 636398

Prepared in Cooperation with the U.S. Department of Transportation, Bureau of Public Roads December, 1967

STATE OF CALIFORNIA—TRANSPORTATION AGENCY
RONALD REAGAN, Governor

DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT
5900 FOLSOM BLVD., SACRAMENTO 95819



December - 1967
Final Report
No. M & R 636398

Mr. J. A. Legarra
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

DYNAMIC TESTS OF

WOOD POST AND TIMBER POLE SUPPORTS FOR ROADSIDE SIGNS

SERIES XV

ERIC F. NORDLIN
Principal Investigator

WALLACE H. AMES and ROBERT N. FIELD
Co-Investigators

ASSISTED BY

J. J. Folsom
R. A. Pelkey

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

# ABSTRACT

REFERENCES: Nordlin, E. F., W. H. Ames, and R. N. Field, "Dynamic Tests of Wood Post and Timber Pole Supports for Roadside Signs, Series XV", State of California, Department of Public Works, Division of Highways, Materials and Research Department, Research Report No. 636398, December 1967.

ABSTRACT: The results of a series of three full scale dynamic impact tests on wood post and timber pole sign supports are reported.

The first test (No. 151) of the series was performed on a 6" x 8" dimensioned wood post support using a 4540 lb. test vehicle at an impact speed of approximately 40 mph. The sign support for the second test (No. 152) was a Class 2 timber pole support with other test parameters similar to Test No. 151. In the final test (No. 153) a Class 2 pole support was modified by drilling three 4" diameter holes at 4", 10" and 16" above the ground through the center of the pole parallel to the sign face. A 2000 lb. Volkswagen traveling at 40 mph was used as the test vehicle for this third test.

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KEY WORDS: Testing, dynamic tests, sign structures, wood, wood structures, posts, poles, timber/structural/, breakaway.

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## I. INTRODUCTION

The use of large signs to provide for the increased sight distance requirements on today's high speed freeways has resulted in an additional safety hazard to the motoring public.

An analysis of accident statistics has revealed that the supporting members required for these large signs present lethal resistance to an impacting vehicle. Several methods have been tried, with varying degrees of success, to eliminate or minimize this hazard.

Until recently, the method most commonly employed was to provide protection from the sign structure by installing a guard rail (or a similar barrier system) between it and the traveled way. Although this generally proved effective in preventing collision with the sign support, damage resulting from impacting the protective barrier was, in many instances, more severe than would be experienced in impacting the sign post. Furthermore, short, unanchored sections of guard rail have proven to be entirely ineffective in redirecting an impacting vehicle traveling at high speed. Oftentimes this results in a more severe accident as the vehicle collides first with the guard rail, which it penetrates, and then the sign supports themselves.

Another corrective method employed, and by far the most effective, is to relocate the sign structure away from any location where the possibility of collision exists. California is following this procedure wherever practical, particularly in the more critical locations such as in gores at off ramps. The recently adopted "CURE" project[1] specifies that large ground mounted signs be located a minimum of 30 ft. from the edge of the traveled way. However, because of geometric considerations and highway alignment, this is not always possible, and it is necessary, in many instances, to position signing and lighting supports closer to the traveled way where collision is possible. Because of this, recent national efforts have been concentrated on the development of breakaway or impact attenuating support posts. The research conducted by the Texas Transportation Institute in developing several operational breakaway designs for steel sign supports[2] has been the most effective.

The present policy of the California Division of Highways for sign supports as outlined in Circular Letter No. 66-279 dated 12-30-66 is that "ground mounted signs up to approximately 90 square feet in panel area shall be mounted on dimensioned wood posts", and that "larger size panels shall generally be mounted on wide flange metal breakaway posts in urban or metropolitan areas and on treated timber poles in rural areas".

In September 1966 a research proposal was submitted to conduct impact tests to assist in: (1) developing design criteria for wood post or timber pole sign supports to be used when the sign size does not require the support of metal posts and the more expensive Texas breakaway system, and (2) determining the size of wood posts or timber poles which will result in no more vehicle damage than that observed with the Texas system. This study was proposed for inclusion in the 1966-67 Work Program HPR-1(4) as "Impact Tests on Wooden Sign Supports". The project was formally approved in November 1966 and was carried as Item D-04-66, Research.

This work was accomplished in cooperation with the United States Department of Transportation, Federal Highway Administration, Bureau of Public Roads. The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

## II. OBJECTIVE

The primary objective of this project was to conduct tests to assist in the development of design criteria for wood post and timber sign supports which would (1) establish the maximum allowable standard size support and (2) evaluate a breakaway concept for larger size supports by drilling holes through the post parallel with the sign face, thereby creating a weakened shear plane.

## III. CONCLUSIONS

The following conclusions are based on an analysis of the results of the testing performed in this study:

1. A 6" x 8" treated wood post sign support does not present excessive resistance when impacted by a standard size sedan. Vehicle damage and occupant deceleration rates can be expected to be within tolerable limits.

2. A Class 2 treated timber pole (approximately 11" dia. near ground line) sign support presents marginal resistance when impacted by a standard size sedan. Vehicle damage and occupant deceleration rates can be expected to be moderate to severe.

3. Modifying a Class 2 timber pole by drilling holes, as shown in Figure 2, will reduce its impact resistance to within tolerable limits, even when impacted by a lightweight rear engined foreign sedan. Static load tests and theoretical analysis indicate that the ability of a wood post or timber pole sign support to resist wind load bending moments is not significantly reduced by this modification.

# IV. DISCUSSION

## A. TEST INSTALLATION

The test site for this study was a portion of an unused airport runway (Exhibit 1). The runway is surfaced with a two inch thick asphalt pavement with no imported base material. To simulate a typical operation installation, the asphalt surfacing was removed from behind each wood post or timber pole support to be impacted for a minimum distance of 24 inches as shown in Figure 1 below.

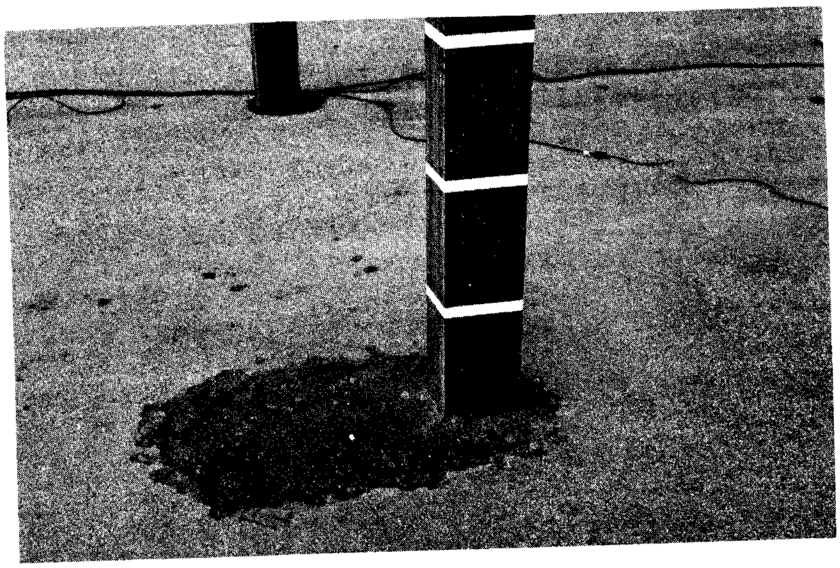


FIGURE 1

This allowed the impacted support to dynamically deflect horizontally on impact and transmit shear forces to the soil with no interference from the surrounding asphalt pavement.

For each test installation the sign supports were set in the ground in augered holes and backfilled with sand in accordance with Section 56-2.03 of the Division of Highways Standard Specifications. The depth of post embedment varied between tests dependent upon the size and type of post.

The sign panels used on the test supports were the California standard laminated panel design consisting of aluminum skin with paper honeycomb core. The signs all consisted of two panels joined horizontally with an aluminum closure strip. For Test 151 the one inch thick laminated panels were bolted directly to the 6" x 8" wood posts with four 3/8 - 16 x 12 inch bolts, cut washers and hex nuts per panel. For Tests 152 and 153, the 2½ inch thick laminated panels were attached directly to the Class 2 timber poles with four 3/8 x 6 inch galvanized lag bolts per panel, screwed through the panel and into the post.

B. <u>TEST PARAMETERS</u>

The test vehicles used in Tests 151 and 152 were 1964 Dodge sedans, weighing 4540 pounds with dummy and instrumentation. The left front door was removed for photographic documentation of the dummy's kinematics through impact.

For Test 153, the test vehicle was a 1961 Volkswagen sedan weighing 2000 pounds with dummy and instrumentation.

The impact speed for the vehicles in each of the tests was approximately 40 mph and the approach angle was 90 degrees normal to the sign face.

In general, the procedures taken to prepare, remotely control, and target the test vehicle were similar to those used in past test series and are detailed in previous California reports[3,4].

C. <u>INSTRUMENTATION</u>

Photographic and electro-mechanical instrumentation procedures and equipment employed in this test series were also similar to those used in past test series and are detailed in previous California reports[3,4]. The test site layout and camera data are shown in Exhibit 2.

A comparison of readings obtained from the "Impactograph" installed in the chest of the dummy driver during each of the three tests in this series is shown in Exhibit 3. The "Impactograph" recorder, utilizing mechanical stylus type accelerometers recording on a strip chart, is used to record the transverse, longitudinal and vertical decelerations during impact. The readings indicate <u>relative</u> impact intensities only and are not to be construed as actual "G" forces.

The recordings indicate deceleration rates for Test 151 of approximately a third those recorded for Test 152. This was expected because of the smaller cross sectional area of the nominal 6- by 8-in. wood post used in Test 151 (43 sq. in.) as compared to the Class 2 timber pole with a diameter of approximately 11 in. at ground elevation used in Test 152 (95 sq. in.). Both were impacted by the 4540 lb. Dodge sedan at approximately 40 mph.

Of particular interest is that, although in Test 153 the test vehicle was a 2000 pound Volkswagen as compared to the 4540 pound Dodge for Test 152, the magnitude of the deceleration recordings are relatively equal for the two tests. This indicates that reduction of the timber pole cross sectional area to approximately 51.8 sq. in. by drilling 4" diameter holes for Test 153, significantly reduced its impact capacity thus resulting in tolerable deceleration rates.

A tolerable limit for deceleration is generally considered to be less than 10 G's on the occupants, although larger forces are tolerable depending on the rate of onset and the time period over which they act.

## D. DESIGN AND PERFORMANCE

### 1. Structural Parameters

In order to evaluate the relative impact resistance of wood post and timber pole sign supports, the first two tests were conducted utilizing a standard size sedan and standard size supports.

At the inception of this project California policy permitted the use of 6" x 8" wood posts as supports for roadside signs up to 90 sq. ft. of area and timber poles as supports for roadside signs up to 265 sq. ft. of area. Therefore, the first impact test (No. 151) was conducted utilizing a 5' x 14' sign panel supported by two 6" x 8" dimensioned posts. The second test (No. 152) was conducted, utilizing a 10' x 20' sign supported with two Class 2 timber poles. In both tests a 4540 lb. test vehicle was impacted into the left sign support at a speed of approximately 40 mph.

Although the results of these first two tests indicated the impact resistance of these standard supports was not excessive and could generally be tolerated, Test 152 on the Class 2 timber pole produced results approaching marginal magnitudes. Analysis of the test results indicated that the impact severity observed in this test was about the maximum that could be tolerated. Therefore, it was decided that for Test 153 the Class 2 timber pole would be altered to produce a weakened shear plane which it was felt would substantially reduce the impact resistance to well within tolerable limits. Furthermore, to more critically evaluate this theory, a 1961 Volkswagen weighing 2000 lb. was used as the impacting vehicle. It was felt that the Volkswagen would test this modification under the more critical condition of impact by a lightweight, rear engined vehicle.

To produce this weakened plane, three 4" diameter holes were bored horizontally through the neutral axis of the Class 2 timber pole parallel to the sign face as detailed in Figure 2.

Theoretical calculations indicated that this 45.4% reduction in cross sectional area would significantly reduce the shear capacity of the pole without materially affecting its capacity to withstand tensile stresses resulting from wind loadings on the 10' x 20' sign it supported.

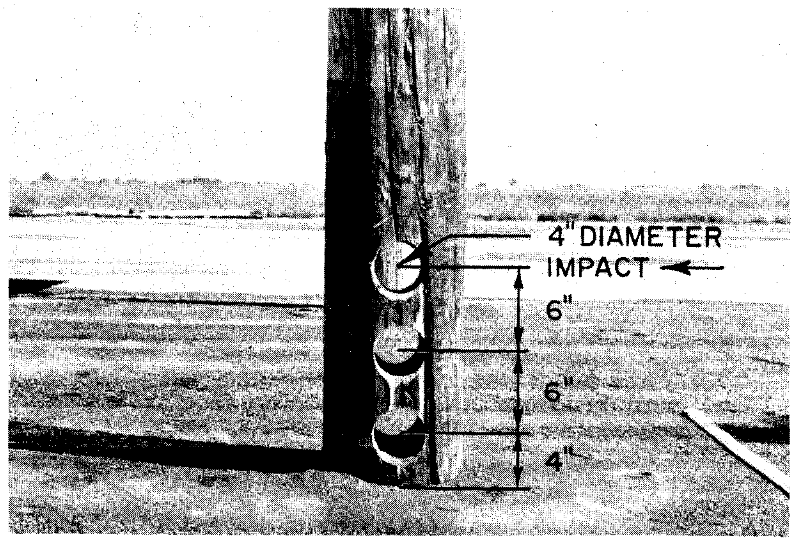



FIGURE 2

The results of the impact test indicated that this modification was effective in reducing the impact severity. However, analysis of the high speed data film of the impact and evaluation of the appearance of the fractured pole revealed that the type of failure which occurred in the pole was not what had been anticipated.

Prior to this test it was felt that failure would result primarily from excessive shear stress and produce a clean break through one of the weakened planes where the cross sectional area had been reduced. However, the high speed data film revealed that a beam type failure occurred with the wood material splitting between the holes, thus allowing vertical slippage. This let the two sides of the pole break independently of one another. Sequence pictures illustrating this failure are shown in Plate A, Test No. 153, of the Appendix. The appearance of the broken pole after impact is shown in Figure 3.

Although failure was not necessarily the result of excessive shear stress, this test did prove that this particular pole modification was effective in reducing the safety hazard presented by a Class 2 pole.

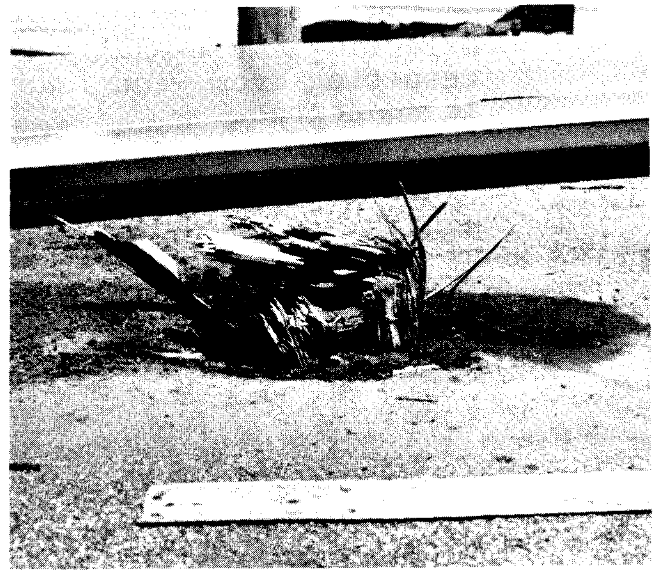


FIGURE 3

As a laboratory check of the theoretical effect a reduction in cross sectional area has on ultimate moment carrying capacity, six static load tests were performed on 8" x 8" x 6' D.F. posts. The cross sectional areas of two of the posts were reduced 30% by drilling a 2½" diameter hole through the post along its neutral axis. The remaining four posts were not altered. Third point loading, as shown in Figure 4 below, was used to minimize the effect of shear. Theoretically the middle one third of the beam will resist maximum moment and shear forces will be negligible.

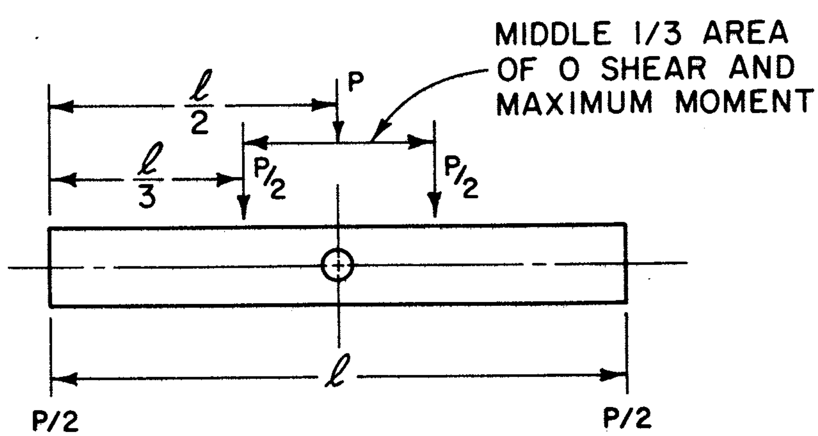



FIGURE 4

Table I lists the ultimate applied loads from the six static tests.

TABLE I

STATIC TEST RESULTS

| Sample Post No. | Ultimate Applied Load (Lbs.) |
|---|---|
| 1. Unmodified | 62,400 |
| 2. Unmodified | 54,100 |
| 3. Unmodified | 38,800 |
| 4. Unmodified | 34,600 |
| 5. Modified (w/2½"Ø hole) | 52,300 |
| 6. Modified (w/2½"Ø hole) | 51,300 |

These results, although inconclusive, do indicate that because of the unpredictable qualities and properties of wood, a greater reduction in moment carrying capacity can result from inherent flaws, such as checks and knots, than from a reduction in cross sectional area by the drilling of holes.

On this basis it appears that the drilling of holes in wood sign supports can be recommended as a method of reducing impact resistance without significantly reducing its sign supporting capacity.

2. Test No. 151

The installation for Test 151 consisted of a 5 ft. x 14 ft. (70 sq. ft.), two panel, 1 inch thick laminated sign mounted on 6 in. x 8 in. treated D.F. posts (Exhibit 1). The post embedment was 6 ft. with a compacted sand backfill.

The purpose of this test was to determine the severity of vehicle damage and occupant injuries when impacting this standard maximum size wood post sign support. This size post is the largest currently specified for use with ground mounted sign panels up to 90 sq. ft.

The radio controlled test vehicle impacted "head-on" into the 6" face of the left support post (the test post) at a speed of 38 mph. The vehicle exit speed was 38 mph, and its line of travel was not altered by the impact.

The impacted post sheared at ground level and was propelled upward and to the right by the force of impact. The pole tore loose from the lower panel, pulling the mounting bolts through the sign panel, but remained attached to the upper panel which it twisted and bent as it swung in an arc down and to the right of the right support post. Neither sign panel could be salvaged.

Data film and impactograph recordings of the dummy driver indicate low deceleration rates were induced. A "live" driver probably would have sustained injuries no more severe than bruises from this impact. The dummy driver was not restrained by a lap belt.

The vehicle sustained moderate front end damage.

It was concluded from this test that there would be little chance of severe occupant injury for a 40 mph head-on vehicle impact into a wood post smaller than 6" x 8" or a timber pole smaller than 7" in diameter at the ground line.

3. Test No. 152

For Test 152 the installation consisted of a 10 ft. x 20 ft. (200 sq. ft.) two-panel, 2½ inch thick laminated sign mounted on Class 2 untreated D.F. timber poles (Exhibit 1). The pole embedment was 9.5 ft. with a compacted sand backfill.

This timber pole is designated for use to support sign panels with areas from 170 to 215 sq. ft. The diameter of the test pole at ground line was approximately 11".

The decision to test this larger size pole was based on the relatively minor damage and low deceleration rates observed in the earlier test on the smaller 6 in. x 8 in. sign post.

The test vehicle impacted "head-on" into the left support pole (the test pole) at a speed of 40 mph. The vehicle exit speed was 36 mph, and its line of travel was not significantly altered by the crash.

Upon impact the pole broke off 11 in. below ground level and 24 in. above the ground. The upper 15 ft. section of pole tore loose from both sign panels, was flipped up and came down on the crash vehicle deforming the roof and shattering the rear window. The four lag bolts, attaching the sign panels to the pole, pulled out of the impacted pole without damaging the sign panels. The panels remained attached to the right support pole and were used in the subsequent test without repairs.

A review of the high speed data film indicated that the pole failure resulted primarily from excessive bending stresses rather than from the direct shear force of the vehicle impact. See Test 152, Plate A of the Appendix.

Data film and impactograph recordings of the dummy driver indicate moderate deceleration rates were induced, particularly in the longitudinal and vertical directions. It is judged that a "live" driver would have sustained only minor injuries from this impact. The dummy driver was not restrained by a lap belt.

The vehicle sustained moderately severe front end sheet metal damage in addition to the aforementioned deformed roof and shattered rear window.

It was concluded that a medium to heavyweight vehicle colliding with a Class 2 timber pole in a manner similar to this test would generally result in tolerable deceleration rates and be a survivable accident. However, because the impact severity of this test did approach marginal magnitudes and the specific conditions of this test were probably less severe than would generally be expected under certain operational conditions, a reduction in impact resistance was considered desirable. It was therefore decided to attempt to reduce the impact resistance of the Class 2 timber pole to make it safer for all conditions of impact. It was considered essential, however, that this be accomplished without sacrificing the ability of the pole to withstand design wind loadings.

4. Test No. 153

The installation for Test 153 (Exhibit 1) was the same as for the previous test except the Class 2 timber pole had three 4-inch diameter holes drilled in it as described in Section D-1 of this report.

Although the primary objective of this test was to evaluate the effective reduction in impact resistance obtained from reducing the cross sectional area of the pole, the relationship between vehicle weight and deceleration rates was also under investigation. It was anticipated that a lightweight rear engine vehicle, such as the Volkswagen used in this test, would sustain lethal deceleration rates in an impact with a standard Class 2 pole. It was therefore felt that impacting this altered pole with a small vehicle would be a particularly critical test of this modification.

The test vehicle impacted "head-on" into the modified post, at a speed of 39 mph. The vehicle's exit speed was 27 mph. The vehicle was redirected approximately 5 degrees to the left, probably as the result of impact being approximately 1.5 ft. to the left of the vehicle center. The impacted pole fractured at the bottom hole approximately 2 in. above the ground and the section containing the three holes split in two and was crushed by the force of impact. The remaining 15 ft. of pole was kicked ahead and up, and it tore loose from the sign panels. Had the vehicle not been redirected slightly, it is probable that this section, as it fell, would have struck the vehicle top as in the previous test. The sign panels pulled loose from the other support post and fell to the ground directly below.

Data film and impactograph recordings of the dummy driver indicate that deceleration rates were approximately of the same magnitude as those observed in the previous test. This is felt to be significant when considering the substantial weight differential between the two vehicles. It is apparent that the drilled hole modification effectively reduced the impact resistance of the pole. A live driver would probably have sustained minor injuries from this impact.

For this test it was necessary to remove the dummy driver's lower legs to facilitate installation into the Volkswagen test vehicle. Without the lower legs, it was felt the dummy might "submarine" on impact, producing inaccurate longitudinal and vertical deceleration recordings. To prevent this, the dummy was secured in an upright sitting position with a conventional lap safety belt. Seat belts were not used in the first two tests of this series.

The vehicle sustained moderate front end and undercarriage damage with the left front wheel pushed back approximately 6" and the steering column 3". Repair costs were estimated at $250.

## E. OPERATIONAL CONSIDERATIONS

Reducing the cross sectional area of wood sign supports by drilling holes, as done for Test 153, appears to be an effective way of reducing the impact resistance of the support. The desired breakaway feature is produced yet the ability of the pole to withstand design wind loadings is not significantly altered. Therefore, as a result of this study, California is now specifying that holes be drilled in 6" x 8" dimensioned wooden sign supports and timber poles 7" in diameter and larger.

Until such time as operational information or additional full scale tests indicate a more efficient pattern, only two holes will be used as shown in Figure 5.

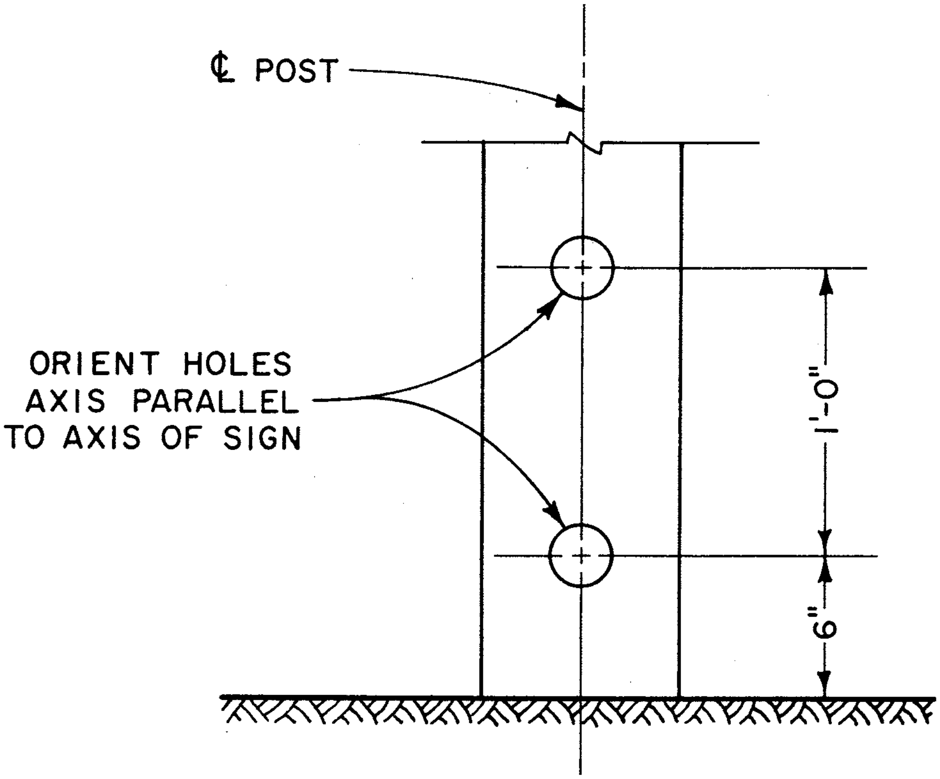



FIGURE 5

For 6" x 8" dimensioned posts 2½" dia. holes are recommended and for timber poles the hole dia. should conform to those listed in Table II below:

TABLE II

| Pole Diameter | Hole Dia. |
|---|---|
| Less than 7" | No hole |
| 7" to less than 8" | 2" Ø |
| 8" to less than 9" | 2½" Ø |
| 9" to less than 10½" | 3" Ø |
| 10½" to less than 12" | 3½" Ø |
| Over 12" | 4" Ø |

This limits the reduction in cross sectional area to approximately 40% of the gross area.

It is recommended that after drilling "breakaway holes" in wood supports of in-service signs, the holes be treated with a wood preservative. The suggested method is:

> "Except as noted below, the drilled holes shall be swabbed or sprayed with two applications of the preservative specified for the posts or poles. When the posts or poles have been treated with pentachlorophenol-liquefied petroleum gas solution, the preservative used for treatment of the holes shall be pentachlorophenol in heavy petroleum solvent conforming to AWPA Standard P9. Care shall be exercised to avoid staining the outside of the pole with the preservative."

At present there is some concern as to the relative influence that the number and spacing of the holes might have in producing the desired breakaway effect. For instance, the hole pattern used in Test 153 was effective in reducing the impact resistance of the pole, but this modification left only 2" of wood material between the adjacent holes.

There exists the possibility that with this closely spaced hole pattern the material between the holes might break out under severe or repeated wind loadings thus producing a 14" long slot. The reaction of a slot under loading is somewhat different than that of a hole in that it can produce a secondary tensile stress buildup which is a function of the slot length. These secondary stresses would be in addition to and would increase the over-all tensile stresses.

Conversely, there is the possibility that the suggested two hole pattern may not produce the desired breakaway effect or that it might be less effective than the results obtained in our test on the three hole pattern. A further consideration is that if the breakaway effect obtained in Test 153 was the result of the reduction of cross sectional area only, then thin horizontal slots may be even more effective than round holes. For this case there would also be less likelihood of introducing the secondary stresses referred to above.

It appears that additional testing might be advisable in the near future to clarify these suppositions unless operational experience and further consultation with other states using this concept proves it to be unnecessary.

## V. REFERENCES

1. Lang, R. K. and J. B. Derby, "Guidelines for CURE", California Division of Highways. August 1967.

2. Samson, C. H., Jr. et al, "Impact Behavior of Sign Supports", Texas Transportation Institute, Texas Highway Department. March 1965.

3. Field, R. N. and R. H. Prysock, "Dynamic Full Scale Impact Tests of Double Blocked-out Metal Beam Barriers and Metal Beam Guardrailing, Series X", California Division of Highways. February 1965.

4. Nordlin, E. F., R. N. Field, and R. P. Hackett, "Dynamic Full-Scale Impact Tests of Bridge Barrier Rails", California Department of Public Works, presented at 43rd Annual HRB Meeting. January 1964.

# VI. APPENDIX

The following groups of plates contain pertinent data and photographs of the impact tests discussed in this report. Each group covers the following:

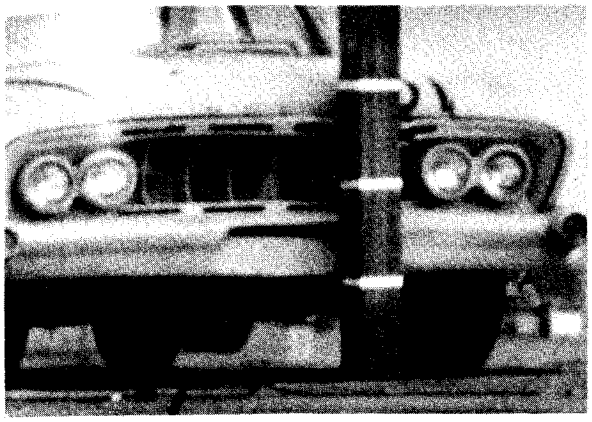
A. A data sheet showing panned camera view of vehicle through impact and a tabulation of test parameters.

B. A series of sequence pictures from the scaffold mounted camera.

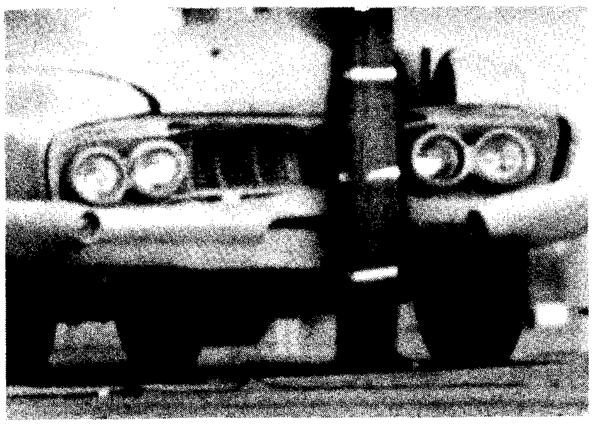
C. & D. Detail photographs of vehicle and sign installation damage.

Exhibits 1 through 3.

TEST 151 PLATE A



Impact



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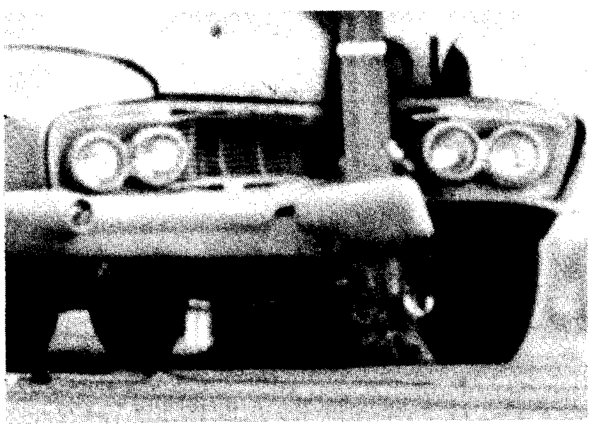

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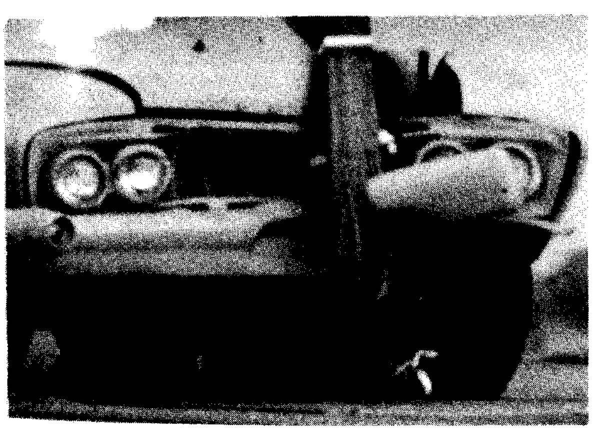
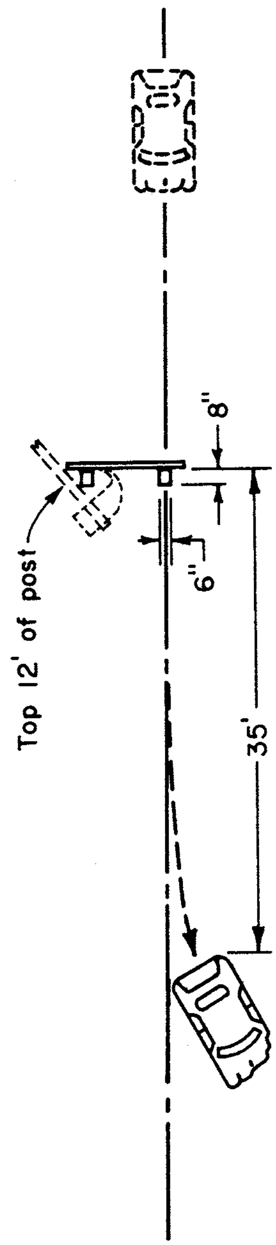
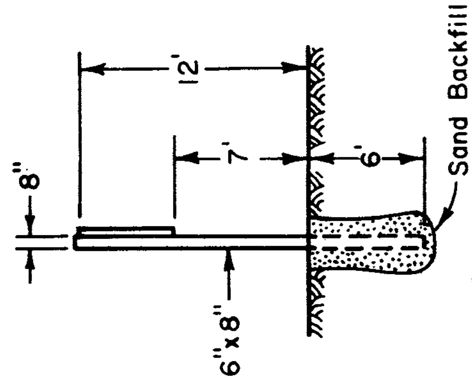


I + .110 Sec.

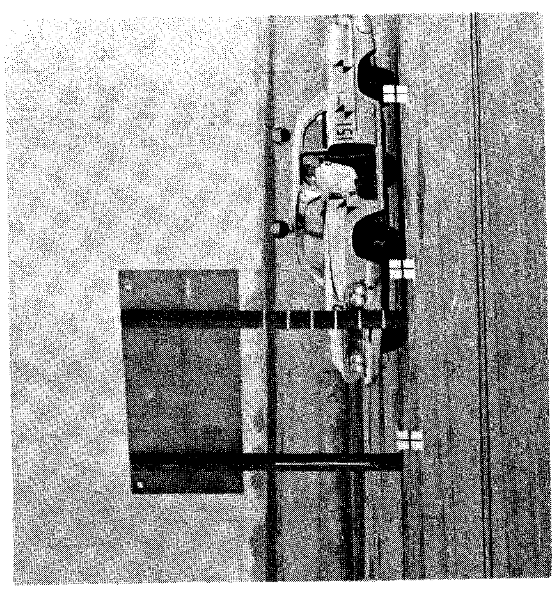


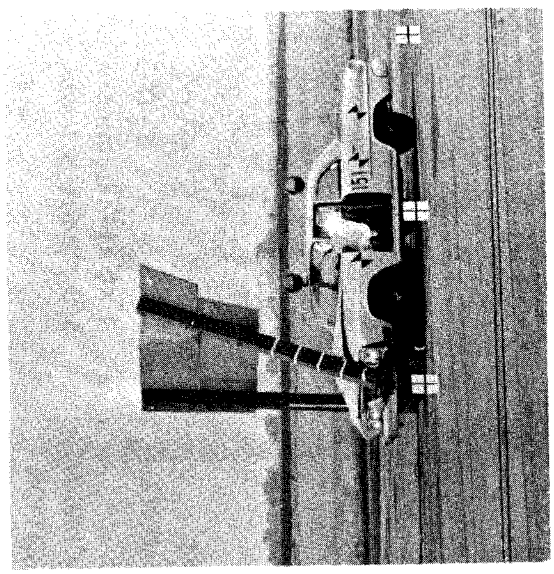

| | |
|---|---|
| POST | 6"x8"x18' D.F. |
| POST SPACING | 9'-0" |
| POST EMBEDMENT | 6'-0" |
| SIGN PANEL | 1"x5'x14' Laminar |
| PANEL ATTACHMENT | 3/8 Ø Bolts & Nuts |
| GROUND CONDITION | Dry |
| DUMMY RESTRAINT | None |

| | |
|---|---|
| TEST NO. | 151 |
| DATE | 11-10-66 |
| VEHICLE | 1964 Dodge Sedan |
| VEHICLE WEIGHT (W/DUMMY & INSTRUMENTATION) | 4540# |
| IMPACT SPEED | 38 mph |
| EXIT SPEED | 36 mph |

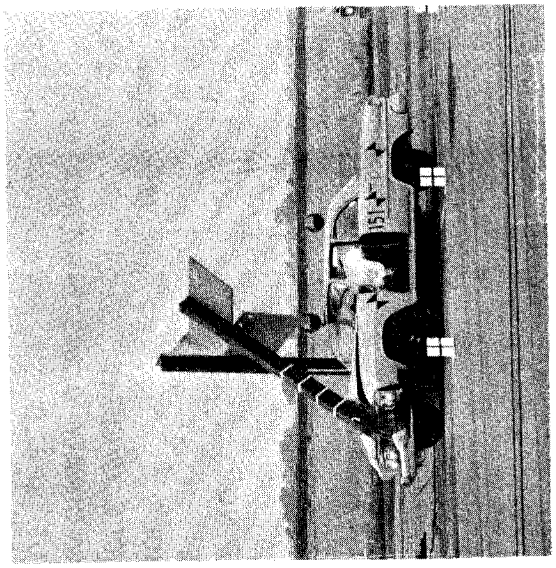
TEST 151 PLATE B



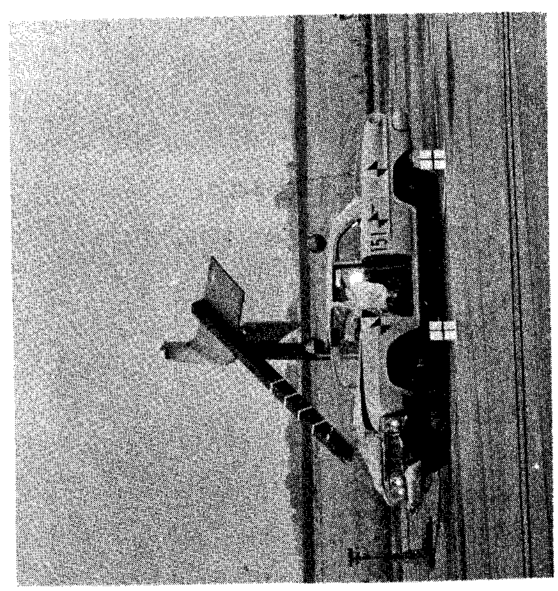
IMPACT



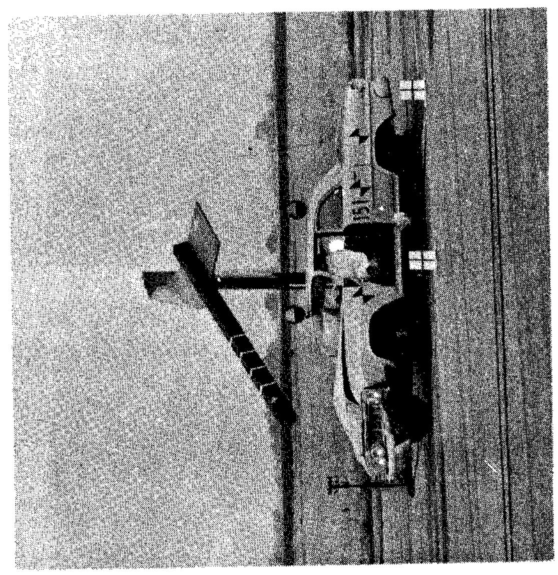
I + .10 Sec.



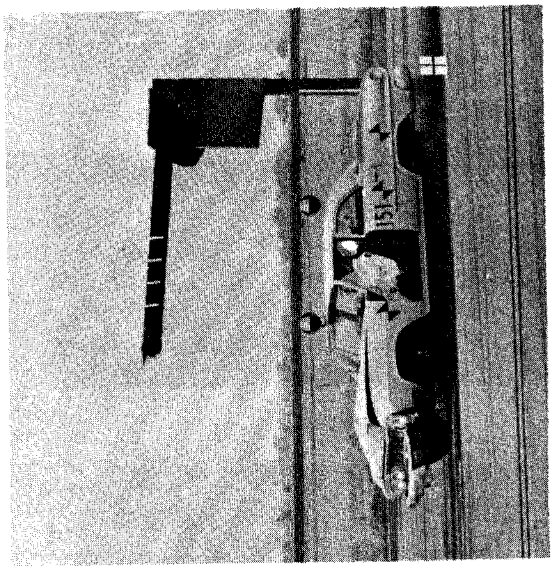
I + .20 Sec.



I + .30 Sec.

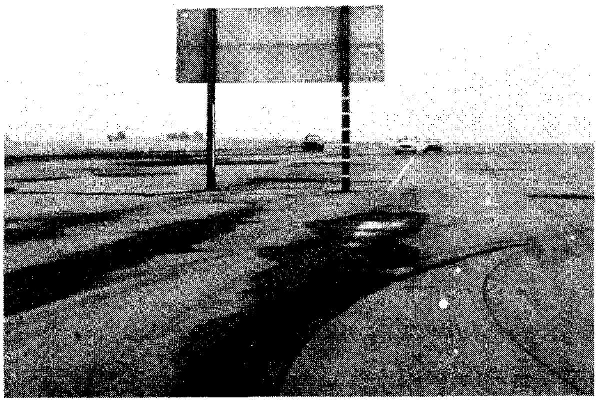


I + .40 Sec.

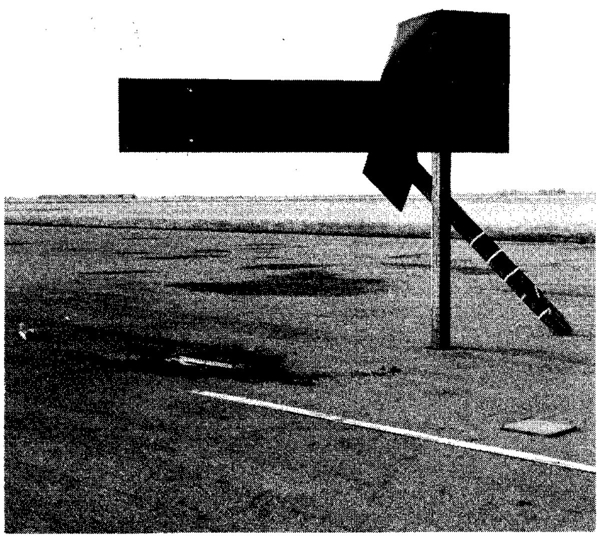


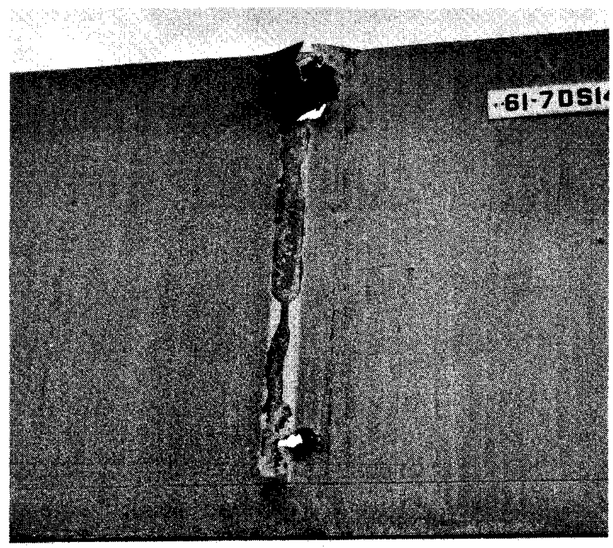
I + .50 Sec.

TEST 151 PLATE C

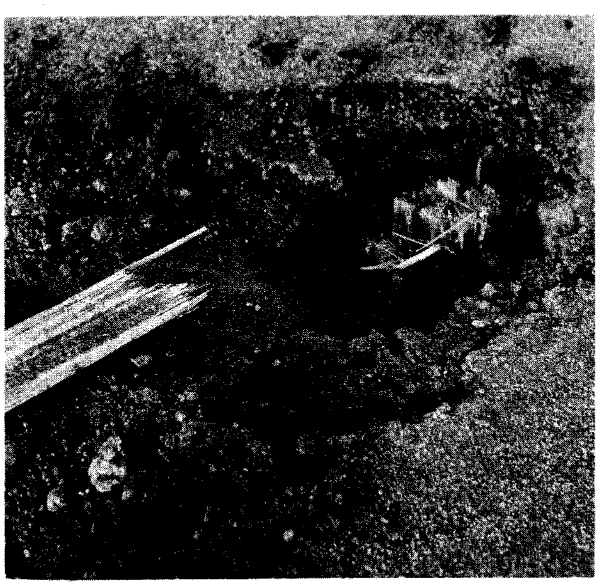


I + .40 Sec.



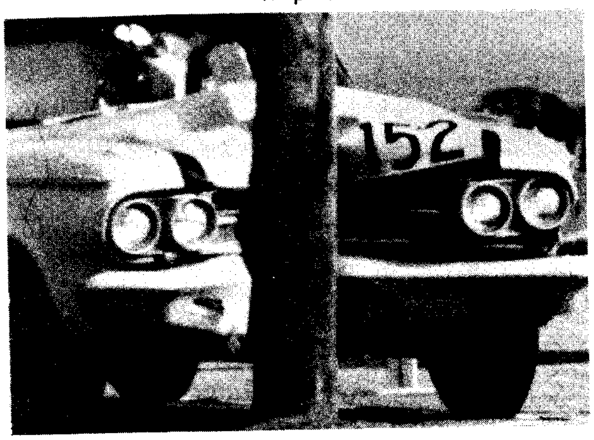


I + .30 Sec.



TEST 152 PLATE A

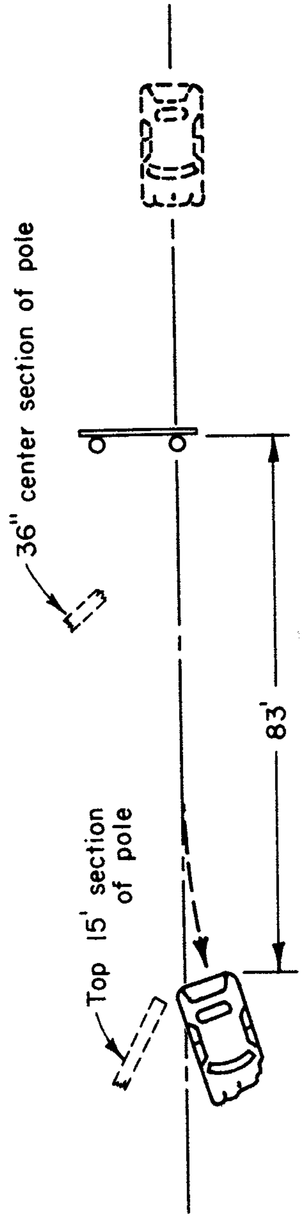
Impact



I + .024 Sec.

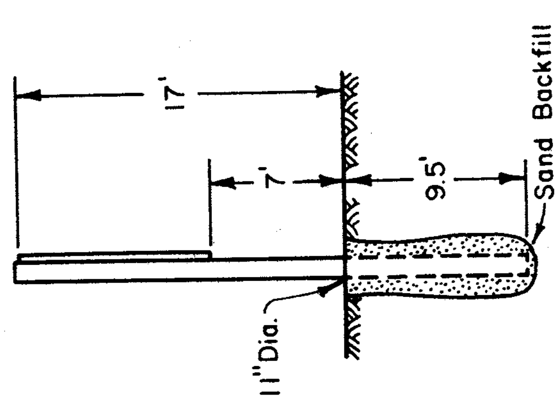
I + .053 Sec.

I + .082 Sec.

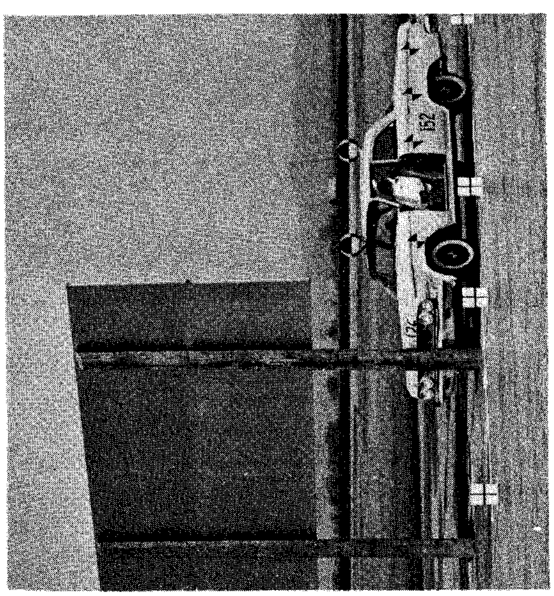



| | |
|---|---|
| POST | Class 2 D.F. Pole |
| POST SPACING | 12' |
| POST EMBEDMENT | 9.5' |
| SIGN PANEL | 2"x10'x20' Laminar |
| PANEL ATTACHMENT | 3/8" Lag Bolts |
| GROUND CONDITION | Dry |
| DUMMY RESTRAINT | None |

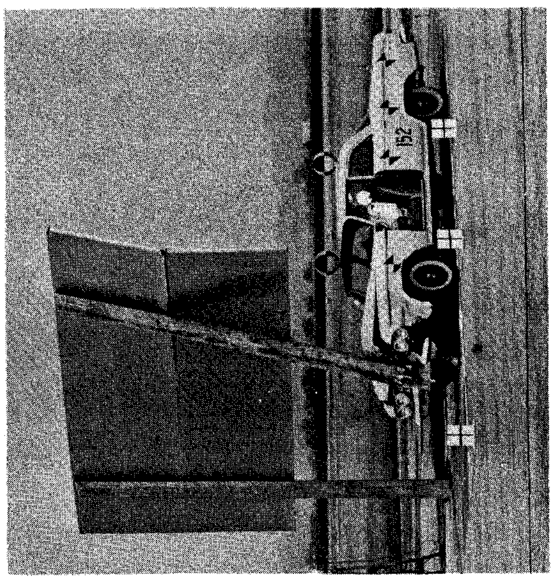
| | |
|---|---|
| TEST NO. | 152 |
| DATE | 5-16-67 |
| VEHICLE | 1964 Dodge Sedan |
| VEHICLE WEIGHT (W/DUMMY & INSTRUMENTATION) | 4540# |
| IMPACT SPEED | 40 mph |
| EXIT SPEED | 36 mph |



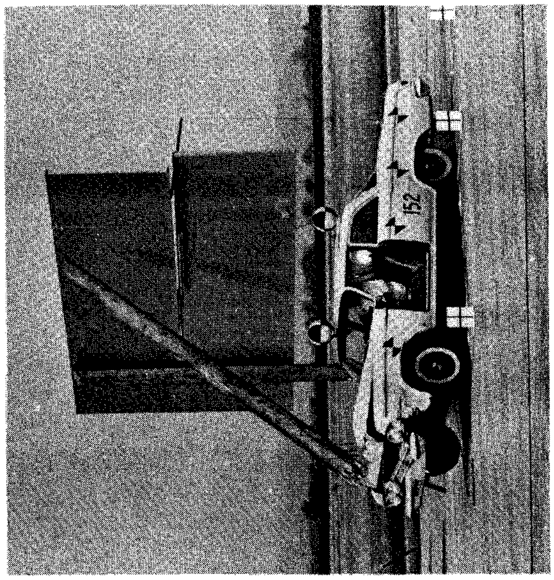
TEST 152 PLATE B



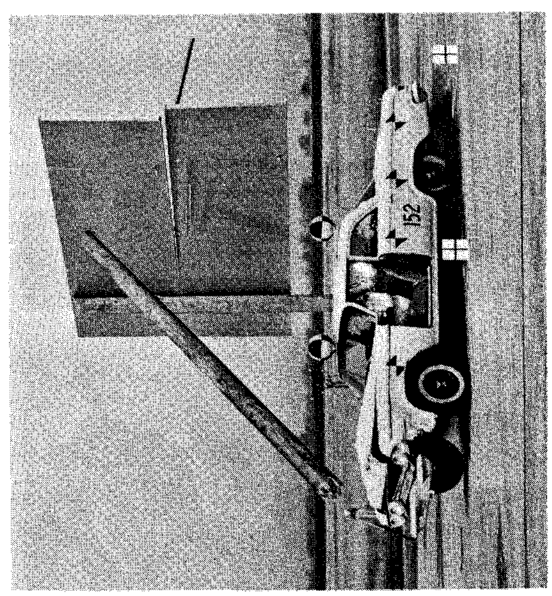
IMPACT



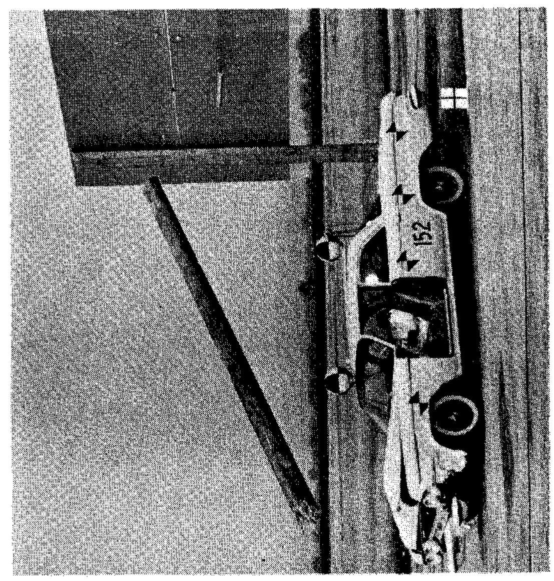
I + .10 Sec.



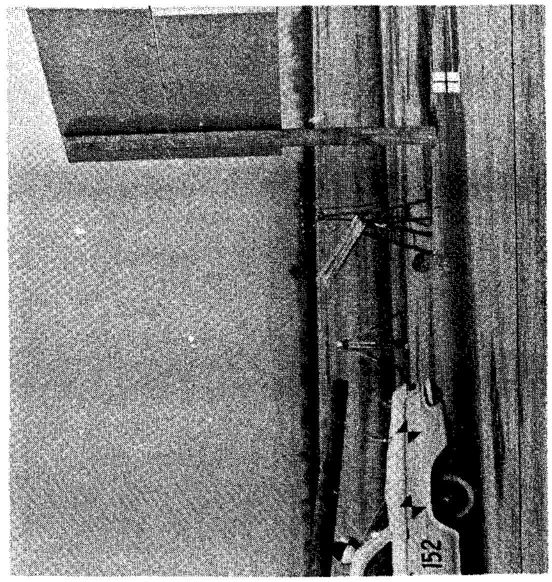
I + .35 Sec.



I + .45 Sec.



I + .60 Sec.



I + .80 Sec.

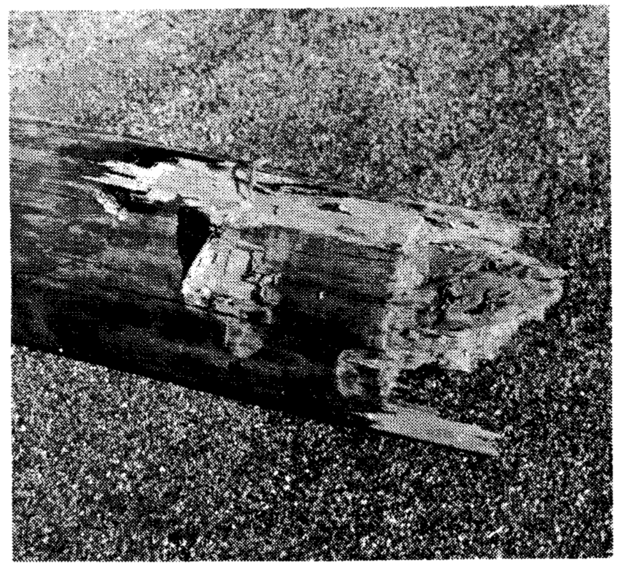
Sand Backfill

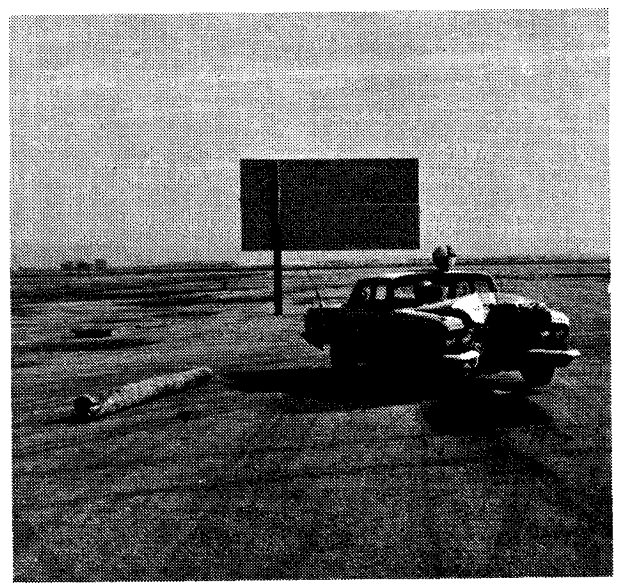
GROUND CONDITION

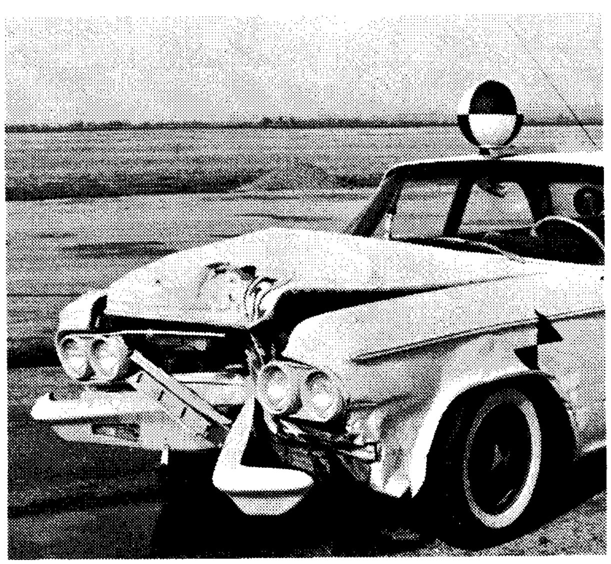
DUMMY RESTRAINT .......... None

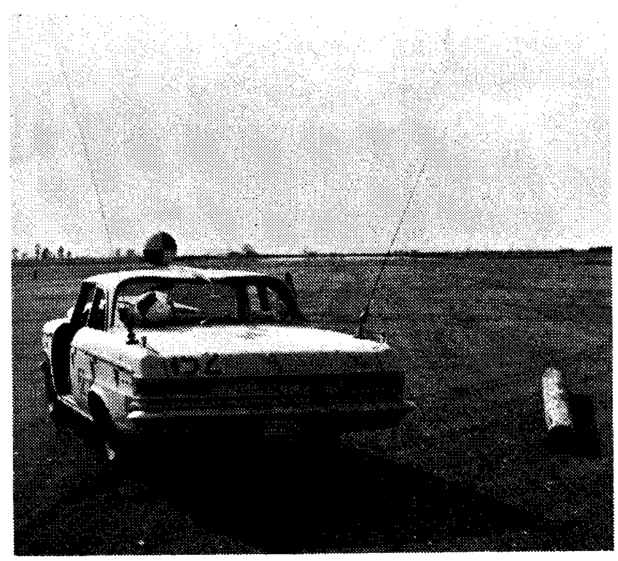
EXIT SPEED ..........

TEST 152 PLATE C

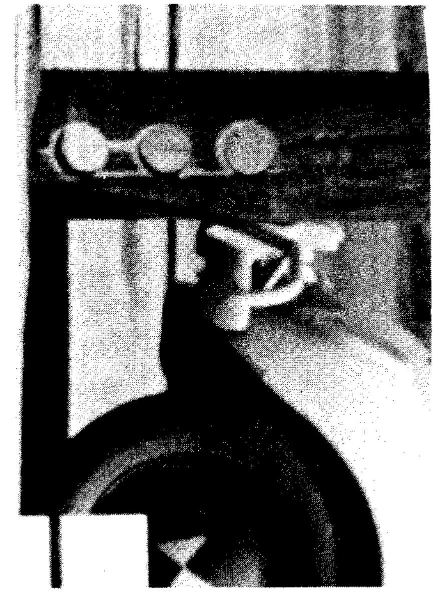




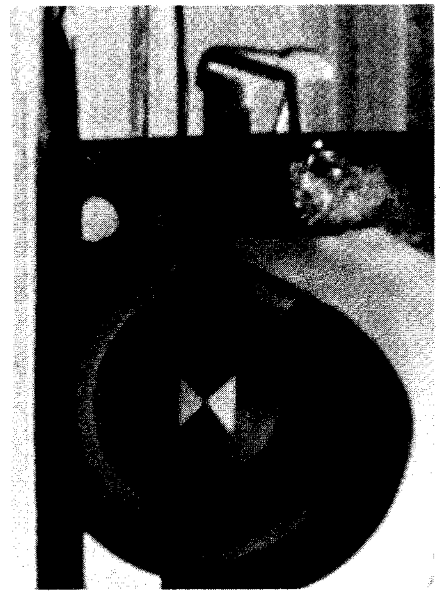




TEST 153 PLATE A



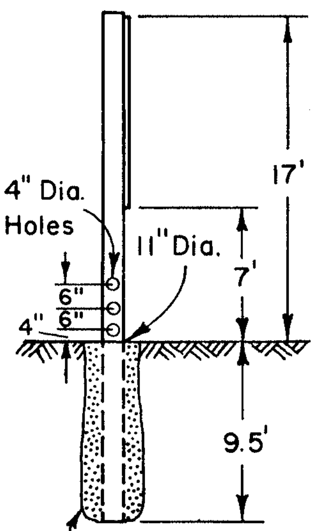
Impact

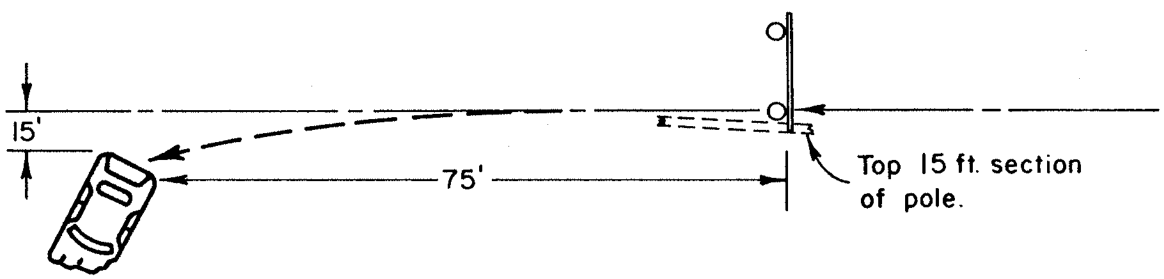


I+.026 Sec.

I+.053 Sec.

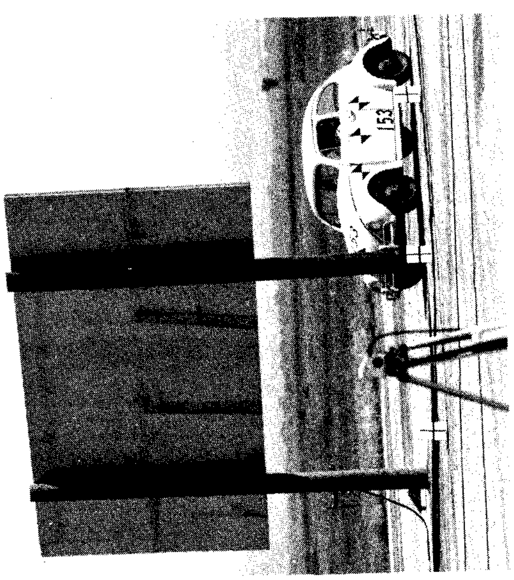
I+.079 Sec.



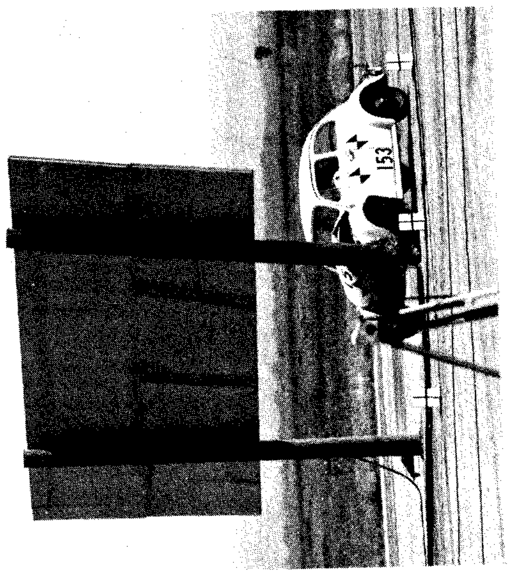




| | | | |
|---|---|---|---|
| POST | Modified Class 2 D. F. Pole | TEST NO. | 153 |
| POST SPACING | 12' | DATE | 5-13-67 |
| POST EMBEDMENT | 9.5' | VEHICLE | 1961 Volks Sedan |
| SIGN PANEL | 2"x 10'x 20' Laminar | VEHICLE WEIGHT (W/DUMMY & INSTRUMENTATION) | 2000# |
| PANEL ATTACHMENT | 3/8" Lag Bolts | | |
| GROUND CONDITION | Dry | IMPACT SPEED | 39 mph |
| DUMMY RESTRAINT | Lap Belt | EXIT SPEED | 27 mph |

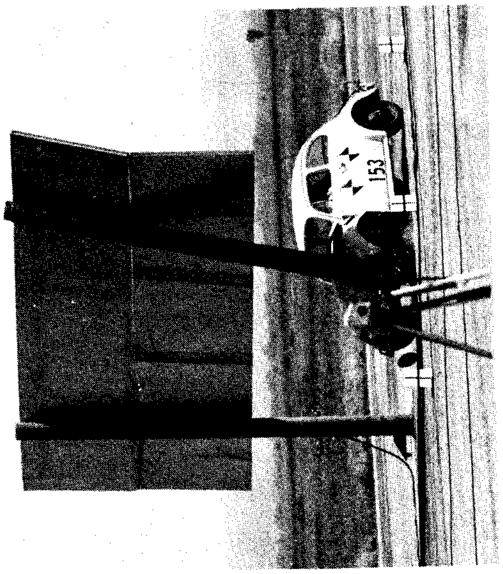
TEST 153 PLATE B



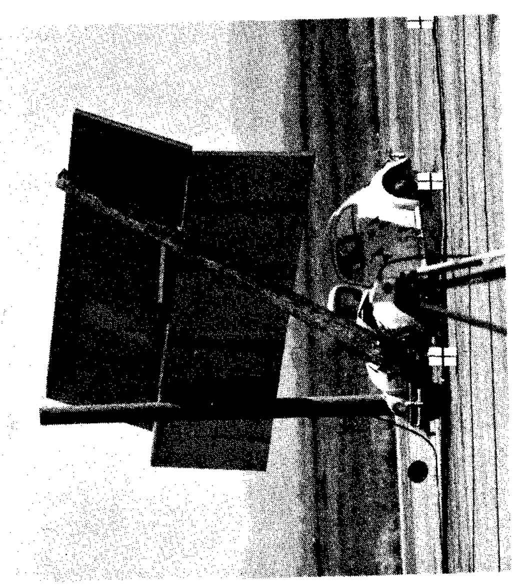

IMPACT



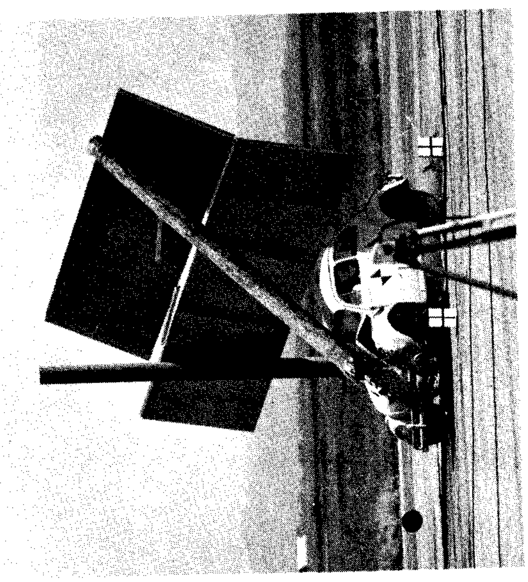

I + .10 Sec.



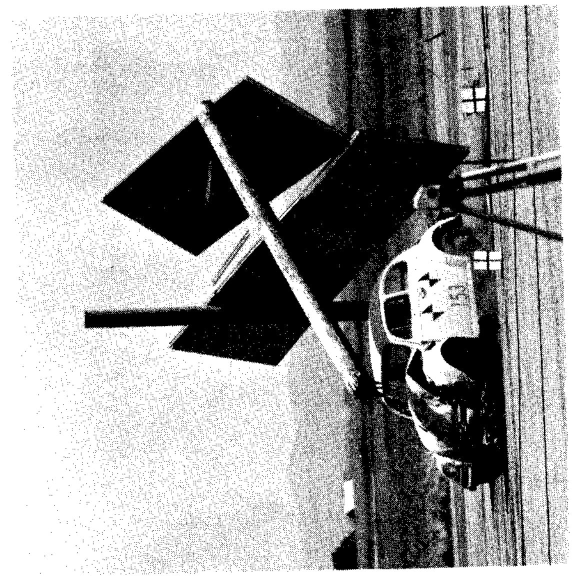

I + .15 Sec.



I + .30 Sec.



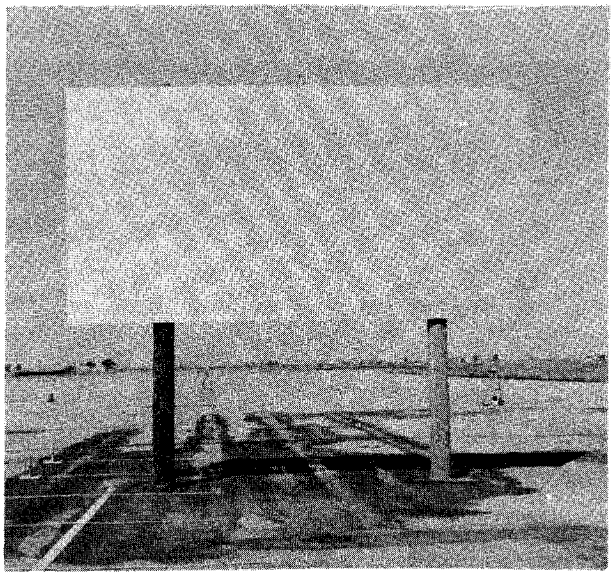
I + .40 Sec.

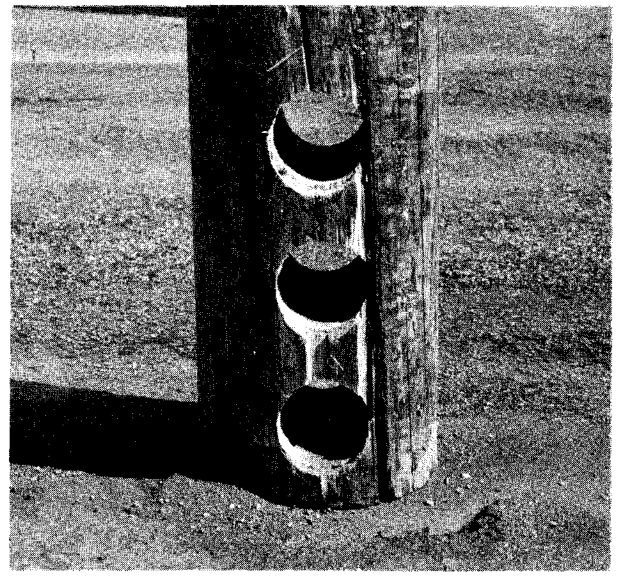



I + .55 Sec.

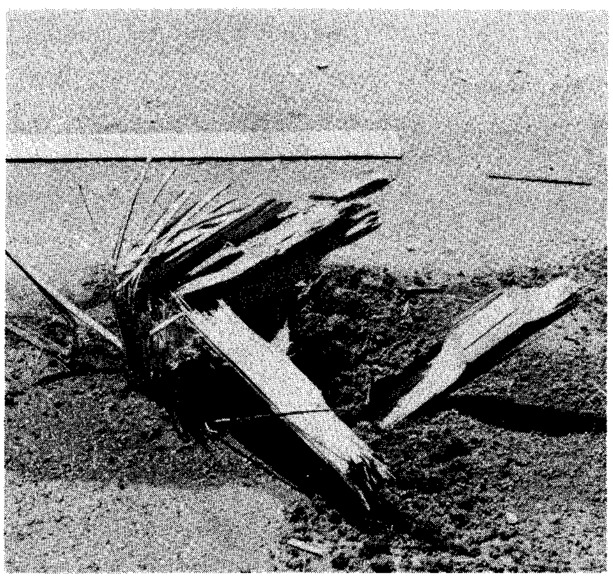
TEST 153 PLATE C

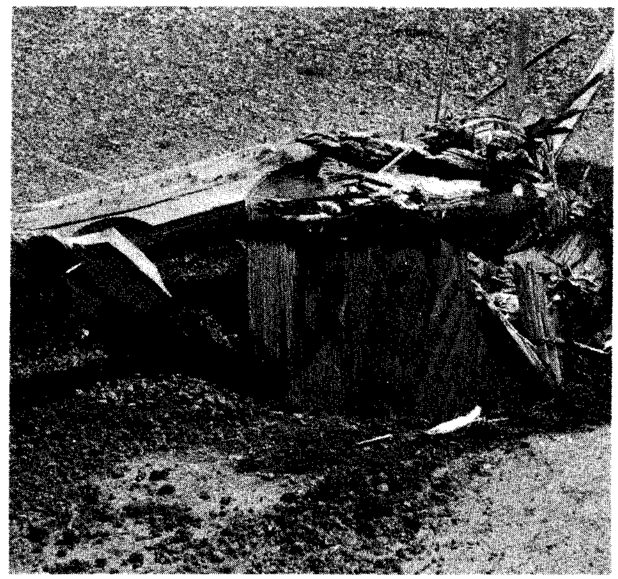
I + .55 Sec.





I + .40 Sec.





I + .30 Sec.

TEST 153 PLATE D

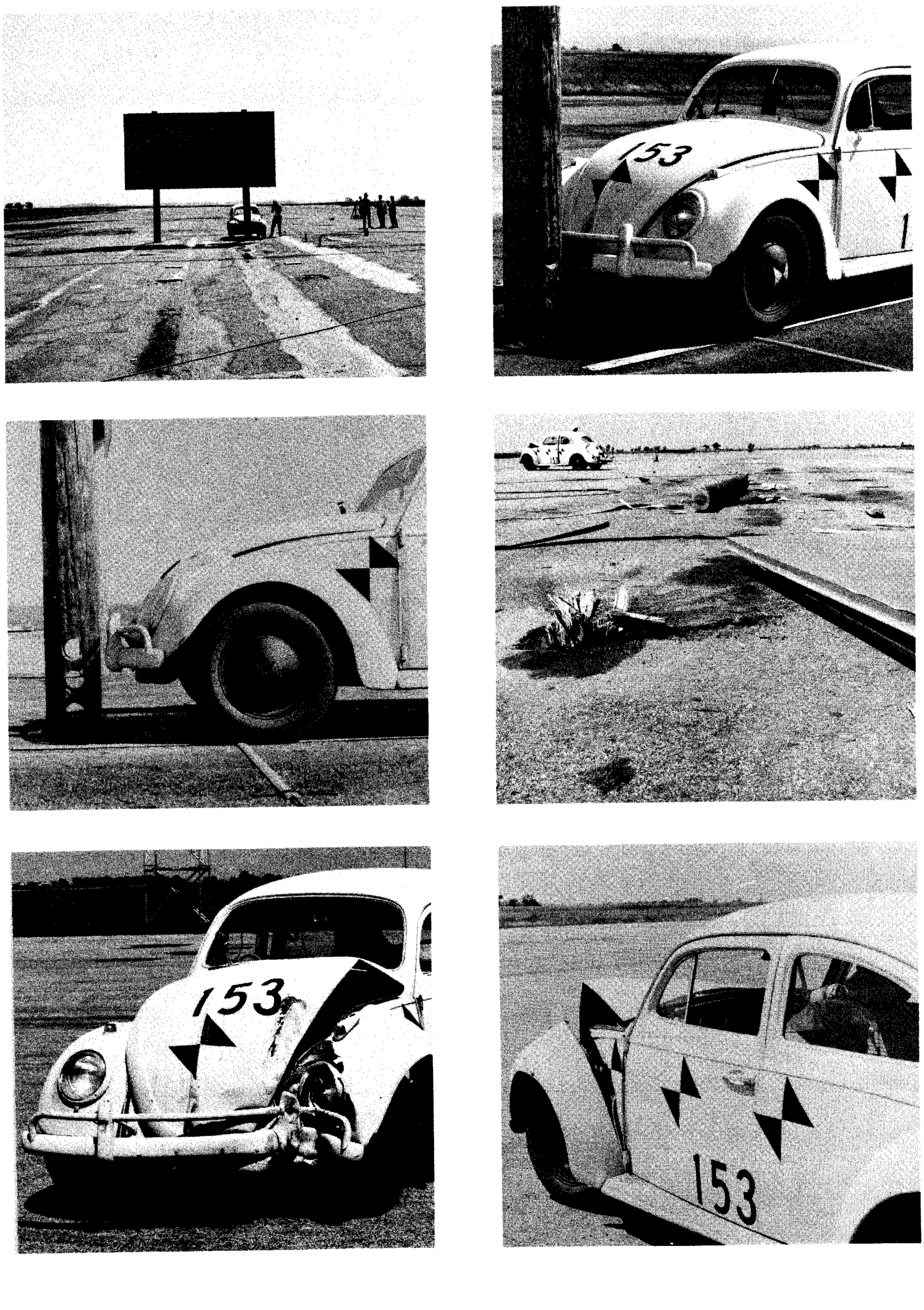
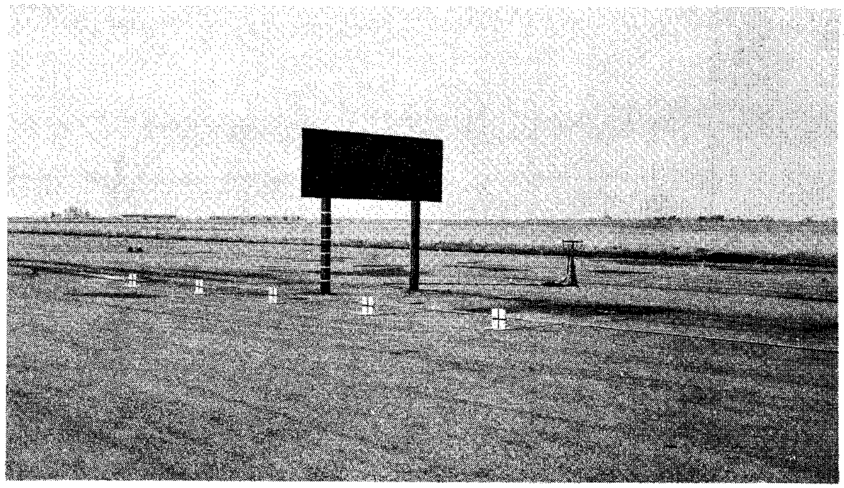
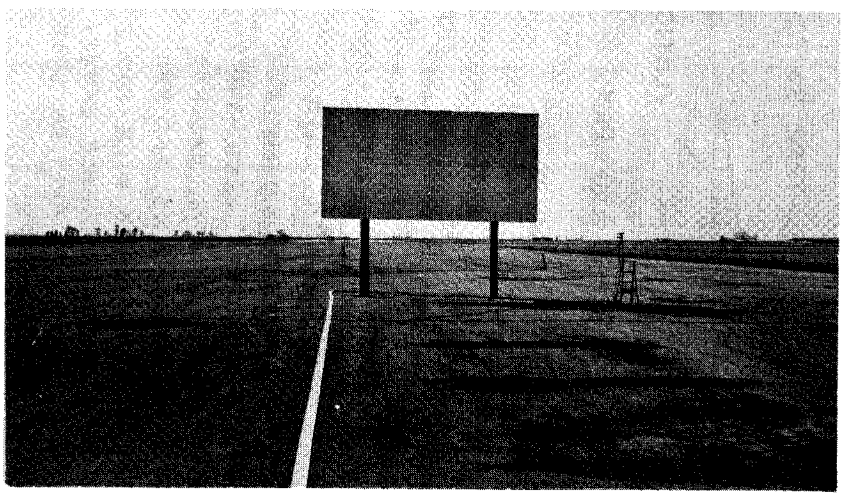


EXHIBIT 1

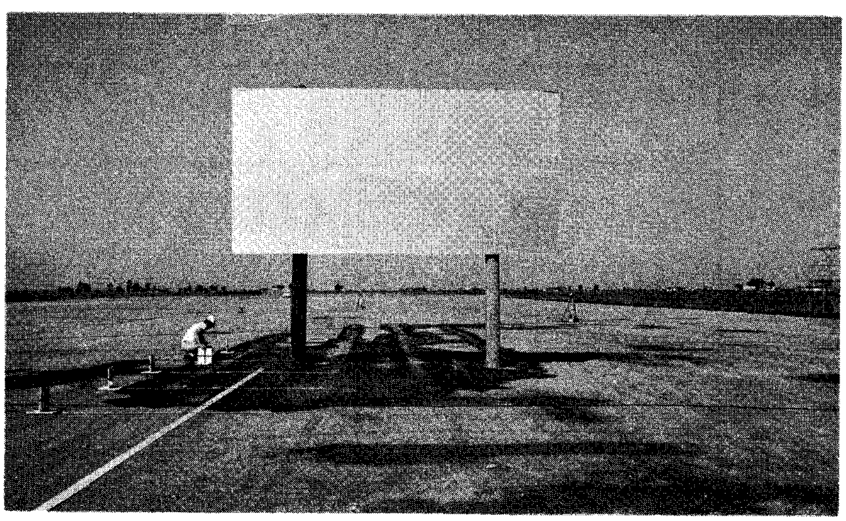
TEST SITE INSTALLATIONS



TEST NO. 151

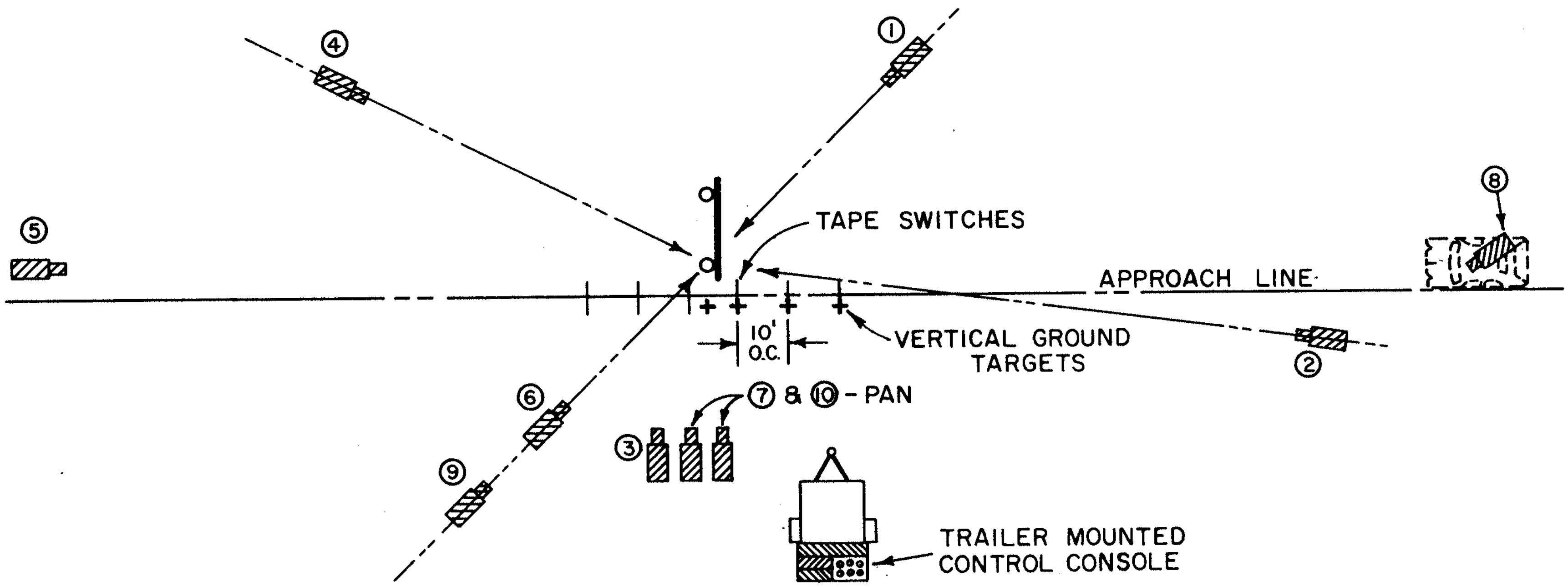


TEST NO. 152



TEST NO. 153

EXHIBIT 2




**CAMERA DATA**

①②③ PHOTO-SONICS, 13.0 MM LENS, 380 FPS,*
④⑤ PHOTO-SONICS, 4" LENS, 380 FPS.
⑥ PHOTO-SONIC, 2" LENS, 380 FPS.
⑦ PHOTO-SONIC, 2" LENS, 380 FPS.
⑧ PHOTO-SONIC, 5.3 MM WIDE ANGLE LENS, 200 FPS, INSIDE TEST CAR.
⑨ HULCHER, 70MM SEQUENCE CAMERA, 12" LENS, MOUNTED ABOUT 12' HIGH ON SCAFFOLD.
⑩ BOLEX, 1" LENS, 24 FPS.
* FRAMES PER SECOND.

PHOTOGRAPHIC INSTRUMENTATION PLAN

EXHIBIT 3

# COMPARISON OF IMPACTOGRAPH RESULTS