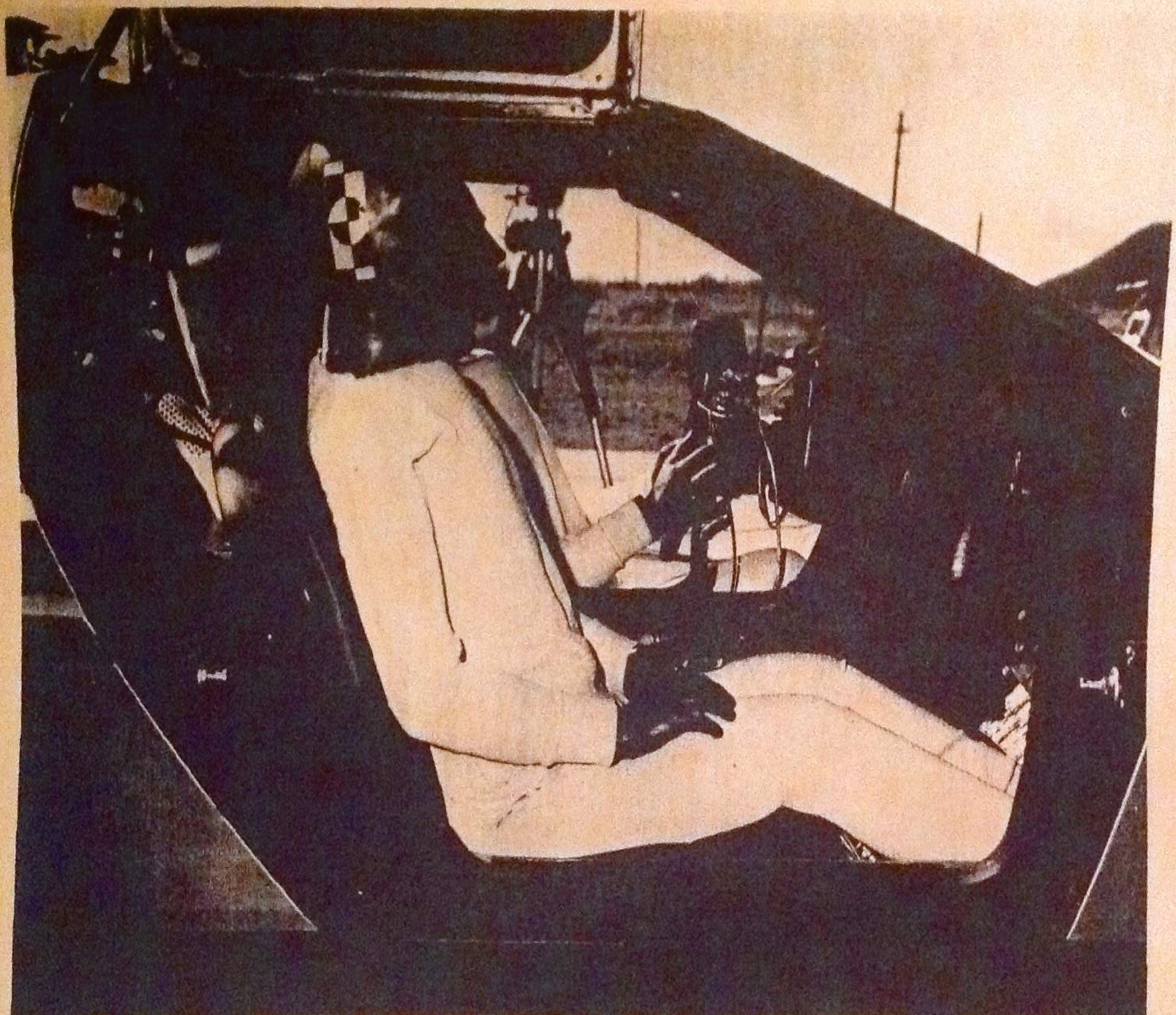
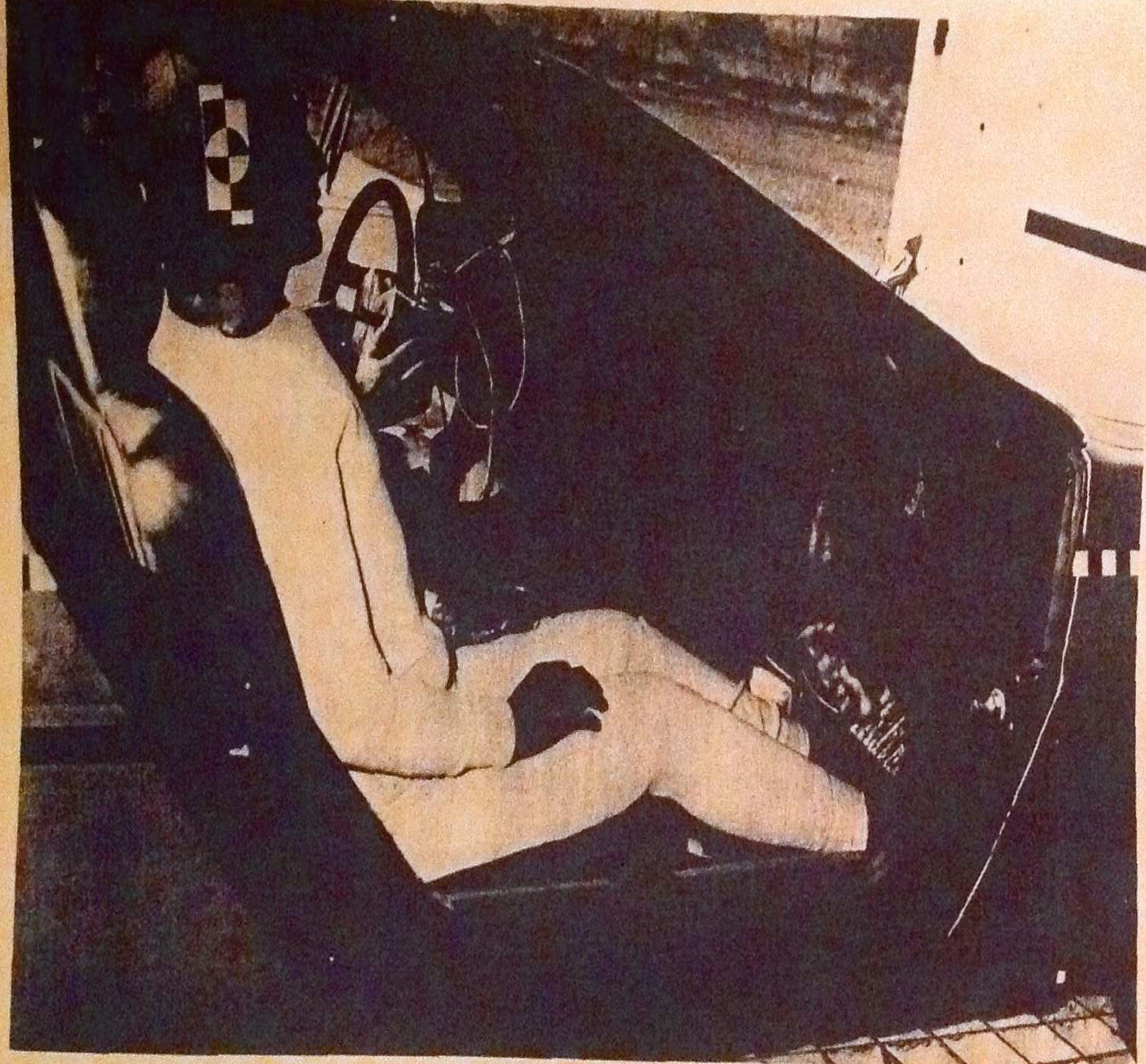


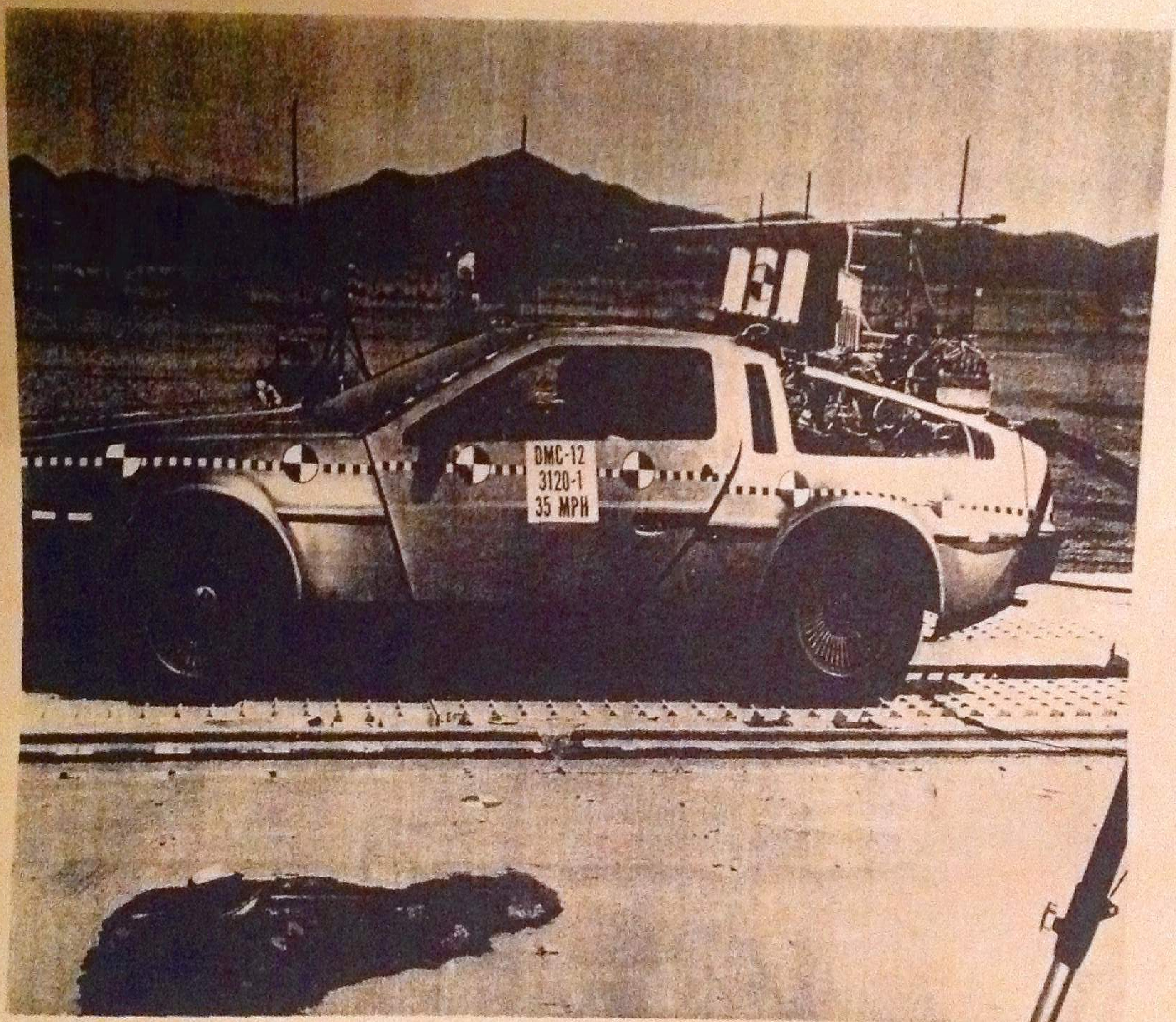
Test No. 1, Side View, Passnger Restraint System

Figure 19.



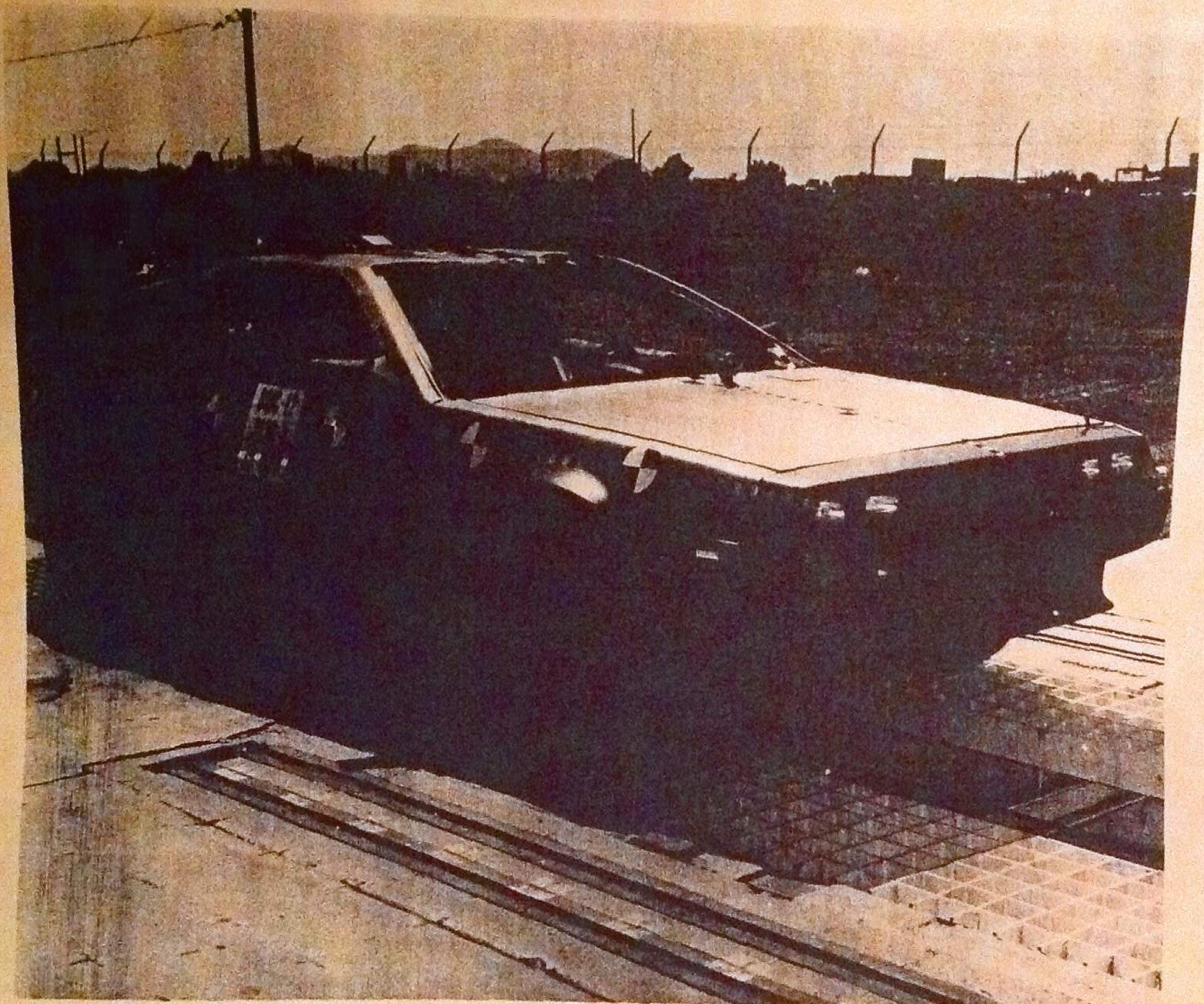
Test No. 1, 3/4 View, Passenger Restraint System

Figure 20.



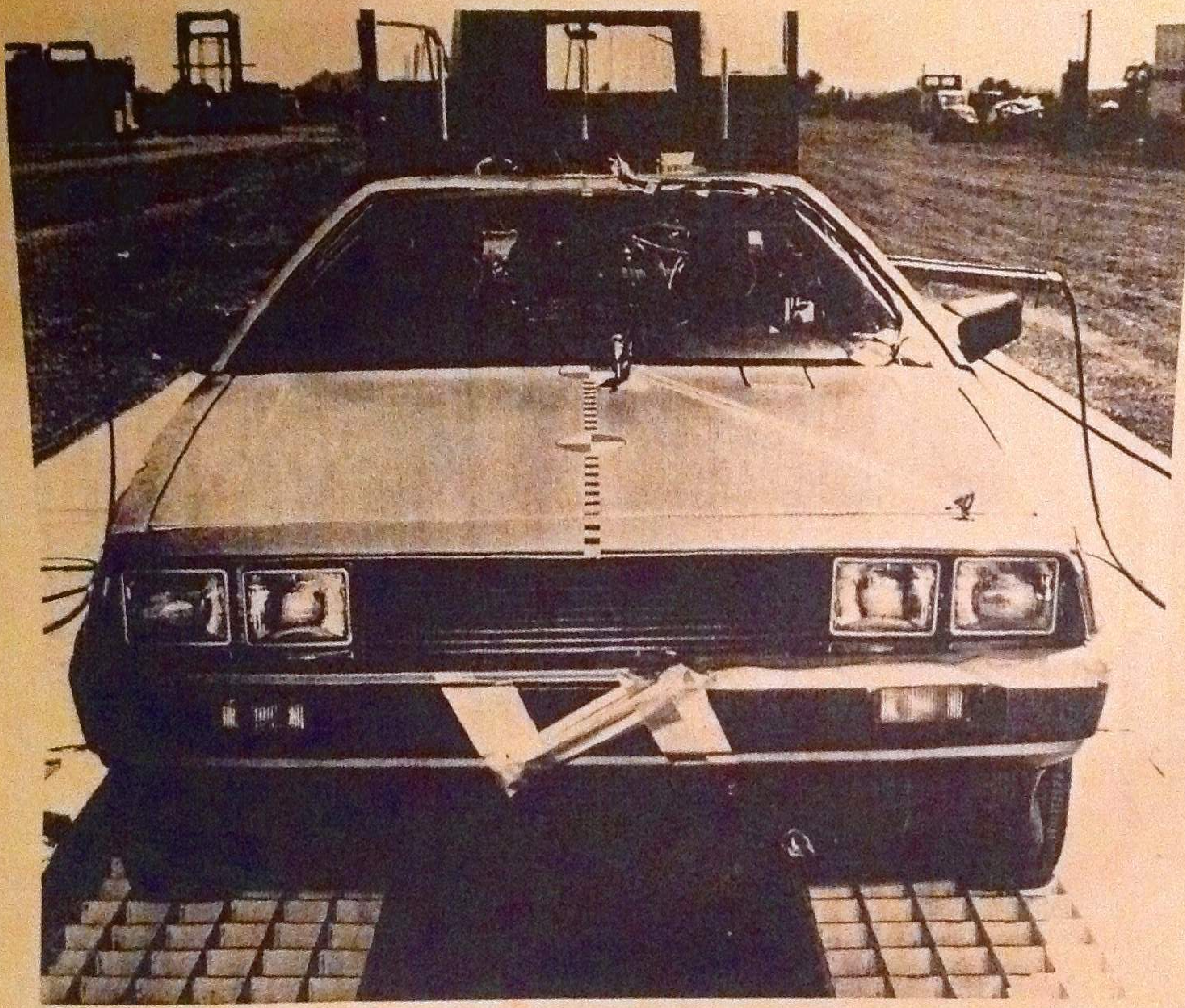
Test No.1, Side View of DeLorean

Figure 21.



Test No. 1, 3/4 View of DeLorean

Figure 22.



Test No. 1, Front View of Delorean

Figure 23.

DeLorean Crash Test No. 1

36 MPH Frontal Barrier Test

Injury Measure	Driver	Passenger	"208" Limit
HIC	404	371	1000
Peak Res. Chest G's (-3 msec.)	44	42.5	60
Femur Loads -Lbs			
Right:	1125	1050	2250
Left:	840	*1750(1220)	2250

As may be seen in the table, the injury measures for this first test are quite low being well below the injury criteria limits.

During this test the steering wheel crushed approximately two inches and the column rotated upward 10½ degrees from its initial angle of 14 degrees from horizontal. In addition, the intruding firewall crushed approximately two inches of the expanded mesh E/A unit of the column (Figure 6).

The onboard "piggyback" sensors which were monitored to determine firing time performed as shown in the table on the next page.

*Believed to be noise spike in data since tension in femur is indicated only one msec after this spike. Number in paranthesis is maximum value if line is drawn through average values of noisy data.

Sensor Type	Location	Firing Time
GM BID	Underneath, aft of radiator, at the junction of the two front frame forks.	47 msec
Bosch (3 ea. set for differ- firing times)	On tunnel between driver and passenger.	t_1 = 13 msec t_2 = 25.5 msec t_3 = 29.5 msec

As may be seen, the sensors will need to be adjusted somewhat to obtain the 10 and 17 msec sensing times desired based upon computer simulation.

Although the test results were very encouraging, especially since there had been no preliminary sled testing in which prelininary restraint tuning had been done, we noticed two areas in which we believed improvement was possible.

First, the driver "submarined" somewhat and, due to the non-stroking column used in this first test, his head was pushed rearward relative to the torso quite severely. Additionally, the driver H-point moved forward and then abruptly downward as the knees became imbedded in the knee restraint. This also contributed to the submarining tendency.

Second, the passenger moved to the outboard side of his air-bag, rotating in a counter-clockwise direction when viewed from above; i.e. so that he faced toward the driver somewhat.

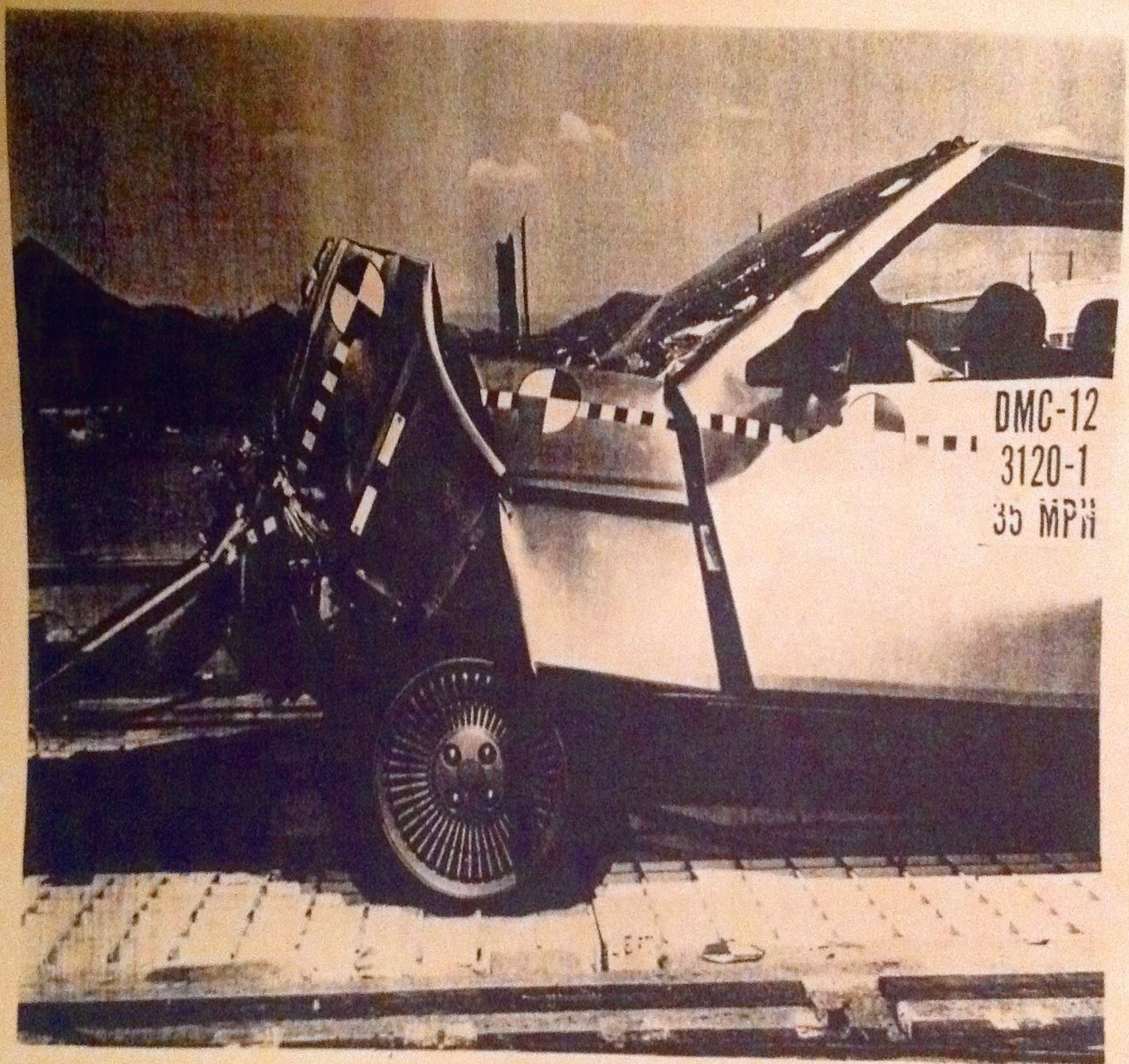
Upon investigation we decided that this rotation was due to the fact that the passenger's module pan containing the gas generators and the airbag were not pointing the airbag at the center of the passenger's chest but was, rather, pointing toward the passenger's left shoulder. The reason for this was that although the module pan was centered on the chest in the fore-aft direction, it was also canted to follow the dash contour thereby aiming the airbag toward the left shoulder.

To fix this prior to the next test, we merely rotated the module pan until its plane was perpendicular to the direction of vehicle travel. The effect of this rotation was that a line perpendicular to the center of the module pan now passed through the chest center.

Figures 24 through 34 show the vehicle, dummies and restraint systems following the crash. There was only light-to-moderate structural intrusion into the passenger compartment and, what little there was, was confined to the lower firewall and toeboard areas.

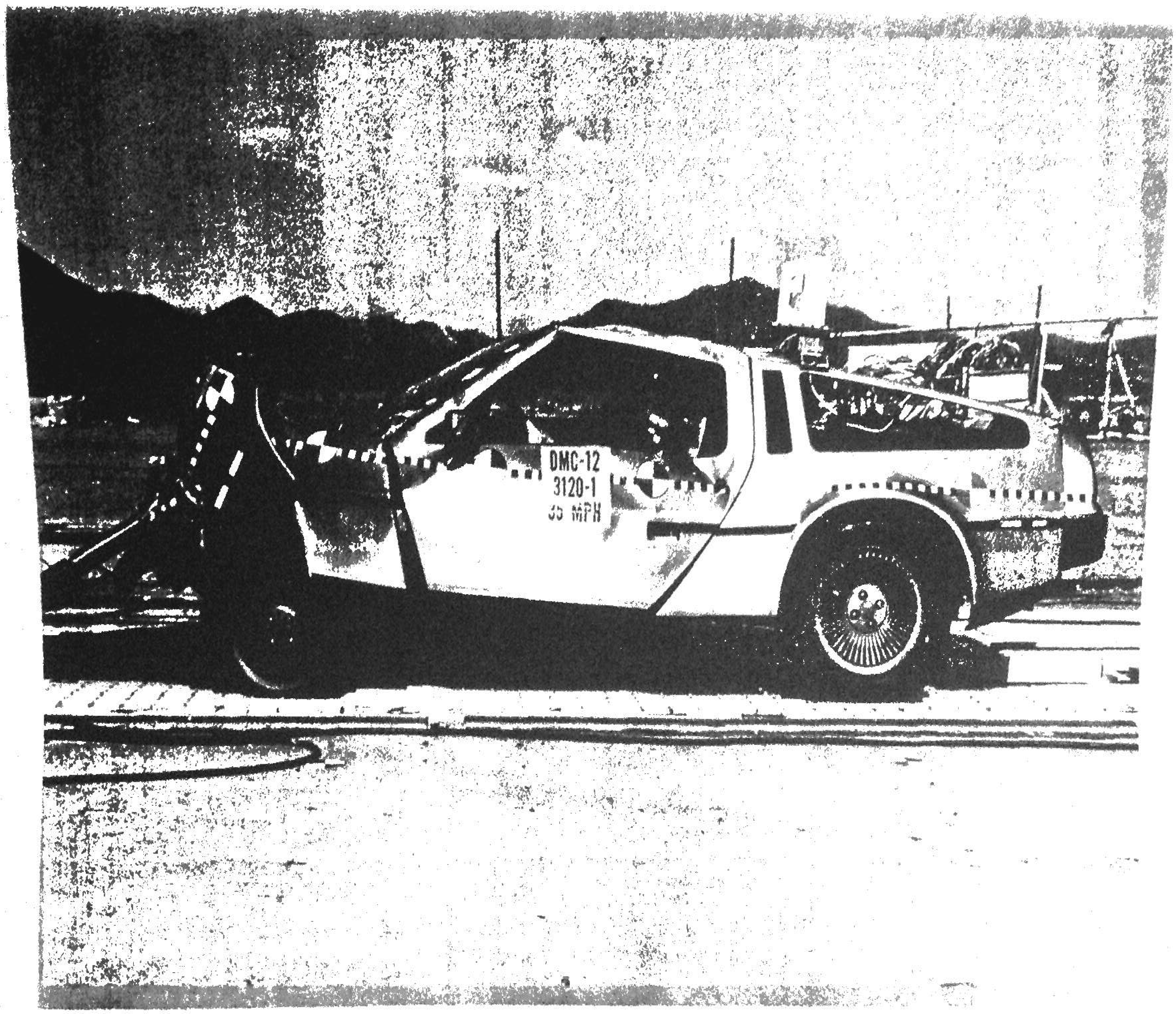
All things considered, the test was very successful indicating that the systems analysis approach to restraint systems design and integration via computer simulation to have great potential in future design and integration efforts.

Appendix A contains the data traces from this first test.



Vehicle, Post-Test No. 1

Figure 24.

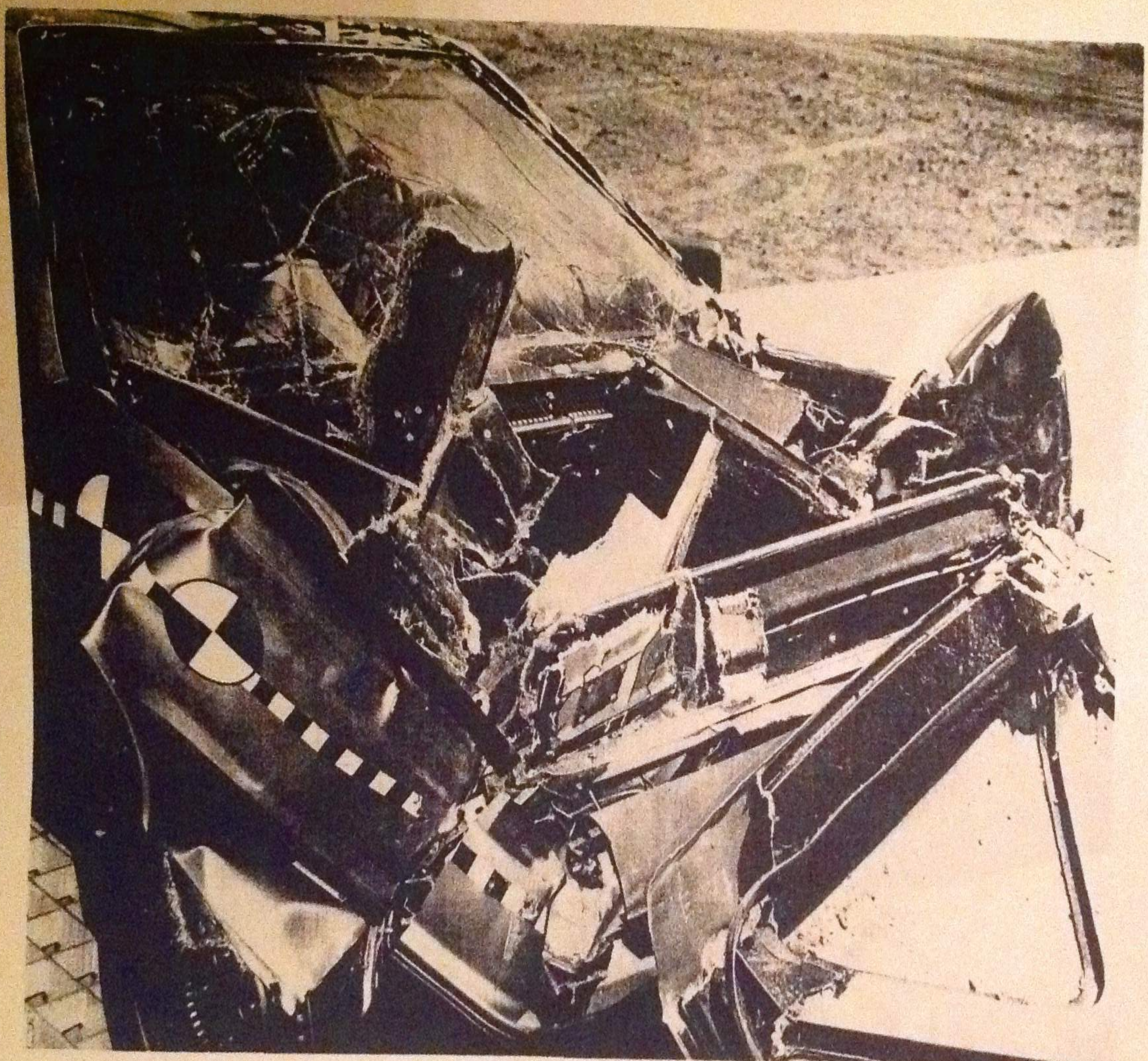


Vehicle, Past-Test No. 1

Figure 25.

Vehicle, Post-Test No. 1

Figure 26.

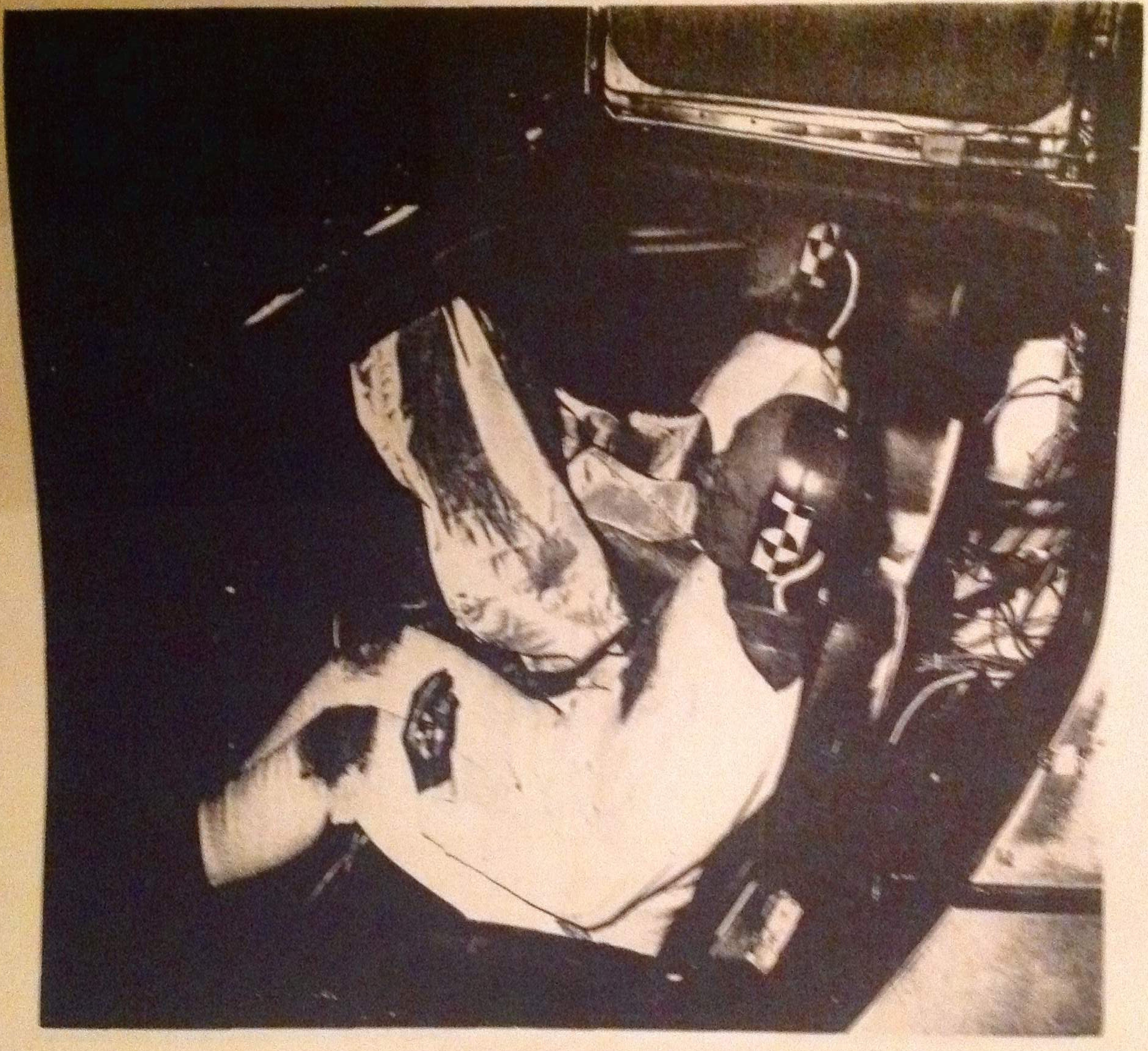


Vehicle, Post-Test No. 1

Figure 27.

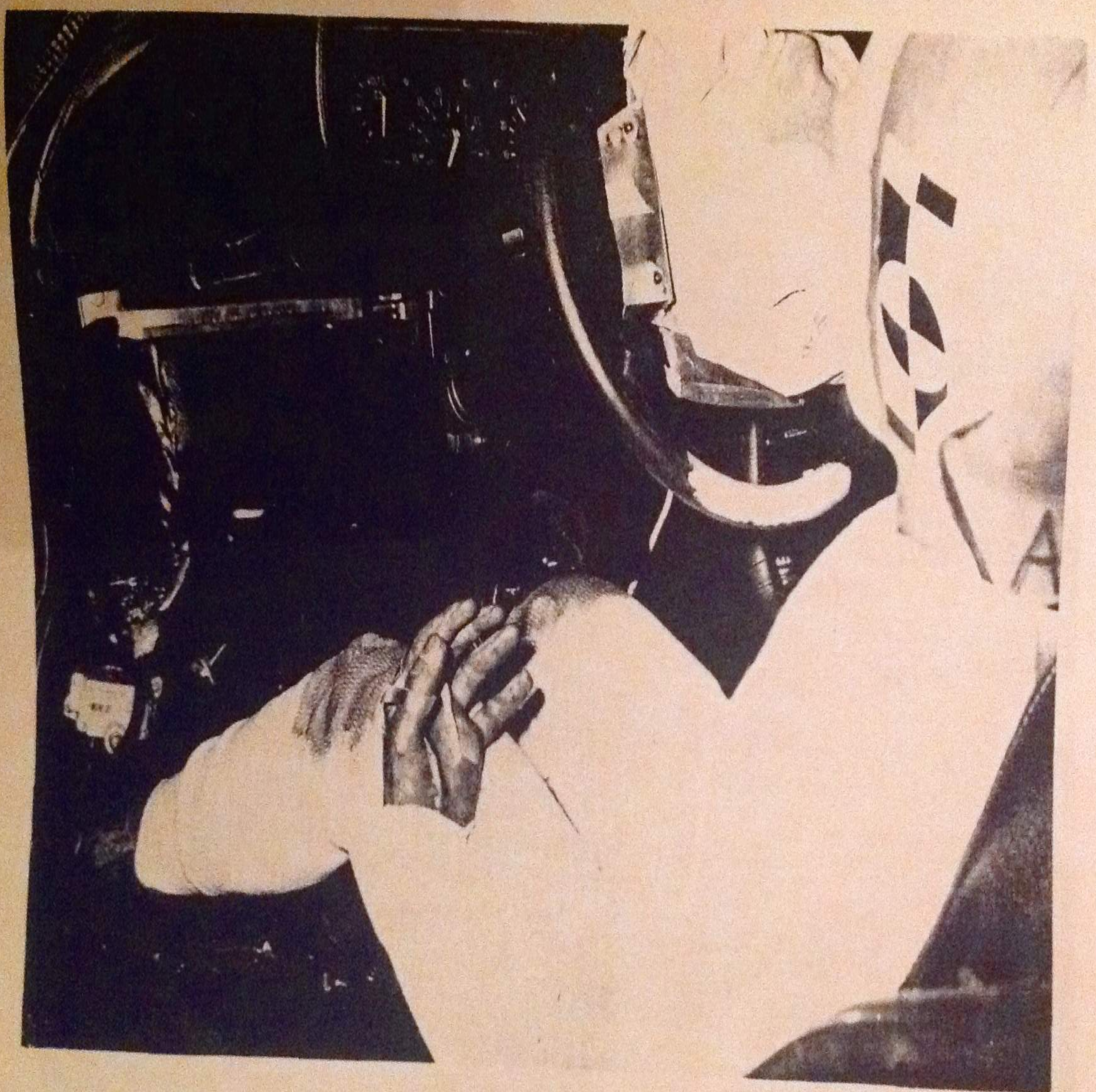
<u>Vehicle, Post Test No. 1</u>

Figure 28.



Vehicle Interior, Post Test No. 1

Figure 29.

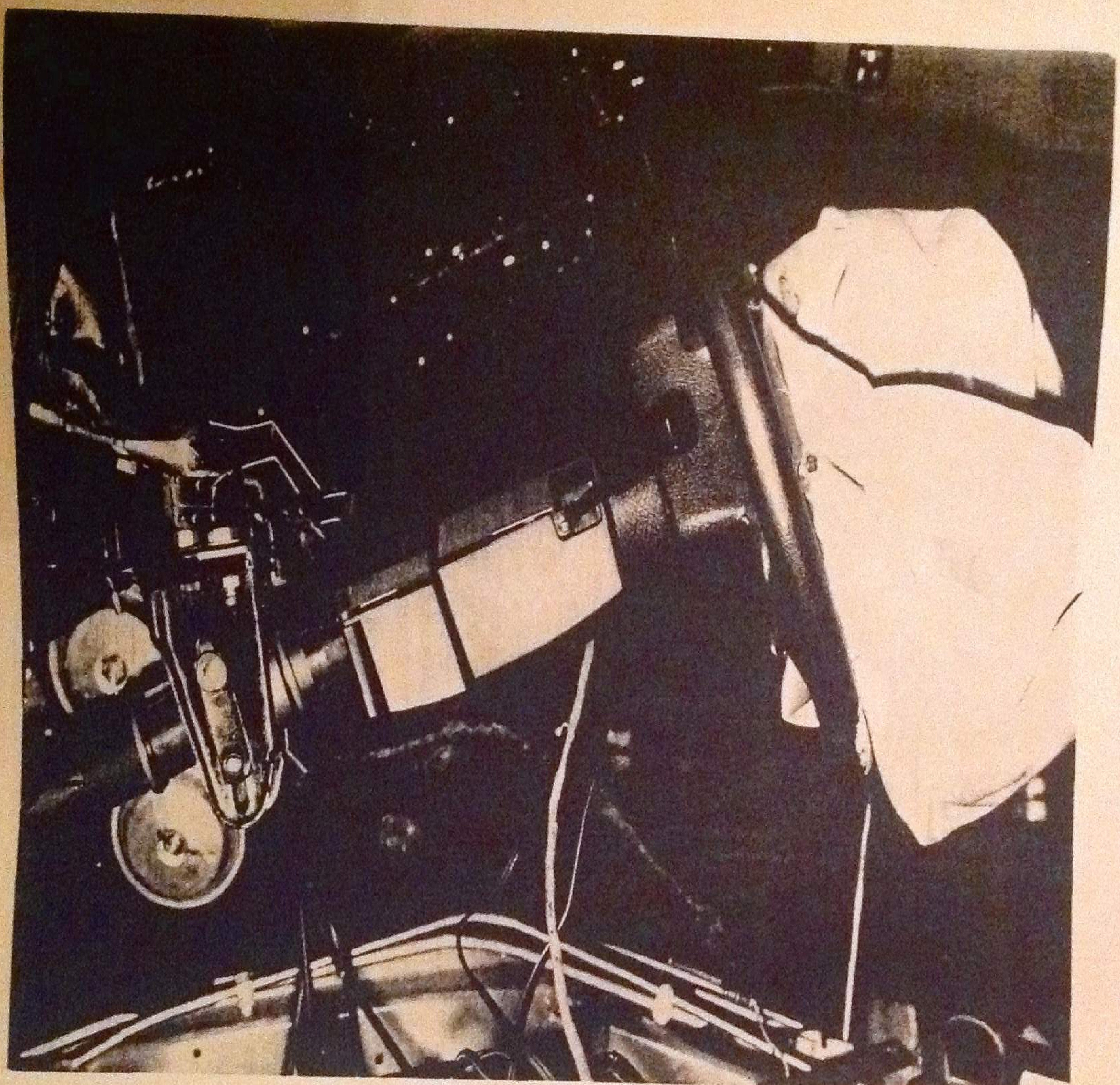


Driver Restraint System, Post-Test No. 1

Figure 30.

Knee Restraint, Driver, Post-Test No. 1

Figure 31.



Driver Restraint System, Post-Test No. 1

Figure 32.

Passenger Restraint System, Post-Test No. 1

Figure 33.

Passenger Knee Restraint, Post-Test No. 1

Figure 34.

4.2 Crash Test No. 2

Based upon the promising results obtained in the first crash test, Fitzpatrick Engineering recommended to NHTSA and DeLorean Motor Co. that we increase the test speed to 40 mph for the next test. We made this recommendation to see if the satisfactory restraint systems performance predicted by the computer simulations for the assumed vehicle structural response would really hold up at this higher test speed. We also wanted to further verify the systems analysis approach to restraint systems design. Both parties agreed to the 40 mph test speed and plans went forward for the next test.

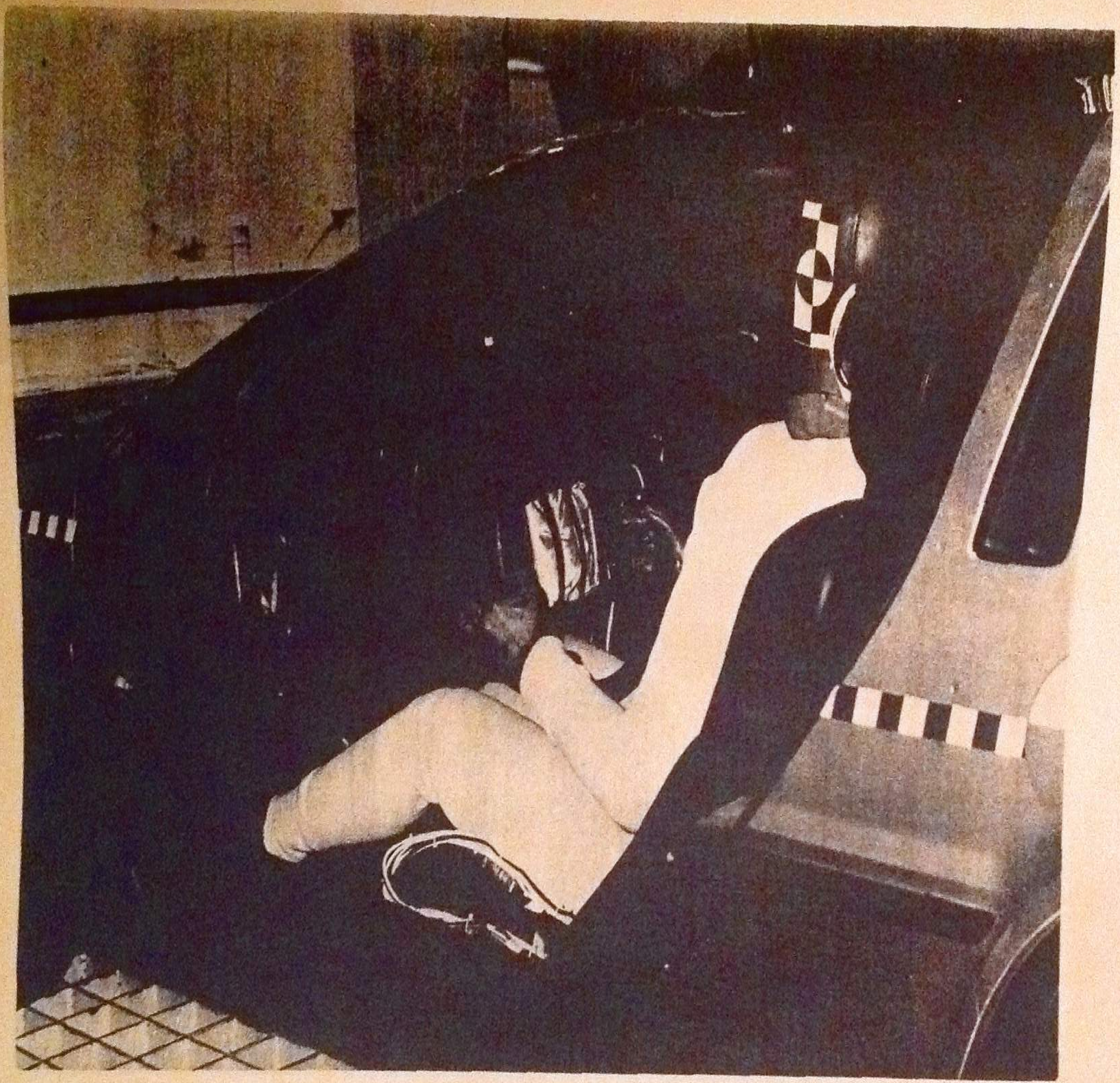
The test set-up in terms of restraint systems installation, dummy size and seat position were very similar to Test No. 1. The only areas where differences occurred were:

a) Passenger module pan was aligned to deploy airbag toward chest center,

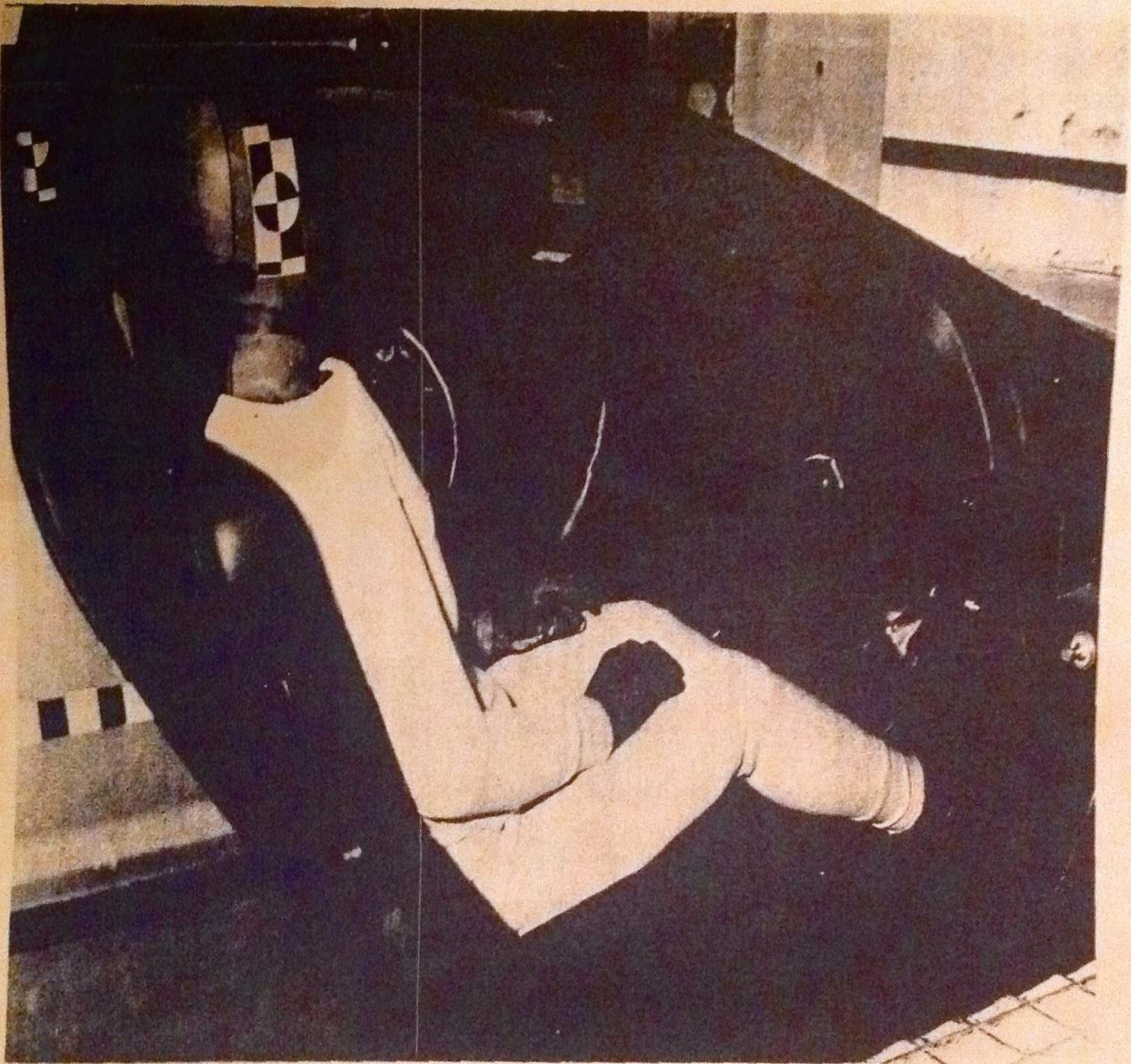
b) Steering column allowed to stroke and,

c) Vent area in driver airbag increased slightly from 1 1/4 inches to 1 5/8 inches diameter.

The second crash test was conducted on October 15, 1981 at a test speed of 40.6 mph. Again, the vehicle was impacted in a full frontal mode into a rigid barrier. Figures 35 and 36 show the pre-test restraint system/dummy configuration while Figures 37 and 38 show the vehicle. The test weight of the car with two dummies, instrumentation and 5 gallons of Stoddard solvent was 3347 lb.



Test No. 2, 3/4 View, Driver Restraint System

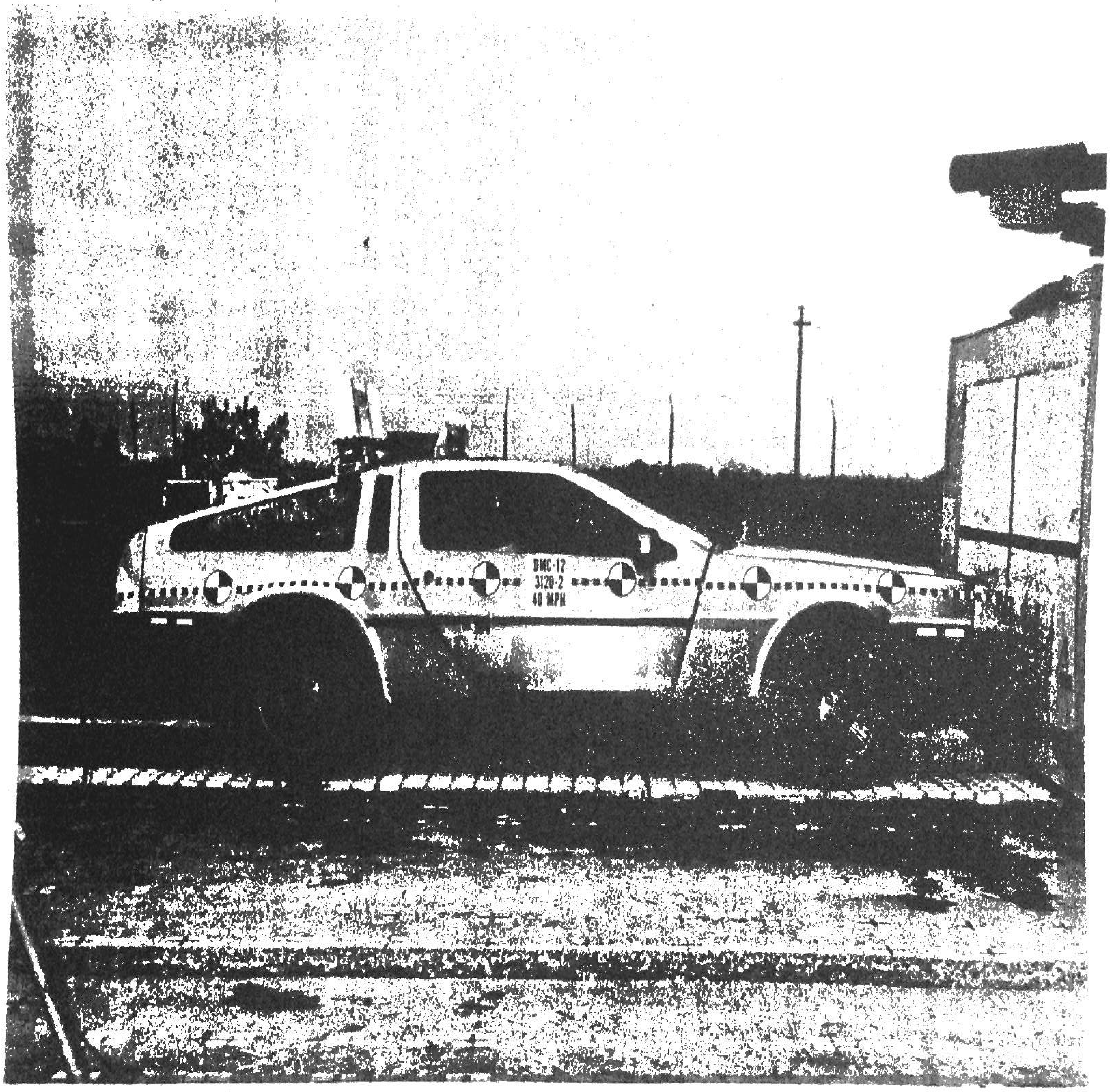


Test No. 2, 3/4 View, Passenger Restraint System

Figure 36.

Test No. 2, Vehicle, Driver Side

Figure 37.



Test No. 2, Vehicle, Passenger Side

Figure 38.

The injury measures for this second crash test are shown in the table below.

DeLorean Crash Test No. 2
41 MPH Frontal Barrier Test

Injury Measure	Driver	Passenger	"208" Limit
HIC	366	684	1000
Peak Res. Chest G's (-3 msec)	46	52.5	60
Femur Loads - Lbs			
Right:	1220	1160	2250
Left:	920	*2110(1150)	2250

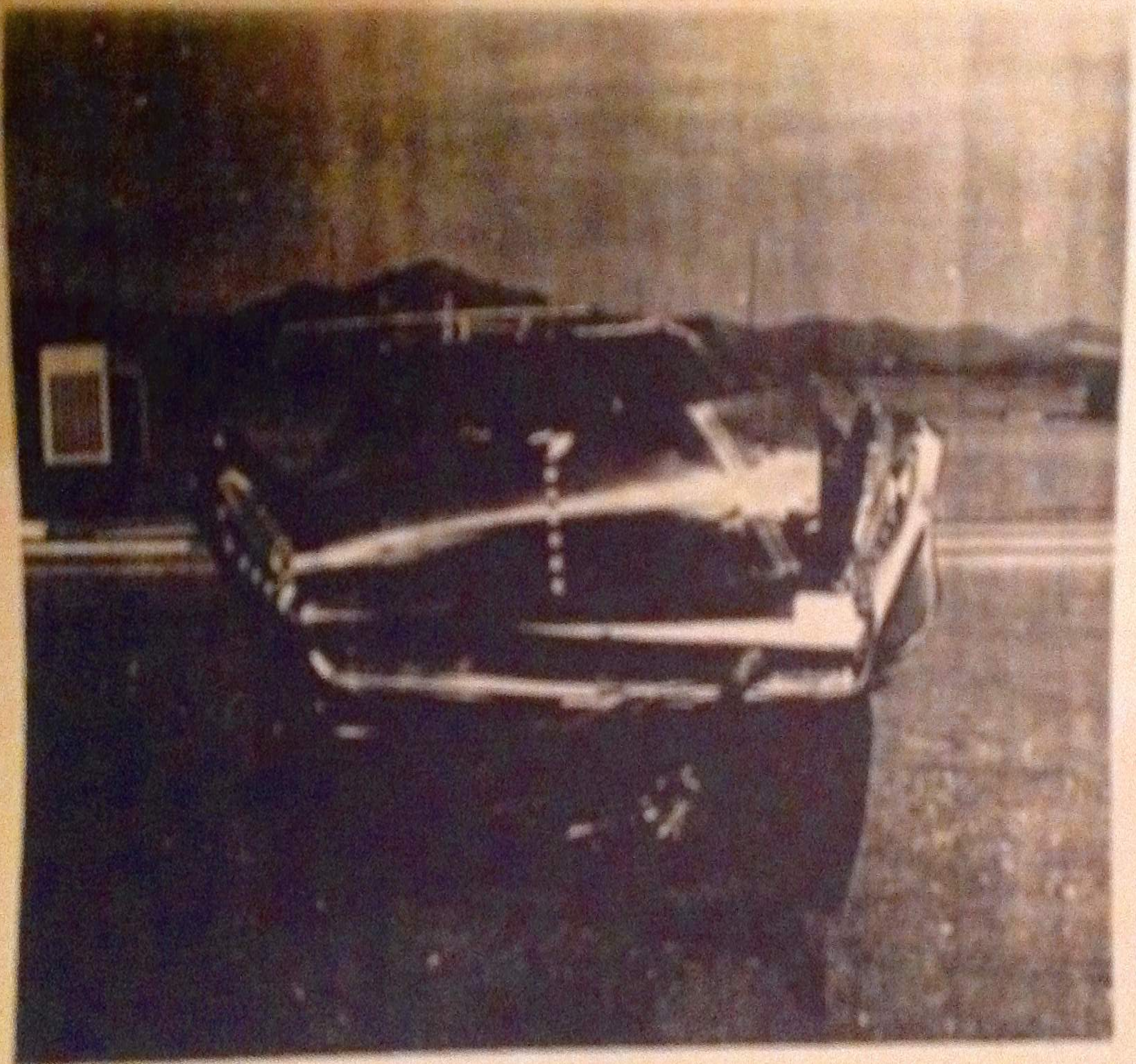
As the table shows, the injury measures for this 40.6 mph barrier test are still well below the injury criteria limits shown in the right column.

Although the outward appearance of the crashed vehicle looks as if the crash was quite severe (Figures 39 through 41), the opposite is true. The vehicle crushed approximately 44 inches but the intrusion into the passenger compartment was again

*The same note shown on page 31 applies here also. Since this is the same femur that was "noisy" in Test No. 1, we suspect a faulty connector, wire or transducer in the right femur of passenger dummy.

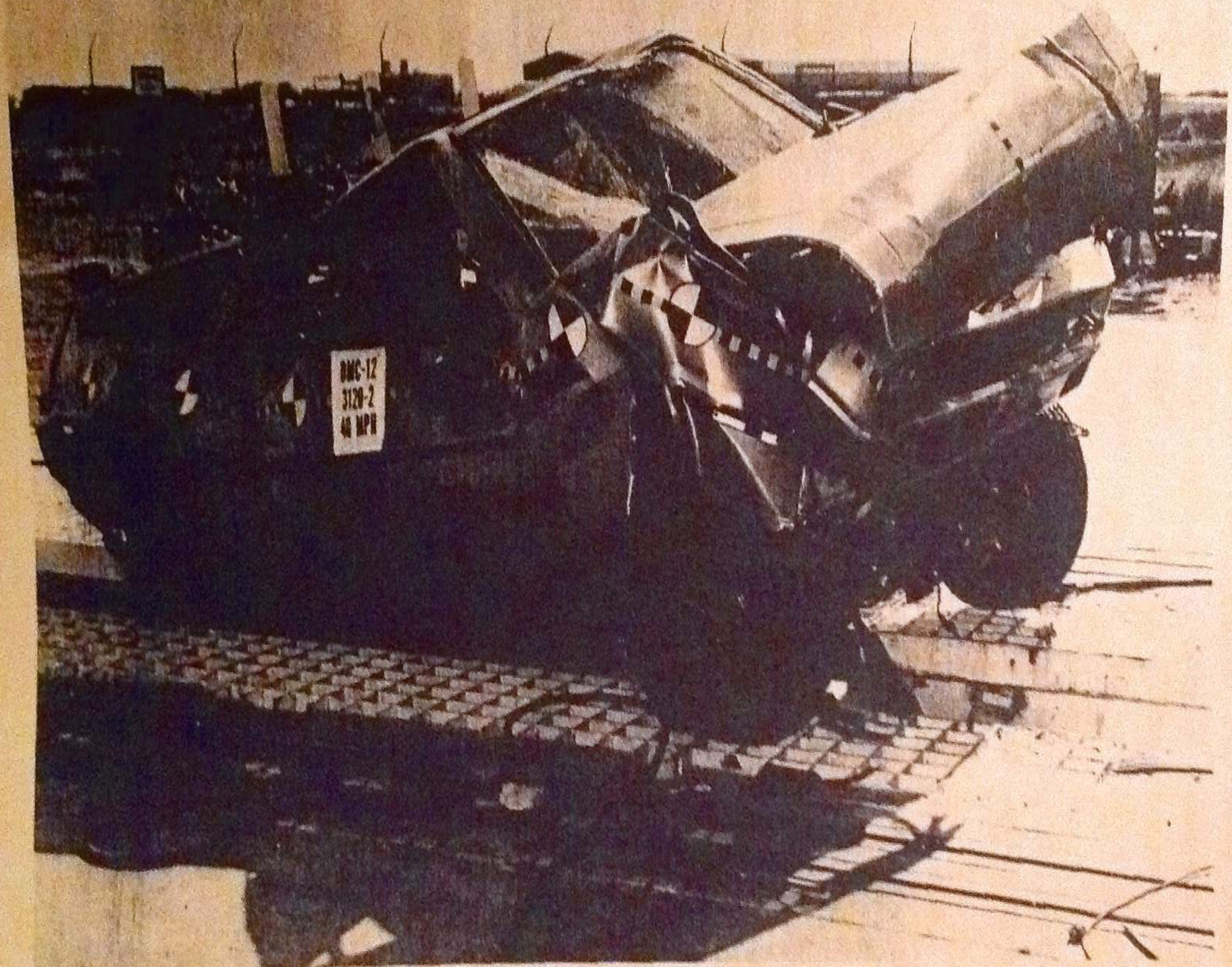
Vehicle, Post-Test No. 2

Figure 39.



Vehicle, Post-Test No. 1

Figure 40.



Vehicle, Post-Test No. 2

Figure 41.

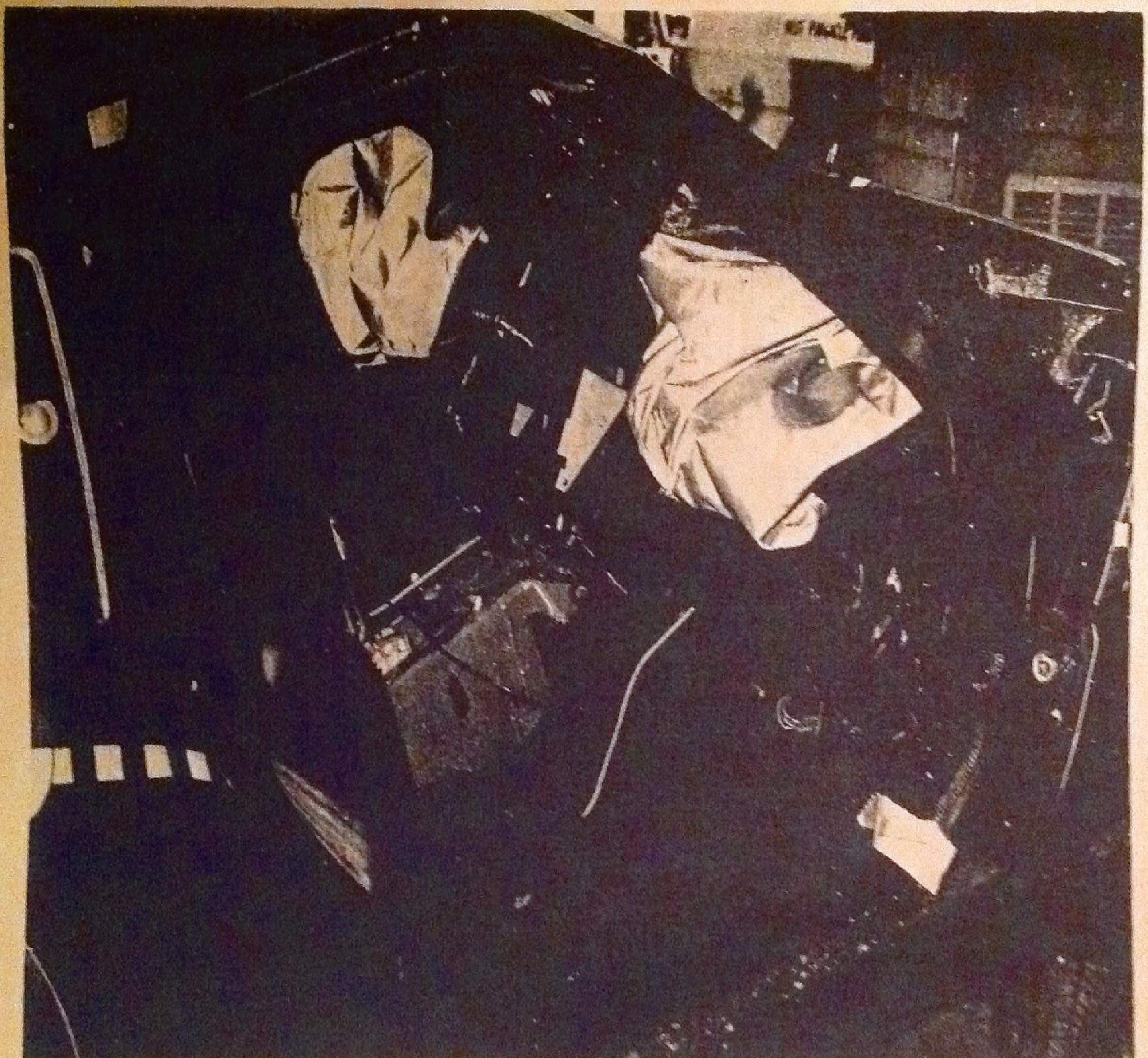
confined to the lower firewall/toeboard area and some console axial collapse (Figure 42). In fact, the compartment interior dimensions following the crash were still quite generous so that most of the original compartment volume was maintained.

This may be seen by comparing Figures 35 and 43 on the driver side and Figures 36 and 42 on the passenger side which show pre and post test photos of the respective sides.

It should be noted that the vehicles tested were pre-production prototypes with various cosmetic flaws. One problem we encountered was the driver door on the Test No. 2 vehicle. Of the two door latches on the driver side - one forward and one rearward - we could at test time only latch the forward latch. Because of this, the aft side of the driver door came unlatched as it began to pick up load, thereby removing an important structural element from the driver side. This was manifested by more crush on the driver side and a net clock-wise rotation (when looking from above) of the entire vehicle during the test.

Another factor contributing to the degree of structural damage seen in the vehicle was the rather massive instrumentation package located immediately behind the seats. We therefore had a "worst case" situation for the vehicle structure. In spite of this worst case test condition however, the "survival space" inside the compartment was maintained so that the compartment interior dimensions were not greatly different than before the test.

As in Test No. 1, the steering column rotated upward another 10 to 11 degrees from horizontal for a final column angle of 25 degrees. Appendix B contains the data traces for Test No.2.



Post-Test No. 2, Compartment Interior and Buckled Tunnel

Figure 42.

Post-Test No. 2, Compartment Interior

Figure 43.

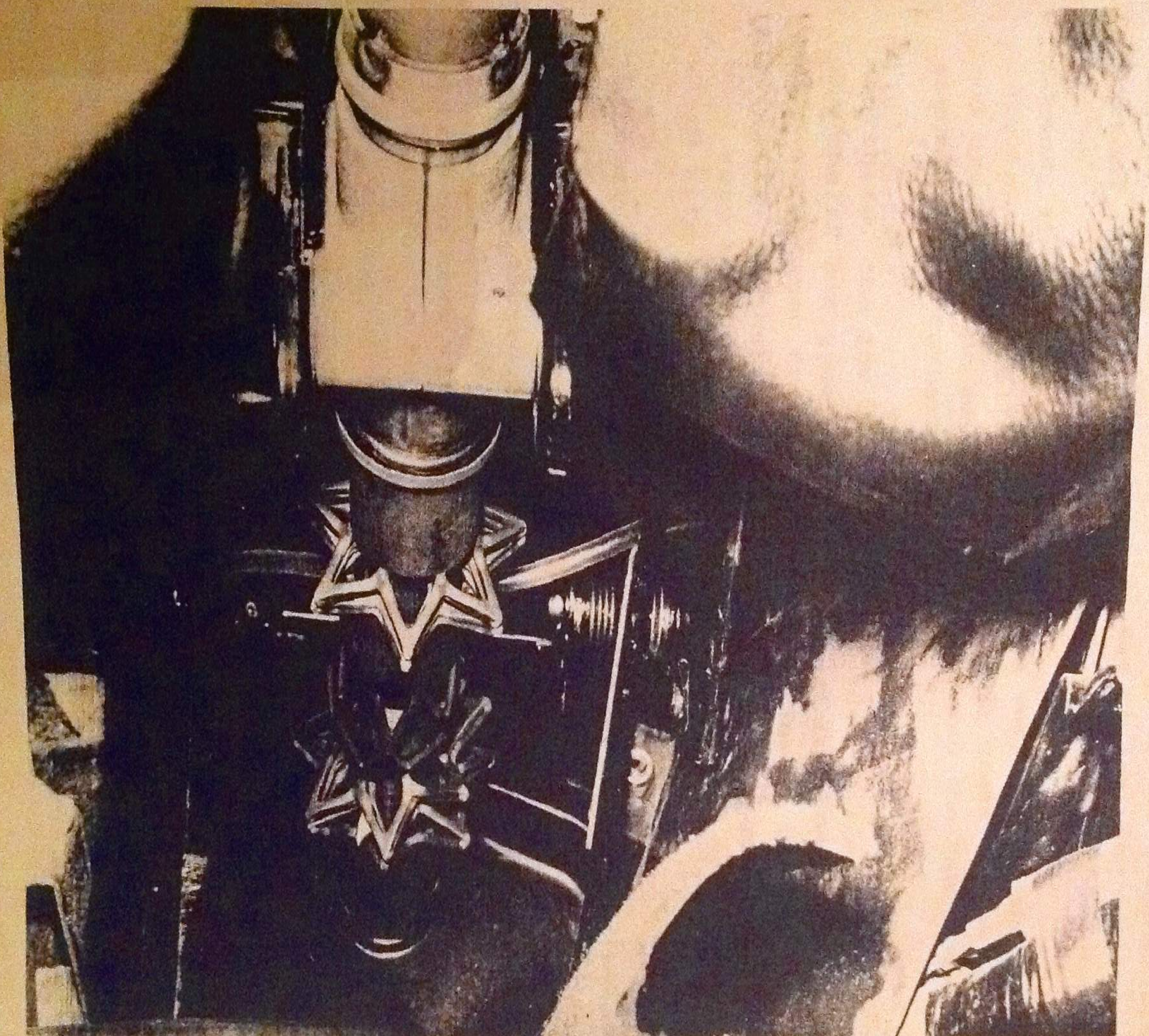
The steering column collapsed approximately six inches forward due to body applied forces. In addition, the intruding toeboard caused another two inches of crush for a total crush of 8 inches for the E/A unit. Figure 44 shows a post-crash, under-dash view of the crushed column. The pre-test length of the uncrushed, expanded metal mesh was 9¼ inches.

Again the on board, "piggyback" sensors were monitored to determine firing time.

Sensor Type	Location	Firing Time
GM BID	Underneath, aft of radiator at junction of two, front frame forks.	43 msec
Bosch (3 level)	Tunnel, between driver and passenger.	t_1=20 msec t_2=22 msec t_3=38 msec
CTAC (S/N 1206, 4 level)	Tunnel, between driver and pass.	t_1=41 msec t_2=47 msec t_3=41 msec t_4=52 msec

Again, some lessening in sensing time will be required from these sensors prior to depending upon them to initiate airbag inflation.

Like Test No. 1, this test was also quite successful from several standpoints. First, and perhaps most importantly, we were able to show that the systems analysis approach to



Post-Test No. 2, Underneath View of Stroked Column

Figure 44.

restraint systems design and integration via computer simulation can be a cost effective way of deriving restraint systems tailored to a specific vehicle's crash environment.

Second, the Delorean proved to be a very well designed vehicle in terms of allowing a relatively great amount of front end crush without adversely compromising the "survival space" in the compartment.

And third, the low injury measures were obtained using "off-the-shelf" gas generators since the Thiokol/Mercedes units used were taken from the production line at the Thiokol facility. Further, all three of the driver type gas generators used were identical so as to obtain the cost advantages associated with larger production runs.

Obviously additional testing and system tuning is required for the restraint systems. Other crash modes should be investigated, out-of-position passengers tested, and other driver and passenger sizes analyzed. We believe, however, that these two preliminary crash tests show the restraint systems to have very good potential for eventual production installation in the DeLorean.