is also used to protect a vehicle from impacting bridge abutments, bridge piers at structures, sign posts on freeway shoulders and sign structures at exit ramps.

In the guard railing portion of this test series, the first test was conducted on the 1960 standard blocked-out beam design. This 12 guage steel "W" section beam is mounted 24 inches above the ground on posts spaced at 12′6″ centers.

Modifications in the succeeding tests included halving the post spacing to 6′ 3″, determining the feasibility of using aluminum alloy as an alternate for the steel in the "W" section beam, and testing the 6′ 3″ post spacing with the steel beam mounted at 24 inches and 27 inches above the ground.

The 1960 standard California beam type installed for the first guard railing test utilizes 8″ x 8″ treated timber posts and blocks at 12′ 6″ centers. The 12 gauge galvanized steel "W" beam was mounted 24″ above the pavement.

This is the 1960 standard guard railing ready for impact Test No. 5.

This initial test was designed to serve as a performance base to compare the results of the succeeding three guard railing tests. It also was the first proof test of this design under a 25 degree angle, 60 mph impact from a late model vehicle. (Sound track of crash.)

The impact speed was reduced from 68 to 60 mph for the guard railing tests.

Typical of the sloped back bumpers on American-made cars from the past four years is the bumper on this 1962 Chrysler that strikes the barrier at the center of rotation of the beam. This high point of impact on the beam combined with the sloped-back bumper design increases the possibility of vaulting. During a later test it is found that by halving the post spacing, there was sufficient resistance to beam rotation to successfully redirect the vehicle.

The first step in preventing vehicle vaulting as experienced in Test No. 5 was to increase the height of the beam from 24 to 27 inches and decrease the post spacing from 12 ft. 6 in. to 6 ft. 3 in.

This is the revised guard railing design with a 12 gauge galvanized steel "W" section beam at a 27 in. height on posts spaced 6 ft. 3 in. apart. (Sound track of crash.) Again, a 6 mph impact speed at 25 degrees. The 6 ft. 3 in. post spacing combined with the added 3 in. in beam height eliminated any tendency to vault. The 27 in. beam height places the beam well above the average sloped back bumper and minimizes the tendency for the vehicle to roll.

Damage was understandably more severe with a single beam guard railing than was noted during the earlier tests on double beam median barrier designs. When the beam is mounted this high, the post is exposed to potential wheel entrapment. This 27 in. beam height is considered maximum for barriers without rubbing rails.

For this third test on guard railing we retained the 6 ft. 3 in. post spacing from the previous test and dropped the steel beam back to the original 24 in. design height.

The purpose of Test No. 7 was to determine the most effective and economical modification that could be made to the 1960 24 in. high guard railing design to provide a more protective barrier. (Sound track of crash.)

The additional posts, even with the beam at the original 24 inch height added sufficient rigidity to the system to effectively redirect the vehicle. At this reduced height, there is a slight tendency for the car to roll.

The steel beam of this guard rail system withstood severe deformation and extremely high stress concentrations in the immediate impact area with no evidence of failure. Again, much of the energy was absorbed in crushing the blocks.

For this last guard railing test in the series, the 24 inch beam height and 6 ft. 3 in. post spacing were retained from the previous test, and a 0.156 in. thick aluminum alloy "W" section beam was substituted for the 12 gauge steel.

This is the installation for Test #8. The 0.156 in. thick aluminum beam is the same that performed satisfactorily in the double beam median barrier design. (Sound track of crash.)

Again, the same 60 mph at 25 degrees as for the previous guard railing tests.

An objectionable characteristic of the alloy 2024 aluminum beam revealed in this test is its unpredictable behavior during the extreme impact loading imposed by the vehicle.

While being redirected in the usual manner, the vehicle is suddenly and violently ejected from the barrier.

The difference in performance between the steel and aluminum appears to stem from the difference in stress-strain relationships and the ductility of the two materials. Of most significance is the difference in impact resistance of the two materials. Laboratory tests indicated that the steel beam could with-