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December 1966

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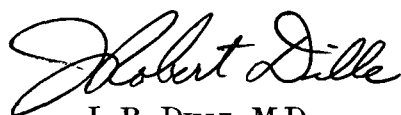
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EVALUATION OF VARIOUS PADDING MATERIALS FOR CRASH PROTECTION

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I. Introduction.

The value of padding on rigid structures as a means of protection of occupants of transportation vehicles against crash impact forces has long been a subject of discussion. This study was conducted to shed some light on the question of whether we can depend on a feasible thickness of padding to reduce crash impact forces to a level tolerable to humans or whether we must redesign the structure beneath the padding to achieve this goal.

II. Procedure and Discussion.

A rigid base structure was constructed at the end of a simple catapult (Figure 1. All figures, 1 through 4, are in the Appendix) and impacted with and without padding materials by an instrumented dummy head at velocities of 15 ft/sec and 30 ft/sec. While it is generally known that head impacts in crash decelerations may be as high as 50 ft/sec, velocities of 15 and 30 ft/sec were chosen for this study because of limits of the accelerometers and it was felt that these velocities would allow adequate comparison of the compression characteristics of the various materials.

The rigid instrumented dummy head weighing about 12 pounds was attached to the sled with a ball bearing joint allowing a free movement of the head and simulated trunk in a forward arc as the sled was suddenly stopped by means of a friction brake. Propulsion of the sled was accomplished by using bungee cords.

Table 1 lists the materials and combinations of materials as well as their thickness for each specimen (1 through 37) tested. Figure 2 is a composite of the deceleration curves of all 74 tests.

Note that test 1 gives base line data obtained by impacting the rigid base structure without padding at velocities of 15 ft/sec and 30 ft/sec. Peak g forces for these impacts were 300g and 810g respectively with very rapid rise time and short duration.

The remaining data plotted in Figure 2 depict

the energy attenuation available from each material tested. Note that there is very little reduction of peak g force (700g to 800g) when $\frac{1}{4}$ " and $\frac{1}{2}$ " materials (tests 2 through 5) were impacted at 30 ft/sec. At 15 ft/sec the reduction is similarly negligible for these tests. Three-quarter inch thick padding (tests 6 and 7) offers little or no more protection.

A study of the eleven 1" thick materials tested shows a few points of interest. First, tests 8, 9, and 10 were impacts on 1" thick Koroseal (Shock foam manufactured by B. F. Goodrich Company, Akron, Ohio) medium #407, firm #407, and hard #334 respectively. With 30 ft/sec impacts the reduction of peak g readings from the base line reading were (a) medium 810g down to 550g, (b) firm 810g down to 430g, and (c) hard 810g down to 320g. Tests 13 through 18 were conducted with 1" samples of rubber and other fairly soft materials and all peak g readings for 30 ft/sec impacts were over 500g. The high g readings in this latter group of tests were probably caused by the soft materials bottoming out with impacts of 30 ft/sec or more. This is borne out by a comparison of tests 14 and 29. Both tests were made with Koroseal HVS 400 (test 14-1" thick, test 29-2" thick). In test 29 the peak g reading dropped from 810g to 270g. Hence, one might conclude that if only one inch of padding is to be used it should be fairly rigid and of slow return material to obtain maximum energy attenuation. If the situation is such that two inches of padding may be used, a softer slow return material will provide considerable protection. Increasing the thickness of the padding material over 2" (tests 32 through 37) further reduces the peak g force readings.

The corrugated cardboard used in the last three tests consisted of layers cut from cardboard boxes $\frac{1}{8}$ " thick and glued together. The aluminum honeycomb was made up of hexagon shaped cells $\frac{5}{16}$ " in diameter with a static crush force of 40 pounds per square inch.

Figure 3 summarizes the peak g readings for all the tests, and data presented in an earlier

APPENDIX

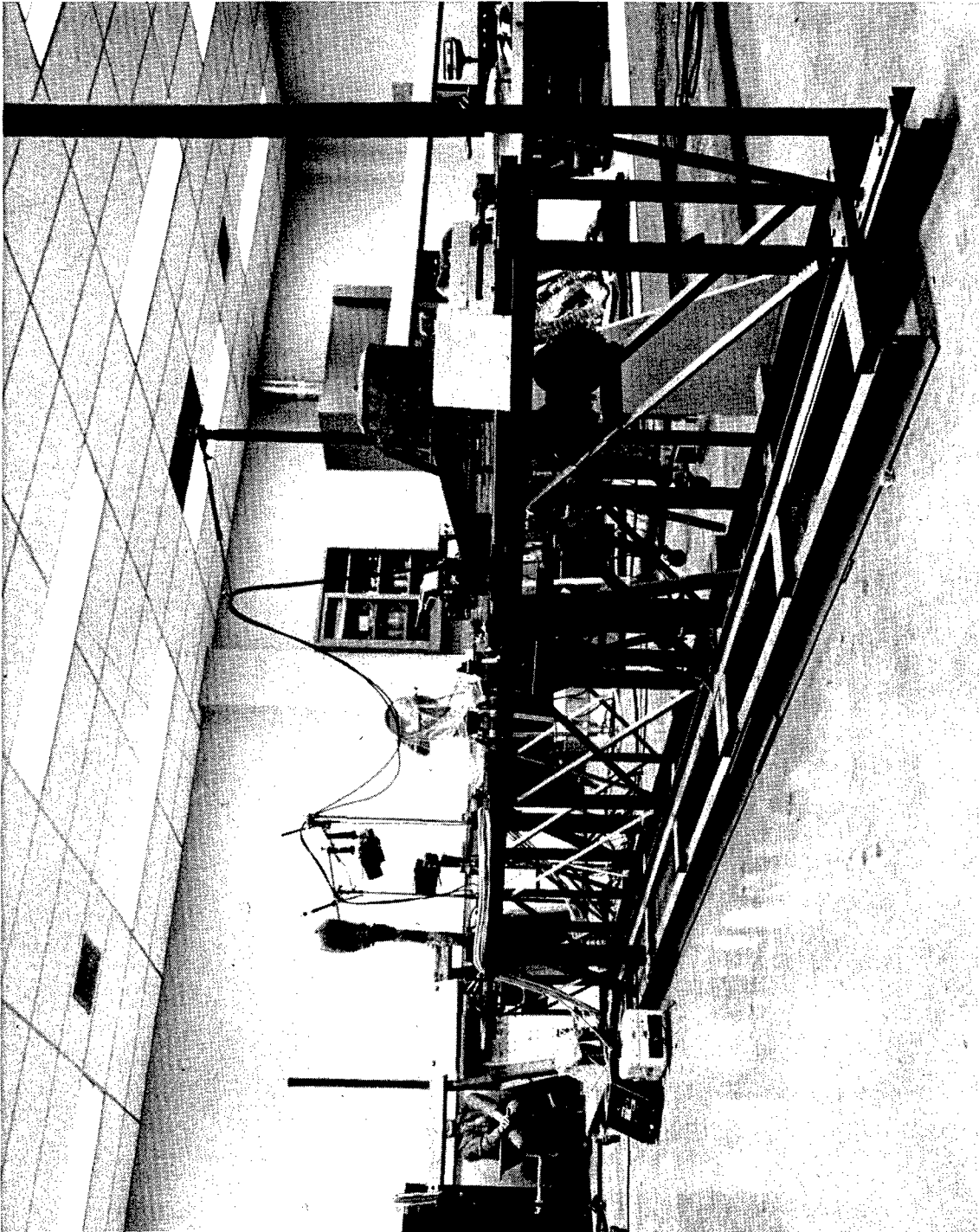
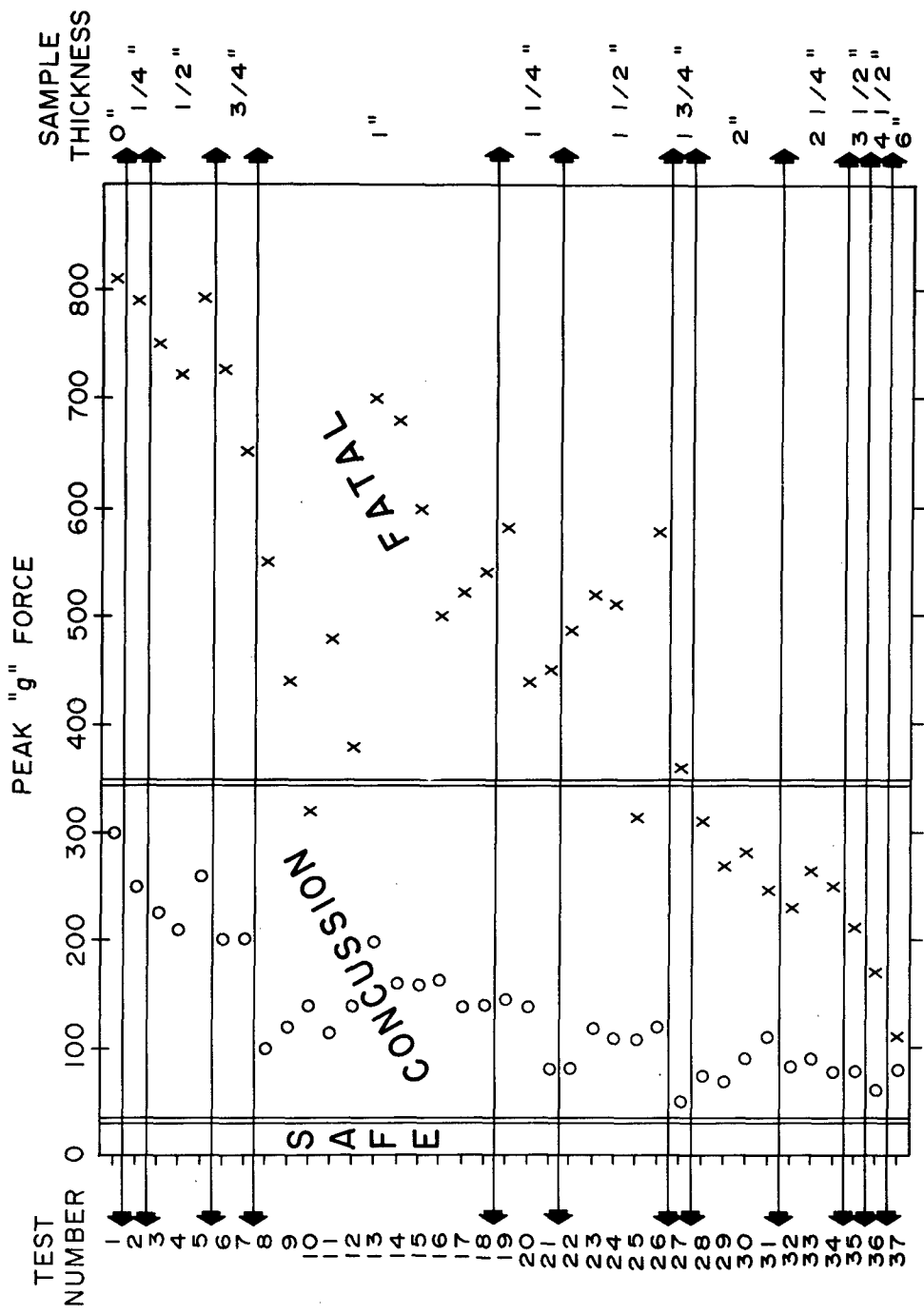


FIGURE 1. Photograph of small catapult used in head impact studies.



IMPACT VELOCITY: o = 15 FT./SEC. x = 30 FT./SEC.

FIGURE 3. Summary of head impacts on padding materials.