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SLED TEST EVALUATION OF A WHEELCHAIR RESTRAINT SYSTEM FOR USE BY HANDICAPPED DRIVERS

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16. Abstract

Four sled impact tests were performed to evaluate a wheelchair restraint device developed by Creative Controls, Inc., Troy, Michigan. Two tests were performed using a 5th-percentile female dummy and two tests with a 50th percentile male dummy. For each dummy, both a head-on and 33-degree oblique impact were performed. The impact pulse was 20 m.p.h. and 16 G's for all tests.

In all tests the Creative Controls device was effective in restraining the wheelchair but the dummies underwent extensive "jack-knifing" and consequent head excursions due to the lack of an upper-torso restraint.

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INTRODUCTION AND OBJECTIVE

Providing for mobility of handicapped adults requires not only development of equipment and devices which will allow independent operation of private vehicles, but development of adequate restraint systems to protect these handicapped drivers and occupants in vehicle collisions. Until recently, little concern and effort has been devoted to the latter area. As a result, handicapped individuals fortunate enough to have found a means for operating a vehicle are, in most cases, completely unprotected in the event of a crash.

While designing for impact protection of normal vehicle occupants is a complex and difficult engineering problem, designing for the protection of handicapped individuals, with their special equipment and assisting devices as well as strength and mobility limitations, presents additional problems in crashworthiness design. For example, one cannot assume that a wheelchair occupant can fasten a standard shoulder harness or that the wheelchair structure can be used without modification to carry the loads due to impact.

As awareness of the need to protect as well as mobilize the handicapped person increases, new devices and equipment will be developed and marketed. An important aspect of the evaluation of these devices prior to installation and use must include dynamic testing under realistic and appropriate conditions.

The purpose of this study was to conduct a series of impact tests to evaluate the performance of a wheelchair restraint device developed by Creative Controls, Inc., for use by handicapped drivers.

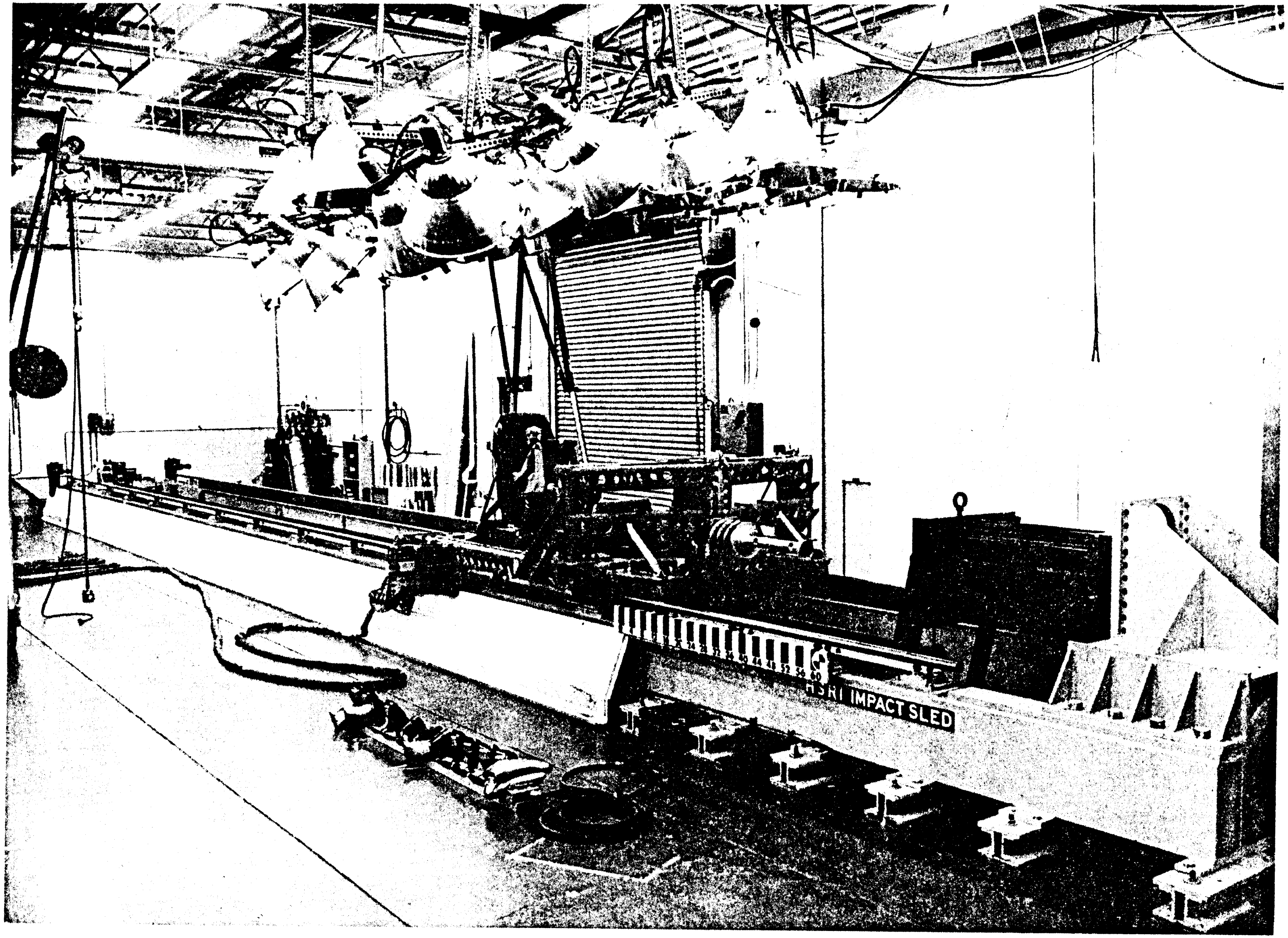


Figure 1. HSRI's Impact Sled Facility

PROCEDURES

Impact testing of the Creative Controls wheelchair restraint was performed at the Highway Safety Research Institute's Impact Sled Laboratory. This facility consists of an impact sled (Figure 1) that moves on a 45-foot track into a pneumatic decelerator and can simulate crashes up to 75 m.p.h. and 75 times the force of gravity. The sled itself is a 975-lb test platform, 6.5-ft square, driven by a compressed-gas-powered ram. The sled operates on the principle of rebound, stopping and reversing direction abruptly by impacting the adjustable pneumatic decelerator.

In this study, four impact tests were performed, each at an impact velocity differential of 20 m.p.h. and an impact deceleration of approximately 16 G's. Figure 2 shows this deceleration pulse. Two runs were

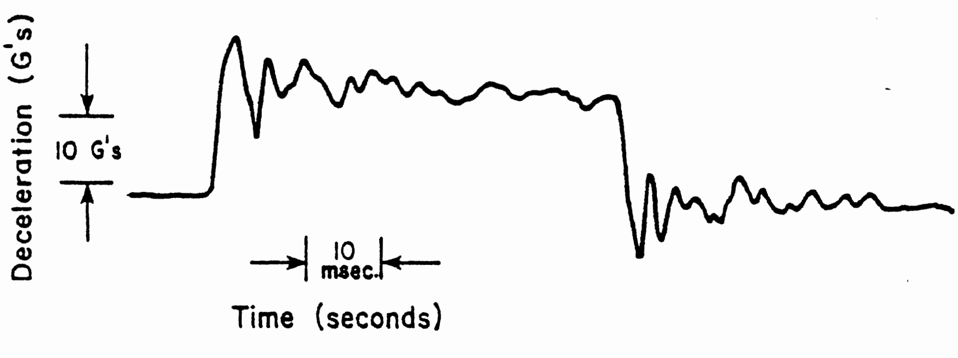


Figure 2. Sled Test Deceleration Pulse

made with the Creative Controls device and wheelchair facing forward on the sled so as to simulate a head-on collision, and two with the wheelchair oriented approximately 45 degrees to the sled motion to simulate an oblique impact. For each orientation, both a 5th-percentile female dummy (105 lbs) and a 50th-percentile male dummy (160 lbs) were tested, resulting in the matrix of four tests shown in Table 1.

TABLE 1

MATRIX OF TESTS

Dummy	Orientation of Sled Forward	45°
5th %ile Female	78W001	78W003
50th %ile Male	78W002	78W004

In each test, side and overhead high-speed cameras recorded the impact response at 1,000 frames/second, and high-contrast markers were placed on the dummy and wheelchair to provide for data analysis. Pre- and post-run photographs were taken with both black-and-white and color slide film, and a polaroid graph check camera was used to provide an immediate sequence photograph of the impact response.

DESCRIPTION OF CREATIVE CONTROLS DEVICE

The basic features of the Creative Controls wheelchair tie-down device are illustrated in Figure 3. As can be seen, a standard wheelchair must be modified by adding the two triangular-shaped plates to the side frames

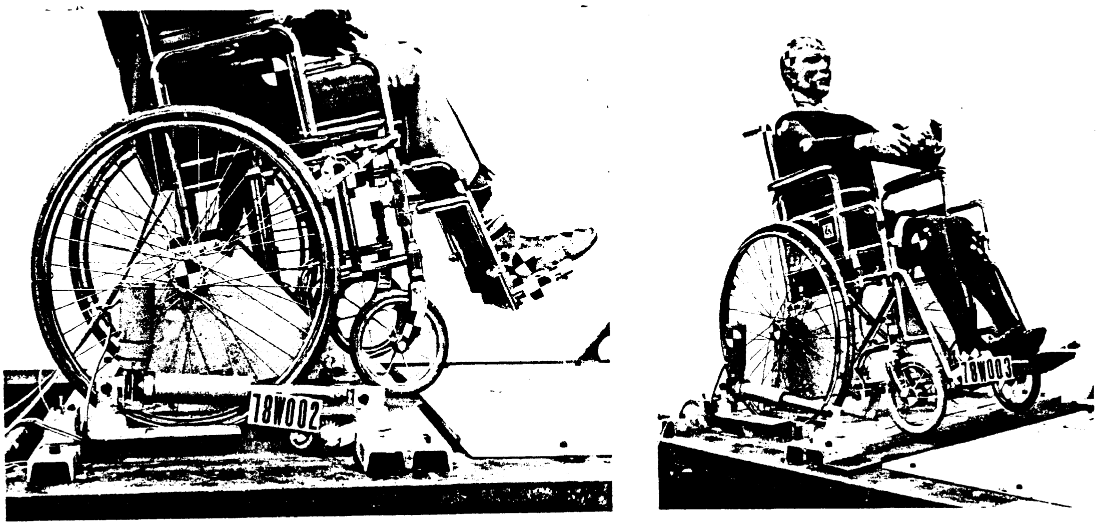


Figure 3. Creative Controls wheelchair restraint device mounted to sled rails.

of the wheelchair. These plates fit over the wheel axles and are fastened to the frame by U-bolts. Two 5/8" aluminum bars fit between the front and rear lower corners of these triangles and are held in place by shear pins. Holes in the upper part of the triangles provide for attachment of a lap belt which fits over the upper thighs of the occupant. Installation of this platform in a van requires cutting out a portion of the van floor and welding of the Creative Controls platform in place. The wheelchair is held by two bar-grips which grab the front and rear, wheelchair bars in opposite directions as shown in Figure 4. The rear bar grip is welded to the platform and is open to the rear, thereby preventing forward motion of the wheelchair. The front grip is movable and grabs the front bar from behind and below as it is activated by the electrically (12 volt) powered hydraulic piston. As this front grip grabs the front bar,

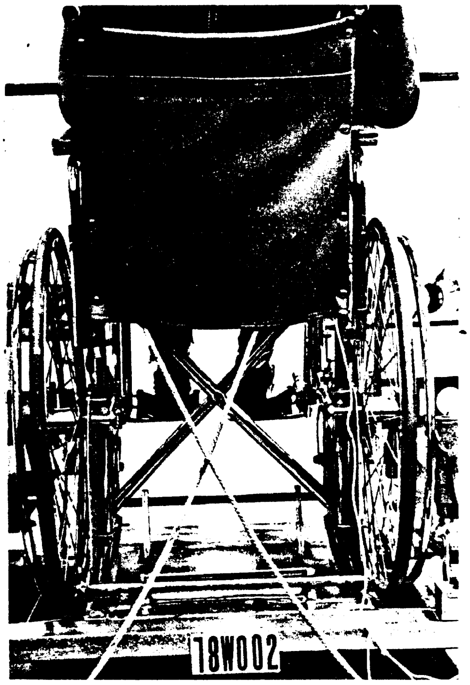


Figure 4. Rearview of Creative Controls device showing front and rear bars and grips.

it lifts the wheelchair and moves it forward, and in the final position prevents rearward motion of the wheelchair. At the same time the front grip is actuated, a portion of the platform drops down, allowing the large wheels of the chair to drop into the wheel wells. In the final position, the wheelchair with occupant is almost entirely supported by the bar grips and, in fact, the wheels may not contact the floor.

TEST RESULTS

The Appendix shows pre-and post-test photographs for each sled run, along with the polaroid sequence photograph of the impact response (except for run No. 78W002). The obvious observation is that the Creative Controls mechanism performed extremely well in terms of holding onto the wheelchair. As shown by the post-test photographs, there was little or no damage to the wheelchair frame itself in these tests, and the wheelchairs were held in place even though the front bar popped out of the grip in each run and the rear bar was bent. It can also be seen, however, from these photographs and the high speed films, that the dummy underwent rather severe torso flexion or "jack-knifing." This would likely result in head and chest injury due to violent impact with vehicle structures and spinal trauma due to hyperflexion. This lack of restraint on the dummy is further indicated by the head and knee excursions shown in Table 2.

TABLE 2

APPROXIMATE HEAD AND KNEE EXCURSIONS IN DIRECTION OF IMPACT RELATIVE TO WHEELCHAIR FRAME

Test No.	Dummy	Head Excursion(in.)	Knee Excursion(in.)
78W001	5th %ile female	37.4	13.3
78W002	50th %ile male	41.6	10.8
78W003	5th %ile female	31.6	14.4
78W004	50th %ile male	35.2	13.6

DISCUSSION AND CONCLUSIONS

The Creative Controls wheelchair restraint device was very effective in restraining the wheelchair with occupant in frontal and 45-degree oblique impacts at 20 m.p.h. and 16 G's deceleration. This is largely a result of the fact that the triangles and bars added to the wheelchair structure provide a path for transmitting the inertial loads to the platform without relying on the wheelchair frame. The lap belt loads are transmitted through the triangles to the rear bar, which is the primary energy-absorbing structure in these tests, as indicated by the bending which results. While some bending of the bar is good, in that it reduces the severity of the inertial forces to the occupant, too much bending could allow the rear bar to pop out of the grip, in which case the wheelchair would be totally unrestrained. In this regard, since the front bar did pop out, the wheelchair was essentially unrestrained from moving backward after the initial impact. For the impact pulse of these experiments, this did not present a problem, but for real-world collisions where multiple impacts are not uncommon, the results could have been much worse.

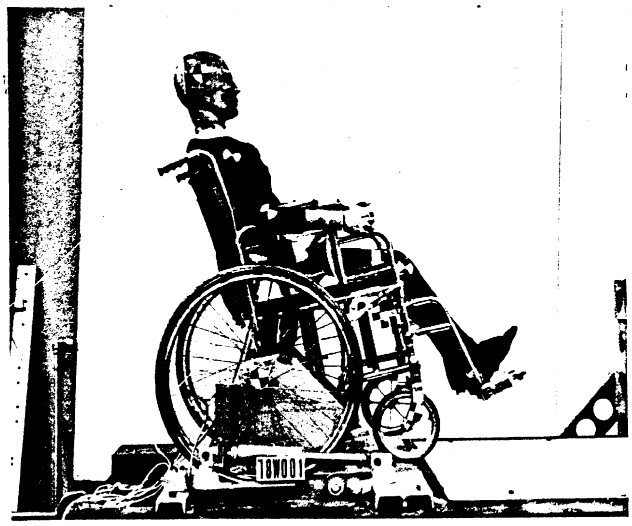
A significant part of the relatively large knee excursions observed is due to the manner in which the lap belt fits around the dummy. Because the attachment points for the belt on the triangles are forward of the seat back, the lap belt fits across the upper thighs rather than on the pelvic region. Placement of the belt anchor points further rearward (with perhaps some modification to the triangles) would provide for more effective lower-torso restraint.

It is also clear from these tests that a lap belt alone is not adequate. A shoulder harness or upper-torso restraint is required to keep the wheelchair occupant from impacting with vehicle surfaces. This restraint must, of course, be designed so that the handicapped individual can put it on and take it off with relative ease or its installation would be useless. For example, the belts of an inverted Y-yoke harness anchored to the van ceiling could be provided with clips that easily attach to the seat frame of the wheelchair and hook to the steering wheel when not in use. With some structural modifications to the wheelchair frame it is also conceivable that the upper torso restraint could be anchored to the wheelchair itself.

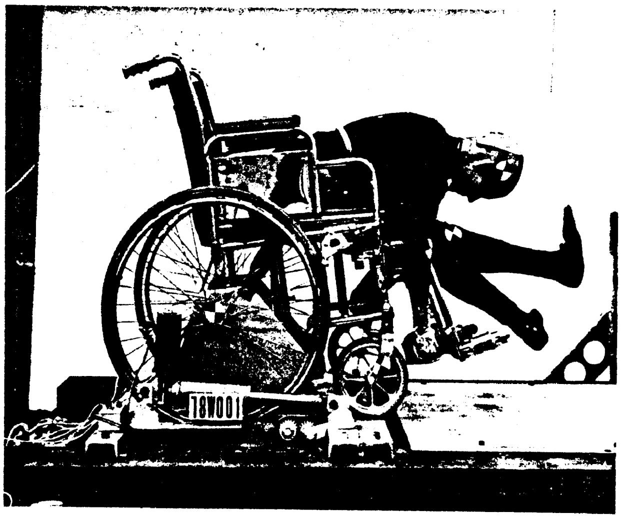
APPENDIX

PHOTOGRAPHS OF TEST RESULTS

78W001 5th Percentile Female (105 lbs), Forward-Facing, 20 m.p.h., 16 G's



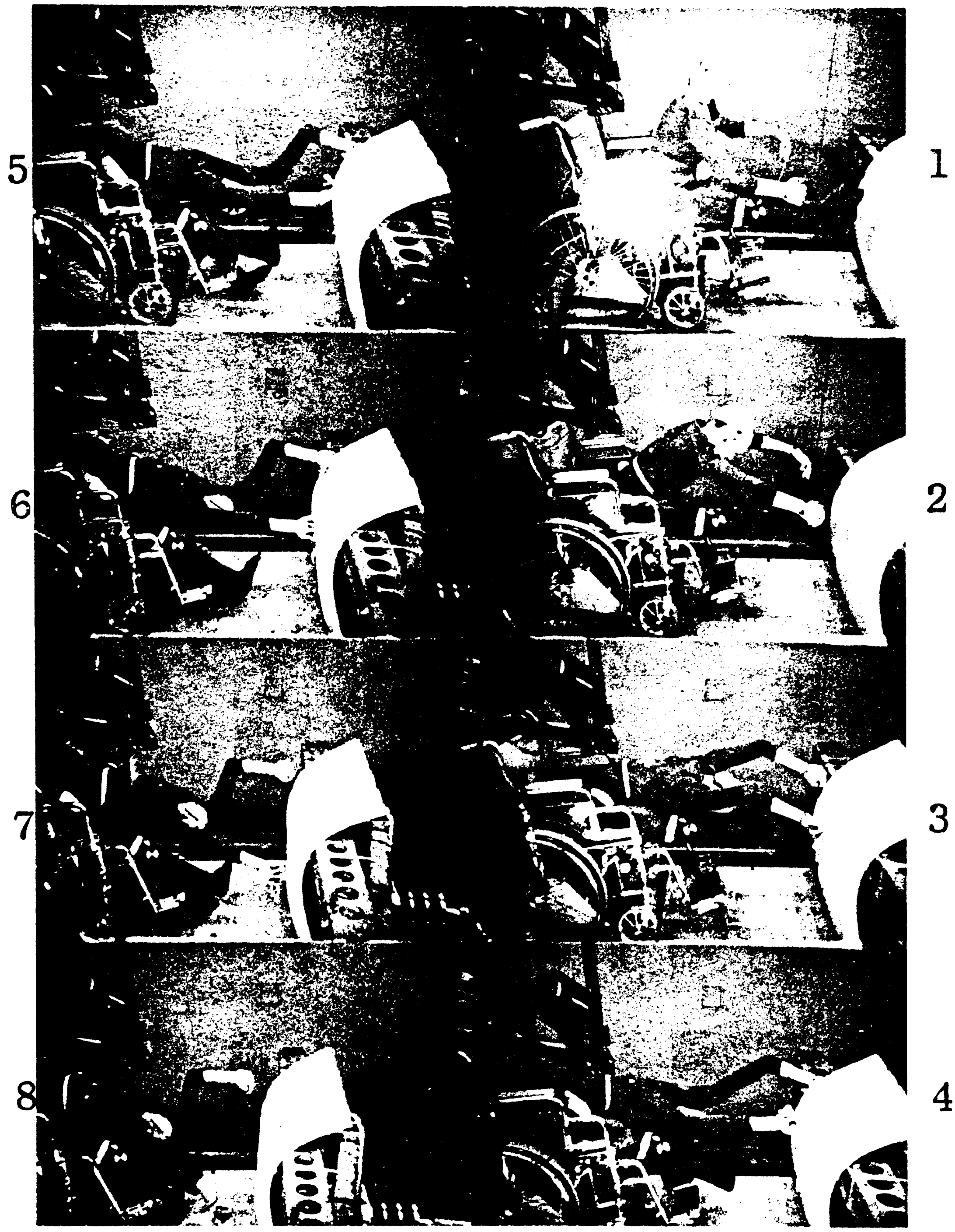
Pretest



Post test

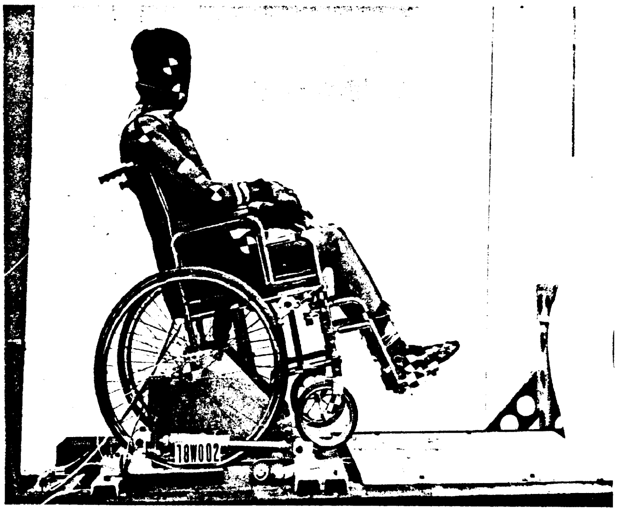
78W001 5th Percentile Female (105 lbs), Forward-Facing, 20 m.p.h., 16 G's

Polaroid Sequence Photograph



78W001

78W002 50th Percentile Male (160 lbs), Forward-Facing, 20 m.p.h., 16 G's



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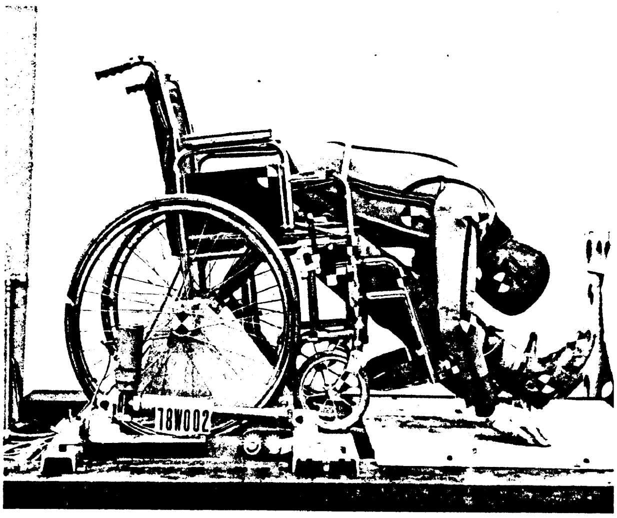

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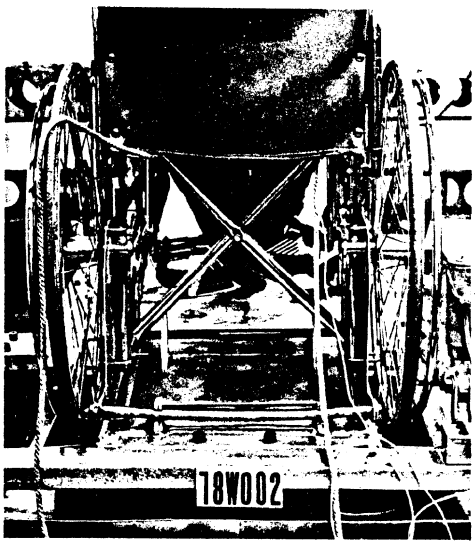
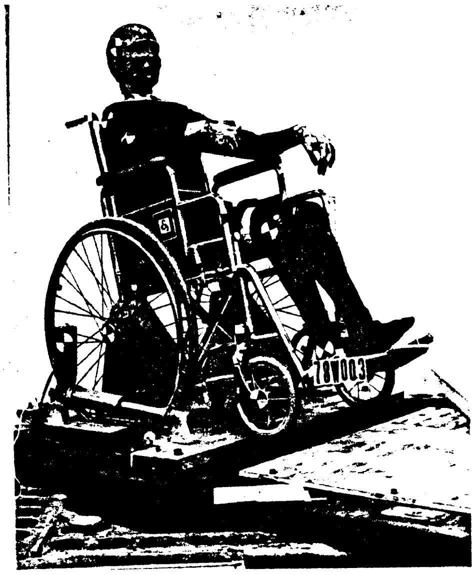


Post test
Rear view

78W003 5th Percentile Female (105 lbs), 45^0 oblique, 20 m.p.h., 16 G's



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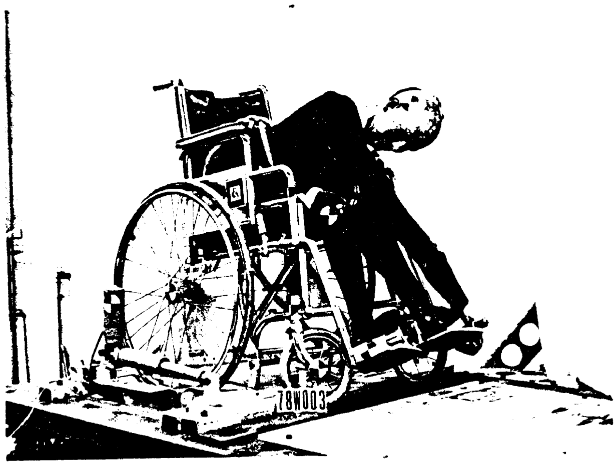
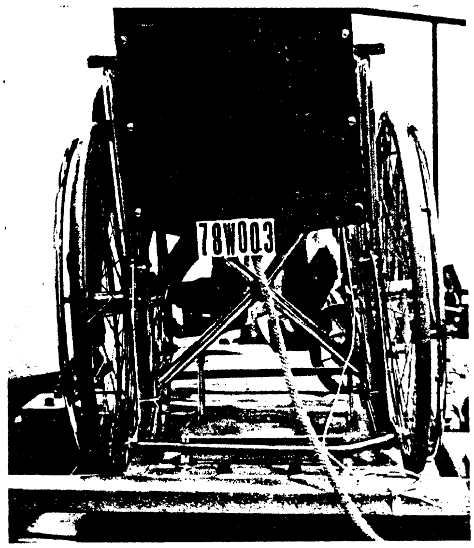


Post test



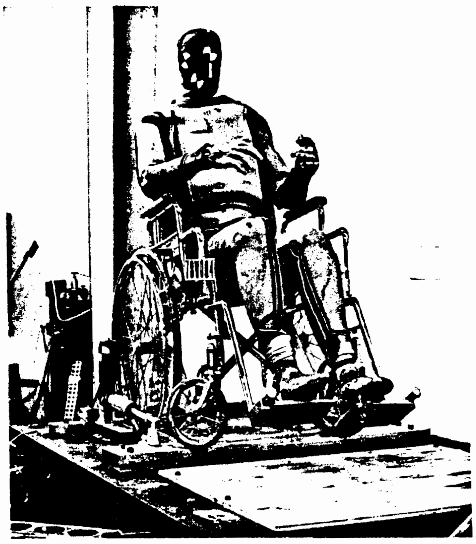
Post test
Rear view

78W003 5th Percentile Female (105 lbs), 45^0 oblique, 20 m.p.h., 16 G's

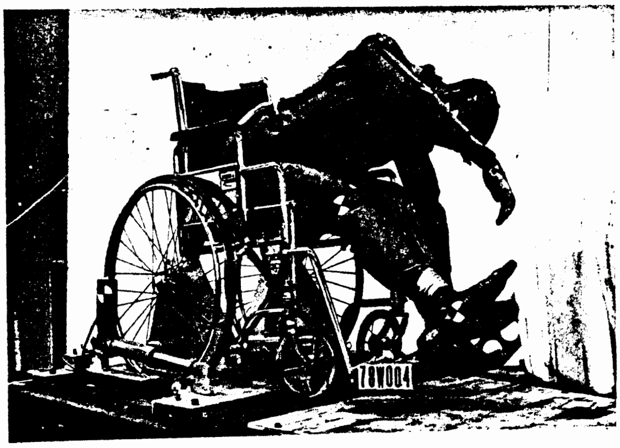
Polaroid Sequence Photograph

78W003

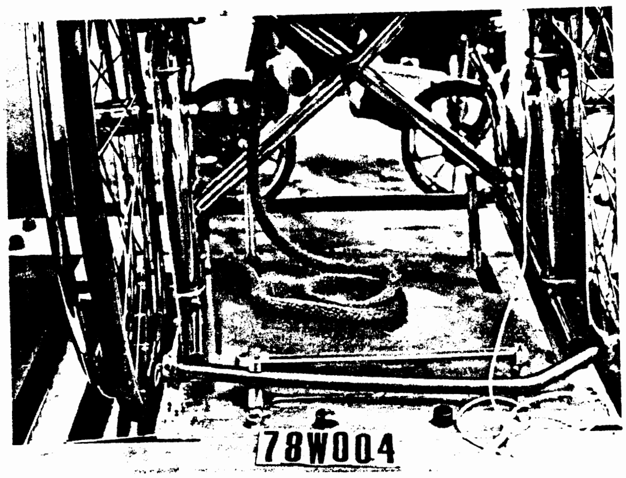
78W004 50th Percentile Male (160 lbs), 45^0 oblique, 20 m.p.h., 16 G's



Pretest



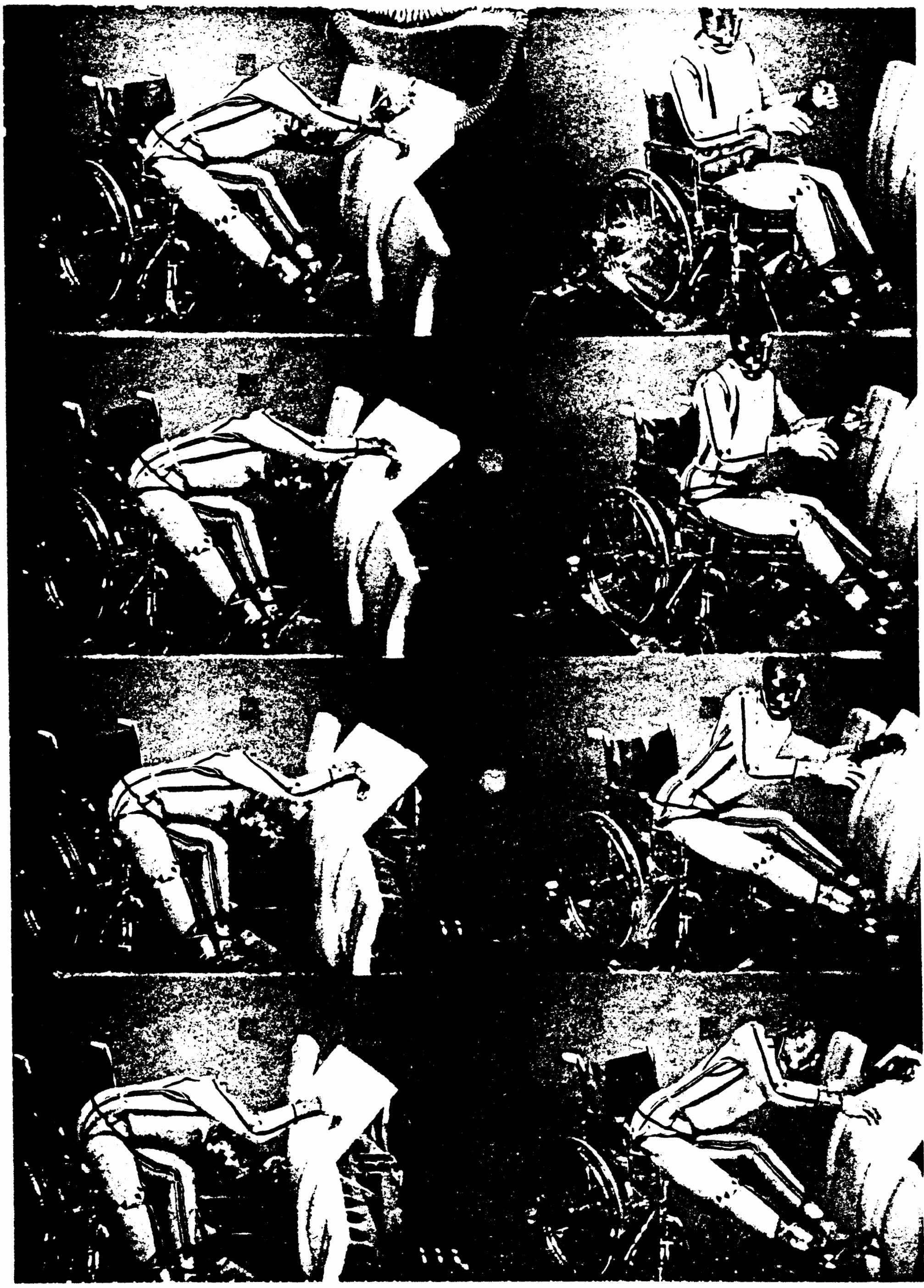
Post test



Post test
Rear view

78W004 50th Percentile Male (160 lbs), 45^0 oblique, 20 m.p.h., 16 G's

Polaroid Sequence Photograph



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78W004