In the Laboratory

Design for an Impact Decelerator[1]

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In an attempt to study the characteristics of forces imposed upon the human in an aircraft crash, an apparatus was constructed to deliver a known impact force of a given duration and direction to an individual. At the moment of impact in an aircraft crash the individual in the plane is thrown against the restraining shoulder straps and seat belt. A similar

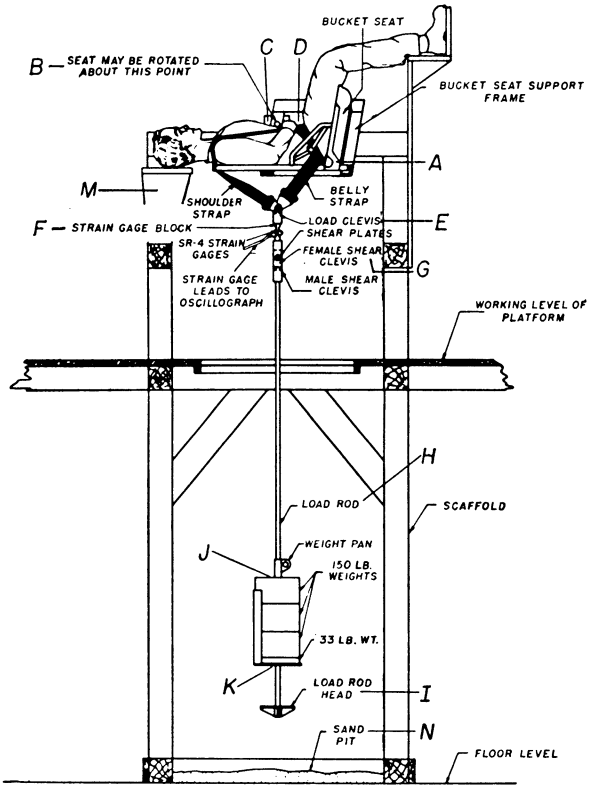

FIG. 1. Crash injury investigation setup, No. 1 series

effect can be obtained if the individual is held in a seat by shoulder straps and seat belt and, at a given time, these are suddenly jerked back against the body. The magnitude and duration of the force allow an estimate to be made of the acceleration of the restraining harness which that force produces. This impact force is transmitted to the individual through the harness.

APPARATUS

The apparatus consists of a scaffold arrangement upon which an aircraft seat is mounted horizontally (Fig. 1, A). The seat support is so constructed that it may be rotated about the center of gravity of the individual on the seat (B). The seat may be fixed in any given position by four set screws (C; see also Fig. 2) and by a long lever arm from the fulcrum to a cross bar. Regular pilot seats in current use may be mounted on this seat support, and the individual

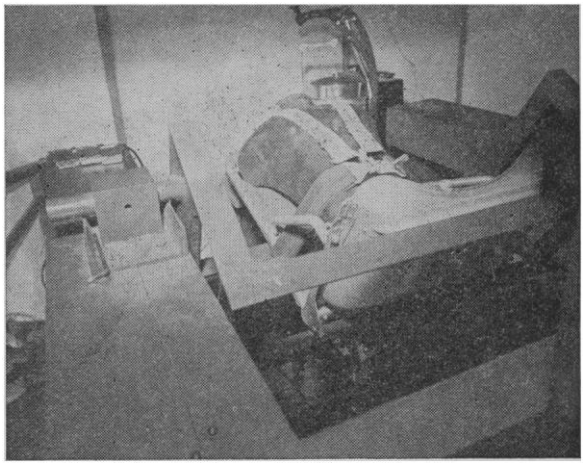

FIG. 2. A three-quarter view of the seat from above and forward; wood dummy secured in seat by shoulder straps and seat belt. The cubic metal block to the left supports the bar which allows longitudinal rotation of the seat. The hole in this block contains one of the four set screws to secure the seat in desired position.

is strapped in the seat with the regulation type of shoulder harness and lap safety belt (Fig. 2). The straps and the belt secure forward to a single quick-release mechanism (D; see also Fig. 2) and are joined behind in a single union at a clevis (E; also Fig. 3). This clevis distributes the weight uniformly to the shoulder straps and the lap safety belt if the length of the straps is adjusted correctly. Below the clevis a steel bar is attached, surrounded by a block gage composed of six SR–4 wire strain gages[2] (F). Immedi-

[1] The apparatus was constructed by the Taylor Model Basin, Carderock, Maryland, through the authority and aid of the following: Capt. H. E. Saunders, USN, technical director; Cdr. G. L. Smith, USN (Ret.); R. T. McGoldrick, S. F. Vane, J. S. Boyle, and L. A. Lofgren. The strain-gage recording elements were developed and kept in operation by L. D. Anderson and J. P. Hendrican. Their help is gratefully acknowledged.

[2] An element consisting of an arrangement of fine wire which is attached to a surface so that compression or tension of that surface will change the resistance and thence the current passing through the wire.

ately below the strain-gage bar is a shear block accommodating shear plates of different thicknesses. Di-

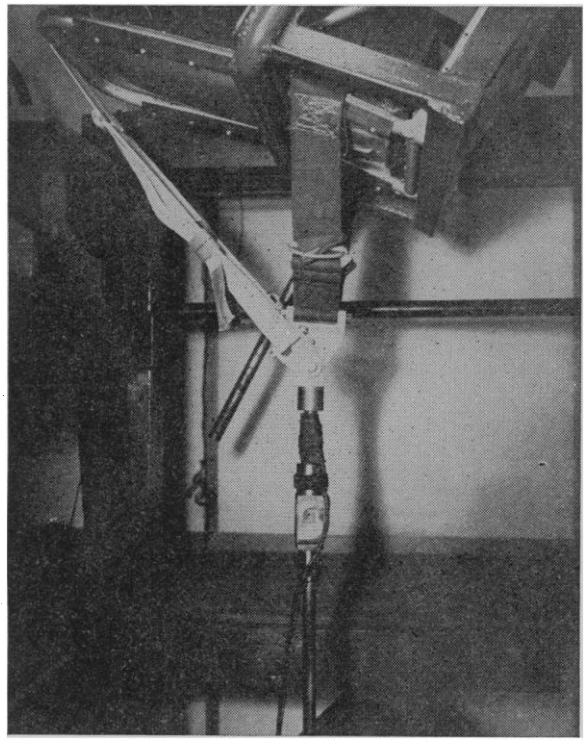

FIG. 3. View below the seat from the side, illustrating the attachment of the shoulder harness and seat belt to the clevis and suspension of shear block and rod. The strain gages are beneath the black tape between the clevis and the shear block. The long cross bar to help fix the seat in position is seen in the background. The headrest for the subject is up and to the left.

rectly below the shear-plate mechanism a 56-inch steel rod (H) is suspended from the male shear clevis, and a fixed arresting plate (load rod head, I) is secured to the bottom of the rod. A pan which supports the weights runs on this rod (J) and may be lifted to various heights along the rod and dropped against the steel arresting plate (Fig. 4). This produces impacts of various magnitudes of given duration. On the bottom of the pan is a circular, ¼-inch-thick, felt pad (K). The head of the subject is usually supported in the horizontal position by a headrest (M), which is separate from the seat. The bottom of the pit is filled wtih sand (N) to catch the rod, arresting plate, and weight as they fall free from the rest of the mechanism after the plate is sheared.

OPERATION

The subject is placed in the chair and the strap and shoulder harness adjusted about him in their correct position. A light load is then applied, and the weight allowed to hang on the individual so that he can adjust the shoulder straps and seat belt for comfort. A trained subject soon learns that impact forces

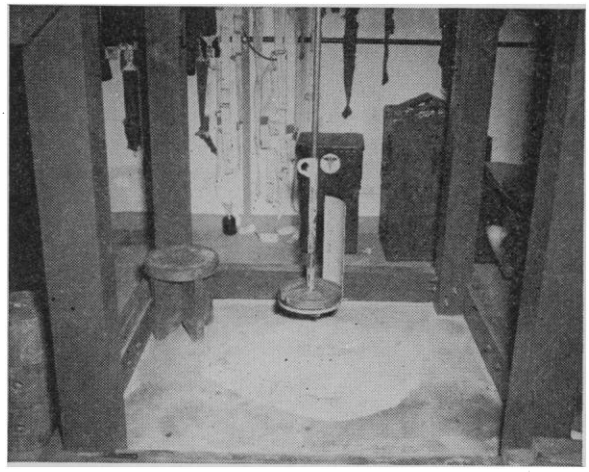

FIG. 4. Lateral view of pan and sand pit. The eye at the top of the pan permits lifting the heavy weights by a pulley system. The stool to the left is used to rest the pan and slack off the weight on the subject between drops.

can be withstood more easily if the force is taken up equally by the shoulder straps and the seat belt. The

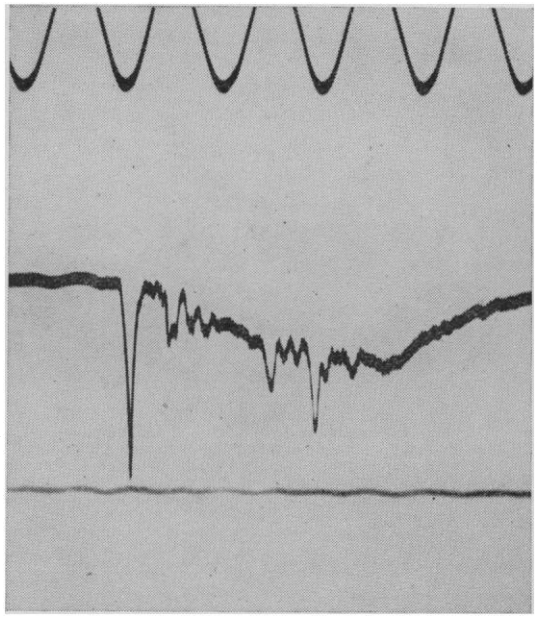

FIG. 5. Recording of the block strain gage. The initial high peak does not indicate forces being applied to the subject. It is probably due to forces set up in the linkage of the metal parts to which the belts and straps attach. The secondary section of the curve represents an impact force upon the subject of 936 pounds. The impact is completed in 70 milliseconds. A 60 cycle second wave is used for timing.

rod, the arresting plate and the pan (even without weight) should be supported below when a drop is not immediately anticipated. Since this assembly

weighs 56 pounds, it will soon tire the individual if he must support it even for short periods. After all recording devices have been standardized and calibrated and the individual is ready for the drop, the rod is swung free of its support and the pan is lifted to its predetermined height, bearing the desired weight. At a given signal the recording apparatus is set in motion, and the weight is dropped. The individual experiences a sudden application of force to his body, transmitted through the shoulder straps and the seat belt.

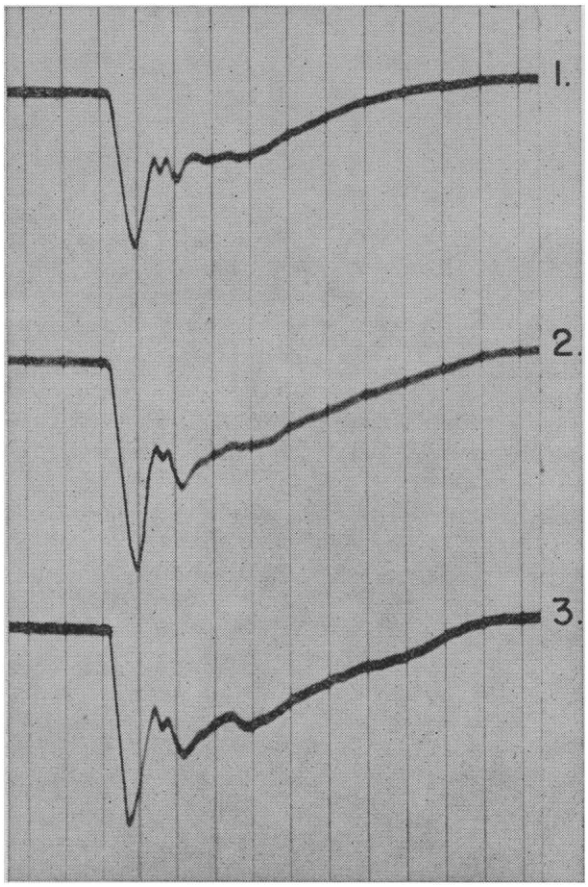

FIG. 6. A simultaneous recording of three beam gages placed in various positions under the shoulder straps. Timing lines indicate intervals of 1/60 second. These curves show both the magnitude and the duration of forces being exerted on the subject upon areas in contact with the gages. The peak force in each case is as follows: (1) 151 pounds, (2) 120 pounds, and (3) 134 pounds.

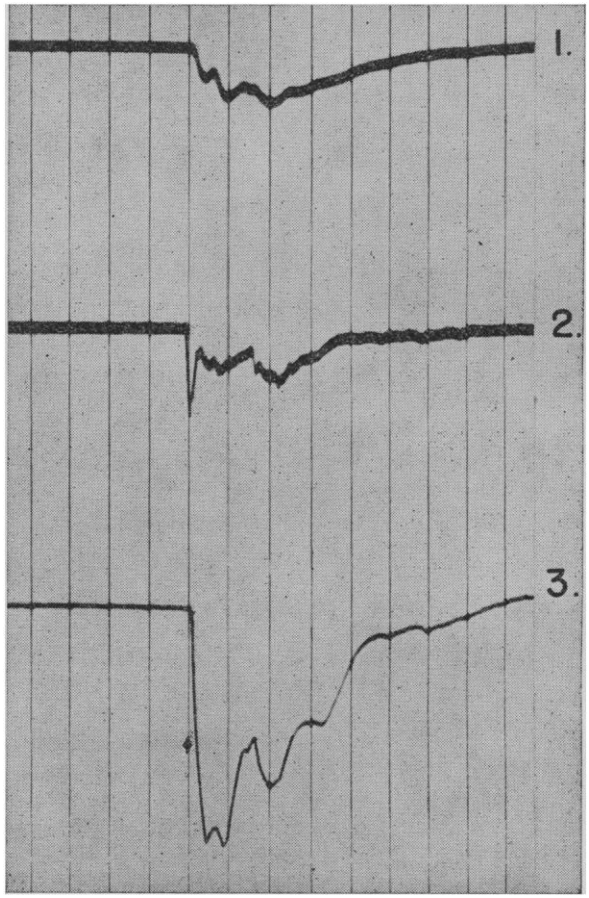

FIG. 7. A simultaneous recording of two beam gages (Curves 1 and 3) and the block gage (Curve 2). The shape of these curves depends upon the position of the strain gage and the type of recording element used. The peak force indicated in each case is as follows: (1) 57 pounds, (2) 713 pounds, and (3) 166 pounds.

The impulse detected by the strain-gage mechanism is amplified electrically and recorded with a string galvanometer. The total force applied to the rod is measured by the block gage (Fig. 5). This group of strain gages permits a reliable estimate of the forces delivered and averages the amount of stretch in the steel bar. The force applied to the body at shoulder straps and seat belt may be recorded separately at any point on the belt or strap by inserting beam-type strain gages at the desired location. Examples of these recordings are shown in Fig. 6. The total force and the forces exerted at positions beneath the restraining harness may be recorded simultaneously (Fig. 7).

The seat may be rotated about an axis in the horizontal plane. This permits a simulation of crashes in a nose-down or nose-up position. The shear-plate mechanism serves as a protection against unanticipated large loads being dropped on the subject inadvertently. It also permits the application of a single impact load to the subject without continued oscillation or bouncing. The duration of the impact may be increased by placing various types of soft material such as putty, felt, or rubber on the plate. During the drop of heavy weights from high distances it is wise to have the head supported free and flexibly

because of the large amount of jarring. Frequently the neck will be flexed forward to an extreme position if the head is supported firmly behind.

Limitations of the Impact Decelerator

One serious objection to this apparatus is that the seat belt does not strike the individual in exactly the same area as it may in an aircraft accident. A set of side-arm rollers which are attached to the seat allows the seat belt to simulate more closely its position in the aircraft (Fig. 1). However, in this type of seat the rollers and side arms absorb 60–70 per cent of the applied force, so that the weights which are dropped on the individual must be increased accordingly to obtain the same impact force as is delivered with the original type of seat.

Another objection is that the vascular system of an individual in position in this apparatus may behave quite differently on impact than if he were sitting upright. This influences responses such as blood pressure and pulse rate immediately following impact. The horizontal position also displaces the viscera posteriorly and superiorly. Visceral movement is more restricted during impacts in this device than it would be in an actual aircraft crash. It must be stressed that the straps, and not the individual, are accelerated. This simplifies observations by electronic and photographic devices during the impact.

The trained subject soon learns to brace himself for impact loads and develops his own technic for taking the simulated crashes. Some individuals tense all muscle groups for the impact, while others relax. It is undoubtedly true that some of the force of the impact is absorbed during an actual crash by the legs and thighs extended against the rudder pedals. Such an opportunity is not present in this apparatus.

Addendum. Since the submission of this paper for publication, studies of controlled aircraft crashes have shown the duration of deceleration of dummies restrained with the regulation restraining harness to vary from 55 to 90 milliseconds. This enhances the usefulness of the impact decelerator for continued investigations in aviation safety.

Letters to the Editor

Suggestions Regarding Principles Acting in the Use of the Bantu Divining Basket

Throughout the Bantu tribes in Africa the divining basket plays an important part in the life of the people. In times of concern and anxiety over illness, the absence of relatives, or adverse agricultural and economic conditions, the services of the diviner are sought. He is an important figure in the community and has learned his art while a young man from an older diviner. The divining basket is a woven basket containing 40–80 articles and covered by a lid. The articles can be described as fetishes, images, and objects having symbolic representation, such as a wounded man, a pregnant woman, etc. For example, the basket usually contains: a duiker horn, the wide open end at the base signifying 'mouth' ("a scolding mouth," "one who talks too much," etc.); a piece of organic tissue representing the placenta; white chalk, meaning innocence; a turtle bone, signifying a patriarch of the family; a piece of stone worn smooth by running water, which means that the patient is being worn down by one pain or trial after another. The diviner shakes the basket in such a way as to manipulate any article to the top of the pile. He then prophesies from the basis of the article at the top of the basket. On many occasions the diviner makes a prophecy which is fulfilled.

It is suggested that two factors are important in the success of the diviner. One is that he is conversant with the situation from local gossip and his position in the village. This is recognized by his clientele, who frequently seek the services of a diviner from another village, fearing that their local diviner may manipulate the fetishes so as to render a course of action favorable to his personal interests or the interests of his vested group.

The second suggestion is that the diviner uses the objects in the basket as a projection test, comparable to Rorschach's Psychodiagnostic Plates. Although he does not insist that his client discuss each object brought to the top of the basket, he has been observed to watch his subject closely, apparently for any responses, verbal and nonverbal. It has been noticed that in the absence of a response to a certain object the diviner will shake the basket again, bringing a different article to the surface. It seems reasonable to presume that over years of experience, working in a specific society, the diviner has learned empirically the characteristics of responses which are related to different types of individuals under various stresses. By observing facial responses, bodily gestures, any exclamations or remarks, and reaction times, he could appraise the individual from these projections, and with a knowledge of local situations he could render a decision which would be more likely to be adequate than if chance alone were the only factor operating.

This hypothesis has been advanced to attempt to relate an important phase of Bantu life, which on first atten-