NASA EXPERIMENTS ON THE B-720 STRUCTURE AND SEATS

Emilio Alfaro-Bou
NASA Langley Research Center
Hampton, Virginia

NASA/FAA Government/Industry CID Workshop
NASA Langley Research Center
April 10, 1985

NASA EXPERIMENTS ON THE B720 STRUCTURE AND SEATS

This presentation addresses the two NASA LaRC experiments onboard: a structural experiment and a seat experiment.

The structural experiment deals with the location and distribution of the instrumentation throughout the airplane structure. In the seat experiment, the development and testing of an energy absorbing seat are discussed.

OBJECTIVES

STRUCTURAL EXPERIMENT

The objective of the structural experiment was to obtain a data base of structural crash loads for use in the advancement of crashworthy technology of materials (such as composites) in structural design and for use in the comparison between computer and experimental results.

SEAT EXPERIMENT

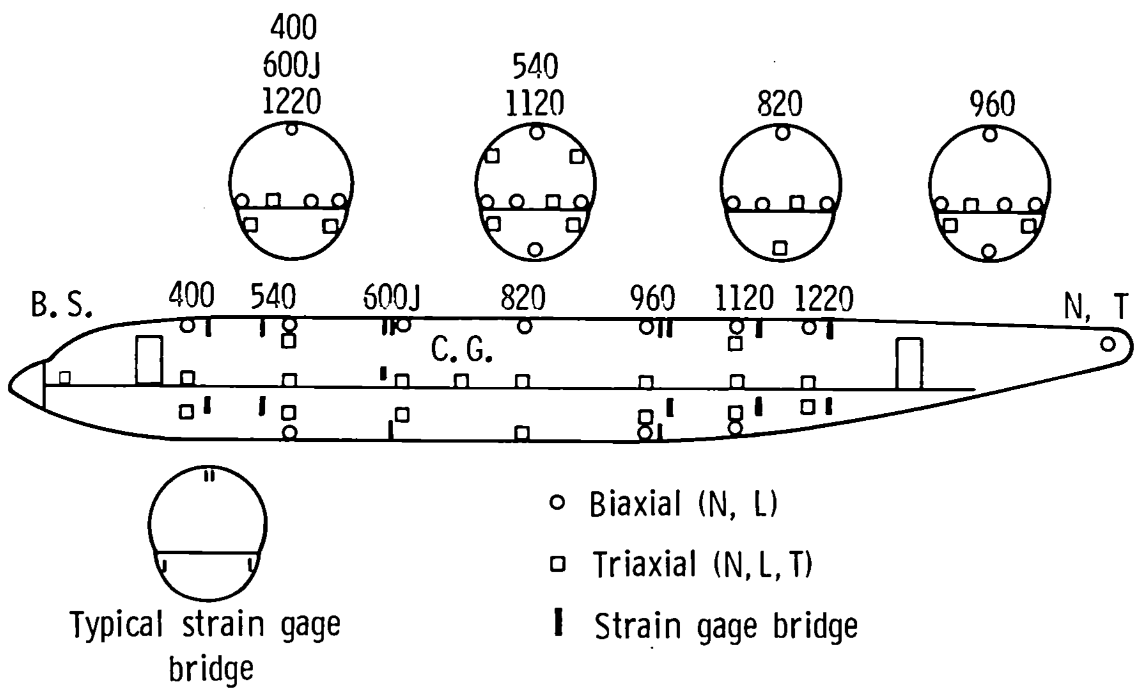
The objective of the seat experiment was to compare the performance of an energy absorbing transport seat and a standard seat when subjected to similar crash pulses.

- To obtain a data base of structural crash loads for advancing the crashworthiness technology in materials and structural design

- To compare the performance of an energy absorbing seat to a standard transport seat

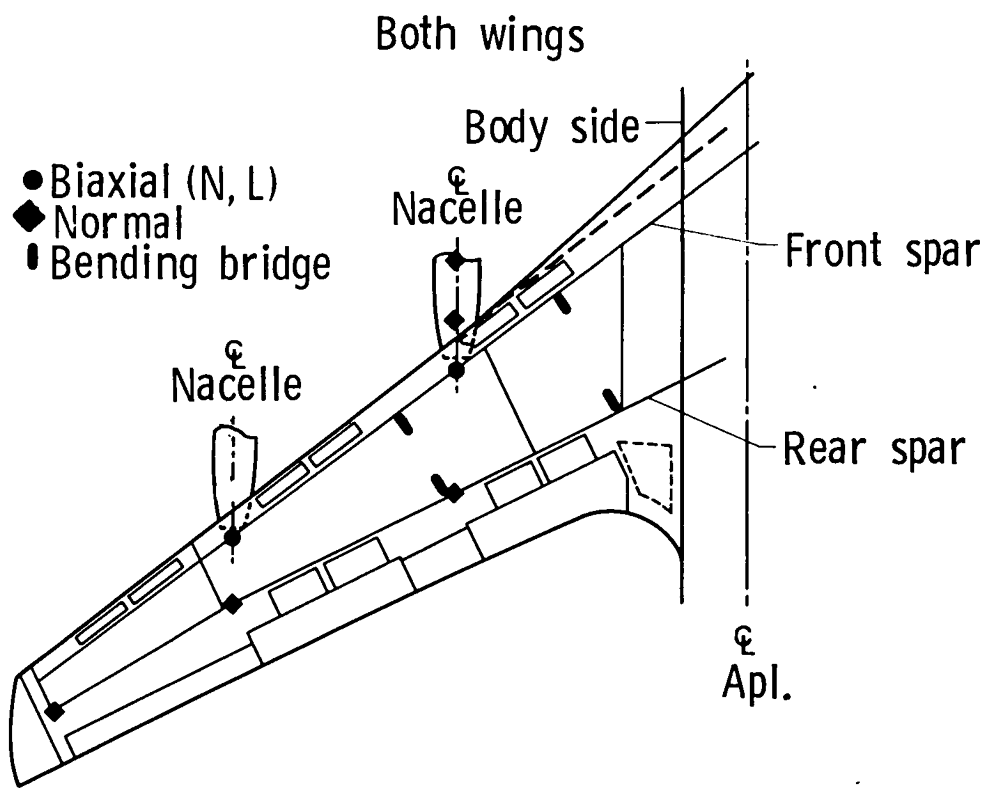
C.I.D. FUSELAGE INSTRUMENTATION

To measure acceleration time histories along the fuselage, distribution of accelerometers was concentrated in seven fuselage frames. Three frames were selected forward in the fuselage, three frames aft, and one frame in the center (wing box). The cross-section of the frames as viewed from the rear of the fuselage shows the placement of accelerometers to measure load transmission from bottom to crown. In addition to the accelerometers located in the seven frames there was a triaxial accelerometer mounted on the floor under the pilot's seat, a triaxial mounted at the center of gravity, and a biaxial mounted at the tail end of the fuselage. Also shown is the location of eight bending bridges to measure the vertical bending moment of the fuselage.



C.I.D. WING INSTRUMENTATION

On the wings, there were three normal accelerometers located on the rear spar. One accelerometer was located on the wing tip and the other two were located in line with the outboard and inboard engines respectively. Two biaxial accelerometers were located on the front wing spar in line with the engines. Two normal accelerometers were located on the inboard engine pylon, one in front and one in the rear. To measure spanwise bending moments in the wing, one strain gage bending bridge was located inboard on the wing and another outboard. The two wings were instrumented in a similar manner.



C.I.D. MEASUREMENTS

A total of 350 instruments were mounted throughout the airplane of which 187 were mounted on the fuselage structure and wings, 157 on the seats and dummies, and 6 on the overhead bins.

I Fuselage:
- Accelerometers 157
- Bending bridges 8

II Overhead bins:
- Accelerometers 3
- Load links 3

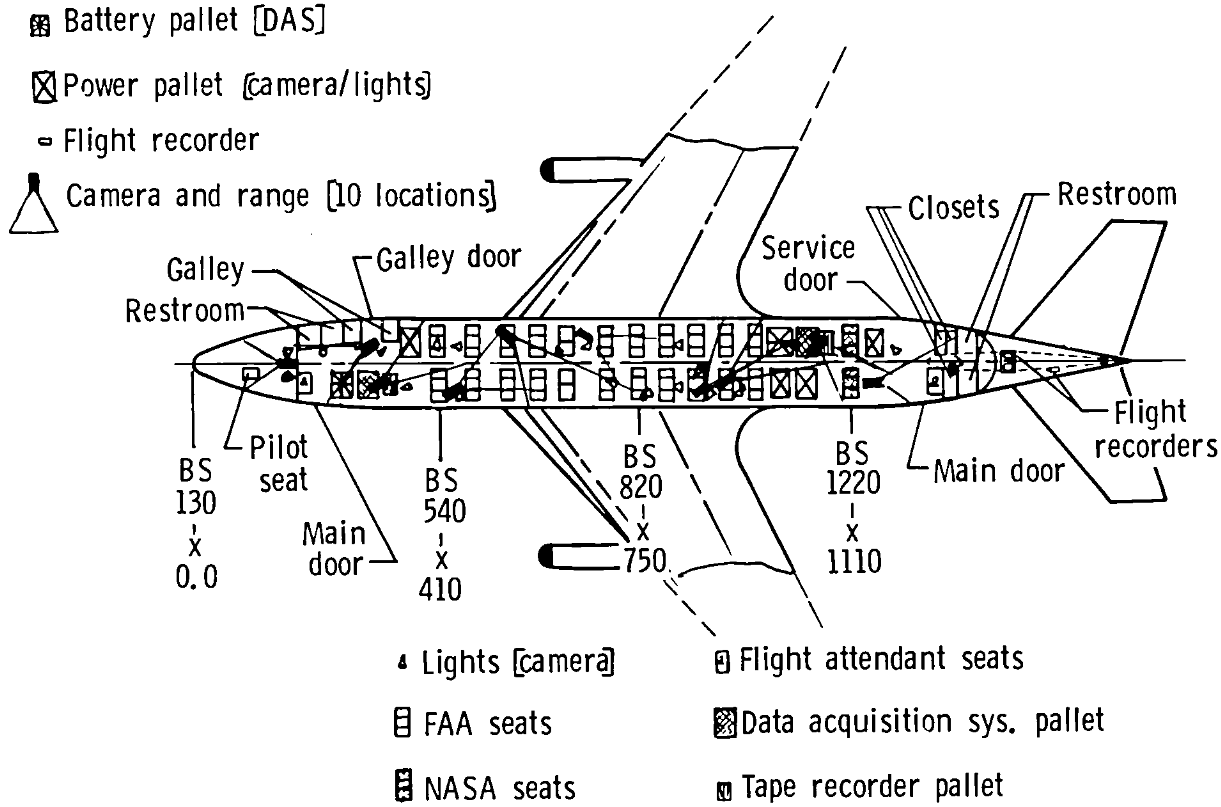
III Wings:
- Accelerometers 18
- Bending bridges 4

IV Seats:
- Accelerometers 75

V Dummies:
- Accelerometers 52
- Load cells 30

C.I.D. PLAN VIEW

This plan view of the cabin interior shows the location of the two NASA seats in Body Station 1220. The energy absorbing seat was located on the left and a standard commercial seat was located on the right. The other 25 seats were part of the FAA seat experiment. Also shown are the locations of the data acquisition system and its power supply, the photographic camera/lights and power pallet, and tape recorders.



B720 CABIN INTERIOR

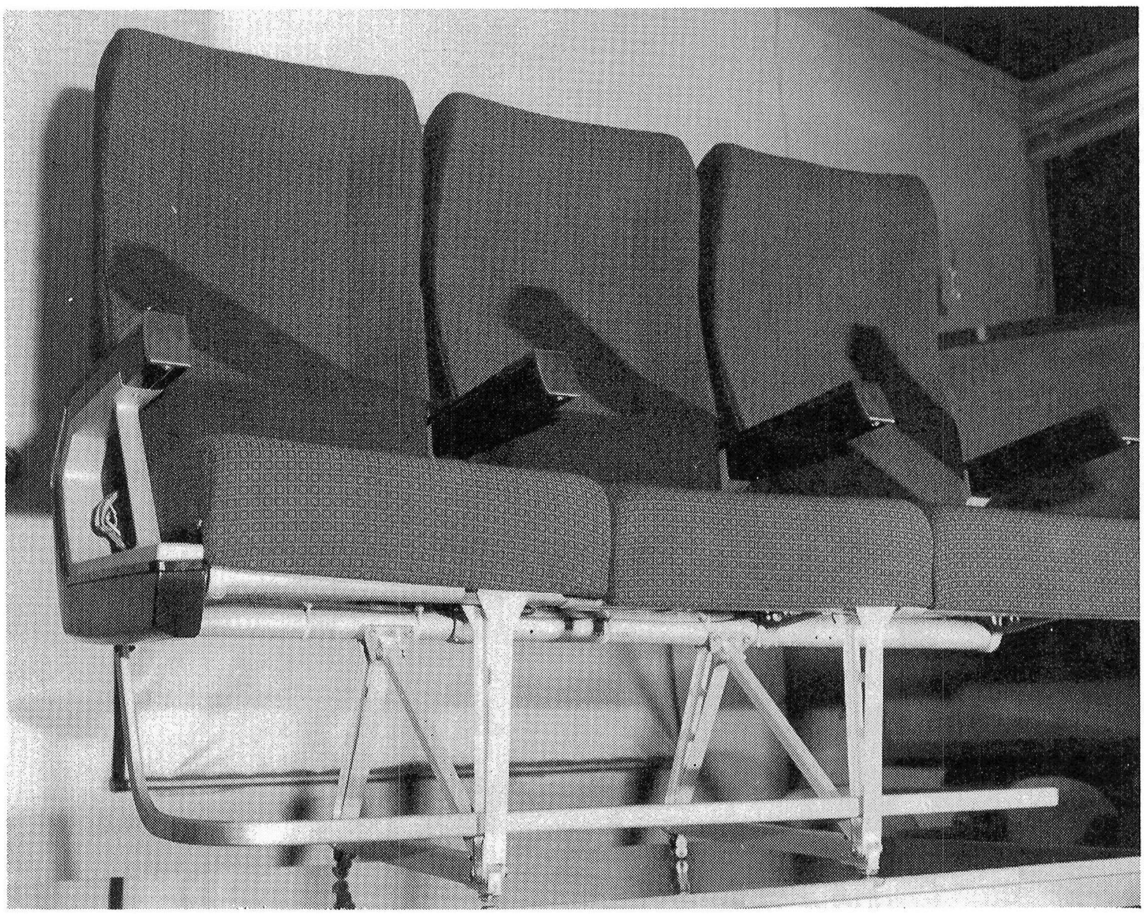
In this view of the rear cabin interior some of the seats, anthropomorphic dummies and CPR dummies are shown. The two NASA seats are located in the rear. Also shown are some of the cameras and lights used in photographing the dummies and seats during the crash sequence.

DUMMIES IN CRASH POSITION

In both NASA seats the dummies were placed bent down in an assumed crash position as shown here. The 50 percentile anthropomorphic dummy at the center in each seat was instrumented with a triaxial accelerometer at the pelvis and with a load cell at each side of the lap belt.

AIREST 2000 TRIPLE SEAT

The standard seat used in the NASA experiment at Body Station 1220 on the right side was a Fairchild Burns Airest 2000 in which the seat cushions were covered with heat blocking material. A similar seat was converted into an energy absorbing seat by replacing the two diagonal members with graphite epoxy energy absorbing tubes. To allow the energy absorbers to load during the crash impact the bolts that fastened the seat legs to the seat frame tubes were replaced with a bearing surface around the tubes.

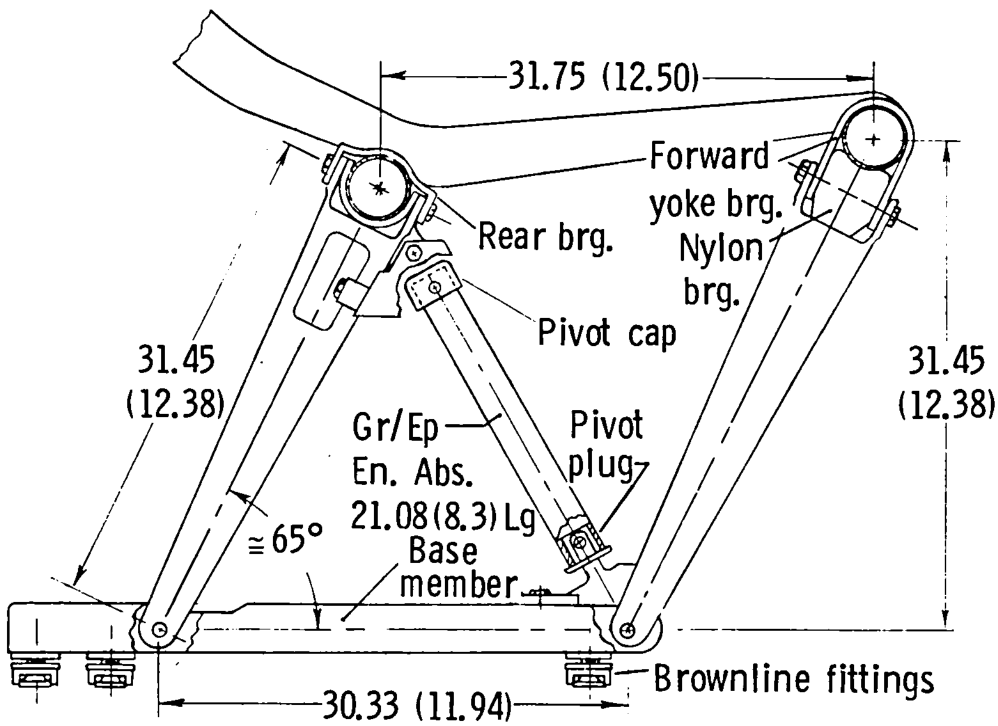


TRANSPORT ENERGY ABSORBING SEAT

The two diagonal energy absorbers and the four bearings attached to the upper portion of the seat legs are shown. The seat frame accelerometer block is shown mounted midway on the rear tube. On the airplane, a triaxial accelerometer was mounted on the floor seat track to determine load transmission from the floor to the seat. The seat cushions were covered with a heat blocking material to retard the propagation of fire.

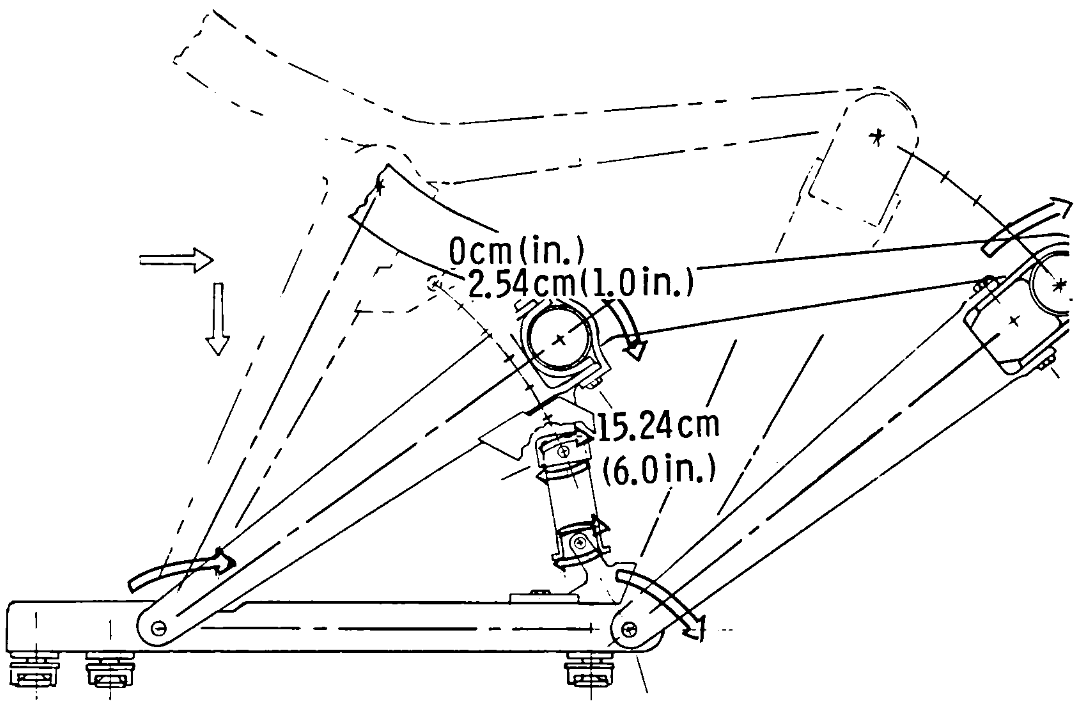
MODIFIED AIREST 2000

Modifications to the seat are shown in more detail. They include the front and rear leg bearings, the graphite epoxy energy absorber and its pivoting mechanism, and the base member with the brownline fittings.



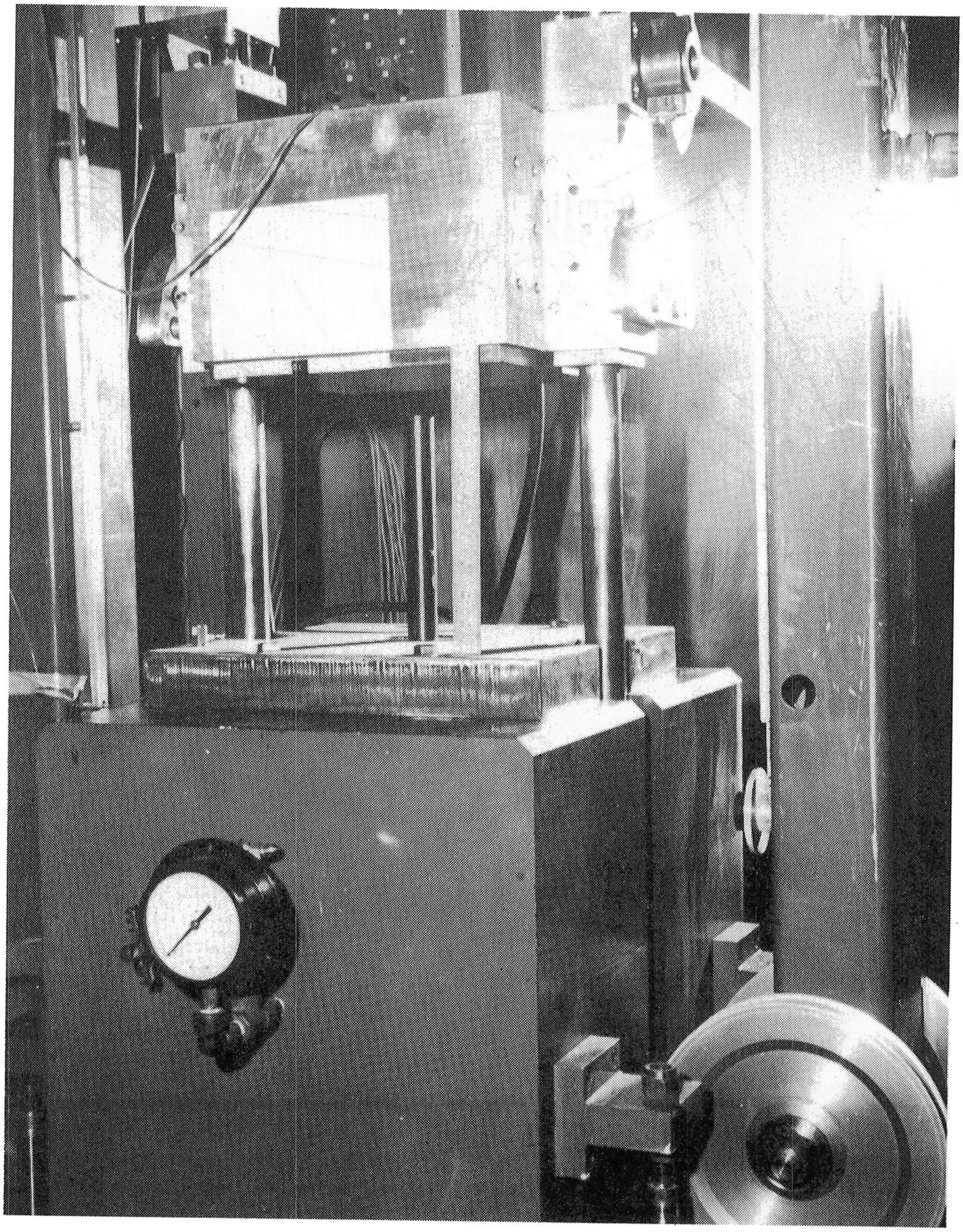
SEAT STROKE GEOMETRY

The stroking action of the energy absorbing seat is depicted in this view. Outlines of the seat in its normal and stroked positions are shown. During stroking, the seat, which is a four-bar linkage, moves downward and forward causing the energy absorber to stroke approximately 6 inches.



ENERGY ABSORBING TUBE IMPACT TEST

The energy absorbing graphite-epoxy tube was impact tested in this machine to investigate its dynamic response during collapse. Of particular interest were the mechanism by which gradual crushing of the walls occurred and the tube stability during stroking. In the test, the tube stroked 6 inches which is also the maximum stroke the tube is subjected to when installed in the seat.

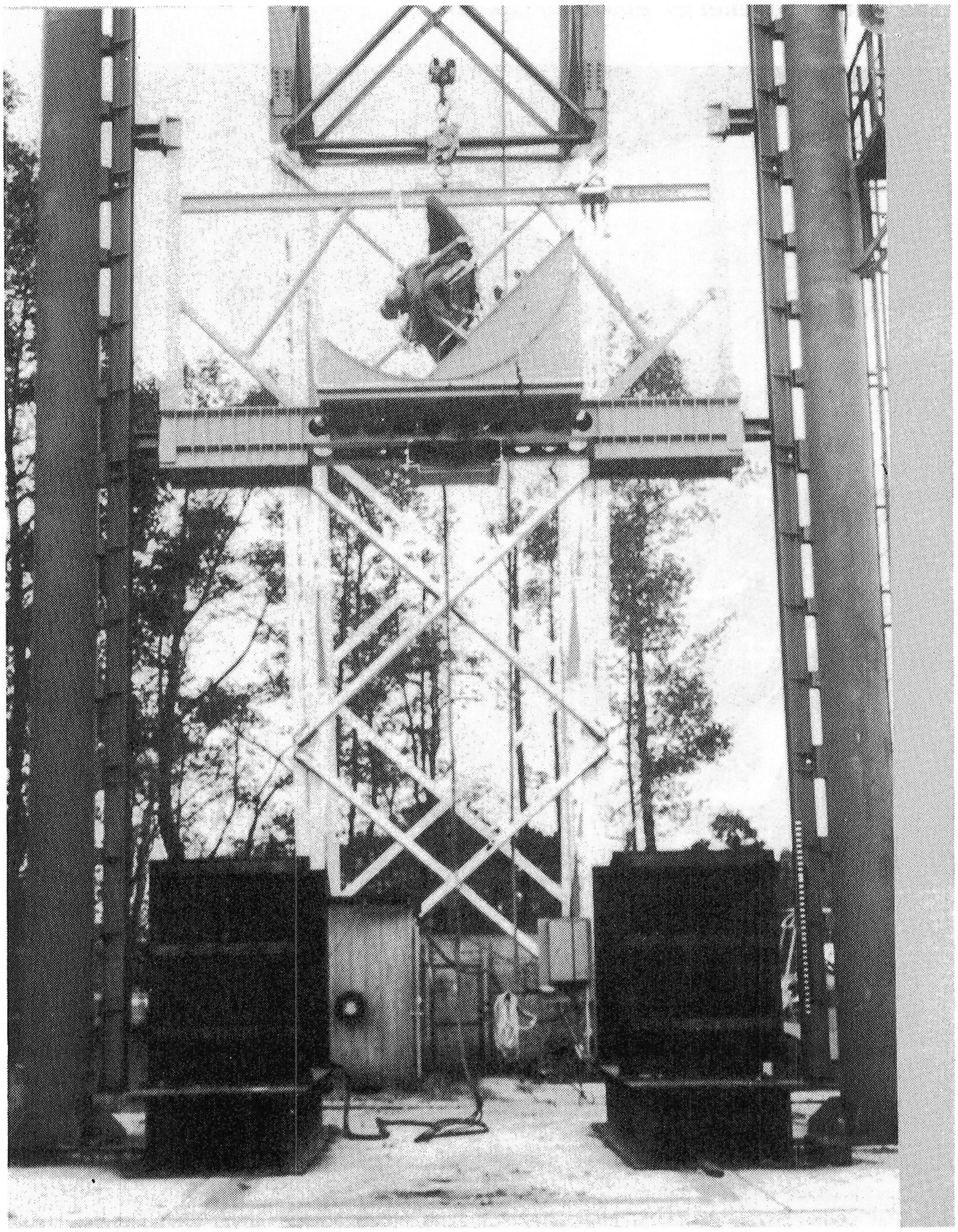


STATIC SEAT TEST

This is the static seat test configuration. It shows the seat mounted on 6-axis load cells under each seat leg. The load cells measure moments in 3 axes and triaxial forces. The seat was loaded in the vertical direction to check the operation of the stroking mechanism. In earlier static tests it was found that during stroking, the energy absorbers were subjected to bending loads and failed prematurely. This difficulty was corrected by installing a self aligning mechanism that held the energy absorbers in place and prevented transmission of bending loads to the energy absorbers by allowing only axial loads in line with the energy absorber axis.

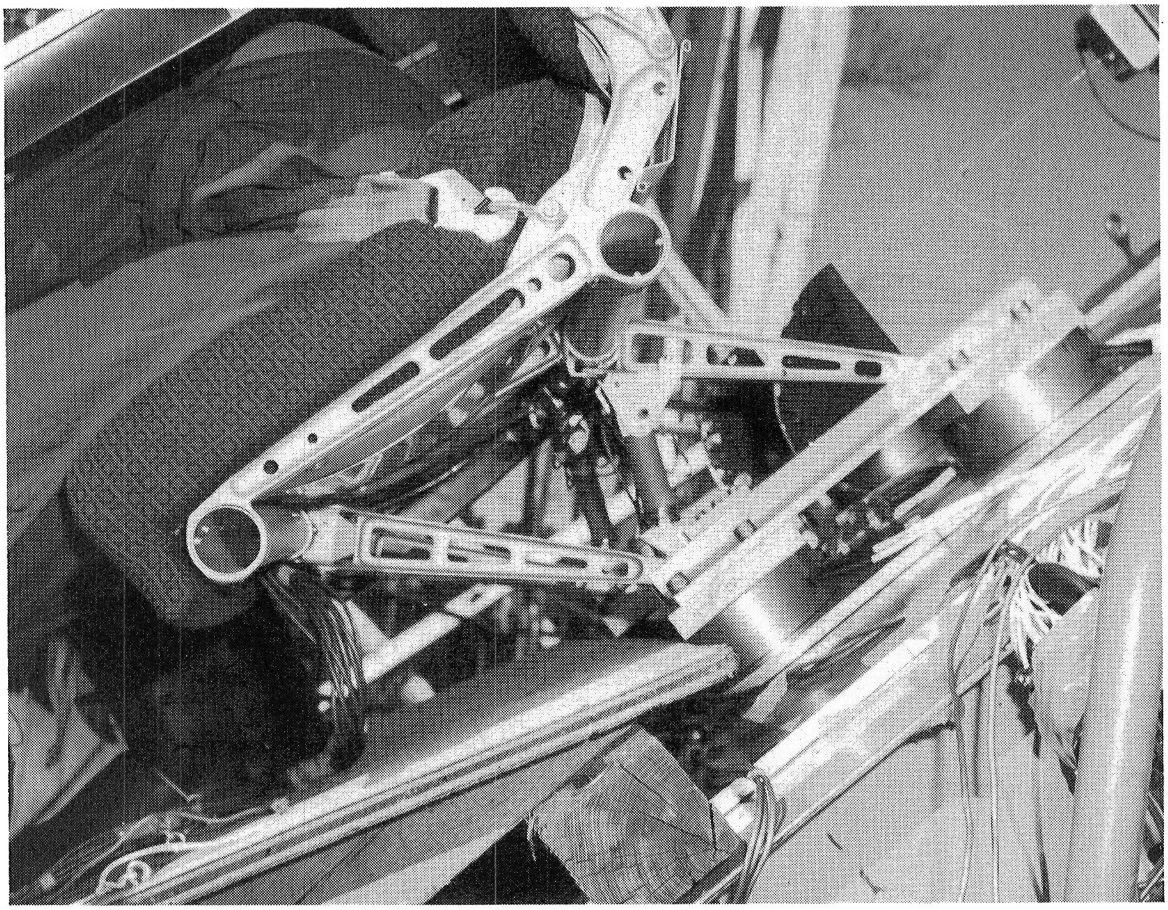
DYNAMIC SEAT TEST

To dynamic test the energy absorbing seat, the sled was raised to a height of 14 ft to achieve an impact velocity of 30 ft/sec and a peak acceleration of 14 g with a 120 ms pulse duration. The dummies were bent in a crash position to simulate the effects of a real crash. The drop tower is 75 ft high and impact velocities to 50 ft/sec are possible. Impact pulses can be obtained with up to 50 g peak acceleration and 50 to 150 ms pulse duration by varying the number of straps (2" wide x 3/8") in the pulse generating system.



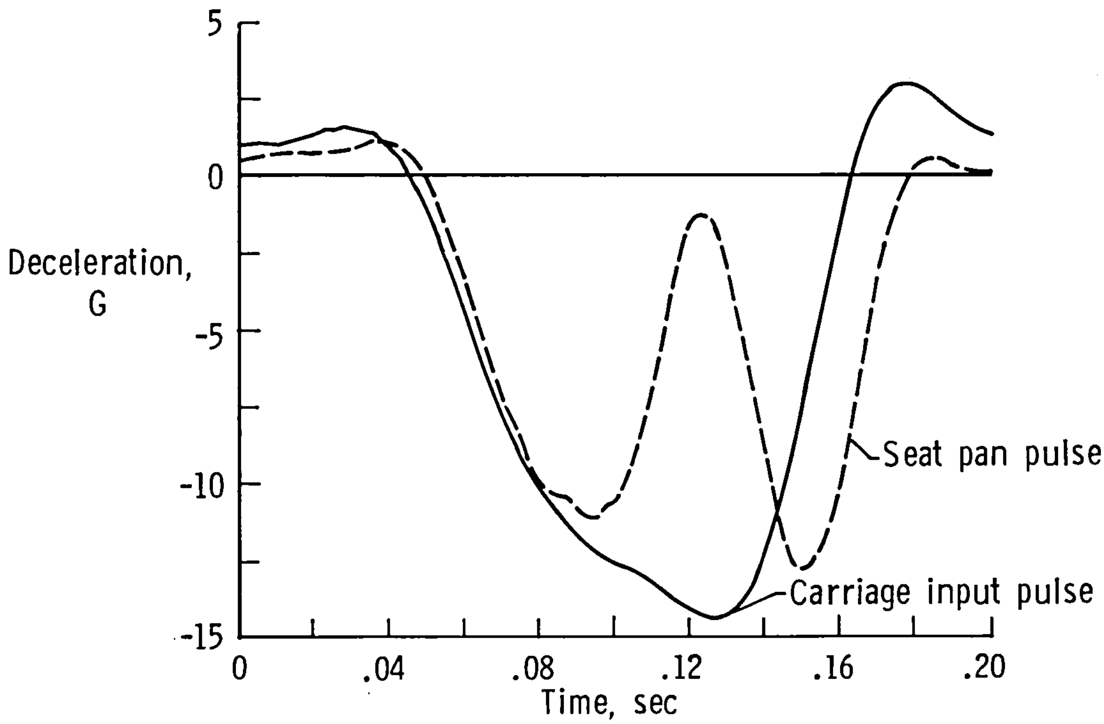
DYNAMIC IMPACT TEST - STROKED SEAT

The energy absorbing seat is shown in the stroked position after the drop test. The seat started to stroke at approximately 11 g's and the stroke length was about 5 inches. The seat and energy absorbing mechanism worked satisfactorily.



DYNAMIC SEAT TEST PULSE

The solid line represents the carriage impact pulse (vertical). A peak acceleration of 14 g's at 120 ms duration was obtained. The dashed line is the seat pan acceleration time history and the data was taken from an accelerometer at 45 degrees to the horizontal. The seat pan pulse duration at 10 g is approximately 25 ms and falls within the voluntary human exposure area in the EIBAND curve.



HEADWARD ACCELERATION LIMITS

It is desirable to design a seat to absorb the maximum energy possible during a crash without injuring the seat occupant. To accomplish this, the seat is designed to limit the maximum acceleration transmitted to the occupant to a value not to exceed the human tolerance level. The chart below gives tolerance levels below 15 g's that could be used to limit acceleration values in the vertical direction in seat design. Values of 10 g at 25 ms were measured in the transport seat and it can be seen that these values fall within the voluntary human exposure levels in the chart.