# XB-70 ESCAPE SYSTEM

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The B-70 weapon system became an active project late in 1957 when North American Aviation was given a contract for development and fabrication of air vehicles. This contract included a requirement for a crew escape system which would be effective over the entire flight profile and which would be compatible with a "shirt sleeve" operating environment. The B-70 air vehicle is capable of Mach 3 performance at altitudes above 70,000 feet. When this altitude and speed capability was combined with the "shirt sleeve" requirement it was apparent that a crew member would require some protection from the pressure and windblast environment to which he could be subjected in an emergency escape. Some means of encapsulating each crew member was required in order to permit sufficient pressurization for survival during an escape from the higher altitudes of the B-70 flight profile.

Two concepts for providing the encapsulated escape environment were investigated. The breakaway nose concept with separation device and recovery chute was examined as one possible solution. The encapsulated ejection seat concept was also considered, and was selected for several reasons. First, it provided an escape capability from 90 knots at ground level thru the maximum performance capability of the B-70 air vehicle. Second, it imposed the least weight and performance penalty on the design of the air vehicle. Third, the cost of developing and testing the encapsulated seat concept was estimated to be lower. One factor which was pertinent was the plan to use the same encapsulated seat in the F-108 which was being worked on concurrently with the B-70 by North American.

Figure 1 shows the general location of the crew members in the crew station of the B-70 as originally planned. The present program for fabrication of three XB-70 air vehicles limits the number of crew members per airplane to two in the first two air vehicles. The third XB-70 will have four crew members located essentially as shown in Figure 1.

Figure 2 shows the open capsule with the occupant restrained by a lap belt and shoulder harness. This restraint system is manually attached at buckles located in the lap belt and on the chest. The shoulder harness is attached to an inertia reel in order to provide the seat occupant with freedom of movement. In addition to the usual features of an inertia reel, this reel has an automatic feature which functions to retract the occupant during the ballistic encapsulation cycle of the capsule.

The capsule, itself, is composed of a seat, shell, clamshell doors, stabilization devices, recovery parachute system, impact attenuator and survival equipment.

The capsule shell and doors are of moulded aluminum honeycomb construction. Windows are located in the doors and the shell so that the occupant may monitor his instrument panel while he is encapsulated and may observe the performance of his parachute and impact attenuator during an escape.

Figure 3 shows an inboard profile of the capsule and seat in the normal flight position and the encapsulated or ejection position. The seat occupant, in normal flight, sits well forward of the capsule shell, with relatively unrestricted mobility, vision and comfort. Actuation of either of the two control levers located on the sides of the seat ballistically retracts the seat and occupant into the shell, stows the control column, closes the two doors from top and bottom and pressurizes the capsule interior. From this condition, the occupant can eject or he may elect to stay in the air vehicle and descent to a lower altitude using an emergency control. This control is stowed in the survival kit container which is located on the left inside wall of the capsule shell opposite the occupants head. If he elects to eject he may do so by pulling either of two triggers which are exposed only when the handgrips are raised and can be operated only when the seat is retracted.

The ballistic encapsulation procedure is a one shot procedure and takes in the order of 1 ½ to 2 ½ seconds to complete. The occupant may elect to encapsulate manually depending on the circumstance. The first step is to stow the control column, which is accomplished by first depressing the column stowage pedal located between the rudder pedals and pushing the wheel forward to the stowed position. The next step in the manual encapsulation is seat retraction which is accomplished by actuating the seat release lever on the right hand seat console. The occupant then pushes against the floor with his feet and moves into the capsule where the seat is automatically locked. The final step is to place his feet on the floor of the capsule and close and lock the doors. When the doors meet they are automatically locked together the emergency pressurization system is actuated. This procedure can be accomplished in 3 to 4 seconds and may be followed either before or after the ballistic encapsulation feature has been used.

The occupant may reopen the capsule at any time he elects to do so by reversing the manual encapsulation procedure.

As mentioned before, the occupant initiates the ejection by pulling either of the triggers which were exposed when the handgrips were raised to start the ballistic encapsulation. This is the only action required of the occupant since the sequence of events which occurs from start of ejection to surface impact is automatically controlled.

The action of pulling one of the triggers fires a mechanically actuated initiator. Gas pressure from this initiator is transmitted to tripper assemblies on the back of the capsule and through a disconnect to the hatch remover. Gas pressure to the trippers extends a piston on each tripper assembly and unlocks them for a subsequent action. Gas pressure to the hatch remover fires the remover and the hatch is removed. When the hatch remover has extended to nearly its full stroke, a port is opened and gas pressure is transmitted thru a onehalf second delay initiator to the inlet port on the rocket catapult.

The rocket catapult, as its name implies, performs as a catapult for the first 55 inches of capsule travel. It develops a peak thrust of approximately 12,400 pounds and takes approximately 0.15 seconds to complete this portion of its motion. The rocket portion is ignited shortly before completion of the catapult stroke and supplies rocket thrust for approximately 0.4 second. The peak thrust from the rocket is approximately 9,800 pounds acting upward and forward at an angle of approximately 28 degrees to the capsule rails, The total impulse for both portions of the rocket catapult is in the order of 4,600 lb/seconds at 70 degrees F.

The sequence of ejection events leading up to the ignition of the catapult are all a direct result of pulling the ejection trigger. The ejection events which follow are initiated when the capsule moves up the rails and actuates the tripper assemblies on the back of the capsule. One of these trippers is directly connected to a valve which activates the capsule mounted oxygen system. Both trippers actuate mechanically fired initiators which supply gas pressure to actuate the stabilization and recovery system.

The stabilization booms are stowed on the rear surface of the capsule while the capsule is in the air vehicle. Gas pressure from the tripper fired initiators is transmitted to a firing mechanism in each boom where it fires a cartridge which in turn supplies the energy to rotate the boom into the deployed position and extend the boom by telescopic action. After a one and one-half second delay small stabilization parachutes are deployed from the ends of the booms. The booms and parachutes provide aerodynamic stabilization for the capsule from separation from the guide rails to deployment of the main recovery parachute.

Gas pressure from the tripper fired initiators is also transmitted to two 1.9 second delay initiators which in turn actuate the chaff dispensing system and remove locking devices from aneroid firing mechanisms. When these aneroid locks are removed the aneroid devices are free to control the recovery system deployment. When the pressure altitude is 15,000 feet or below, the aneroid devices immediately initiate the parachute deployment. In the event that the ejection takes place at an altitude above 15,000 feet the aneroid device delays the parachute release until the capsule has descended to this altitude. Gas pressure from cartridges in the aneroid devices initiate the parachute release by unlocking the parachute compartment door release and propelling the door from the compartment.

The door is attached to the pilot parachute deployment bag which it withdraws when it is propelled from the compartment. The pilot chute inflates and in turn pulls the main recovery parachute from the compartment. The main recovery chute inflates to a reefed condition which is maintained for approximately two seconds before the reefing line is cut and the chute then inflates. The main recovery parachute is a 34.5 feet diameter solid extended skirt canopy with 36 gores and suspension lines. A reefing line 106 inches long is used. Three reefing cutters of 2 second time delay are used. The recovery parachute has been designed to give the capsule a rate of descent of 28 feet per second at sea level.

Gas pressure from the aneroid devices is also transmitted to a one-half second delay initiator which in turn furnishes gas pressure to release the impact attenuator door and open a valve on the attenuator bladder gas storage cylinder. Nitrogen gas from the cylinder then inflates the bladder which becomes the first point of contact during the landing. The increase of pressure within the bladder associated with the landing attenuates the landing impact and ejects blowout plugs in the sides of the bladder which allow controlled release of the pressure, thus preventing rebound.

The capsule testing program can be divided into two general categories; those associated with capsule development, and the airworthiness testing program. Some of more significant development tests are tabulated in Table 1.

The development testing began with wind tunnel tests for evaluation of aerodynamic characteristics. A total of nine series of wind tunnel tests were conducted ranging in speed from low subsonic to Mach 3.

Parachute drop tests were made from aircraft of various types to establish parachute configuration and obtain structural integrety data. A total of 52 test drops were made in this phase of the program. The speed range of the drops ranged from 25 to 377 knots indicated air speed at 1,500 to 15,000 feet altitudes.

Weighted capsule shells complete with simulated stabilization system and complete recovery system were dropped from an airplane in order to further study the aerodynamic characteristics and recovery system performance.

A series of twelve ejections were then made from a B-47 airplane at altitudes ranging from 2,000 to 41,000 feet. The capsule shells were ejected from the B-47 bomb bay, from an inverted position, using M-4 catapults. These tests were made to obtain further data on stability and recovery system performance. The aircraft speed at ejection ranged from 250 knots IAS at 2,100 feet to 240 KIAS at 41,000 feet.

Full scale capsule shells with completely operational propulsion, stabilization and ejection systems were ejected from a test sled as part of the development program. Zero speed and 90 knot ejections were made at Edwards AFB. Five sled tests were accomplished at Hurricane Mesa at speeds ranging from 388 knots to 650 knots IAS.

Impact tests were conducted for the purpose of selecting the optimum configuration of the impact attenuator.

Floatation tests were conducted to determine bouyancy characteristics and to test various configurations of floatation bladders. The XB-70 version of the escape capsule does not incorporate any of these floatation devices, however, it does float on its back in a stable altitude.

The airworthiness test portion of the program (see Table 2) was conducted to demonstrate the function reliability and structural integrity of the escape system and its components. The capsules and components used in nearly all these tests were representative of the production items as they are installed in the XB-70 air vehicles.

A total of 10 impact tests were conducted, three of the drops were on water and the remainder were on concrete. The capsules contained a human occupant in 2 of the water drops and 2 of the concrete impacts. The vertical impact velocity in all but two of the tests was 28 feet per second. In five of the tests, a horizontal velocity equivalent to a 17 knot wind was also introduced.

A static ejection of the hatch and capsule was made in order to check the timing sequence and performance of the ballistic system during this portion of the escape sequence.

There were five sled ejections accomplished during this phase of the test program. Test speeds ranged from 90 knots to 650 knots IAS.

Two ejections were accomplished from a modified B-58 pod. These were inverted downward ejections, the first one from an altitude of 20,000 feet at a speed equivalent to Mach 0.8. The second ejection from the B-58 test pod was conducted at a velocity equivalent to Mach 1.58 at 37,000 feet altitude. Deployment of the recovery system was delayed until the capsule descended to 15,000 feet altitude in each of these tests in order to prove the capsule free fall stability.

Other tests conducted during the airworthiness testing phase included structural testing of the capsule and components, altitude chamber tests, breadboard tests of the ballistic components, operational check tests and checks for toxic gas leakage.

The data shown in Table 3 are typical of the data obtained in the track tests when the escape system performed as programmed. It is interesting to note that tail clearance is not a critical item in the XB-70 escape trajectory.

The acceleration experienced during a maximum indicated airspeed ejection with a 5 percentile occupant is shown on figure 5. The accelerations produced by deploying and opening the recovery parachute are not shown on this history. However, forces in the seat to head direction usually predominate and 11 gs are typical of a maximum indicated air speed recovery system deployment.

The accelerations shown in Figure 6 are typical of a landing impact. The direction and magnitude of the lateral and transverse forces will vary considerably depending on the heading of the capsule at the time of surface contact.

There were many problems in the design of this capsule which required considerable study and testing in order to provide a usable escape system. The first one was capsule stability.

Stable attitude during the initial portion of the escape trajectory is essential while the rocket is providing thrust in order to achieve sufficient altitude for a safe recovery. Stability is also essential to prevent pitch yaw and roll rates which may be intolerable to the capsule occupant.

A considerable portion of the wind tunnel testing and the drop testing was conducted to solve this problem. Several configurations of telescoping booms were tried. The final solution incorporated a parachute in each boom tip which deploys 1.5 seconds after ejection. These parachutes provide augmented stabilization at low capsule speeds and during free fall.

Another problem was toxic gas leakage from the ballistic gas operated devices within the capsule. This was brought to our attention as a possible problem area early in 1962 and preliminary check tests showed excessive leakage from the XB-70 ballistic system. The initiators were the worst offenders. Additional or improved sealing and other modifications were accomplished and the last operational firings showed a reduction in carbon monoxide concentration to 450 parts per million or less throughout the hour following discharge of all ballistic devices within the capsule.

Future plans for the B-70 encapsulated seat depend entirely on the future of the B-70 as a weapon system. If the B-70 is developed as an operational system, a sequencing system may be added to provide for sequenced multiple ejection of the escape hatches and capsules. Foot positioning devices will be incorporated in order to provide positive foot retraction into the capsule and speed up the ballistic encapsulation. Floatation devices will be added to insure survival on the water for three days or more. These devices were originally planned for inclusion on the B-70 capsules but were omitted from XB-70 capsules for economic reasons. Additional testing will be required to fully qualify the capsule and its components. And finally, the testing program may be expanded to include airplane ejections of the capsule using animal subjects and possibly human occupants.

## TABLE 1

## DEVELOPMENT TESTING

1. WIND TUNNEL TESTS
2. RECOVERY PARACHUTE TESTS
3. CAPSULE DROP TESTS
4. CAPSULE EJECTIONS FROM AIRCRAFT
5. CAPSULE SLED EJECTIONS
6. IMPACT TESTS
7. FLOATATION TESTS

## TABLE 2

## AIRWORTHINESS TESTING

1. IMPACT TESTS, GROUND AND WATER

2. STATIC HATCH AND CAPSULE EJECTION

3. HIGH SPEED SLED EJECTIONS

4. B-58 BOMB POD EJECTIONS

5. COMPONENT TESTING

6. MISCELLANEOUS TESTING

## TABLE 3

### TYPICAL TEST RESULTS

| | |
|---|---|
| EJECTION TRAJECTORY HEIGHT AT 90K | 360 feet |
| AT MAX. SPEED | 190 feet |
| CHUTE FULLY OPEN ABOVE SLED AT 90K | 120 feet |
| AT MAX. SPEED | 113 feet |
| TAIL CLEARANCE AT MAX SPEED | 68 feet |

# ARRANGEMENT-CREW CABIN

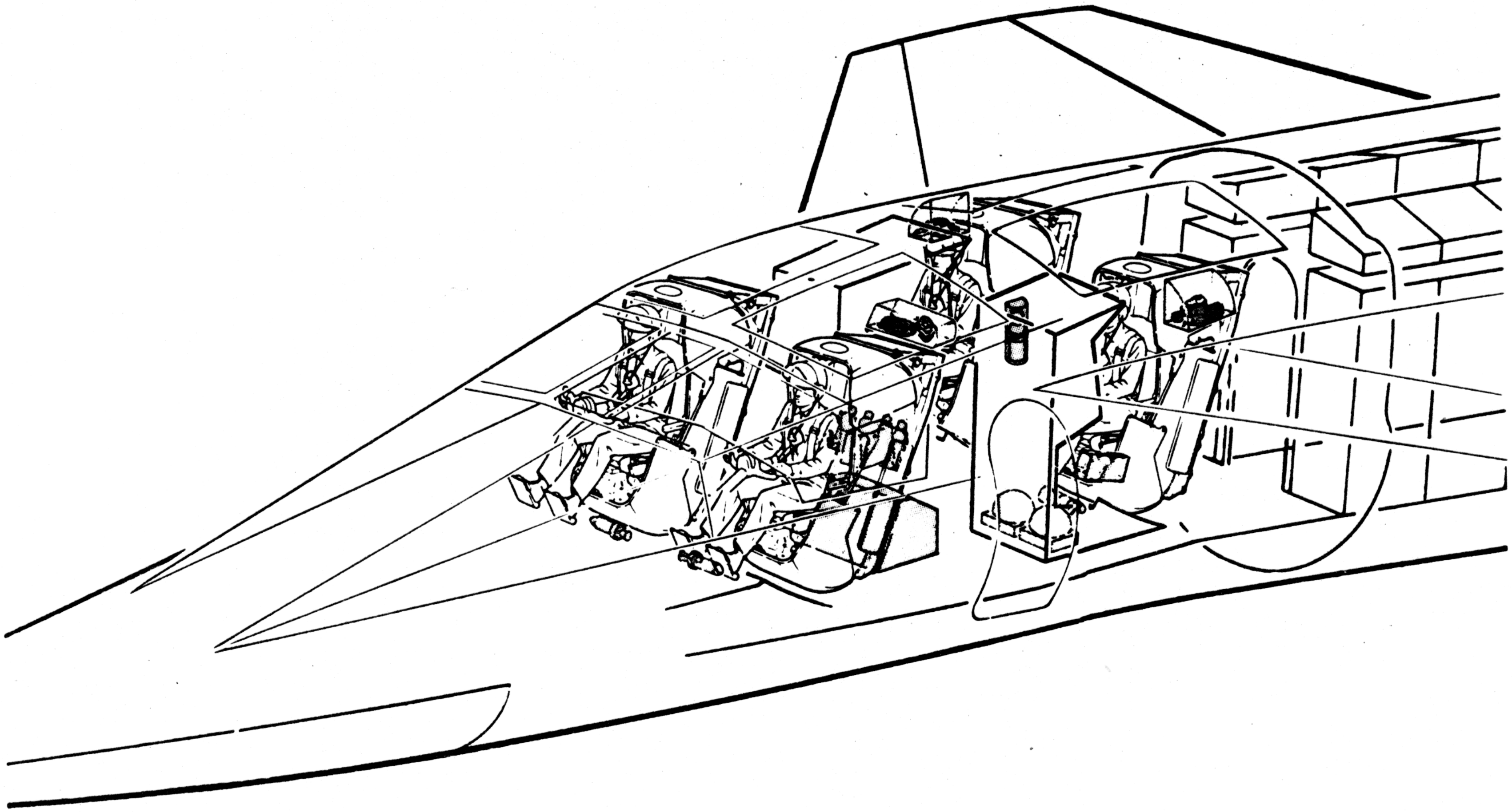


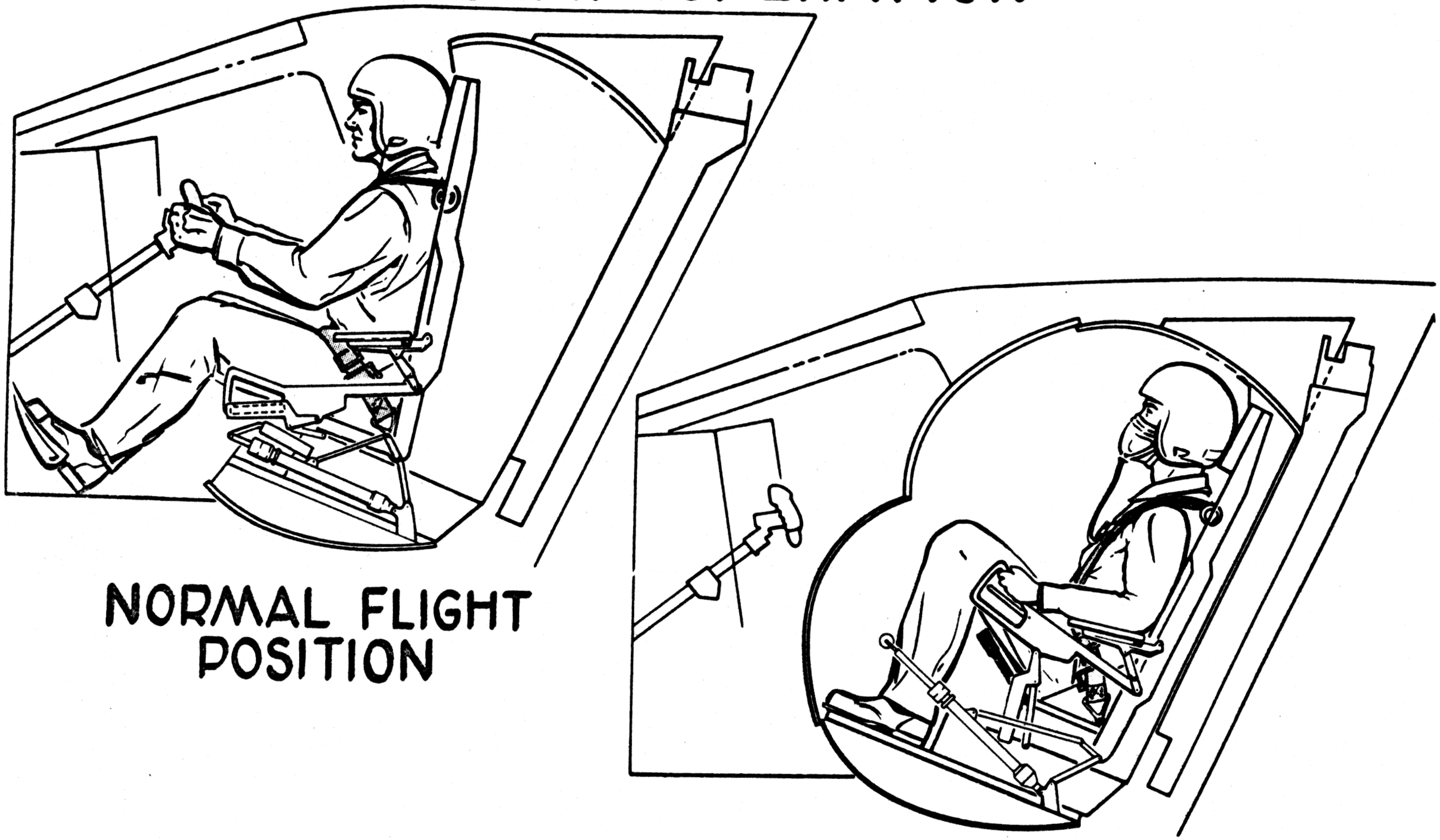
FIGURE 1

# AIRCREW SEATING FACILITIES
## GENERAL CONFIGURATION

- UNRESTRICTED VISION
- COMPLETE CONSOLE ACCESS
- FREE MOBILITY

FIGURE 2

## SEAT OPERATION



NORMAL FLIGHT POSITION

RETRACTED EJECTION POSITION

FIGURE 3

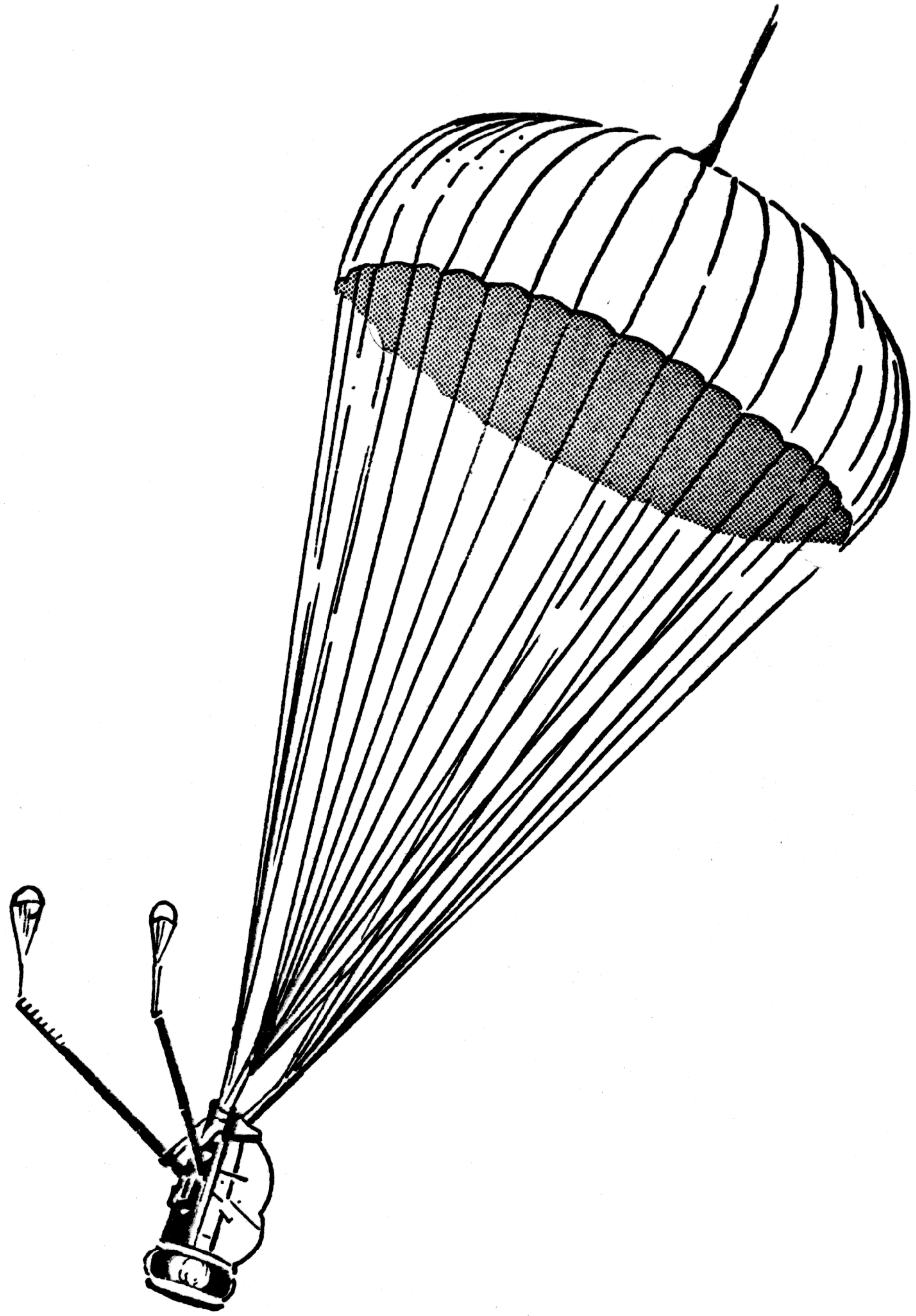


FIG. 4

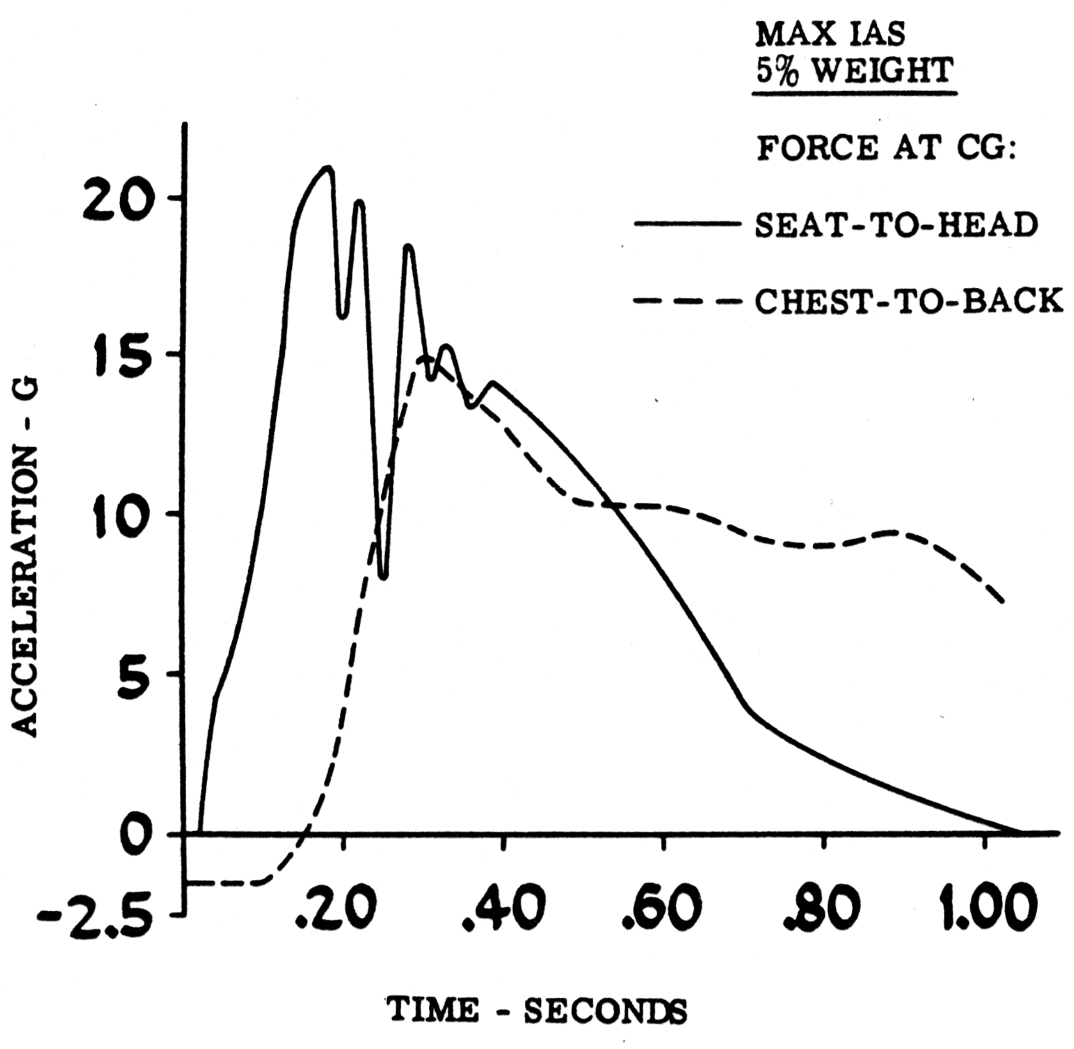
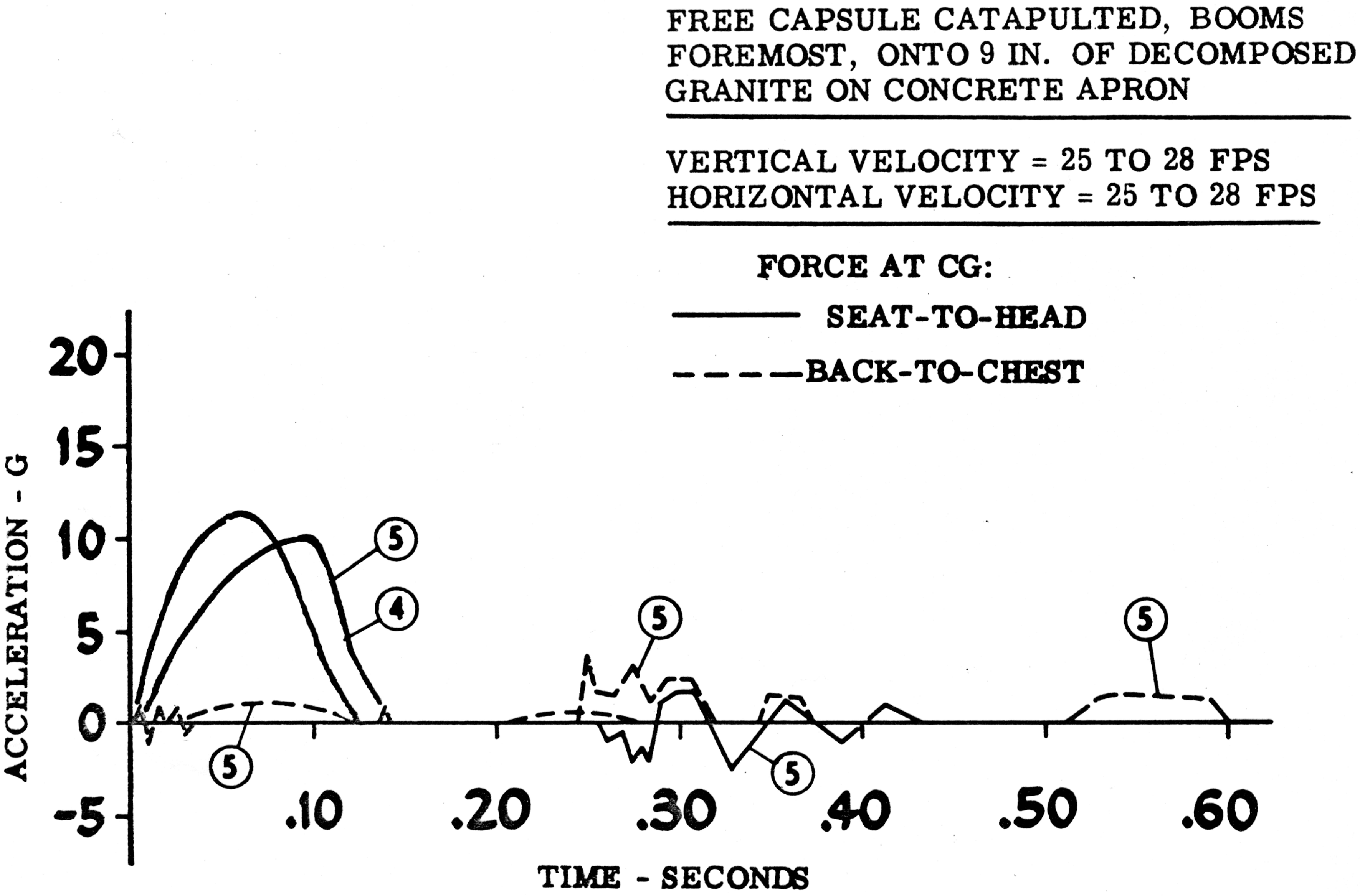


FIGURE 5

EJECTION EXIT HISTORIES



FREE CAPSULE CATAPULTED, BOOMS FOREMOST, ONTO 9 IN. OF DECOMPOSED GRANITE ON CONCRETE APRON

VERTICAL VELOCITY = 25 TO 28 FPS
HORIZONTAL VELOCITY = 25 TO 28 FPS

FORCE AT CG:
——— SEAT-TO-HEAD
- - - - BACK-TO-CHEST

FIGURE 6