AERIAL AND SLED TESTING OF THE B-70 AIRCREW ESCAPE CAPSULE

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For presentation at the Annual Symposium of the
Society of Experimental Test Pilots
at Los Angeles, California
6-8 October 1960

INTRODUCTION

The encapsulated ejection seat of the B-70 weapon system provides both shirtsleeve occupancy of the air vehicle in normal flight and immediate abandonment in emergency. Crew clothing is reduced to a flying suit and lightweight helmet, the capsule's functions eliminating the requirement for counter-pressure, ventilation and anti-exposure garments. The oxygen mask is relegated to a ready position on the crewman's chest.

The seat occupant, in normal flight, sits well forward of the capsule shell, with unrestricted mobility, vision and comfort. Actuation of either of two control levers ballistically retracts the seat and crewman into the shell, closes the two doors from top and bottom, and pressurizes the capsule interior to an equivalent altitude close to sea level. From this condition, the pilot, monitoring his instrument panel through the capsule's center window, may control the air vehicle, or he may eject by pressing either of two triggers at his side. The retracting-enclosing sequence may be performed alternately by hand, and may be reversed at will to restore the crewman to his usual position in the cabin, (See figure 2.)

Ejection can be accomplished safely at all points within the performance envelope of the air vehicle. From trigger actuation through hatch jettison to capsule departure from the guide rails, four-tenths of a second elapse. The catapult rocket produces a maximum of 17 "g" vertical acceleration to lift the capsule to 360 feet height after ejection at 90 knots and to clear the air vehicle's empennage by 45 feet at maximum indicated airspeed.

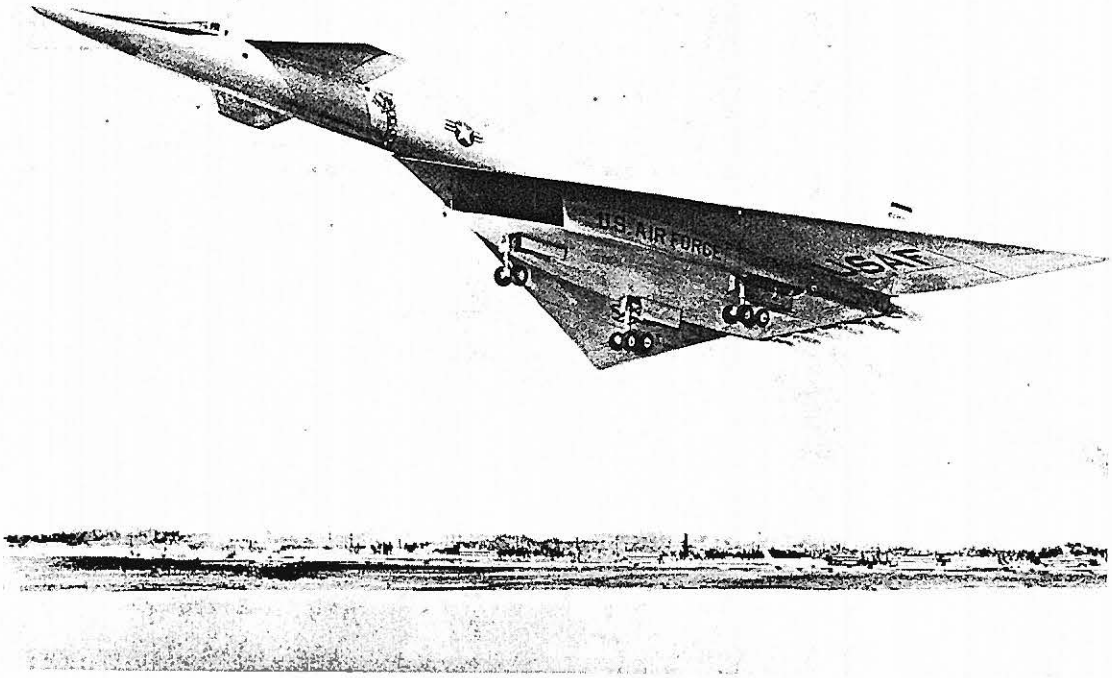

FIGURE 1
B-70 AIR VEHICLE

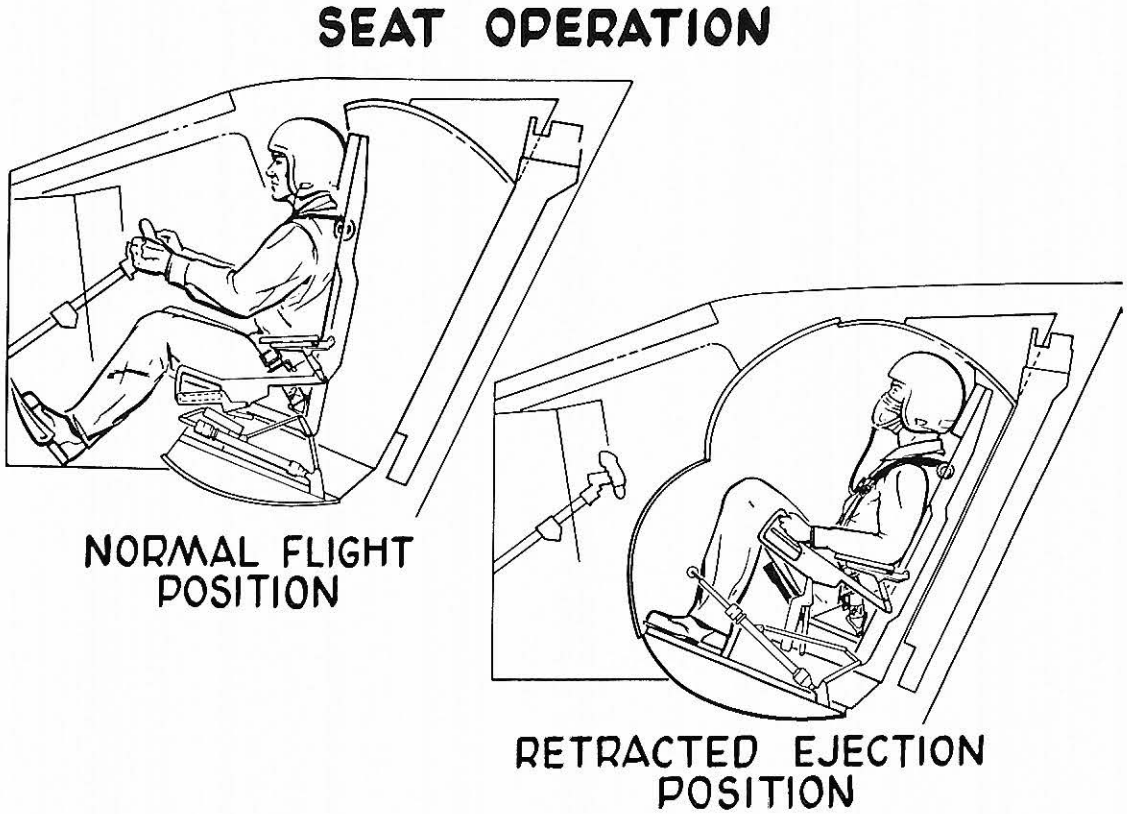

FIGURE 2
SEAT OPERATION

Medium and high speed aerodynamic stability is imparted to the capsule by long cylindrical booms, while low speed and free-fall stability results from the addition of a small parachute to the end of each boom. The booms are fully extended one-tenth second after ejection, the stabilization parachutes opening 1-1/2 seconds later under all flight conditions.

If ejection occurs above the nominal 16,000 feet altitude, the main recovery parachute withholds deployment until the capsule descends to this altitude. Under all other circumstances, the parachute is released 2.3 seconds after ejection, passes through a two-second reefing stage and is fully open between six and nine seconds after ejection. To achieve maximum reliability the recovery parachute system is not restricted by airspeed or force sensing devices.

Simultaneously with main parachute activation, the ground landing impact attenuator, an inflated bladder, is extended from the bottom of the capsule. Acting as alighting gear, the attenuator and booms bring the capsule and occupant to rest at a maximum acceleration of approximately 15 "g". (See figure 3.) In the water, the capsule is self-righting from all attitudes, with or without the supplementary flotation bladders attached to its sides. Fifty pounds of survival gear are provided.

DISCUSSION

The test program was arranged to examine mechanical components individually at first and then progressively within complete subsystems. Wind tunnel work was begun early so that the stabilization configuration could be developed in time for full-scale air drop testing.

Recovery parachute experiments initiated the hardware field test phase. Characteristics such as deployment sequence, opening shock, tendency toward twisted lines, oscillation and rate of descent were determined.

As the program proceeded, supplementary system tests were conducted. Elements of the capsule, the rocket catapult, recovery mechanisms, impact attenuator, ballistic devices, and actuators were evaluated for incorporation in the prototype configuration. These tests were accomplished both by equipment suppliers and by North American Aviation, Inc. in the laboratory and in the field. Included were centrifuge, functional, and ballistic breadboard experiments; flotation, survival, impact, structural and fatigue testing.

Weighted shell air drops, high altitude and minimum velocity ejections have been completed. Major sled testing is scheduled near the end of the program. In the final of two series of sled tests, full-scale ejections of prototype capsules containing anthropomorphic dummies will be effected at air vehicle maximum equivalent airspeed.

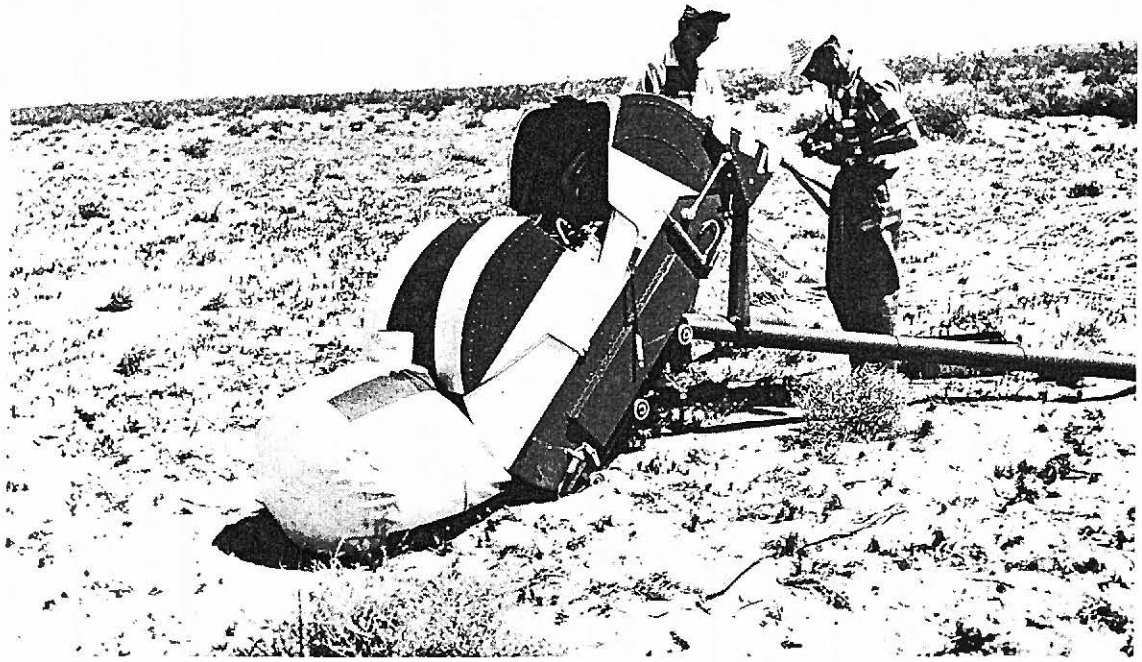

FIGURE 3
CAPSULE AFTER AIRDROP

FIGURE 4
MAXIMUM AIRSPEED TEST OF PARACHUTE BOMB

Aerial Tests

Parachute Testing Drops

Fifty-seven preliminary parachute tests were conducted at the Naval Auxiliary Landing Field, El Centro, California, with the cooperation of the USAF 6511th Parachute Test Group. Rate-of-descent and canopy oscillation tests were performed from C-119 and C-130 airplanes and a helicopter, using a weighted container simulating the capsule weight. Data were derived from the photographic-theodolite range. On a number of tests the rate of descent was cross-checked by a 300-foot drop line with measurement by stop watches and time-base cameras.

In operational speed tests a weighted cylindrical vehicle was suspended from a pylon under the wings of F-100 and A4D airplanes, this vehicle consisting of a bomb modified for onboard telemetry, with the parachute packed in a cavity in the aft portion. Parachute load data were measured during the drop with strain gage tension links and telemetered to the ground receiving station.

For full system tests a 2000-pound bomb was stripped to capsule weight. Telemetry gear was installed inside the bomb casing and the parachute assembly mounted on the aft end. The complete unit was attached to the wing pylon of an F-100 airplane and released during flight. (See figure 4.) Testing begun in April 1959 was completed successfully in November 1959, the parachute recovering the test vehicle in every instance. Drop speeds ranged from 25 knots, using an H-19 helicopter, to 474 knots true from an F-100, while altitudes ranged from 1500 to 15,000 feet. Maximum snatch or opening force recorded was 10,000 pounds total, corresponding to 15 "g" on the suspended mass.

Capsule Drops

Next, a series of full-scale capsule aerial tests were initiated. The primary purpose of these drops, of course, was to prove the parachute system adequate for safe recovery of the encapsulated seat, with effectiveness of the stabilization and impact attenuation devices being secondary objectives. The program included three phases: low altitude-low airspeed, low altitude-high airspeed and high altitude-high airspeed tests. The first airdrop was made in October 1959, followed by 16 tests ending in May 1960.

The capsules duplicated weight, center of gravity location, external aerodynamic shape and size of the B-70 capsules. Each contained onboard instrumentation, power supply, impact attenuator inflation controls, air supply bottle and ballast for center of gravity control.

The low altitude-low speed tests of phase one were conducted from a C-130 airplane fixture which suspended the capsule over the aft end of the cargo loading ramp. (See figure 5.) Since it was the purpose of these tests to evaluate recovery system performances as affected by capsule stability prior to parachute deployment, conditions of airstream entry from an operational installation were simulated by releasing the capsules in an inverted position. As the capsule was displaced by gravity along the guide rails, two initiators were fired by trippers to arm the parachute recovery system control units. Parachute deployment was effected approximately 3 seconds later with simultaneous impact attenuator inflation.

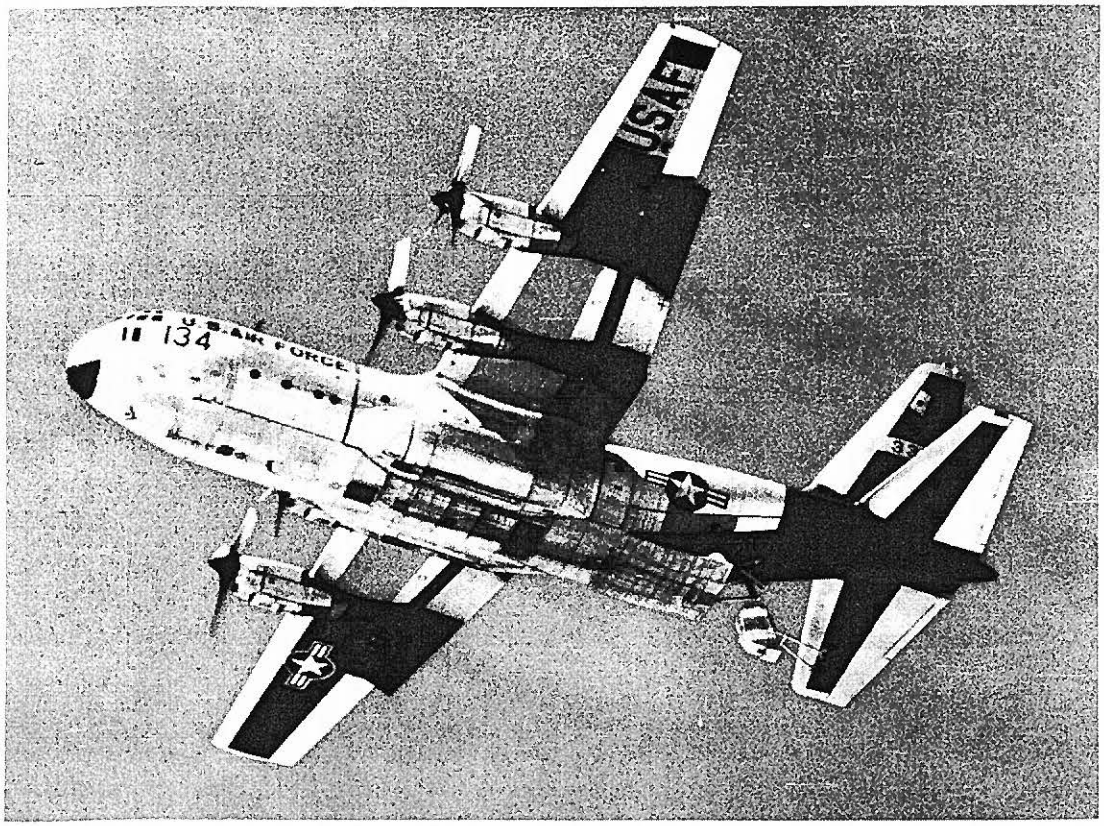

FIGURE 5
LOW SPEED AIRDROP OF CAPSULE

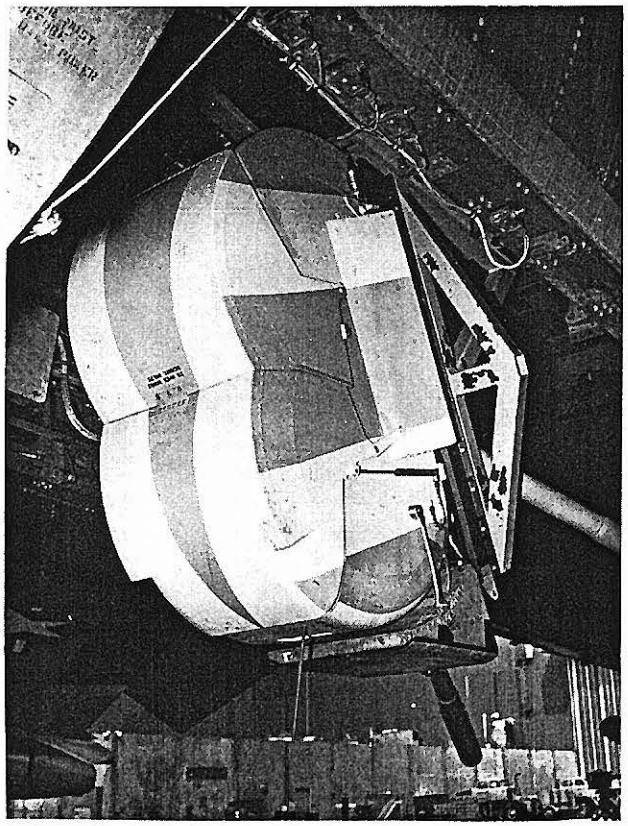

FIGURE 6
CAPSULE INSTALLED IN B-47

There were five drops, all successful, from the C-130 airplane at 1500-2000 feet altitude and speed of 130 knots IAS. Accelerations and parachute deployment forces experienced by the capsule were recorded by telemetry. The average force produced by parachute opening was 2000 pounds per riser.

The second phase, low altitude-high speed tests, employed a B-47 test bed. A capsule rail support fixture was installed in the airplane's bomb bay with doors removed. (See figure 6.) Because of the higher speed, the capsules were ejected by M-4 catapults to assure clearance of the airplane. Cameras, camera heaters, firing circuits, and power wiring, with master control panel at the copilot's station, were incorporated in the B-47.

Five tests were accomplished from the B-47 at 2000-2500 feet altitude and speeds ranging from 200 to 300 knots IAS. Although the capsule exhibited moderate instability during those airdrops, the recovery system operated properly in each instance.

Phase three, the high altitude-high speed tests, was conducted at the Edwards Air Force Base Ballistic Test Facility. The capsule stabilizing booms had been enlarged upon entering this phase. Seven ejections were performed from the B-47, four at 20,000 and three at 40,000 feet with speeds ranging from 230 to 380 knots IAS. (See figures 7 and 8.) After ejection, the capsule fell as a free body until programmed recovery parachute deployment occurred at under 16,000 feet. During descent smoke grenades, attached to the capsule exterior, emitted a continuous trail enabling observers to track the capsule. Acceptable accelerations and forces were experienced in each test, excellent stability having been demonstrated.

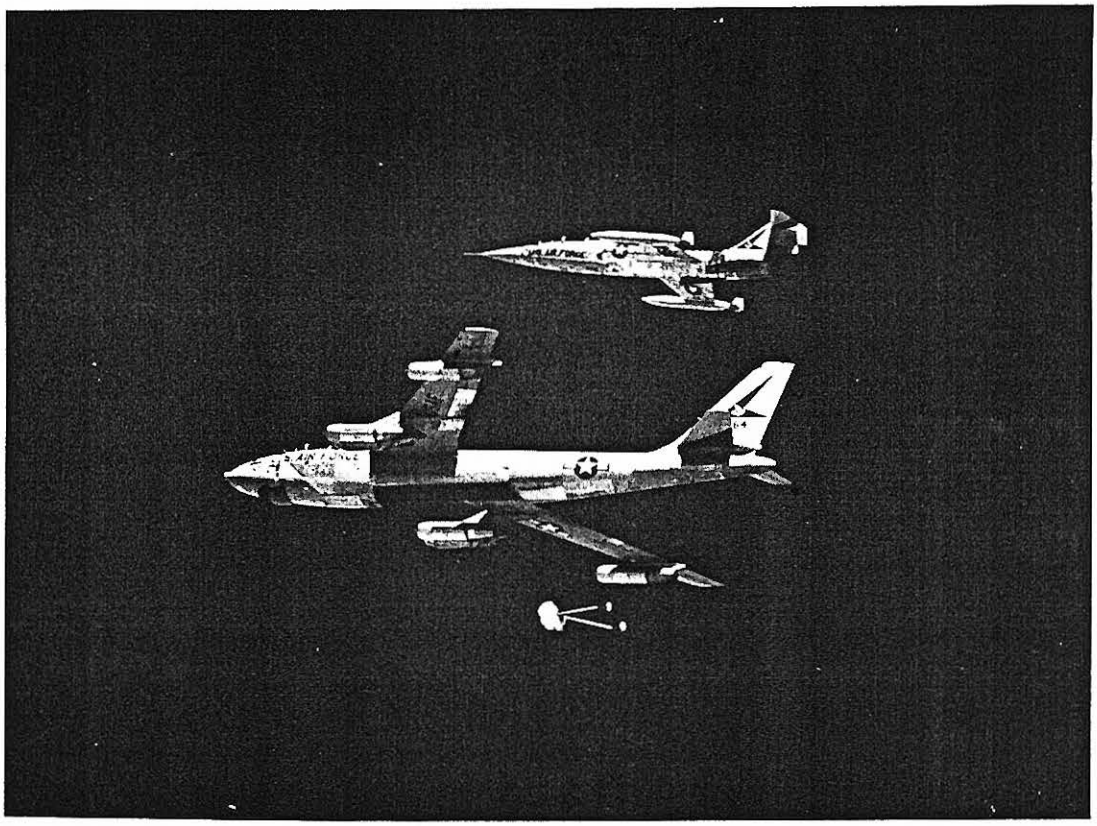

FIGURE 7
ONE SECOND AFTER EJECTION AT 40,000 FT

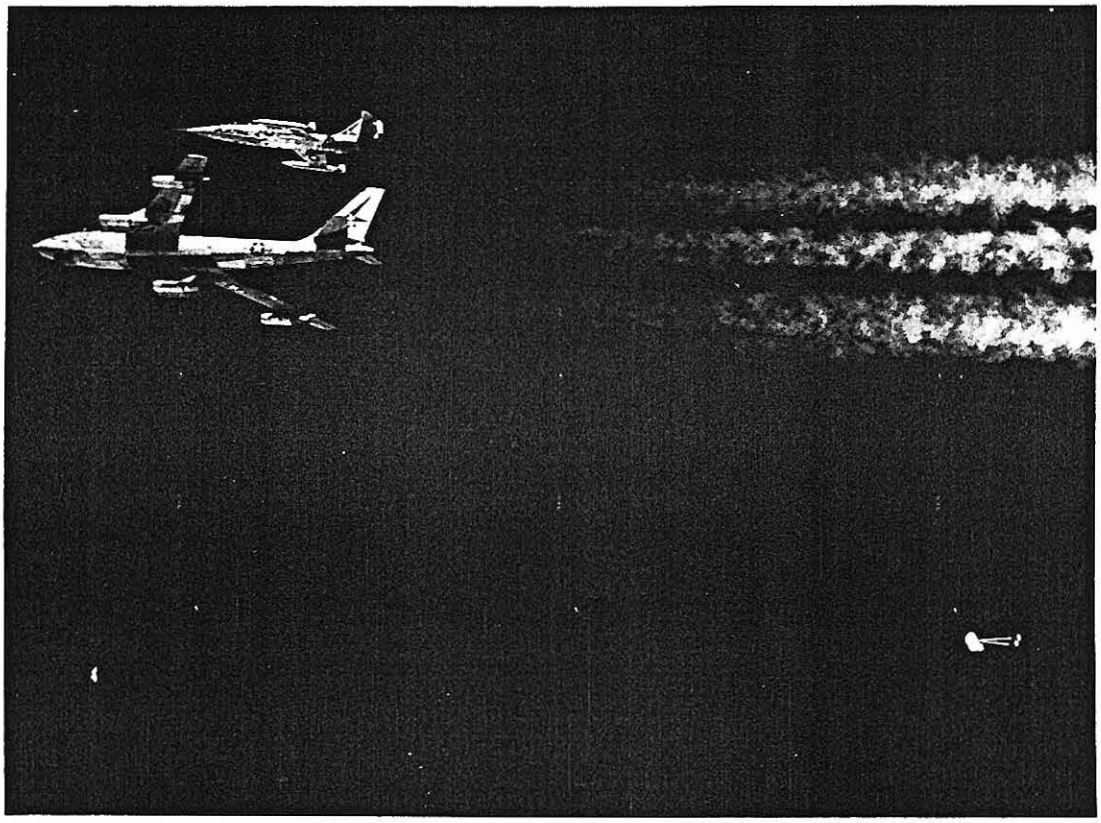

FIGURE 8
3 SECONDS AFTER EJECTION AT 40,000 FT

The success of this program is evidenced by the fact that in the seventeen tests, one capsule was used five times and another six times. Only one capsule was damaged beyond repair. This was attributed to a ballistic failure after the capsule was exposed for two hours at 40,000 feet with the temperature at -89°F. The design of the ballistic system was changed to compensate for extreme cold conditions and on the remaining drop there was no difficulty.

Photographic Instrumentation

The photographic coverage consisted of 16mm and 35mm motion picture cameras and 70mm sequence cameras. One 16mm camera, directed through a window in the top of the capsule, recorded capsule orientation and recovery system operation. When convenient, as was the case in the C-130 drop airplane, hand panned 16mm cameras and 70mm camera within the drop airplane were used.

In the B-47 tests, six stationary 16mm cameras located aboard the airplane recorded action from three seconds before ejection until the capsule departed from the camera range. Hand panned 16mm and 70mm pictures were taken from F-100 and F-104 airplanes, and H-21 and H-43 helicopters. Chase airplanes flew at the same altitude as the B-47. Helicopters, hovering at 15,000 feet, recorded parachute opening, then descended with the capsule to record ground touchdown. On the ground, hand-held 16mm and 70mm cameras followed the action. Ground equipment included two 35mm cameras with 48-inch and 60-inch focal length lenses and two 70mm cameras with 160-inch lenses, on M-45 tracking mounts. (See figure 9.) The phototheodolite range provided space-time data for trajectories, rate-of-descent and canopy oscillation.

FIGURE 9
70MM SEQUENCE CAMERA (FOREGROUND)

FIGURE 10
ZERO AIRSPEED EJECTION

Electronic Instrumentation

Telemetry was provided by an airborne package in the capsule and the Edwards Air Force Base ground receiving station. Telemetered data included parachute riser forces, capsule accelerations, capsule rates of pitch, roll and yaw, and time correlation impulse.

Sled Tests

The first B-70 sled ejections were conducted in April-May 1960 at the Edwards AFB high speed track. The 20,000-foot Edwards track is operated by the Track Branch of the Air Force Flight Test Center, which furnishes not only the track, sleds, and rockets for tests such as these, but also provides extensive telemetric and photographic recording facilities. Instrumentation was similar to that of the capsule airplane drops.

Zero Speed Ejection

The purpose of this test was to determine capsule stability and trajectory, and to study the functioning of the rocket catapult and the recovery system, when ejected at zero airspeed. Since the recovery system was designed for a 90-knot minimum, full parachute opening in a zero airspeed firing could not be assured. In order to allow maximal time for observing the parachute opening sequence, the capsule was ejected from a hillside at the Edwards Air Force Base Rocket Test Site.

Upon ejection by rocket catapult from the stationary sled, the capsule rose almost vertically to a height of 375 feet above the firing point. (See figure 10.) Since the resultant velocity was low (25ft/sec) at the time of pilot parachute deployment, a lengthy time was required for parachute opening. Full

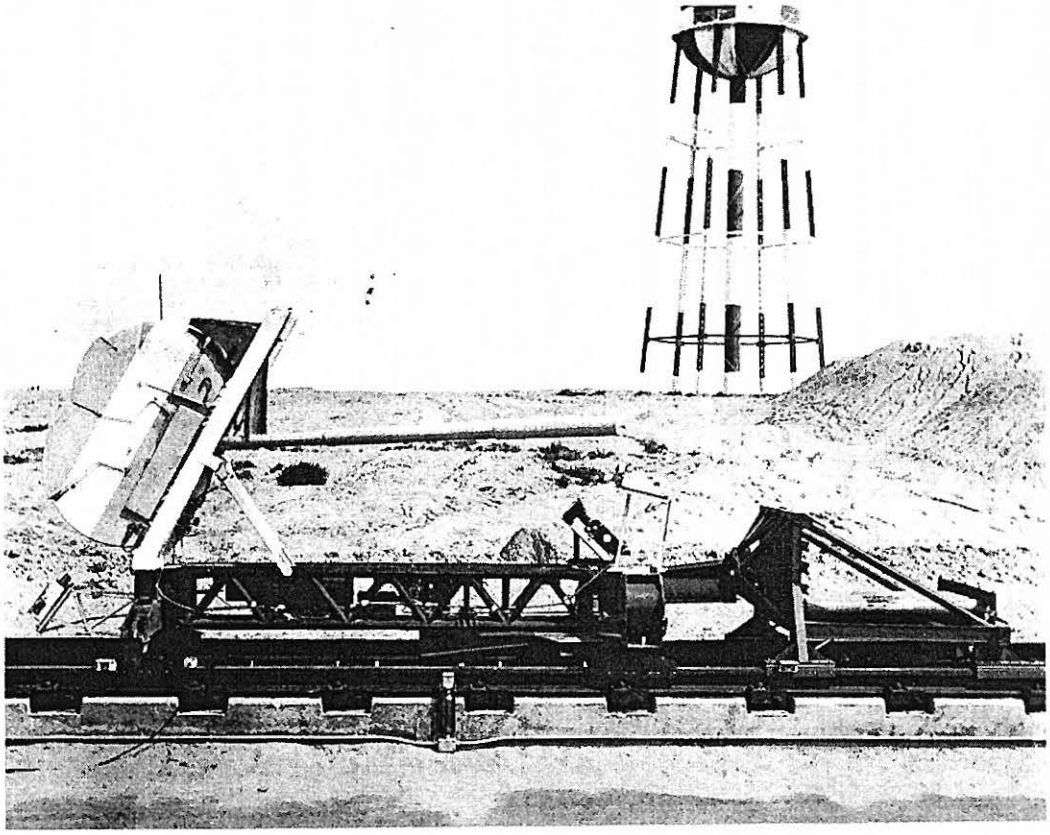

FIGURE 11
CAPSULE MOUNTED ON SLED

line stretch occurred 10.3 seconds after catapult firing, with capsule ground contact 1-1/2 seconds later under the reefed parachute. All objectives were accomplished, the rocket catapult and recovery system functioning properly and satisfactory capsule trajectory and stability being demonstrated.

Minimum Speed (90-Knot) Ejection

The objective of this test was the determination of the capability of the capsule when ejected at minimum air speed and zero altitude. Specifically, this was a demonstration of rocket catapult performance, full-scale stability and trajectory, and recovery system functioning. (See figure 16.)

1. Sled - The test vehicle was an Air Force utility sled with pusher propelled by five HVAR rockets. B-70 capsule ejection rails, cameras and power supplies were installed on the sled.
2. Capsule - A weighted capsule containing airdrop instrumentation and ballast was ejected in this run. The fixed stabilization booms, the recovery system, and the impact attenuator were identical to those evaluated in the aerial tests.
3. Catapult - Designed to North American's specifications, the 4600-pound-second rocket catapult is the most powerful yet applied to an escape device. Although the initial cartridge phase of catapult operation alone is sufficient to safely eject the capsule from the air vehicle at higher altitudes, the rocket provides additional thrust to assure adequate trajectory for on-the-deck recovery at speeds as low as 90 knots.

4. Booms - The capsule stabilization system is designed to prevent physiologically harmful motion of the capsule from ejection to recovery parachute opening. In the case of low altitude ejection (below 16,000 feet), the time period involved is under 2-1/2 seconds. The time from ejection to recovery parachute opening when escape is effected at high altitude, however, is as long as two minutes.

In the ejection (figure 12), the rocket catapult propelled the capsule to a height of 362 feet above the track. The recovery parachute container lid was ejected at normal delay time and full line stretch occurred at 5.5 seconds, with dis-reefing two seconds later. The parachute was fully open at 9.1 seconds, while the capsule was 97 feet above the ejection altitude. There was no damage to the capsule or instrumentation.

This test successfully demonstrated the ground level capability of the B-70 escape system when ejection is initiated at 90 knots.

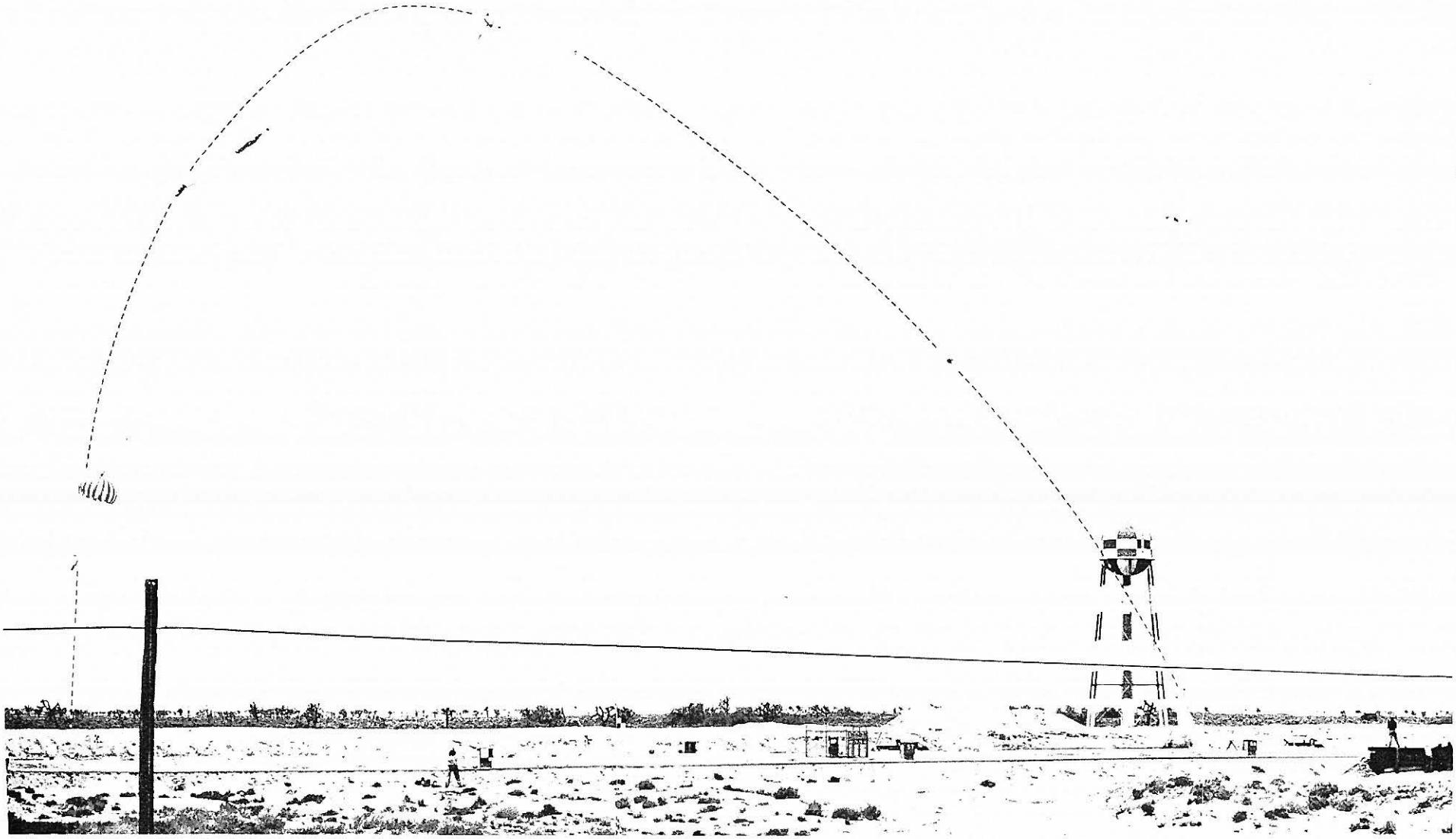

FIGURE 12
90 KNOT EJECTION

CONCLUSION

The B-70 escape capsule has passed or favorably exceeded specification in these categories:

1. Parachute deployment through complete range of indicated airspeeds.
2. Rate of descent.
3. Low altitude airdrops of capsule.
4. 20,000 and 40,000 ft airdrops of capsule.
5. 90-knot on-the-deck recovery.

Remaining to be tested are performance at high Mach number and high dynamic pressure, with continued development in the areas of ground and water impact and environmental control.