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August 1966

Development Report

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B-52/KC-135 COLLISION NEAR PALOMARES, SPAIN (U)

S. V. Asselin, 1544
Sandia Laboratory, Albuquerque

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August 1966

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ABSTRACT

On January 17, 1966, a B-52G aircraft carrying four Mk 28FI bombs collided with a KC-135 tanker in the vicinity of the village of Palomares on the southeast coast of Spain. Both aircraft were destroyed. The four bombs were damaged to various degrees. Upon ground impact, two were subjected to HE detonation in which the pits were destroyed and plutonium was scattered. DOE b(3)

The other two weapons survived impact, one on land and one at sea, with very little damage. The weapon impacting at sea suffered the effects of water pressure and long submergence in sea water, which resulted in some damaged components and corrosion effects.

DOE b(3)

(SRD)

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The data in Appendix B was provided by W. H. Langham, LASL. This contribution to the report and all others provided by AEC/ALO, LASL, and Sandia participants in the accident investigation are acknowledged and appreciated.

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B-52/KC-135 COLLISION NEAR PALOMARES, SPAIN

Introduction

On January 17, 1966, a B-52G aircraft carrying four Mk 28FI Y1) weapons in an MHU-20/C clip-in assembly (Figures 1 and 2) collided with a KC-135 tanker in the vicinity of the village of Palomares on the southeast coast of Spain (Figure 3). The accident occurred at 10:25 AM, local time, in good weather. The accident happened during a routine refueling of two airborne alert (Chrome Dome) B-52G aircraft from Seymour Johnson AFB, North Carolina, by two KC-135 tankers from Moron AFB, near Sevilla, Spain.

The collision resulted in the destruction of both bomber and tanker, the loss of seven lives from the two crews, and damage of various degree to the four weapons. A large amount of publicity resulted from the international aspects of the accident, plutonium contamination from two impacted weapons, and the long search operation which was necessary for the location and recovery of one of the weapons.

No injuries were incurred on the ground, although a large amount of debris landed near homes in Palomares. The four survivors who parachuted to safety from the B-52 were injured in various degrees but none critically.

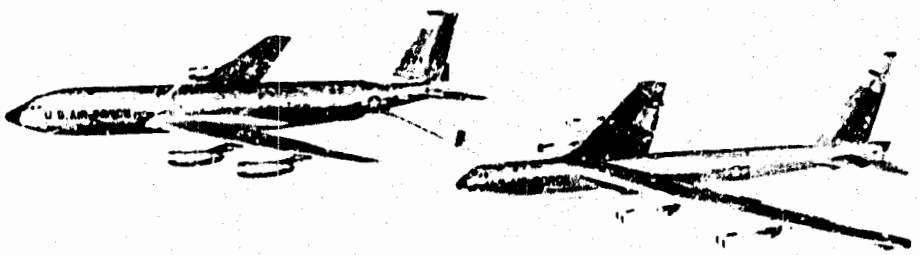


Figure 1. KC-135/B-52 Mid-Air Refueling

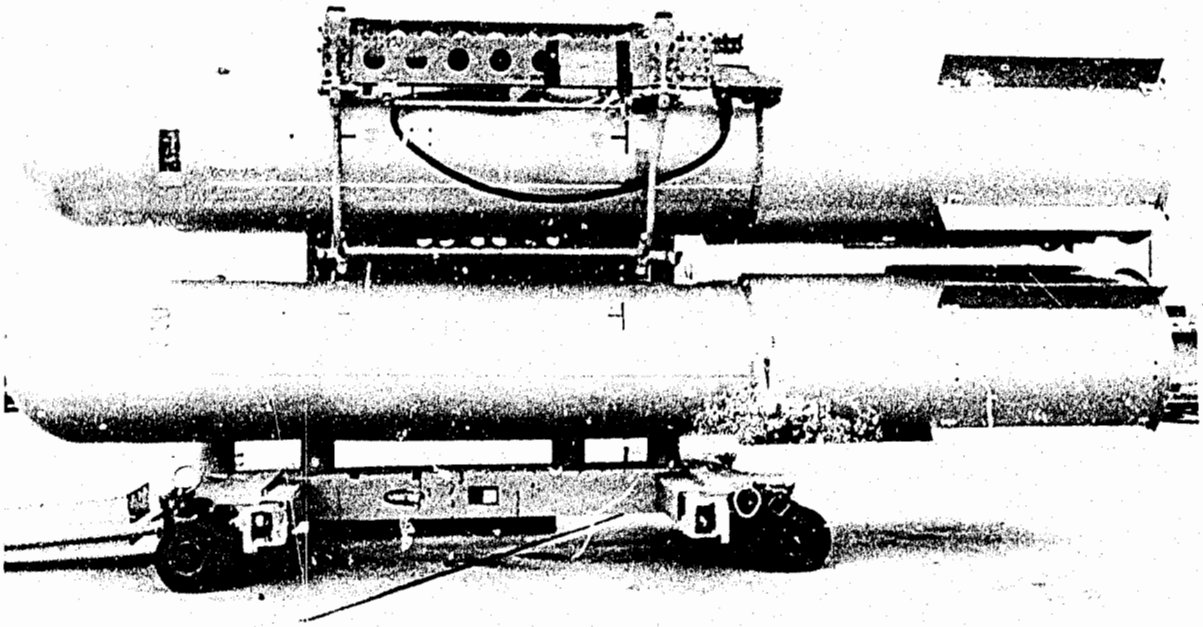


Figure 2. Mk 28FI Bombs in MHU-20/C Clip-In Assembly

Figure 3. Map of Spain Showing Accident Location

Investigating Parties

AEC/ALO received notification of the accident from the Air Force Directorate of Nuclear Safety (DNS) at Kirtland AFB shortly after the accident occurred, and a team of AEC representatives were contacted in accordance with the AEC/ALO Radiological Assistance Plan. DNS informed ALO that a team was being dispatched to the accident scene via C-135 aircraft, and the AEC representatives were invited to accompany them. The AEC team consisted of D. J. Hart (ALO), W. H. Chambers and D. F. Evans, Los Alamos Scientific Laboratory (LASL), and S. V. Asselin, Sandia Corporation (SC). The DNS team consisted of Col. W. E. Gernert, Director, Col. J. A. Norcross, Lt. Col. H. E. Fjeseth, and Capt. J. S. Pizzuto. Field Command, Defense Atomic Support Agency (FC/DASA) was represented by Maj. J. Hanlin.

This group left KAFB at 11:30 AM, MST, and arrived at Palomares, Spain, the crash scene, at approximately 4:30 PM, local, (8:30 AM MST) January 18. Travel was by C-135 to Torrejon AB near Madrid, C-54 aircraft from there to the Spanish Air Base at San Javier, and by bus the final 70 miles.

Major General D. E. Wilson, Commander, 16th Air Force, was in charge of operations at the crash scene. A large number of officers and men from both the Torrejon and Moron bases of the 16th AF were based at the crash scene during the cleanup and search operations.

Major General A. J. Beck was in charge of the Headquarters, Strategic Air Command (SAC), team. After his departure on January 22, Col. C. Rhodes led the SAC Headquarter's team.

Rear Admiral W. Guest, of the 6th Fleet, headed a special task force designated CTF-65 which undertook the U. S. Navy sea search and recovery operations.

General A. Montel was the government of Spain representative for most of the period of recovery and cleanup operations. Representatives of local governments and members of the Junta de Energia Nuclear (Spanish AEC) were involved in the operations.

The accident investigation effort was roughly divided into three phases: the recovery and shipment of the remains of the first three weapons, the search and investigative efforts directed to the missing fourth weapon, and the recovery and shipment of the remains of the fourth weapon.

Recovery of Weapons #1, #2, and #3

At the intermediate stop of Torrejon Air Base on the way to the crash scene, the Albuquerque group was briefed at the 16th Air Force command post by Col. R. Jenkins, Vice Commander of the 16th Air Force and by members of his staff. Background was given on the refueling operation and on recovery information available at the crash scene. At that time only one weapon was known to be found.

Because of late arrival on Tuesday, activities started on Wednesday morning with a briefing of recovery operations to date by Col. Rhodes. Three weapons had been located by this time. The first was being guarded by Guardia Civil (Spanish federal police) personnel when the first U. S. Air Force group arrived. The second and third weapons were found by U. S. Air Force personnel early on Tuesday, January 18. The debris pattern on land is described in Figure 4.

The Albuquerque group toured the three weapon sites and viewed the weapon remains. Explosive ordnance disposal (EOD) work had been performed in various degrees on each weapon or weapon remains, and thus the exact original conditions were not observed. A summary of the weapon conditions at recovery follows; the weapons are numbered in the order they were discovered. Figures 5 through 16 illustrate the debris from the three weapons. Serial numbers of all four weapons are listed in Appendix A.

Weapon #1 (Left upper position in clip-in assembly) -- The weapon was in relatively intact condition, having been retarded by abnormal deployment of the 16-1/2 foot parachute and impacting on a steep bank of soft earth. The nose section of the fuze was crushed and dented and the afterbody (shape component) suffered a few dents. The tail plate and three fins were missing. The MB-3A

Figure 4. Photo Map Showing Debris Pattern on Land

Figure 5. Weapon #1

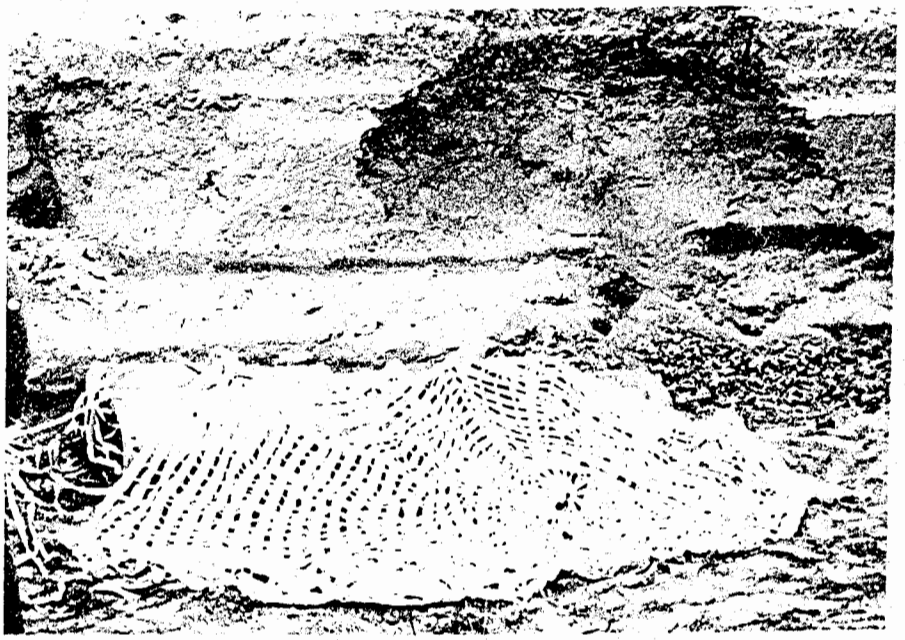


Figure 6. Weapon #1

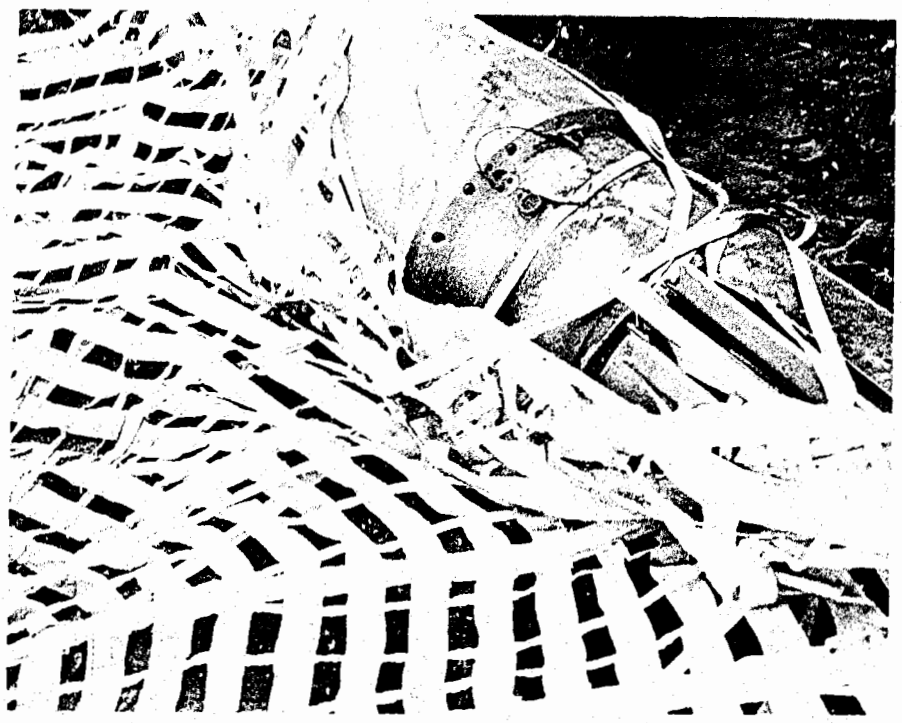


Figure 7. Weapon #1 (extracted pullout rod)

DOE
b(3)

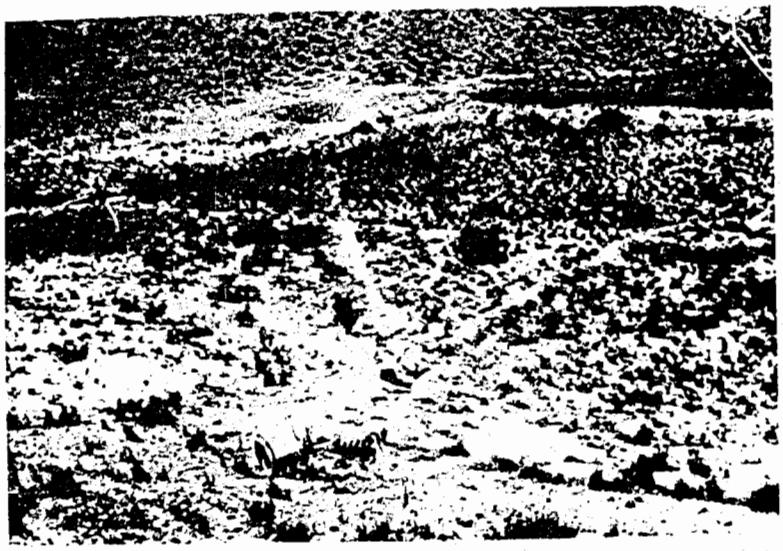


Figure 9. Weapon #2 Afterbody (crater in background)

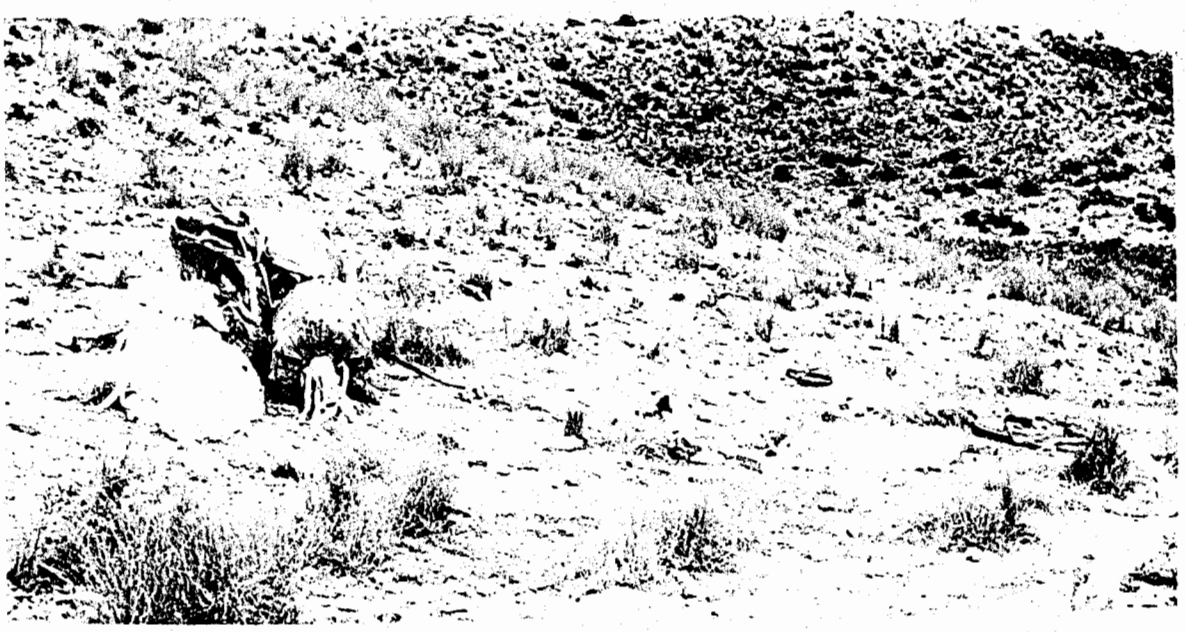


Figure 10. Weapon #2 Afterbody Debris

DOE
b(3)

DOE
b(3)

DOE
b(3)

DOE b(3)

Figure 16. Weapon #3 Impact Area

rack was attached to the weapon lugs, and two pieces of the MHU-20/C clip-in assembly were attached to the rack. One pullout rod had been extracted. [redacted] DOE b(3)

Weapon #2 (Right upper position in clip-in assembly) -- An HE detonation which occurred on impact broke up most of the fuze and warhead components. The afterbody was broken open and thrown, along with its parachutes, about 100 feet by the detonation. [redacted] DOE b(3) Parts of electrical components, structural material, and HE were scattered over a large area. The ready-safe switch was found; however, its crushed condition precluded visual monitoring. Extensive plutonium contamination surrounded the impact point. A discussion of the extent of plutonium contamination and the clean-up operation is contained in Appendix B.

Weapon #3 (Right lower position in clip-in assembly) -- An HE detonation resulted when the weapon impacted at the base of a low retaining wall. The 16-1/2 foot parachute had been abnormally deployed in a damaged condition prior to impact. Most of the fuze and warhead components were scattered over a large area and were so broken up that they were difficult to recognize. Recognizable debris indicated the MB-3A rack had remained attached to the weapon. [redacted] DOE b(3) The rear cap of the warhead and the afterbody were found a few feet away. In general the afterbody was less damaged than that from Weapon #2. No recognizable remains of the ready-safe switch were found. Extensive plutonium contamination surrounded the impact point (Appendix B).

During January 19 and 20, material from the three weapon impact sites was brought to a central location and prepared for shipment. The intact Weapon (#1) was airlifted by helicopter cargo net a short distance to a truck because irrigation ditches and dikes prevented direct truck access to the weapon. Major de' ris from weapon sites 2 and 3 (most of it plutonium contaminated) was transported by truck to the preparation area.

DOE 6(3)

The shipment, which was by truck to San Javier and then by C-130 aircraft to Torrejon AB, arrived late the night of January 20. D. J. Hart of ALO preceded the shipment to Torrejon, and W. H. Chambers of LASL accompanied it during the air portion. Both participated in the repackaging operations that followed.

In a designated assembly bay, the contaminated debris was repackaged for air shipment to the U. S. This included mounting the warhead and fuze of Weapon #1 on a standard handling dolly and putting the remainder of material in clean plywood boxes; unpacking of the temporary containers from the site was kept to a minimum. The repackaging was completed on January 22. Contamination cleanup of the work area included disposal of plastic sheeting that had been laid down, and washing and mopping operations.

On January 30, the material was airlifted from Torrejon AFB for delivery to Pantex Ordnance Plant, Amarillo, Texas.

As further on-site cleanup took place, more weapon bits and pieces were recovered. Because there was no further weapon analysis value in this material, it was disposed of with other contaminated parts.

Search for Weapon #4

On January 18, by order of General J. Ryan, SAC Commander-in-Chief, a large number of officers and men from the 16th Air Force bases at Torrejon and Moron were dispatched to the crash scene by land transport for the purpose of search and cleanup operations. The search concentrated on the missing fourth weapon or debris resulting from its possible HE detonation. Early search patterns were concentrated in the vicinity of the aircraft debris and weapon impact points. The ground search was supplemented by air search by helicopters.

On January 19, a portion of the missing weapon was found in the temporary camp set up in a dry river bed near Palomares. It consisted of the tail closing plate attached in the normal manner to the rear ring forging of the afterbody (Figure 17). The ring had separated from the inner and outer skin sections of the afterbody at the riveted attachment points. This assembly was verified to have come from the fourth weapon by the identification of a rear ring forging on each of the remains of the other three weapons. Later investigation revealed that the assembly had impacted some distance from the camp on a steep hillside (Figure 4). and had been brought to the camp by a Guardia Civil who had been given the item by a local resident.

On January 22 and 23, the B-52 aircraft debris associated with the bomb bay was examined for information as to how the weapons left the aircraft. The center fuselage section (Figure 18) contained the rear bomb bay where Quail (ADM-20A) missiles were located. The break between this section and the forward portion of the B-52 was directly between the forward and rear bomb bays. There appeared to be no damage to the rear bomb bay caused by the Mk 28 weapons in the forward bomb bay.

The forward portion of the B-52 had impacted on a small hillside and burned (Figure 19). The major portion of the MHU-20/C clip-in assembly, which was still in position in the bomb bay attached to the MAU-6/A clip-in rack, was removed for examination (Figure 20). No weapon racks remained with the clip-in assembly, and a portion of the vertical structure was missing. A major portion of the missing structure was found at sea in shallow water on January 31.

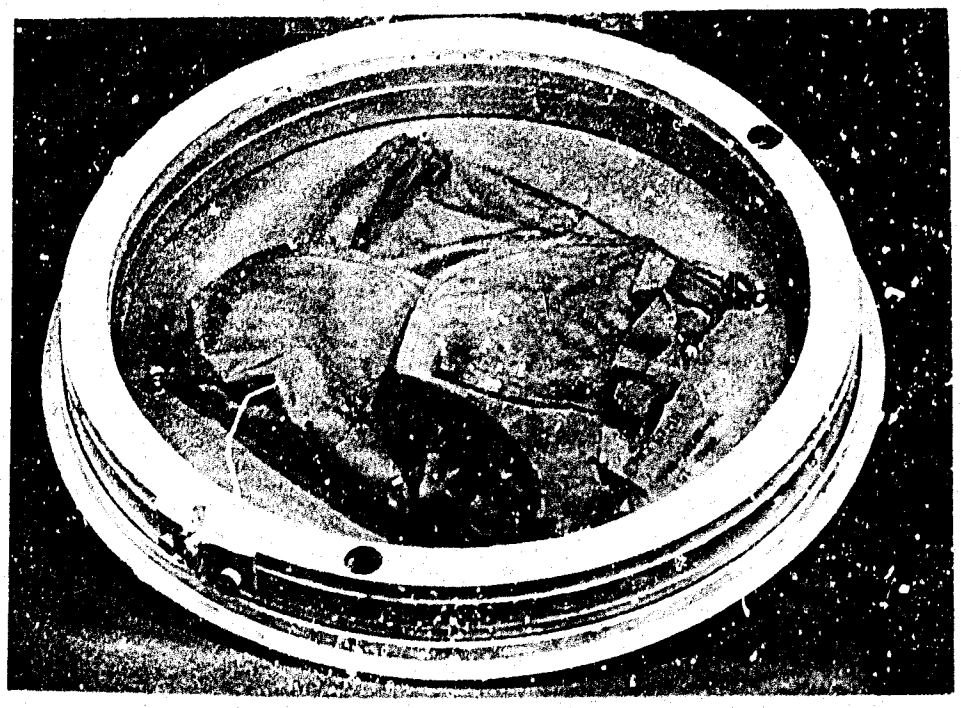


Figure 17. Weapon #4 Tail Plate and Ring Forging

Figure 18. Examination of Rear Bomb Bay, B-52

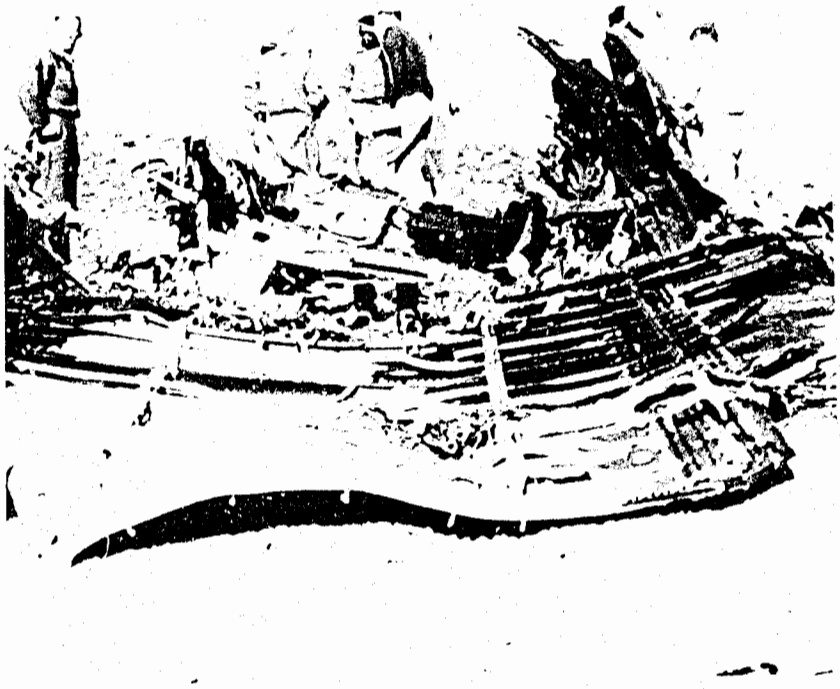


Figure 19. Examination of Forward Bomb Bay, B-52

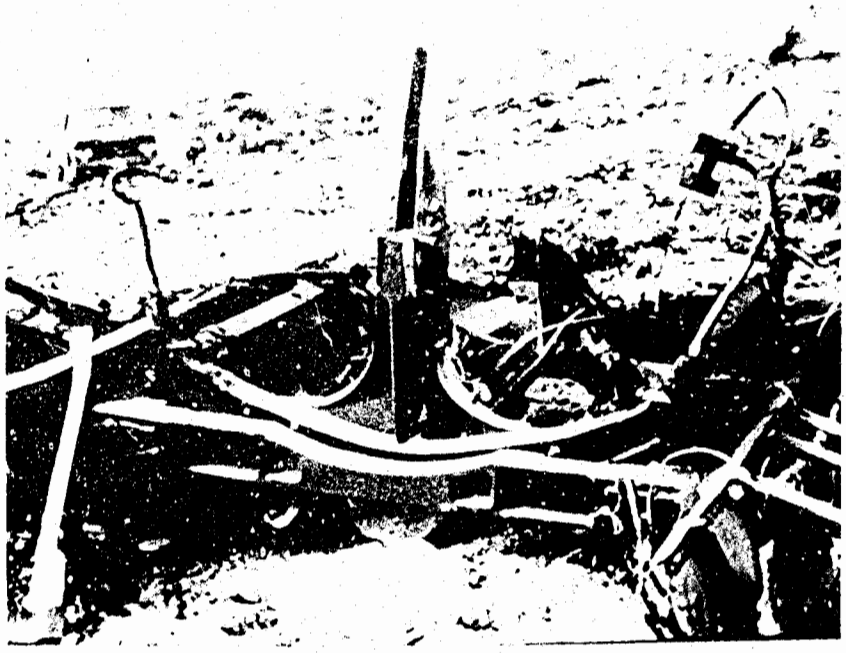


Figure 20. Remains of MHU-20/C Clip-In Assembly

During the parachute descent of survivors at sea on January 17, another object suspended from a parachute had been observed descending into the sea by a number of witnesses. Its parachute was generally described as different in color from those of the survivors.

DOE b(3)

Extensive ground and air search over a large area had substantially ruled out the possibility that Weapon #4 had impacted intact on land.

DOE b(3)

Thus, the ground search became more detailed and thorough.

During the period January 26 through 29, W. R. Hoagland (SC 1544) interrupted a European trip to join the investigating party.

On January 27, Major General Wilson requested a group of aerodynamicists and ballisticians to travel to the crash site and to work together to theoretically predict where the missing weapon had impacted. The group consisted of R. C. Maydew, Sandia Corporation, 9320, who arrived on January 29, and M. R. Bennett and D. A. Campbell of Eglin AFB, and R. W. Bachman of Wright-Patterson AFB, all of whom arrived on January 30.

R. C. Maydew and other personnel of the Sandia aerodynamics organization had already been making theoretical computer studies based on early information in answer to a request on January 22 by the Hon. W. J. Howard, Assistant to the Secretary of Defense (Atomic Energy).

On February 7, a report was published by the group, known as the Systems Analysis Team (SAT), which theoretically reconstructed the accident and predicted the most probable locations of the missing weapon. The predictions were based on the impact conditions and configurations of the three recovered weapons, the testimony of many witnesses including some special interviews, and an examination of the aircraft debris. Of particular significance were the high winds blowing

toward the sea which resulted in a widespread distribution of debris and a distance of 11 miles between debris on the land and the impact point of one of the survivors at sea. There was also evidence, including witnesses' reports, that the 64-foot diameter parachute had been deployed. Three principal theories as to what happened to the missing weapon were presented:

1. DOE b(3)

2. DOE b(3)

3. Mechanical damage during weapon separation from the aircraft resulted in impact of a relatively intact weapon at sea after successive deployment of the 16-1/2 foot and 64-foot chutes.

Because of the many sequences that could have resulted in final deployment of the 64-foot parachute, a large number of impact points were predicted. However, since a number of them substantiated the credible sighting of the fisherman Francisco Simo Y Orts and his crew, this location was given primary emphasis.

Briefings of both the Air Force and Navy staffs emphasized these theories as the most fruitful for subsequent search operations.

On February 2, R. E. Reed replaced S. V. Asselin as the Sandia weapon safety representative on the scene and, on February 8, P. Schneider replaced D. Hart as the AEC/ALO representative.

DOE b(3)

DOE b(3) [redacted] S. A. Moore then replaced R. E. Reed as the weapon safety representative from Sandia.

Additional theoretical studies were made by S. A. Moore, P. Schneider, and W. R. Barton, 9324, who had arrived on the scene February 14 to continue the theoretical work of R. C. Maydew and, on March 4, a report was published which supplemented the SAT report of February 7. The principal conclusion made was that lack of evidence supporting a mid-air detonation and further evidence pointing to an object being carried out to sea by parachute clearly indicated the impact at sea of a reasonably intact weapon. The predicted location area was in the area of the sighting of Señor Francisco Simo and in line with sightings by two witnesses on shore. The position on the sea bottom in relation to this location was also predicted using underwater current data provided by the U. S. Navy.

On March 3, the ground search was suspended.

On March 3 and 4, Moore, Schneider, and Barton left the accident scene; they briefed DOD and State Department representatives at the Pentagon and the SAC command staff at Omaha during their return trip.

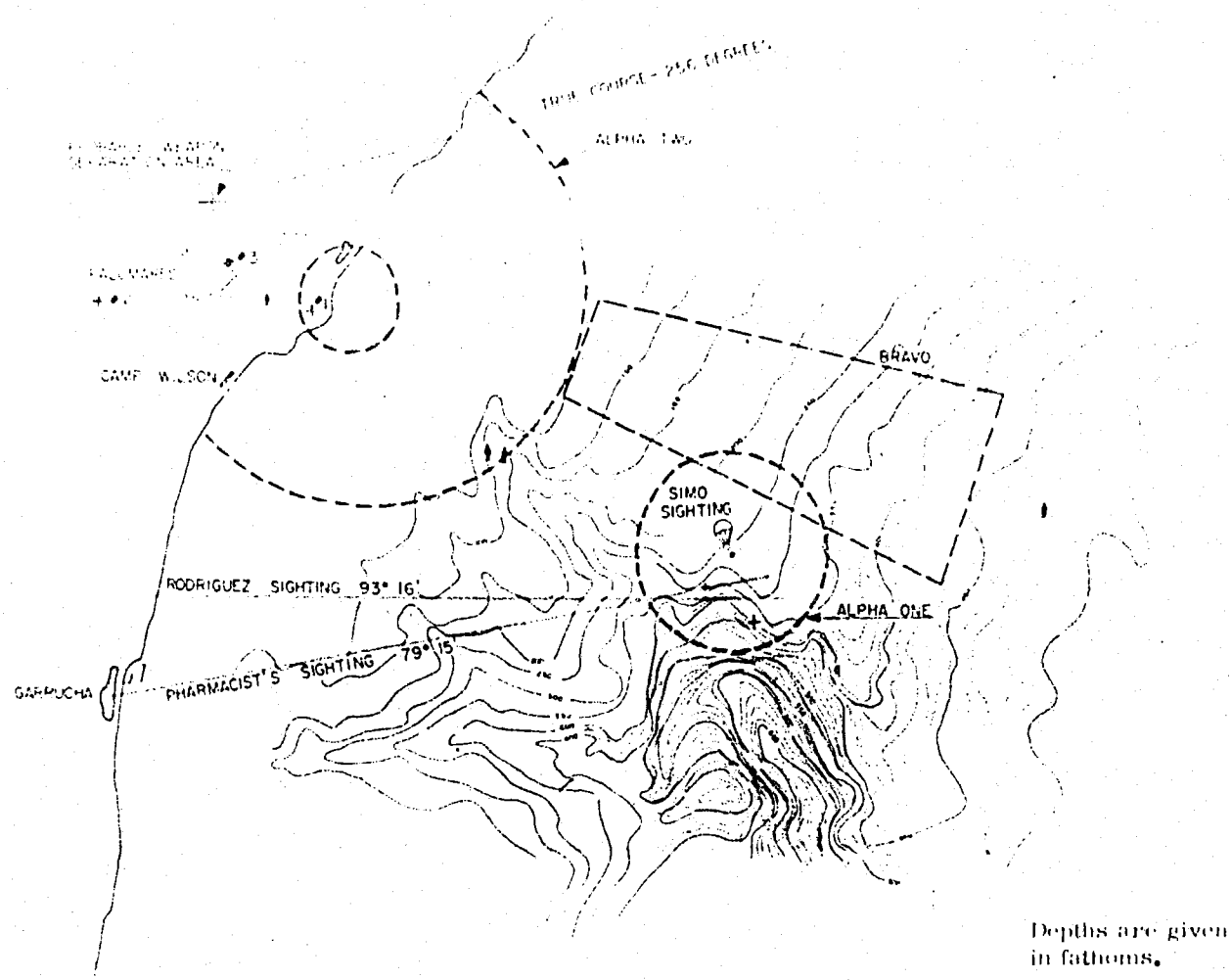
D. F. Evans, LASL, departed the accident scene on March 4 and E. W. Griffith, AEC/ALO, who had arrived on March 2, remained at the scene as the AEC representative.

Recovery of Weapon #4

During an underwater search operation on March 15, crew members of the Alvin submersible discovered the missing weapon on a 70-degree slope at a depth of 2550 feet. The location was within the predicted impact area (Figure 21).

On March 22, S. V. Asselin returned to the scene as a result of a request for Sandia Corporation participation by General Wilson.

DOE b(3) [redacted] The 16th Air Force provided a J79 engine container and modified



Note:
Small + in Alpha-One area is predicted bottom impact point with underwater currents accounted for. Large + in Alpha-One area is location of weapon when discovered on March 15.

Figure 21. Sea Search Area and Weapon #4 Location

it by removing the inner engine support frame, by cutting holes in the cover for ventilation, and by building an inner box to permit covering of the warhead portion with sand. This container and 16 drums of beach sand were loaded aboard the USS Hoist which was the recovery vessel designated at that time. Two EOD sergeants from the 16th Air Force accompanied the material.

On March 24, a line attached by a grapnel to the parachute of the weapon was used in an attempt to pull it to shallow water. During the operation, the line parted, apparently cut over a sharp object, possibly one of the anchors in the recovery rig. An upslope drag followed by downward movement resulted in the weapon having a net movement of about 300 feet downslope from its original resting place. This new position, on a 30-degree slope at a depth of approximately 2900 feet, was found by the Alvin crew on April 2.

On April 7, the weapon was lifted aboard the USS Petrel, a submarine rescue vessel (Figures 22, 23, and 24). As previously arranged, General Wilson, Lt. Col. M. Neal, DNS, and S. V. Asselin were brought aboard for this operation. The weapon was lifted most of the distance by two lines attached to the parachute. The lift was complicated in that the CURV (Cable-Controlled Underwater Research Vehicle) was tangled with the parachute during an attempt to attach a third line and was lifted at the same time as the weapon. When the weapon was within 100 feet of the surface, EOD divers attached an additional line around its casing and the CURV was freed from the parachute.

The EOD operation, which was a joint service effort led by LCDR Moody, CINCLANTFLT, consisted of a team of officers and enlisted men including the two sergeants from the 16th Air Force.

The weapon was placed on a wooden stand (Figure 25) for the render safe and disassembly procedures.

The weapon was subjected to two principal sources of damage: the forces during aircraft breakup and the water pressure at the considerable depth.

The breakup forces resulted in the tearing and squeezing of the afterbody (Figures 26 and 27), the separation of tail plate and ring forging (previously

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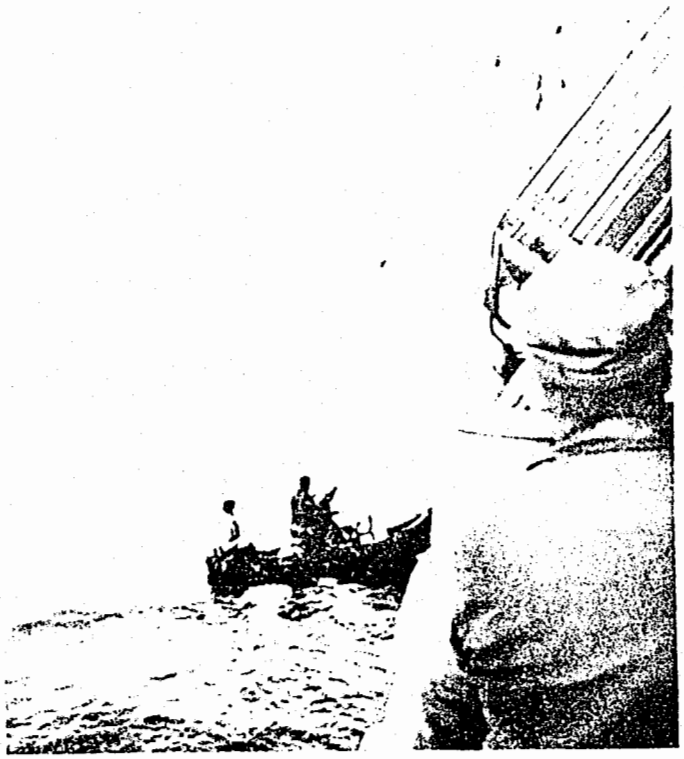

Figure 22. Lines to Weapon #4
Before Surfacing

Figure 23. Weapon #4

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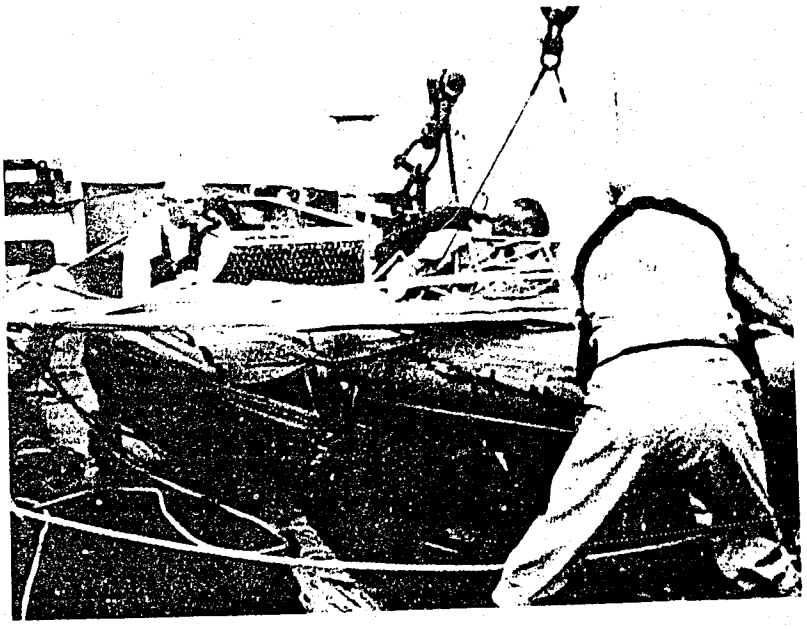

Figure 24. Weapon #4

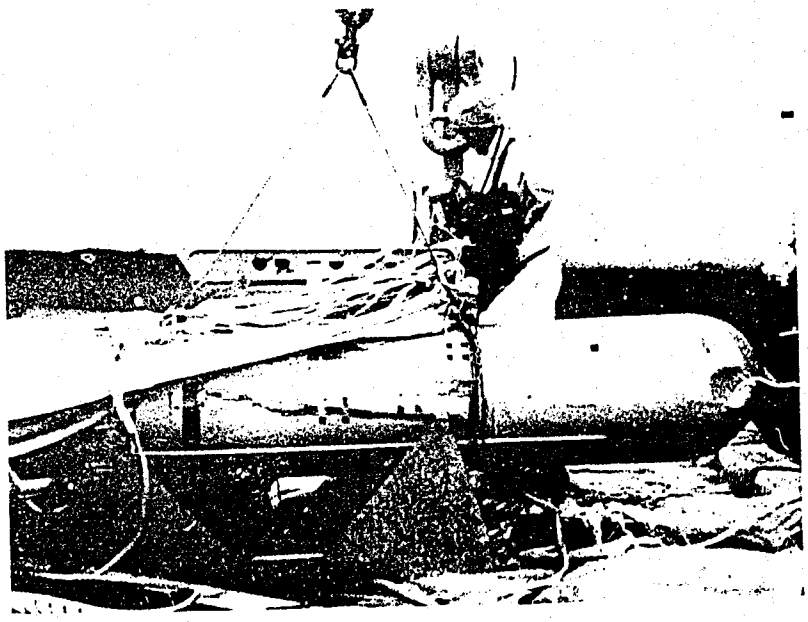

Figure 25. Weapon #4

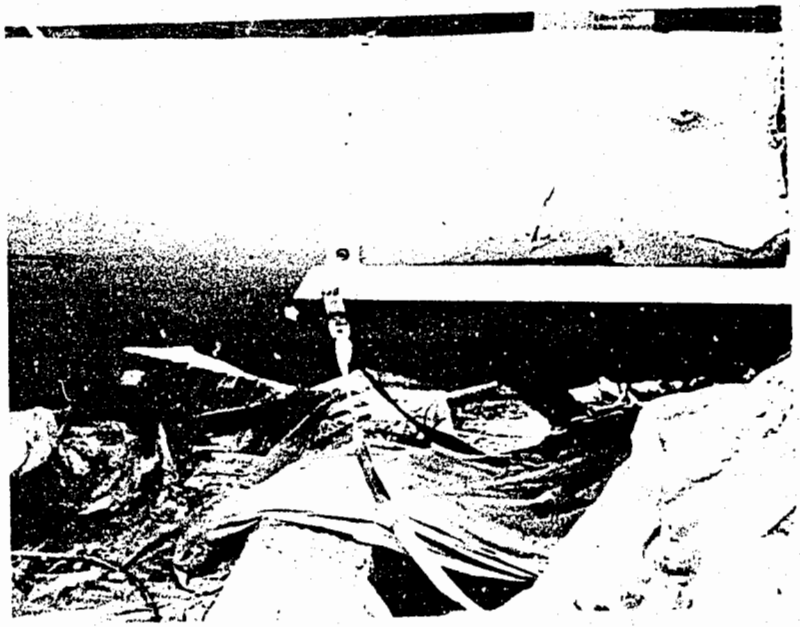

Figure 26. Weapon #4, Dents on Left Side of Afterbody

Figure 27. Weapon #4, Damage to Afterbody

recovered), and deployment of both 16-1/2 and 64-foot parachutes (Figure 28). In addition, separation from the aircraft resulted in the extraction of both pullout rods (Figure 29) and the retention of the MB-3A rack and a beam from the MHU-20/C clip-in assembly (Figure 30).

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Additional water pressure damage became evident during the render safe and packaging procedures.

Water pressure effects resulted in difficulty in removing the MC796 high-voltage thermal battery. Pressure distorted the warhead pressure cover over the battery and produced a great amount of friction.

DOE b(3)

With the warhead electrically disarmed, operations were suspended until after the viewing by Spanish officials and the press the next day, April 8.

Removal of the fuze section revealed the effects of pressure on the warhead pressure cover (Figure 33). Apparently the pressure seal withheld the pressure during the crushing of the cover, and subsequent leakage filled the warhead with sea water.

The cover had to be forced off by cutting, prying, and pulling (Figure 34). Components under the cover had been submerged but looked in good condition (Figure 35).

Detonator cables were disconnected with no difficulty, and the tube from the pit was disconnected from the reservoir (Figures 36 and 37).

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Figure 28. Weapon #4, 16.5-Foot Chute on Left, 64-Foot Chute on Right

Figure 29. Weapon #4, Pullout Rods Extracted

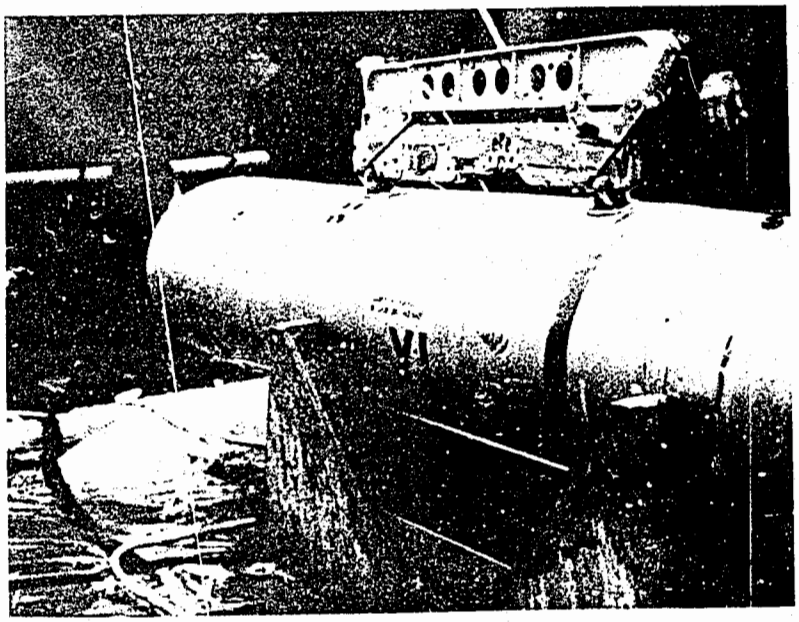

Figure 30. Weapon #4, MB-3A Rack and Portion of MHU-20/C Clip-In Assembly

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Figure 32. Weapon #4, Battery Removed

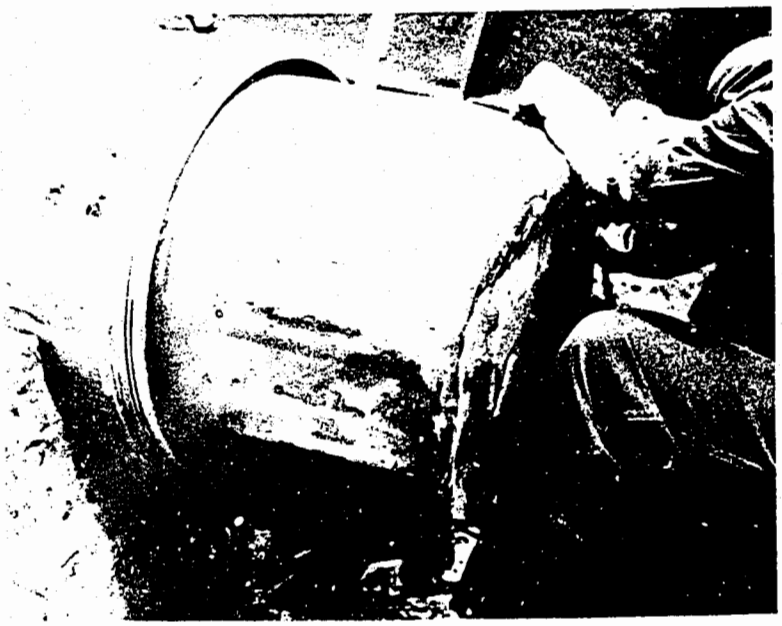

Figure 33. Weapon #4, Crushed Warhead Pressure Cover

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[redacted] DOE b(3)

The afterbody was disassembled for removal of parachute deploying detonators. The forward portion was in near normal condition (Figure 39) except for the large quantity of silt in the interior. All parachute loops were still connected in the normal manner (Figure 40), but the 64-foot parachute bag had been torn out of the straps.

[redacted] DOE b(3)

All bomb components except the parachute were placed on a bed of sand in the container bottom, with the warhead portion contained in the center wood box. The warhead was then covered with sand, the other components shored in place, and the cover put in place (Figures 41, 42, and 43). The two parachutes were packed together in a 55 gallon drum for shipment.

At approximately 4:50 PM, local, April 8, the two containers were transferred from the USS Petrel to the USS Cascade, a destroyer tender, for shipment to the U. S. The engine container was lashed down in the open on a high deck to permit the maximum natural ventilation through the container. The weapon was transported directly by sea to Quonset Point, Rhode Island, and then by air to Pantex Ordnance Plant, Amarillo, Texas.

Summary of Damage to Weapons

Examination of weapon and aircraft debris indicated that the four weapons separated from the aircraft in a relatively clean manner except for a varying amount of damage to each of the afterbodies. This damage resulted in deployment of the 16-1/2-foot parachute in two of the weapons and deployment of both the

Figure 39. Weapon #4, Forward End of Afterbody

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Figure 40. Weapon #4, 16-Foot and 64-Foot Chute Shroud Line Connections in Afterbody

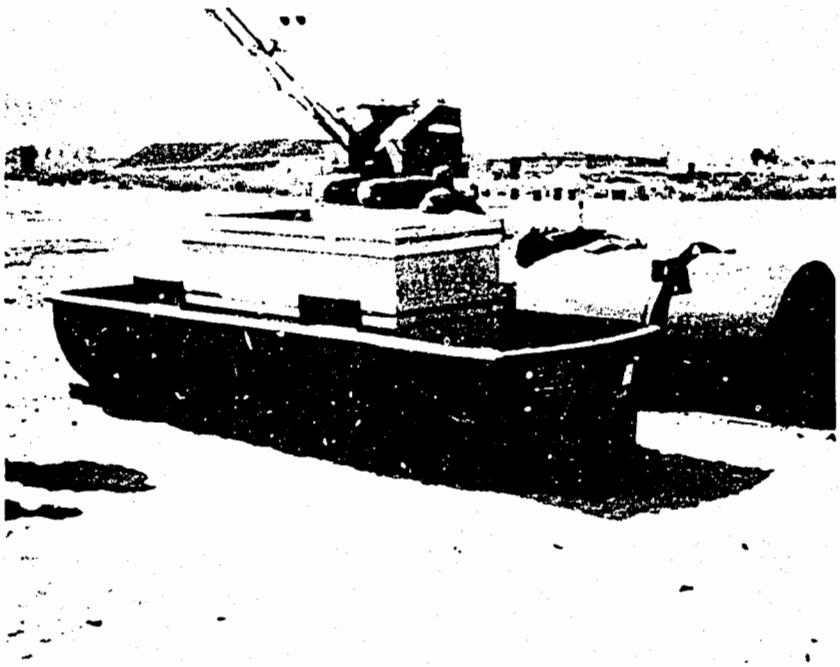

Figure 41. Modified J79 Engine Container

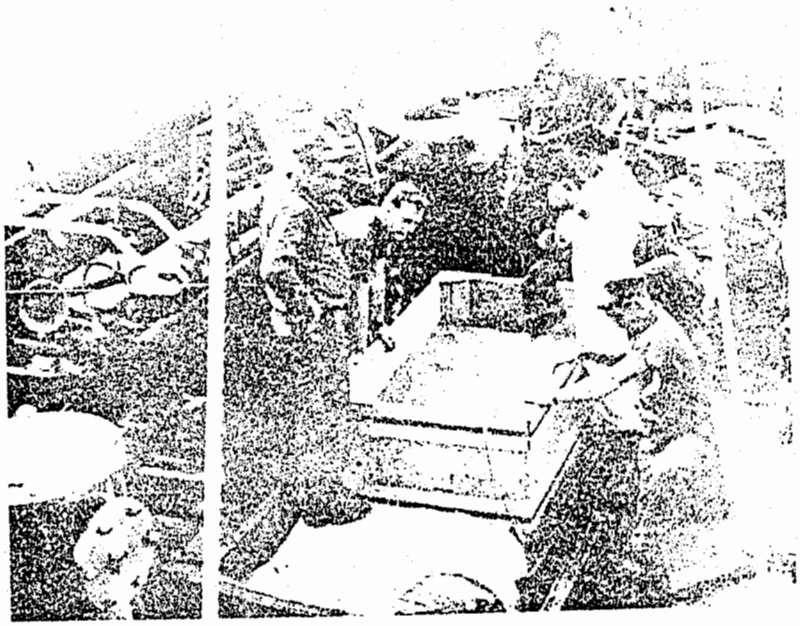

Figure 42. Weapon #4 Warhead Being Covered with Sand

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16-1/2-foot and 64-foot parachutes in one other weapon (Figures 44 and 45). An analysis of the parachute operation is presented in Appendix C.

The impact conditions are summarized as follows:

	#1	#2	#3	#4
Parachute Deployment	16-1/2'	None	16-1/2' damaged	16-1/2' & 64'
Estimated Impact Velocity*	130 fps	325 fps	225 fps	30 fps
Surface Material	Soft clay bank	Hard caliche soil	Hard caliche soil	Water
Impact Effects	Crushed nose	HE detonation	He detonation	Water pressure effects

*These estimates are based on projected trajectories, the parachute conditions, and the effects on the surviving weapon material.

After impact, there was no further damage to the weapons except the sea water pressure and submergence effects on Weapon #4. Some minor damage probably occurred on Weapon #4 during underwater movement and recovery, especially in the exposed parachutes.

Safety Considerations

Separation from the aircraft resulted in extraction of pullout rods from at least two of the weapons, and preliminary post-mortem has revealed that the safe-separation timers ran down as expected. No other components that survived had been activated or operated.

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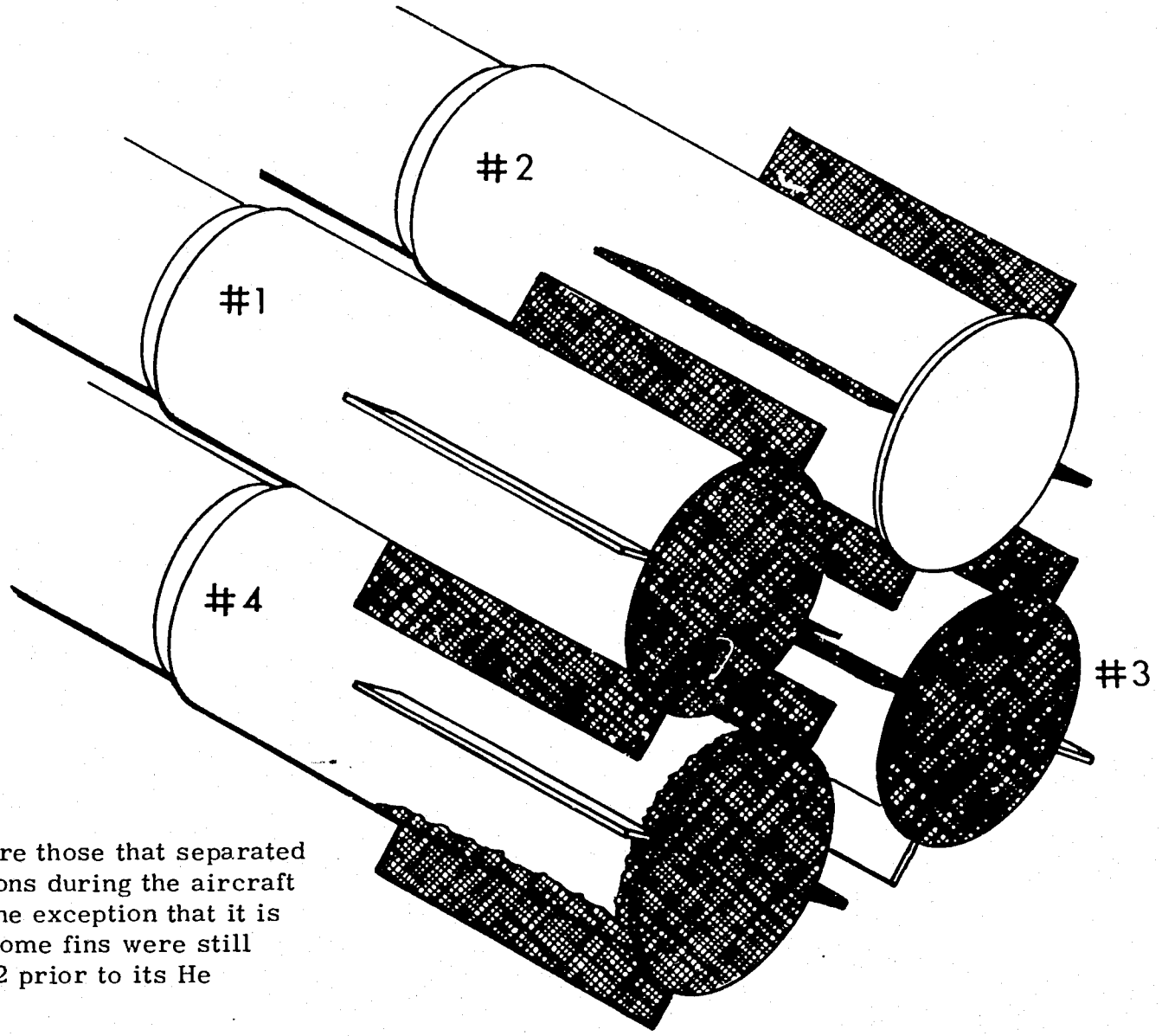

Note:
Shaded parts are those that separated from the weapons during the aircraft breakup with the exception that it is possible that some fins were still with Weapon #2 prior to its He detonation.

Figure 44. Weapon Damage at Aircraft Breakup

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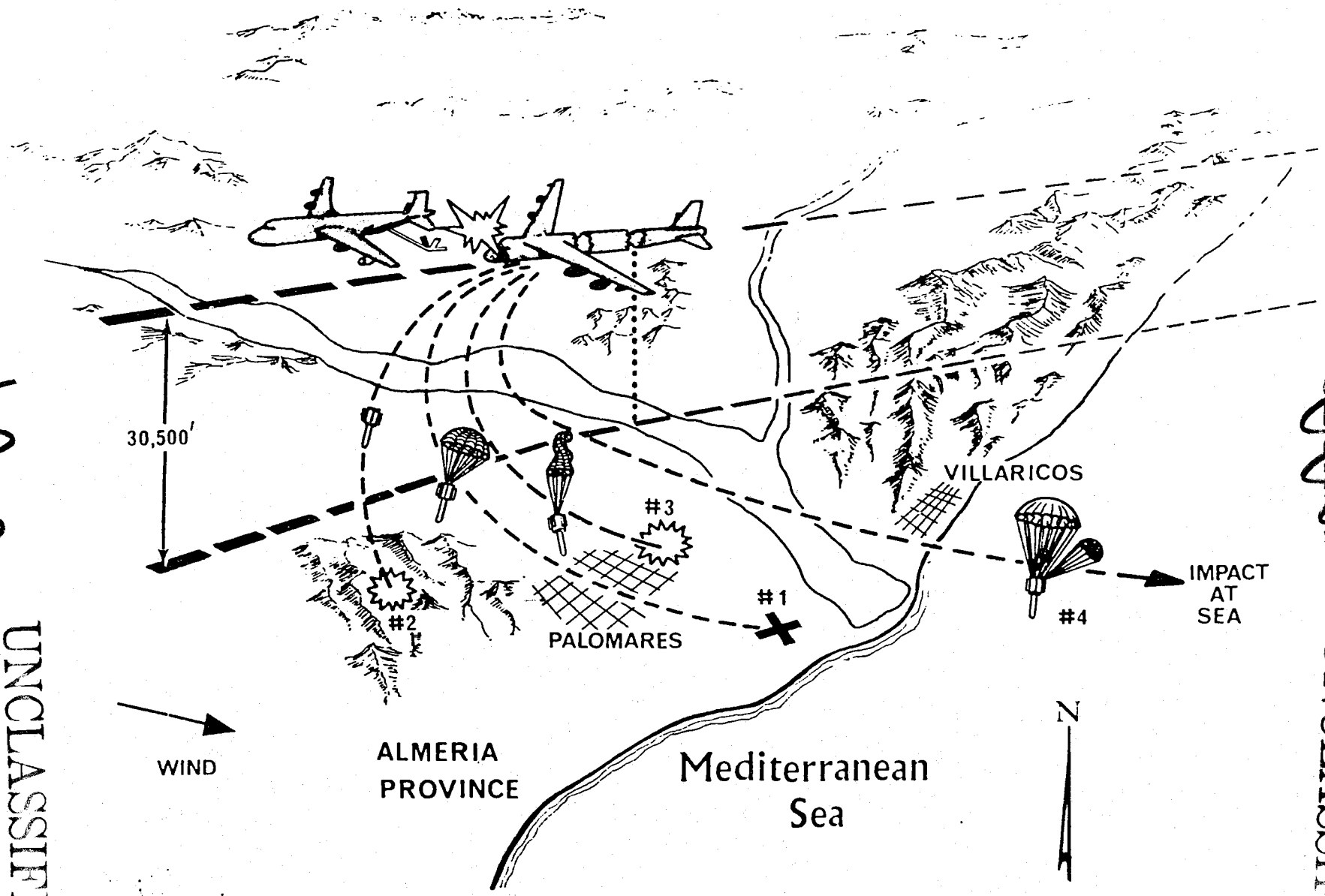

Figure 45. Dispersal of Weapons After Collision

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Security and Public Relations

Custody of the #1 (intact) weapon was first taken by Spanish Guardia Civil who assumed security responsibility for the whole accident scene shortly after the accident occurred. After the arrival of U. S. personnel, security was handled by the combined forces of U. S. Air Police and Spanish Guardia Civil. Because of the widespread area of accident debris and the publicity resulting from weapon search and cleanup, the continuing security support given by the Spanish authorities was extremely helpful in that no known compromise of weapon design information occurred. It is assumed that there was some visual access by Spaniards to components that survived the HE detonation of Weapon #3, but lack of knowledge and means of examination prevented compromise of information. Since Weapon #4 was recovered aboard a U. S. Navy vessel, security was easily controlled, Two Spanish officials viewed Weapon #4 aboard the recovery ship, the same view that the press was given at long range.

From a public relations standpoint, this event was by far the most publicized nuclear weapon accident. Neither widespread plutonium contamination nor a prolonged search for a missing weapon had occurred in a previous accident and here they occurred together along with the further complication of a setting in a foreign country. Initial information provided by the DOD was contained in a release revealing the aircraft accident only; a later release, on January 20, revealed the presence of nuclear weapons aboard the aircraft. On March 2, the fact that plutonium had been scattered and that one of the weapons was missing was released. Initial information provided by the U. S. Government came only from DOD, Washington, and later included information being officially released at the scene and by the U. S. Embassy, Madrid. Press coverage content included officially released information, observation by on-scene reporters including television coverage, background stories concerning known or surmised facts, reports based on interviews with local residents, Spanish officials, and American spokesmen, and reports based on press conferences, given both by Spanish and

American officials. Foreign, as well as the American press, took great interest in the proceedings, and a semipermanent press corps took shape at the scene.

The combination of widespread public interest and tight security on the scene resulted in much misinformation being published in the press. In a number of press reports, estimates of yield, size, and weight appeared. [redacted] DOE b(3) The size and shape (unclassified) were revealed during the Weapon #4 press review. Even after that event, estimates of weight were high, 16,000 pounds appearing to be the most popular. The correct nominal weight is 2350 pounds.

The display of the fourth weapon during the press review of April 8 was largely based on the need for convincing the world that the weapon had been found and recovered. This display was directed by the Secretary of Defense, and a joint plan was worked out between the 16th Air Force and TF65, which included the visit to the weapon by Spanish officials. Access by the press included viewing of the weapon from the USS Albany, a missile cruiser, as the USS Petrel slowly moved past and a followup press conference with Admiral Guest on the recovery operation. A picture of the weapon taken from the Albany appeared in at least one U. S. national magazine. In addition, four photos of the weapon during recovery were released. In all cases, markings were covered, and the opening in the afterbody was covered or not shown.

Because of the popularity of the search and contamination issues, the safety aspect took a back-seat in the press, but a significant number of statements did appear indicating that safety design did prevent a nuclear disaster resulting from the accident. Of particular interest was an article which appeared in the March 30 issue of the Spanish weekly ABC. It described the previously publicized nuclear accidents and the fact that safety devices prevented a nuclear detonation. It also quoted statements from AEC and DOD sources indicating the protection provided by series elements and emphasising the extremely remote possibility of an accidental nuclear detonation.

The long term political effects and the technological achievements resulting from the sea search and recovery indicate that press reports will continue for some time.

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APPENDIX A

WEAPON SERIAL NUMBERS

Bomb Bay Location (looking forward)	F28 Fuze	W28-4 Warhead	FISC28-0 Afterbody
Left Upper (#1)	88071 (Mod 3)	54327	34744
Right Upper (#2)	33348 (Mod 3)	330448	26676
Right Lower (#3)	87952 (Mod 7)	434379	33195
Left Lower (#4)	62166 (Mod 7)	45345	34615

Alts 205, 223, 246, and 252 had been performed on all four warheads. No alts had been performed on the fuzes or afterbodies.

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APPENDIX B

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APPENDIX C
ANALYSIS OF PARACHUTE OPERATION

The Mk 28 FI parachute system consists of four chutes packed one behind the other in the tail section (afterbody) of the weapon. Starting at the front there is a 30-inch diameter stabilization chute, a 64-foot solid canopy chute, a 16.5-foot ribbon chute, and a 4-foot guide surface chute. Two normal trajectory options are available: the retarded option utilizing the deployed 64-foot chute and the near free fall option utilizing the deployed 30-inch chute for stabilization.

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[redacted] For both options, after the unit separates from the aircraft, the tail plate is ejected from the weapon by timed electrical signals which initiate a ring of MDF (mild detonating fuze) explosive. Ejection of the tail plate deploys the 4-foot extraction chute which pulls the 16.5-foot chute pack out of the weapon and pulls the bag off the 16.5-foot chute. The 16.5-foot chute then inflates. After a short time interval, a second electrical signal is provided which initiates one of two MDF rings in the shroud line attachment plate assembly (spider). In the retarded mode, the signal releases the 16.5-foot chute shroud lines which pull out the 64-foot chute pack and pull the bag off the chute; this sequence results in inflation of the chute and a retarded trajectory. In the free fall mode, the signal releases both the 16.5- and 64-foot chute shroud lines and permits the 16.5-foot chute to extract the 64-foot chute pack completely and to deploy the 30-inch chute.

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In addition, examination of debris indicated that parachute deployment explosive devices were unaffected by the accident. Therefore, the forces resulting from the aircraft collision and breakup caused deployment of the parachutes.

On weapons #1 and #3, the tail plates were torn off by forces apparently being applied at the edges that overlap the afterbody proper. This resulted in near normal deployment of the 16.5-foot chutes, although the chute in #3 weapon was apparently torn in the process.

Weapon #4 was damaged in a different manner; the afterbody was subjected to a crushing action in the area of one fin which resulted in (1) the splitting of the afterbody case section and (2) the apparently progressive failure of rivets connecting the afterbody skin section to the rear ring forging and subsequent separation of the rear ring forging and cover plate from the weapon. Again, this resulted in deployment of the 16.5-foot chute; but, in addition, the afterbody damage resulted in abnormal removal of the bag from the 64-foot parachute, which permitted its subsequent deployment. Since the 16.5-foot chute shroud lines were still attached by loops to the spider, the weapon descended with both chutes deployed.

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APPENDIX D

SUMMARY OF AEC ON-SCENE PARTICIPATION

AEC/ALO

D. J. Hart	Jan. 18	-	Feb. 9
P. Schneider	Feb. 8	-	March 3
E. W. Griffith	March 2	-	March 19

LOS ALAMOS SCIENTIFIC LABORATORY

W. H. Chambers	Jan. 18	-	Jan. 27
D. F. Evans	Jan. 18	-	March 4
W. H. Langham	Jan. 23	-	Jan. 27
J. Lawrence	Jan. 23	-	Jan. 27
D. D. Meyer	Jan. 24	-	Jan. 27

SANDIA CORPORATION

S. V. Asselin	Jan. 18	-	Feb. 3
	March 22	-	April 8
W. R. Hoagland	Jan. 26	-	Jan. 29
R. C. Maydew	Jan. 29	-	Feb. 8
R. E. Reed	Feb. 1	-	Feb. 19
W. R. Barton	Feb. 14	-	March 4
S. A. Moore	Feb. 16	-	March 3

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