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ANALYSIS OF THE SAFETY ASPECTS OF THE MK 39 MOD 2 BOMBS INVOLVED IN B-52G CRASH NEAR GREENSBORO, NORTH CAROLINA

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February 1961

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ABSTRACT

This report presents the results of the investigation and analysis of the safety aspects of the Mk 39 Mod 2 bombs involved in the B-52G crash near Greensboro, North Carolina. This investigation was conducted by Sandia Corporation subsequent to a preliminary investigation at the scene of the crash.

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Introduction

On January 24, 1961, a B-52G carrying two Mk 39 Mod 2 bombs broke up in mid-air and crashed near Seymour-Johnson AFB, North Carolina. During the mid-air breakup of the aircraft, the weapons separated from the aircraft. The parachutes of the weapon in the aft bomb bay (hereinafter called weapon No. 1) deployed, and in its retarded trajectory the weapon impacted approximately 1 mile short of the impact point of the major section of the aircraft. The parachutes of the weapon in the forward bomb bay (hereinafter called weapon No. 2) did not deploy, and the weapon impacted in the free-fall condition approximately 1500 feet past the impact point of the major portion of the aircraft fuselage.

An AEC team consisting of members from ALO, LASL, and Sandia Corporation went to the scene of the crash to assist in the preliminary investigation of the weapons involved in the crash. A report of the accident and the on-site investigation is contained in SCDR 106-61.* Subsequently, some components of weapon No. 2 were returned to Sandia Corporation for further analysis. Detailed post-mortem of these components, along with information from the preliminary investigation, has made possible a determination of the status of the weapons during the crash.

Summary of Results

Analysis of the components and reports from the crew of the aircraft indicate that none of the prearming functions required to release a live nuclear weapon had been performed prior to the time the weapon separated from the aircraft. However, some events normally requiring crew action must have occurred mechanically due to aircraft breakup. It is known that the safing pins were extracted from the Bisch generator actuation rods, and the rods themselves were extracted from the pullout assembly. On both weapons the fuzing sequences were initiated, but, due to the fact that the aircraft-controlled Arm/Safe switch was in the safe condition at time of release, neither weapon armed. This in itself would have prevented a nuclear explosion.

When the MC-772 Arm/Safe Switch of weapon No. 2 was recovered, there was an indication that the switch might have been armed. Post-mortem results indicated that the indicator drum had rotated to the ARM position, but that the switch contacts in all probability never actually closed in the ARM position. The rotation of the indicator drum was undoubtedly due to the impact shock; however, the impact shock also damaged the switch contacts to the extent that there was no continuity through the switch in either the ARM or SAFE position.

Weapon System Description

B-52G Aircraft

The B-52G has two bomb bays, each capable of carrying one Mk 39 weapon. The weapons are separately controlled through two T-249 Aircraft Monitor and Control units. The arming circuits to the weapons are interlocked by the T-380 Readiness Switch. The T-380, under the aircraft commander's control, must be placed in the ready position and the appropriate T-249 must be placed in the air or ground position in order to prearm either weapon. The aircraft is also equipped with lanyards from the bomb bays to the crew compartment to allow extraction of safing pins during flight.

*SCDR 106-61, Accident Report of B-52G Near Seymour Johnson Air Force Base, North Carolina, SRD, H. D. Bickelman, 7162-1, dated February 1961.

A modification program, ALT 197, was approved in January 1960. When incorporated, ALT 197 will make the lanyards for extracting the safing pins unnecessary in aircraft equipped with the T-380 Readiness Switch.

The aircraft system also incorporates a solenoid-operated lock which either allows the weapon to fall in free-fall trajectory or initiates parachute deployment at release. The static line from the parachute is attached to the solenoid lock, and, when the lock is operated, the parachute deploys at release.

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Mk 39 Mod 2 Weapon

The Mk 39 Mod 2 is capable of either free-fall or completely retarded trajectories. It has a dual-channel, timer-armed and impact-fired fuzing system. The firing signal at impact is derived from closure of a crush switch in the nose of the weapon. In addition, there is a trajectory-arming feature in this weapon which functions after separation from the aircraft; before arming is allowed, the weapon must undergo a pressure change corresponding to 1500 feet at sea level.

A single channel block diagram of the fuzing and firing system is shown in Figure 1, and the normal trajectory sequence is shown in Figure 2. Detailed operation is as follows: Prior to release, the MC-772 Arm/Safe Switch, controlled from the T-249, must be placed in the ARM position, and the safing pins in the Bisch generator rods must be removed by the lanyard extending to the crew compartment. At release of the weapon, rods are extracted from the Bisch generator assembly which in turn delivers an initiation signal to the low-voltage battery and the safe-separation timer. Rods also actuate the pullout valve assembly causing the valve to close and sealing a reference pressure in one chamber of the MC-832 Differential Pressure Switch. Five to eight seconds after release, the thermal battery voltage rises to approximately 28 volts.

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When the weapon has fallen the required vertical distance, the differential pressure switch contacts close, passing battery current through the MC-772 to the MC-788 High Voltage Safing Switch. Upon receipt of this current, the MC-788 is operated, connecting the output of the high-voltage thermal battery to the X-unit. When the timer contacts close, 42 seconds after release, initiation power is delivered to the high-voltage thermal battery. The high-voltage thermal battery comes up to voltage 1 to 2 seconds later. The X-unit is charged, and voltage is applied to the trigger circuit. At impact the crush switch closes, grounding one side of a firing transformer in the trigger circuit. The other side of the transformer is connected to the 28-volt low-voltage thermal battery through a fuse. When the crush switch closes, a pulse is delivered to the transformer, causing a signal to be transmitted to the gap switch, and discharging the X-unit. Each channel of the crush switch firing circuit is fused. In the event of premature operation of one channel, that fuse will clear in a few milliseconds to allow subsequent operation of the opposite channel.

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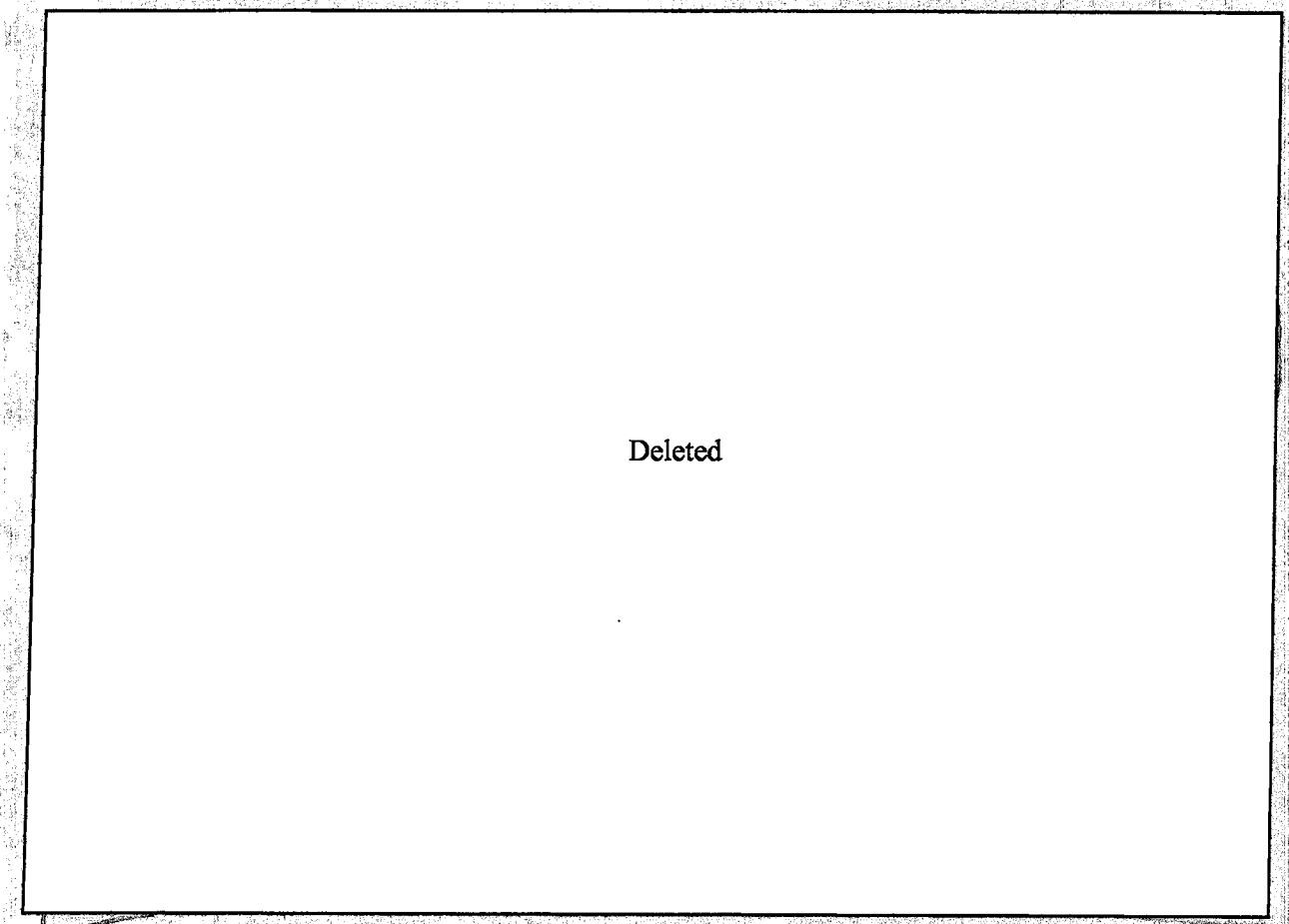

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Figure 1. Single Channel Block Diagram of Mk 39 Mod 2

T-380 READINESS SWITCH IN READY POSITION
T-249 CONTROL POWER SWITCH ON
T-249 SELECTOR SWITCH IN ARMED POSITION,
ARMING MC-772 ARM/SAFE SWITCH
LANYARDS PULLED, REMOVING SAFING PINS

AT RELEASE
MC-845 GENERATOR OPERATES
ACTIVATING MC-640 THERMAL
BATTERY AND STARTING
MC-543 TIMER. PILOT PARA-
CHUTE DEPLOYED. PULLOUT
PLUGS REMOVED AND VALVES IN
PRESSURE SWITCH SYSTEM CLOSED.

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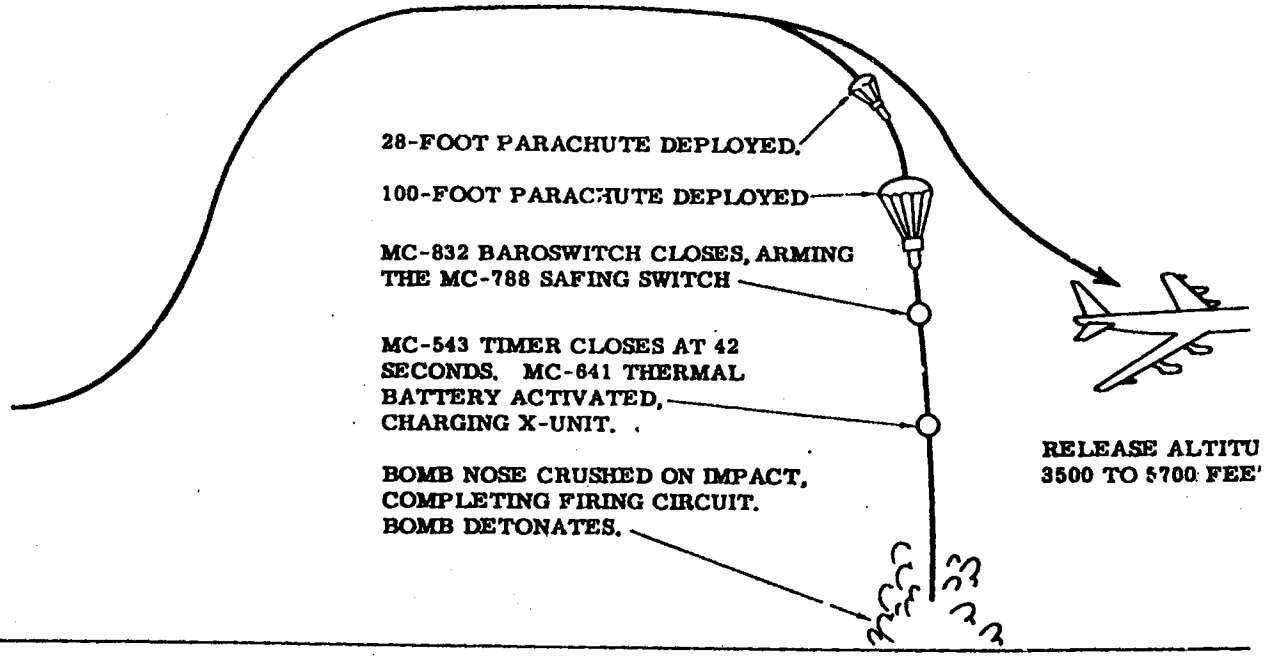

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Figure 2. Normal Trajectory Sequence of Mk 39 Mod 2

MC-832 Differential Pressure Switch -- The MC-832 contains four individual barometric elements. The elements of this switch are set to operate when a differential pressure equivalent to approximately 30 mm Hg is applied to the element. In the weapon, one chamber of each element is open to ambient atmospheric pressure. The opposite chamber is open to ambient pressure through a mechanically actuated valve.

Pullout Valve Assembly -- The pullout valve assembly contains rods which, when extracted from the weapon at release, close to seal the ambient pressure in one of the chambers of each of the differential pressure-switch elements. Prior to operation, the rods are retained in the weapon assembly by shear pins.

MC-772 Arm/Safe Switch -- The MC-772 is a solenoid-operated rotary switch with detents so that, if a pulse of power is delivered to the solenoid, the switch will step from SAFE to ARM or from ARM to SAFE. The solenoid operates through an axial air gap. The axial force is translated to rotational motion by balls which ride in grooves in an inclined plane. A drum attached to the rotary switch, which indicates the ARM or SAFE condition, can be observed through windows in the side of the housing. There is an auxiliary lever at the end of the switch assembly which will allow manual movement of the switch from the ARM to the SAFE position, but not vice versa.

MC-788 High-Voltage Safing Switch -- The MC-788 is also a solenoid-operated switch. The solenoid device is similar to that used in the MC-772; however, there is no detent action to cause the switch to remain in the ARM position. Continuous power must be applied to the solenoid in order to keep the contacts closed in the ARM position.

MC-641 High-Voltage Thermal-Battery Pack -- The MC-641 contains ten MC-583 or MC-818 thermal batteries. The batteries are connected in a series-parallel arrangement with five in each series leg. The complete assembly provides a total voltage of 2500 volts to charge the X-unit. Individual batteries are initiated when energy is delivered to their matches through an isolation transformer.

MC-787 Trigger Circuit -- The MC-787 contains two krytron tubes which are supplied plate voltage from the high-voltage thermal battery through a divider network. Pulse transformers are connected in the grid circuits of these tubes so that when the transformer is pulsed, the tubes conduct and deliver a firing pulse to the X-unit gap.

Crush Nose Switch -- The nose of the weapon is arranged so as to close an electrical circuit when it is deformed inwardly. Spaced behind the nose cap are six metal plates, each covering a 60-degree sector of the weapon's cross section. Alternate plates are connected in parallel to one trigger-circuit grid transformer through a fuse. When the nose cap is deformed at impact, contact is made with sharp projections on the switch plates, completing the circuits and pulsing the transformers.

ALT 197 provides additional safing by introducing Arm/Safe switch contacts between the Bisch generator output and the low-voltage thermal battery matches. In this ALT, the MC-1288 Arm/Safe switch is installed in place of the MC-772. In addition to the contacts in lines presently controlled by the MC-772, MC-1288 contacts in the Bisch line insure that the thermal battery will not be operated if the weapon is released in the safe condition. A block diagram of the system with ALT 197 is shown in Figure 3. When this ALT is accomplished, it is considered that the system is adequately safe for alert flying without safing pins installed in the pullout rods.

ALT 193 is a modification to provide compatibility with the aircraft clip-in suspension system by adapting the Bisch and valve pullout connections to the clip-in supporting structure. The lanyard arrangement for removing safing pins in flight cannot be used with ALT 193. For this reason, ALT 197 must be performed at the same time or prior to completion of ALT 193.

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Figure 3. Block Diagram Mk 39 Mod 2 with ALT 197

Analysis of Weapon No. 1

Observers reported that this weapon separated from the aircraft 7000-9000 feet above terrain. Fully retarded, it impacted in the near-vertical position, penetrated the earth approximately 18 inches, and remained in an upright position with the parachute hanging in adjacent trees. The weapon was intact with only minor damage, and it was possible to analyze the components at the scene. It was found that the safing pins and Bisch generator rods had been extracted and the pullout valves had operated. The low-voltage thermal battery pack had been initiated and the timer had run down. The differential pressure switch contacts were closed and the high-voltage thermal battery pack had been initiated. The MC-772 Arm/Safe Switch and the MC-788 Safing Switch were in the SAFE positions. The gas reservoir valve had not been actuated and the gas remained in the reservoir. The crush nose assembly was deformed, and it can be assumed that it supplied a fire signal at impact. The probable trajectory sequence is shown in Figure 4.

From examination of the MC-845 Bisch generator assembly, it appears that the pullout rods were extracted in the normal fashion. There was no scoring or other physical damage to the assembly which would indicate that any unusual forces had been applied. Also, since the holes for the safing pins were not in any way damaged, it must be assumed that the safing pins were extracted prior to separation of the weapon from the rack. It is known that the aircraft broke up in mid-air and impacted the earth in several pieces, over a wide area. One intact safing pin and a portion of the lanyard were recovered, indicating that the pin must have been removed at the time the Bisch rods were pulled. It is believed that the lanyards attached to the safing pin in this weapon caused the safing pins to be extracted during the breakup of the aircraft.

This weapon appeared to have a completely normal retarded trajectory; therefore, it is assumed that the parachute solenoid locking device had been operated, securing the parachute static line to the aircraft structure.

From the information available on this weapon, it is apparent that all components behaved in the normal manner that would be expected if the bomb were released from the aircraft with the T-249 in the safe condition. Under these conditions, arming of the weapon is prevented by the MC-772 and the MC-788.

Analysis of Weapon No. 2

This weapon probably separated from the aircraft between 2000 and 5000 feet above terrain. It impacted in a free-fall trajectory. The tail of the weapon was buried approximately 12 feet below the surface. The structure of the weapon was severely damaged, and there was considerable breakup due to the impact conditions; however, no HE explosion resulted. Components of the fuzing system, which are located in the aft portion of the weapon just ahead of the parachute (see Figure 5), were recovered relatively intact; however, the extent of the damage did not readily allow complete evaluation at the scene. The gas reservoir was essentially undamaged. The actuator had not been initiated and the gas remained in the reservoir. The MC-772 Arm/Safe Switch appeared to be intact when recovered from the unit, and the indicator drum indicated that the switch was in the ARM position. It was therefore requested that this component, along with other components of the fuzing system, be returned to Sandia Corporation for further analysis. Post-mortem results of various components at Sandia indicated that the fuzing sequence had been initiated similarly to weapon No. 1. The Bisch generator had been actuated, causing the low-voltage thermal battery to be activated and the timer to be started. The pullout valves had been closed and subsequently the differential pressure switch contacts had closed. The timer had not completed its timing cycle, but had stopped after approximately 12 seconds of operation as a result of the deformation which occurred at impact; therefore, the high-voltage thermal battery had not been actuated.

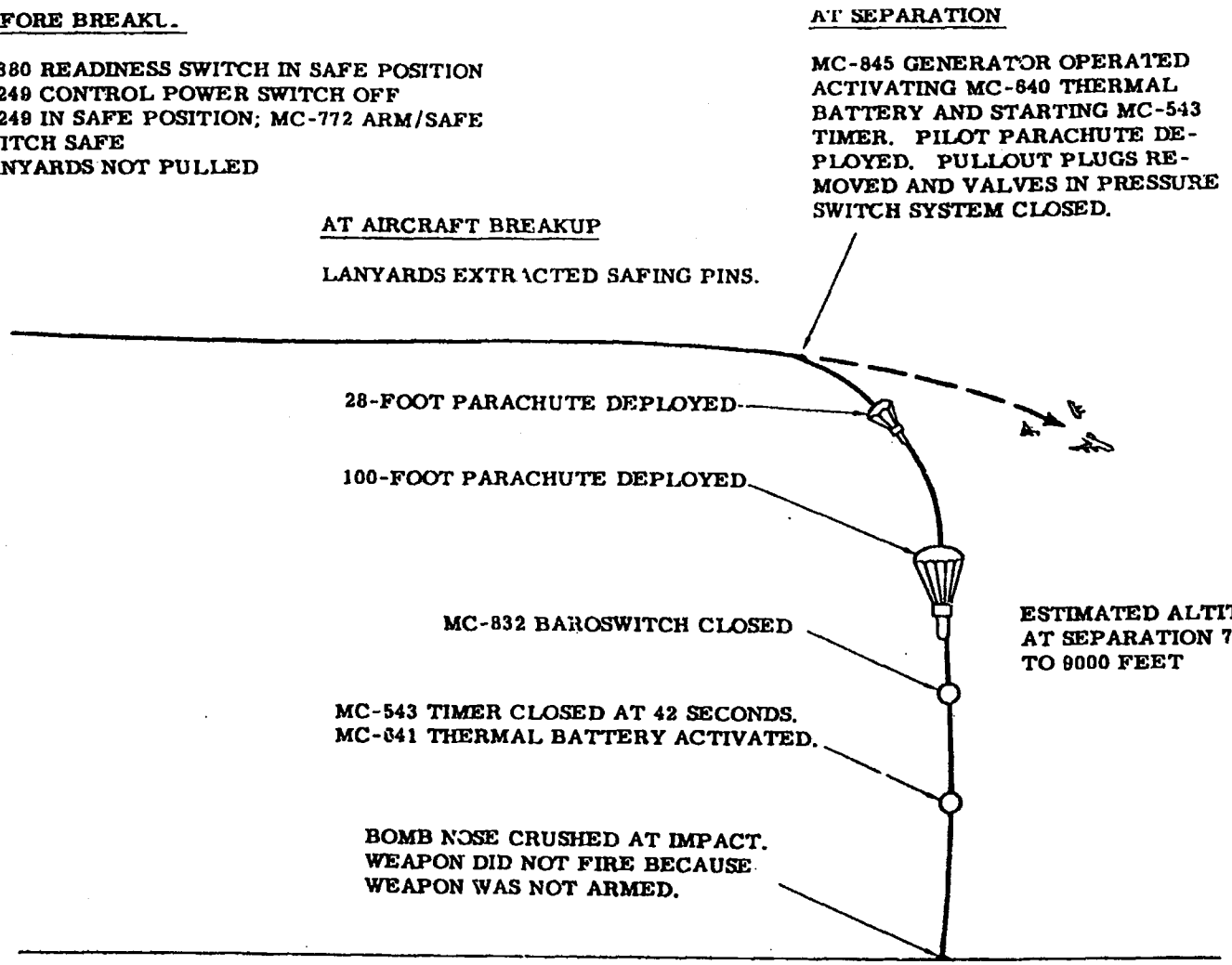

Figure 4. Probable Trajectory Sequence, Weapon No. 1

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Figure 5. Cutaway of Mk 39 Mod 2

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The probable trajectory sequence of this weapon is shown in Figure 6.

As the indicator drum of the MC-772 did indicate that the shaft of this switch was in the ARM position after impact, detailed examination of this switch was conducted. Photographs of the switch as it appeared when recovered are shown in Figure 7. The "A" indication can be seen in the window. At the time it was recovered, there was no continuity through any contacts of this switch. Upon disassembly of this switch, it was found that the stationary members of the switch contacts had been physically displaced at impact approximately 1/4 inch in the direction of travel. The direction of impact force is in the opposite direction that would be expected to operate the solenoid of this switch. However, because of the mounting configuration of the switch (see Figure 5), there is good reason to believe that a severe rebound shock would occur after impact which could cause the solenoid to rotate the switch shaft.

From the evidence available, it must be concluded that the MC-772 was in the SAFE position until time of impact. It is quite probable that the contacts of this switch never operated to the ARM position. The circumstances of this weapon up until the time of impact are very much the same as those of weapon No. 1, except that there was insufficient time between separation of the weapon from the aircraft structure until impact for the timer to operate; consequently, the high-voltage battery was not initiated.

Detailed post-mortem results on various components recovered from this unit are available in separate reports. They are summarized here to provide completeness to this report.

MC-772 Arm/Safe Switch -- Electrical checks of the circuits of the switch revealed that there was no continuity through any of the switch circuits in either the ARM or SAFE condition. Disassembly of this switch revealed that the structure on which the switch is mounted internal to the housing was severely deformed in the direction of travel of the weapon at impact. A comparison of Figures 8 and 9 shows that the plastic wafers which support the stationary contacts of the switch broke from their supporting posts and were displaced away from the switch rotor contacts. The indicator drum remained attached to the switch rotor, and the rotor was displaced to the ARM position.

MC-640 Low-Voltage Thermal Battery Pack -- The MC-473 batteries were removed from the battery pack. Scorching of materials around the batteries indicated that they had been activated. The batteries were opened and it was found that they had been activated by electrical energy to the matches and that power was probably available during the trajectory sequence.

MC-543 Timer -- The case on the MC-543 was severely distorted. The cover plate had been deformed so as to jam the gears on both timer channels. Figure 10 shows a comparison of this timer with a normal reset timer. The position of the mechanism indicated that the timer had been set at 42 seconds and had run approximately 12 seconds after initiation. Examination of the actuators indicated that they had been fired electrically.

MC-641 High-Voltage Thermal Battery Pack -- Each of the ten MC-583 Thermal Batteries was removed from the battery pack and opened. It was found that none of these batteries had been activated at any time. The squib switches used to indicate whether the battery had received an initiation pulse were also examined and it was found that they had not been activated.

MC-845 Bisch Generator -- The Bisch generator rods were found to have been extracted. There was no evidence of any unusual scoring or other damage which would indicate that the rods were extracted in other than a normal fashion. The holes through which the safing pins are installed appeared normal, and it is believed that the safing pins were extracted before separation of the weapon from the rack.

MC-788 High-Voltage Safing Switch -- The switch was crushed and severely distorted. The stationary and movable contacts were smashed, together with their plastic supporting members. Although the connectors had been ripped loose from the housing, electrical checks at the ends of the broken leads showed continuity in the SAFE position. These checks and the examination of the switch parts would indicate that the switch was in the SAFE position at time of impact.

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BEFORE BREAKUP

T-380 READINESS SWITCH IN SAFE POSITION
T-249 CONTROL POWER SWITCH OFF
T-249 IN SAFE POSITION; MC-772 ARM/SAFE SWITCH SAFE
LANYARDS NOT PULLED

AT SEPARATION

MC-845 GENERATOR, OPERATED ACTIVATING MC-640 THERMAL BATTERY AND STARTING MC-543 TIMER.
PILOT PARACHUTE DEPLOYED.
PULLOUT PLUGS REMOVED AND VALVES IN PRESSURE SWITCH SYSTEM CLOSED.

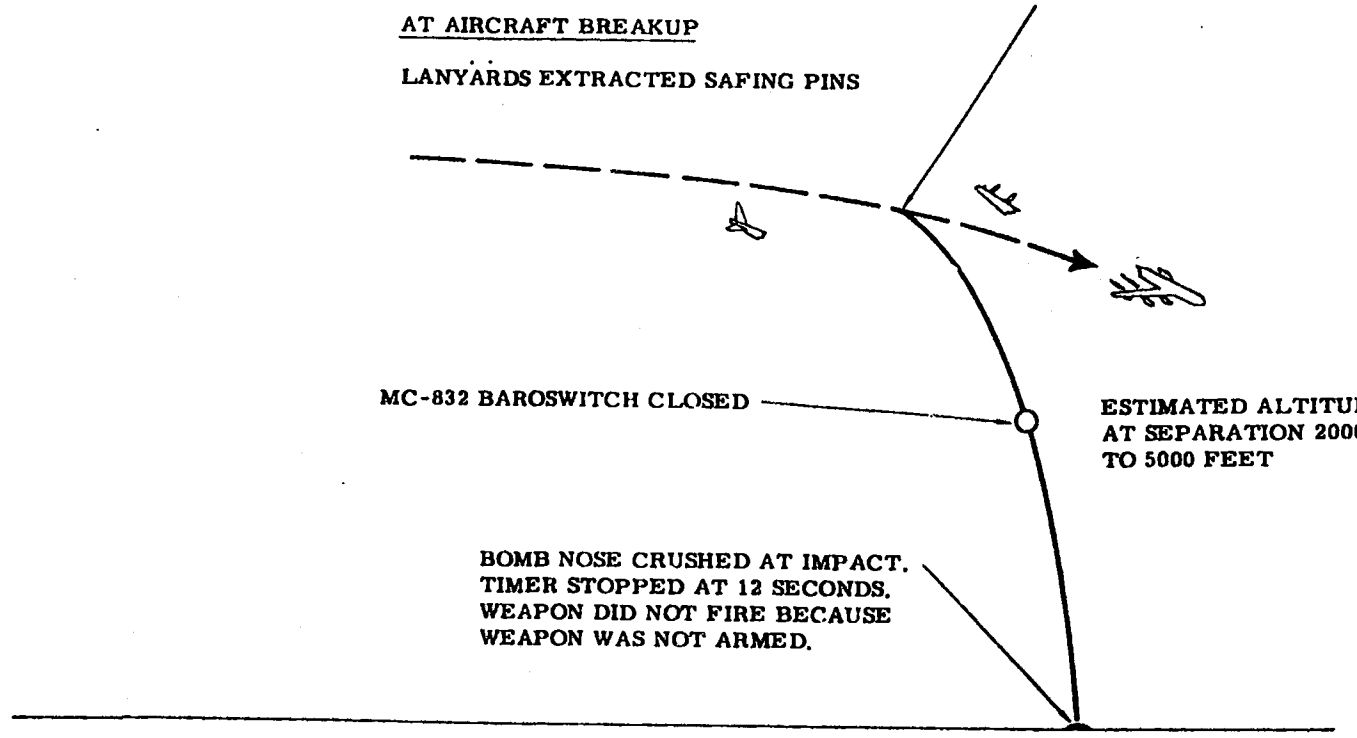

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Figure 6. Probable Trajectory Sequence, Weapon No. 2

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Figure 7. MC-772 Recovered from Weapon No. 2

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MC-832 Differential Pressure Switch and the Pullout Valve Assembly -- The pullout rods had been extracted from this valve assembly and the valves were closed. No conclusions can be drawn from examination of the MC-832; but, since it received normal inputs, it can be assumed that it operated normally.

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As in the case of weapon No. 1, the fuzing sequence on this weapon appeared to have been initiated when the weapon separated from the aircraft structure.

Since the system was not armed at any time during the trajectory sequence, no nuclear explosion could have resulted.

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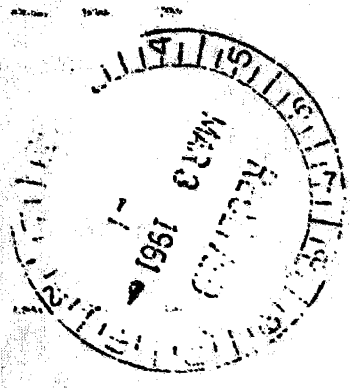
Conclusions

1. The lanyard-controlled safing pins cannot be relied upon to prevent initiation of the fuzing sequence when the aircraft is involved in this type of accident.

2. The Arm/Safe switch prevented a nuclear detonation in these weapons as it was designed to do.

3. Since it is undesirable to have the fuze power supply activated except when a live release is intended, ALT 197 should be incorporated as rapidly as possible in all Mods of the Mk 15/39 family which are used in the airborne alert.



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