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Operation

DOMINIC

FISH BOWL SERIES

PROJECT OFFICERS REPORT—PROJECT 8C

REENTRY VEHICLE TESTS [redacted]

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REENTRY VEHICLE TESTS [redacted]

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[redacted]

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[redacted]

Project 8C was designed to determine directly the effects of a high-altitude, high-yield nuclear detonation on an operational reentry vehicle's (R/V) heat shield, substructure, and selected internal components. Two modified [redacted] vehicles were to [redacted] carried aboard a Thor booster, separated from the Thor, and exposed to [redacted]

DNA (1)(3)

The vehicle design included an attitude control system that oriented the vehicles side-on to the burst and a parachute-flotation system for recovery. Instruments contained on or within the vehicle were to measure total momentum [redacted] various response modes of the vehicle, the orientation of the vehicle with respect to the burst, and the radiation environment. Aircraft and ground stations were set up to optically track the vehicles [redacted]

NOTE: THIS IS THE FIRST NUMBERED PAGE WITH A PAGE NUMBER

[redacted]

[redacted]

The experiment was not completed because after approximately 1 minute of flight the missile blew up. [redacted]

[redacted]

CONTENTS

[redacted]

[redacted]

[redacted]

FIGURES

[redacted]

[redacted]

[redacted]

CHAPTER 1

INTRODUCTION

1.1 OBJECTIVES

The primary objectives of Project 8C were: to [redacted] to determine the [redacted] effects of a high-altitude nuclear explosion on a [redacted]

The secondary objective of the project was to measure selected structural and material response modes resulting from the effects of the weapon [redacted]

1.2 BACKGROUND AND THEORY

[redacted]

Pages 12 + 13 deleted in entirety

[redacted]

Gaseous or solid explosives have been applied directly to full-scale vehicles to simulate structural responses [redacted] These phenomena have been exemplified by analysis and laboratory tests on projects supported by the AFSWC. [redacted]

Material responses are not as readily simulated or correlated with the real case as structural responses. [redacted]

Thus, during the past 3 years, a large-scale theoretical and experimental simulation program has been carried out to determine the exact nature of [redacted] kill radii on operational [redacted]

[redacted]

[redacted]

Three nuclear tests were conducted to verify theory and simulation techniques. Shot Marshmallow was an underground test using a low-yield device [redacted] This event was fired in June 1962 and proved to be a highly successful experiment. The Star Fish and King Fish events of the Fish Bowl series were high-yield weapons detonated [redacted] altitude respectively. [redacted]

This experiment was designed [redacted] and to obtain the maximum amount of scientific information. [redacted]

[redacted]

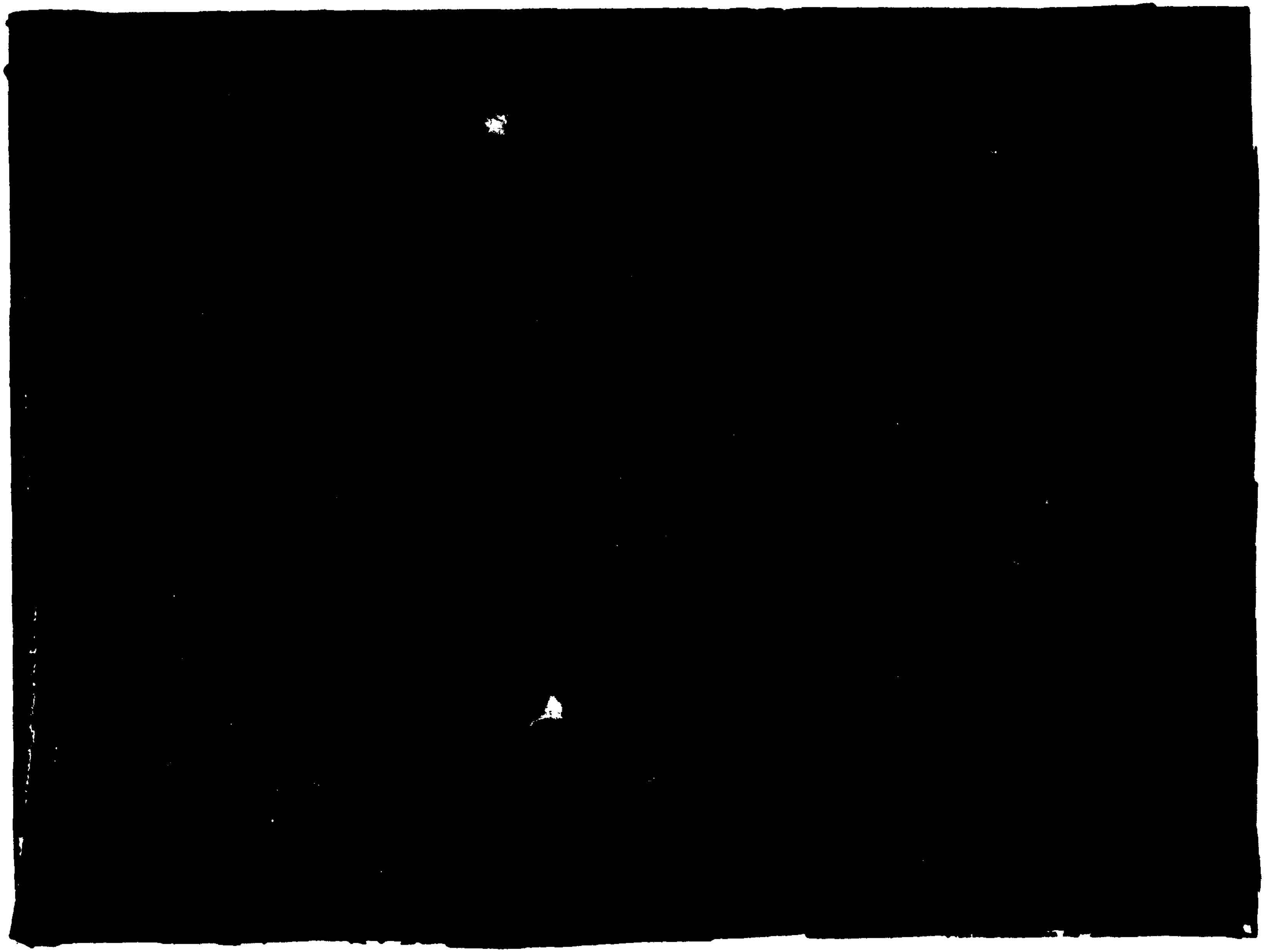
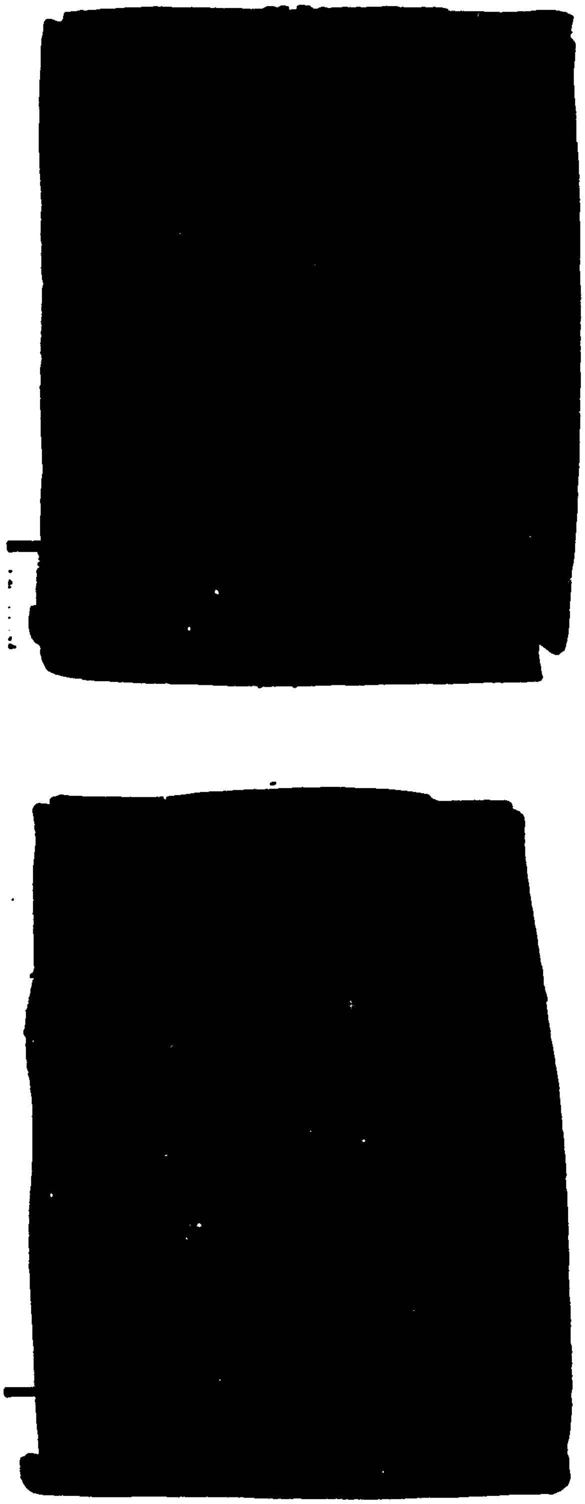


Figure 1.1 Delamination, fracture, and bond rupture after explosive test (AVCO Wilmington 6997–G).



(b)

Figure 1.2 Final configuration of cylinders with stiff outer layer after explosive test (AVCO Wilmington 6653).

[redacted]

Figure 1.3 Closeup of failure of heat shield and bond after explosive test (AVCO Wilmington 6997-M).

CHAPTER 2

PROCEDURE

2.1 SHOT PARTICIPATION

This project participated during Shot Star Fish at Johnston Island. In this test a Thor booster was programmed to carry [redacted] warhead on a trajectory that positioned the weapon [redacted]. The Thor carried two R/V's and one instrumented pod (Project 8B). These were to be released during ascent so as to position the vehicles [redacted]

The activities at the test site consisted of the following: disassembly; final checkout of instrumentation and components, and reassembly preparatory to mating to the Thor booster; participation in the countdown to monitor telemetry and lockout switches, and to assure the controller that the project was ready to go; preparations to coordinate the recovery plan with other agencies; [redacted]

[redacted]

Figures 2.1 and 2.2 illustrate the reentry vehicle used during this test operation. These vehicles were operational [redacted]ehicles modified to incorporate an attitude control system, a vehicle recovery system, and the required instrumentation (Appendix B). The reentry vehicles were designated as 1, 2, and 3. R/V 1[redacted] was used as the backup vehicle, with R/V's 2[redacted] and 3[redacted] designated as the prime flight vehicles. R/V 2 was attached to the Thor [redacted] and it was planned to separate this vehicle from the Thor so [redacted]. R/V 3 was attached to Thor [redacted] with its [redacted] (Figure 2.3).

As previously mentioned, several design factors were incorporated into the R/V's. These were:

1. [redacted]ould this criterion be achieved.

2. [redacted]

[redacted]

[redacted]

[redacted]ion was incorporated in the vehicles [redacted]. This information was to have been obtained from analysis of [redacted] and range tracking radar data (Appendix A).

[redacted]

The R/V's were carried on the Thor booster [redacted] Separation from the Thor was accomplished by [redacted] was supplied by the Thor's guidance computer.

2.2 INSTRUMENTATION

2.2.1 [redacted]

This instrument consisted of a plastic plug loaded with fine metal particles. Two steel rings were inserted circumferentially, and a steel plate was attached to its base. [redacted]

2.2.2 Arsenic Attitude Sensor. Capsules of arsenic were placed in 1/8-inch-diameter holes drilled in a polyethylene half cylinder, 1 inch in height and 1.75 inches in radius (see Figure

[redacted]

2.5). A strip of gold foil was placed over the curved portion of the block. Six such sensors were regularly spaced around the outside of the recovery package tunnel in the flare area. Radioassay of the various arsenic capsules and gold foils would indicate the attitude of the vehicle with respect to the burst.

2.2.3 Tungsten Ball Attitude Sensor. 75 sets of neutron-sensitive foils were spaced over the surface of a 6-inch-diameter tungsten ball. Radioassay of the foils was to indicate the direction of the high-energy component of the incident flux [redacted]

2.2.4 Ballistic Spall Gages. Total momentum was to be measured by introducing a number of indenter gages. [redacted]

2.2.5 Displacement Indentometer. A rigid foam (Styrofoam) collar was bonded directly to the aluminum backup structure in the nose-cylinder interface region, [redacted] In addition, an indication of the relative displacement between the inner and outer structures can be obtained

[redacted]

by examination of impressions in the collar.

2.2.6 Accelerometers. Accelerometers were mounted on the arming and fusing (A&F) shelf and along the recovery package deployment tunnel to record the accelerations undergone by the structure as a result of the weapon effects and the trajectory environment (Appendix C).

2.2.7 Permanent Strain Gage. In order to determine permanent structural deformation, instrumentation consisting of Berry gage marks and resistance strain gages was located on the inner surface of th[redacted]ubstructure (Appendix C).

[redacted]

2.2.9 Gamma Dosimeter Package. This dosimeter package contained pieces of cobalt glass, glass needle dosimeters, and a film badge [redacted] The total gamma dose incident on the package was to be determined by post test analysis.

[redacted]

2.2.10 Impact Detectors. Four standard arming and fusing impact detectors were installed [redacted] These instruments operate on the piezo-electric principle. (During ground impact, the shock causes the crystal in the impact detector to emit an electric signal which detonates the warhead.) For this experiment, the capacitance and electrical output of the piezo-electric crystal was measured under a known shock [redacted]

2.2.11 Arming and Fusing Components. Several [redacted] arming and fusing components were to be monitored during the flight of the vehicle. These components were: the frangible grid, the safety and arming device, and the inertial timer switch. These would have provided electric signals at various times; therefore, the continuity of these components could have been ascertained. [redacted]

2.2.12 Optical Tracking Instruments. Two aircraft, a C-54 and a KC-135, were positioned west of the launch pad, approximately 55 and 75 nautical miles, respectively. Camera equipment was placed aboard these aircraft and at a ground station [redacted] Cameras aboard the aircraft were K-24's, 70-mm Hulcher, 35-mm Mitchell motion picture, ballistic plate, cine-telescope, spectrometer, boresight, U/V, image orthicon, rapid-scan monochrometer, high-speed Millikin, and radiometer.

Ground-based equipment included K-24 and high-speed Millikin motion-picture cameras placed on top of [redacted] and ballistic cameras located 1 km apart on [redacted]. Gratings were placed on the K-24 cameras [redacted]

[redacted]

2.2.13 Separation Signals. The time of separation from the Thor was monitored by including two separation switches in the spacer assembly. One separation signal was transmitted via Thor T/M. The other signal was transmitted by an FM/FM one-channel T/M unit contained within the [redacted] adapter through a stub antenna [redacted]

[redacted]

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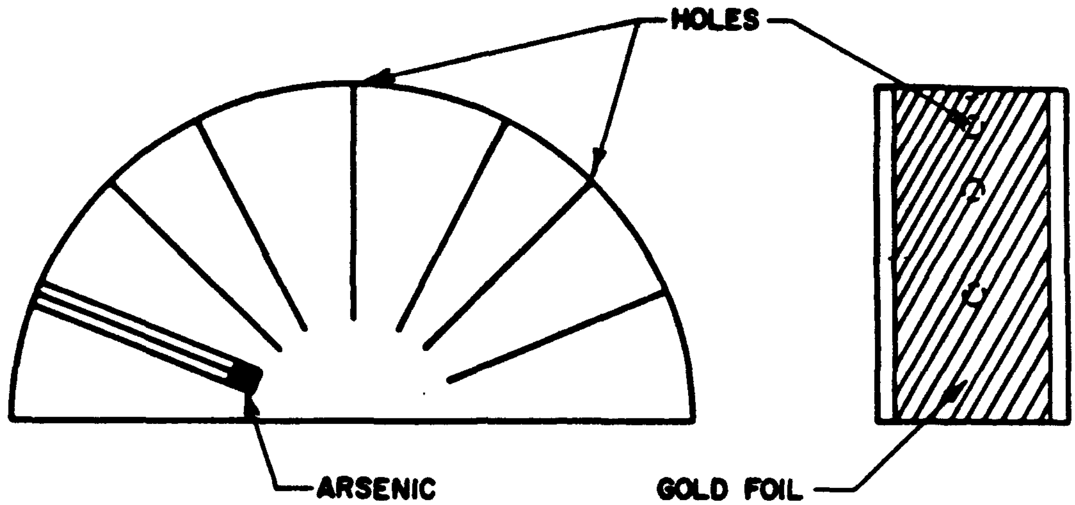

Figure 2.5 Arsenic attitude sensor.

[redacted]

Figure 2.6 Ballistic spall [redacted]

[redacted]

CHAPTER 3

RESULTS

The Thor booster carrying two Project 8C R/V's and one Project 8B pod lifted off at 0846:16.8Z, 20 June 1962. Approximately 1 minute later, after reaching an altitude of about 30,000 feet, the missile blew up. The cause was determined to be recirculation of hot turbine exhaust gases up the side of the missile, destroying the integrity of the missile structure supporting the main engine. The telemetry equipment associated with the separation switches continued transmitting until, it is believed, the vehicles impacted. [redacted] R/V 3, which was attached to Thor [redacted] stopped radiating at 0849:23.7Z. This R/V was not recovered. R/V 2, which was attached to Thor [redacted] stopped radiating at approximately 0849:31Z. R/V 2 was found on Johnston Island, on the taxiway about 150 feet due north of Building 327. The vehicle was crushed, twisted, and ruptured upon impact; [redacted]

No data was obtained by the project because of this failure. [redacted]

 [redacted]

[redacted]

[redacted]

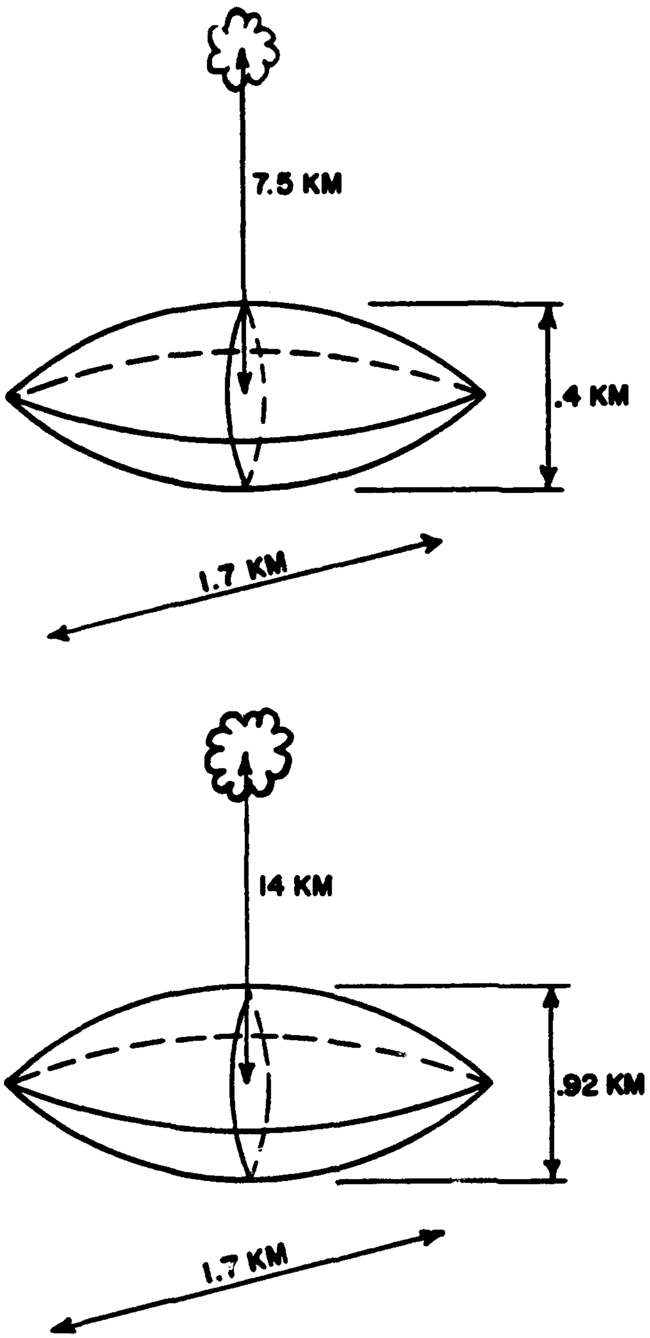

Figure A.1 Uncertainty spheroids.

[redacted]

APPENDIX B

[redacted]

[redacted]

The attitude control system contained in the test vehicle was the [redacted] pitch-spin system. [redacted]

Recovery of the test vehicles following exposure to the nuclear detonation was to be provided by a vehicle-contained recovery system. The system consisted of a ribbon brake chute for initial deceleration of the vehicle, a 24-foot main chute which was deployed first in a reefed condition and later disreefed, a flotation bag to buoy up the vehicle following entry into the water, and location aids including

[redacted]

a SARAH beacon, flashing light, and sea dyemarker.

B.1 ATTITUDE CONTROL SYSTEM

The attitude control system for the test [redacted] was designed to assure maximum side-on vehicle presentation to the nuclear detonation, thus precluding an aft-end presentation and assuring a reentry attitude of approximately 90 degrees. The attitude control system selected for the test [redacted] was similar to the control system designed for the Minuteman [redacted] which consists of a pitch and spin system utilizing solid-propellant rocket motors to rotate and stabilize the vehicle in its proper orientation.

The pitch and spin system for orienting the vehicle was an open-loop system, which operates in the following manner:

1. An acceleration switch sensing 2 g during launch closes and connects the initiating squib of a squib switch to a dry-cell battery, thereby initiating the squib switch. Closure of the squib switch connects the output of the attitude control thermal batteries to the attitude control timer switches, thus arming the attitude control system.

2. At physical separation of the vehicle from the booster, a separation switch closes, connecting the dry-cell battery output to another set of squib switches and thus operating the squib switches. Closure of the squib switches connects the thermal battery, initiating squibs to the output

[redacted]

of the dry-cell battery, and results in activation of the thermal battery.

3. The thermal batteries rise to full output voltage in approximately 0.8 second and, in so doing, initiate the timer switches.

4. One and one-half seconds after initiation of the timer switch, the timer switch pitch contacts close and electrically initiate a solid-propellant rocket to impose a pitch rate on the vehicle.

5. One and one-half seconds after the closure of the pitch contacts, the retro-pitch contacts close and initiate a second solid-propellant rocket opposing the pitch rocket and effectively cancelling the pitch rate.

6. The vehicle is now oriented in the proper attitude and the spin contacts of the timer close, initiating two solid-propellant rockets mounted as a couple about the vehicle spin axis. The solid-propellant rockets accelerate the vehicle about its spin axis to a spin rate of approximately 40 rpm, thereby stabilizing the vehicle spatial attitude.

B.2 [redacted]

[redacted]

[redacted]

pages 38-40 deleted in entirety

was composed of subcomponents which were chosen for their ability to withstand the flight environment. The components were arranged so as to safeguard against prematures causing a complete system failure. Components that were in this system included squib switches, dry-cell batteries, thermal batteries, inertial acceleration switches, and separation switches.

[redacted]

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[redacted]

[redacted]

[redacted]

APPENDIX C

INSTRUMENTATION

[redacted]

[redacted]

Pages 45-47 deleted in entirety

[redacted]

C.4 ACCELEROMETERS

Three types of accelerometers were mounted on the arming and fuzing (A and F) shelf and along the recovery package

[redacted]

deployment tunnel to record accelerations undergone by the structure as a result of the nuclear blast and the flight environment.

The three types of accelerometers were (1) a peak reading accelerometer, (2) a tuned-reed accelerometer, and (3) a powered accelerometer.

[redacted] accelerometer provided a measurement of the peak acceleration along the vehicle axis. Acceleration was measured by a spring anvil contained in the unit crushing a bead of clay-like plastic against a calibrated scale. [redacted]

The powered accelerometer [redacted]

[redacted]

[redacted] also utilized tuned reeds; however, in this case, no attempt was made at spectrum analysis, and hence, no pulse shape information could be obtained. [redacted]

[redacted]

The Berry gage marks were two small punchmarks placed in the structure with a special tool. The distance between these marks was accurately determined by use of a Berry gage. At the conclusion of testing, the distance between the marks would again be measured, and the change in this distance would have been the permanent deformation that occurred in the structure in the direction of a line between the two points. The final dimension between points must be measured with the same gage as the initial readings, or if a different gage is used, it must be calibrated to the initial gage. The punchmarks must also be thoroughly and carefully cleaned before taking a measurement to ensure proper seating of the gage. For this particular gage and setup, [redacted]. These are paper-backed gages, applied with Duco cement, and can survive temperatures [redacted] Initial readings of these gages were made using a particular dummy gage and strain-indicating device. The difference between this initial reading and a final reading, taken after the test using the identical dummy gage, and preferably (although it should not be absolutely necessary) the identical strain indicator, would represent the permanent set in the direction of the strain element in

[redacted]

units of μin/in. When making the final strain gage reading, the length and size of lead wire to the active and dummy gage should be the same as used for the initial readings. [redacted]

C.6 PASSIVE ARMING AND FUZING COMPONENTS

C.6.1 Inertial Primer Initiator. The inertial primer initiator was used to activate the [redacted] thermal batteries. They [redacted]

C.6.2 Trigger Circuit. The trigger circuit acted as an energy-storing device [redacted]

C.6.3 Blocking Circuit. The blocking circuit acted as a voltage-sensing device [redacted] A post-flight electrical checkout was to determine whether this component was affected by the flight environment.

C.6.4 Passive Electrical Test Kit. A variety of electronic components (transistors, diodes, resistors, capacitors) pres-

[redacted]

ently used in the [redacted] programs were tested as passive experiments. Each component was checked prior to flight and was to have been checked after flight to determine effects of the nuclear environment.

C.6.5 Magnetic Recording Tape. Three types of magnetic recording tape used in the flight-recording system [redacted] Recording signals were placed on the magnetic tape to determine degradation of the recorded information from the nuclear environments. Post-flight analysis of the tape was to determine the effects of the nuclear environment.

C.7 PASSIVELY MONITORED [redacted] ARMING AND FUZING COMPONENTS.

Critical [redacted] arming and fuzing components were electrically monitored at specific times during the flight to determine whether the nuclear environment affected proper operation of the components. The passive instrumentation system consisted of a number of squibs which were monitored before and after the flight. The electrical circuits were energized at specific times during flight, and if continuity existed, a squib was fired. The time and sequence during which the component was actuated was to be determined from post-flight laboratory tests. [redacted]

[redacted]

2. It monitored the frangible grid at critical times during the flight.

3. It monitored the safety and arming device during re-entry.

4. It monitored the inertial timer switch.

The passive instrumentation system was powered by dry-cell batteries, which activated a safing squib when the acceleration switch was closed during powered flight. [redacted]

[redacted]

broken. In this experiment a passive circuit monitors the frangible grid at separation, the start of re-entry, and the end of re-entry to determine whether grid breakage occurred.

C.7.2 Inertial Timer Switch. The inertial timer switch as used in the [redacted]ystem was mounted on the [redacted] structure. This inertial switch was activated by a deceleration history and, when activated, it, in turn, activated the timer circuits.

[redacted] The switch was electrically monitored to determine whether it was affected by the flight environment.

C.7.3 Safety and Arming (S and A) Device. The safety and arming device is an A and F component, which is used in the [redacted] systems. [redacted]

[redacted]

Pages 56-59 deleted in entirety