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1958

Operation HARDTACK

Preliminary Report

Project 9.2b

OPERATION OF BALLOON CARRIER FOR VERY-HIGH-ALTITUDE NUCLEAR DETONATION [redacted] (U)

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OPERATION HARDTACK—PROJECT 9.2b

OPERATION OF BALLOON CARRIER FOR VERY-HIGH-ALTITUDE NUCLEAR DETONATION [redacted]

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FOREWORD

[redacted] This report presents the preliminary results of one of the projects participating in the military-effect programs of Operation Hardtack. Overall information about this and the other military-effect projects can be obtained from ITR-1660, the "Summary Report of the Commander, Task Unit 3." This technical summary includes: (1) tables listing each detonation with its yield, type, environment, meteorological conditions, etc.; (2) maps showing shot locations; (3) discussions of results by programs; (4) summaries of objectives, procedures, results, etc., for all projects; and (5) a listing of project reports for the military-effect programs.

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ABSTRACT

The project provided a platform for a nuclear device and measurement instrumentation at a pressure altitude of 85,000 feet ($16\frac{1}{2}$ millibars) by means of a large plastic balloon. The original plan called for a development program based on a pay load of 600 pounds and a floating altitude of approximately 90,000 feet. The actual weight was increased in small increments to a final weight of 761.5 pounds, with a corresponding decrease in altitude to 85,500 feet. The balloon system was launched from the deck of the USS Boxer (CVS-21). Prior to reaching ceiling altitude, the nuclear device was separated from the balloon a distance of 568 feet by a hydraulic load-lowering device, and the measurement instrumentation was additionally deployed along a nylon line at specific intervals totaling 3,000 feet below the nuclear device. Both the load-lowering device and the instrumentation-deployment system were developed by the project. Because of the support nature of the project mission, this report does not contain weapon-effect data.

It is concluded that the large, plastic, constant-volume balloon vehicle provided a stable and reliable platform for the very-high-altitude nuclear detonation, Shot Yucca.

PREFACE

Project 9.2b acknowledges the support and assistance provided by Task Group 7.3, specifically, Captain James E. Vose and the staff of the USS Boxer. The full cooperation extended, both materially and professionally, substantially enhanced the smoothness of the operation.

Acknowledgment is made to Lt James A. Winker, James Dwyer, and John Morrell, of the Air Force Cambridge Research Center, for the basic design and initial developments of the canister-deployment technique.

Acknowledgment is made to Walter Wagner, Frank Doherty, James King, and Sidney Rosenthal, of the Air Force Cambridge Research Center, for the personal initiative taken in the basic design, development, and operational refinements resulting in the load-lowering device. This major component of the operational system was produced in a highly refined configuration under extremely stringent time limitations and in addition to regularly assigned responsibilities.

CONTENTS

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OPERATION OF BALLOON CARRIER FOR VERY-HIGH-ALTITUDE NUCLEAR DETONATION ([redacted]

OBJECTIVE

The objective of Project 9.2b was to provide a suitable vehicle and platform to permit the nuclear detonation of a suitably instrumented 2-kt nuclear device at an altitude of approximately 90,000 feet above sea level. Additional requirements assigned to this project included the development of: (1) a device which would physically separate the balloon carrier from the nuclear device by 500 feet of nylon cord during ascent; (2) a technique and the equipment required for the deployment and relative positioning of five detonation-effect canisters along a 3,000-foot nylon line suspended below the device; (3) suitable balloon-system-launching techniques and equipment; and (4) associated rigging and techniques for relative positioning of all pay load items both in a compact and extended train.

BACKGROUND

An approved program (USAF Project 7672, Task 76722) was conducted for the design, development, and refinement of gear and techniques for the performance of this effort. During the period from 20 October 1956 to December 1957, this program was successful in defining the final pay load configuration to be launched, carried, and deployed and in producing each individual component and the complete integrated flight system. See Appendixes B and C.

The outline below reflects each major component or link in the final flight-train configuration (see Figures 2, 3, 4).

1. Balloon.
2. 5,000-pound test nylon load line.
3. Adapter fitting and T-bar (radar reflectors).
4. Adapter fitting and pressure switch, go—no-go lift indicator.
5. Adapter fitting double eyebolt (release mechanism fitting).
6. Load lowering device (reel).
   a. Cannon, command actuation of reel.
   b. Cannon, backup actuation of reel.
   c. Backup aneroid-pressure-actuated reel starting.
7. X-band transponder beacon.
8. Flight termination cannons.
9. Safety lanyard, emergency support of purpose item.
10. Nuclear device suspension harness and fittings.
11. Nuclear device.
12. Load-actuated lever, for pulling safety pins on purpose item.
13. Canister deployment system.
    a. Cannons, command actuation of deployment.

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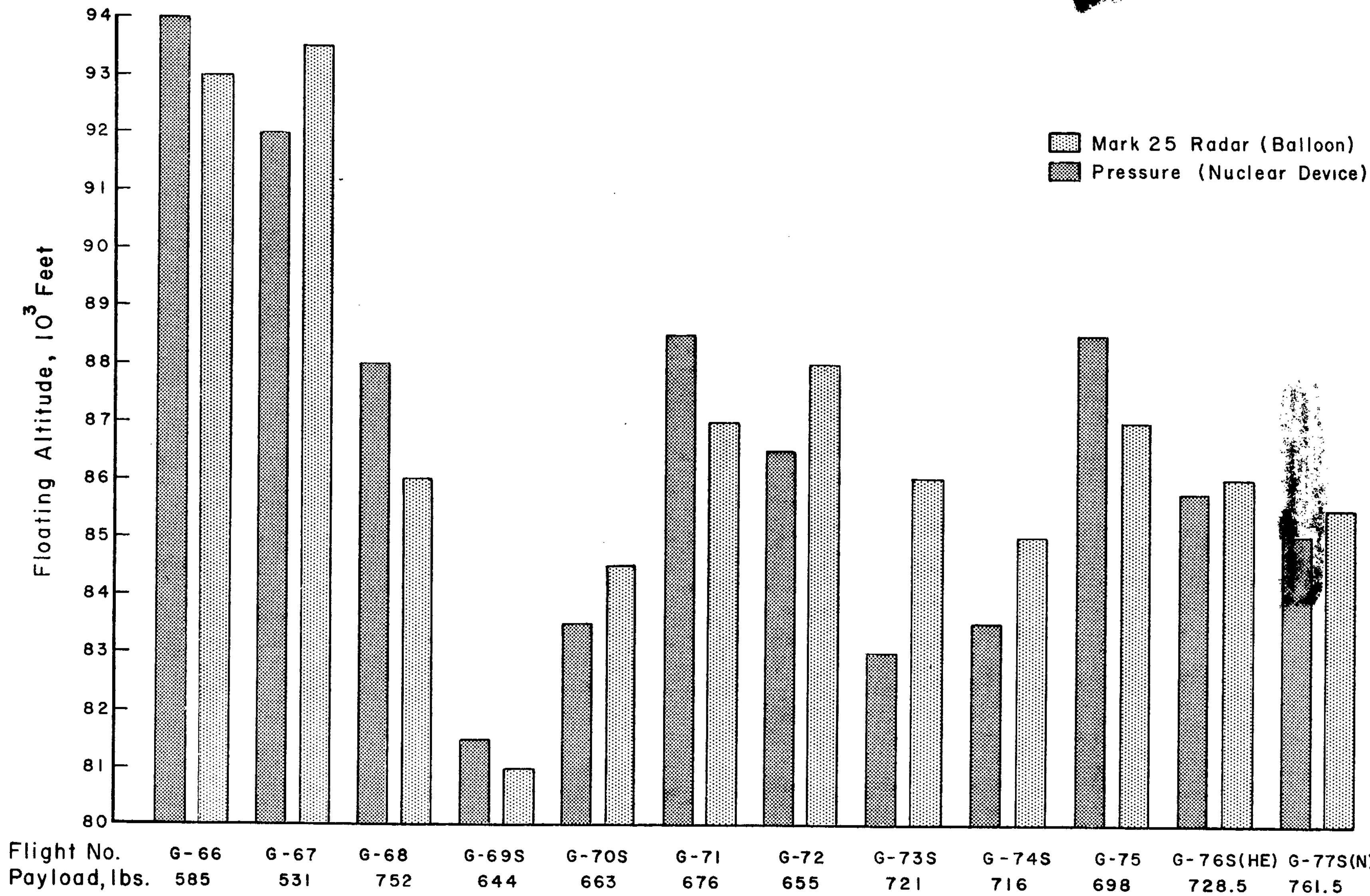

Figure 1 Floating altitudes by radar and pressure element.

b. Cannons, backup actuation of deployment.

c. Backup aneroid-pressure-actuated deployment start.

d. Fiberglass tube, parachute deployment assembly.

e. Canisters (5 each).

f. Antenna deployment, located on nylon line between nuclear device and Canister A.

g. Nylon line, separation of the canisters.

OPERATIONS

Six preliminary flights were flown to performance-test the balloon and obtain ceiling altitude information for the system. These flights also served to test final refinements of the load-lowering device, the attachment and suspension system for the corner reflectors and X-band transponder beacon, and to test the canister-deployment system using final canister weight and length. In addition, these tests served to define operational techniques for the balloon-launch crew and for the crew of the USS Boxer, and the development of techniques by the tracking and positioning activities (see Appendix A and Figures 1 through 18).

Five service flights were flown to provide a vehicle for testing the techniques, hardware, and instrumentation components for Projects 1.10, 2.7, 8.2, 9.2a, and 9.2c, in addition to all the items mentioned above.

At 1125 hours, 28 April 1958, Flight G-77-S was launched from the deck of the USS Boxer (CVS-21). The purpose of this flight was to carry a nuclear device and detonation-effect instrumentation to as great an altitude as possible within design limitations of the balloon carrier for the pay load of 761.5 pounds.

The following equipment was used on this flight: (1) GRD reel (production model), (2) X-band transponder beacon, (3) Sandia instrumentation (P-15), (4) deployment tube internally fitted with Bendix Canisters A, B, C, D, and E for Project 1.10, and (5) two radar corner reflectors attached to the balloon load line for assisting the radar facility.

Delineated below, in detail, is the schedule of events in temporal order; in the interest of completion, other complementary pertinent information is also furnished:

0650 Hours. The equipment, material, and test gear to start nylon-line coiling, canister-weight determination, and fiberglass-tube loading was readied on station (No. 3 elevator). Four hours prior to the launching for Shot Yucca, Project 9.2b was informed that the canister weight had been increased by 32.4 pounds overall. This raised the weight to 39 percent above that for which the deployment system was developed. This was the second time the canisters' weight had been increased.

	Canister weight for which system was developed	Weight as declared by Project 1.10 on 4 April 1958	Weight actually used on Shot Yucca
	lb	lb	lb
A	40.50	44.50	55.00
B	50.25	61.00	72.00
C	50.25	68.00	74.50
D	50.25	63.00	75.75
E	62.50	75.00	84.00

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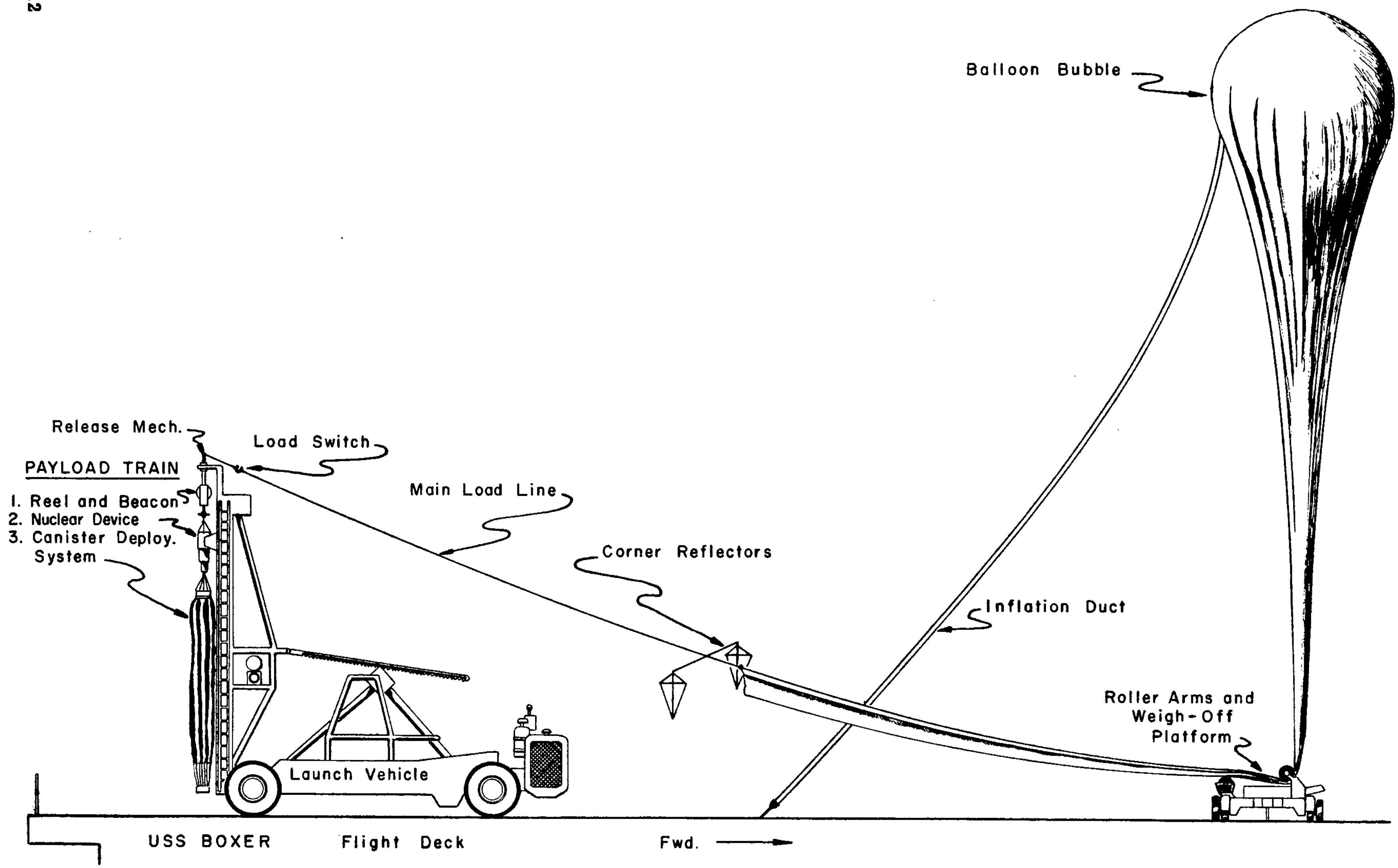
Balloon Bubble
Release Mech.
Load Switch
PAYLOAD TRAIN
1. Reel and Beacon
2. Nuclear Device
3. Canister Deploy. System
Main Load Line
Corner Reflectors
Inflation Duct
Roller Arms and Weigh-Off Platform
Launch Vehicle
USS BOXER
Flight Deck
Fwd.

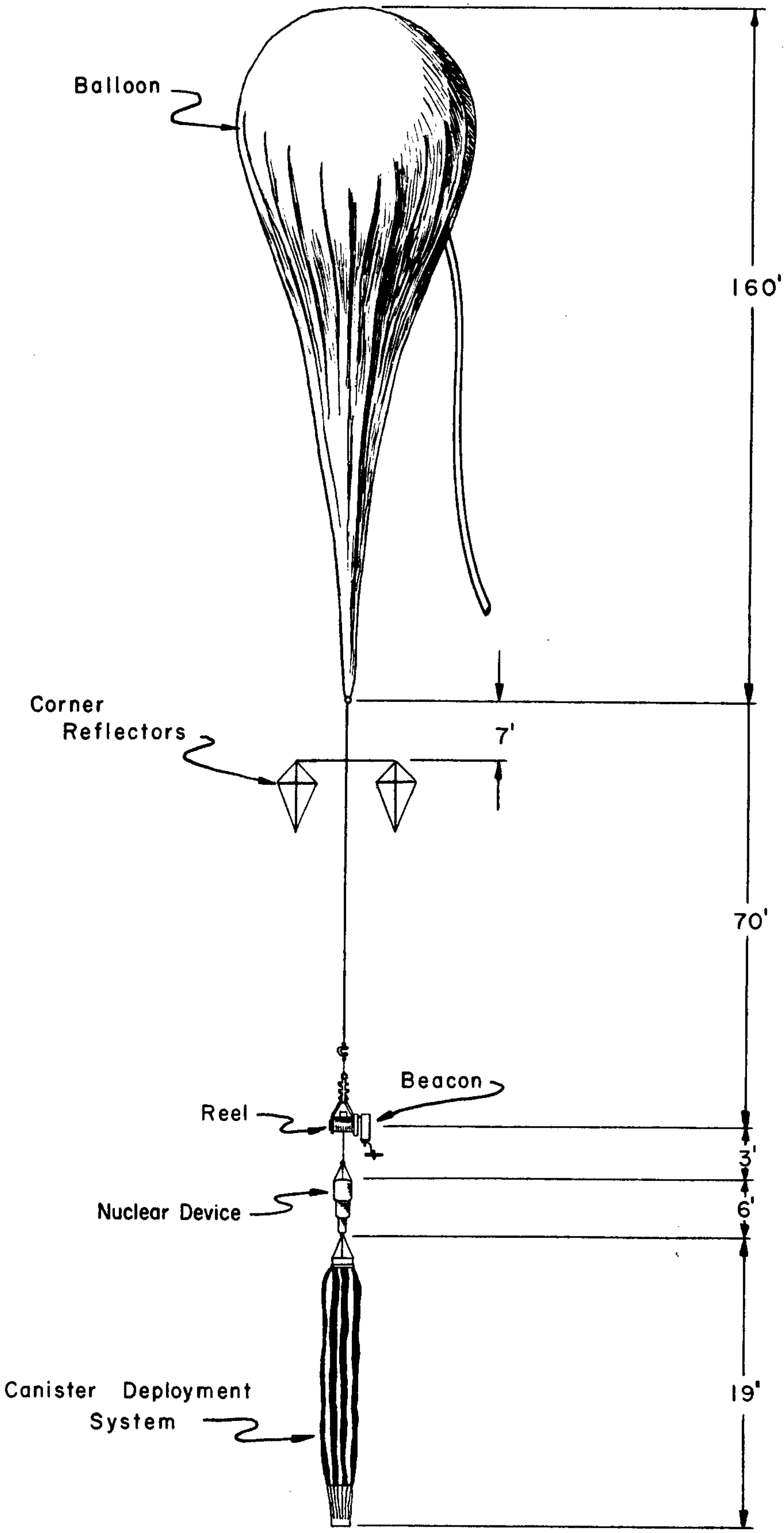

Figure 3 Balloon vehicle and pay load immediately after launch and prior to deployment.

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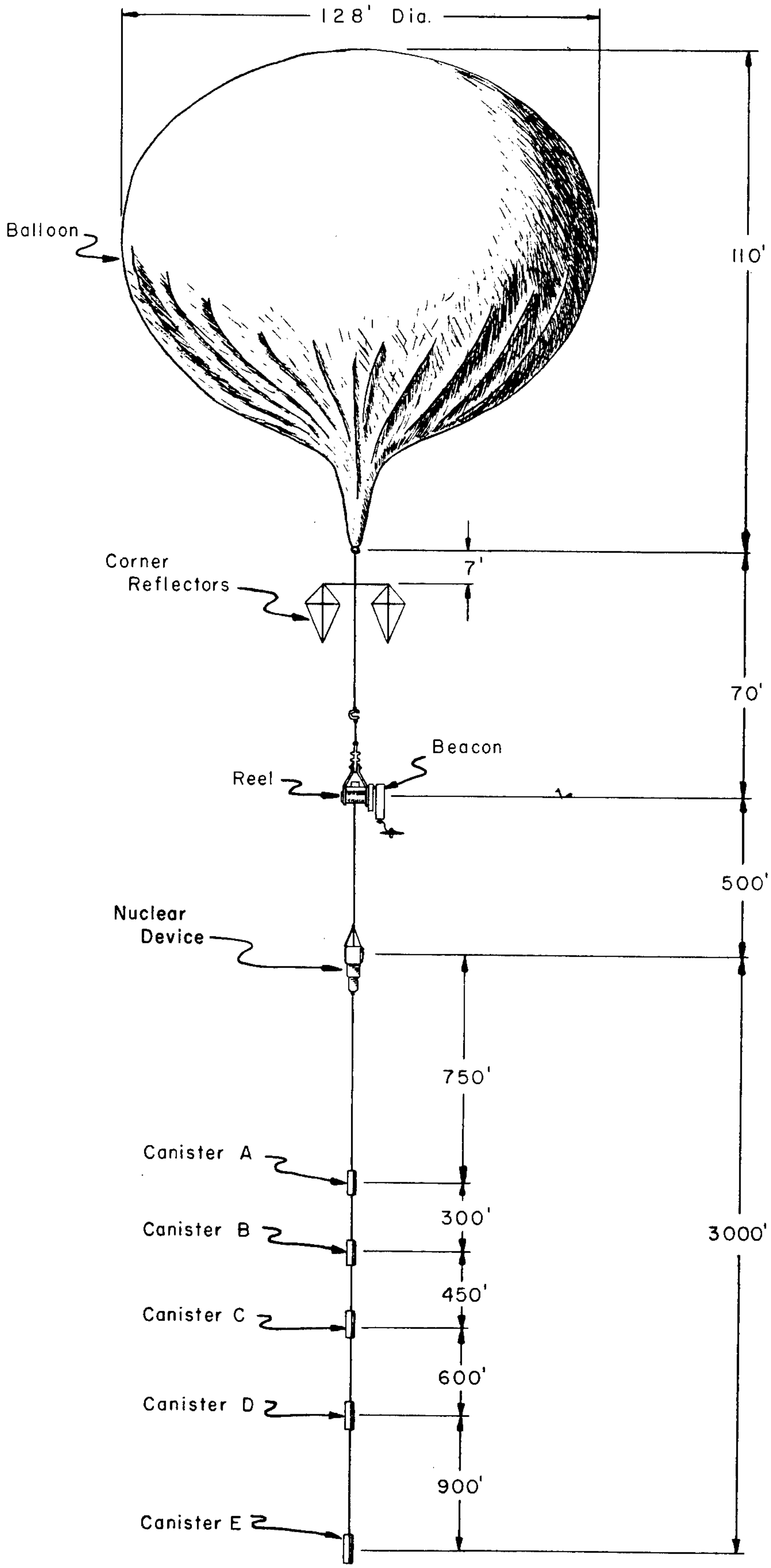

Figure 4 Yucca in-flight configuration.

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Canister	Length	Diameter	C. G. (measured from top)	Weight	Nylon line weight	Total weight
No.	in	in	in	lb	lb	lb
A	$34\frac{5}{8}$	$10\frac{1}{4}$	16	52.00	3.00	55.00
B	$43\frac{5}{8}$	$10\frac{1}{4}$	$18\frac{1}{2}$	69.50	2.50	72.00
C	$43\frac{5}{8}$	$10\frac{1}{4}$	$18\frac{1}{2}$	70.00	4.50	74.50
D	$43\frac{5}{8}$	$10\frac{1}{4}$	$18\frac{1}{2}$	69.50	6.25	75.75
E	$44\frac{1}{2}$	$10\frac{1}{4}$	19	84.00	—	84.00

	pounds
Weight of nylon line between nuclear device and Canister A	7.75
Parachute and fiberglass tube with 12-pound weight	49.00
Total weight of deployment system	418.00

Nylon line length: (measured under $7\frac{1}{2}$-pound tension)	feet	Breaking strength pounds
Weapon to Canister A	667	1,500
Canister A to Canister B	268	1,500
Canister B to Canister C	400	1,000
Canister C to Canister D	546	1,000
Canister D to Canister E	855	1,000

0825 Hours. Project 9.2a arrived at the balloon launcher with the nuclear device. Project 9.2b had previously installed the reel in the balloon release latch, put in the release latch safety pin and tilted the mast 20 degrees forward to facilitate the rigging of the balloon train.

0830 Hours. Project 9.2a and 9.2b started the rigging procedure of the weapon to the reel and attachment of safety lanyard.

0900 Hours. The canister-loading operation was completed. The canister-laden deployment tube was moved from No. 3 elevator to the balloon launcher.

0916 to 0922 Hours. The nuclear device was raised approximately $2\frac{1}{2}$ feet above the deck to permit easy access for rigging of the deployment tube to the lower end-fitting on the device. The ground strap was attached to the device from the launcher, the receiving antenna was routed to the device and connected, and the mast was returned to the vertical position.

0922 to 0944 Hours. Completed checkout sequence on deck and loaded Sandia test equipment on the elevator platform.

0945 Hours. Removed the preflight tester and raised the balloon train in a vertical position.

0950 to 1000 Hours. The main load line was attached to the upper end of the double eyebolt and routed over the top of the launcher mast to the balloon loading on the deck.

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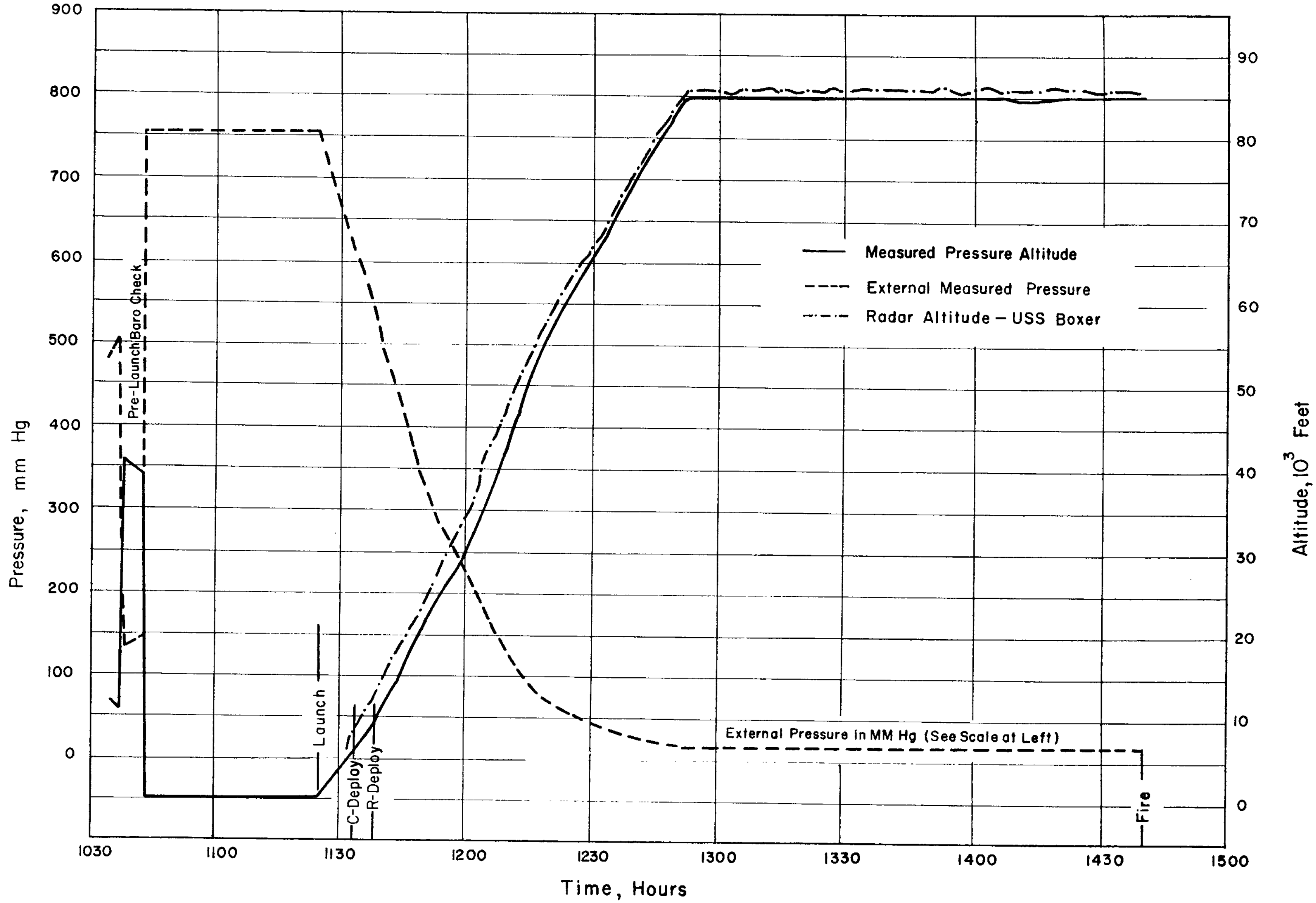

Figure 5 Altitude and pressure versus time, Flight G-77-S (N), uncorrected for temperature. Pressure transducer was located 568 feet below the balloon which the radar tracked.

[redacted]

The reflectors and T-bar were attached to the load line 7 feet below the balloon load ring.

1005 Hours. The arming party climbed to the elevator platform for preliminary checkout of the nuclear device.

The calculation for the helium volume to be metered in the balloon was made at this time. The outline below describes the procedure used in the computation of gas metering for balloon inflation.

The success of the gas-metering method depends upon knowledge of the exact gross weight of equipment to be flown. First, the system weight by components:

	pounds
Balloon	539.00
Reel and beacon	68.75
Nuclear device	309.00
Deployment tube and parachute	37.00
Ballast, to compensate for canister weight increase	12.00
Canisters with nylon line	369.00
Load line and pressure switch	11.50
Reflector and T-bar	3.25
Total load	1,349.50
Free lift	60.00
Free lift after deployment	109.50

The second operation is to determine how much gas is required from the available helium supply.

Total load + free lift = gross inflation. 1,349.5 pounds + 60 pounds = 1,409.5 pounds. Therefore, total lift is 1,409.5 pounds.

Gas temperature = 80 F = 27 C.

Helium gas pressure per cylinder = 2,380 psi.

For this temperature and pressure, the helium inflation tables give a lift per cylinder of 82.5 pounds.

Lift available in 18 cylinders = 1,485.0 pounds.

Lift required for gross inflation = 1,409.5 pounds.

Lift overage in 18 cylinders = 75.5 pounds.

Amount of lift to remain per cylinder = 4.2 pounds.

Drain all tanks (18 each) from a pressure of 2,380 psi to a pressure of 11 psi. This quantity of gas, about 20,000 ft^3 at standard conditions, will provide the necessary lift for 1,409.5 pounds.

1034 Hours. The arming party notified 9.2b to start the inflation.

1034 to 1059 Hours. The balloon was inflated during this period (see Figure 1).

1055 Hours. The arming party returned to the deck from the elevator platform to permit the release of the balloon in the vertical.

1101 Hours. The balloon bubble (80 feet long) was released from the platform into a vertical position over the launcher mast.

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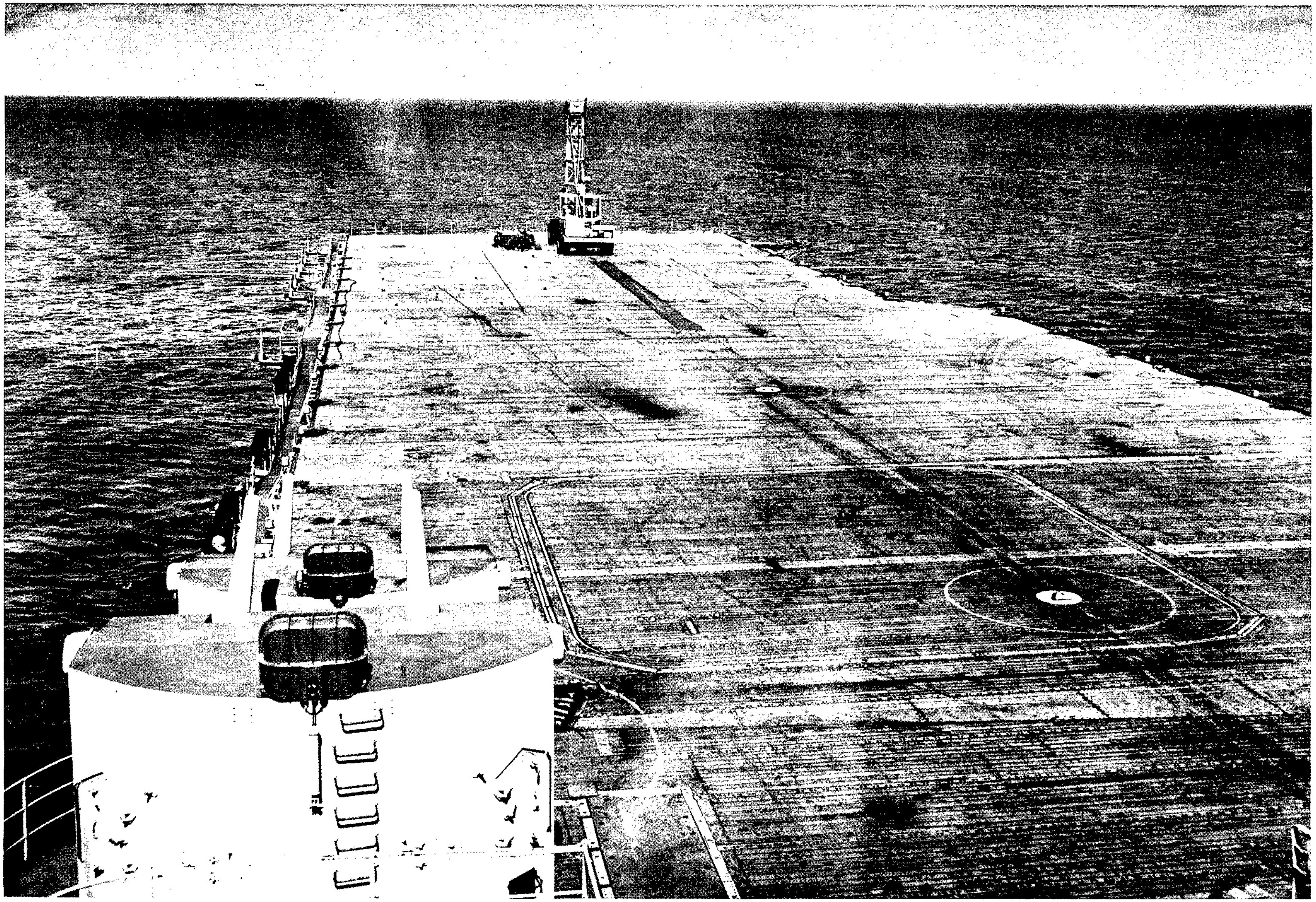

Figure 6 Balloon launch vehicle with layout canvas, from bridge, looking aft.

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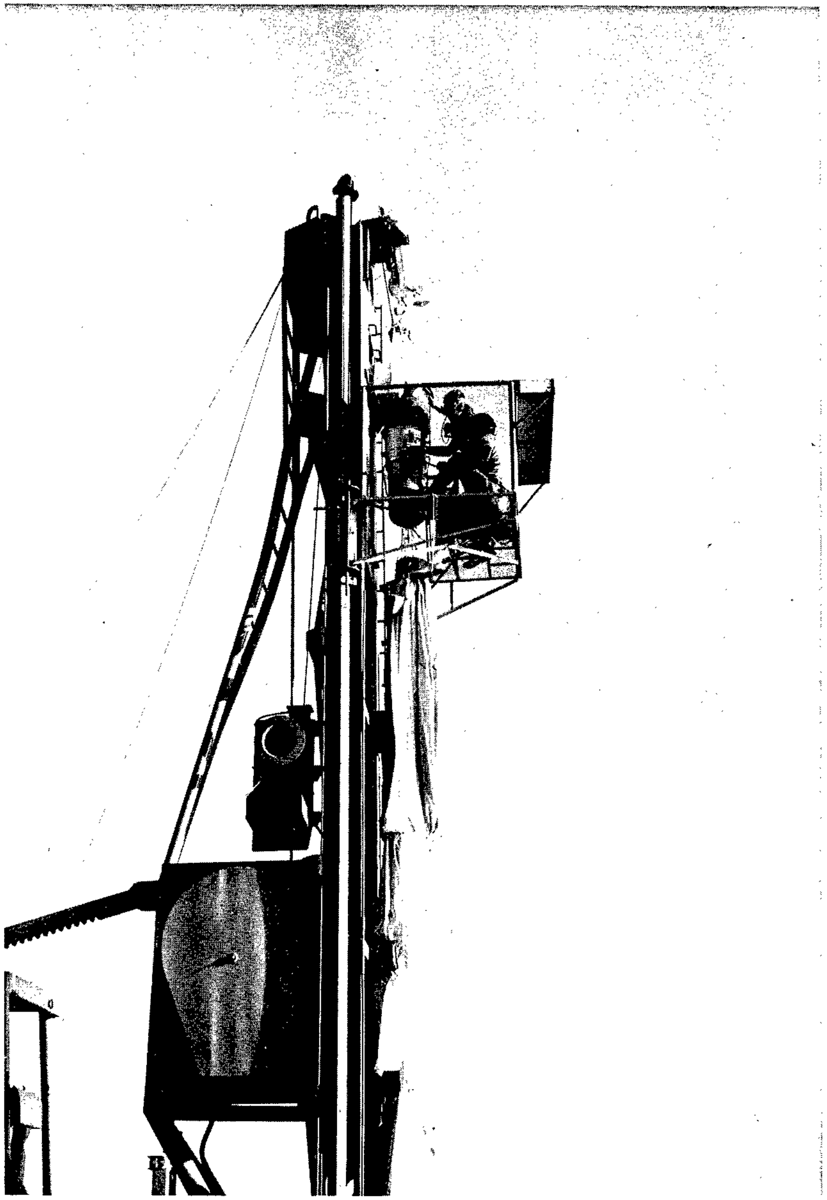

Figure 7 Load train assembled and in place on mast with arming party working on elevator platform.

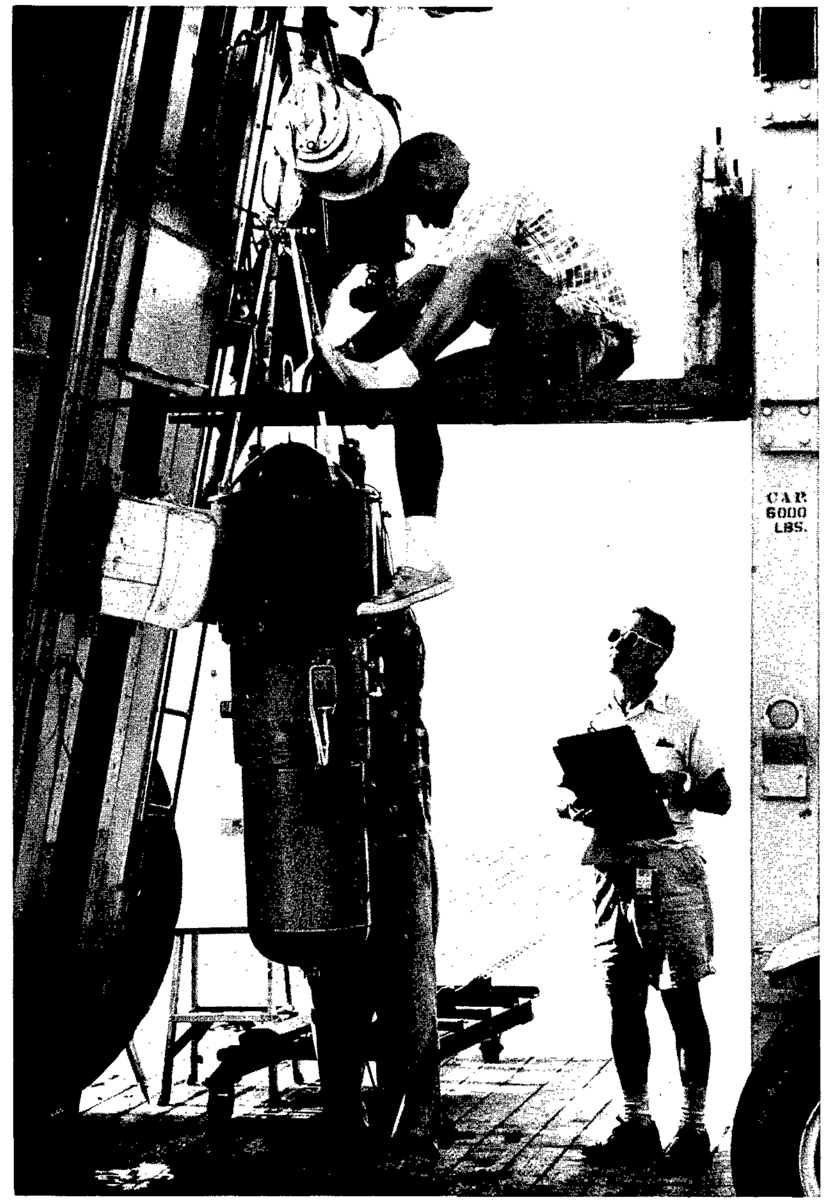

Figure 8 Attaching nuclear device to reel (transponder beacon in foreground), mast tilted forward.

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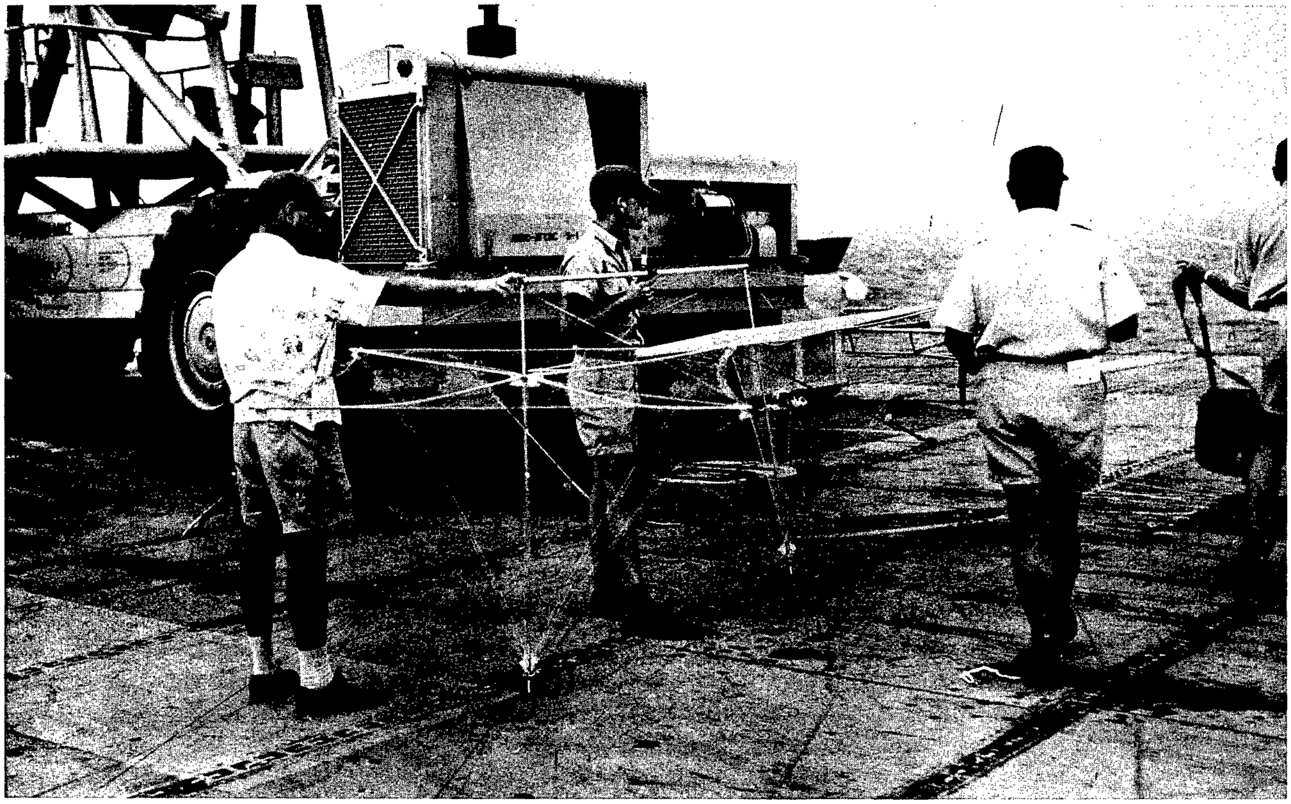

Figure 9 Radar corner reflectors mounted on T-bar, prior to rigging on main load line.

Figure 10 Attaching fiberglass tube (canister deployment assembly) to nuclear device, mast tilted forward.

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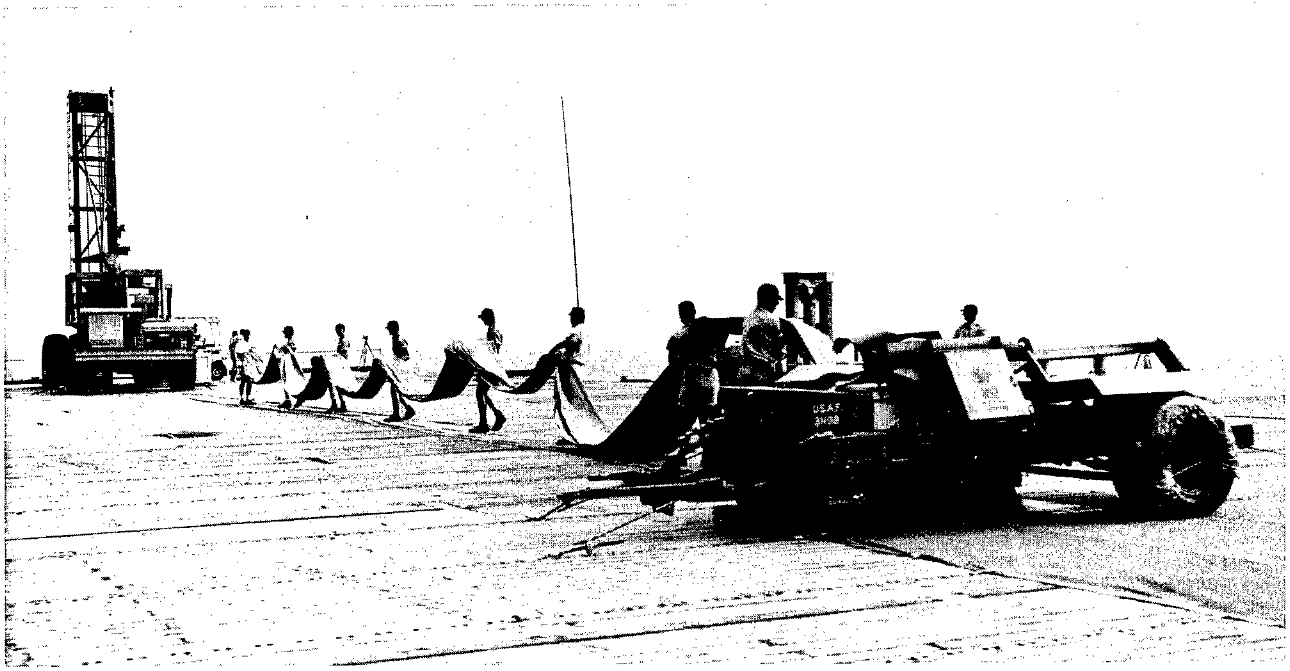

Figure 11 Layout of the balloon on canvas, launch arms vehicle in foreground, balloon launch vehicle in background.

Figure 12 Feeding the balloon material through the launch arm rollers prior to inflation.

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Figure 13 Attaching the gas diffuser and fill base to the balloon inflation appendix and taping in place.

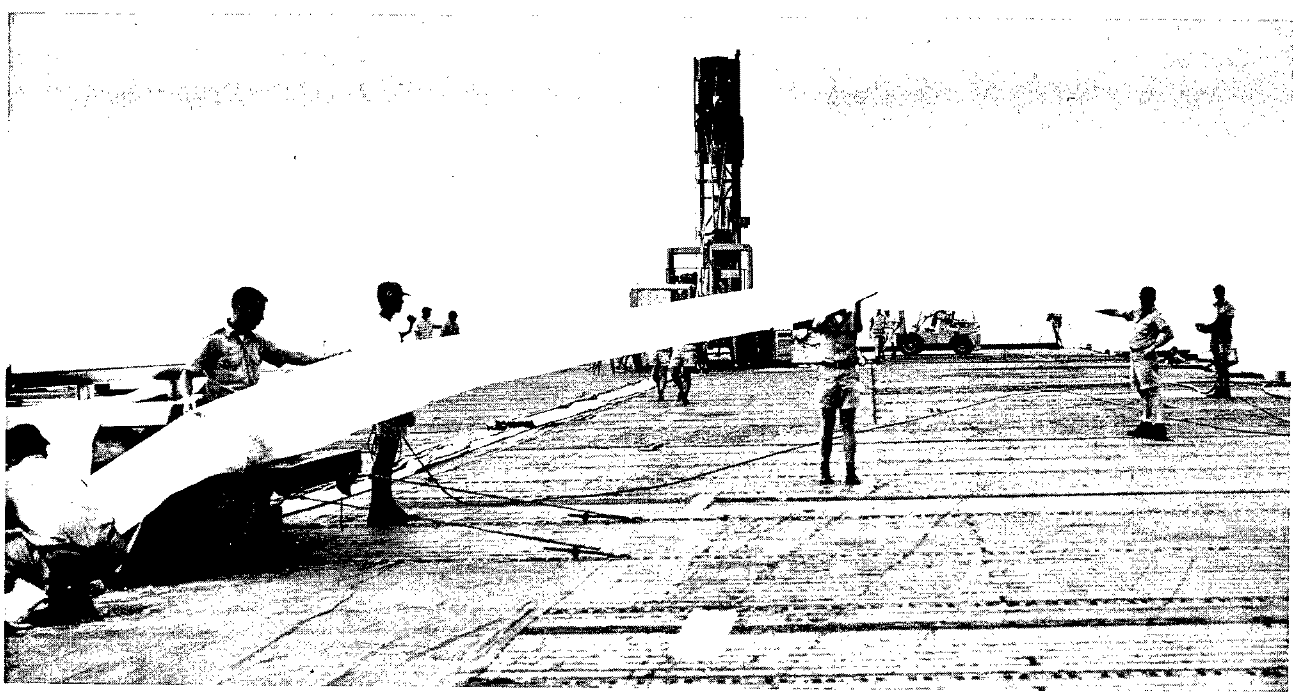

Figure 14 Start of the balloon inflation prior to erection of the bubble.

1102 Hours. Project 9.2b notified the arming party that the balloon was ready for flight.

1103 Hours. The arming party returned to the elevator platform to complete the arming procedure.

1115 Hours. The arming of the nuclear device being completed, the arming party came down to the deck and notified 9.2b that the nuclear device was ready for launching. The next step was to lower the elevator platform to its locked position on the side of the launcher out of the balloon launch path.

1119 Hours. The final checks for prerelease were made by 9.2b and the command was given, from Flag Plot, to "Launch the balloon when ready."

1120 to 1125 Hours. The following checks were relayed to Flag Plot from the Launch Officer over sound-powered phones: (1) latch safety pin out, (2) beacon on, (3) lanyard pin out (safety line for weapon), and (4) balloon launched.

1136 Hours. A routine deployment was observed, all canisters were withdrawn with facility.

1250 Hours. The balloon reached floating altitude.

1440 Hours. The nuclear device was detonated.

See Appendix B of this report for a recapitulation of conclusions drawn for the nine series of 76 flights preceding Shot Yucca.

INSTRUMENTATION

On each of the six preliminary flights operationally controlled by AFCRC personnel, the following instrumentation and their functions were utilized:

One instrumentation unit (Type WD5D) was flown for pressure-altitude information, radio-direction finding (DF), and radio command control. The altitude and DF signals were transmitted from a telemetering transmitter having a radiating power of approximately 3 watts on a frequency of 1,724 kc. The DF signal is a steady carrier and was transmitted during 30 seconds of each flight minute. The altitude information was transmitted during the remaining 30 seconds in international Morse code (A1 emission). Command signals (100 to 150 watts, A2 emission) were transmitted from ship to balloon on a frequency of 6,700.5 kc for telemetering antenna deployment, canister-tube deployment, load-lowering device (reel) actuation, and flight termination by radio remote control.

One safety-timer unit was flown as a backup device (mechanical timer) for flight termination in the event of command system failure. This unit also contained a safety mechanism to terminate the flight if the balloon was below 30,000 feet at any preset time after launch (usually 2 hours).

Two aneroid-switch units were utilized on each flight as backup devices to deploy the canister tube and the load-lowering device in the event of command system failure. The WD5D instrumentation unit had a self-contained aneroid-operated switch as a backup for the telemetering-antenna deployment.

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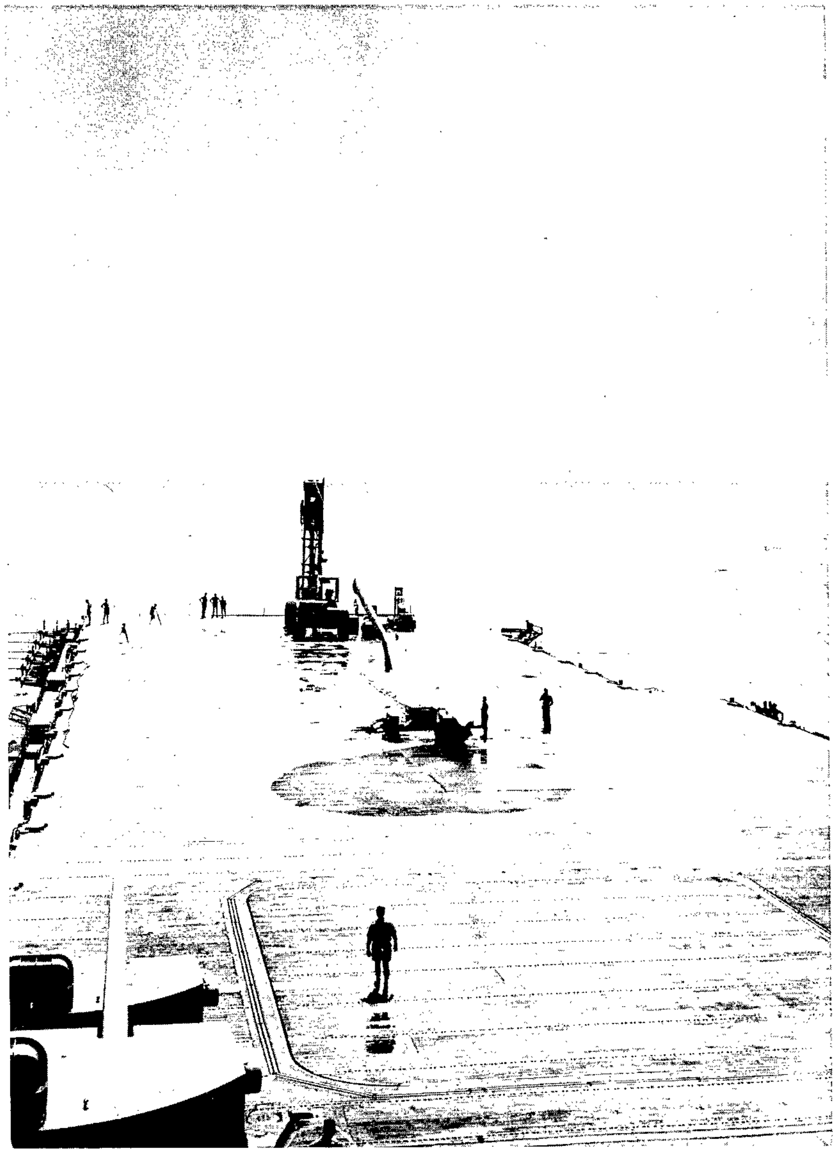

Figure 15 General view of inflated balloon bubble from bridge, with complete pay-load train assembled, just prior to balloon release from launch arms.

Figure 16 Inflated bubble immediately after release from launch roller arms.

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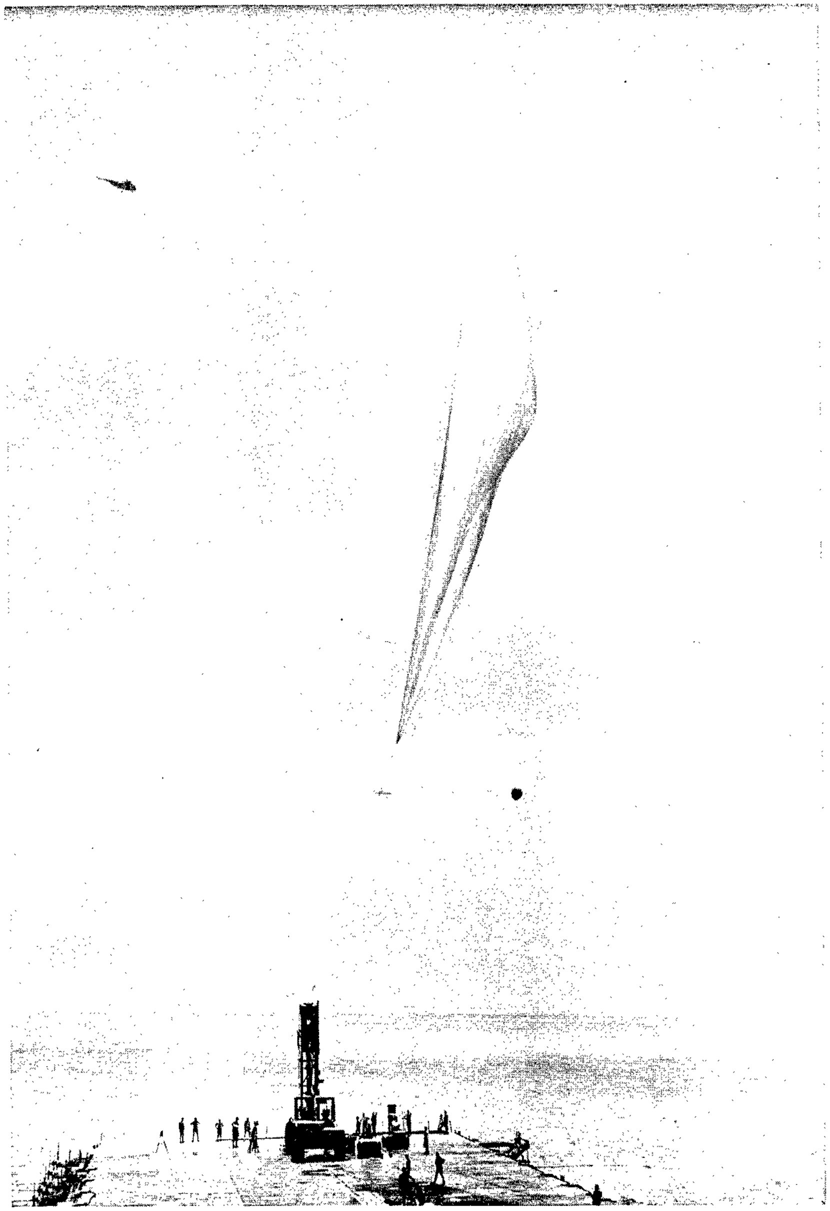

Figure 17 Balloon released into the vertical, just prior to balloon system launch.

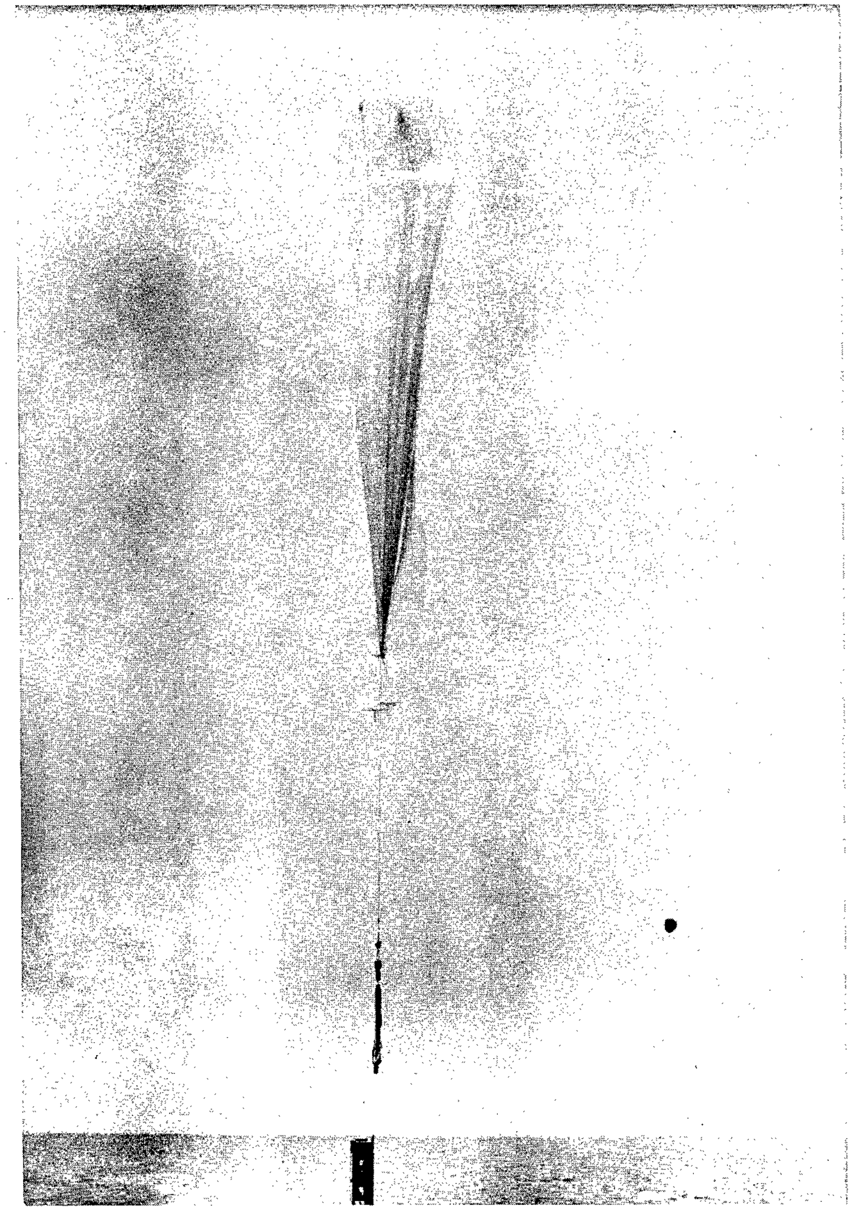

Figure 18 Complete balloon system, immediately after launch, load train free and above mast.

On each of the five preliminary Sandia Corporation controlled flights and the Yucca flight, the only AFCRC instrumentation utilized consisted of two aneroid-switch units. These served as backup devices for deploying the canister tube and reel in the event of command system failure.

All of the squib cannons, squibs, and associated cabling for this final flight series were furnished and installed by Project 9.2b personnel.

RESULTS AND CONCLUSIONS

The Project 9.2b balloon team successfully launched the balloon system from the deck of aircraft carrier USS Boxer (CVS-21) for Shot Yucca at 1125M, 28 April 1958. The initial launch preparations, the equipment functions, and the balloon performance were normal. A final increase in canister weights, totaling 32.4 pounds, did not appear to materially effect the stability of the deployment system.

The average rate of rise (ascent rate) of the balloon system was 986 ft/min. The total flight duration was 3 hours 15 minutes. The total flight duration at ceiling altitude was 1 hour 50 minutes. The balloon maintained a constant uniform floating altitude (see Figure 5).

The floating (pressure) altitude of the weapon was 85,000 feet MSL. The floating altitude of the balloon vehicle (Mark 25 radar) was recorded as 85,500 feet MSL (see Figure 5).

The gross weight of the balloon system at altitude was 1,300.5 pounds. The gross weight of the balloon system in the launch configuration was 1,349.5 pounds. The net weight of the payload system at ceiling altitude was 761.5 pounds.

Project 9.2a successfully detonated the nuclear device by command at 1440 hours at coordinates 12 degrees 37 minutes north and 163 degrees 01.5 minutes east.

It is concluded that the large, plastic, constant-volume balloon vehicle provided a stable and reliable platform for the very-high-altitude nuclear detonation.

Appendix A
FLIGHT SUMMARIES, SERIES VII

FLIGHT G-66, 9 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To familiarize the USAF launch crew with balloon launching technique aboard an aircraft carrier. Technique to include balloon inflation system from gas (helium) supply trailers on hangar deck.
2. To enable the ship's bridge to develop maneuvering techniques for a successful balloon launch.
3. To observe deployment of canister system with Canister E increased in weight from 62.5 pounds to 75.5 pounds.
4. To test a new launching plan as follows:
   a. Launch vehicle, mast facing aft, center lined on the flight deck 30 feet from aft end.
   b. Launch platform centered approximately 200 feet from aft end of flight deck.
   c. Balloon so laid out that at release from launch platform, balloon motion will carry balloon to a vertical position above launcher mast. If feasible, this launch plan will minimize travel time of the balloon system over the flight deck.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 94,000 feet MSL (pressure altitude).

Flight Duration. 2 hours 40 minutes.

Tropopause Temperature. −83 C.

System Weight by Components, pounds.

Balloon	541.0
Load line (75 feet long)	7.0
Reel (aneroid backup included)	49.0
Control instrumentation (double eyebolt)	120.0
Simulated nuclear device	300.0
Tube and parachute	35.0
Canisters: A	40.5
B	50.25
C	50.25
D	50.25
E	75.50
Safety aneroid, T-bar and radar reflectors	8.50
Total weight	1,337.0
Free lift	68.0
Total lift	1,405.0
Total pay load	761.5

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 5A (Transducer 4A) with timer-safety device, a reel modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna in the event of command system failure. All instrumentation functioned properly when preflight-tested in the laboratory and from its position on the vehicle prior to launch.

Command deployments were successful on (1) the telemetering antenna at 500 feet (AMSL), (2) the canister tube at 3,000 feet, and (3) the reel at 5,000 feet. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating for 15 minutes at a starting speed of 28 rpm and a stopping speed of 6 rpm.

The flight was terminated by the timer-safety device at 1701 hours local time. The command system appeared to respond in all respects— selecting, holding, and firing—but the balloon load line would not sever. This trouble was probably caused by (1) a defective squib, squib cannon, or squib cable, or (2) a run-down squib firing battery. Floating pressure altitude was 94,000 feet.

Discussion and Results. Flight G-66 was launched 9 March 1958 at 1421 hours. The following equipment was used for the flight:

1. AFCRC control instrumentation (WD5D Unit and Timer Safety Device).
2. GRD reel E (Tested at Goodfellow AFB, Texas, during Phase VI).
3. Simulated nuclear device with attached harness and end-fitting.
4. Deployment tube internally fitted with simulated canisters A, B, C, D, and E.
5. Two radar corner reflectors and T-bar attached to balloon load line 7 feet from double eyebolt.

Relative wind speed on the flight deck during inflation averaged 1.5 knots with a maximum of 4.5 knots. Wind readings were taken at 3-minute intervals. Ship control relative to wind was very good.

In contrast to standard procedures, the trailers for helium supply were kept remote from the balloon inflation area. The trailers, stowed on hangar deck, were connected to the inflation area by 300 feet of 1-inch (id) diameter fill hose. Sound powered phones were used to communicate between helium supply trailers and the balloon inflation area.

[redacted]

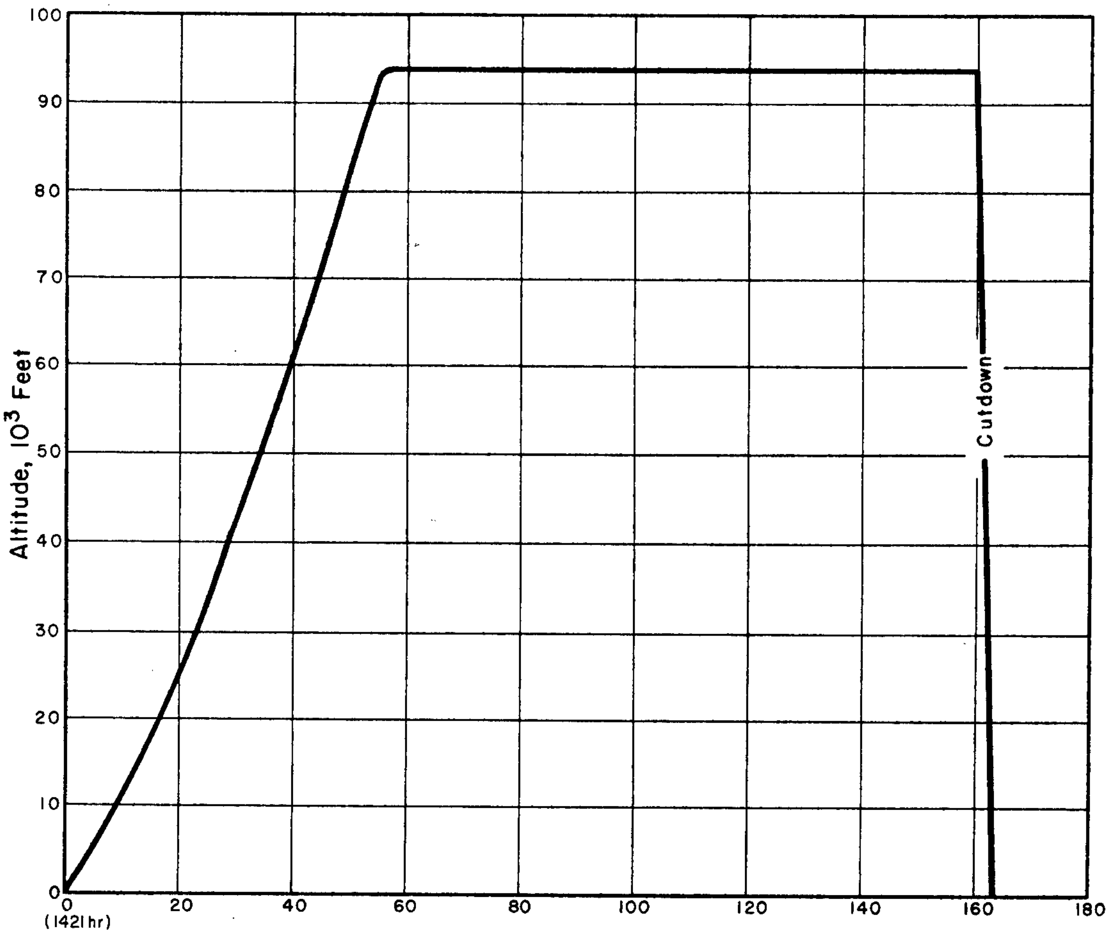

Figure A.1 Flight G-66, time-pressure altitude (uncorrected for temperature).

The entire inflation method appears satisfactory and 9.2b foresees no future difficulties.

Launching was smooth and orderly.

Canister deployment was observed from a helicopter at an altitude of 3,000 feet (approximately 300 feet from system). The tube separated correctly and began its parachute descent. However, the nylon line (1,500-pound test) which connected the simulated nuclear device to Canister A appeared to be entangled, causing premature deployment of Canister A. Immediately after the canister withdrawal, the line untangled and Canister A fell to the maximum extension of its load line. This rapid descent (free-fall) caused Canister A to drop through the chute canopy of the slowly descending tube which was upset and ejected the remaining undeployed canisters. The shock of the added canister load in free fall broke the deployment line between Canisters B and C, and Canisters C, D, and E fell into the sea. This loss of weight caused the balloon to reach a floating pressure altitude of approximately 94,000 feet.

The performance of the reel was satisfactory.

A different method of packing the deployment lines should ensure proper deployment without subsequent loss of canisters.

Despite the canister mishap, Flight G-66 significantly contributed to familiarization of balloon launch procedures, from a carrier, for all agencies concerned. The new plan of launching from over the back of the launch vehicle succeeded well enough to be included in all future launchings since it reduces over-the-deck balloon travel from 350 feet to approximately 24 feet.

The curve for pressure altitude versus time is shown in Figure A.1.

(U)

FLIGHT G-67, 11 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To familiarize the USAF launch crew with balloon-launching techniques aboard an aircraft carrier.

2. To enable the ship's bridge to develop maneuvering techniques for a successful balloon launch.

3. To observe deployment of canister system

[redacted]

with Canister E increased in weight from 62.5 pounds to 75.5 pounds.

4. To test the deployment system.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 92,000 feet MSL (pressure altitude).

Flight Duration. 2 hours 30 minutes.

Tropopause Temperature. −76 C.

System Weight by Components, pounds.

Balloon	548.0
Load line	5.0
Reel	50.0
Control instrumentation (double eye-bolt and adapter)	120.0
Simulated nuclear device	300.0
Tube and parachute	35.0
Canisters: A	40.5
B	50.25
C	50.25
D	50.25
E	76.50
Safety aneroid and corner reflectors	8.50
Total load	1,340.5
Free lift	60.0
Total lift	1,400.5
Total pay load	757.5

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 2A (Transducer 2A) with a timer-safety device, a reel modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna in the event of command system failure. All instrumentation functioned properly when preflight-tested in the laboratory and from its position on the vehicle prior to launch.

Command deployments were successful on (1) the telemetering antenna at 500 feet (AMSL), (2) the canister tube at 3,000 feet, and (3) the reel at 5,000 feet. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating for 14 minutes at a starting speed of 30 rpm and a stopping speed of 8 rpm.

The flight was terminated by command at 1154 hours local time. Floating pressure altitude was 92,000 feet.

Discussion and Results. Flight G-67 was launched at 0924 hours, 11 March 1958. The following equipment was used for this flight:

1. AFCRC control instrumentation (WD5D Unit and Time Cutter).
2. GRD reel (production model).
3. Simulated nuclear device with attached harness and end-fitting.
4. Deployment tube internally fitted with simulated canisters, A, B, C, D, and E.
5. Two radar corner reflectors and T-bar attached 5 feet below the balloon load ring.

Several difficulties in reel operation had to be overcome prior to the launching of this flight. Shortly after the train was raised in the full vertical position, the reel-locking device failed and caused the reel to start prematurely. The tube was lowered to the deck but the entire balloon system appeared undamaged. An inspection of the reel locking device indicated three material flaws. The train was disassembled, a new locking device was installed on the reel, and the train was again rigged to the vertical position on the vehicle launch mast. A few minutes later the newly installed reel-locking device also failed. An examination of the two failures indicated the following: The two reel-locking devices (scissors release mechanism) were identified as the last two of four units fabricated under a Wentworth Institute contract. Two of these units were tested successfully during Phase VI at Goodfellow AFB, Texas. It was assumed, therefore, that the remaining two would perform equally well, hence they were installed on the reel. The failure of the devices was apparently caused by defective material. In both cases the failure occurred across the female joint and at the pivot of the locking device and in one instance three rusty cracks at the failure cleavage were observed.

To ensure satisfactory performance of the locking device for all future flights, a complete testing procedure will be established. Each locking device will be static-tested to an actual tension of 1,200 pounds at the load suspension point. If any distortion or slippage is apparent, the faulty locking device will be rejected on a hundred percent basis.

A production model locking device (from the Harvard Machine and Tool Company) was tested and used in the load train for Flight G-67. This reel locking device held fast and functioned normally.

Relative winds across the carrier deck during inflation were less than three knots and ship maneuvering relative to wind was satisfactory.

Balloon layout and inflation were routine and the launching of the balloon was smooth and orderly.

When tube separation occurred at 2,500 feet MSL, it was immediately apparent that the parachute would not open. Although the canister deployment tube was in free fall, Canister A deployed satisfactorily. The rate of acceleration of the tube system was so rapid that the nylon line between Canisters A and B broke and the tube system with four remaining canisters free fell into the sea, approximately 200 feet off the port beam. This was the first parachute failure since the beginning of the development program.

A girdle device, employed to retain a safety aneroid, was located on the tube and under the apex of the parachute. Possibly the girdle device slid up

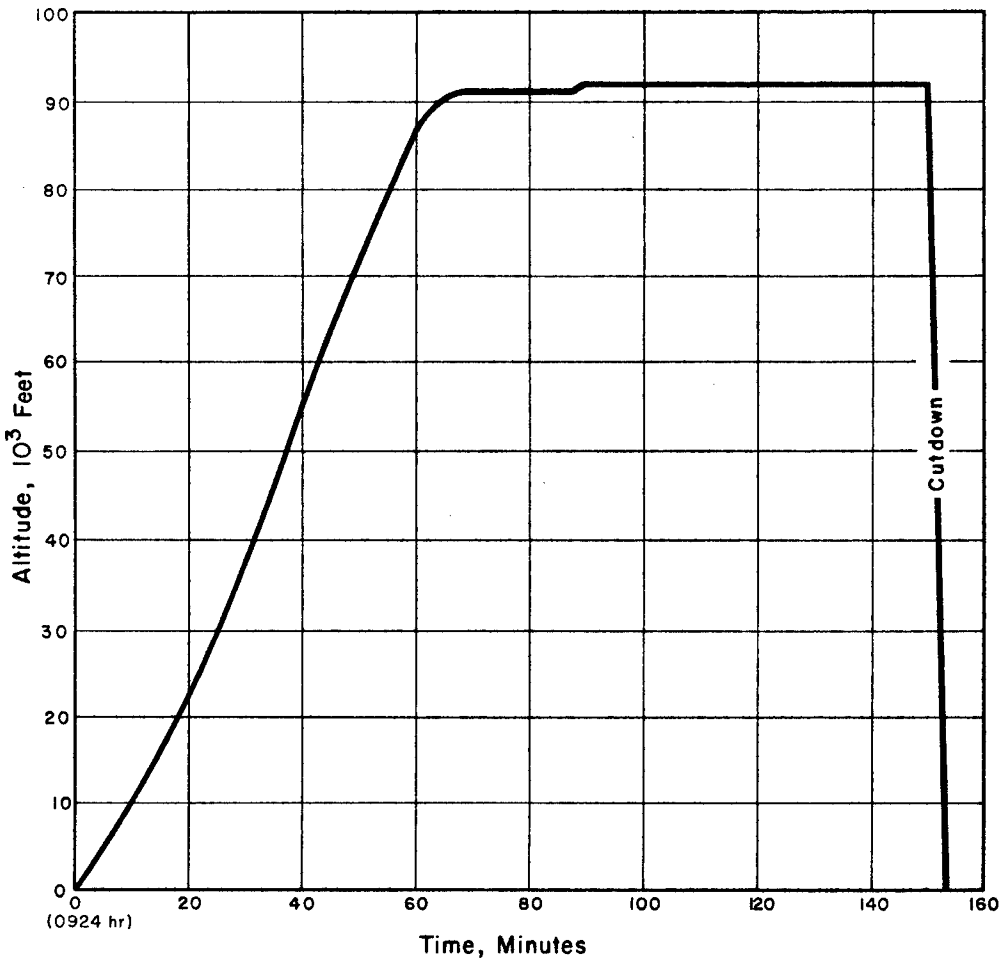

Figure A.2 Flight G-67, time-pressure altitude (uncorrected for temperature).

the tube and fouled the parachute and prevented normal deployment. This girdle device will not be used on future flights.

The balloon performance was normal except for the rapid rate of rise caused by the loss of 261 pounds of load. The balloon reached a floating pressure altitude of 92,000 feet MSL.

The reel performance was satisfactory, with reel-out requiring 14 minutes.

Cut-down was made by radio command at 1154 hours.

The USAF balloon-launch crew had achieved a high level of proficiency for carrier type launchings and was ready to accept the greater responsibility for the full dress rehearsals and the final launch. The launch officer expected no future difficulties caused by relative winds on the flight deck during inflation and launch.

The curve for pressure altitude versus time for this flight is shown in Figure A.2.

(3) FLIGHT G-68, 11 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.
1. To test the deployment system.
2. To observe deployment of canister system with Canister E increased in weight from 62.5 pounds to 75.5 pounds.
3. To enable the ship's bridge to develop maneuvering techniques for a successful balloon launch.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 88,000 feet MSL (pressure altitude).

Flight Duration. 2 hours 30 minutes.

Tropopause Temperature. −76 C.

System Weight by Components, pounds.

Balloon	546.0
Load line	5.0
Reel	47.0
Control instrumentation (double eye-bolt and adapter)	117.0
Simulated nuclear device	300.0
Tube and parachute	35.0

[redacted]

Canisters:	A	40.5
	B	50.25
	C	50.25
	D	50.25
	E	76.50
Safety aneroid and corner reflector		8.50
Total load		1,333.0
Free lift		60.0
Total lift		1,393.0
Total pay load		752.0

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 4A (Transducer 5A) including a timer-safety device, a reel-modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna in the event of command system failure. All instrumentation functioned properly when preflight-tested in the laboratory and from its position on the vehicle prior to launch.

Command deployments were successful on (1) the canister tube at 2,500 feet, (2) the telemetering antenna at 5,000 feet, and (3) the reel at 6,000 feet. The telemetering antenna was deployed after the canister tube, so that it would not interfere with the parachute during tube drop. This sequence will be followed on all future flights. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating 14 minutes at a starting speed of 30 rpm and a stopping speed of 8 rpm.

The flight was terminated by command at 1647 hours local time. Floating pressure altitude was 88,000 feet.

Discussion and Results. Flight G-68 was launched at 1417 hours, 11 March 1958. The following equipment was used for the flight:

1. AFCRC control instrumentation (WD5D Unit and timer-safety device).
2. GRD reel (production model).
3. Simulated nuclear device with attached harness and end-fitting.
4. Deployment tube internally fitted with simulated canisters A, B, C, D, and E.
5. Three radar corner reflectors attached to the balloon load line, for assisting the radar tracking facility.

The girdle device used for supporting the tube safety aneroid was not used. The aneroid was attached to the outside surface of the parachute canopy. The layout and inflation were conducted routinely.

Launching was smooth and orderly.

The first command for tube separation was made successfully at 2,500 feet altitude. The deployment was excellent. The added weight in Canister E did not appear to impair the deployment operation. The nylon line (1,000-pound test) between Canisters D and E was sufficiently strong to support this added weight provided parachute performance was normal. The deployment of Canister E was not altered by the weight change.

The reel operation was started by command at 6,000 feet with complete reel-out in 14 minutes.

The balloon performed satisfactorily with a rate of rise of approximately 1,000 feet per minute to a floating altitude of 88,000 feet (pressure altitude).

The pressure altitude time curve for this flight is shown in Figure A.3.

FLIGHT G-69-S, 15 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.
1. To test the Sandia instrumentation.
2. To rehearse for the Yucca event.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 81,500 feet MSL (pressure altitude).

Flight Duration. 3 hours 44 minutes.

Tropopause Temperature. −82 C.

System Weight by Components, pounds.

Balloon		543.0
Load line		5.0
Reel		50.0
Sandia instrumentation		305.0
Tube and parachute		35.0
Canisters:	A	40.5
	B	50.25
	C	50.25
	D	50.25
	E	75.50
Reflectors, aneroids and T-bar		8.50
Total weight		1,222.0
Free lift		61.0
Total lift		1,283.0
Total pay load		644.0

Instrumentation. The AFCRC instrumentation utilized on this Sandia Corporation controlled flight consisted of two aneroid-switch units as backup devices to deploy (1) the canister tube at 10,000 feet

[redacted]

and (2) the load-lowering device (reel) at 15,000 feet in the event of command system failure.

All squib cannons, squibs, and associated cabling for this flight were also furnished and installed.

Discussion and Results. Two days prior to the launching of Flight G-69-S several rehearsals were conducted to insure component rigging compatibility. The Sandia item was fitted to the reel thimble and to the fiberglass tube suspension nylon loops. The check list for this orderly rigging and preparation of the train array was being tested for possible changes. The front elevator on the launch vehicle was modified to better accommodate the arming party during the instrumentation check out. Finally, personnel were thoroughly briefed and specific jobs were assigned.

Flight G-69-S was launched at 1137 hours, 15 March 1958. The equipment used on this flight consisted of the following:

1. GRD reel (production model).
2. Sandia instrumentation.
3. Fiberglass tube fitted internally with five simulated canisters.
4. A train of three radar reflectors attached to the balloon load line.

Balloon layout and inflation were accomplished routinely.

The balloon was released from the launch platform into a vertical position over the launch vehicle and held in this attitude for a period of 1 hour 45 minutes while the arming party made the necessary final checks.

The balloon launching was routine. Canister de-

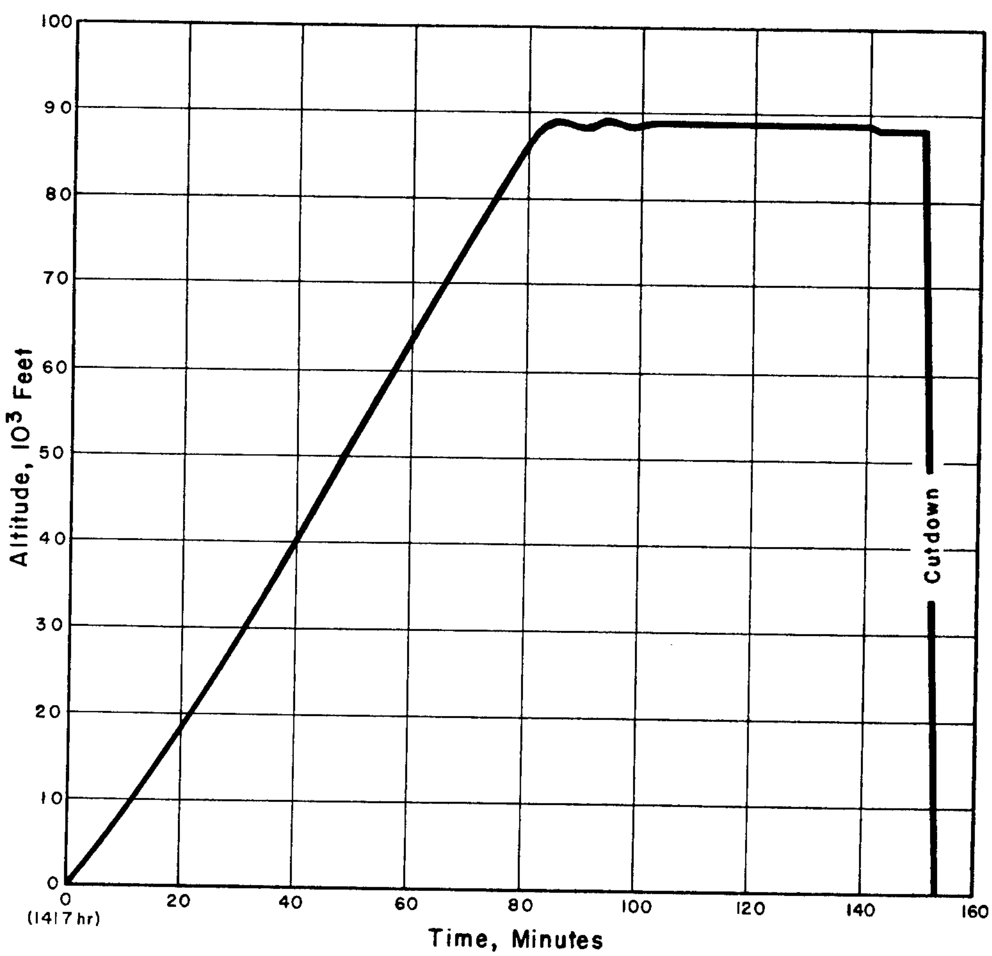

Figure A.3 Flight G-68, time-pressure altitude (uncorrected for temperature).

[redacted]

ployment and reel-out were conducted at 3,000 and 6,000 feet respectively. The radio commands employed to start these two operations functioned on time and aircraft observers indicated a successful deployment and reel-out.

The balloon rate of rise averaged 700 feet per minute to a final floating altitude (pressure) of 81,500 feet. This altitude was confirmed by the Mark 25 radar aboard the USS Boxer (CVS-21). Possibly during the long hold period (balloon in vertical 1 hour 45 minutes) air was introduced to the balloon and subsequently increased the gas density, hence the lowered floating altitude between 81,500 and 78,000 feet.

Reports from the Sandia technical staff indicate excellent results from Flight G-69-S.

This flight contributed significantly to the isolation of the numerous communication problems associated with the Yucca event. It could be termed as a very successful rehearsal.

The pressure altitude time curve for this flight is shown in Figure A.4.

5

FLIGHT G-70-S, 21 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To test flight the Sandia instrumentation.
2. To provide positioning experience, at altitude, for the B-36 aircraft crews.
3. To simulate a second full dress rehearsal for the Yucca event.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 83,500 feet MSL (pressure altitude).

Flight Duration. 3 hours 32 minutes.

Tropopause Temperature. −76 C.

System Weight by Components, pounds.

Balloon		543.0
Load line		5.0
Reel and X-band transponder beacon		64.0
Sandia instrumentation		307.0
Tube and parachute		35.0
Canisters:	A	40.5
	B	50.25
	C	50.25
	D	50.25
	E	75.50
Pressure switch		4.0
Reflectors, aneroids, and T-bar		5.0
Total weight		1,241.0
Free lift		62.0
Total lift		1,303.0
Total pay load		663.0

Instrumentation. The AFCRC instrumentation utilized on this Sandia Corporation controlled flight consisted of two aneroid-switch units as backup devices to deploy (1) the canister tube at 10,000 feet and (2) the load-lowering device (reel) at 15,000 feet in the event of command system failure.

All squib cannons, squibs, and associated cabling for this flight were also furnished and installed.

Discussion and Results. Balloon Flight G-70-S was launched at 0919 hours, 21 March 1958. The equipment used on this flight consisted of the following:

1. GRD reed (production model) and X-band transponder beacon.
2. Sandia instrumentation.
3. Fiberglass tube fitted internally with five simulated instrumentation canisters.
4. A train of four radar reflectors.

The balloon was released from the launch platform and held in this attitude for a period of 40 minutes. The arming procedures were changed so that balloon inflation was conducted during the preliminary arming checks. After the balloon was inflated, the arming party descended from the mast, the balloon was released to the vertical and the arming party returned to the mast for the final portion of the arming procedure. This routine was successful in reducing the time of vertical balloon hold to 40 minutes. The primary concern was to reduce the balloon hold time to a minimum consistent with safety in the arming of the nuclear device.

The balloon launching was routine. The canister deployment at 7,000 feet MSL and the reel operation at 12,000 feet MSL were successful.

The balloon tracking was immediately effected by the two participating B-36's and continued successfully throughout the flight. Reports from the flight personnel indicated a need for more practice and a reorientation in the tracking procedures, but confidence was expressed in the successful solution of current problems.

The Sandia technical staff was satisfied with the performance of their instrumentation.

The primary results of Flight G-70-S were instrumental in showing the weakness of certain areas in communications and have assisted the program director in more realistic appraisal of the timing and coordination of procedures.

The curve for pressure altitude versus time for this flight is shown in Figure A.5.

6

FLIGHT G-71, 26 MARCH 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To compare floating altitude of a balloon launched immediately upon its release from launch platform with floating altitudes of Flight G-70-S and G-69-S which were held in the vertical over the

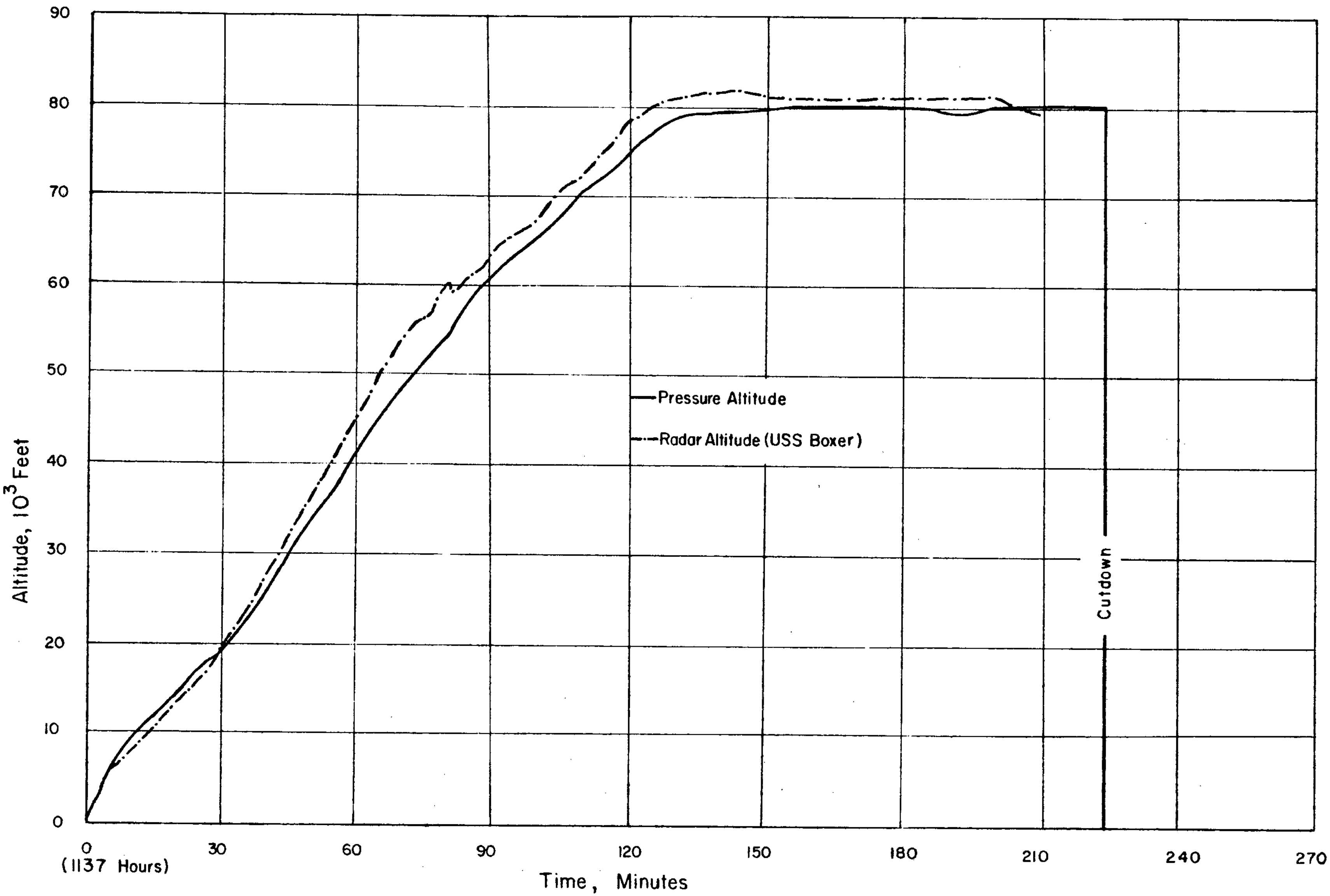

Figure A.4 Flight G-69-S, time versus altitude (uncorrected for temperature).

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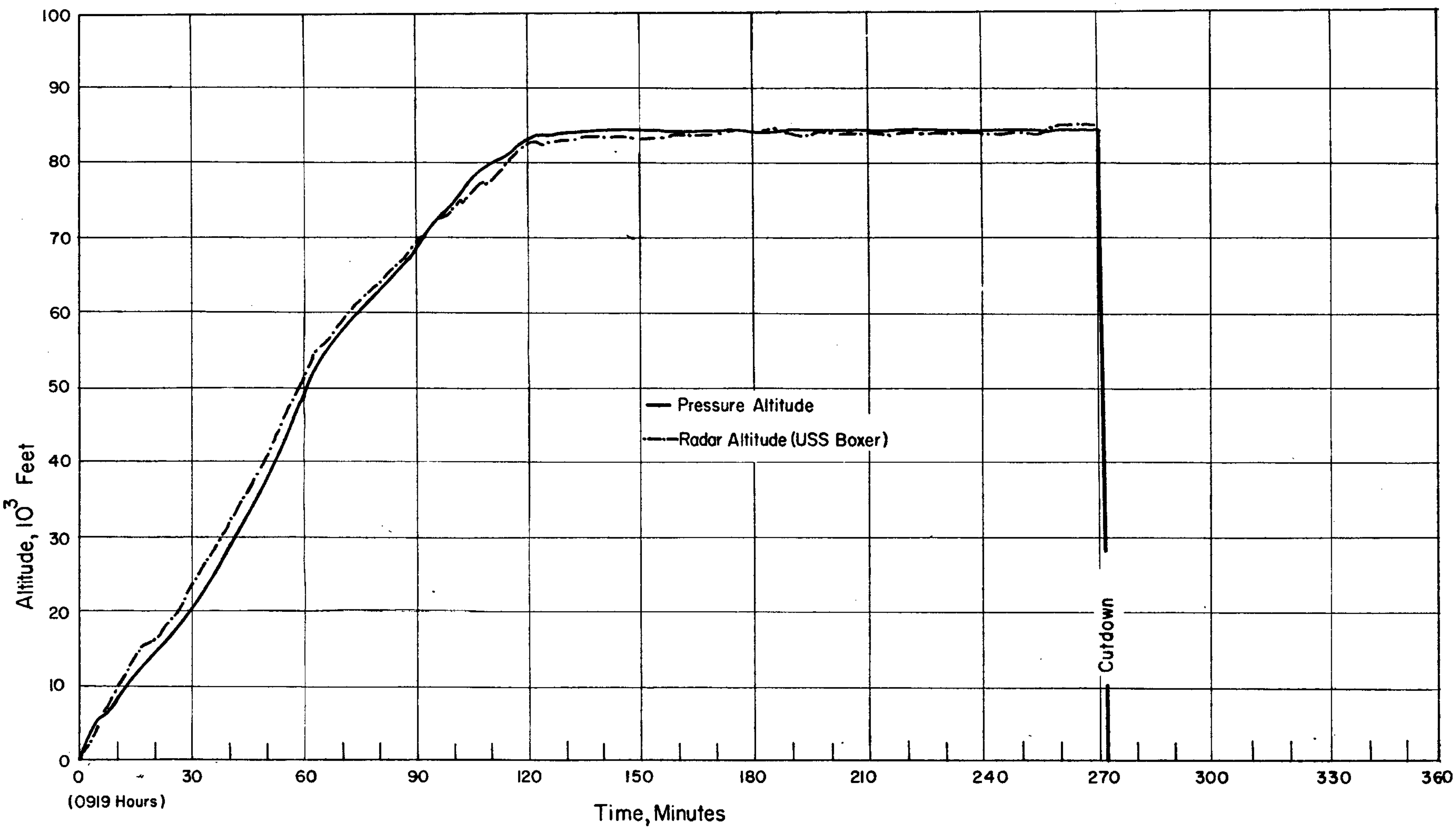

Figure A.5 Flight G-70-S, time versus altitude (uncorrected for temperature).

launch vehicle 40 minutes and 1 hour 45 minutes respectively.

2. To provide a second rehearsal for the B-36 effects-measuring aircraft.

3. To establish more discrete communication procedures among the participating agencies.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 88,500 feet MSL (pressure altitude).

Flight Duration. 4 hours 23 minutes.

Tropopause Temperature. −82 C.

System Weight by Components, pounds.

Balloon	543.0
Load line	5.0
Reel and X-band transponder beacon	68.0
Control instrumentation	119.0
Simulated nuclear device	195.0
Tube and parachute	35.0
Canisters: A	40.5
B	50.25
C	50.25
D	50.25
E	75.50
Safety aneroid, T-bar and radar reflectors, pressure switch	13.0
Total weight	1,254.0
Free lift	63.0
Total lift	1,317.0
Pay load	676.0

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 1A (Transducer 1A) including a timer-safety device, a reel modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna in the event of command system failure. All instrumentation functioned properly when preflight tested in the laboratory and from its position on the vehicle prior to launch.

Command deployments were successful on (1) the canister tube at 7,000 feet, (2) the telemetering antenna at 9,000 feet, and (3) the reel at 12,000 feet. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating for 15 minutes at a starting speed of 28 rpm and a stopping speed of 7 rpm.

The flight was terminated by command at 1518 hours local time. Floating pressure altitude averaged 88,500 feet.

Discussion and Results. Flight G-71 was launched at 1055 hours on 26 March 1958. The instrumentation used on this flight was as follows:

1. AFCRC control instrumentation (WD5D Unit and timer-safety device).
2. GRD reel (production model).
3. Simulated nuclear device with attached harness and end-fitting.
4. Deployment tube fitted internally with simulated canisters A, B, C, D, and E.
5. A train of four corner reflectors attached to the balloon load line.

Balloon layout and inflation were conducted routinely.

Air apparently entered the balloon during the long hold period on Flights G-69-S and G-70-S. This air induction is unsatisfactory and has great bearing on the floating altitude provided a significant volume is introduced. To prevent a possible recurrence of air entry during the hold period, G-71 balloon was launched immediately after release from the launch platform. The floating altitude with this technique reestablished the original floating altitude of 88,500 feet (pressure altitude) as compared to 81,500 feet for G-69-S (hold period 1 hour 45 minutes) and 83,500 feet for G-70-S (hold period 40 minutes). This comparison, or correlation of floating altitudes and hold periods prior to balloon rélease does not firmly establish a decreased floating altitude for a corresponding increase in balloon hold time. It does indicate, however, that possibly there is a relationship. With these limited data as evidence, an attempt to reduce the balloon hold time to a minimum will be made.

Successful canister deployment and reel-out were performed at 7,000 feet and 12,000 feet respectively.

The B-36 aircraft were in-flight and had a very successful rehearsal.

The communications and liaison among the interested parties were more discrete as a result of this flight rehearsal.

The curve for pressure altitude versus time for this flight is shown in Figure A.6.

FLIGHT G-72, 2 APRIL 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To provide additional positioning experience for the B-36 aircraft crews.
2. To exercise the overall communication net.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 86,500 feet MSL (pressure altitude).

Flight Duration. 5 hours 6 minutes.

Tropopause Temperature. −84 C.

System Weight by Components, pounds.

Balloon	535.0
Load line	5.0

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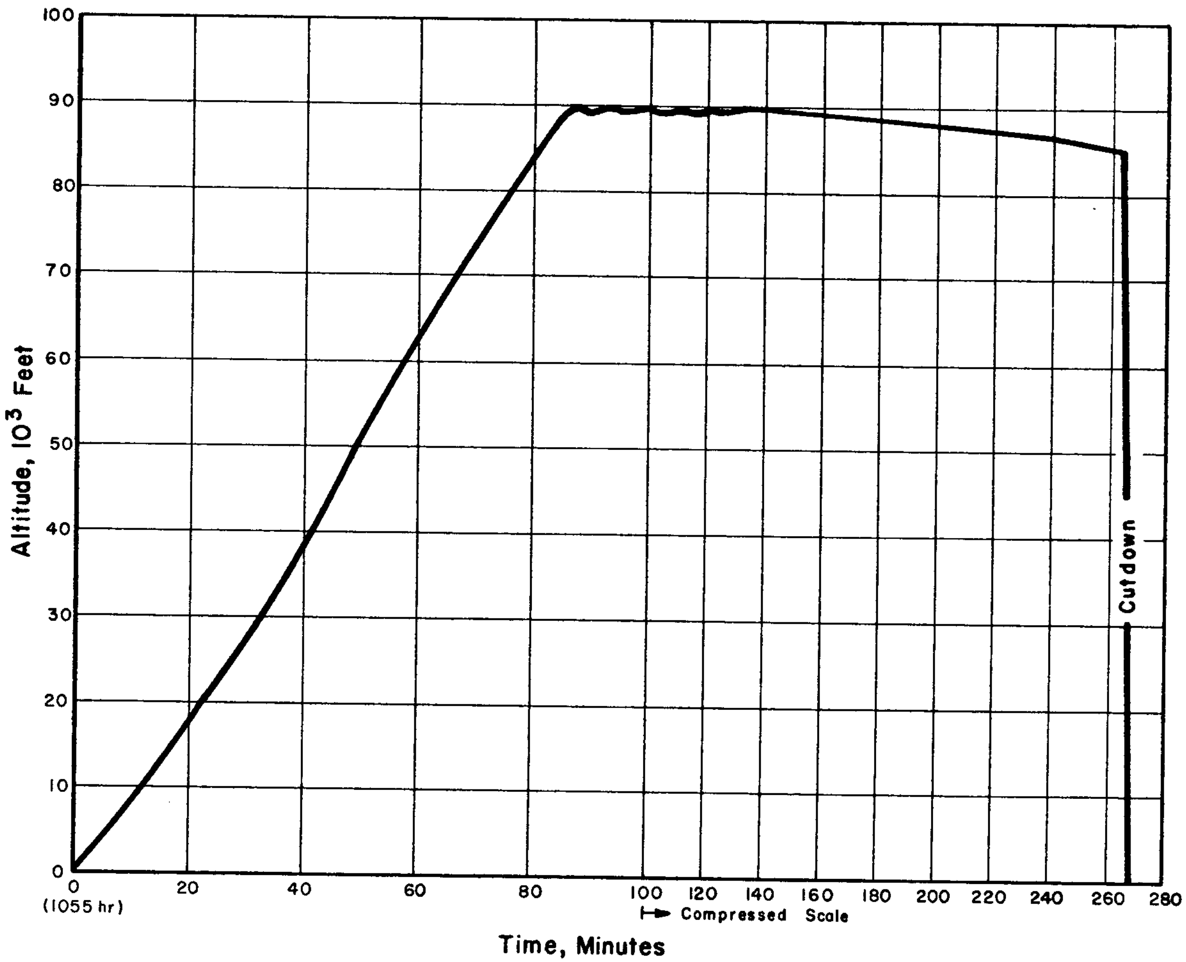

Figure A.6 Flight G-71, time-pressure altitude (uncorrected for temperature).

Reel (aneroid backup included)	47.0
Control instrumentation (double eyebolt)	119.0
Simulated nuclear device	195.0
Tube and parachute	35.0
Canisters: A	40.5
B	50.25
C	50.25
D	50.25
E	75.50
Pressure switch	5.0
Reflectors and rigging	8.0
Total weight	1,225.0
Free lift	61.0
Total lift (gross inflation)	1,268.0
Total pay load	655.0

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 3A (Transducer 3A) including a timer-safety device, a reel-modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna in the event of command system failure. All instrumentation functioned properly when preflight-tested in the laboratory and from its position on the vehicle prior to launch. Before launch two heavy rain showers fell on the instrumentation. Subsequently, water seeped into the timer-safety device causing a short circuit which detonated a flight termination squib. The timer-safety device was replaced with a dry one in 10 minutes without delay to the flight launch. In all future flights, efforts will be made to waterproof all instrumentation with poly jackets and tape.

Command deployments were successful on (1) the canister tube at 7,000 feet, (2) the telemetering antenna at 9,000 feet, and (3) the reel at 12,000 feet. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating for 13 minutes at a starting speed of 30 rpm and a stopping speed of 8 rpm.

After 4 hours of flight it was discovered that the command system would not respond to the "select" interrogation. It is the belief of the electronic scientist that the command code-drum motor stopped rotating because of reduced battery voltage; a similar trouble was encountered during one of the recovered San Angelo flights during October 1957. Flight termination was accomplished by the timer-safety device at 1615 hours local time. Floating pressure altitude averaged 86,500 feet.

Discussion and Results. Flight G-72 was launched 2 April 1958. The following equipment was used for the flight:

1. AFCRC control instrumentation (WD5D Unit and safety-timer device).
2. GRD reel (production model).
3. Simulated purpose item with attached harness and end-fitting.
4. Deployment tube internally fitted with simulated canisters A, B, C, D, and E.
5. Three radar corner reflectors attached to balloon load line 7 feet below the balloon load ring.
6. Force switch with a lower setting of 730 pounds and upper setting of 860 pounds.

Layout and inflation were routine.

The balloon was held in the vertical position, above the launch vehicle for five minutes pending more favorable launching winds.

All flight functions performed satisfactorily.

The balloon rate of rise was normal with final floating altitude readings as follows:

Pressure altitude (AFCRC instrumentation)	86,000 feet
Mark 25 radar	86,000 feet
MSQ radar (earth curvature correction)	89,000 feet

The command cut-down did not operate. Flight termination was made by the mechanical timer.

It was revealed, during the flight critique, that valuable positioning experience was gained by the B-36 aircraft crews and that the communication weakness indicated in earlier flights is being corrected by these sustained rehearsal efforts.

The pressure altitude time curve for this flight is shown in Figure A.7.

FLIGHT G-73-S, 5 APRIL 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To provide a test flight for Sandia Corporation instrumentation.
2. To provide a test flight for Bendix Corporation instrumentation.
3. To provide a vehicle for practice positioning by B-36 aircraft and by USS Boxer radar.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 83,000 feet MSL (pressure altitude).

Flight Duration. 3 hours 46 minutes.

Tropopause Temperature. −79 C.

System Weight by Components.

Item	Weight pounds
Balloon	553.0
GRD reel	48.0
Sandia instrumentation	309.0
X-band transponder beacon	19.5
Pressure switch	5.75
Radar reflectors	3.50
Deployment tube	37.0
Canisters: Load line between nuclear device and Canister A	9.00

[redacted]

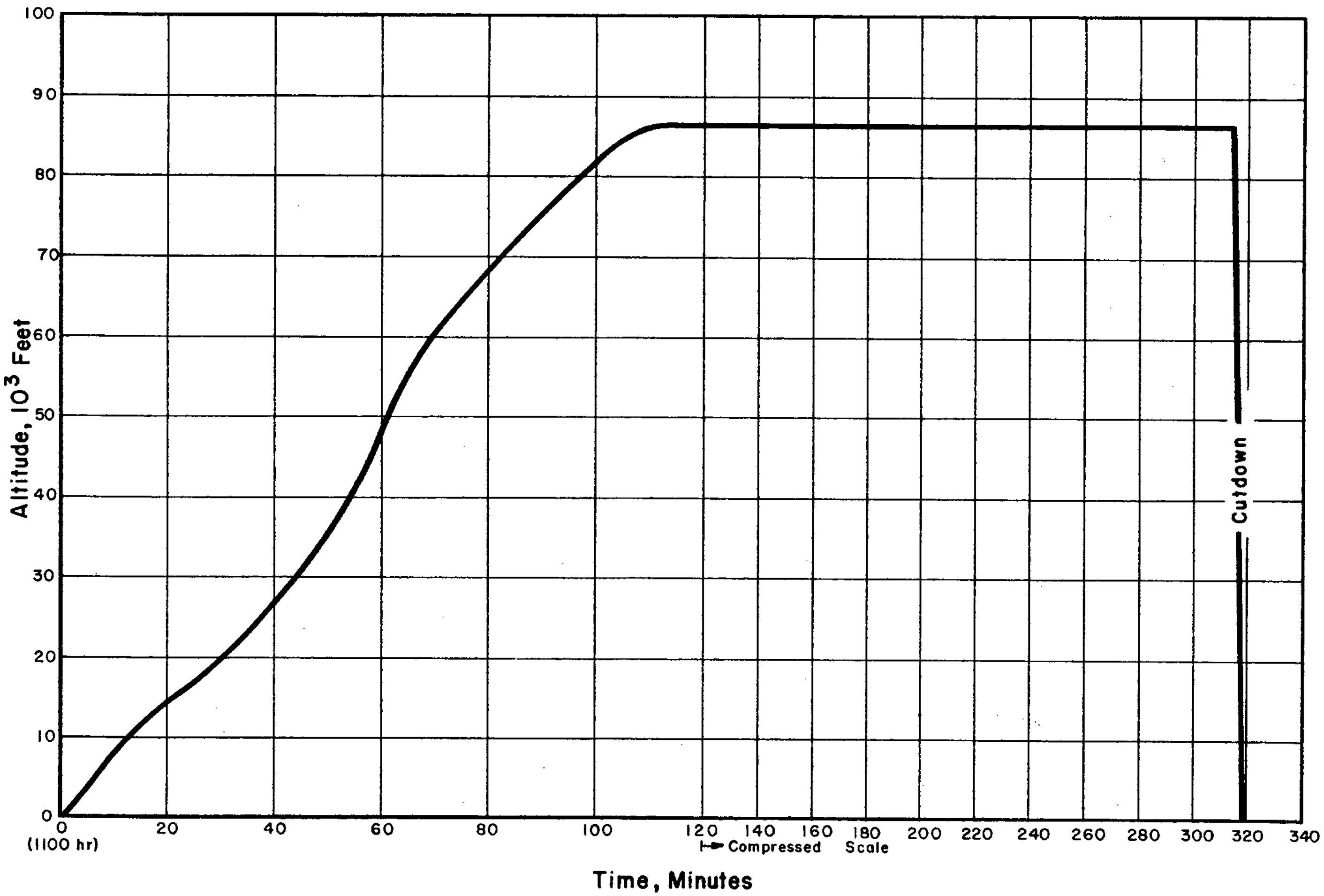

Figure A.7 Flight G-72, time-pressure altitude (uncorrected for temperature).

[redacted]

	Canister weight pounds	Nylon line weight pounds	
A	41.5	3.00	44.5
B	64.75	3.25	68.0
C	64.75	3.25	68.0
D	58.00	5.50	63.50
E	75.00	—	75.00
Miscellaneous rigging			7.25
Load line			6.00
Total load			1,311.0
Free lift			66.0
Total lift			1,377.0
Total pay load			721.0

Instrumentation. The AFCRC instrumentation utilized on this Sandia Corporation controlled flight consisted of two aneroid-switch units as backup devices to deploy (1) the canister tube at 10,000 feet and (2) the load-lowering device (reel) at 15,000 feet in the event of command system failure.

All squib cannons, squibs, and associated cabling for this flight were also furnished and installed.

Discussion and Results. Balloon flight G-73-S was launched at 1152 hours, 5 April 1958. The following equipment was used for the flight:

1. GRD reel (production model).
2. X-band transponder beacon.
3. Sandia instrumentation (P-11).
4. Deployment tube internally fitted with the Bendix canister D and simulated canisters A, B, C, and E.
5. Three radar corner reflectors attached to the balloon load line for assisting the radar tracking facility.

Equipment rigging and layout were normal.

A heavy rain squall produced undesirable conditions during inflation. After initial bubble inflation, a connection in the balloon fill hose separated because of an abnormally high rate of gas flow. The inflation was halted immediately, the break was repaired, and then the inflation proceeded to completion. The balloon was held in the launch arms for 72 minutes while the arming party made its instrumentation check. During this time it rained for 42 minutes, and the Sandia arming party halted their checkout.

The balloon was released to a vertical position and held for 30 minutes, while the final electrical connections were being made by the arming party.

When the balloon was released to the vertical position, it shed rain water for approximately 15 minutes.

The pressure switch indicated positive lift, the final safety pins were removed, and the balloon was launched.

The tube separation was made at 7,000 feet.

The canister deployment was excellent, and reel-out was satisfactory.

The balloon performance, in spite of the delay caused by the forty-minute rain storm, was ideal with a rate of rise of approximately 1,000 feet per minute to a floating altitude of 83,000 feet (pressure altitude).

This flight was successful in meeting the test objectives for the Bendix and Sandia Corporations.

The aircraft controllers indicated that they were now ready for the final flight. However, in case of a long delay they would like to participate on one more trial balloon flight to maintain their established positioning efficiency.

The pressure altitude time curve for this flight is shown in Figure A.8.

FLIGHT G-74-S, 8 APRIL 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To test the Sandia instrumentation (P-12).
2. To test the Bendix Corporation instrumentation.
3. To provide a full dress rehearsal for the Yucca event.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 83,500 feet MSL (pressure altitude.

Flight Duration. 4 hours.

Tropopause Temperature. −83 C.

System Weight by Components.

Item			Weight pounds
Balloon			533.0
Load line			6.0
Reel			49.5
Sandia instrumentation			309.0
Tube and parachute			37.0
Pressure switch			5.75
Reflectors and T-bar			3.75
X-band transponder beacon			19.50
Miscellaneous rigging			1.25
Canisters: Load line between nuclear device and Canister A			9.0
	Canister weight pounds	Nylon line weight pounds	
A	41.5	2.5	44.0
B	64.75	3.0	67.75
C	54.0	3.5	57.50
D	64.75	4.75	69.50
E	75.0	—	75.0
Total load			1,286.25
Free lift			64.00
Total lift			1,350.25
Total pay load			716.0

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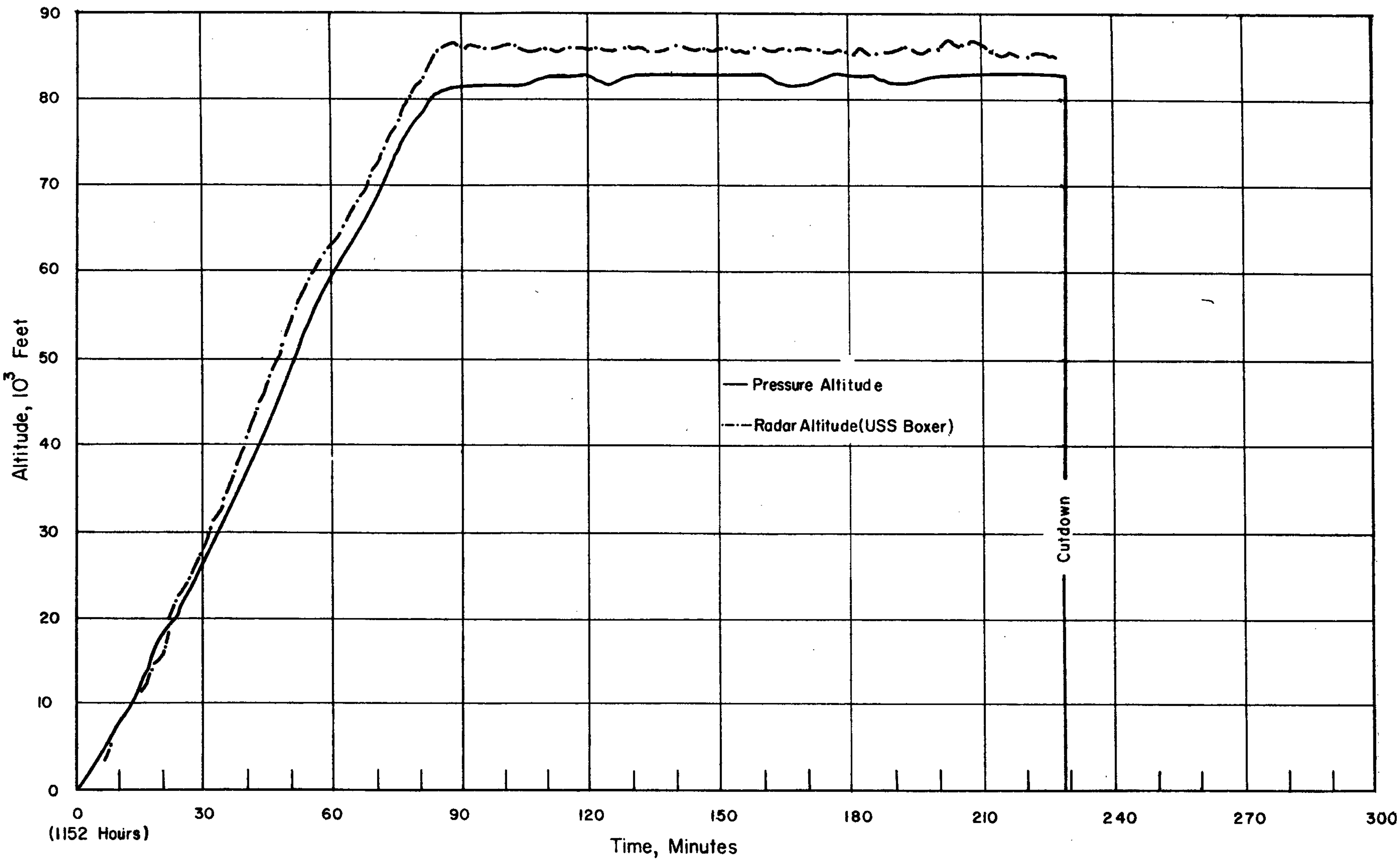

Figure A.8 Flight G-73-8, time versus altitude (uncorrected for temperature).

Instrumentation. The AFCRC instrumentation utilized on this Sandia Corporation controlled flight consisted of two aneroid-switch units as backup devices to deploy (1) the canister tube at 10,000 feet and (2) the load-lowering device (reel) at 15,000 feet in the event of command system failure.

All squib cannons, squibs, and associated cabling for this flight were also furnished and installed.

Discussion and Results. Balloon Flight G-74-S was launched at 1102 hours, 8 April 1958. The following equipment was used for the flight:

1. GRD reel.
2. Beacon (X-band transponder).
3. Sandia instrumentation (P-12).
4. Bendix instrumentation (Canister D).
5. Deployment tube internally fitted with simulated Canisters A, B, C, and E.
6. Two each radar corner reflectors.

The plan to adhere to the check list for the Yucca rehearsal, 8 April 1958, was not compromised. The check list, as prepared by the Program Director, stressed time economy consistent with safety. The experience gained through the previous rehearsals successfully reduced the performance time of each operation to a minimum, the balloon hold time being only 30 minutes as compared to 1 hour 45 minutes for the first flight. This time schedule was carefully budgeted and was reflected in the check list so that the schedule of events was precise and realistic.

The balloon layout, inflation and launching were routine.

The Sandia instrumentation performed satisfactorily to separate the deployment system and start the reel-out. Both functions were successful.

A careful study of results of Flight G-74-S, by the Bendix engineers, indicates that the development effort is correctly oriented.

Flight termination was made by radio command.

All agencies reported a very successful Yucca rehearsal.

The pressure altitude time curve for this flight is shown in Figure A.9.

FLIGHT G-75, 14 APRIL 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.
1. To provide test flight for Bendix Corporation canister equipment.
2. To provide test flight for aircraft positioning.

Balloon Type. 128-foot-diameter balloon.

Floating Altitude. 88,500 feet MSL (pressure altitude).

Flight Duration. 3 hours 55 minutes.

Tropopause Temperature. −81 C.

System Weight by Components.

Item			Weight pounds
Balloon			542.0
Reel			46.75
Instrumentation (control) AFCRC			120.00
Simulated nuclear device			190.00
Load line			6.00
Pressure switch and reflectors			9.25
Tube and miscellaneous rigging			38.25
Canisters: Load line weight, simulated nuclear device to Canister A			8.00
	Canister weight pounds	Nylon line weight pounds	
A	41.5	3.00	44.50
B	56.25	3.75	60.00
C	64.75	3.50	68.25
D	64.75	4.50	69.50
E	75.00	—	75.00
Total weight			1,277.5
Free lift			63.8
Total lift			1,342.0
Total pay load			698.0

Instrumentation. The instrumentation utilized on this flight consisted of Winzen WD5D Package 16A (Transducer 16A) including a timer-safety device, a reel modulation circuit, and individual backup aneroid units for deploying the canister tube, reel, and telemetering antenna, in the event of command system failure. All instrumentation functioned properly when preflight-tested in the laboratory and from its position on the vehicle prior to launch.

Command deployments were successfully accomplished on (1) the canister tube at 2,500 feet, (2) the telemetering antenna at 9,000 feet, and (3) the reel at 15,000 feet. All telemetering, DF, and command signals received were loud and clear. The reel operated satisfactorily, rotating for 14 minutes at a starting speed of 30 rpm and a stopping speed of 7 rpm.

The flight was terminated by command at 1655 hours in time with an Edgerton, Germeshausen and Grier (EG&G) count-down. Floating altitude (pressure) was 88,500 feet.

Discussion and Results. The X-band transponder beacon was not flown because the E-4 radar on the B-36 was inoperative. A two-hour delay was imposed by the effects-measuring aircraft.

Balloon flight G-75 was launched at 1300 hours, 14 April 1958. The following equipment was used for the flight:

1. AFCRC control instrumentation (WD5D unit and timer-safety device).
2. GRD reel (production model).
3. Simulated nuclear device with attached harness and end-fitting.
4. Deployment tube internally fitted with simu-

[redacted]

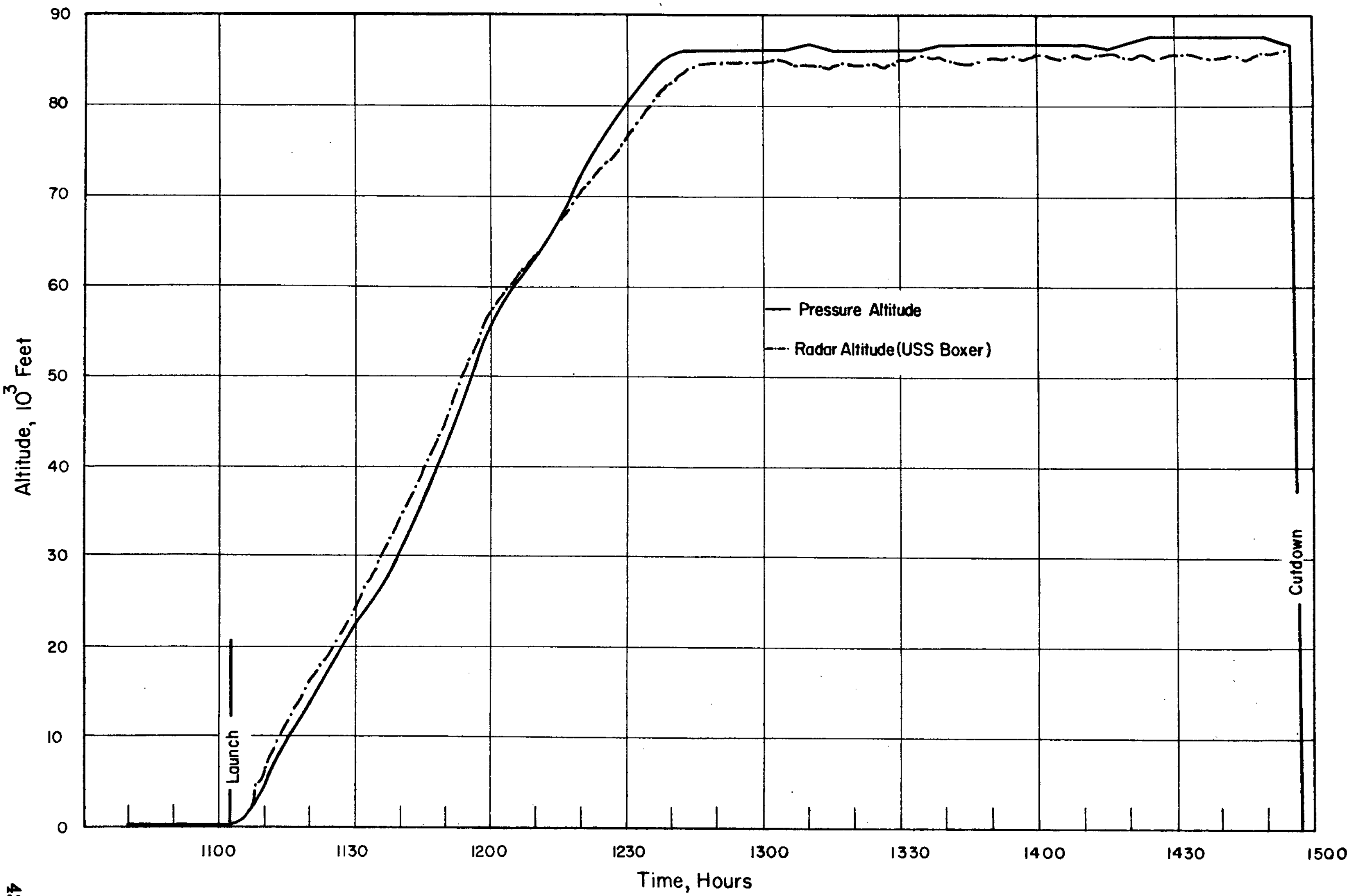

Figure A.9 Flight G-74-S, time versus altitude (uncorrected for temperature).

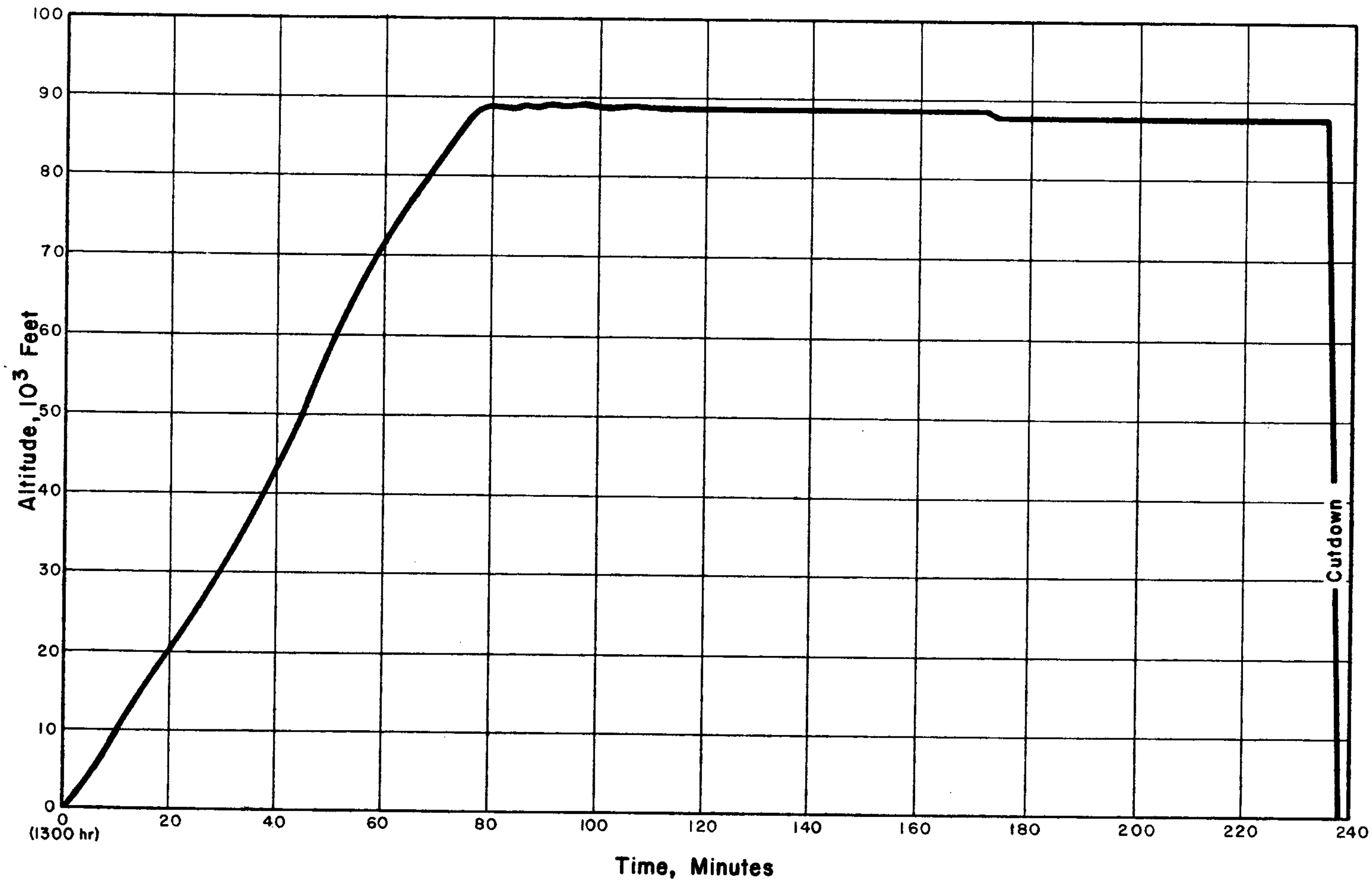

Figure A.10 Flight G-75, time-pressure altitude (uncorrected for temperature).

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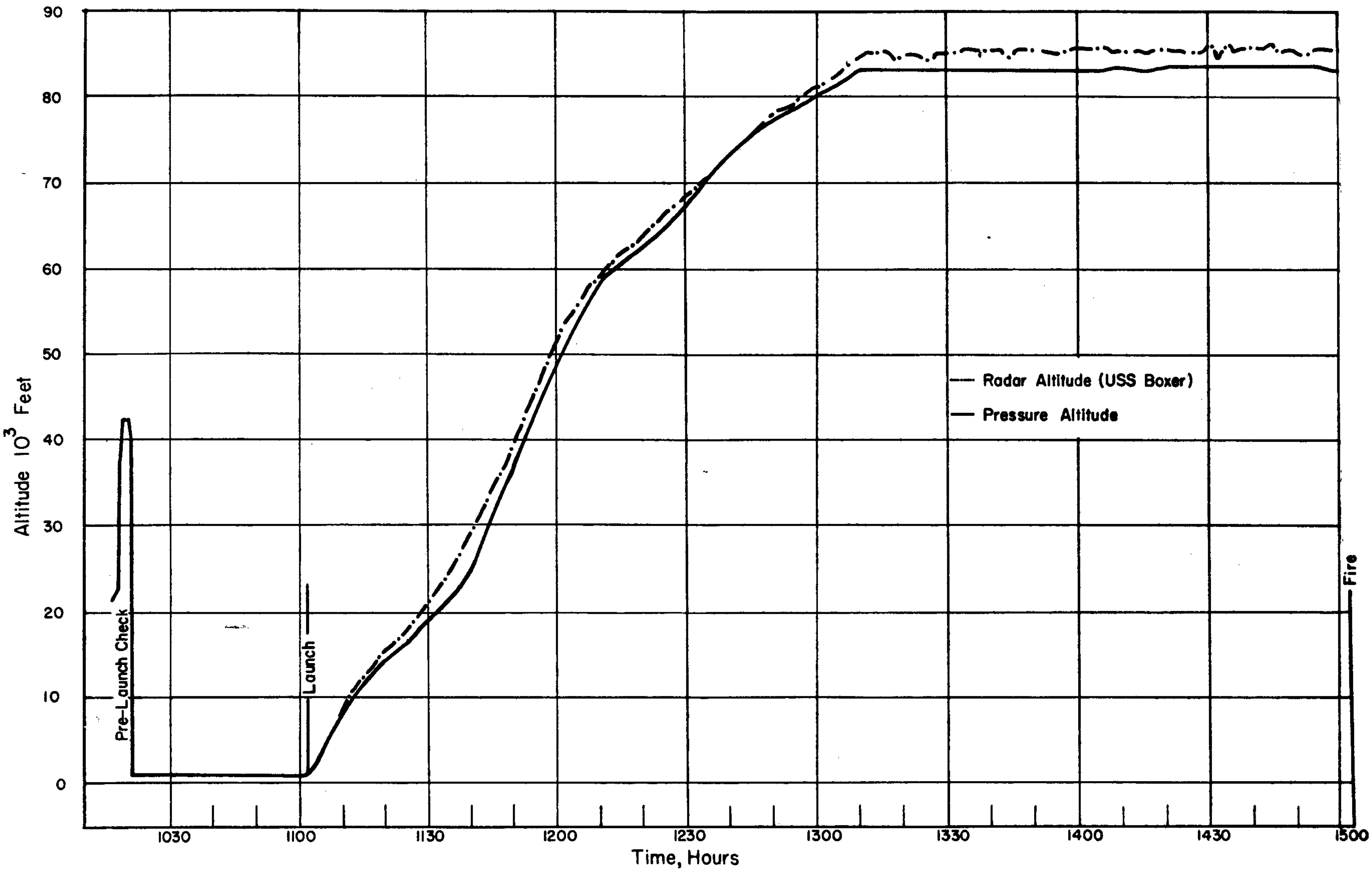

Figure A.11 Flight G-76-S (HE), time versus altitude (uncorrected for temperature).

lated Canisters A, B, C, and E and Bendix Canister D.

5. Two radar corner reflectors and T-bar attached to balloon load line 7 feet below the balloon load ring.

Balloon layout and inflation were routine.

Inflation was started at 1221 hours and ended at 1239 hours. After final check-out of the AFCRC, WD5D unit, the balloon was released into the vertical at 1247 hours and launched at 1300 hours.

The canister deployment and reel-out were successfully started by radio command at 2,500 feet and 15,000 feet respectively. Both operations were normal.

Balloon performance was satisfactory with an ascent rate of 1,160 feet per minute (average) to a floating altitude of 88,500 feet (pressure altitude) with a pay load of 698 pounds.

Flight G-75 was successfully terminated by radio command at 1655 hours.

This flight was successful in meeting the test objectives.

The pressure altitude time curve for this flight is shown in Figure A.10.

FLIGHT G-76-S (HE), 18 APRIL 1958
USS BOXER (CVS-21), MARSHALL ISLANDS

Purpose.

1. To test the Sandia instrumentation (P-13).
2. To test the Bendix instrumentation (Canisters A and E).
3. To rehearse (full dress) the Yucca event.

Balloon Type. 128 foot diameter balloon.

Floating Altitude. 85,800 feet (pressure altitude).

Flight Duration. 4 hours 1 minute.

Tropopause Temperature. −81 C.

System Weight by Components, pounds

Balloon	543.00
Load line	5.25
Reel and X-band transponder beacon	66.00
Sandia instrumentation (HE)	309.00
Tube and parachute	37.00
Canisters: A	41.25
B	64.75
C	64.75
D	64.75
E	78.00
Nylon canister load line	23.25
Clevis and force switch	6.75
Reflector and bar	4.00
Total weight	1,308.50
Free lift	65.00
Total lift	1,373.50
Total pay load	728.5

Nylon Line Lengths:

	Weight pounds	Length feet	Strength lb. test
Nuclear device to Canister A	8.0	667	1,500
Canister A to B	3.00	268	1,500
Canister B to C	3.25	400	1,000
Canister C to D	3.25	546	1,000
Canister D to E	5.75	855	1,000

Instrumentation. The AFCRC instrumentation utilized on this Sandia Corporation controlled flight consisted of two aneroid-switch units as backup devices to deploy (1) the canister tube at 10,000 feet and (2) the load-lowering device (reel) at 15,000 feet in the event of command system failure.

All squib cannons, squibs, and associated cabling for this flight were also furnished and installed.

Discussion and Results. Balloon flight G-76-S was launched at 1102 hours, 18 April 1958. The following equipment was used for the flight:

1. GRD reel (production model).
2. X-band transponder beacon.
3. Sandia instrumentation (P-14 high explosive device).
4. Deployment tube internally fitted with the Bendix canisters A and E and simulated canisters B, C, and D.
5. Two radar corner reflectors attached to the balloon load line for assisting the radar facility.

The equipment layout and rigging were normal.

The balloon inflation procedure was normal. The balloon was released to a vertical position and held for 30 minutes while the final electrical connections were being made by the arming party.

The pressure switch indicated positive lift, the final safety pins were removed and the balloon was launched.

The tube separation was made at 7,000 feet. Canister deployment and reel-out operation was normal.

The balloon performance was satisfactory with an average rate of rise of 641 feet per minute to a floating altitude of 85,800 feet (pressure altitude).

The test objectives for this flight were successfully met.

The pressure altitude time curve for this flight is shown in Figure A.11.

[redacted]

Appendix B

RÉSUMÉ OF DESIGN AND DEVELOPMENT OPERATIONS

SERIES I
FLIGHTS G-1 THROUGH G-12 AT HOLLOMAN AIR DEVELOPMENT CENTER (HADC)
23 OCTOBER TO 7 NOVEMBER 1956

The indoctrination and orientation of personnel in the inflation and launching of large plastic balloons was of paramount importance to the success of this mission. It was necessary that each member of the launching team thoroughly understand his role, and through exhaustive practice, exhibit a professional skill which would leave no doubt concerning a successful team operation. The HADC launching crew had not been trained for this specialized type of launching. As a result, evidence predominated throughout the test series that some new techniques and some modified techniques would be required, and that specialized training of each member of the team would be essential. During this test period the key members of the crew received instruction in the general phases of balloon handling, inflation, rigging and launching. Most important, these airmen observed at first hand the difficulties encountered by the HADC contingent in launching this unique flight equipment and they received instruction in corrective measures and proposed equipment changes required for reliable operations.

The canister deployment technique using a parachute and tube was deficient in several respects. The following corrective requirements have been established as a result of observations of the deployment action during this test series and subsequent studies of motion pictures of the test: (1) A new fiberglass tube with modified and increased strength characteristics is mandatory. (2) A parachute apex retaining ring should replace the upper tube flange. (3) The lower end of the tube requires some modifications to accommodate the lower parachute shroud lines. (4) A new type parachute must be tested to give increased stability.

The technique of launching a long load train as a compact unit and later deploying the train when the system is airborne appears to be feasible. A careful study of results from this phase indicates that the development effort, in general, is correctly oriented. A reliable launching and deployment method is forecast pending further refinements and tests.

As a result of these Phase I tests we have proven conclusively that a commercial mobile crane is not a good choice for a launching vehicle because: (1) it does not accelerate with required smoothness to top speed, (2) its maneuverability is limited, and (3) the vehicle as a launching platform under moderate and heavy wind conditions is unstable. A new launching vehicle has been designed, specified and ordered. The mass distribution of this vehicle is such that it will be stable under all launching conditions. Its maneuverability and acceleration characteristics will provide an adequate margin of safety for the most adverse wind conditions under which a launch may be required.

SERIES II
FLIGHTS G-13 THROUGH G-18 AT GOODFELLOW AFB
10 FEBRUARY TO 27 FEBRUARY 1957

During the field tests conducted under Series II, the VHA launch crew was given its indoctrination into the intricacies of balloon-launching techniques. This phase was started with one experienced officer and four experienced airmen. The remainder of the crew (one officer and four airmen) had never observed a balloon launching operation. During this series of flights, the experienced men became better acquainted with the specialized techniques used in this program, and the inexperienced men gained valuable training, both from the experienced members of the team and from working as members of the launch team.

A series of lectures and instructions were given covering such subjects as balloon theory, rigging, layout, inflation and gas computation, launching, safety, and personal conduct during tests.

Due to the great variation in surface wind conditions and launching techniques, the entire crew was exposed to many different problems. The crew performed well considering the initial level of experience.

Toward the end of this series, the crew was observed to start working as a team. Less time was needed for detailed job instructions. Thus, this important first phase in training the crew toward the required high level of proficiency was satisfactorily completed.

In Series II, the fiberglass deployment tube developed and manufactured by the Young Development Laboratories was used exclusively. This tube replaced the Series I (Prototype) tube which was of questionable uniformity, had uneven inside and outside surfaces, and had weak spots where application of resins on lapped surfaces was wanting. The new tube was manufactured from a continuous glass filament, giving one piece of construction and a strength increase in every plane. The weight of the new tube is 29 pounds which is considerably below the specification weight range of 35 to 43 pounds.

The parachute top was fitted to the tube by an apex attachment ring. This ring was a metal girdle which clamped around the top of the tube and had 24 attachment points for the parachute apex lines. The parachute shroud lines were attached to the bottom of the tube through 24 holes which had been drilled in the open elipsoidal tube end.

The canisters were the same as those used in the Series I tests.

In an effort to stabilize the deployment tube during its fall, a blank gore parachute was used. This chute gave such a dangerously rapid rate of fall that its use was discontinued after the first test.

The first test using a standard parachute on the tube resulted in failure. When the parachute opened initially, it snagged in the attachment ring and completely ripped out a panel. The tube and canisters broke away from the rest of the load train and fell with a partially opened chute. As a result of the analysis of this test, the attachment ring was modified to eliminate sharp edges and protuberances.

The deployments using the standard parachute, modified attachment ring, and the Young Development Laboratory fiberglass tube were successful.

The load-lowering device used in the Series II tests was designed and fabricated by Prototypes Engineering and Development Corporation. The device consisted of a spool of nylon cord, a stop-start mechanism and an energy dissipating mechanism. The mechanism transferred the energy of the falling load train to a small electric generator with a resistance load which dissipated the generated electricity to the atmosphere in the form of heat. The electric generator thus serves as an electrical brake.

The load-lowering device (reel) was tested in all six flights of the series. In two flights (G-13 and G-15) the reel appeared to function properly, since it payed out a full 500 feet of nylon cord. In flights G-16 and G-18, the reel did not operate. In both cases, the recovered reel was found to be damaged beyond field repair. Results of reel performance during the two remaining flights (G-14 and G-17) were inconclusive. During test flight G-14, the weight of the canisters (262 pounds) was removed from the load train, leaving an insufficient load for operation of the reel. In flight G-17, the reel apparently began to operate, wound out 75 feet of line and then stopped. This reel was found to be damaged when recovered.

In an effort to determine if the damage to the load-lowering device occurred before the balloon system was airborne, a test was made attaching the instrument package, the reel and a 550-pound load to the head of the Lorain launching crane. Several simulated launching runs were made over the same terrain. After each run, the reel performed satisfactorily. From this test, it is concluded that the damage to the reel did not occur prior to launch.

When the reel operated satisfactorily, it invariably touched the ground 500 feet from the package immediately below it. Observers were present at both such impacts and noted that when the heavy object below the reel touched the ground, it acted as an anchor and that the parachutes then began to act in the manner of kites, gently lowering the reel to the ground. Conversely, impact was observed in two flights in which the load-lowering device did not operate, and in these cases the reel appeared to land violently on top of the heavier unit immediately below it. Orange paint from the heavy item was observed on one of the damaged reels. From this, it is apparent that the damage to the load-lowering devices occurred on impact.

From the results of the Series II tests, it is obvious that the present load-lowering device is inadequate and unreliable. Work will have to be done either to modify the existing reel or to design a new reel which will give the desired performance.

The new VHA balloon was used in all six flights of this series. These tests indicate a much better balloon than the one used in the Series I tests.

The one balloon failure will be discussed first. On flight G-14, the balloon burst at 82,000 feet. The load train had separated earlier in this flight reducing the weight of the pay load to 338 pounds. This lightened load train was sufficient to keep the balloon stable during ascent, but caused a high rate of ascent and introduced large transverse stresses in the balloon material at the high altitudes. Since the balloon was specifically designed for a minimum pay load of 466 pounds, it was obviously operating outside of its design limits. The balloon failure in this flight is not believed to be caused by poor material or faulty fabrication.

The balloons used in the other five flights of Series II performed well. The balloons had a satisfactory rate of rise and a satisfactory floating altitude.

SERIES III
FLIGHTS G-19 THROUGH G-26
21 MARCH TO 10 APRIL 1957

Encouraging progress was noted in the practical skills of balloon handling, rigging, layout and launching. The balloon layout through this series was made unhesitatingly, accurately, and with confidence. The balloon handling during inflation in high winds approached a high degree of competence. A concentrated effort was made to instruct personnel in calibration of flight control instrumentation which would result in a more balanced work load for

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our instrumentation section. Complementary to the actual launching activity, the launching personnel received formal classroom training in the theory of balloon flight. Such training of entire launching crews has been proven to increase launching proficiency. Oral testing of these personnel has indicated the need for continuation of this phase of training.

An evaluation of the results of personnel training to date showed that the launch crew was a team, worked as a team, and during the last three flights of the series, consistently performed in an above-average manner.

Another important purpose for the Series III field effort was to begin testing and evaluating the performance of the new launch vehicle. For purposes of familiarization, this vehicle has diesel electric drive, four-wheel mounted pneumatic tires, and a tilting vertical mast and elevating car equipped with a quick-release mechanism. The top cross member of the car and the release mechanism have a maximum vertical height of 36 feet. The vertical mast and elevating car are mounted on the front end of the vehicle. This vehicle was designed to launch a large plastic balloon attached to a 32-foot-vertical-load train of multiple instrument packages.

Fortunately, surface wind conditions during this period were so variable, in direction and velocity, that testing was possible under conditions that ranged from routine to most difficult. The maneuverability of the vehicle was manifestly displayed in the execution of three cross-wind launchings. This particular case of launching is difficult due to improper system orientation to wind direction and requires two distinct forward movements interrupted by a turn from cross wind to down wind. The two launchings in calm surface conditions demonstrated the usefulness of the smooth and uninterrupted travel speeds, both forward and reverse, and through a continuous speed selection range. This type of launching requires smooth speed control and rapid forward movement to mitigate the balloon release shock from the balloon release platform, then decreased forward speed as the balloon approaches the vertical. Finally, on the command of release, two actions are taken simultaneously: (1) the balloon system is released, and (2) the vehicle is reversed very rapidly to remove it from the immediate launching. This removal eliminates possible equipment damage in the case of pedulous action of the balloon system back into the launching vehicle.

The stability of the launching vehicle was demonstrated repeatedly both statically and dynamically. The technical evaluation of this vehicle, though not completed, indicates that it will handle the VHA balloon system with an adequate safety factor. Additional training of operators is required in order to assess optimum performance.

The two attempts to test the load-lowering device were unsatisfactory. As noted under the Series II test conclusions, development or redesign of the reel is necessary. The original reel is now being redesigned to include a planitary gear link instead of a worm-gear-driven link to the electrical generator brake. A second reel which employs a hydraulic brake is being designed. Comparative tests of these two types of reels are planned.

The deployment system has again performed very satisfactorily. The fiberglass tube in this system is acceptable for the mission in its present form. Two flights in this series served additionally as service test flights for the Sandia Corporation. The Bendix Corporation utilized four of the flights for test of equipment. The launching, deployment of equipment, flight duration and ceiling altitude of these flights were reported as satisfactory by both companies.

The VHA balloons were critically observed in all tests. All tests resulted in successful balloon performance in accordance with design specifications.

SERIES IV
FLIGHTS G-27A TO G-36
28 JUNE TO 26 JULY 1957

The Eniwetok tests were successful in meeting the Series IV objectives of the development plan which were to (1) train crews, (2) test the VHA balloon in operational latitudes, (3) test load-train components, (4) gain experience in launching under the high velocity wind conditions of this geographical location, and (5) flight test the Sandia package.

A summary of Series IV tests showed that: (1) Sixteen balloon systems were readied for launching. (2) Nine of these balloon systems were released (launched) and these nine systems flew successfully. (3) Three balloon systems were readied for flight but were not launched. The balloons of two of these systems were cut away or destroyed during the launching runs. The third balloon system was not launched due to failure of test support instrumentation (electronic) which was not a part of the VHA system proper. (4) Four balloons were destroyed on the ground by high winds during inflation attempts.

The performance of the launching crew reached a high degree of professionalism for the VHA balloon system as a result of these tests. Of the flights that were launched, the VHA balloon performed satisfactorily. The ascent rates were correct, thus verifying proper inflation techniques, and the floating altitudes attained were as specified. The performance of the balloons was not affected by passage through tropopause temperatures of −80 C; temperatures were verified by radiosonde data obtained within 2 hours of each actual flight time. All load-train components performed correctly in each of the nine flights. The launching officer was informed by Sandia representatives that the three service flights for the Sandia Corporation were satisfactory.

It is noted that a partial simulation of a wind screen launching technique using a hangar as a shel-

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ter resulted in the successful flight of all balloon systems launched.

USS BOXER SERIES
FLIGHTS G-37 TO G-41
6 TO 13 SEPTEMBER 1957

The development and testing of Project 9.2b was revised as a result of revision of launching techniques, and the decision to employ an aircraft carrier as the launching platform. The Series V tests, scheduled for October 1957, and the Series VI tests, scheduled for January 1958 were, in effect, combined and reprogrammed for the period 1 October 1957 to 15 December 1957. Subsequent to our meetings on the USS Antietam, 5 August 1957, and the U. S. Naval Air Station, North Island, San Diego, California, 21 to 24 August 1957, a revised schedule of operations was prepared to perform an additional series of flights aboard the USS Boxer (CVS). The purpose of this series was to determine if the VHA balloon carrier configuration could be launched from this type of naval vessel. Five flights were successfully launched during this series. It was concluded that an aircraft carrier was a suitable and feasible platform.

SERIES V AND VI
FLIGHTS G-42 TO G-58
1 OCTOBER TO 15 DECEMBER 1957

The purpose of the combined series was (1) to flight test the two load-lowering devices (reels), compare and evaluate their performance, and incorporate minor modifications, and (2) to develop and refine the canister deployment rigging, test new methods of nylon line coiling, and flight test the new canister size and weight. This operation permitted the further testing of Sandia Corporation equipment, and provided a flight platform for the instrumentation contractors.

The field test program during the period 1 October to 1 November 1957 was severely retarded by adverse weather for balloon flying. Eight balloons were launched carrying Project 9.2b equipment. All of the flights with the exception of G-48, which carried the Sandia equipment, were purposely cut down by command, after completion of the tests of equipment flown, to facilitate recovery. General test results from the eight flights are:

1. The GRD-developed load-lowering devices (reels) functioned correctly during each of the five flights on which the devices were flown.
2. The Prototype-Company-developed reel was used on three flights. It functioned satisfactorily on one flight and partially so on two flights. Deficiencies uncovered could be corrected without major modification.
3. The GRD reel design has been selected for the final VHA system because of its demonstrated reliability, simplicity and ease of manufacture in the limited time for procurement before overseas tests.
4. The VHA balloon performed satisfactorily in Flight G-48, the only flight permitted to reach ceiling altitude.
5. The Sandia representatives indicated that Flight G-48 provided a satisfactory test for their equipment.
6. The flights carrying Bendix equipment were conducted satisfactorily but failure to recover two Bendix instrumented canisters precluded postflight examination. Additional test flights for Bendix will be required.
7. The testing of machine-coiled nylon line for canister deployment did not prove satisfactory. The line knotted and snarled and subsequently weakened. Ground tests were conducted to observe this knotting problem and the results were conclusive to the extent that future flights would use the hand-packed nylon deployment system exclusively. This hand method which requires greater preparation time has proven to be satisfactory on all previous flights.

The field test program during the period 2 November to 30 November 1957 was also retarded by adverse weather for balloon flying. Three flights were prepared, one of which was not launched. Flights G-50 and G-51A were made to test the Sandia Corporation instrumentation.

The field test program during the period 1 December to 15 December resulted in the successful launching of seven flights. The purpose of these flights was to test the GRD reel after making final refinements, test the VHA balloon, test flow meters, and provide support for the Bendix Corporation instrumentation effort.

VERNALIS SERIES
FLIGHTS G-59 TO G-65
2 JANUARY TO 13 JANUARY 1958

At the conclusion of the Series VI flights, Project 9.2b was requested to provide six additional service flights, not scheduled in the original plan, for the purpose of testing the Bendix Corporation (Project 1.10) instrumentation. Accordingly six flights were planned for the period 2 to 13 January 1958 at the AFCRC Operation location, Vernalis, California. These flights were to carry only Bendix instrumentation and supporting equipment for a normal short-duration balloon flight, and did not include the VHA deployment and flight system. Immediate recovery of the instrumentation was requested.

Seven flights, one in excess of the plan, were launched on schedule.

The flights were successful in meeting the test objectives for the Project 1.10 instrumentation.

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SERIES VII
FLIGHTS G-66 TO G-76 AT ENIWETOK PROVING GROUND
6 MARCH 1958 TO 1 MAY 1958

The Series VII tests were successful in meeting the objectives of the field test plan which were:

1. To familiarize the USAF launch crew with balloon launching techniques aboard an aircraft carrier. Technique to include balloon inflation system from gas (helium) supply trailers on hangar deck.
2. To enable the ship's bridge to develop maneuvering techniques for a successful balloon launch.
3. To observe deployment of canisters with an increase in weight of the total canister system from 274 pounds to 337 pounds.
4. To establish a new launch plan to minimize travel time of the balloon system over the flight deck.
5. To flight-test the Sandia instrumentation.
6. To flight-test the Bendix instrumentation.
7. To provide tracking experience for the B-36 aircraft crews.
8. To provide full dress rehearsals for the Yucca event.

The success of Phase VII and the final Yucca event is a tribute to each member of the launching team. The results of exhaustive practice provided the proficiency to accomplish the transition from a land-launching operation to an aircraft-carrier operation with no apparent crew perturbation. The confidence won through many months of successful training contributed to the ease of assimilating the revised techniques and this continuity of job knowledge was amply displayed during the first three flights of this series. It follows that the fourth flight was made with such dispatch and facility that all fears of future launching complications were immediately dispelled.

Another important feature of the training program, for this phase, was to emphasize that each step in assembling the components would be entrusted to a check list only. A final assessment of crew performance indicates the validity and soundness of such a thorough training program.

The preliminary balloon flights provided the ship's bridge the necessary experience in maneuvering so that relative winds across the deck were favorable for balloon handling. A study of wind speed and direction during the inflation, holding, and launching of the first three flights indicated variable winds averaging 1.5 knots and maximum winds of 4.5 knots. It has been repeatedly shown that winds of this magnitude do not adversely affect the inflation and launching operation, nor cause damage to the balloon. It was soon evident, therefore, that ship maneuvering relative to wind would be satisfactory. A final assessment of test series showed that the ship's bridge was successful in providing optimum inflation, hold, and launching conditions on the flight deck.

On 4 April 1958, the project officer learned that the original canister weights which had been used during the development and testing phases to date were inaccurate. Not only were the established weights wrong but the assumption that the canister weight included the nylon line was also faulty. A meeting with Project 1.10 personnel established the fact that this information about increased canister weight had not been given to Project 9.2b. Delineated below are the old weights for which the whole system was developed and the new weights which were used subsequent to 4 April 1958, and furnished belatedly by Project 1.10:

Canister	Canister weight for which system was developed	New canister weight to satisfy Project 1.10 requirements
	pounds	pounds
A	40.5	44.5
B	50.25	68.0
C	50.25	68.0
D	50.25	63.5
E	62.50	75.0

On 5 April 1958, G-73-S was flown and the new canister weights included in the simulated train. To insure sufficient nylon line strength in the load train, the strength of the line from Canister A to Canister B was increased from 1,000-pound-test nylon to 1,500-pound-test nylon. Results of this test flight and subsequent flights with a similar load indicated parachute stability unchanged and satisfactory performance of the deployment system.

The first Boxer series was conducted to establish the feasibility of launching large plastic balloons from an aircraft carrier. During this series, the orientation of launching was such that at release time the balloon and load traveled over the flight deck for a distance of 300 plus feet. During several discussions within the laboratory and with the Sandia Corporation it was decided in the interest of safety to reduce this travel distance over the deck in the event of a premature cut-down immediately after the launch. Several possibilities were considered within the limited balloon-launching possibilities, and the following plan selected for trial: (1) Launch vehicle, mast facing aft, center lined on the flight deck 24 feet from aft end. (2) Launch platform centered approximately 200 feet from aft end of flight deck, roller arm operating toward the fan tail. (3) Balloon so laid out that at release from launch platform, balloon motion will carry balloon to a vertical position above launcher mast (located 24 feet from aft end of flight deck); at balloon release, the load would travel 24 feet and be clear of the flight deck.

In contrast, the first launching series conformed to the following vehicle-to-flight-deck orientation:

(1) Launch vehicle, mast facing aft, center lined on the flight deck 300 feet from aft end. (2) Launch platform centered approximately 100 feet from aft

end of flight deck with roller arm opening toward the bow. (3) Balloon so laid that at release from launch platform, balloon motion carried to a vertical position above launch mast (located 300 feet from aft end of ship); at balloon release, the load would travel 300 feet and be clear of the flight deck.

The new launching plan was successful and used through the whole series of flights. It is significant that the over-the-deck travel was reduced by 92 percent and the safety of the operation supplemented by this corresponding factor.

An evaluation of the flight results by the Bendix and Sandia Corporations indicates that their test requirements were satisfactorily met. Encouraging progress was noted through the flight series by the B-36 aircraft crews. The many flight critiques demonstrated their difficult problems in establishing suitable and compatible tracking patterns and the repeated test flights were used to great advantage in defining these parameters.

Appendix C

DESCRIPTION OF EQUIPMENT AND TECHNIQUES

BALLOON VEHICLE SYSTEM COMPONENTS

The Project 9.2b Balloon Vehicle System incorporates the following component links in the flight configuration, suspended from the balloon.

Balloon Vehicle. The balloon is basically a standard USAF 128 foot diameter tailored tapeless envelope. It is fabricated of a special resin two-mil polyethylene material under rigid material and fabrication controls and inspections. It is essentially cylindrical in shape with the bottom and top materials gathered in a special fitting. The balloon takes an oblate spheroid shape at altitude and is approximately 128 feet in diameter at its equator. It displaces a volume equivalent to 810,000 cubic feet. It is inflated with approximately 20,000 standard cubic feet of helium gas.

Main Load Line. The main load line consists of a doubled length of 5,000-pound-test nylon line, separating the bottom apex fitting of the balloon and the top of the load-lowering device by approximately 70 feet. It is rigged with an aluminum T-bar, 7 feet below the bottom fitting, that supports two each corner reflectors for radar positioning. It also incorporates a tension loading switch 5 feet above its base. The purpose of this switch is to check the lift of the balloon after it has been released into the vertical and just prior to launch of the system.

Load-Lowering Device. This device, commonly referred to as the reel, permits the separation of the nuclear device from the balloon by a distance in excess of 500 feet. The reel-out of the 3,000-pound-test nylon line is controlled by a braking system consisting of rotor and stator disks in a high viscosity silicon fluid (G. E. Viscosil, 700 stokes). The reel-out operation is started by command firing of a squib that releases a locking device on the shaft. It incorporates a pressure-actuated backup starter. The reel-out operation requires approximately 14 minutes. The nylon line is wound on the drum under 1,000 pounds tension. A special bracket is mounted on the brake side of the device to support the X-band transponder beacon. Two squib cannons are rigged into this nylon line for command and timer cut-down of the system.

Nuclear Device (Sandia Corporation Project 9.2a). The nuclear device support harness incorporates provisions for attachment of a safety support lanyard to anchor the load train to the mast of the launch vehicle in the event of premature firing of actuation squibs prior to the launch of the balloon system. The base load supporting fitting also incorporates a load-actuated pin release lever that permits sequence arming of the weapon upon actuation of the canister deployment. The receiving antenna for the weapon is rigged to the canister load line prior to load train assembly on the mast and is attached to the weapon upon assembly on the mast.

Canister Deployment System. This system for the deployment and spacing of the weapon effects instrumentation was conceived, designed, and developed approximately 2½ years ago based upon ultimate performance criteria less than 50 percent as stringent from a weight and stability standpoint as the final configuration. The heart of the system is a specially designed and fabricated fiberglass tube inclosed in a modified 30-foot personnel parachute for deceleration control purposes. The tube and parachute assembly is suspended below the weapon by a continuous nylon line through four rings in the top of the tube. The assembly is supported by two loops of this line over the two (of three) outside rollers of the special load fitting on the bottom of the weapon. The deployment is actuated by firing a squib cannon in this line. The main canister load line is attached to the pin release lever. The canisters (Projects 1.10, 2.7 and 8.2) are joined by specially stowed 1,000- and 1,500-pound-test nylon line attached to load rings on the tops and bottoms of the canisters. The pressure-actuated (backup) deployment box is attached to the outside of the parachute canopy, approximately 2 feet from the top.

LAUNCH AND INFLATION EQUIPMENT

Launch Vehicle. The balloon launch vehicle is a specially modified equipment utilizing the basic chassis and design of the R. G. LeTourneau Company small Log Stacker. It features an all-electric drive for all mechanical and propulsion operations. Special gearing permits a smooth and rapid acceleration to 22 mph. An extended mast (37 feet high) accommodates the VHA load train. The mast may be tilted fore and aft. A load carriage on the mast permits the train to be attached in sequence from the ground and be raised to the release position. In ad-

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dition, the mast incorporates a ladder and an electric drive elevator platform for inspection, rigging, and arming of the nuclear device. The gross weight of the fully assembled vehicle is approximately 60,000 pounds. This weight is required for stability prior to and during launch.

Launch Arms. These are standard USAF equipment. They permit the controlled feeding of balloon fabric to the bubble during inflation while simultaneously retaining the balloon in a confined manner to facilitate pre-launch handling. The roller arms are also incorporated into an accurately balanced platform that gives a direct reading of lift. In this application, the vehicle is anchored in a fixed position.

Gas Supply Trailers. The VHA balloon is inflated from standard USAF gas supply trailers of 48,000 and 38,000 standard cubic foot capacities. Approximately two flights may be obtained from each trailer. The gas is stored under resulting pressures averaging approximately 2,300 psi. The trailers are built up of 38 and 30, respectively, tubes of accurately known volumes valved together in a common manifold. The gas inflation of the balloon is initially determined by computation using the volume, pressure, and temperature of the gas. The pressure and temperature are determined by laboratory type instruments. The gas is serviced from the hangar deck of the carrier through 300 feet of 1-inch (inside diameter) rubber hose to a gas diffuser at the inflation appendix of the balloon on the aft of the flight deck. Communication is by sound-powered phones.

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